The Eurasia Proceedings of Science, Technology, Engineering & Mathematics

EPSTEM

ICONTECH 2022 NOVEMBER

Volume 19, Pages 1-131 (November 2022)

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)

e-ISSN: 2602-3199

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Address: Istanbul C. Cengaver S. No 2 Karatay/Konya/TURKEY

Website: www.isres.org

Contact: isrespublishing@gmail.com

Conference: ICONTECH2022: International Conference on Technology (ICONTECH)
Conference website: https://www.2022.icontechno.net
Dates: November 16 – 19, 2022
Location: Antalya, Turkey
Edited by: Prof. Dr. Sabri Kocer

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In the past, accessing information was tiring both financially and morally, but today, thanks to technology, it is easier and faster to access information. With this feature, technology not only makes daily life easier, but also accelerates the developments in science. Therefore, the focus of the conference is to share the studies on the developments in technology and the applications of technology in fields such as science and engineering by the participants. Studies in the fields of technology are accepted to the conference.

The aim of the conference is to bring together researchers and administrators from different countries, and to discuss theoretical and practical issues in the field of technology. At the same time, being aware of the applications of technology in different fields (such as engineering) is among the objectives of the conference.

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IConTech 2022: International Conference on Technology

Electrical Load Forecasting Methodologies and Approaches

Seemant TIWARI
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Abstract: Load forecasting is indeed a strategy used mostly by power providers to predict the amount of power or energy required to match market dynamics at all moments. Electricity load prediction is a dangerous process trendy the electrical company's development besides theatres a dangerous character in electrical capacities allocation and power structure organization; as a result, it consumes increasingly gained research interest. As a result, the reliability of power demand prediction is critical for electricity resource planning and electrical management system. The increasing rise of database files in market research, together with data processing, created an urgent need development of an effective instrument process for capturing concealed and crucial understanding of load prediction from accessible enormous data sets. Many machine learning techniques, as a potential subset of computer engineering, are well suited to the answer to this issue. This text delivers an impression of authority weight prediction practices besides algorithms. Notwithstanding the complexity of all studied methods, the evaluation demonstrates that regression analysis itself is frequently utilized and economical for long-term prediction. Machine learning or artificially intelligent methods like Neural Networks, Support Vector Machines, and Fuzzy logic are ideal for short-term estimates.

Keywords: Artificial Neural Networks (ANNs), Prediction of load demand, Forecasting methods and algorithms, Time Series

Introduction

Forecasting is a critical component of the electricity system. Forecasting systems are now used for both wind power generation (Seemant & Ling, 2021), and wind speed (Tiwari, 2022). Forecasting electrical load is also beneficial to the power grid and power corporations. Electricity is an environmentally friendly and cost-effective type of energy that is indispensable in our everyday lives (Lin Y. et al., 2017). Electricity's importance has lately grown dramatically, which has also become an important issue in studies (Nalcaci et al., 2018). Furthermore, as likened to other conventional electricity sources like natural gas, coke, and petroleum, electrical energy is much more appropriate and effective for the requirements of an environmentally conscious community.

Furthermore, energy as a production differs from material goods in that it can't be held in quantity and must be produced as quickly as required. Furthermore, because of the liberalization of the electricity industry, including such energy glut and shortages, the sales volume for energy is complicated, which might result in faulty forecasts and severe loss of money. Furthermore, as the world's population grows and living conditions increase, world energy consumption is predicted to skyrocket. Additionally, industries are expanding, as is the use of increased electrical items and the advancement of technologies including micro-grids, electrical vehicles, and the manufacture of renewable energy. All of these issues brand managing the electric grid complex (Khamaira et al., 2018). As a result, when choosing on generating electricity, it is vital to forecast the requirements of energy.

The biggest issue in forecasting requests is deciding on a suitable method. With an annual increase rate of 4 to 7% in electrical energy usage, multiple features have now become leading in the production of generated electricity. Predicting energy demand has long been criticized for managing clients' needs, new activities, and maintaining power systems. The utilization of electricity in the shape of energy is referred to as an electricity network. The cost of electricity, consumption, and reliance on fossil fuels are all steadily rising. The creation of

innovative electrical consumption prediction models to satisfy rising demands is a massive issue for any government concerned with energy or power generation. Because electric power is challenging to store in a reserve, forecasting energy needs is critical to ensuring an appropriate supply of electricity to power consumers. Predicted electric load numbers are utilized for: Choosing the quantity of fuel to allocate to distributed generators and maintaining them, distributed management and load preparation, and addressing the needs of customers throughout the year.

This work is divided into the following sections: Section 2nd discussed load forecasting categorization. The 3rd section classified load forecasting methodologies. Section 4th discussed the model chosen for their quality and source of data. Section 5th discussed a critical challenge in load forecasting. Section 6th discussed the benefits, and drawbacks of load forecasting. The last section is the conclusions besides future research.

Load Forecasting Categorization

Depending on the amount of power consumed, load forecasting could be divided into two categories. The first is spatial prediction, whereas the other is temporal prediction. Spatial prediction anticipates the power to the load for a specific area of the globe, like an entire nation, a province, or a specific town. Temporal prediction is the prediction of the energy demand for a given dealer or group of users for a specific interval of time, such as minutes, weeks, seasons, or years. Load predictions in respect of predicted durations into the following categories (Gordillo-Orquera et al., 2018).

Forecasting of Ultra-Short-Term Load

It is utilized for actual authority and can vary from very few minutes to an hour ahead. Used for the Systems of Energy Management as well.

Forecasting of Short-Term Load

This prediction approach typically spans a range of one hour to one week. This could help us estimate load flow and then formulate choices to avoid overburdening. Short-term prediction is employed to give necessary details for such platform's everyday processes including units' commitments. Additionally used to allocate fuels to diesel generators, perform short-term repairs, and pledge to generate units.

Forecasting of Medium-Term Load

The timeframe of this predicting approach ranges between six-seven days to one year. Predictions for various periods are critical for various functions inside a utility firm. Medium-term prediction is utilized for fuel supply planning and equipment maintenance. Often utilized in gasoline buying and pricing revision considerations.

Forecasting Long-Term Load

This predicting approach has a lengthier time frame than one year. It is employed to provide electrical power utility administration with a precise estimate of future development, component selection, or workforce employment requirements. It is also used for the development and increase of electricity generation. It plans to build additional power stations and cables.

Load Forecasting Methodologies

There have been several methodologies proposed for predicting power usage, which can be divided into two types modeling and methodologies. Such tactics and approaches take a more conventional methodology, employing principles like time-series data and linear regression approaches from the domains of AI (artificial intelligence) and computer intelligence (Hong, 2010). Univariate modeling, as well as multivariate modeling, are two different types of load demand prediction. Univariate methods, commonly known are time series analysis, include models in which the load is represented as a factor of its previously measured data.

Extracellular elements including such climate and the day kind are ignored in this prediction. Multiplicative autoregressive algorithms are instances of this kind of model, dynamic linear and nonlinear systems, thresholds auto-regressive concepts, and Kalman filtering (Abdel-Aal, 2008). Multivariate models are those in wherein demand is represented as a consequence of certain external features, most notably meteorological and sociological variables. Box and Jenkins transfer functions, ARMAXS modeling, non-parametric regression, and curve fitting processes are a few applications. Multivariate approaches are often known as causality approaches (Jain, 2009). Below is a summary of various concepts.

Models Based on Regression

Such methods are applied to create correlations among load demand and independent variables such as maximum temperature, minimum temperature, as well as date information, which are mostly employed in linear regression. Forecasting in regression appears to mean estimating a quantity, whether it be upcoming, present, or previous concerning the available data. The nonlinear link between power systems and moderating variables causes difficulties in determining the appropriate models. It is simple to create a connection among the model's O/P and I/P parameters. Such structures are simple to implement as well as manage. Multiple regression methods are also available to express the demand as a consequence of external inputs (Hahn et al., 2009).

In (Fan et al., 2014), this study outlines a method for building a model through ensemble modeling for estimating energy use for the following day. Ensemble programming is a machine learning technique where more than different base algorithms are combined to get a final output. Ensemble Learning as well as Ensemble Training is accomplished in two stages: In the initial phase, a no. of regular methods were produced, whether simultaneously or in succession, while in the second step, basis modeling is employed to produce the ultimate output through employing various clustering strategies. The genetic algorithms are utilized to calculate values for every one of the regular models employed in this approach. In Hong Kong, the approach is employed to predict electrical load requirements for a complex. Multiple Linear Regression was found to necessitate additional time for computing time inside this study.

Neural Networks

Warren McCulloch and Walter Pitts developed the artificial neural network (ANN) technique in 1990 as an alternate methodology to time series prediction. ANNs are being used effectively in a variety of fields, particularly predicting and categorization. ANN methods have recently been widely utilized and investigated as a technique for electricity load prediction and also have achieved popular success in recent years (Adhikari & Agrawal, 2013). The neural net is essentially a non-linear device susceptible to non-linear logistic regression. It depicts a knowledge acquisition approach that's been influenced either by the way the human-natural systems, including the mind, may analyze a particular piece of data. Inside this procedure, the ANNs attempt to discover constants and trends in the data received train through history, and afterward deliver extended outcomes based on the previously current information. An ANN is made up of numerous linked functional units (PE) named neurons that change their dynamic state reaction to exogenous variables (Kuster et al., 2017).

In (Slobadan et al., 2013), this research introduced an ANN methodology using a regression methodology; the records of electricity needs utilized in this research were obtained from Jeddah, Saudi Arabia. The electrical demand was forecasted using this method, and comparing it with certain other approaches revealed that Artificial Neural Network is superior in terms of outcomes. A randomly generated no. the producer was employed to generate the weights for the various input parameters in System. The things performed by the method are separated into two cycles: preparation of data in the first step and forecasting of electricity in the second phase.

In a short-term load-predicting approach that uses ANN, the research is split into two stages a first stage is employed aimed at data foundation, then the additional portion is utilized to forestall power usage expanding a neural network. It has been established that there is a very significant nonlinear link between everyday load demand and everyday temperatures. Three input parameters are utilized as input data: Last day's electrical consumption, Temp., as well as daily types. The "Modified Back Propagation" methodology is utilized to understand Artificial Neural Networks inside this method. Sigmoid initiation is utilized across overall hidden layers throughout neural network training.

Methodologies to Time-Series

Prediction in time series seems to imply approximating upcoming standards founded on ancient measurements of time-series data (Himanshu et al., 2008). The Time Series Technique commonly referred to as Univariate or Multivariate is one of the fundamental procedures utilized in energy consumption forecasting. Univariate analysis has the benefit of not necessitating additional time-series data from outside I/P (Abdel-Aal, 2008). A Time Series Technique, in the form of univariate methods, is utilized to forecast short-term electricity energy needs. Univariate methods were utilized to forecast electrical energy requests; in this research, such methods employed previous investigational results while disregarding additional associated variables. Univariate Process Methods include Multiplicative Autoregressive Methods, Threshold Autoregressive Methods, Dynamic Linear Methods, and Kalman Filtering Techniques. Multivariate approaches are also utilized to anticipate electrical power usage, however, in this research, such methods employed several external elements such as sociological variables, temperatures, and others (Hahn et al., 2009). These methods have the drawbacks of being time-demanding, requiring a lot of humanoid involvement, and then potentially fetching mathematically unreliable (Jain, 2009).

In (Gonzalez-Romera et al., 2006), this study attempts to service a two-step approach. The first step represents the tendency in electricity load demand, although the second step represents the variation in that tendency. When compared with the direct estimation of electricity load predictions, the findings of this technique are excellent.

Support Vector Machine

Support vector machines are regression and categorization methods developed by Vapnik in 1992. SVM was originally designed to solve pattern categorization difficulties. Following that, Vapnik expanded the usage of SVM to be used in regression techniques. Over the past two decades, SVM has gained popularity not just for pattern classification and regression analysis, in addition for predicting and tackling time series modeling issues. The fundamental goal of SVMs is to deduce particular decision rules with a better prediction capability by selecting a specific group of training data named support vectors (Weron, 2006).

A nonlinear mapping of the I/P space into such an advanced dimension is used in SVM methods, and then an ideally separated hyper-plane is generated. As a result, the complexities and accuracy of SVM algorithms are not directly impacted by the I/P vector. While creating SVM methods, the training method is similar to that used for addressing a linearly controlled quadratic software design challenge. As a result, in contrast to many other systems' training, SVM responses seem to be constantly universally optimal and distinct. But at the other hand, the fundamental flaw of SVM is that they demand a large number of computing, which significantly increases the temporal complexities of the responses (Zhang et al., 2017).

Fuzzy Logic

Fuzzy logic seems to be a modification of the ordinary Boolean concept, but rather than receiving some 0 or 1, that has certain subjective limits connected with this. In those other terms, a temp could be lower, middle, or higher; nevertheless, employing fuzzy logic permits outcomes to be determined using noise or fuzzy input without the necessity for exact mappings of input to output. Fuzzy approaches are extremely advantageous when dealing with uncertainty and are critical for human specialists' information literacy. A membership function could be expressed for just any fuzzy numbers, in which a function about any fuzzy numbers, or a membership function, demonstrates particular continuous curves that change from 0 to 1 or conversely, and the location of a matching transition reflects the period's fuzzy boundaries. To produce good predicting outcomes, fuzzy theories are frequently integrated with many other methodologies (Weron, 2006).

Azeem (2012), in these kinds of instances, fuzzy logic could be employed. The mathematical formula either doesn't exist or is too complicated to encode. The mathematical formula is just too sophisticated to be analyzed quickly enough yet for actual use. On the defined processor architectures, the statistical approach integrates far too much RAM. The experts are accessible to describe the model of development guidelines and the fuzzy systems that describe the features of every parameter. The processes are either too sophisticated, non-linear, or unknown to construct employing typical techniques.

Methods of Hybridization

This method integrates upwards of two methods or strategies in regulations to overcome the disadvantage of the originating methodology. Thus a strategy is referred to as a hybrid strategy. By combining the benefits of multiple single prediction models, hybrids or mixture methodologies and approaches can achieve greater predicting effectiveness over single methodologies so they are commonly utilized in several predicting domains. Therefore in regard, there are many multiple predicting methodologies, mathematical programming, and information processing approaches accessible for constructing various hybrid methodologies (Zhang et al., 2017). As a result, fresh research has shifted their main investigation attention to the creation of successful hybrid methodologies to boost forecasting accuracy (Wang et al., 2019). As a result, it is appropriate to seek out newer hybrid approaches that are offered to include new technical foundations (Verdejo et al., 2017).

Model Chosen for Their Quality and Source of Data

We discovered the significant findings through numerous research creations: methodology, set of data, I/P, O/P, methodology of training, and utilization of the suggested scientific study. Table 1 shows an overview of the research. Table 2 lists some of the most common textbooks on the topic of load forecasting models.

Table 1. Overview of the research

Ref.	I/P	O/P	Set of Data	Methodology	Methodology of Training	Utilize
Friedrich et al., 2015	Data on power and meteorology	Abu Dhabi, short-term load prediction	SCADA municipality of Abu Dhabi Emirate's energy supplier and Masdar area's monitoring system	Neural network	Algorithms of Levenberg-Marquardt	Electrical load usage forecasting
Prakash et al., 2014	Information on electricity and meteorology	Uttarakhand(State) short-term load prediction	Dehradun city load-shedding unit	Neural network	Formula of Levenberg-Marquardt	Electric load usage estimation
Slobadan et al., 2013	The method's inputs include loading and temp readings collected for a particular client on the electricity network	Short-term load prediction	Load data from the old days	Artificial neural network	The initial approach used a singular NN using 24 O/P to anticipate the load demand, whereas the other used 24 independent NN with just 1 O/P.	Predicting the hour load could be done rather well.
Deng, 2010	Energy consumption	Electricity consumption forecast	Details source China's national bureau of statistics	Linear Regression, ANN	Backpropagation	Long-term electricity forecast for China
Jain, 2009	Information on electric load	Load prediction	Data from the previous two years	SVM	SVM Clustering	Load forecast for the coming day

Table 2. Covers some of the most widely used textbooks

Title	Ref.
An Introductory Study on Time Series Modeling and Forecasting	Adhikari & Agrawal, 2013
Electrical Load Forecasting: Modeling and Model Construction	Soliman et al., 2010
Forecasting: Principles and Practice	Hyndman & Athanasopoulos, 2018
Short-Term Load Forecasting by Artificial Intelligent Technologies	Hong et al., 2019
Modeling and Forecasting Electricity Loads and Prices: A Statistical Approach	Weron, 2006

A Critical Challenge in Load Forecasting

Estimating power demands has entered a mature stage. Predictions reaching the short range (a few seconds, hour, or coming days) to the lengthy period (up to 12-15 years ahead) were becoming highly prevalent since the reorganization of power networks. Several nations have followed a policy of containment and commercialized their energy networks, transforming electrical into a precious asset with market values. Demand forecasts are a hard process. Firstly, since the demand sequence is dynamic and has multiple layers of periodicity, the demand at a particular hour is reliant not just on the prior hour's longer load, but as well as the demand at the exact hours of the prior date, and the exact hourly demand the day before its same amount the prior week. Furthermore, there are numerous relevant external things to consider, particularly weather-related factors (Hippert et al., 2001). Such problems can be tackled utilizing a variety of techniques and approaches such as auto-regressive methods, dynamically linear or nonlinear approaches, fuzzy inference, fuzzy-neural concepts, Box and Jenkins transfer functions ARMAX methodologies, and neural network (NN), among others.

In the energy market, predicting demands and pricing are linked to activity, and errors in load prediction will spread to price prediction. Power prices have unique properties. It is distinguished by at least three key characteristics. One of these is its lack of energy storage, therefore implying that costs are strongly reliant on electricity consumption. The second distinguishing feature is the periodic nature of power prices at various levels (every day, monthly, and yearly periodicity), and the last is its uncertain issues to deal with. The hourly price changes in today's highly aggressive power sector contain elements like instability, non-stationarity, repeated periodicity, peaks, and high intensity. A price crash can be induced by economic power, that is a freak incident, as well as by unanticipated events including transmission delays, transmitting delays, and production consequences. Additional elements that can influence it include energy prices, production plant operating costs, weather patterns, and, perhaps most importantly, the equilibrium among complete system demand and supply. Power price predicting uses are classified into three timeframes: short-term prediction, medium-term prediction, and long-term prediction.

Benefits and Drawbacks of Load Forecasting

It allows the power corporation to strategy effectively because they have a good grasp of upcoming spending or load profile. Load predicting is used to prepare for the upcoming regarding the scope, position, and kind of upcoming output growth. It ensures the most efficient use of power generation plants. Prediction prevents under-generation and over-generation. Helpful for determining the necessary assets, like fuels necessary to run energy is converted as well as other materials necessary to provide continuous and cost-effective electricity production and distribution to customers. This is critical for any short, medium, or long-term management.

Taking a decision primarily based on a prediction might lead to monetary devastation for such a company, hence choices should not be created purely on a prediction. Accurate forecasting of tomorrow is impossible. Because of the subjective nature of predicting, a company might generate a variability of situations founded on the analysis of the information. Corporations must never depend entirely on prediction models. Furthermore, a company can utilize prediction in combination with other tools, instruments for assessment to provide the maximum possible data to the organization concerning the future.

Conclusions and Future Research

Various prediction algorithms for electricity load prediction have already been thoroughly examined in this study. Numerous factors, including the development's volume, the forecast horizons timescales, temporal determination, I/P, O/P, information pre-processing, and so on have indeed been assessed and inspected. The investigation also looked at certain trends in the application of such approaches. Several of these, including regression analysis-based methods like artificial neural networks (ANN), which are the greatest commonly used methods in electrical estimates, are now more suitable and favored for electricity load projections. Artificial neural networks (ANN) methodologies are primarily utilized in this context for short-term estimates wherein electricity and energy ingesting rates are far more intricate. Regression methods, in contrast, hand, are still commonly utilized and effective for long-term prediction wherein regularity and variations become less important. Furthermore, support vector machine (SVM) algorithms are used in a large fraction of studies, indicating a growing interest in them. In contrast, statistical methods (particularly the Box-Jenkins modeling group) are no longer as prominent as they once were, yet their contribution cannot be overlooked. Furthermore, the special focus could have been paid to studying extremely short-term and mid-term load predicting to address the identified vacuum in the area.

Scientific Ethics Declaration

The author declares that he is solely responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

Cross-Cultural Ventures to Design Stone Products

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Abstract: This paper is part of an ongoing research, addressing the design of stone products to guide materials to new applications in a reality that asks for local qualities, sustainability, and change. The authors present the thesis that unexpected materials can be obtained through the mix-combination of its basic components. Accidental materials speak through a complex network of interrelationships in relation to the context. So, the power of expressiveness can be obtained through the controlled mixture of its elementary components. In a world where things deliberately unstable are the raw material for the construction of unstable identities, it is urgent to be constantly attentive. It is necessary to ensure that the flexibility and the ability to adapt quickly follow changing patterns from the outside world. The study is based on a mixed practice and supports cross-fertilization and design-driven innovation to create cooperation between different mediators to communicate new meanings with the sense of future. The design process involved design students and the productive sector. The authors want to prove that it is possible to find innovative ways, looking for references in new scenarios that can determine innovation and guide the material to new applications that affirms globally by local qualities.

Keywords: Education, Technology, Materials, Innovation, Sustainability.

Introduction

Cross-cultural competence is a set of culture knowledge developed through education, and experience that provide the skill to operate successfully within a culturally complex environment. In fact, cross-cultural capability can be seen as a toolkit if one deal with different cultural software in one place, at the same time and considering analogous circumstances. Although, it is important to learn the culture just as it is vital to learn its language, studying them in the same way, by learning how to participate in meaningful practices (Hooker, 2003). Thus, in this study, to design materials to new unforeseen and extraordinary requests can be achieved through cross-cultural ventures guide by the sense of culture, and language.

For one side, culture is the whole complex which includes knowledge, beliefs, art, morals, laws, customs and other capabilities and habits acquired by human being as a member of a society (Berry, 1992). The concept of culture covers different human activities and becomes dynamic in its ability to interact with time and contemporarily, with the other areas with which it relates. Plus, cultures are ways of interacting diversity and even in the same society social actors use language for very different purposes (Hooker, 2003).

For another side, about language it is possible to define it as the power to speak logically enough to respond to and to create recognizable social skills to define the sense of humanity. In fact, language is the first global interpretation of the world and therefore cannot be replaced with nothing (Gadamer, 2002). This statement seems to indicate that not always language has been understood as an entity, that has a meaning, and that does

not serve just to describe or classify things. This path seems to announce that we use language to produce, and that interpretation is a process to know about the world, by the involvement of factors that cooperate to qualify this experience (Soares & Aparo, 2022). Having this judgement in mind, for instance, radical unconventionality from normal speech interaction can cause interlocutors to judge one not only insane, but less than completely human (Wilce, 2005). This paper explores the connection between madness - as part of language - and fundamental human dialectal capacities, such as the act of designing materials.

Madness was no longer to be inscribed in the negativity of existence, as one of its most brutal figures, but it progressively took its place in the positivity of known things (Foucault, 2006). For instance, as Erasmus of Rotterdam (2004) states, madness can be understood as synonymous of creativity, in the sense that it accompanies an inspiring force, proper to young people and move away from a rational way of thinking, stimulating unconventional ideas and, by this reason, innovative positions. It means the competence to create connections among things that characterized youth. In design materials, accidental (madness) materials speak through a complex network of interrelationships inherent to the context and, the control of expressiveness can be achieved through the controlled crossing of their elementary components (Branzi, 1983). This purpose, connects with the idea of working with young people, directs this study to interpret design materials as a system of product more complex and biunivocal and, the attempt to give a symbolic order in society and in the market. Moreover, it is a system of meaning as the consumer does not buy a product because it has quality, but because it shares a system of values that the company, through the product system, managed to communicate to the consumer (Zurlo, 2003).

Background

Today's relativity presents complexity, liquidness, and contradiction, and "in a world in which deliberately unstable things are the raw building material of identities that are by necessity unstable, one needs to be constantly on the alert; but above all one needs to guard one's own flexibility and speed of readjustment to follow swiftly the changing patterns of the world 'out there'" (Bauman, 2000). In fact, the History of Design is full of cases that present design as a facilitator for new applications for materials, referring to parallels worlds and defining new operational scenarios. In this paradigm, there are materials such as Technogel and Corian.

This paper highlights the statement of the partner company - the Portuguese company ValeuOptimized - about vStone. It is a stone product enormously versatile, allowing one to change some paradigms in the use of natural stone in all its application segments, enhancing creativity and the development of new decorative solutions. Consequently, the cautious designer Latour (2008) is qualified to (re)educate for a fair and sustainable consumption of society. The designer will be able to propose new solutions for the change, carriers of meanings and, at the same time, with the sense of the future (Aparo & Soares, 2012). In recent years, many designers have been able to interpret the innovations that come from the research world – also through cross-fertilization operations, that is, technology exchanges between different sectors – to create highly successful products (Raimondo, 2005).
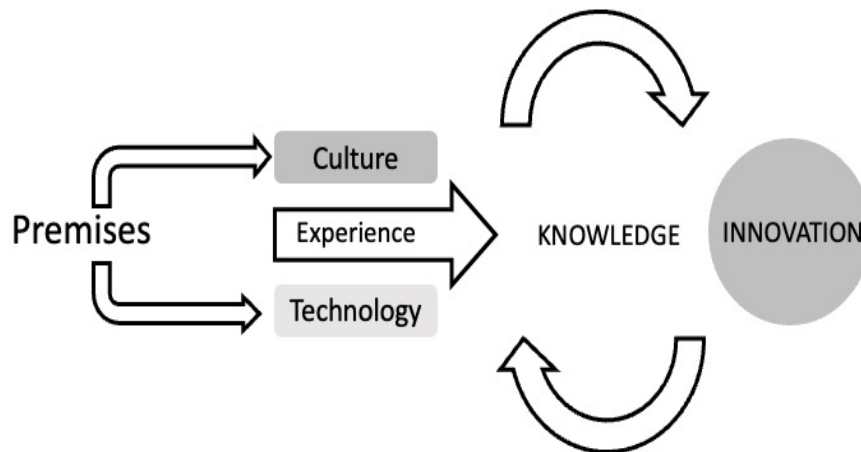

Figure 1. Design and materials to find innovation

Historically, one of these principles was applied during the seventies, notably, with primary design (Branzi, 1983) that started operating the first research in this direction, expanding the concept of design for the invention

of new materials and for the linguistic improvement of existing ones. Following the principles of lateral thinking (De Bono, 2017) perhaps the designer can find innovative ways, observing the material from a different position, leaving of trying to formulate logical answers, to look for references in new scenarios that can determine innovation. Based on the concept of cultural transfer (Manzini, 2006) the designer can guide the material to new application scenarios that go through the stories but, mainly, through the cultures of a world that is affirmed in a global way by the local qualities.

Research Process

Purpose

The study aims to highlight transversal participation in design process, relating different professionals from different subjects. It integrates a design school - including 34 students and 3 professors – a stone sheet material company - the Portuguese company ValeuOptimized – and several micro companies of the same place.

The main goals are:

- To develop an academic project that offers opportunities for the company and the students.
- To create innovative proposals in product areas that may consider sheet stone as the main material.
- To develop products that know how to enhance the properties and characteristics of the stone sheet.
- To increase concepts that may contribute in the future to the design of new products bearing new quality values for the sheet of stone.

The project was organized in four patterns connected with the stone field. The first scope was the stone and the culture of the north and was focused oriented on megalithic monuments, rock carvings and the first tools. The second option was the stone in Baroque poetry and was concentrated in the fields of architecture, painter, and sculpture. The third scope was the stone, the fragment and all, and was determined on Portuguese pavement and the mosaics. Finally, the fourth choice was the dry walls; the "mariolas"; and the stones between natural phenomena and legends (the rocking stones, the Moorish stones, the rocks brooders). Therefore, in this paper it was intended to analyze the stone sheet material culture as something systemic and interactive, which the result should be applied to a design product. Students developed different products, such as, seats, bags, toys, glasses, jewels, dresses, cutlery, vases.

Related work

The design professors has already developed projects related with stone material and the stone sheet material. For instance, in 2016 the authors created Lapis Lapidem's project developed by under-degree design students. Lapis Lapidem was established under a protocol between IPVC, Mondim de Basto City Council – a city located in the North of Portugal - and Travassos Gold Museum – a museum situated in the North of the country. The project consisted of the creation of jewelry projects that cross yellow granite and filigree technique. In 2017 and in 2021 the stone sheet material was developed by two master design students during their dissertations. The students designed sheet stones focus oriented on lighting (Mendes, 2018) and furniture design (Vieira 2021).

Methodology

The research project was directed in distinctive phases and based on mixed, non-interventionist and interventionist methodology, linking quantitative and qualitative methods. In the non-interventionist phase, the study was established on analyzing theoretical concepts and literature review to create case studies that supported the theme. This paper studied the interventionist stage by saving and analyzing data and generating ideas, brainstorming, and prototyping. The students created connections with micro companies of the place to know procedures and specific techniques. The principal purpose was to implement this knowledge in new product development, linking sheet stone with different materials, such as, wood, ceramics, textiles, metals, natural fibers, cork, among others. Throughout this process it was necessary to create several mind maps and to realize the diversity and quantity of materials, technologies, and techniques.

Materials and appropriation

During the process, the diversity of sheet stone was highlighted. Thus, it was created team work to discover the potentialities of this material while connected with other materials. Creativity process promoted transversal work among students guaranteeing testing for all students. The cooperation among students were important to design process, considering that principles such as unity and co-design among students were introduced. Therefore, transversal work was promoted, ensuring the experimentation and testing phase for students. The cooperation among students was very important do design process.

Table 1. Cooperation process

Variables		Number	Mean
Age	20-24		22
Gender	F	20	57.2
	M	15	48.8
Total		35	100

Figure 1. Students prototypes with the connection of the stone sheet to different materials and in diverse environments.

Students worked on different qualities of stone sheet, namely:
- D. Black;

- Black with polyester resin;
- Zeera Green;
- Galaxy;
- Silver gold;
- Forest brown marble;
- Tecla wood;
- Diamond Shimmer;
- Red Clay;
- Autumn grey;
- Blazing Cooper;

With the support of the company, the characteristics of each material were identified. With this knowledge it was possible to move on to an experimentation phase, relating the different qualities of stone sheets with other materials such as fabric, ceramics, wood, metal.

Results and Discussion

- In this process the malleable sample, such as D. Black, it is possible to cut the sheets with scissors.
- With some sheets of stone, sewing thread was experimented with either using a sewing machine or using hand sewing and the result was achieved. In this sewing process, the stone sheet was linked to fabrics and cardboard.
- Another successful result was the bonding of the stone sheet to pine wood agglomerate, using nails.
- Likewise, the cutting process was developed, using a circular drilling machine measuring 1.5cm and 2.5cm.
- In another experiment, curves and rounded shapes were created in the stone sheet, using dull files. The result was positive when dealing with harder samples such as Silver Gold. This type of experience fits into implementation areas such as jewelry.
- An alternative process developed was the bending of the material through heating with a flame. The material cools down after 10 seconds, hardening and taking on the new shape.

With the experiments carried out, it is concluded that not only the material connects naturally to other materials, but also that it is possible to assume it in diversified areas.

Conclusion

In the scope of Product Design, the methodology of cross-fertilization was used, which allowed students to interpret the innovations that dispute the world of research to create new products.In terms of application, around 32 prototypes were materialized, many of them developed in collaboration with companies - both industrial and artisanal - in the northern region of Portugal, particularly in the district of Viana do Castelo. On the one hand, one of the objectives of the project was to give students the opportunity to achieve reading and interpretation of the material. On the other hand, one of the purposes was to make the material known to the companies that collaborated with the students in the project.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

A Real-Time Video Surveillance for Rule Violation Detection on High Ways

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Abstract: Processing of images obtained with cameras is important for monitoring and/or securing highways. Early warning is important for highway safety in cases such as accident, traffic rule violation, automatic detection of people or animals entering the road. For this purpose, besides the detection of objects such as vehicles and people, other moving targets or objects falling on the road, such as boards, etc., must be detected. For this, besides object recognition, motion detection and object tracking are also needed. The purpose of motion detection is to classify pixels in an image as background and foreground. Within the scope of this study, deep learning-based machine learning method was used for the detection of vehicles and people entering the highway, and classical image processing methods were preferred for the detection of any moving object other than these. In this context, a software infrastructure has been developed in which different processes can work together and share data with each other. The developed software was tested on the Nvidia Jetson development card, and algorithm performance and speed tests were carried out on the selected GPU supported Nvidia Jetson card.

Keywords: Traffic surveillance, Highway security, Vehicle detection, Vehicle tracking

Introduction

Instant processing of images obtained with cameras is important for monitoring and/or securing highways. It is important for highway safety to create an early warning in cases such as accident, rule violation, automatic detection of a person or animal entering the road. For this purpose, besides the detection of objects such as vehicles and people, other moving creatures or objects such as boards falling on the road must be detected. For this, besides object recognition, object tracking and motion detection are also needed. The purpose of motion detection is to classify pixels in an image as background and foreground. The classification to be made is complicated according to the dynamic changes of the background such as the motion state of the camera, the ambient lighting, the movement of the trees in the image that are not defined as motion in the wind, and the ripple in the sea. The cameras from which the images are taken can be static or moving. In static cameras, the center of motion is fixed and the camera does not rotate. Therefore, it is easier to detect background fixed and moving objects. Moving cameras, on the other hand, are divided into cameras that move freely and rotate around a fixed center. Moving cameras with a fixed camera center can perform rotations called pan, tilt and zoom. The most well-known of these types of cameras are PTZ cameras. Drones/UAVs are the best examples of free-motion cameras. Considering that the cameras used in traffic monitoring will be PTZ cameras that can move at certain intervals in a way that changes angle, camera movement should be detected at least to prevent false detections when the camera moves.

When the object detection studies in the literature are examined, it is seen that the best results are obtained with Convolutional Neural Networks (CNN) based methods. In these artificial neural network (ANN) based methods, with the increase in the number of layers to be trained in the proposed architectures, deeper neural networks have been designed and the name "deep learning" has been used. In this context, different architectures have been proposed for the problem of detecting certain objects in an image, that is, finding the location of an object in the image and the class it belongs to. Unlike object classification, this problem also includes finding the re-

gion containing the object. The proposed architectures can be grouped under two main categories. In regional-based CNN architectures proposed as the first type, a neural network first selects the regions that may belong to an object, and then another neural network performs the classification process. R-CNN (Girshick et al., 2014). Fast R-CNN (Girshick, 2015) and Faster R-CNN (Ren et al., 2015) are deep learning architectures for this category. YOLO (Redmond et al., 2016) and SSD (Liu et al., 2016) architectures can be given as examples of the second type. In this type of architecture, detection and classification processes are performed together, so it is more advantageous in terms of speed. Within the scope of this study, it is considered to use one of the current object detection architectures developed based on YOLOV5 (https://github.com/ultralytics/yolov5), considering speed and performance.

Studies on motion detection in the literature can basically be grouped under three categories; subtraction of consecutive frames, background modeling and optical flow methods. Although the first and simplest method, the subtraction of consecutive frames, can adapt to dynamic environments, its performance is extremely low, especially in moving cameras and moving backgrounds. In background modeling based methods, a model is constructed according to a certain number of previous frames, and pixels that differ from the background model are classified as moving pixels. For background modeling, classical image processing based methods (Gianni et al., 2016), statistical models (Sriram et al., 2013; Kwang et al., 2018) and neural networks (Massimo & Maurizio, 2017) have been used in studies in the literature. In optical flow-based methods, optical flow vectors obtained with deep learning architectures are used. There are studies on detecting moving pixels with the operations applied on the estimated flow vectors for each pixel and adaptive threshold value approaches (Junjie et al., 2018). FlowNet2 architecture is widely used in optical flow prediction (Ilg et al., 2017). Although good performances can be achieved in deep learning-based optical flow calculation, it is not suitable for use in real-time systems because it requires excessive processing power in high-resolution images. Therefore, considering the computational cost-performance balance, statistical methods based on background modeling can be considered as the most reasonable method in motion detection problem at present.

In this paper, we track the motion regions and detect object bounding boxes to determine some traffic rules violation. The details of the object detection, motion detection and tracking algorithm used in our method are given in Section 2.

Proposed Method

Object Detection

In this study, a training set was created from the images selected from the VisDrone (Zhu et al., 2021) dataset. The images taken from very vertical angle and including occluded objects were not selected in our dataset. Sample images from the data set are shown in Figure 2. The dataset, which is a subset of this Visdrone, was used to train a convolutional neural network model to detect vehicles and pedestrians on highways.

Figure 1.   Sample images from VisDrone dataset

While selecting the deep learning model, the model inference speed and accuracy criteria were taken as a basis, and I have decided to use the YOLOV5 architecture. Firstly, I have coded a conversion script to use the object labels of the VisDrone dataset in YOLOV5 model training. The loss function (loss) and mAP (mean Average Precision) metric values obtained during the training process are shown in Figure 2.
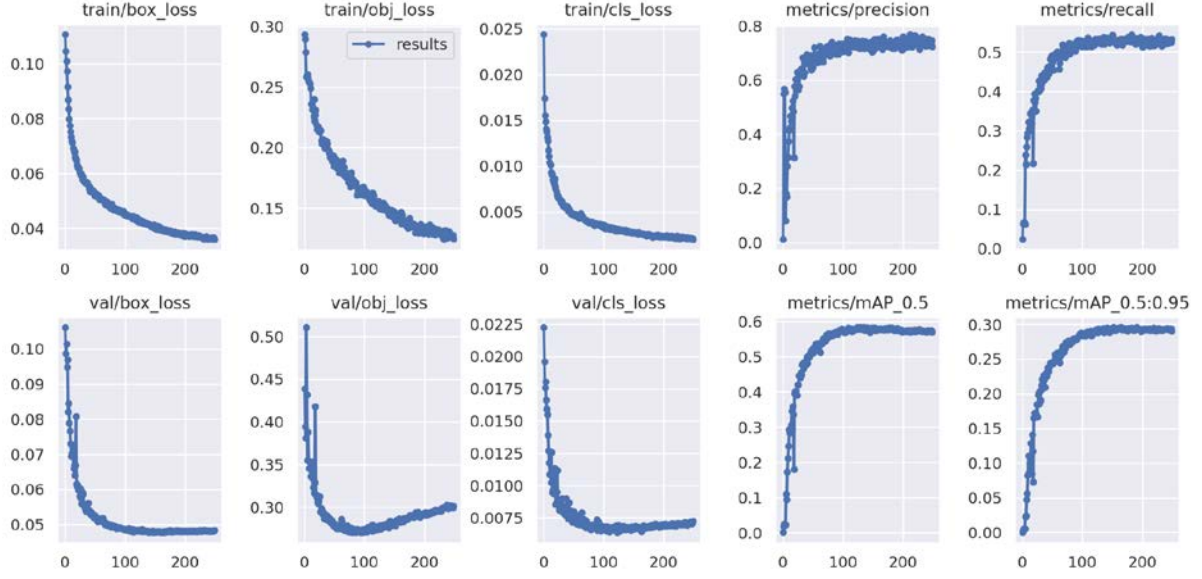
Figure 2. Training graphics

Motion Detection

Motion detection algorithm is implemented using C++ and CUDA. Background modeling-based method was widely used to solve motion pixels in the literature (Kim et al., 2013; Yu et al., 2019). In this work, we have developed motion detection algorithm based on BSDOF (Delibasoglu., 2021) method. In order to increase the speed of the algorithm for a better performance over Nvidia Jetson card, some minor changes were made to the BSDOF algorithm, and the background model was created on gray images instead of three band (RGB). While calculating the Homography matrix to detect camera movement, the CUDA implementation of the Lucas Kanade[4] algorithm, which is implemented in OpenCV, was used. The images used for testing and the sample motion mask images obtained are shown in Figure 3.

Figure 3. Sample motion mask and detected motion regions

Tracking and Producing Alarms

In the last step, motion detection and object detection results are merged and tracking is applied to produce the alarms. For this, firstly bounding boxes are obtained from the motion mask by extracting contours from binary masks and applying a region growing to merge so close bounding boxes. We compare the motion boxes (B_m) with the detection boxes (B_d), and eliminate the motion boxes intersected with the detection boxes. Thus, we only use the motion boxes, which could not be detected by an object detector, in the tracking stage. We store the tracked objects in a list, called $L_{tracker}$. In each frame, we compare the *B_m and B_d with $L_{tracker}$* and update tracked object positions in the $L_{tracker}$. We control whether the intersection of union (IOU) is greater than $T_{iou}=0.5$ to match the boxes.

$$\frac{B_m \cap B_d}{B_m \cup B_d} > T_{iou} \tag{1}$$

There is set a *hit counter* and *miss counter* for each tracked object. The targets are deleted if they are missed Tmiss times. Then, the movement of each object in the last *n* frames is calculated, and a distance threshold (T_{dist}) is used to decide whether a target is moving or not. T_{dist} is dynamically assigned to be the maximum of the width and height of the box. Thus, it is determined whether each target is moving or stationary. In the last step of the tracking, we check some specific situations to produce the following alarms:

- If a target classified as a vehicle is stopping for a long time, the system produces an alarm for "Stopping car".
- If a target classified as motion (B_m *detections*) is moving for a while, the system produces an alarm for "Moving target".
- If a target is moving in the opposite direction of the traffic flow (for example: going backwards or trying to turn), the system produces an alarm for "traffic rule violation".

The software developed in this study generates these three alarms. The overview framework of proposed method is shown in Figure 4. However, we would like to emphasize that the task of finding the traffic flow direction, which is extremely important for the final alarm, is not done within the algorithm.
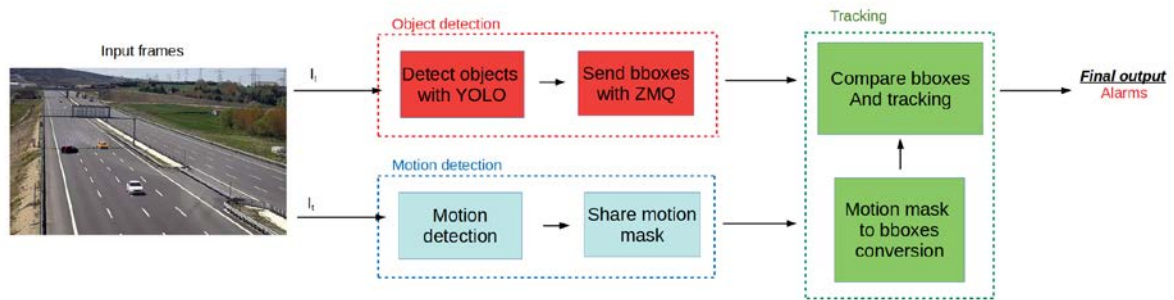

Figure 4.   General framework of the proposed method.

Results and Discussion

In this study, a software has been developed to detect traffic rule violations. The developed software has been tested on a PC with an Nvidia graphic card RTX 2070, and an Nvidia Jetson NX development card. The object detection process is implemented with Python, while the motion detection and tracking parts are implemented in C++. The algorithm mostly uses the GPU to speed up the process for better performance, especially on the Jetson development board. The working speed of each step in the algorithm is given in Table 1.

Table 1. The speed of the modules used in the proposed method

Algorithm steps	Nvidia Jetson NX development board (FPS)	Nvidia RTX 2070 (FPS)
Motion detection	~14	~70
Object detection	~14	~80
Tracking	~50	~166

The "*motion detection*" and "*object detection*" algorithms/methods run in different processes in the implemented software architecture. Thus, the total speed of the proposed method is increased. The motion and object detection results are merged in the "*Tracking*" process, in the last step. Figure 5. shows the sample outputs for the three different alarms. The left columns show the produced alarms with the red bounding box, while the right column represents the object detection and motion detection outputs. The green bounding boxes represent the object detector result (with the object name) and the blue rectangles represent the boxes extracted from the motion mask. In the first row of the figure, two vehicles that are stationary for a while are detected. In the second row, the vehicle moving the opposite of the traffic flow is detected and the alarm is produced. While the camera is zooming in the second image, the blue boxes are also found as a motion region. These are eliminated with the help of the tracking algorithm, so that false alarms are not produced. In the last image, a vehicle trying to stop and turn back is detected.

Figure 5. Sample detections and produced alarms

Conclusion

This article proposes a motion detection method that can work with a reasonable speed for high-dimensional videos in a Jetson NX edge device. The motion detection and object detection results are merged with a tracking approach to produce the alarms for traffic rule violation. Although the proposed tracking method is simple, it is sufficient to follow vehicles on not very busy roads. The motion detection algorithm, on the other hand, is very suitable for detecting any moving target (such as an animal) that cannot be detected by object recognition.

In future work, the tracking method could be improved to distinguish vehicles that are very close to each other to prevent the ID changes. Thus, the method could run in more heavy traffic. However, it is also important that deep learning-based ID assigning methods may run so slow for many targets and it results a lower FPS specially for edge device.

Scientific Ethics Declaration

The author declares that he is solely responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

Knowledge Transfer Mechanisms Using Text Mining and Sentiment Analysis – Case in an Online Collaboration

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Abstract: This study aims to test, examine, and validate text-based human-machine knowledge transfer (KT) by comparing it with human-human KT. The online discussion experiment was carried out via WhatsApp group chats. Chat sentiment was determined using text mining and sentiment analysis and then compared with the respondent's understanding of the knowledge obtained from interviews. The results have shown that human-machine KT is close to human-human KT. By analyzing the correlation coefficient between the two, it is proven that sentiment indicates an understanding of knowledge. Positive sentiment shows similar or in-line understanding between the source and recipient of knowledge and indicates the achievement of KT objectives. Neutral sentiment indicates incomprehension due to the failure of KT. Meanwhile, negative sentiment is ambiguous; it may indicate an incomprehension or a misunderstanding of the knowledge received. This study contributes to the area of knowledge and sentiments, showing that the effectiveness of text-based KT activity can be identified using the sentiment analysis approach.

Keywords: Human-machine, Knowledge transfer, Online, Sentiment analysis, Text mining

Introduction

Knowledge transfer (KT) disseminates knowledge, ideas, experiences, and skills between human agents (Duan et al., 2012). It continuously creates new knowledge (Nonaka et al., 1995) and improves the quality and productivity of knowledge (Becerra-Fernandez & Sabherwal, 2014). An example of a KT is online collaboration activities such as online discussions carried out using various media, such as social media, online communities or forums, and online learning platforms (Widyahastuti & Tjhin, 2018; Zhao et al., 2021; Ollesch et al., 2022; Shang et al., 2022). Social media is widely used because of its flexibility and multifunctionality with various modes of communication, and an example of a globally popular social media app is WhatsApp Messenger (Leng et al.,2013 ;Anireh & Amadi, 2020; Iqbal, 2022).

Social media is a source of written knowledge usually analyzed to research a topic. Social media analysis was carried out using text mining techniques and sentiment analysis methods, as has been done in previous studies (Kušen & Strembeck, 2018; Gorodnichenko et al., 2021; Liu & Liu, 2021; Perikos et al., 2021; Saura et al.,

2022). Sentiment analysis, a.k.a. opinion mining, determines the sentiment polarity, i.e., positive, negative, or neutral, to understand the opinions and emotions contained in a text (Fimoza, 2021). Sentiment analysis is commonly used for various needs, e.g., to obtain business insights and analyze user satisfaction in the business field or to assist the decision-making process in an organization (Allahyari et al., 2017; Birjali et al., 2021).

KT is widely needed in various fields, however it's difficult to achieve because knowledge comes from various sources and most of them are tacit, i.e., personal knowledge obtained from individual experience involving intangible factors such as beliefs, perspectives, values, and intuition (Terra & Angeloni, 2003; Dubickis & Gaile-Sarkane, 2017; Narendra et al., 2017). Problems such as miscommunication, inconsistency, and misinformation frequently occur in the dissemination of information and knowledge (Kušen & Strembeck, 2018; Ragili et al., 2020; Sheehan et al., 2020; Zhao et al., 2021).

In recent years, several studies have discussed the dissemination of knowledge using the concept of sentiment, for example, to test tools or transfer media on online platforms. Testing and validation of KT are needed to evaluate and verify the effectiveness of knowledge dissemination (Levine & Gilbert, 1998) as well as to determine the validity of the methods, frameworks, tools, or media used whether knowledge is conveyed as it should be or not. (Cruz et al., 2018; Zhao et al., 2021; D'Orazio et al., 2022).

Existing studies generally examine KT in educational contexts (Huang et al., 2019; Ollesch et al., 2022; Wyeld et al., 2021) or professional work areas (Justin & Lim, 2013; Leng et al., 2013; Cruz et al., 2018; Zhao et al., 2021). The online platforms studied in KT-related research are generally online forms (Aji & Agichtein, 2010; Zhao et al., 2021; D'Orazio et al., 2022), online learning platforms (Huang et al., 2019; Ollesch et al., 2022), and social networking sites (Justin & Lim, 2013). However, from the existing studies, few discuss the use of social media as an intermediary in the transfer of human-machine knowledge in the wider context of online collaboration, especially chat mode social media apps such as the WhatsApp chat application, despite its worldwide popularity. Therefore, this study aims to test, examine, and validate text-based human-machine KT in the context of online collaboration.

Literature Review

Knowledge is formed when someone can find and understand patterns in the information and its implications (Uriarte, 2008). In other studies, Becerra-Fernandez & Sabherwal (2014) stated that knowledge is at the highest level in the knowledge hierarchy, above data and information, and knowledge is information that enables action and decision-making as well as information that has a specific purpose. Knowledge is either explicit or tacit (Terra & Angeloni, 2003; Uriarte, 2008; Dubickis & Gaile-Sarkane, 2017). Explicit knowledge can be easily expressed through words and can be disseminated in the form of guides, specifications, pictures, audio, videos, computer programs, etc. Meanwhile, tacit knowledge is personal and comes from individual experiences such as insight, intuition, and feelings of a person, making it harder to express, formulate, and disseminate (Becerra-Fernandez & Sabherwal, 2014).

KT is traditionally carried out directly, where the sources and targets of knowledge meet face-to-face at the same time and space (synchronous), as is applied to formal education (Gulau, 2021b). Ragili et al. (2020) studied the KT process that occurred in the library based on the activities of librarians and staff and found obstacles, i.e., problems in conveying and absorbing information, which ultimately led to miscommunication. They stated that it was caused by the dissemination of information, which is mainly done directly through informal discussions without documentation. In this study, we will use a machine as tool (online chat application) to analyze and optimize KT as the solution to problems in KT (Zhao et al., 2021; Ollesch et al., 2022).

The development of science and technology today allows the dissemination of information between humans without having to be in the same space and time (asynchronously) through various online media that can be accessed anywhere and anytime (Gulau, 2021a). Many studies have been conducted on the transfer of knowledge carried out using online media, tools, applications, or machines. Various intermediary tools or machines are examined and tested for their effectiveness in the process of disseminating information and knowledge. For example, a group awareness tool in a social media learning community with a wiki-like platform environment in the study conducted by Ollesch et al. (2022) was tested to prove its effectiveness in improving the quality of content and learning outcomes. This tool combines the visualization of the knowledge level (cognitive awareness) and friendliness level (emotional awareness) by analyzing the content of the text, the comments, and the sentiments. The test was carried out using experimental methods, and the results showed that the knowledge level information displayed had a good impact on the quality of the distributed knowledge content. While the friendliness level of information has a good impact on friendliness in the knowledge

exchange process and indirectly has the potential to produce well-learning outcomes. In another study, the online health community on the social media platform Baidu was evaluated using the model proposed by Zhao et al. (2021). The sentiment analysis model applies a machine learning approach to detect misinformation contained in forums. Based on the research results, it is concluded that the proposed model is valid in detecting misinformation and text features related to behavior, giving better detection results than linguistic features. The two studies above turned out to involve the element of sentiment in testing social media as an intermediary for the dissemination of knowledge.

Sentiments or opinions are subjective expressions of human feelings towards particular things or events that can be used as indicators for various purposes and can be found in textual information such as conversational texts and comments (Justin & Lim, 2013). Huang et al. (2019) stated that sentiment plays an essential role in knowledge recipients' engagement and knowledge creation. Positive sentiment is expressed in statements that support or like an opinion. Negative sentiment is contained in a different statement, contradicts, or dislikes an opinion. While neutral sentiment exists when there is ambiguity, a feeling of indifference, and an unclear tendency, it often arises when positive or negative sentiments are absent or very small.

Previous studies in knowledge management have discussed the role of sentiment. Some of them use sentiment to build and validate designs or tools to improve the dissemination of information and knowledge, such as automated systems, frameworks, or learning models. Cruz et al. (2018) introduced an automated framework based on sentiment analysis to identify the level of trust between members of a global software development team. Sentiment analysis is performed automatically on team member interaction data on the online collaboration platform and versioning system, GitHub. Framework validation is done through a survey. This study successfully validates the proposed framework, which can provide better trust estimation than conventional automated models to improve communication, cooperation, and dissemination of information and knowledge in working groups.

Huang et al. (2019) examine interaction patterns and sentiment dynamics in the learning process by conducting learning experiments on an online discussion platform. The interaction patterns and learning sentiments were codified manually, then analyzed using latent semantic analysis and correlation analysis methods. Based on the results, a model with four learning phases is proposed, describing the dynamics of sentiment and changes in interaction in the learning process. This model contributes to asynchronous or online learning as a basis for advancing the dynamics of sentiment in the learning process and interaction of students involved.

D'Orazio et al. (2022) validated the automatic building maintenance request detection method that applies sentiment analysis techniques with a lexicon approach. The computerized management system uses email as a medium for delivering information related to maintenance requests. The results of the maintenance request severity classification using sentiment analysis are compared with manual annotations by humans, which is considered the gold standard, using contingency tables and correlation coefficients (classifications by machine vs human). Based on the results, automated detection with sentiment analysis can classify maintenance requests based on their severity and urgency, which increases efficiency and reduces the analysis effort of human agents as maintenance personnel when faced with large requests. However, sentiment analysis can only provide basic analysis to exclude less important requests, whereas further detection of which part is affected and where the problem is not possible to generate, like manual annotations made by humans.

All of the above studies examine KT in the context of online collaboration using social media as an intermediary machine (human-to-machine KT). They all involve an element of sentiment for various purposes, such as for methods of learning, testing, validation, and analysis, as well as for information visualization. The sentiment is used as a tool in KT research. For testing or validating human-machine KT intermediary media, the application of sentiment analysis methods is accompanied by manual research methods such as human manual annotations, interviews, and questionnaires as gold standard data collection methods (Cruz et al., 2018; D'Orazio et al., 2022). Machine and human interpretations are then compared (machine vs. human) with various comparative analysis techniques, e.g., contingency tables and correlation analysis (Huang et al., 2019; D'Orazio et al., 2022). Several other studies examine how sentiment affects the dissemination of knowledge. Aji & Agichtein (2010) identified the effect of sentiment on the dynamics of knowledge sharing on the online collaboration site Yahoo! Answer. This study conducted manual sentiment analysis and calculation of the accumulated answers and votes received from time to time on several questions that expressed different sentiments. From the exploration results, it was found that sentiment may have a strong influence on the dynamics of knowledge distribution in collaboration forums, especially negative sentiments that evoke "negative bias".

Leng et al. (2013) studied the effect of sentiment on knowledge sharing among knowledge workers in virtual communities of practice through social networking sites. Questionnaires, interviews, and text and sentiment analysis were conducted to test several proposed hypotheses. From this research, it is evident that sentiment is

positively related to knowledge sharing and affects the quantity of knowledge shared. On another occasion, Justin and Lim (2013) conducted a similar study to analyze employee performance improvements as implications of sentiment on social networking sites, which also proved the positive relationship between sentiment and the quality of knowledge and individual worker performance.

In another study, Huang et al. (2019) stated that in knowledge exchange and learning, positive sentiments (enjoyment, pride, hope) signify a proactive state and continuous participation, which can increase the quality and frequency of interactions. Negative sentiments (frustration, boredom, and anxiety) can have an impact on the lower learning process and KT but may increase self-motivation. While neutral sentiments indicate non-involvement in the process of learning and knowledge exchange.

Based on the literature review that has been carried out, especially regarding sentiment in KT, we propose that if the sentiment is positive, then KT is likely to be successful. If the sentiment is negative, then the knowledge is most likely received with the opposite understanding. Meanwhile, if the sentiment is neutral, then the knowledge is most likely not successfully transferred.

Method

Data

This study uses data from human-to-machine activities of KT in the form of chat data from the online chat application, WhatsApp, to build a sentiment classification model tool (hereinafter referred to as tool data) and validate KT. Tool data is obtained from the conversational data of eight founders of a digital start-up, consisting of 25 people, who provide a marketplace platform (hereinafter referred to as start-up A). In the conversation, the founders collaborated online to discuss the planning and implementation of a marketplace platform for buying and selling organic products. Of these eight founders, two of them come from IT circles, while the other six are from non-IT backgrounds, such as business people. In a start-up that provide IT platform, these two founders from IT circles usually become the main sources of knowledge, especially when exchanging knowledge in the area of IT.

The data for validation is chat data obtained from an online discussion experiment (hereinafter referred to as experiment data). This experiment replicates the KT activity of start-up A founders but is executed with different human agents. In addition, validation data is also obtained through direct interviews as a representation of human-human KT activities (hereinafter referred to as interview data). The interview data illustrates the understanding of the knowledge recipients of the knowledge conveyed through online discussion experiments. More details will be explained later in the section of experiment methods. Detailed information about the data can be seen in Table 1.

Table 1. Data source

Data	Source	Date obtained	Total data	Format	Purpose
Tool data	WhatsApp group chat from the eight founders of Start-up A	March 11, 2022	14,746 lines	text (.doc)	to build a tool for sentiment classification
Experiment data	WhatsApp group chat from eight participants of online discussion experiment	March 24-25, 2022	463 lines	text (.txt)	to validate human-machine KT
Interview data	Direct interviews with six (non-IT) participants regarding the level of understanding of the knowledge gained from the experiment.	March 26-28, 2022	60 answers	audio/video recordings (transcribed)	to validate human-machine KT

Modeling of the Sentiment Classification Tool

The sentiment classification model was built through several processes, as shown in Figure 1. These are modifications and combinations of the general sentiment analysis and text mining processes proposed by previous studies (Birjali et al., 2021; Fimoza, 2021). Tool data with the main language of Indonesian was

obtained in a document file format (.docx), then the content was transferred to a text file (.txt) for further processing using Jupiter Notebook programs.
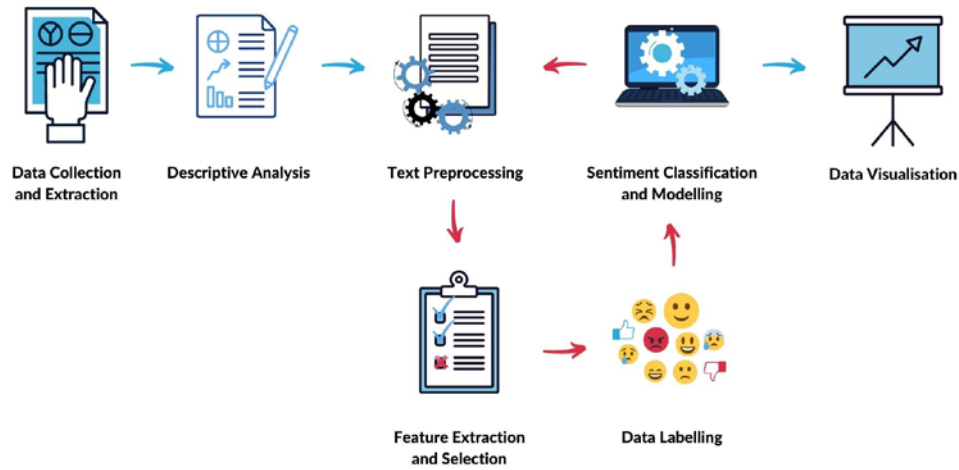

Figure 1. Sentiment classification modeling processes

In the extraction process, the data is tokenized to form separated chat data with the structure of timestamp, chat text, and sender name. Data not required for sentiment analysis, such as timestamps and sender names are excluded. Emojis contained in chat texts are first converted to text so that they can be included in text-based processing. The chat data is then saved into a comma-separated values (.csv) file for next processing. Furthermore, a descriptive analysis was carried out to get an overview of the data to be used, related to the size, dimensions, and characteristics of the data. The next stage is text preprocessing, to simplify chat data through a series of operations such as case folding, data cleansing, tokenization, stop words removal, stemming, and normalization, producing data in the form of simple term features. Then, feature extraction is conducted by calculating term frequency, Bag-of-words, and Term Frequency-Inverse Document Frequency (TF-IDF) to get the dominant feature. The feature list is selected by removing unnecessary terms (filtering). When obtained, chat data has not been categorized into any sentiment class, therefore it is necessary to carry out a labeling process to complete the data attributes needed in the sentiment analysis process. Labeling is carried out using the VADER (Valence Aware Dictionary for Sentiment Reasoning) method, as has been used in previous studies (Liu & Liu, 2021; D'Orazio et al., 2022). However, to be able to use this method, the chat data must first be translated into English. The translation is then performed collectively using the document translation feature in the Google Translate web application. Using VADER, the chat data was then labeled with one of three sentiment classes, i.e., positive, negative, and neutral, as applied in other studies (Liu & Liu, 2021; Muttineni & Deng, 2021).

The chat data that has been selected and labeled is then used for training and testing of the Multinomial Naive Bayes machine learning model for sentiment classification. This modeling phase combines several techniques described in several sources, including the processes of cross-validation and resampling data, training, testing, and evaluating the classification model (Abusalah, 2019; Birjali et al., 2021; Lyashenko & Jha, 2022; Olugbenga, 2022). The machine learning model that has been built is then used to analyze sentiment in the KT process. The results of the sentiment analysis are then supported by data visualization.

All data processing is carried out using the Jupyter Notebook programs in Python 3, utilizing data processing libraries such as pandas and NumPy, machine learning modeling libraries such as scikit-learn and imblearn, natural language processing libraries such as NLTK, and sastrawi (Indonesian only), data visualization libraries such as matplotlib and seaborn, and other Python libraries.

Experiments

In this study, experiments were designed to test and validate human-machine KT by comparing it with human-human KT. Here, we test and validate KT in online collaboration activities through the WhatsApp chat application. The experiment consisted of 2 activities, i.e., online group sharing and discussion as a representation of human-machine KT and interview as a representation of human-human KT. Through the experimental and interview methods, as also applied in previous studies (Justin & Lim, 2013; Leng et al., 2013). We obtained data from the human interpretation, which is to be used as a standard in the validation process.

The series of activities included is described by the experimental design, which can be seen in Figure 2. The topics of online discussion were 10 knowledge terms in the information technology (IT) world in the context of online collaboration, viz., online, online collaboration, IT startup, platform, cross-platform, marketplace, crypto, blockchain, crowdsourcing, and virtual enterprise. The group members, participants of the online discussion experiment, consisted of 8 people: 2 from IT circles and 6 others from non-IT circles, adjusted in such a way that it is similar to the conditions at start-up A, which is the source of the tool data. Two IT members become knowledge sources, while the other 6 non-IT members become KT targets or recipients. The group chat data generated from the experiment was then analyzed using the sentiment classification model developed.
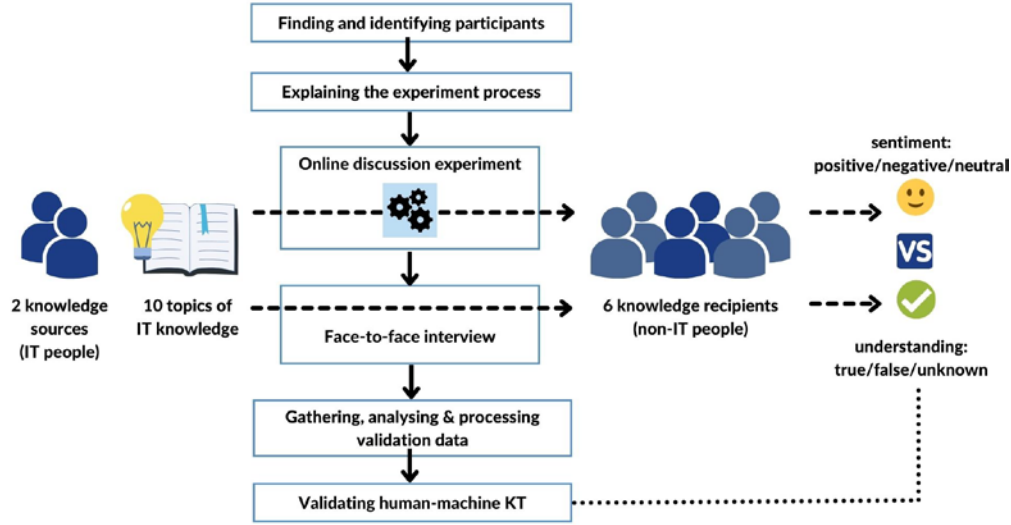

Figure 2. Experimental process design

The interviews were conducted by the same human agents and the same knowledge sources. The 2 IT members met with the 6 non-IT members in turn to re-investigate the knowledge recipients' understanding of the topics discussed in the online discussion. One IT member acted as the interviewer, asking one question on each topic (10 questions in total), with a detailed list of questions as can be seen in Table 2. While the others acted as observers who assess the level of understanding of non-IT members on certain topics, whether their level of understanding is in the true, false, or unknown categories.

Validation of human-machine KT was carried out by comparing KT activities through machines (human-machine) with direct KT between human agents (human-human); comparing knowledge received based on machine interpretation (tool) vs. human interpretation. This is done by comparing the sentiments of the respondents during online discussions (human-machine KT) and the level of understanding of the respondents from the results of the interview (human-machine KT). A contingency table and correlation coefficient were used (Howell, 2010; Zychlinski, 2018; Roflin & Zulvia, 2021) to determine the relationship between two variables in human-machine KT, i.e., sentiment and the level of understanding of knowledge. (Howell, 2010; Zychlinski, 2018; Roflin & Zulvia, 2021). Human-machine KT was validated regarding its success in transferring knowledge and the extent to which knowledge can be conveyed.

In addition to validation, experiment results were also used to examine the extent to which knowledge can be conveyed through human-machine KT. Has knowledge been successfully transferred to the knowledge level, or is it limited to the information level? This was carried out due to the differences in information and knowledge in terms of depth and complexity of understanding (Becerra-Fernandez & Sabherwal, 2014; Terra & Angeloni, 2003). This was conducted by examining the interview answers given by respondents who received knowledge. From the list of questions in Table 2, were the respondents able to answer the main questions and questions based on the keywords 'how' and 'why' with in-depth answers? Or did the respondents only briefly answer the alternative questions based on 'what' or yes-or-no questions without further explanation? This method corresponds to the differences in questions on the levels of information and knowledge mentioned in another study (Taylor, 2022).

Table 2. Interview topics and questions

Topics	Main question	Alternative questions
Online	Explain how you	What is online?
Online collaboration	understand each	What is an example of online collaboration?

Start-up IT	topic that has been	What is a start-up?
Platform	through online	What is an example of a platform?
Cross-platform	discussion. What did	What is an example of a cross-platform app?
Marketplace	you get from the	What makes marketplace and online store different?
Crypto	discussion regarding	Is it legal to use crypto in Indonesia? Why?
Blockchain	each topic?	What makes crypto and blockchain different?
Crowdsourcing		What is crowdsourcing?
Virtual enterprises		What are the characteristics of virtual enterprises?

Results and Discussion

Sentiment Classification Model

The development of a machine learning model for sentiment classification was carried out using group chat data on the WhatsApp application. The data used for the classification model training is group chat data with context around online collaboration, which consists of 14,746 lines of text. Before being used for model training, chat data goes through a series of processing as described in the section of sentiment classification tool modeling method. After going through the process, the remaining data consists of 8,021 rows of data. 80% of the data is then used for model training, and the rest is used in the testing process.

The classification model resulted has a balanced accuracy value of 78.94% and an F1 score of 81.41% for the test data. The confusion matrix from the test results can be seen in Figure 3. This value is still relatively low, and in the future, it can be improved by various model tuning techniques. This rather low metric value could be caused by the fact that the data is too unbalanced (the amount of negative chat data is very small compared to neutral and positive data). Another factor is that automatic labeling may give inaccurate results because it only depends on the sentiment value of the word in the dictionary (lexicon). Moreover, before being labeled, the data was first translated into English. This can affect the final accuracy. However, the accuracy of the resulting model is sufficient to be used in this study. This machine learning model becomes a tool that will later be used to analyze sentiment in the human-machine KT validation process.
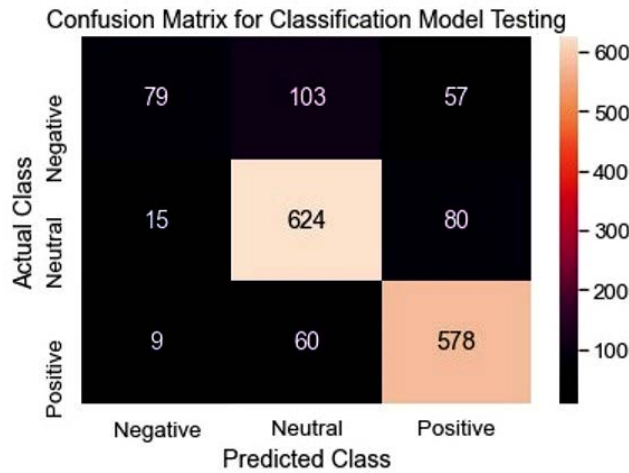
Figure 3. Confusion matrix of classification model testing

Experiment Results

The online discussion experiment generates chat data that will be used in the validation of human-machine KT. Experimental data was obtained from exporting WhatsApp chats to a text file, and the total data consisted of 463 lines of text. Furthermore, data extraction and text preprocessing were carried out, leaving 334 lines of data ready for further analysis. The chat data is then classified using the Multinomial Naive Bayes Classifier sentiment analysis model tool that has been developed previously. As can be seen in Figure 4, there are positive, negative, and neutral sentiments in the chat data resulting from this online discussion experiment. The three sentiments have been previously explained in other studies. Positive sentiment supports the quality of knowledge understanding; negative sentiment indicates a contradictory understanding; and neutral sentiment indicates indifference in the exchange of knowledge (Justin & Lim, 2013; Leng et al., 2013; Huang et al., 2019).

The majority of online discussions are neutral, which may indicate a lack of attention in the process of knowledge transfer, resulting in knowledge not being conveyed.

Figure 4. Distribution of chat sentiments

The classifications obtained using the machine learning model didn't give good results if judged based on the basis of common sense by human agents, especially within the boundaries of the Indonesian language. For example, "pah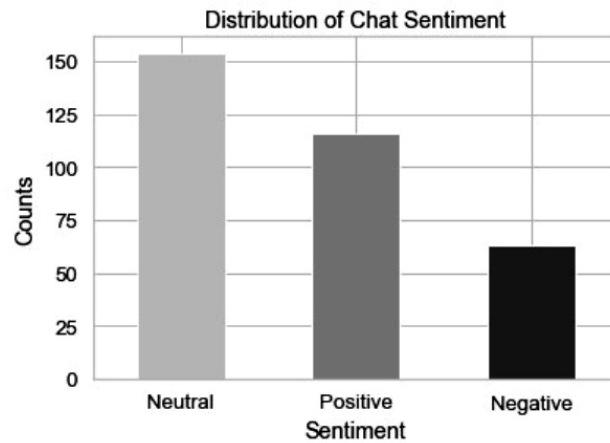am", which means "understand", is generally considered a positive sentiment in Indonesian, but neutral in English. This difference in perception can be caused by the labeling process carried out using the VADER library, which was created for English text analysis. Another example can be seen in the group chat data snippet from the sentiment classification results in Table 3.

Table 3. Snippet of chat sentiment classification results

Chat text (translated)	Sentiment class
in my opinion, online it is a device that is connected through a network	Neutral
if this one I've never heard of	Neutral
not really understand ☺	Neutral
I don't know sis :(	Negative
okay understand 👆	Positive

The next activity was to directly interview all respondents who had received knowledge. Of the total 60 questions (10 questions for each respondent), 35 of them could not be answered because the respondent didn't know the answer or had forgotten it already. Most of the other questions were answered briefly, as can be seen in Table 4.

Table 4. Snippet of interview answers

Topics	Respondents' answers (translated)
Online	Online is connected to a network.
	Online is an internet network.
Online collaboration	Online collaboration is when two people or groups are connected online.
Start-up IT	A startup is a new company.
	A start-up is a business that is run by a company in the industrial sector in a modern way.
Platform	An example of a platform is YouTube.
	The example is YouTube.
Cross-platform	Cross-platform is cross-lane.
Crypto	Crypto legality depends on government regulations.
	Not prohibited.
	Not allowed.
Blockchain	A blockchain is part of crypto, which is a database of the crypto transaction history.
Crowdsourcing	Crowdsourcing is a way for people to share information online.

When examining the list of questions in Table 2 and the answers in Table 4, we can see that respondents could only briefly answer alternative questions, i.e., 'what' or yes-or-no questions. Respondents didn't understand the topic of discussion in detail and in-depth. Regarding the differences in knowledge levels described in other studies (Terra & Angeloni, 2003; Becerra-Fernandez & Sabherwal, 2014; Taylor, 2022). These findings suggest

that in online discussions (human-machine KT) knowledge only reaches the recipient at the information level. KT through machine intermediaries has not been able to convey comprehensive and in-depth knowledge from one human agent to another. As has also been described in previous research (Terra & Angeloni, 2003). Machine intervention leads to limited knowledge transfer at the information level.

From the results of this interview, data about the level of understanding of knowledge recipients was obtained through the codification of respondents' answers, as shown in Table 5. The overall distribution of the data can be seen in Figure 5. Based on the bar plot, it is known that the majority of respondents still do not know or do not understand the knowledge topics that have been conveyed previously through online discussion experiments.

Table 5. Coding result of the interview answers

| Source knowledge (translated)	Respondent's answer (translated)	Code
A marketplace is different from an online store. Marketplace provider companies facilitate operational activities such as website management and payment methods for several sellers, while in online stores, single sellers make transactions directly with buyers with no intermediaries.	In the marketplace, there are intermediaries between sellers and buyers, such as (for) cost issues. Meanwhile, in online stores, sellers directly send (goods) to buyers.	True
	Haven't found the difference yet. In my opinion (both things) are the same.	False
	Don't know; do not understand; forgot already	Unknown
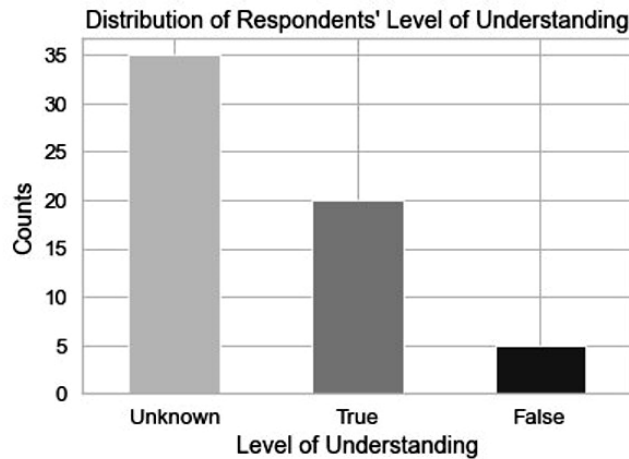
Figure 5. Distribution of respondents' level of understanding

Validation of Human-Machine Knowledge Transfer

Validation of human-machine KT was carried out by comparing the sentiments of the respondents during online discussions with the level of understanding of the respondents from the results of the interviews. The two experimental datasets were compared to see the relationship between the two types of KT. Sentiment class in online group chat data has a distribution similar to the level of understanding of respondents obtained from direct interviews, where there is one label with a very large amount of data (majority), one minority label, and another label right between the two. This can be seen by comparing the bar charts in Figure 4 and Figure 5.

Table 6. Comparison of machine and human interpretation of chat data

Chat text (translated)	Sentiment (by machine)	Understanding (by a human)
in my opinion, online it is a device that is connected through a network	Neutral	True
if this one I've never heard of	Neutral	Unknown
oo, it turns out that there are a lot of meanings to the word platform	Negative	Unknown
Isn't crypto like a stock game? Isn't it?	Negative	Unknown
So crowdsourcing is the method, while for the application on the website, that's how it is.	Positive	True

This proves that both types of KT give similar results. In other words, human-machine KT resembles or approaches human-human KT. From this resemblance, further analysis is carried out between the two KT variables, viz., sentiment and the level of understanding, because of the possibility of a relationship (correlation)

between the two. To find out more about the relationship, sentiment data (interpreted by machine) and level of understanding data (interpreted by a human) are juxtaposed in a new analysis table, as can be seen in Table 6.

There is a gap between the amount of chat data (sentiment) and interview data (understanding). Therefore, the data included in the comparison table (Table 6) is only core chat sentiment data from non-IT respondents discussing the topic of knowledge. The respondent's understanding (during the chat) is adjusted to the results of the interview. Simply put, when discussing a topic, the respondent's level of understanding is assumed to be unknown before the source of knowledge conveys knowledge related to the topic, but after that, the respondent's level of understanding is assumed to be the same as the interview data on that topic. The comparison data is then quantified in the form of a contingency table or cross-tabulation (crosstab) and normalized based on sentiment data to show more clearly the relationship between sentiment data and level of understanding, as shown in Table 7.

Table 7. Cross-tabulation of sentiment and understanding (normalized)

Understanding	False	Unknown	True	Total
Sentiment				
Negative	0.077	**0.69**	0.23	1
Neutral	0.037	**0.63**	0.33	1
Positive	0.048	0.24	**0.71**	1

From the crosstab, it can be seen that the majority of negative and neutral sentiments are related to a lack of understanding of the knowledge transferred (unknown). Meanwhile, positive sentiment relates to the true level of understanding; that is, a similar or in-line understanding between the recipient and the source of knowledge. However, from this positive sentimental knowledge, not everything is understood. Only 71% of knowledge can be understood correctly; the rest is unknown and misunderstood (false). The relationship between variables can be seen through the distribution of data in the cross-tabulation, but how the relationship between the sentiment variable and the level of understanding based on existing standards is still not known for certain. A correlation matrix was made using Pearson's r formula to determine with certainty the relationship between each category of sentiment and the level of understanding.

Based on the correlation matrix in Figure 6 and the standard classification of correlation coefficients used (Schober et al., 2018). İt can be seen that positive sentiment is related to the true level of understanding with a moderate unidirectional proportional relationship (correlation coefficient 0.4 = moderate positive correlation), whereas negative and neutral sentiments were associated with the unknown level of understanding with a weak but definite proportional relationship (correlation coefficients 0.19 and 0.22 = weak positive correlation). Meanwhile, the relationship between negative sentiment and the false level of understanding in this study is very small (0.07 = negligible positive correlation) and can be ignored. However, negative sentiment might also mean a misunderstanding in KT. This shows the ambiguity of negative sentiment in text-based human-machine KT.
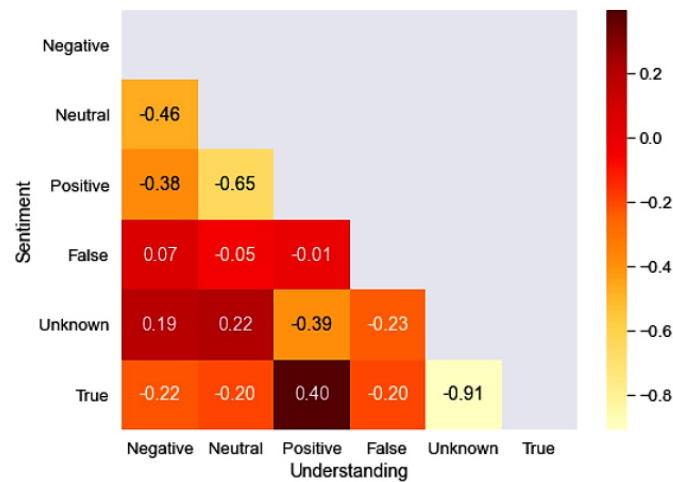
Figure 6. Pearson correlation matrix of sentiment data and level of understanding

Based on the results of the comparison and correlation analysis that have been carried out, it was found that in human-machine KT, sentiment is related to KT. This statement is quite similar to the results of research conducted by previous researchers who stated that sentiment greatly affects the quantity of knowledge disseminated online through social networking sites or social media (Aji & Agichtein, 2010; Leng et al., 2013).

Positive sentiment relates to the correct understanding and shows the success of KT, where the recipient of knowledge has a similar or in-line understanding with the source of knowledge. Neutral sentiment is related to incomprehension and shows the failure of KT, where knowledge is not conveyed at all to the target of knowledge transfer. While the negative sentiment is ambiguous, it can indicate incomprehension or misunderstanding. Misunderstandings can be in the form of different understandings or conflicting opinions between the recipient and the source of knowledge.

Based on the distribution of sentiment data in Figure 4, associated with previous findings regarding the correlation between sentiment and KT, it can be concluded that neutral sentiment data indicating incomprehension is more than positive sentiment data indicating correct understanding. In other words, there is still more knowledge that is not accepted than the knowledge that is properly accepted and understood. This shows that text-based KT via machine (human-machine KT) such as group discussions on online chat applications, has not been successful. KT is not achieved because the majority of knowledge fails to pass from the source to the transfer target.

As stated in the section of experiment results, KT through machines (human-machine KT) has approached or resembled direct KT (human-human KT) but machine intervention has limited the transmission of knowledge only at the information level. The validation results also prove that human-machine KT has not been effective in transferring knowledge between human agents. Whereas in reality, machines are very commonly applied and used in the dissemination of knowledge, i.e., social media applications, online chat applications, or chatbots. From these findings, we can finally conclude that there are deficiencies or gaps in knowledge management studies. This deficiency or gap can be overcome by combining the concepts of knowledge transfer and knowledge management with sentiment analysis, as we proposed through the validation method in this study.

Conclusion

As explained in the results and discussion section, this study proves that sentiment indicates knowledge transfer. It is evident that positive sentiment indicates that knowledge has been transferred successfully, neutral sentiment indicates that knowledge is not conveyed, and negative sentiment is found to have multiple meanings. Negative sentiments are proven to indicate that knowledge is received with contradictory understandings, but can also indicate the failure of knowledge transfer.

Recommendations

Although the aim of this study to test, examine, and validate human-machine KT has been achieved, there are some limitations and shortcomings. This research is only to test and validate, not to build an analytical tool that can be used directly by end-users. This research is limited to text-based human-machine KT and sentiment analysis on knowledge texts in the context of online collaboration. Further processing was only applied to knowledge in Indonesian, while knowledge in other languages is still included in data processing but is only considered as a collection of terms. The analysis was carried out purely on the knowledge text data and its sentiments without considering differences in age, gender, and background of the source and target of KT as research respondents. The analysis also does not consider other factors, such as prior knowledge and human behavior, in transferring knowledge.

Future research is advised to overcome the limitations of this study. For example, research to optimize KT by developing a KT machine that applies sentiment analysis. One of the ideas is to develop a chat application that can perform sentiment analysis so that during the KT process, users can find out in an instant whether KT was successful or not, through the sentiments displayed. Another idea is to develop a chatbot engine that can generate questions and conversational rules based on sentiment and user understanding. Further research related to testing and validation of human-machine KT can also be carried out, not only considering sentiment factors but also other factors such as prior knowledge and the behavior of human agents in transferring knowledge. Another recommendation for future research is to test the human-machine KT to determine the understanding of silent readers on a text-based online group platform. A sentiment-based approach, such as the solution given in this study, certainly cannot be used. This kind of research is very interesting to do because the silent reader did not give any response, so data-driven analysis could not be done.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

David, F., Nursyahrina, N., Syahrani, A., Mandarani, P., & Putra, D.W.T. (2022). Knowledge transfer mechanisms using text mining and sentiment analysis – case in an online collaboration. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 19,* 21-34.

End-to-End AutoML Implementation Framework

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Abstract: Automated machine learning (AutoML) has been an active research area in recent years. Researchers investigate the potential of AutoML as more stakeholders want to maximize the value of their data. The methods are designed to increase the effectiveness of machine learning (ML), accelerate model development processes, and make it accessible for domain experts that are not ML professionals. The systems without the aid of humans are feasible with AutoML, an area that has been increasingly studied recently. Even though efficiency and automation are two of AutoML's key points, a number of critical steps still require human involvement, such as understanding the characteristics of domain-specific data, defining prediction problems, creating a suitable training dataset, and choosing a promising ML technique. A comprehensive and updated analysis of the state-of-the-art in AutoML is presented in the study. AutoML techniques, including hyperparameter optimization (HPO), feature engineering, and data preparation are presented. As-is prediction structure and AutoML-based benchmark model are compared to show how to implement these methods. It is stated what a real end-to-end machine learning pipeline looks like and which parts of the pipeline have already been automated. Our AutoML implementation framework has been introduced and presented as a road map for the entire ML pipeline. Several unresolved issues with the current AutoML techniques are discussed. The obstacles have been outlined that must be overcome in order to achieve this objective.

Keywords: Automated Machine Learning (AutoML), Hyperparameter Optimization (HPO), Data preparation, Machine learning pipeline

Introduction

A unique idea of automating the whole ML process has emerged to lower development costs. AutoML, which combines automation and ML, involves the automated structure of a pipeline with the limited computational budget. AutoML enable domain experts to automatically create applications without high level statistic or ML knowledge. It has become a hot topic in both industry and academia with the exponential growth of computing power (He, Zhao, & Chu, 2020). The professionals are becoming more dependent on AutoML techniques as advances in ML are released quicker than researchers can integrate them. This encourages researchers to study AutoML methods and systems rather than only ML algorithms (Milutinovic, et al., 2020). Studies that produce high quality outputs in the fields of natural language processing and image processing are raised with the recent rapid progress in deep learning methods (Kadıoğlu & Takcı, 2022). Even an open source AutoML tool like H2O made it possible to work on text data.

Providing cost advantage in development processes is one of the main financial goals of almost all technology companies. Various solution proposals have been developed on how to use this advantage (Kadıoğlu, 2021). Automating the processes is one of the significant solutions to get more work output with less qualified human resources in development. AutoML tools provide a simple web GUI or API to train many models or a powerful single model. It can be a helpful tool for either a novice or advanced machine learning practitioner. There is still a fair bit of expertise that is required to achieve state-of-the-art results. It simplifies the training and tuning of ML models by offering a single function to replace a process that would typically require tons of code lines. AutoML saves time to focus on data preprocessing, feature engineering, and model deployment (LeDell & Poirier, 2020).

There is not a unique optimum AutoML solution. AutoML techniques differ by their optimization method, generated pipelines, the library of algorithms they select from, used meta-learning to learn from runs on prior datasets, or performed post-processing (Gijsbers, et al., 2019). For this reason, it should be defined whether it is appropriate to develop a model with AutoML tools for the correct analysis of needs and to solve the business problem. The study provides a general overview of the AutoML and implementation framework for a ML pipeline. A proper understanding of AutoML tools and the solutions they offer is critical for positioning these tools correctly.

AutoML Methods

Hyperparameter Optimization

One of the AutoML fundamentals is to automatically configure hyperparameters to enhance performance. Especially there is a wide range of hyperparameter choices regarding the neural network's architecture, regularization, and optimization. The performance of ML algorithms and the reproducibility of scientific research can both be improved through automated hyperparameter adjustment. As one of these methods, Bayesian optimization, recently gained popularity in HPO by achieving new state-of-the-art outcomes in tuning deep neural networks. Bayesian optimization is an iterative algorithm with two key ingredients. These components are a probabilistic surrogate model and an acquisition function to decide which point to evaluate next. The surrogate model is fitted to all observations of the target function made so far in each iteration. Then the acquisition function, which uses the predictive distribution of the probabilistic model, determines the utility of different candidate points, trading off exploration and exploitation (Feurer & Hutter, 2019).

The two AutoML tools, Auto-WEKA (Thornton, Hutter, H. Hoos, & Leyton-Brown, 2013) and auto-sklearn (Feurer & Eggensperger, 2015) use Bayesian optimization to select and tune the algorithms. Auto-WEKA uses Bayesian optimization in a machine learning pipeline based on WEKA and auto-sklearn did the same using scikit-learn (Pedregosa, et al., 2011) and added meta-learning to warm-start the search with the best pipelines on similar datasets, as well as ensemble construction (Gijsbers, et al., 2019). The main idea behind the genetic algorithm, which is another optimization method and a relatively new technique, is to simulate how a species evolves by Darwin's "survival of the fittest" theory (Leardi, 2009). By using genetic programming, TPOT (Olson, et al., 2016) optimizes scikit-learn pipelines by starting with the simplest and improving them over time. Besides these methods, H2O AutoML stacks the best results of a random search in order to optimize H2O components.

Meta-Learning

Meta-learning covers all learning based on prior experience with other tasks. How different ML methods perform on a wide range of learning tasks are observed systematically. This significantly accelerates and improves the design of ML pipelines or neural architectures. Meta-data that describe prior learning tasks and previously learned models are collected. The first step includes the exact algorithm configurations and measurable properties of the task itself, also known as meta-features. The second one is to learn from this experience or meta-data. It is needed to learn from this prior meta-data, to extract and transfer knowledge that guides the search for optimal models for new tasks. There are three fundamental meta-learning methods based on the type of meta-data they leverage, from the most general to the most task specific. Learning from model evaluations includes recommending useful configurations and configuration search spaces, as well as transferring knowledge from empirically similar tasks. Learning from task properties characterizes tasks to more explicitly express task similarity and build meta-models that learn the relationships between data characteristics and learning performance. Learning from prior models covers how can be transferred trained model parameters between inherently similar tasks (Vanschoren, 2019). As an AutoML tool, auto-sklearn uses meta-learning to warm-start the Bayesian optimization procedure and includes ensemble construction which allows to use all classifiers that were found by Bayesian optimization (Gijsbers, et al., 2019).

Architecture Search

Automated neural architecture search methods can be categorized according to three dimensions. The first dimension, the search space, defines which architectures can be represented. Prior knowledge can reduce the size of the search space and simplify the search. However, this also may prevent finding novel architectural

building blocks that go beyond the current knowledge. The second dimension, the search strategy, details how to explore the search space. It aims to find well-performing architectures quickly, but at the same time, needs to be avoided premature convergence to a region of suboptimal architectures. The third dimension, performance estimation strategy, refers to the process of estimating predictive performance on unseen data. Because of to perform a standard training and validation of the architecture on data (it is the simplest option) is computationally expensive and limits the number of architectures that can be explored, recent research focuses on developing methods that reduce the cost of these performance estimations (Gijsbers, et al., 2019).

Automatic Feature Generation

Applying machine learning models to capture the correlations over different features has remarkably progressed. Self-attention mechanisms and graph neural networks are designed to generate high-order interactive features. automatic feature generation improves the effectiveness of the processes in several applications such as recommender systems. On the other hand, the explainability of these features is weakened due to the black-box nature of adopted neural networks. Search-based automatic feature generation methods are proposed to meet the demand for interpretability. Besides that, search-based methods required computation resources and training time can become intolerable when the scale of the considered data is large. Some of the studies in automatic feature generation try to find an optimal solution that possesses both feature interpretability and search efficiency. The open questions for automatic feature generation can be listed as how to exploit prior knowledge and how to balance the trade-off between the usefulness of generated features and their completeness, especially when the running time and computation resources are limited (Li, et al., 2021).

Solution Architecture

Data Pre-Processing

H2O AutoML provides automatic data pre-processing which includes automatic imputation, normalization, and one-hot encoding. Various automatic target encoding strategies has been benchmarked for high-cardinality features in experimental versions of the algorithm. H2O AutoML has a pre-processing option with minimal support for automated target encoding of high cardinality categorical variables (LeDell & Poirier, 2020).

Model Generation

H2O AutoML includes Gradient Boosting Machines (GBM), Random Forests (RF), Deep Neural Networks (DNN) and Generalized Linear Models (GLM). After training the base models, stacked ensembles is created as a class of algorithms that involves training a second level meta learner to find the best combination of the base models. Two stacked ensemble models, the "All Models" ensemble includes all the models, and the "Best of Family" ensemble includes the best performing model from each algorithm class/family, are trained using H2O's Stacked Ensemble algorithm. Stacked Ensembles predict well if the base models are individually strong and make uncorrelated errors. Random search across a number of algorithm families produces a very diverse set of base models, and when paired with stacking, produces powerful ensembles. Generally, both ensembles produce better models than any individual model. By default, the meta learner in the Stacked Ensemble will be trained using the k-fold cross-validated predictions from the base learners. This version of stacking is called the Super Learner algorithm (Laan, J., Polley, & Hubbard, 2007) to represent an optimal system for learning.

Model Evaluation

AutoML tool includes a leader board which ranks all models by model performance. The leader board presents the information about model performance, training time and per-row prediction speed for each model trained in the AutoML run, ranked according to user preference. The models are ranked by a default metric based on the problem type. In binary classification problems, that metric can be AUC, and in multiclass classification problems, the metric can be MAPE. In regression problems, the default sort metric can be RMSE. H2O AutoML covers the leader board, provides a model list and prepares the best model to use in predictions.

Experiments

The current solution proposal is compared with the AutoML model to measure the contribution made to the business problem. If the business unit does not currently use a solution for the business problem and a solution proposal is to be developed from scratch, a benchmark model is developed that uses the methods in the business unit's skill set. In order to develop a benchmark model, the business needs should be understood correctly, the current conditions and capabilities of the business unit should be well defined, and the outputs of business and data analysis should be used as a substantial resource. Communication and mutual knowledge transfers between the business unit and the data science team are vital in modelling the current situation. The business unit's familiarity with data science as well as the data science team's knowledge about the business unit's operational processes can be a crucial factor in strengthening this mutual communication.

The benefit of the data science team to the business unit is measured by comparing the developed model performance with the estimation method used in the current structure. Where there is no estimation method used in the existing structure, a model that represents the current state can be designed using simple statistical methods, or a reference model can be developed using AutoML tools to set a more challenging target. Even in some business problems, the ML model developed by the data science team may not outperform the model developed with AutoML.

Table 1. Confusion matrix of As-Is model

	Predicted - False	Predicted - True
Actual - False	24853	6212
Actual - True	6020	1619

The confusion matrix provides to measure how well the model does the classification task by comparing the predicted values with the actual ones. It is used to evaluate the accuracy of a model created for a classification problem. The actual and predicted values in the confusion matrix create performance criteria such as accuracy, recall, precision, and F1-score and they are calculated by the following formulas. Test results that correctly or wrongly indicate the presence of a condition are used to define the performance of the classification (Kadıoğlu & Işıklı, 2022). The outputs of the benchmark models that show the as-is situation and developed using AutoML can be seen in Table 1 and Table 2.

Table 2. Confusion Matrix of AutoML Best Model

	Predicted - False	Predicted - True
Actual - False	19262	11803
Actual - True	1979	5660

For a classification problem, the AutoML solution framework has been implemented and the results are monitored. Target variable is defined, and the features which are learned by business units has been added to the dataset. Feature types are defined to the model and, response should be a factor for binary classification. AutoML uses DRF, GLM, XGBoost, GBM algorithms and produce the model depend on their AUC scores. H2O AutoML runs for 20 base models and Stacked Ensemble of all models is used as best model. The performance metrics of the AutoML model with better classification performance are shown in Table 3.

Table 3. Model Performance Scores f or Benchmark Model and AutoML Experiments

Experiments	AUC	F1-Score
As-Is Model	0.5034	0.2054
AutoML - Best Model	0.6804	0.4509

Conclusion

There are many open source AutoML tools allow novice users to create useful ML models. However, defining prediction problems has significant challenges. The data scientist must work with the domain expert to understand the context of the business problem. Many vital steps of this ML process are generally still done manually by the data scientist. This often requires a lot of work between the data scientists and domain experts, making the whole process more difficult and inefficient. Data science project methodologies emphasize the importance of collaboration between domain experts and data scientists and how it can be improved (Kadıoğlu & Takcı, 2022). To improve these collaborations, the difficulties can be overcome by following the relevant

main development areas. On the other hand, a significant portion of the ML process today requires involvement from a data scientist, making the whole process inefficient and inaccessible to a wider audience. First, formulating a prediction problem is challenging, and there is currently no established standard for accomplishing this task systematically. The challenges, automated task formulation, effective prediction engineering, and the recommendation of useful tasks, must be addressed to reach the eventual goal of an automated ML process (Karmaker, et al., 2021).

There are similar studies tries to reduce human bias in the search space and develop a solution to the automatic discovery of whole ML algorithms from basic operations with minimal restrictions on form (Real, Liang, So, & Le, 2020). In addition to these studies examined in the literature review, the performance of two solution architectures, which express the current situation and developed using AutoML, was examined and it was seen that AutoML constitutes a substantial starting point in data science projects.

Scientific Ethics Declaration

The author declares that he is solely responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

Prediction of the Amount of Raw Material in an Algerian Cement Factory

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Abstract: Factories are currently confronted with multifaceted challenges created by rapid technological Many technologies have recently appeared and evolved, including Cyber-Physical Systems, the Internet of Things, Big Data, and Artificial Intelligence. Companies established various innovative and operational strategies, there is increasing competitiveness among them and increasing companies' value. A smart factory has emerged as a new industrialization concept that exploits these new technologies to improve the performance, quality, controllability, and transparency of manufacturing processes. Artificial intelligence and Deep Learning techniques are revolutionizing several industrial and research fields like computer vision, autonomous driving, predicting failures, etc. The idea of this work is the development of a predictive model to predict the amount of raw material in a workshop in a cement factory based on the Deep Learning technique Long Short-Term Memory (LSTM). The excellent experimental results achieved on the LSTM model showed the merits of this implementation in the production performance, ensuring predictive maintenance, and avoid wasting energy.

Keywords: Intelligent automation, Smart manufacturing, Prediction, Deep learning, LSTM

Introduction

Companies have a vital need to adapt universally if they are to remain competitive. The automation has not eliminated the malfunctions that can cause unnecessary stoppages during the execution of the process. These problems have forced companies to look for effective solutions, such as the use of new technologies like Artificial Intelligence and Machine learning. The lack of a guiding theoretical framework of Machine Learning technology in manufacturing, the amount of redundant data, and the complexity of processes present a knowledge gap. Consequently, many problems are facing the applications of data analytics and machine learning in the industry at first (Kusiak, 2018; Sharma et al., 2021; Van Heerden & Bas, 2021).

In this work, we focus on new trends in the manufacturing field, particularly the industry 4.0 and the smart factory, which will revolutionize manufacturing systems. Along with the industry 4.0 revolution, in several industries, machine learning has been effectively used in process optimization (Li et al., 2020), monitoring and control applications in production, and predictive maintenance (Wang et al., 2021). Also, on new technologies like artificial Intelligence. We chose the cement factory to be our field of application to create a program for predicting the quantity of raw material in a raw mill workshop and the cement workshop using the deep learning algorithms the Long Short-Term Memory (LSTM).

Methods

Artificial Intelligence (AI) in a sense is the simulation or replication of intelligence processes by computer systems that can think and act rationally in a way similar to humans. In other words, AI can be defined as a branch of computer science by which we create intelligent machines which can think like a human, act like humans, and be able to make decisions like a human (Jokanović & Jokanović, 2021). Because it is relevant to such a wide range of use cases, machine learning is generating a lot of interest. Classification is a supervised learning method in machine learning in which the computer program learns from the data input given to it and then utilizes this learning to categorize new observations. Choosing an algorithm is a key stage in the machine learning process, so ensure it genuinely matches the problem's use case (Mohana-Priya et al., 2021; Usuga Cadavid et al., 2020).

Deep learning is a specific method of machine learning that incorporates neural networks in successive layers to learn from data iteratively. A neural network consists of three or more layers: an input layer, one or many hidden layers, and an output layer. Data is ingested through the input layer. Then the data is modified in the hidden layer and the output layers based on the weights applied to these nodes. The typical neural network may consist of thousands or even millions of simple processing nodes that are densely interconnected. Deep learning has become a powerful tool widely used in many fields like medicine, social media, and as this work in industry, with the help of its algorithms and one of the most important deep learning algorithms is recurrent neural networks (RNN). An architecture of Recurrent neural networks (RNN) is displayed in Figure 1.
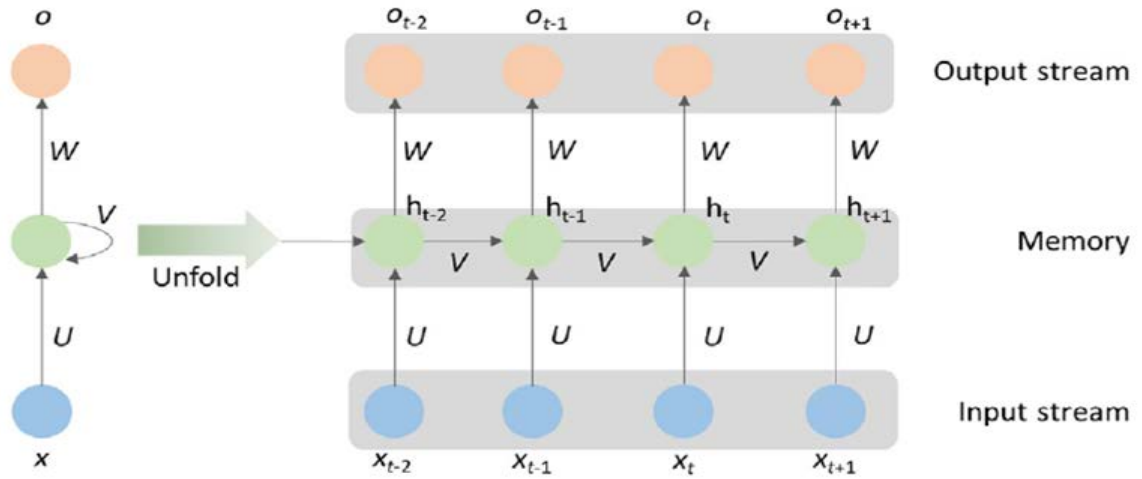
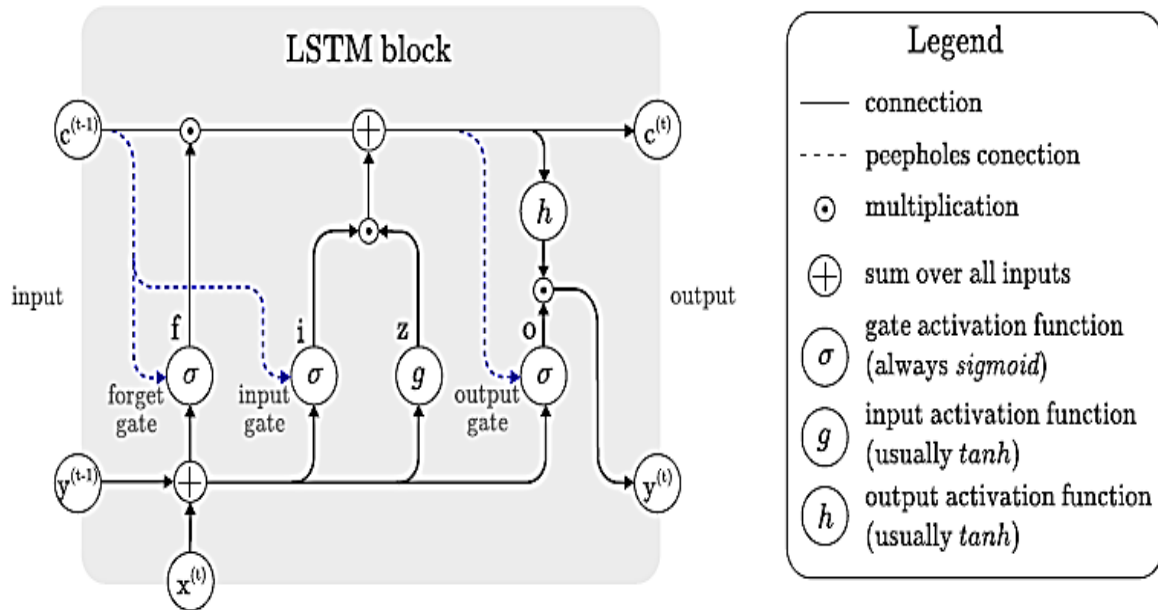

Figure 1. Architecture of RNN

Figure 1. LSTM technique principle

The LSTM model is an extension for RNNs designed to overcome the exploding and vanishing gradient problems that typically arise when learning long-term dependencies, even when the minimal time lags are very

long in between. this is because the LSTM model has three gats the input and the output gate, also the forget gate (Van Houdt et al., 2020).

Although RNNs are successful in short-term memory operations, they have failed to learn long-term dependencies. The most important reason for this is the vanishing and exploding gradient problem. Long Short-Term Memory (LSTM) is an extension of RNN has been introduced by Hochreiter and Schmidhuber in 1997 to solve the problem of vanishing gradient, one of the major difficulties in performing long-term memory. The architecture of the LSTM model is represented in Figure 2.

Materials

In this study, in an East Algerian cement plant of Ain Touta (SCIMAT), the workshop of a raw mill is selected. Throughout the production line, the product passes via a collection of electrical, mechanical, and automated equipment and a large number of other devices to process and maintain this operation and keep it on functionality mode if the system needs. Description of the workshop features are collected in Table 1.

Table 1. Description of the workshop features

Parameters	Interval	Units	Designation
Z2M03_J1	[0-120]	%	Engine Crusher Power
Z2M01_T3	[0-150]	C°	Crusher Temperature Output
Z2M01_T2	[0-150]	C°	Crusher Temperature Input
Z2M01_P2	[0-40]	mbar	Crusher Pressure Output
Z2M01_P1	[0-4]	mbar	Crusher Pressure Input
Z2M01_X1	[0-100]	%	Crusher acoustic equipment
Z2S01_S1	[0-100]	%	Separator Speed
Z2S01_I1	[0-120]	%	Separator Current
Z2J01_J1	[0-120]	%	Elevator Power
Z2S03_J1	[0-120]	%	Fan's Power
Z2S05_Z01	[0-100]	%	Butterfly Register Position
Z2P06_Z01	[0-100]	%	Butterfly Register Position
Z2P25_Z1	[0-100]	%	Butterfly Register Position
Z2M03_T8	[0-150]	C°	Crusher Bearing Temperature
Z2M03_T9	[0-150]	C°	Crusher Bearing Temperature
Z2A01_F1	[0-140]	t/h	Transp.Tape Flow
Z2B01_F1	[0-140]	t/h	Transp.Tape Flow
Z2C01_F1	[0-8]	t/h	Transp.Tape Flow
Z2D01_F1	[0-40]	t/h	Transp.Tape Flow
Z2M01I01_TOTAL	[0-150]	t/h	Total Feed Rate
Z2M01_Y1_SPM	[0-140]	t/h	Total Feed
Z1L01_L21	[0-100]	%	Clinker Hopper Level
Z1L02_L21	[0-100]	%	Clinker Hopper Level
Z1L03_L21	[80-100]	%	Silo Cement Level
Z1L04_L21	[0-100]	%	Silo Cement Level
P1L03_L21	[0-100]	%	Silo Cement Level
P1L02_L21	[0-100]	%	Silo Cement Level
P1L01_L21	[0-100]	%	Silo Cement Level
P2L01_L21	[0-100]	%	Silo Cement Level
P2L02_L21	[0-100]	%	Silo Cement Level

Results and Discussion

The heatmap presented in Figure 3 illustrated the correlations between the different attributes of the selected dataset. All characteristics/features given in the dataset are very less correlated with each other. This implies that we have to include all the characteristics because we can only eliminate the characteristics where the correlation of two or more characteristics is very high.
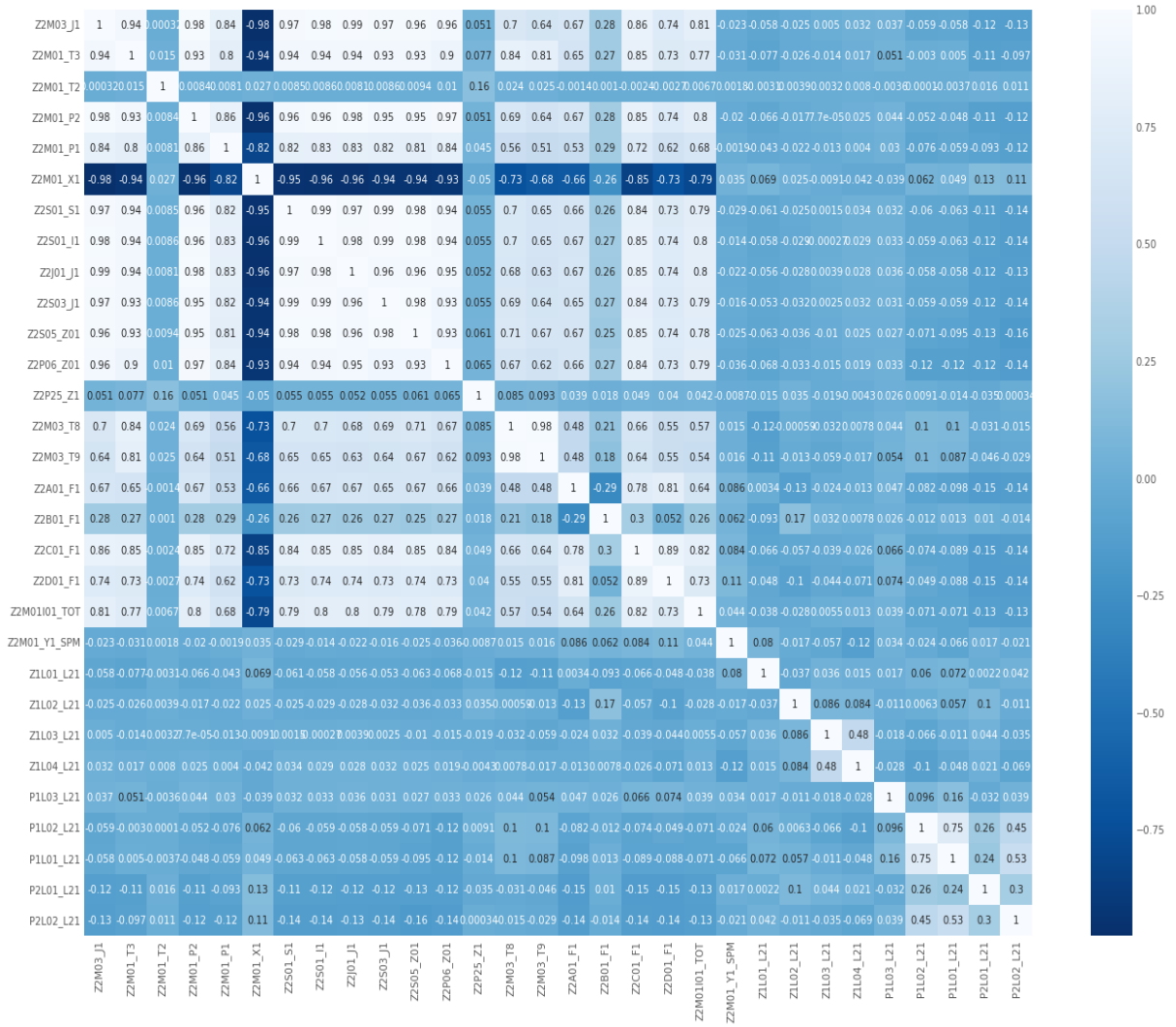
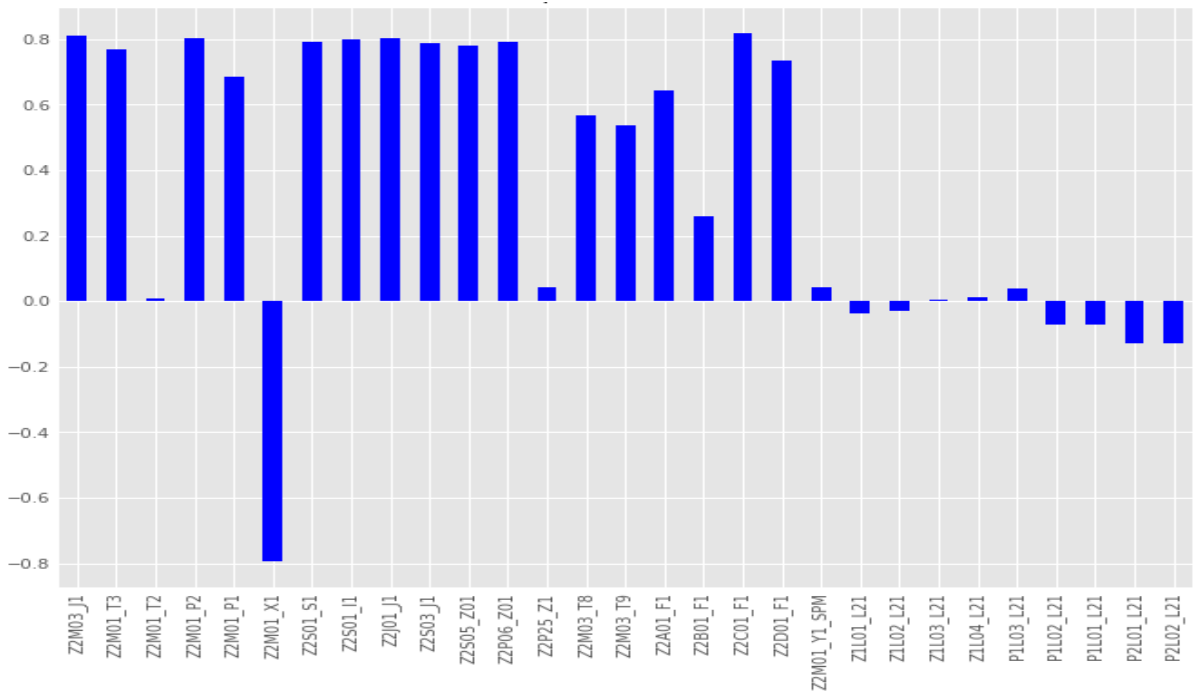Figure 3. The heatmap of features.

Figure 4. Influential factors

Regarding the plot displayed in Figure 4, several observations are noted. Factors indicators that influence negatively the state of the line production are the crusher acoustic indicator (M01X1) and the operator sp03 (QCXH20). Figure 3 displayed the different influential factors on the functioning of the line production. In our experiments, the data set is split into two parts, respectively as the training set (67%) and testing set (33%). The training set is used to train the prediction model while the testing set is used to validate the performance of the trained model.

More specifically, the accuracy of predictions on the testing set, the core and key of further applications, plays an essential part in the validation and directly affects whether it could be used. During the first stage, the LSTM algorithm is applied to a training dataset and the performance was evaluated. Later, the algorithms were applied to a testing dataset to make predictions (see Figure 5).
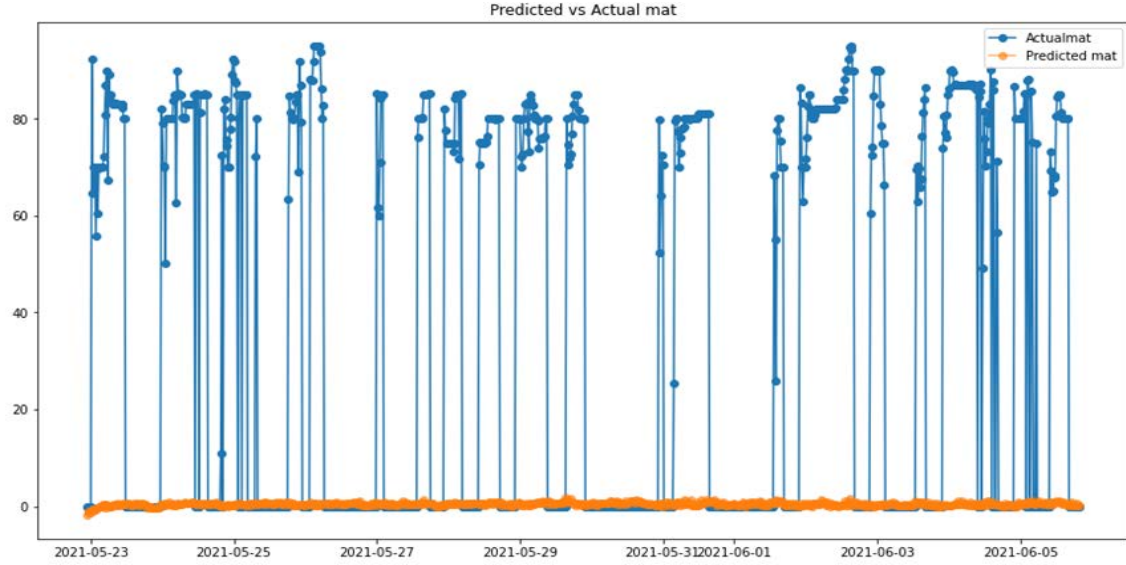

Figure 5. The prediction of first material with the LSTM algorithm.

Results demonstrate the overall system performance enhancement in predicting bearing failure when modeled data are included with SCADA data. Based on data from the cement plant, the performances of different machine-learning models on unseen data are then evaluated using industry-standard metrics including training accuracy, testing accuracy, sensitivity, and specificity. Evaluation results are collected in Table 2.

Table 2. The evaluation metrics of the predictive model

Metrics	Value
Mean Error (ME)	-21.16
Mean Absolute Error (MAE)	22.17
Root Mean Squared Error (RMSE)	40.94
Validation Loss	0.29

Conclusion

The learning model and architecture presented improve control flexibility. The capacity to handle data and a great deal of information to boost productivity, minimize maintenance costs, and several other advantages. In the future, we can use test the presented dataset with other improved machine learning algorithms to provide better efficiency.

Recommendations

We believe that the following research directions are required for the next generation of prognostic and health management systems, especially in complicated industrial processes with enormous real-time alarms and faults. The final objective is to obtain an autonomous system able to supervise the factory in real-time.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

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To cite this article:

Zermane, H., Madjour, H., & Bouzghaya, M. B. (2022). Prediction of the amount of raw material in an Algerian cement factory**.** *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 19,* 41-46.

Hybrid Battery Balancing System for Electric Drive Vehicles

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Abstract: In electric vehicles, cell and module voltage equalization plays a vital role in Battery Management System (BMS). The capacity, temperature, and aging imbalances in the cells and modules of electric vehicles battery packs restrict the amount of power that can be delivered to the vehicle. Spurred by this issue, we propose a new class of battery balancing systems, called hybrid balancing, capable of simultaneously equalizing battery capacity while enabling cost-effectiveness of cell-level passive balancing and module-level active balancing, modules consist of a number of cells connected in series, with cell-level passive balancing performed in a module, together with the module level switched capacitor that performs active balancing among the modules. The strategy is called hybrid balancing because it pursues goals beyond conventional state-of-charge equalization, including temperature and power capability equalization, and minimization of energy losses. Design details and MATLAB Simulink simulation results are provided for a hybrid balancing system implemented on a lithium-ion battery pack.

Keywords: Electric vehicles, hybrid balancing, battery balancing, automotive systems

Introduction

Rechargeable batteries have been widely used in many fields, including the telecommunications industry, electric vehicles, and renewable energy storage systems to meet the demands for energy storage systems. Due to the individual battery cells low terminal voltage in the majority of applications, a battery bank is often formed by connecting the batteries in series to achieve the desired voltage level. However, there is a commonly known imbalance between battery cells in a battery bank. State-of-Charge (SoC) differences across cells are a well-known imbalance (Aizpuru et al., 2013). Differences between battery cells is caused by both intrinsic and extrinsic reasons (Jonghoon et al., 2012). Intrinsic variances are mostly a result of manufacturing process variation. It is not possible to create two cells with the exact identical properties. Cell performance varies during operation due to differences in capacities, self-discharge rates, and internal resistances. The effects of temperature and extraneous circuitry are extrinsic variables. The characteristics of the cells are impacted by the battery bank's uneven temperature distribution, which can cause performance variations (Belt et al., 2005). Electric-drive vehicles (EV, PHEV, HEV) use high voltage (HV) traction battery packs, which are consist of multiple battery cells linked in series. The capacity, inner resistance, and run-time state-of-charge (SOC) of individual cells differ from one another, hence a battery management system must include cell balancing (BMS) (Smith et al., 2016). In practice, passive balancing is considered the most cost-effective and most commonly used in lithium-ion battery packs for electric vehicles (Chan et al., 2001). The BMS consists of a series of special battery monitoring and passive balancing circuits (ICs) that sense individual cell voltages and activate cell discharge through shunt resistors command from BMS controller. A disadvantage of conventional passive balancing systems is that the available energy capacity of the entire battery pack is determined by the weakest cells (Baumhöfer et al., 2014). The weakest cell issue is getting worse over time due to uneven degradation among cells, causing reduced battery life (Smith et al., 2016).

Mitigating the impact of the weakest cells on a large battery pack requires tight cell binning and efficient thermal control (Chen et al., 2016). On the other hand, active balancing systems became popular nowadays, the weakest-cell effect is mitigated by using high efficiency power converters, supercapacitors, capacitors and inductors to transfer energy from one cell to another. There have been numerous active balancing architectures and realizations examined. However, active balancing strategy needs extra power electronic devices which makes additional costs for applications, this has been a major concern in practical applications (Einhorn et al., 2011; Hopkins et al., 1991).

In this paper, the strategy outlined in Paul et al. (2022), and Pognant-Gros et al. (2014) is expanded in order to determine the optimal trade-off between the advantages of the active balancing with switched capacitor-based circuitry. Fig. 1 presents a proposed circuitry for hybrid balancing strategy. The system concept and the hybrid balancing approach are covered in Section II. The hybrid balancing implementation is covered in Section III, and the simulation results, conclusion and recommendations are covered in Section IV, V and VI.

Hybrid Balancing Strategy

In the hybrid battery balancing system shown in Fig 1. Battery cells in the battery packs grouped into modules. Active cell balancing is applied at the module level and conventional passive balancing is applied at the cell level within a module.
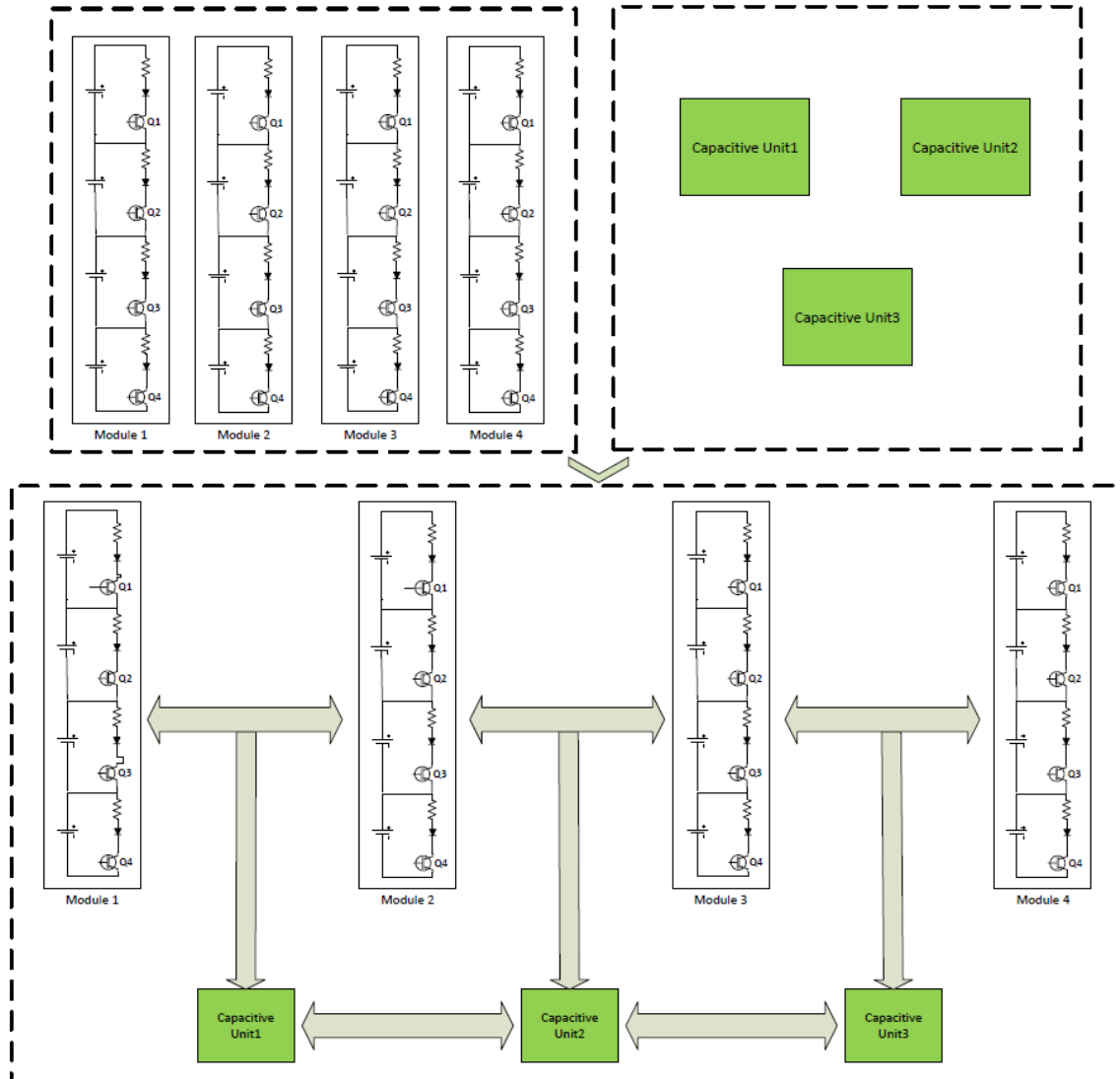

Figure 1. Hybrid balancing system

Cell Level Passive Balancing

This method uses a resistor to dissipate the energy of the cell with the highest voltage in a series module. In general, the weakest cell reaches its maximum voltage threshold earlier when the same current flows through the rest of the cells in the pack. When the cell voltage exceeds the SOA (safe operating area), the switch is turned on and the cell is discharged through a resistance, also called bleeding resistance, lowering the cell voltage and SoC, as shown in Fig. 1. to a safe level. Repeating this procedure allows for the eventual voltage uniformity of all cells. While active module level balancing is performed, additional passive balancing must be used within each module using one of the standard passive balancing algorithms as mentioned (Xiong R et al., 2019).

Module Level Capacitor-Based Active Balancing

One of the most crucial advantages of active balancing in EV/HEV applications is battery life extension. In physically, large EV/HEV battery packs, the temperature fluctuations across the pack lead to uneven aging between the cells, which is one of the main reasons of short battery life. Because nearby cells in a battery pack have lower temperature variations and degrade more gradually, the modular approach described here is driven by this fact (Muneeb Ur Rehman et al., 2016). Thus, passive balancing at the cell level can be carried out inside each module, and nearby cells can be grouped into modules for active balancing at the module level. Capacitor-Based cell balancing has been developed and tested in (Pognant-Gros et al., 2014). This study has been extended and applied at the module level and same strategy followed.

Module Level SOC and SOH

The module level state of charge (SOC) and state of health (SOH) must be known in order to implement module level active balancing. Various advanced cell level SOCs and SOH development methods has been investigated in (Muneeb Ur Rehman et al., 2016), (Plet et al., 2011). The extraction of module-level data needs to be carefully evaluated because the SOC and SOH vary for each cell inside a module. Extra consideration needs to handle if the slow passive balancing action has not completely balanced the module's cells during the balancing time. Passive balancing is applied to the subset of cells in a module; hence the module SOH should be based on that subset's worst-case cell. Eqs. (1) and (2), where n and j are the overall number and the index of cells within a module, respectively, provide the inner resistance and total capacity of Module i (Zhang et al., 2017).

$$R_{modules,i} = n.\max(R_{cell,j}) \tag{1}$$

$$Q_{modules,i} = n.\min(Q_{cell,j}) \tag{2}$$

It takes more careful calculations and consideration to determine a module's SOC. Assume that $SOC_{max} > SOC_{min}$. Significant considerations are needed when calculating the module SOC. If $SOC_{max} > SOC_{min}$ for the two cells with the highest and lowest SOC values. In the same way that safety restrictions for the SOC_{min} cell may be violated during module discharging if the module SOC is thought to be SOC_{min}, safety limits, for the SOC_{max} cell may be violated during charging if the module SOC is thought to be equal to the highest cell SOC (SOC_{max}). The SOC of module i is determined using the formula presented in Eq (3) and Eq (4), in order to properly accommodate various module-level active balancing strategies under various cell-level passive balancing conditions (Zhang et al., 2017).

$$SOC_{module,i} = \frac{\min(SOC_{cell,j}Q_{cell,j})}{\min(SOC_{cell,j}Q_{cell,j})+\min(1-SOC_{cell,j})Q_{cell,j})} \tag{3}$$

after all cells in a module balanced;

$$SOC_{module,i} \approx \frac{SOC_{cell,j}\min(Q_{cell,j})}{SOC_{cell,j}\min(Q_{cell,j})+(1-SOC_{cell,j})\min(Q_{cell,j})} \approx SOC_{module,k} \tag{4}$$

where index k represents the cell with the least total capacity.

Switched Capacitor Based Hybrid Balancing Strategy

Switched Capacitor based hybrid balancing system is shown in Fig. 1. Basically, it is the mix of the passive and active balancing strategies. A switched capacitor balancing system, it aims at balancing a set of modules in series. In the illustration, a specific module could be substituted by a group of modules operating in parallel, which is a common scenario in EV/HEV batteries. Electrical scheme of the switched capacitor is shown in Fig. 2.
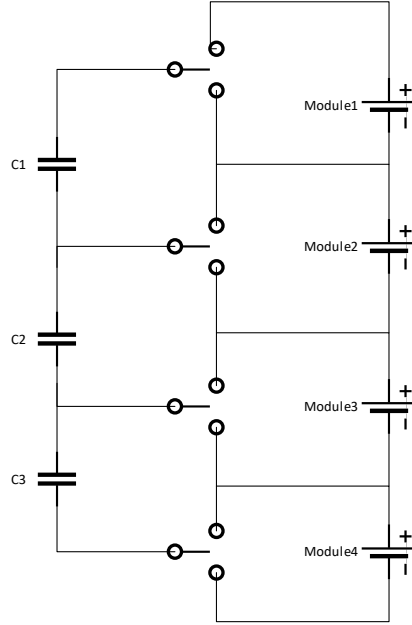
Figure 2. Electric scheme of the switched capacitor-based module balancing system

The switches are interlocked and alternately connected to the top and bottom contacts. Switching the capacitor back and forth gives the exact same voltage across the battery modules. Physically, the dynamics depend on the capacitance C, the equivalent resistance including cells inside the module, switches and capacitors and the chemistry of the cells inside the module.
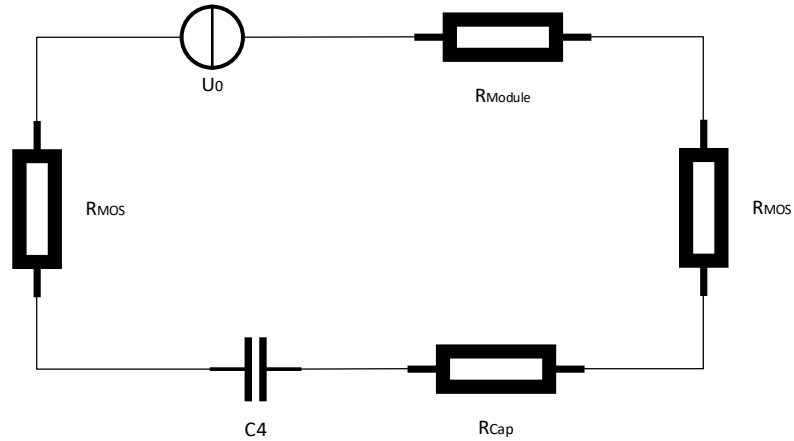
Figure 3. Module level electric equivalent scheme of each module while switching

The circuit depicted in Fig. 3 is taken into consideration without losing generality. The electrical connection between a capacitor and a module is shown in the figure during the switching period, which is $[t_k, t_{k+1}]$, with $t_{k+1} - t_k = T_s$. The Eqs. (5) and (6), regulating the electric circuit can be described as follows in the continuous time domain.

$$C\frac{dv}{dt} = I = \frac{U_{0_i} - V}{R_{tot}} \tag{5}$$

$$\frac{dQ_i}{dt} = -I = -\frac{U_{0_i} - V}{R_{tot}} \tag{6}$$

where V is the capacitor voltage (in V), Q_i is the cell discharge/charge (in C) and, symmetrically, the capacity charge/discharge, U0i is the cell open circuit voltage (in V), function of the cell charge Q_i, R_{tot} is the sum of module, capacitor and MOSFETs resistances (in W).

Simulation Results

The hybrid battery balancing strategy has been tested in MATLAB/Simulink. A battery pack composed of 4 module and each module consist of 4 cells connected in series was considered with a uniform initial dispersion of charge between 10% and 100%. The evolution of voltage and charge for the cells, modules and capacitors has been also collected, in order to verify that the imposed thresholds were respected. The figures below summarized the results. In details, Figure 4 compares the module open circuit voltage dispersion before and after the balancing. Figures 5, 6 and 7 show the evolution of, respectively, cells state of charge during the balancing, cells voltage equalization with passive balancing and voltage difference between load and 4 modules highlighting that, accordingly to the imposed condition, the balancing is achieved in the expected time. Li-ion cell and capacitive unit parameters are given in Table1.

Table1. Li-ion cell and capacitive unit parameters

Parameter	Value	Unit
Cell Capacity	2,3	Ah
Nominal Cell Voltage	3,3	V
Fully Charged Voltage	3,748	V
Cell Series Resistance	30	Ω
Capacitive Unit	0.033	F
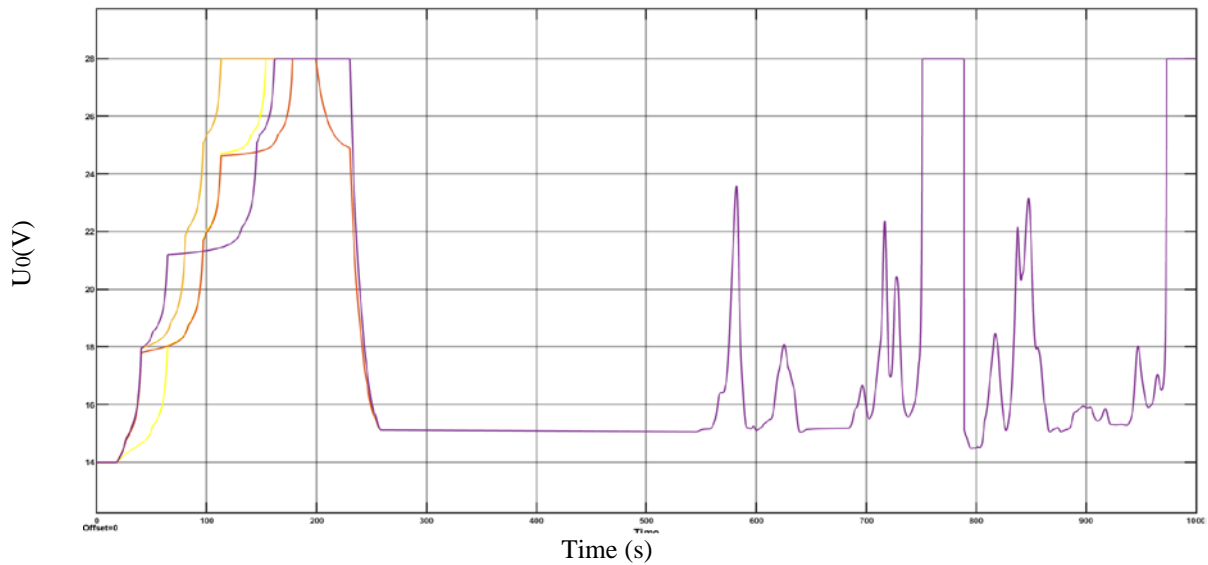
Figure 4. Module voltage equalization with fluctuated charging current
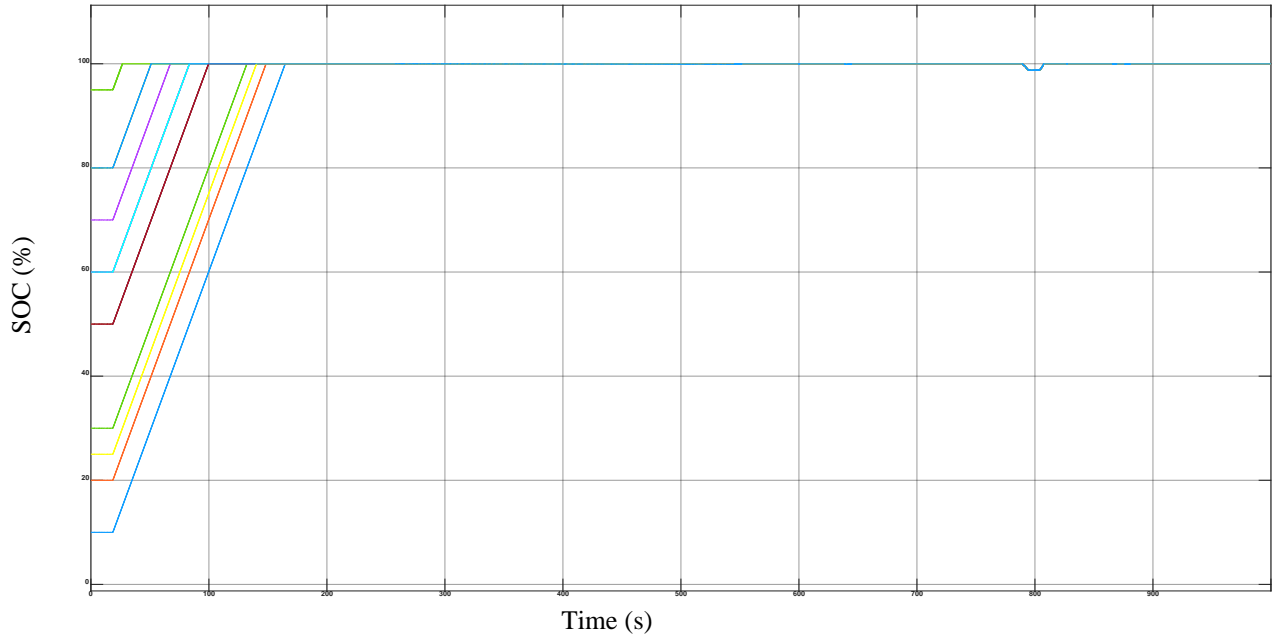
Figure 5. Cell SOCs equalization during charging
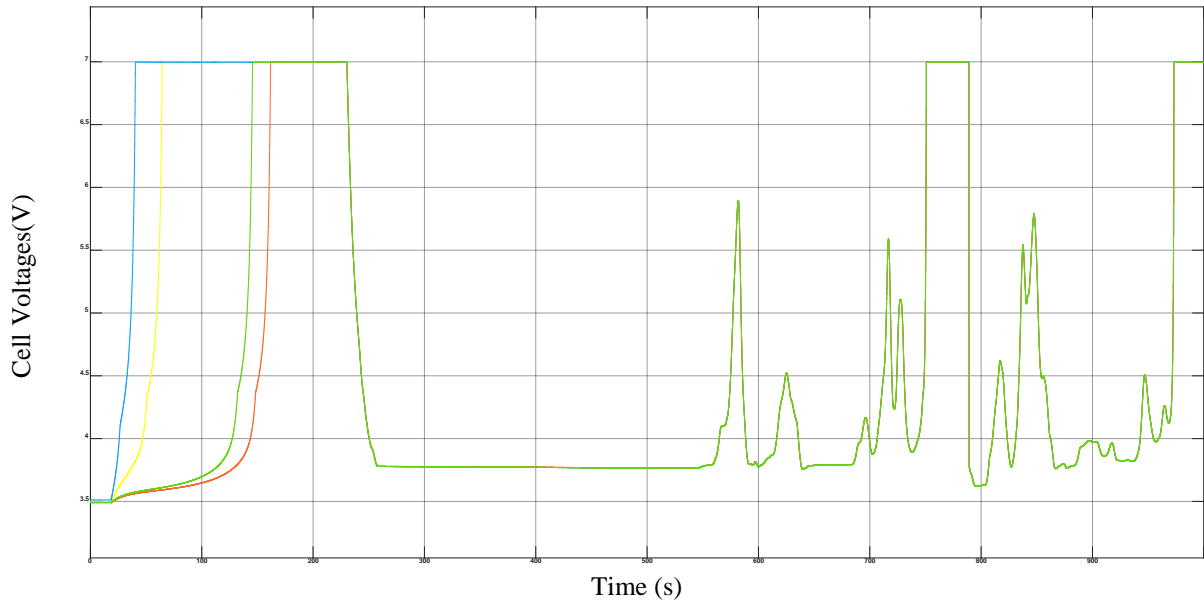
Figure 6. Cell Voltage equalization via passive balancing in Module1 during charging with fluctuated charging current

Conclusion

Cell balancing is a crucial function of the battery management system. It prolongs battery pack life time, improves the safety of the battery system and maximizes the battery pack total capacity. Hybrid battery balancing system has been investigated and simulated with the aid of MATLAB/Simulink. A novel hybrid balancing system has been proposed and designed with module level active balancing and cell-level passive balancing is presented in this paper. The advantages of the proposed control strategy are: reducing the system size, cost as well as the balancing time. Module-level active balancing is performed by switched capacitors. The hybrid system features favorable cost/performance tradeoffs and is capable of implementing a range of system and module-level control strategies. The system simulation results demonstrated on a Lithium-ion battery pack, which composed of 4 module and each module consist of 4 cells connected in series.

Times (s)
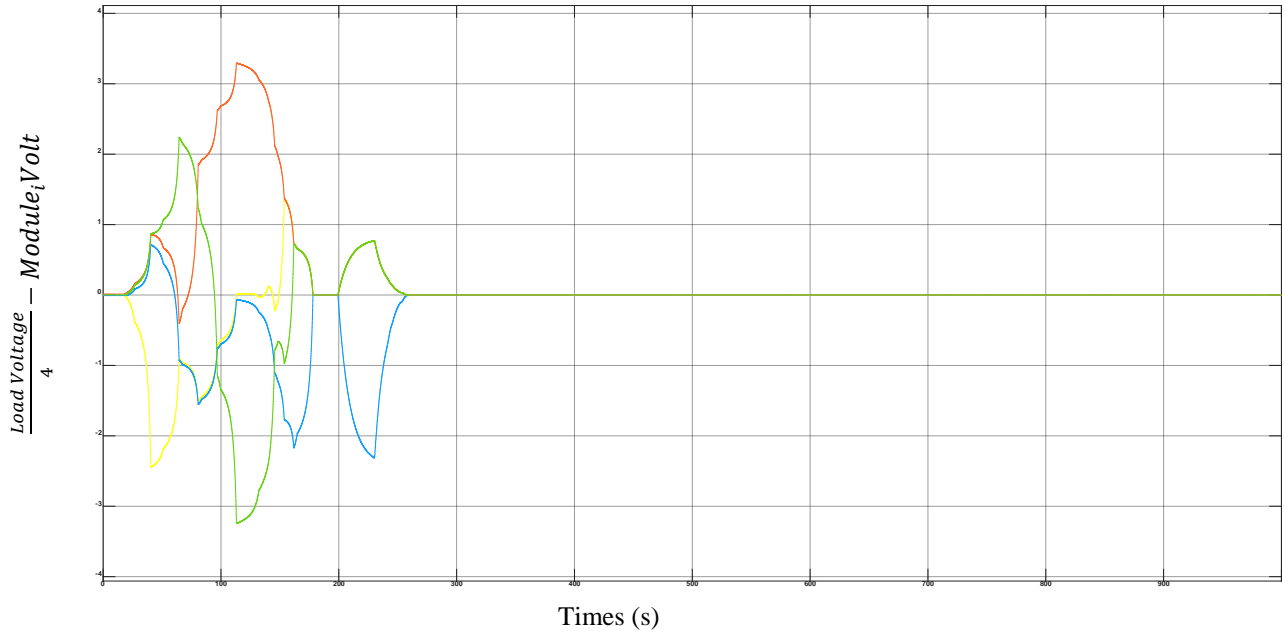
Figure 7. Difference between (Load Voltage/4)-(Module i Voltage) results

Recommendations

This structure is probably the easier way to design an active balancing system at the module level, but its convergence is intrinsically governed by the lithium chemistry, capacitor size and switching frequency. The selection of switching frequency and capacitor size is an optimization problem in switched balancing capacitors to maximize the energy transfer rate among high charge module capacitor to low charge module. The proposed structure can be extended by using supercapacitors at the module level. This will help to reduce balancing time.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article:

Kocyigit, D. & Ayten, U. E. (2022). Hybrid battery balancing system for electric drive vehicles. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 19,* 47-54.

Investigation of Fresh Air-Intake Split Air Conditioner Indoor Unit

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Abstract: Clean air is a necessity for physical and mental health. Today, many people cannot get enough fresh air because they have to live and work in closed environments. Especially in single-volume heating or cooling, the indoor air is reconditioned several times, and the air regresses to an insufficient level of air quality over time. The users can only overcome the situation by simply opening the windows and getting fresh air but unfiltered and unconditioned air. In this study, a fresh air supping unit was developed for split air conditioners to create healthier and more comfortable living environments. For the selection of the fan in the fresh air intake module, the amount of fresh air needed in the living room according to the ASHRAE standarts, the ability to change the fan speed, and the ability to overcome pressure drop caused by hose and filter were evaluated. In addition, a filter group was utilized in the unit against particles that may come from the outside environment. The prototype of the designed unit was produced and tested in terms of temperature and performance. The obtained results were investigated in detail.

Keywords: Split Air Conditioner, Fresh Air, Indoor Air Quality, HVAC

Introduction

Split air conditioners are essentially heat pumps with two units, one indoor and one outdoor unit. One of the two units has heat exchanger plates that act as an evaporator and the other as a condenser. The refrigerant circulating between these two units is driven by the compressor and conditions the environment according to the simple cooling cycle. Split air conditioners are devices that condition the indoor environment to the desired air temperature as their main function. The American Society of Heating, Refrigerating, and Air-conditioning Engineers established the standards required per person in the room for comfort and health in neighbourhoods that are living spaces today (ASHRAE, 2015). In addition to air conditioning, the requirements for providing

comfort conditions in indoor environments are factors such as room temperature, relative humidity, odour, oxygen and amount of fresh air in the environment.

The importance of fresh air from comfort conditions has been understood once again with the Covid-19 pandemic (Aviv et al., 2021). While split air conditioners climatize the indoor air, they provide the desired air conditioning temperatures by subsequently circulating the indoor air. The fact that the air circulated for climatization is indoor air means that dust, particles, dirt, bacteria, and viruses that can be found in this air are circulated many times (Kang et al., 2017). The traditional method of cleaning this air, is to ventilate the environment. The fact that Covid-19 is a virus transmitted directly by breathing and affects the respiratory system revealed the importance of having a system that will provide fresh air to the ambient air in split air conditioners in the air conditioning sector. Researchers showed that fresh air intake plays a vital role in the indoor air quality of living areas (Yang et al., 2021). Ho et al. (Hoa et al., 2021) investigated the position of fresh air vent effects on airflow to maintain the room at 22 ºC for cooling function. Hsieh and coworkers (Hsieh et al., 2018) proposed a heat-pump fresh air exchanger design to reduce energy consumption during cooling applications. Apart from indoor air quality, Liu et al. (Liu et al., 2019) reviewed a comparative study on fresh air supply technologies for zero-energy buildings. In this study, a split air conditioner with a fresh air intake function is developed. This product is being studied experimentally. The fan, filter, hose used for the fresh air intake function, and a fresh air intake module were designed. Studies were carried out to examine this module regarding performance and efficiency in the PTC laboratory.

Method

A fresh air intake module, which will work integrated with the split air conditioner, has been designed to provide the fresh air requirement of an indoor environment climatized with a split air conditioner unit. The prototype of this designed module was made and shown in Figure 1.

Figure 1. Fresh air intake module

Filters

The module, which will feed fresh air to the split air conditioner indoor unit, will filter the air it feeds from outside before it is fed into the system, so inside the module; There is a hose to supply air from outside and a filter assembly at the outlet of the hose. In the filter assembly, a multi-layer filter structure is used based on traditional air cleaner products.

Hose

A split air conditioner with a fresh air intake module will be used for a living room with an area of 30 m². In order for this module to take fresh air into the room, a hose extending out of the room will be used.Flow rate calculations that can be provided with different sizes of hoses have been made for the options of mounting the split air conditioner in different areas in the room. The selected hose is 30mm in diameter and 2m in length.

Centrifugal Fan

During the development of the fresh air intake module, it is important to choose the right fan that can meet the system requirements. The type of fan to be used in this system has been determined as a centrifugal fan, both due to its structure and its ability to provide the airflow required to be fed to the system (Eck, 1973).
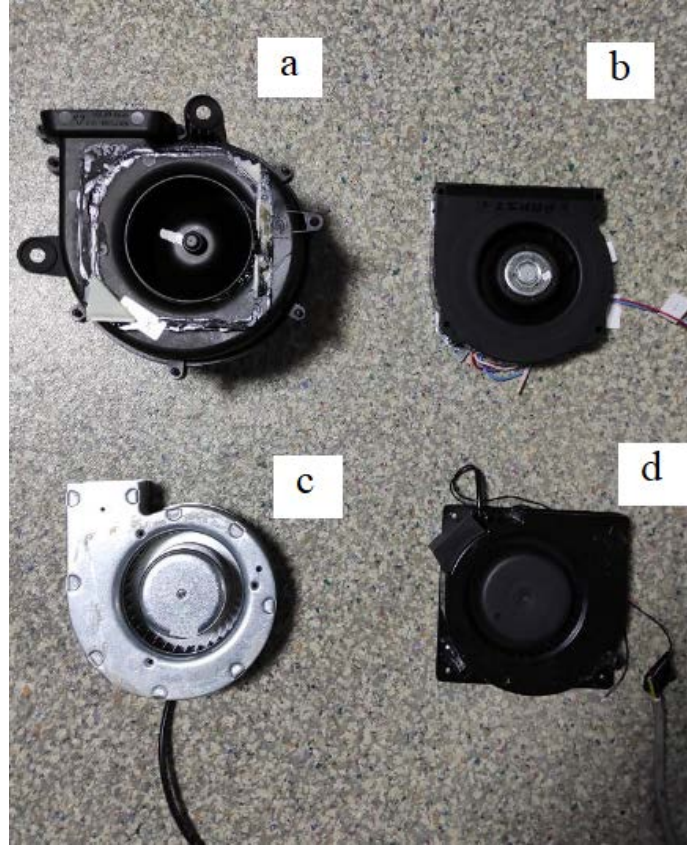
Figure 2. Tested centrifugal fans a)Fan-Ref b)Fan-1 c)Fan-2 d)Fan-3

Experimental Study

Performance Test

Figure 3. Comparative PTC laboratory tests a) without fresh air module b) with fresh air module

The fresh air intake module, in which the final state of the design was determined with the test results taken from the fan trial setup, was tested in terms of performance, efficiency and heat transfer in the Psychrometric Test Chamber (PTC) laboratory. The fresh air intake module is integrated into the split air conditioner. Tests were carried out with and without modules on it, and the results were evaluated comparatively. Thermocouples were placed at the air outlet section of the split air conditioner at regular intervals, and the temperature differences due to the fresh air supplied to the split air conditioner were examined.

Results

Fan Selection Results

The results obtained from the centrifugal fans, which were tested with the help of the fan test setup, are as given in Table 1. The centrifugal fan in the row indicated in green in the table has been selected. The fan given as the Fan-Ref in the table is the fan whose fan curve is known and used in the calculation of the required flow rate for the pressure drop. When the test results were evaluated Fan-3 was chosen as the fan of the system for performance tests, due to its ability to feed the amount of fresh air needed in the room, variable-speed motor and size advantage.

Table 1. Fan selection results

Fan	Volumetric Flowrate [m³/h]	Mass Flowrate [kg/h]	Density [kg/m³]	Velocity [m/s]	Diameter [m]	Area [m²]	Fan [rpm]	Fan [voltage]
Fan-Ref (known fan characteristic curve)	37,36	45,76	1,225	2,35	0,075	0,004416		
	32,59	39,92	1,225	2,05	0,075	0,004416		
	34,97	42,84	1,225	2,2	0,075	0,004416	1560	230V
	35,61	43,62	1,225	2,24	0,075	0,004416		
	38,79	47,51	1,225	2,44	0,075	0,004416		
	42,92	52,58	1,225	2,7	0,075	0,004416		
	33,22	40,7	1,225	2,09	0,075	0,004416	860	125 V
	31,79	38,95	1,225	2	0,075	0,004416	2485	120 V
Fan-1	14,31	17,53	1,225	0,9	0,075	0,004416	1200	
	23,84	29,21	1,225	1,5	0,075	0,004416	1750	
	42,13	51,6	1,225	2,65	0,075	0,004416	2650	
	50,87	62,31	1,225	3,2	0,075	0,004416	3250	
Fan-2	45,62	55,89	1,225	2,87	0,075	0,004416	3127	
	39,74	48,68	1,225	2,5	0,075	0,004416	2800	
	31,79	38,95	1,225	2	0,075	0,004416	2400	
Fan-3	61,36	75,17	1,225	3,86	0,075	0,004416	2830	230 V
	32,11	39,34	1,225	2,02	0,075	0,004416	1900	

Performance Test Results

Table 2. Performance test results PTC laboratory

		COOLING						
Test Number		1	2	Temperature difference [%]	3	4	Temperature difference [%]	
Fresh Air Module		Yes	No		Yes	No		
Id fan motor speed	rpm	900	900		650	650		
Od fan motor speed	rpm	850	850		450	450		
Thermocouple-1	°C	14,73	14,67	-0,41	19,37	19,26	-0,57	
Thermocouple-2	°C	13,89	13,83	-0,43	18,62	18,54	-0,43	
Thermocouple-3	°C	13,72	13,71	-0,07	18,74	18,42	-1,74	
Thermocouple-4	°C	14,14	14,25	0,77	18,92	18,87	-0,26	
Thermocouple-5	°C	14,31	14,41	0,69	19,18	19,14	-0,21	
Thermocouple-6	°C	15,17	15,22	0,33	20,2	20,12	-0,4	
Thermocouple-7	°C	14	14,07	0,5	19,1	19	-0,53	
Thermocouple-8	°C	14,63	14,71	0,54	19,9	20,1	1	
		HEATING						
Test Number		1	2	Temperature difference [%]	3	4	Temperature difference [%]	
Fresh Air Module		Yes	No		Yes	No		
Id fan motor speed	rpm	1000	1000		650	650		
Od fan motor speed	rpm	850	850		500	500		
Thermocouple-1	°C	42,9	42,69	-0,49	33,45	33,42	-0,09	
Thermocouple-2	°C	42,54	42,28	-0,61	33,15	33,17	0,06	
Thermocouple-3	°C	42,54	42,41	-0,31	33,12	33,16	0,12	
Thermocouple-4	°C	43,16	43,15	-0,02	33,85	34,01	0,47	
Thermocouple-5	°C	43,46	43,49	0,07	34,02	34,2	0,53	
Thermocouple-6	°C	42,5	42,5	0	33,6	33,71	0,33	
Thermocouple-7	°C	42,8	42,79	-0,02	33,35	33,55	0,6	
Thermocouple-8	°C	43,65	43,6	-0,11	34,33	34,5	0,49	

Performance test results for split air conditioners with and without the fresh air intake module in PTC laboratory are given in Table 2. The tests were carried out both in the heating mode of the split air conditioner and in the

cooling mode. When the test results in Table 2 were evaluated, it was observed that the use of the module did not cause a significant change in the performance and the outlet temperature of the indoor unit of the split air conditioner. The warmer air blown from the fresh air unit in the cooling mode and the cooler air blown from the fresh air unit in the heating mode is sucked from the area of the air conditioner suction area close to the fresh air unit. This situation causes the deviations of thermocouples between 1 and 4 to be negative. The fact that all deviations in Table 2 are less than 1% shows that the fresh air unit does not have a negative effect in terms of performance and temperature.

Conclusion

The fresh air intake split air conditioner unit developed in the study was calculated for the amounts specified in ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality in the literature and designed to meet these standards. By using the equations given in this standard, a module design has been made that can provide the 32.4m³/h fresh air intake requirement determined for a room with an area of 30m² and more if more is needed.

Since the fan used for the room is chosen as a fan whose speed can be changed and it is easy to drive with an electronic card, it is the fan that can best meet the fresh air requirement specified by the standards. The most suitable fan will easily meet the fresh air requirement of 32.4m³/h in the indoor area with an area of 30m². Also 32.11m³/h at the lowest fan speed and 62.36m³/h at the highest fan speed. If the need for fresh air in the room will increase for any reason (for example; an increase in the number of people, an increase in polluting factors in the room, etc.), the selected fan is selected at a level that can provide the required amount of fresh air.

Considering the test results of the PTC laboratory, the temperature difference does not exceed 1% even for the thermocouples which are closest to the part where the fresh air intake module is located. This result is a negligible value when considering the area of the dimensions where the system is used. When other thermocouples were evaluated at the same measurement time, it was observed that there was no change compared to the situation where the fresh air intake module was not used.

The developed module enabled the split air conditioners to be able to climatize the environment by adding fresh air to the indoor air without affecting the cooling and heating performances. The use of the developed module will provide the opportunity to provide fresh air with a higher level of hygiene, in addition to providing the comfort conditions of split air conditioners. Additionally, the compact structure of the developed module allows not disturb the aesthetic structure of the split air conditioner.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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Intelligent Control System of a Real Industrial Process

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Abstract: Industrial systems are difficult to control and supervise efficiently because of the complexity of the production process. The aim is to automatically control in real-time as an alternative for operators as possible and highlight the importance of machine learning in the field of industry. Integrating SVM into the industrial supervision system in the cement factory (SCIMAT) permits the classification of different measurements coming from sensors to the Programmable Logic Controller (PLC) that indicates when the process is in good functioning or bad indicating that a default has occurred. These measurements are classified after training in three classes of level (low, medium, and high) that are classified in their turn into two classes (good and bad functioning). The three classes present the inputs of the fuzzy controllers. Based on this classification, the PLC makes orders for industrial equipment. Then a regression of variation of measurements in real-time is carried out to predict the good or the bad functioning of the production line. In conclusion, the proposed approach innovates the complex supervision system to learn how to control and preserve the habitual linguistic language used by operators, react in the right way, and prevent critical situations.

Keywords: Fuzzy control, machine learning, support vector machine, classification, regression

Introduction

In industry, intelligent automation must increase the productivity of the production system (cost reduction, reliability, availability, and quality); however, it increases the complexity of the development of the supervision systems too. The remarkable situation is that the data and knowledge are extracted from experts who usually rely on common sense when they solve problems. They use vague and ambiguous terms. A knowledge engineer would have difficulties providing a computer with the same level of understanding. This has led to the need for efficient technologies, such as Fuzzy Logic (Zadeh, 1965) and Machine Learning. This late contains several techniques including one of the most efficient, Support Vector Machine (SVM) (Awad M., 2015; Cristianini & Schölkopf, 2002).

SVM is developed to classify data according to their characteristics or make a regression for them. All this is to get the ability to predict the position that new data should be on. This work comes through this science, to drive it into the industry. The applications focus on meeting control challenges of pyro processes through best-applied technologies. The idea is to create an intelligent model that monitors the industrial supervision system instead of the operator and improves the existing system of supervision.

In this work, fuzzy logic and SVM technique using Python, and Simatic Step 7 code is implemented. The model treats the collected data from the real industrial system in real-time to get to the end of the Programmable Logic Controller (PLC) code. In the first section, machine learning and artificial intelligence are discussed. In the second part of this work, the big advantage is to integrate machine learning (ML) using SVM as a binary classification of different measurements coming from sensors to the PLC.

Materials

Clinker is an assembly of four artificial minerals that have hydraulic properties and harden when they are mixed with water. Fast cooling and freezing of these artificial minerals then happen in the clinker cooler, the third element of a cement kiln system. A crucial ingredient to make this mineral transformation happen is fuel. Historically oil and gas were used, then coal and petcock, but since the 1980s more and more alternative fuels are employed for heating.

In the present work, the dataset is collected from the cement factory of Ain Touta in the Est of Algeria (SCIMAT). The workshop of the raw mill is favored to be the case study. This workshop has a specific production line, within this line the product moves across a group of the electric, mechanic, automatic equipment, and many others, for processing this operation and keep it on functionality mode if the system needs. Classes of the dataset in our case are the presence or the absence of a default detected by an alarm. All the sensor settings are configured to be used in the training of the machine learning model.

Methods

Machine learning is briefly introduced in more detail concerning the manufacturing domain. It is based on knowledge extraction from data. It is a research field at the intersection of statistics, artificial intelligence, and computer science and is also known as predictive analytic or statistical learning. Fuzzy set theory was formalized by Lotfi Zadeh in 1965 (Zadeh, 1965, 1973). The generality and ambiguity are sufficient for human comprehension of complex systems. Fuzzy logic has rapidly become one of the most successful techniques for developing sophisticated control systems. It addresses such applications perfectly as it is like human decision-making with the ability to generate accurate solutions from uncertain or approximate information.

SVM is a supervised machine learning algorithm proposed by Vapnik (Corinna & Vapnik, 1995; Vapnik, 1998). SVM has been shown to provide higher performance than traditional learning machines and has been introduced as a powerful tool for solving classification problems. However, there are some limitations, including outlier handling, long learning times, and an increased number of support vectors (Lee et al., 2017). With the assistance of SVMs, one can perform both linear as well as non-linear classification (Goudjil et al., 2018; Liu et al., 2012). SVM has become very widespread in research and has been incorporated into several fields including medical (Bromová et al., 2014; Mark Chang, 2020), military (Mohril et al., 2020; Rozek et al., 2020), industry (Zermane & Kasmi, 2020), and so forth; and a variety of applications, including image classification (Elaziz et al., 2020), text mining (Chatterjee et al., 2021; Court & Cole, 2020), video recommendation (Bălan et al., 2020; Massiris Fernández et al., 2020), and multimedia concept retrieval (Aslam & Curry, 2021; Moreno-Schneider et al., 2017).

Proposed approach

The developed application consists of the classification of all features into specific ranges according to their setpoints interval, which are:

- High range: value greater than the setpoint.
- Medium range: value inside the interval of high and low setpoints.
- Low range: value less than the setpoint.

After calling the dataset, SVM takes its place to analyze these later using the two functions, classification, and regression. The most used of these two is coming separating, each one is for a different type of dataset according to the form that this data is shown. In this work, the two functions are aggregated.

SVM technique analyses the datasets by training each other together, testing this training motivation, then making validation. After training and testing the datasets, SVM classifies them according to our order and then gives us the ability to predict and put each new data into its special and fitted class.

The types of kernel functions include splines, polynomials, hyperbolic tangents, sigmoid functions, and radial basis functions (RBFs) (Hsu et al., 2010). In this study, we used an RBF kernel, which is generally known to have an excellent performance capability. SVM is a high-performance classification technology that has attracted much attention in various fields.

The developed code in Python is connected to the PLC code developed in Simatic Step 7. Thus, it allows us to import the data inside Python (v3.8) to predict and classify them from real data, or the industrial system, we work on. This is how we can make the program accessible to the system parameters, then it can control them automatically instead of the main control room operators. This operation has a special library known as Snap 7. The advantages of such architecture are its flexibility in control, and its ability to data process a lot of information to improve productivity and reduce maintenance costs. The architecture of the new contribution is illustrated in Figure 1.
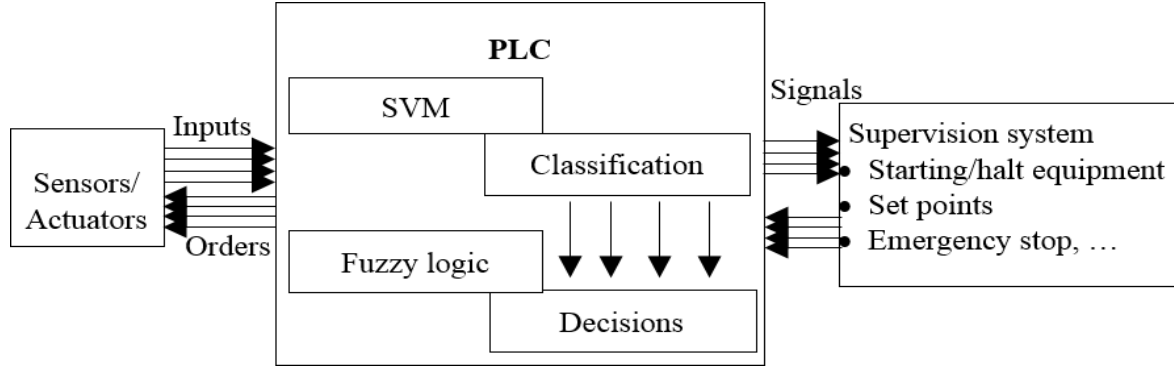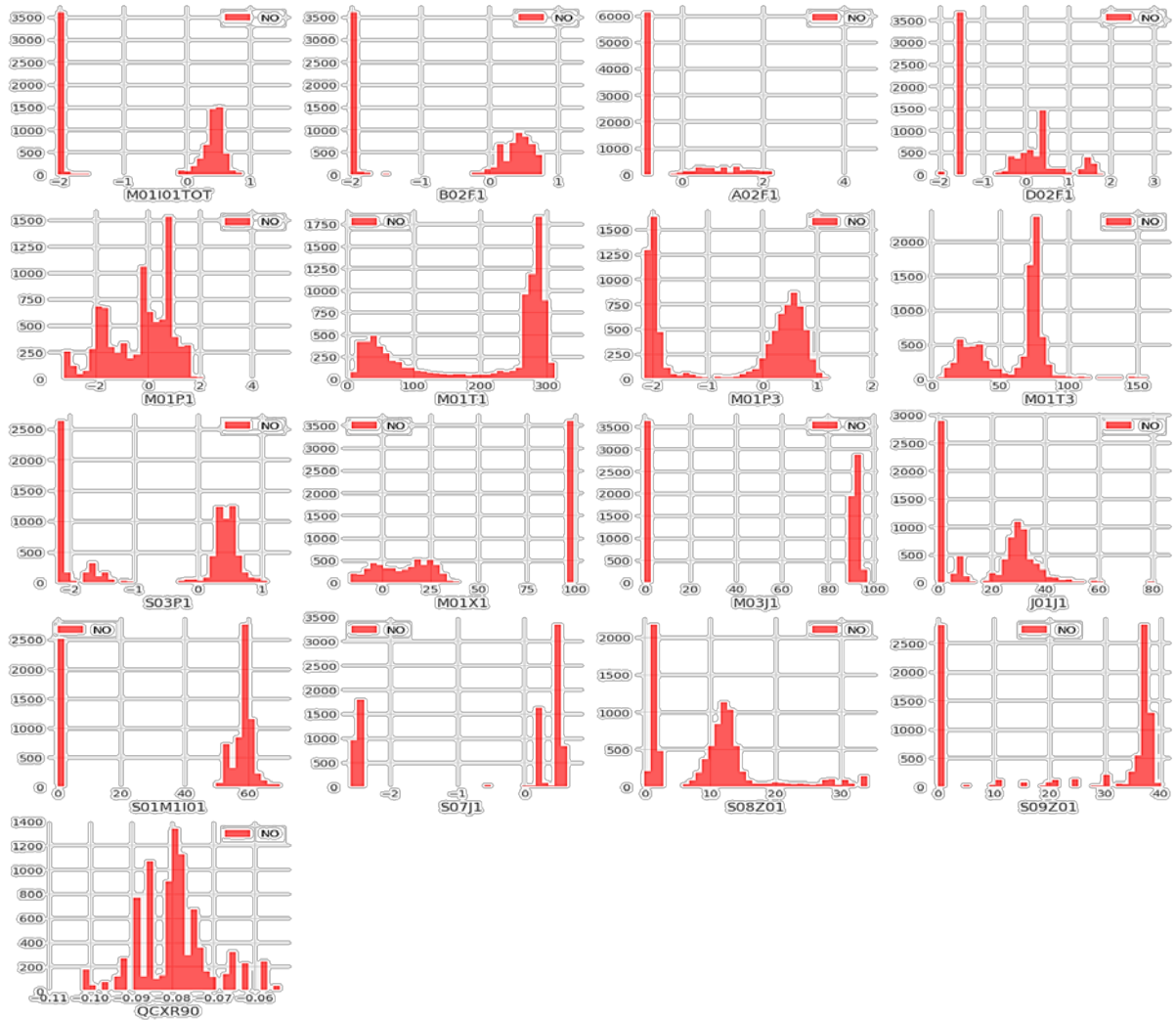

Figure 1. The proposed architecture

Figure 2. Distribution of features according to class 0 (bad functioning)

Results and Discussion

Creating such architecture needs in addition to the automation programming language Step 7, a programming language Python which is very helpful for the development of the predictive model. Characteristics/features given in the dataset are very less correlated with each other. This implies that all features are included in the study (Figure 2). Factors' indicators that affect negatively the state of the production line are the crusher acoustic equipment (M01X1) and the Operator sp03 (QCXH20). Several observations are noted. To evaluate the prediction model, several metrics are carried out (see Table 1).

Table 1. Model evaluation

Metrics	Value
Accuracy score	94.18039964970943
Training Accuracy	0.9887847535390769
Testing Accuracy	0.9418039964970942
Sensitivity	0.9245982694684796
Specificity	0.9459246102230117

Connecting python to Simatic Step 7 needs another tool which is NetToPlCSim and the Snap7 library. The running of this tool allows getting accessibility to run any automatic code after configuration of the network IP addresses including the computer, Simatic PlCSim, and Rack/Slot. In the case of the acquisition of new values in real-time, curves move and the classes change according to the amount of the values. This allows the operator knows that when the system is out of range, it means that there is one feature measure or more that are out of range.

The "Graphs" function in the menu allows operators to get access to SVM graphs for each one of the features. There are several measurements in the process control, the changes of the engine temperature input (M01T1) are selected as an example. M01T1 feature has a setpoint range of [220-400] C°. The SVM curve for this feature is illustrated in Figure 3.
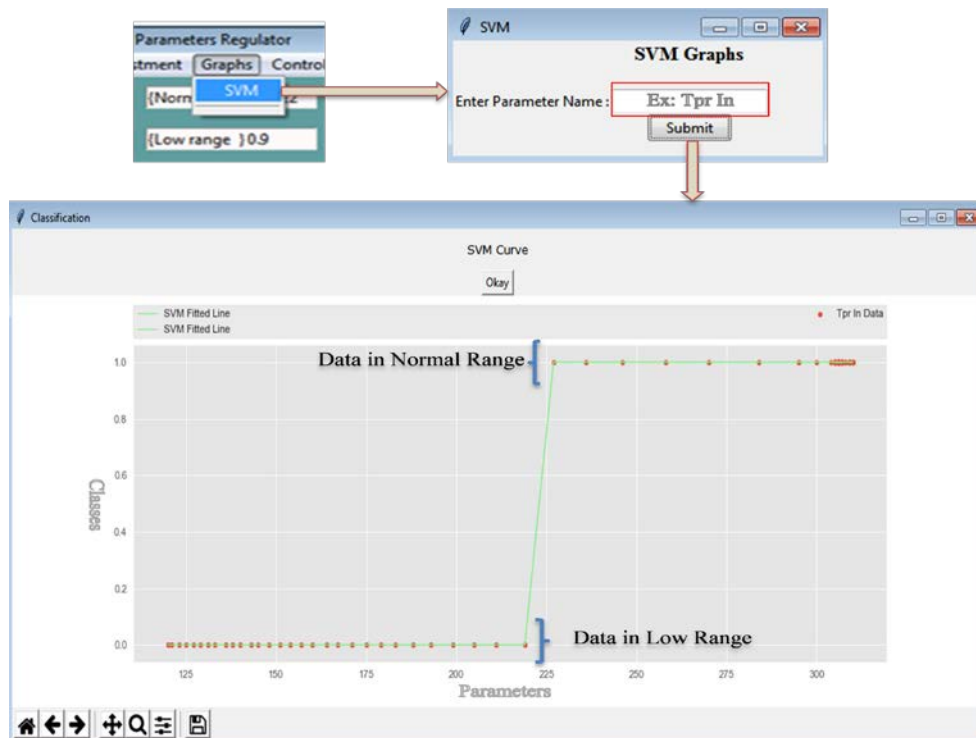
Figure 3. Classification of the system's state

The fuzzy controllers consist of establishing the fuzzy inference between inputs and outputs. The diagnosis tool is used to prevent, identify, and recover from abnormal operations or failures. Several controllers are developed to control the workshop. One of these fuzzy controllers is the controller that monitors the level of materials in the feeder and the elevator to commence the transportation of materials to the raw mill. The acoustic equipment indicates the level of materials inside the raw mill.

The fuzzy controller created to control and synchronize the control loop of the material's feeders and the other parameters in the cement mill workshop is displayed in Figure 4.

Figure 4. Inputs of the feeder's fuzzy controller

An example of the running of the fuzzy controller consists of two inputs and one output. The material level in the elevator, which is input J01J1 = 15%, and the acoustic equipment value, which is the input M01X1 = 25%. Consequently, the feeders' amount is M01I01 = 60%. Results are illustrated in Figure 5.
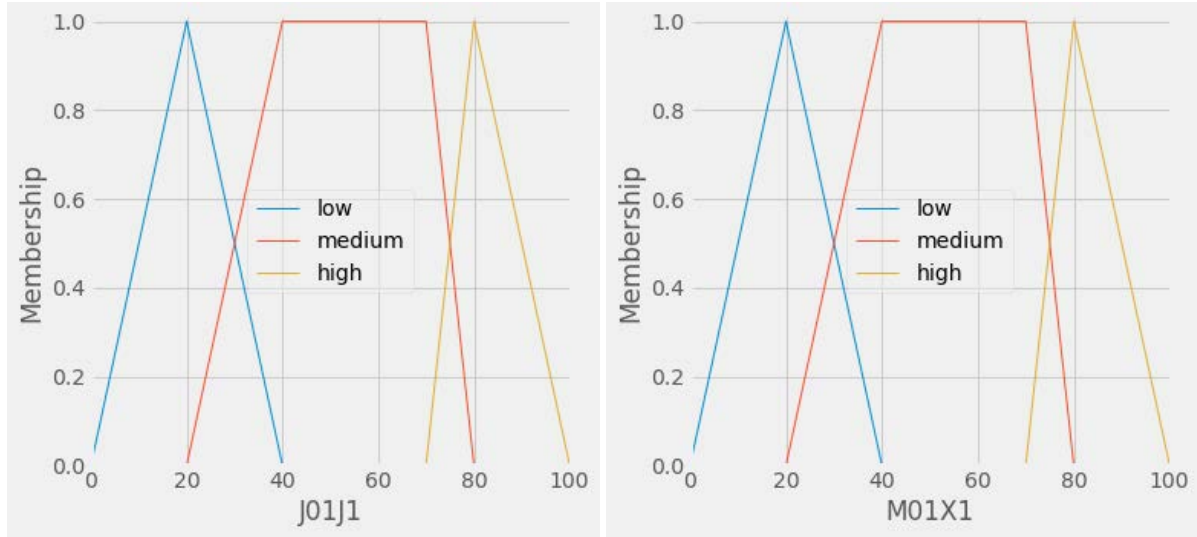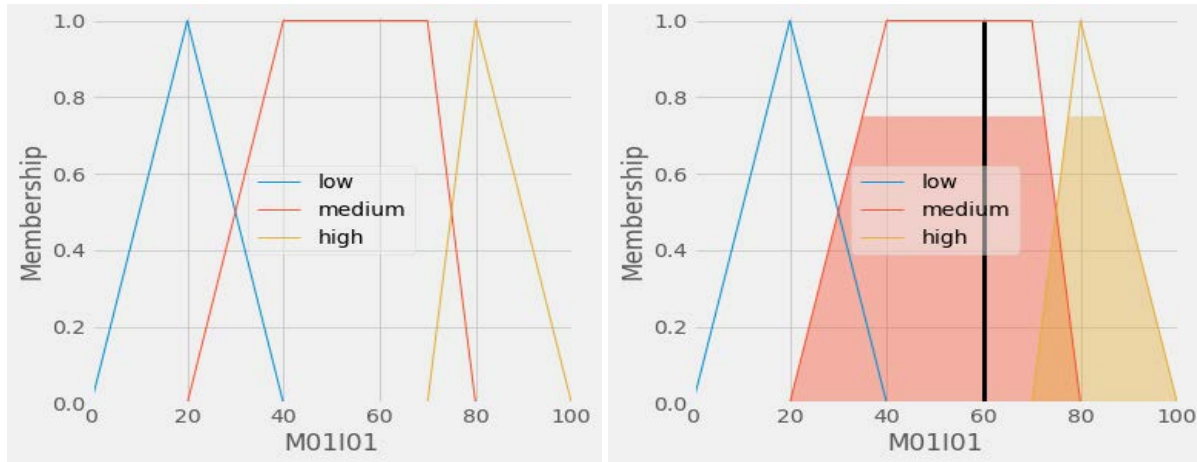

Figure 5. Output and result of the feeder's fuzzy controller

Conclusion

One of the most important points in this aim is the interactivity of the system interface. This can help the operator to get accessibility to control the system as much as he needs. Machine Learning can pass missing in industrial supervision systems and gets a better production system. This means we need to push up and insert machine learning inside the industry, where it can do better and drive the industry to the top, especially in our country where we miss this propriety very much. This proves that it can do more than just classify data and plot them, this technique can do very well in the industrial field too. It can be an alternative for human beings' missions in this issue. This gives us a chance to control the industrial system faster and more precisely, and get access to all system parameters without getting back to the human being handed. This can cost a lot of money and takes a long time as well as insufficient control, higher production, Consistent quality, more stable operation, lower fuel consumption, a lower standard deviation of free lime, and payback of investment in less than a year.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

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To cite this article:

Industrial Scale Testing and Evaluation of Silver Recovery Process

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Abstract: In this paper an industrial scale testing and evaluation of a silver recovery process for treating silver-containing materials is presented. The process that is based on the thiourea leaching, followed by silver cementation allows for recovery of the majority of silver as a metallic product. The thiourea leaching was developed specifically for the zinc cake residue, produced from the conventional zinc roast-leaching process at the KCM 2000 AD (Bulgaria), which contains up to 200 g/t silver. The material has a complex zinc ferrite dominated mineralogy with minor zinc hydrosulfate, gypsum, anglesite and plumbojarosite. The feed zinc cake residue is washed with water to remove water soluble zinc by pulping it into 25-30% solids slurry. The washing is carried out in 60 minutes and the resulted slurry is sent to the solid/liquid separation section for filtration. The resulted solids are sent to thiourea leaching and the zinc-containing solution is sent for further zinc recovery. The washed (water-soluble zinc free) solids is pulped into 20% solids slurry. Using thiourea as lixiviant, ferric iron as oxidant, sodium metabisulfite as a reductant and sulfuric acid for pH control, the leaching is performed for 35 minutes at 35°C. Within the leaching process the operating conditions are controlled to allow high silver extraction, while reducing the detrimental effects of thiourea degradation. Silver is recovered from the pregnant leach solution by cementation that results in the formation of a high-grade silver cement product. Iron powder is used as a cementation agent to recover over 94% silver at ambient temperature for 90 minutes. Details of the development work and key process steps are described. The operational data and outcomes of the industrial scale testing are presented along with process performance evaluation.

Keywords: Silver, thiourea, leaching, cementation

Introduction

Process Description

Silver recovery process is a hydrometallurgical process for treating silver-containing materials that combines thiourea leaching and silver cementation to produce high quality silver cement. The key process steps involved are outlined in more details below.

Feed Pretreatment for Water-Soluble Zinc Removal

The majority of zinc in the feed zinc cake residue exists primarily as franklinite ($ZnFe_2O_4$) with lesser amounts of water-soluble gunningite (Zn, Mn^{2+})SO_4H_2O). Prior to the leaching, it is necessary to remove the water-soluble zinc which otherwise interfere with the process. This zinc if not removed reports largely to pregnant leach solution that is undesirable as it has the potential of consuming excessive thiourea amounts (Hiskey, 1984). Removal of water-soluble zinc is achieved by water leaching of the material in mechanically agitated reactors, followed by solid/liquid separation to produce washed solids and zinc-containing solution.
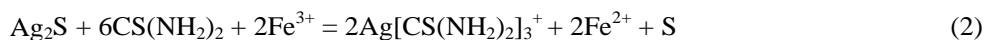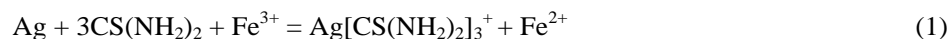
Thiourea Leaching

The chemistry of the thiourea leaching is complex. However, by maintaining suitable pH and by controlling the concentrations of reagents, its addition, temperature and leach time, high silver extraction with low reagent consumption can be achieved.

The leaching of silver and silver sulfide by thiourea, using ferric iron as an oxidant can be represented by the following reactions (Bruckard et al., 1993):

$$Ag + 3CS(NH_2)_2 + Fe^{3+} = Ag[CS(NH_2)_2]_3^+ + Fe^{2+} \tag{1}$$

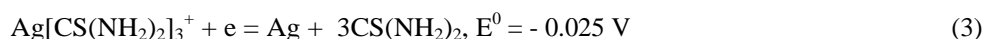$$Ag_2S + 6CS(NH_2)_2 + 2Fe^{3+} = 2Ag[CS(NH_2)_2]_3^+ + 2Fe^{2+} + S \tag{2}$$

The washed (water-soluble zinc free) material from the previous process step is slurried to 20% solids with sulfuric acid solution at about pH 1.7 in mechanically agitated leach reactors. Thiourea, iron (III) and sodium metabisulfite are added to the leach slurry to achieve following concentrations: 6 g/l $CS(NH_2)_2$, 1 g/l Fe (III) and 0,3 g/l $Na_2S_2O_5$. Sodium metabisulfite is used in the process to control the leach potential at a value where adequate silver leaching rate is achieved and thiourea degradation is minimized. Leaching is maintained at an optimum temperature of 35°C with the addition of steam. The leaching time is limited to 20 minutes and then the leach slurry is pumped to a solid-liquid separation stage, where the leach residue is separated from the silver-containing pregnant leach solution by filtration.

Silver Cementation

Silver cementation involves precipitation of silver by addition of fine iron powder to the silver-containing solution. The process is based on the fundamental principle, according to which "more electropositive" metals are recovered from the solution in metallic form through addition of ''more electronegative'' metal.

The mechanism for silver cementation on to iron metal from the thiourea leach solution (Lee et al., 1997) can be expressed as:

At the cathode:

$$Ag[CS(NH_2)_2]_3^+ + e = Ag + 3CS(NH_2)_2, \; E^0 = -0.025 \; V \tag{3}$$

At the anode:

$$Fe = Fe^{2+} + 2e, \; E^0 = -0.440 \; V \tag{4}$$

The overall cementation reaction can be expressed as:

$$2Ag[CS(NH_2)_2]_3^+ + Fe = 2Ag + 6CS(NH_2)_2 + Fe^{2+} \tag{5}$$
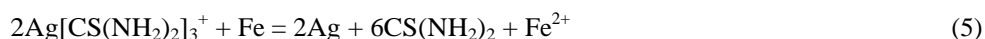
Reaction (5) indicates that one mole of iron can cement two moles of silver.

Silver is recovered from the silver-containing pregnant leach solution, generated in the thiourea leaching process step by cementation for 90 minutes in mechanically agitated reactor using an excess then the stoichiometric amount of iron powder. The produced silver cement is filtered out from the solution after cementation and the thiourea solution is sent to the effluent treatment.

Simplified Block Process Diagram

As can be seen in the block process diagram shown in Figure 1, the process contains the following steps: feed material pretreatment to remove water-soluble zinc and solid/liquid separation of the resulted slurry, thiourea leaching of silver and solid/liquid separation of the leach slurry, silver cementation and solid/liquid separation to recover silver cement product.
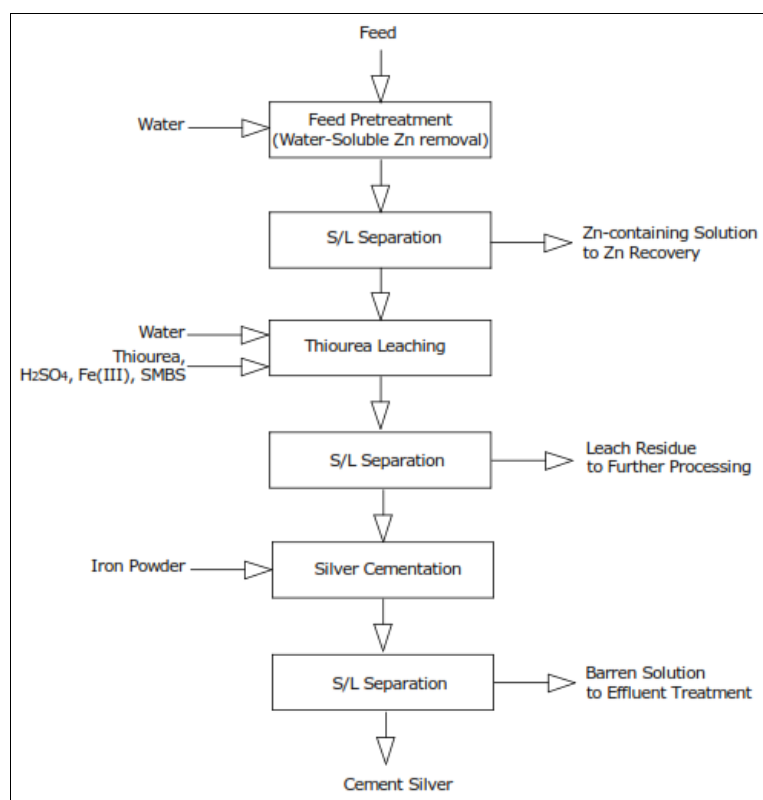
Figure 1. Simplified silver recovery process block diagram

Method

Background

Central Laboratory of Raw Materials Processing and Waste Management at the University of Mining and Geology "St. Ivan Rilski" (UMG) performed extensive metallurgical laboratory testing of the zinc cake residue, produced after two stage of leaching of a zinc calcine from KCM 2000 AD, Plovdiv, Bulgaria. The test sample contained 150 g/t silver, 18.7 % zinc, 1.03 % copper and 5.0 % lead. The purpose of the testwork was to examine a variety of leach systems and cementation agents and to indentify the optimum operating conditions for silver recovery from the material (Angelov et al., 2016a; Angelov et al., 2016b). Because of environmental concerns only non-cyanide lixiviants - thiourea and thiosulfate - were considered. The overall results of the testwork indicated that:

o   Of the two leach systems trialed the thiourea was found to be more feasible for the recovery of silver from the zinc cake residue;
o   Silver extraction over 94% was achieved using 10 g/l $CS(NH_2)_2$; 4 g/l Fe(III) as $Fe_2(SO_4)_3.9H_2O$; 0,5 g/l $Na_2S_2O_5$; pH=1; 40% solids, at 30°C in 20 minutes;
o   Iron was selected as cementation agent due to its high-performance efficiency and relatively low cost;
o   More than 90% of the silver was recovered from thiourea pregnant leach solution with iron powder at ambient temperature in 60 minutes.

Industrial Scale Testing Design

Following the successful laboratory testing that demonstrated viable process options for silver recovery from zinc cake residue, further laboratory testwork was carried out to provide essential data for the industrial testing design. The work, undertaken again at UMG's Central Laboratory of Raw Materials Processing and Waste Management was aimed at:

o   Assessing the influence of pH on leaching behavior of copper and iron, which are detrimental to both silver leaching and cementation;

    o   Defining the optimum operating conditions to allow high silver extraction, while suppressing the dissolution of copper and iron.

Two series of leach tests were conducted. The first explored the effect of pH, Eh and iron (III) on copper and iron dissolution and the second series was carried out to establish the reagent concentrations and its addition. First test series: A series of 4 tests were undertaken to assess the effect of pH on copper and iron dissolution. The parameters studied were pH and addition of iron (III). The test conditions are summarized in Table 1 and the test results in Table 2.

Table 1. First series test conditions

Parameter	Test 1	Test 2	Test 3	Test 4
Slurry density, %	20	20	20	20
pH	1.5	1.5	1.0	1.0
Fe (III), g/l	-	4	-	4
Temperature, °C	22	22	22	22
Time, min	45	45	45	45

Table 2. First series test results

Test №	pH	Eh, mV	Cu, g/l	Fe (III), g/l	Fe (II), g/l
1	1.45	248	0.051	0.28	-
2	1.42	251	0.057	4.31	-
3	1.10	270	0.060	0.30	-
4	1.10	278	0.063	4.33	-

The results indicate that lowering the pH (with or without the addition of iron (III)) leads to: 1) an increase of Eh; 2) a slight increase of copper concentration in the solution and 3) essentially no iron dissolution. Second test series: In order to clarify the conditions under which maximum silver extraction could be achieved, a further series of 6 tests were conducted. The tests were carried to optimize parameters such as leach time, the reagent concentrations and its addition. The thiourea remaining in the solution was determined at the end of each test to indicate its consumption. A summary of the test conditions is shown in Table 3, while metallurgical results are shown in Table 4 and in Figure 2.
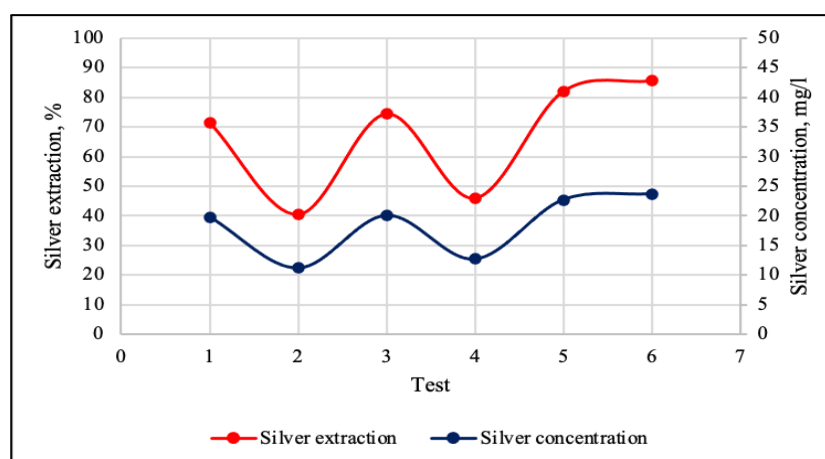
Figure 2. Second test series: silver extraction (%) and silver concentration (mg/l)

Table 3. Second series test conditions

Parameter	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Slurry density, %	20	20	20	20	20	20
pH	1.7	1.7	1.7	1.7	1.7	1.7
$CS(NH_2)_2$, g/l	10	5	6	6	6	6
Fe (III), g/l	4	4	2	-	2	1
$Na_2S_2O_5$, g/l	0.5	0.5	0.3	-	0.3	0.3
Temperature, °C	22	22	22	22	22	22
Time, min	45	45	45	45	30	30

Table 4. Second series test results

Test №	pH	Eh, mV	Cu, g/l	Fe (III), g/l	Fe (II), g/l	$CS(NH_2)_2$ (res.), g/l
1	1.71	239.2	0.080	0.65	3.49	4.4
2	1.74	237.6	0.077	2.34	2.05	0.2
3	1.73	228.2	0.083	0.48	1.90	3.3
4	1.70	241.8	0.063	0.06	0.22	3.7
5	1.72	240.1	0.072	0.23	2.06	2.7
6	1.70	236.4	0.067	0.11	1.17	3.0

The conclusions obtained from the results of the second test series are:

o The highest silver recovery of 85.6% was achieved at thiourea and iron (III) concentrations of 6 g/l and 1 g/l respectively, in the presence of $Na_2S_2O_5$ and with a leach time of 30 minutes as shown in Tables 3 and 4;
o Higher iron (III) concentration increases thiourea consumption significantly;
o The ratio of thiourea and iron (III) must be closely controlled;
o Shorter leach time is beneficial for silver extraction.

Based on the metallurgical results from testwork conducted, the following operating parameters were selected for the industrial scale testing:

o Leach slurry density - 20%
o pH – 1.7
o Thiourea concentration in the leach solution - 6-8 g/l
o Iron (III) concentration in the leach solution - 1 g/l
o Sodium metabisulfite concentration in the leach solution – 0.3 g/l
o Temperature - 35°C
o Leach time – 20, 25 and 35 min.

Industrial Scale Testing

Further to the laboratory testwork, an industrial testing was performed to address the following:

o Demonstrate the silver recovery process on a big scale;
o Confirm thiourea leaching process parameters and silver extraction;
o Confirm that the silver can be recovered as a metallic product by cementation.

Figure 3. Industrial testing facility, KCM 2000, Plovdiv, Bulgaria

The testing was conducted in the Installation for water/alkaline washing at the KCM 2000 production site in Plovdiv, Bulgaria. The test schedule included testing of the thiourea leaching process, followed by separate testing of silver cementation, both under a preferred set of conditions. The operating conditions are summarized in Table 5 and the specifications of the key equipment are listed in Table 6.

Table 5. Industrial testing operating conditions

Parameter	Тест 1.I	Тест 2.I	Тест 3.I
Thiourea Leaching			
Slurry density, %	20	20	20
pH	1.7	1.7	1.7
$CS(NH_2)_2$, g/l	6	8	6
Fe (III), g/l	1	1	1
$Na_2S_2O_5$, g/l	0.3	0.3	0.3
Temperature, °C	35	35	35
Leach time, min	20	35	25
Cementation			
Iron powder dosage, % excess stoichiometric requirement	110	110	110
Cementation time, min	90	90	90

Table 6. Industrial testing equipment specifications

Item	Characteristics	Number
Leach Reactor	Mechanically agitated; Capacity - 20 m^3	1
Cementation Reactor	Mechanically agitated; Capacity - 20 m^3	1
Filter press	Plate and frame type; Number of filter plates - 72; Filter plate size - 800 x 800 mm;	1
Filter press	Plate and frame type; Number of filter plates - 25; Filter plate size - 800 x 800 mm	1

For the industrial testing 3 separate bulk samples of prewashed zinc cake residue were prepared. Analyses of the prepared samples are presented in Table 7.

Table 7. Prewashed zinc cake residue analysis

Parameter	Тест 1.I	Тест 2.I	Тест 3.I
Silver, g/t	161	163	157
Gold, g/t	0.35	<0.3	<0.3
Zinc, %	18.6	18.1	18.3
Copper, %	1.36	1.38	1.5
Iron, %	30.85	32.03	32.95

Results and Discussion

Thiourea Leaching

Key variables investigated were thiourea concentration, thiourea to oxidant ratio and leach time. A series of 3 batch tests were carried out in 20 m^3 mechanically agitated leach reactor at 20% slurry density. The required reagents were added as a 50/50% split prior to and after zinc cake addition.

Table 8. Leach Residue Composition

Parameter	Тест 1.I	Тест 2.I	Тест 3.I
Silver, g/t	27	28	26
Gold, g/t	< 0.3	< 0.3	< 0.3
Zinc, %	18.45	18.25	18.2
Copper, %	1.39	1.35	1.35
Iron, %	33.3	32.3	33.6

Silver extractions over 80%, accomplished at 35°C, 20 – 35 minutes and pH=1.7, 6 - 8 g/l $CS(NH_2)_2$); 1 g/l Fe (III), 0.3 g/l $Na_2S_2O_5$, indicated fast leach kinetics. No significant dissolution of copper and iron was observed. The composition of leach residue and silver extractions are presented in Table 8 and Table 9.

Table 9. Silver extraction

Test	Silver content in leach residue, g/t	Silver extraction, %
Тест 1.I	27	83.2
Тест 2.I	28	82.8
Тест 3.I	26	83.4

Silver Cementation

A series of 3 batch cementation tests were carried out for 90 minutes in 20 m³ mechanically agitated cementation reactor using freshly produced silver-containing thiourea leach solution and iron powder. The amount of zinc powder used in each test was estimated based on the silver, copper and iron concentrations. The iron powder was added upfront with 110% excess than stoichiometric requirement. The silver cementation process efficiencies for Test 1.I, Test 2.I and Test 3.I were 93.4%, 94.6% and 94.8%, respectively. The data in Table 10 shows that cementation process generated a cement product containing up to 7.8% of silver. The cement silver normally contains unreacted iron and co-cemented gold, copper and zinc.

Table 10. Silver cement product composition

Parameter	Тест 1.I	Тест 2.I	Тест 3.I
Silver, %	4.085	7.82	4.95
Gold, g/t	34.8	NA	53.4
Zinc, %	2.04	4.4	7.95
Copper, %	12.35	25.45	27.8
Iron, %	3.13	12.25	14.3

Tests Results Evaluation

Key data and results from the industrial scale testing are discussed in detail below:

Thiourea Leaching

- o Silver extractions obtained in Test 1.I, Test 2.I and Test 3.I were 83.2%, 82.8% and 83.4%, respectively. The repeatability of the results indicates that the operating conditions of the thiourea leaching are properly selected;
- o Maximum silver extraction of 83.4% was achieved using 6 g/l $CS(NH_2)_2$, 1 g/l Fe (III), 0.3 g/l $Na_2S_2O_5$, pH=1.7, 20% solids at 35°C in 25 minutes;
- o Silver extraction is consistent with the results from batch leach tests;
- o Optimum operating conditions:

  - pH of 1.7: The rate of silver dissolution is strongly dependent on pH value. Maintaining this pH limits the oxidative degradation of thiourea and consequently the passivation of the silver surfaces with fine adhesive elemental sulfur, excessive copper dissolution and possible silver-thiourea complex formation (Pesic & Seal, 1990).
  - Thiourea concentration - 6 g/l: An increase in thiourea concentration decreased the efficiency of silver extraction and increased thiourea consumption.
  - Iron (III) concentration - 1 g/l: There is an optimum amount of oxidant that can be used depending mainly on the material being leached. Excess iron (III) although beneficial in slowing thiourea oxidation decreased the efficiency of silver extraction and increased both thiourea consumption and copper dissolution from the material (Pyper & Hendrix, 1981). In addition, higher iron (III) concentration negatively affects cementation process performance. During the process iron (III) is reduced to iron (II) that leads to (1) an increase in the iron powder consumption (Gupta & Mukherjee, 1990) and 2) possible re-dissolution of the cement product due to increased ferrous ions concentration.

- Sodium metabisulfite concentration – 0.3 g/l: Addition of sodium metabisulfite to the leach slurry to control the redox potential decreased thiourea consumption.
- Leach time - 35 minutes: Leach times in excess of 35 min could lead to extraction and recovery problems that may be attributed to adsorption and reaction of silver with other mineral phases present in the material.
- Temperature - 35°C: An increase in leach temperature leads to an unmanageable decomposition of thiourea.
- Reagents addition - 50/50% split prior to and after zinc cake addition. This type of reagents addition increased the efficiency of silver extraction and decreased thiourea consumption and losses in silver during the leaching.

Silver Cementation

o Silver recovery from the acidic thiourea solution by cementation with iron powder is a high complexity process mainly due to (1) concentrated solution matrix, including thiourea, acid and various salt species, and (2) presence of some base metals co-leached with the silver.
o Efficiency of silver cementation process is in the range of 93.4-94.8%.
o Optimum operating conditions:

- Cementation time - 90 minutes: Prolonged cementation time could possibly result in the re-dissolution of the cemented silver due to the increased concentration of ferrous ions, which are formed during the process.
- Iron powder dosage - 110 % excess stoichiometric requirement. Theoretically, the silver cementation process requires one mole of iron for every two mols of silver in solution. However, due to side reactions as a result of acid and other species present in the solution, much more iron powder is required.

Silver Cement Product:

o Product composition: The average metal composition of the silver-bearing cement is approximately 4-8% Ag, 35-53 g/t Au, 12-28% Cu, up to 14% Fe and 8% Zn. The presence of more copper, zinc and iron in the product is due the use of excess than stoichiometric amounts of iron powder in the cementation process.
o Product further processing: The silver-bearing cement could be melted and cast into impure Dore bars and then refined and purified.

Process Performance

Silver recovery process performance at an industrial scale with silver extraction efficiency and reagents consumption is summarized in Table 11.

Table 11. Silver recovery process performance

Parameter	Unit	Value	Comment
Silver leaching extraction	%	83.1	Average of the three tests performed
Silver cementation efficiency	%	94.3	Average of the three tests performed
Overall silver recovery	%	78.4	Average of the three tests performed
Reagent consumption			
Thiourea	kg/t	23.5	To achieve thiourea concentration in the leach solution of 6 g/l
Ferric sulfate (as an Iron (III) source)	kg/t	25.3	To achieve iron (III) concentration in the leach solution of 1 g/l
Sulfuric acid	kg/t	14-26	To achieve and maintain pH of 1.7
Sodium metabisulfite	kg/t	1.2	
Iron powder	%	~110	The iron powder excess is needed for the silver cementation and side reactions

The table shows a silver extraction in thiourea leaching of 83.1% with silver cementation efficiency of 94.3%, yielding an overall process recovery of 78.4%. Further optimization of the process chemistry is required during larger scale testing to avoid excessive reagent consumption consistent with high silver extraction from the feed material.

Conclusion

In this work a silver recovery process was tested and evaluated at an industrial scale to demonstrate the optimal flowsheet and to generate the data needed to define process design criteria for construction of a commercial plant for treating silver-bearing zinc cake residue. The zinc cake residue responded favorably to thiourea leaching with silver extraction of over 80%. The optimal conditions in the leach stage were pH=1.7, 6 g/l $CS(NH_2)_2$); 1 g/l Fe (III) as $Fe_2(SO_4)_3.9H_2O$; 0.3 g/l $Na_2S_2O_5$, a temperature of 35°C and an approximately 35-minute leach time. The pregnant leach solution also proved to be amenable to the subsequent silver cementation using iron powder. Dissolved silver was successfully recovered to a cement product with acceptable purity in the batch cementation process. Greater than 94% of silver contained in the leach solution was cemented.

Although there is much left to do, this work demonstrated a technically feasible process for treatment of silver-bearing materials and provided essential data to be used for a further scale-up. The silver recovery process highlights can be summarized as follows:

- o Direct recovery of silver from thiourea leach solution as a high quality, high value product.
- o Simplified process flowsheet to save capital and operating cost.
- o All reagents are commercially available and in reasonable price.
- o The process can be readily coupled with zinc crystallization and electrowinning to obtain different zinc products.

Scientific Ethics Declaration

The author declares that he is solely responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements

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To cite this article:

Angelov, T. (2022). Industrial scale testing and evaluation of silver recovery process. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 19,* 68-77.

Ransomware Target: Linux. Recover Linux Data Arrays after Ransomware Attack.

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Abstract: The events of the previous two years have forced many businesses from many industries to fast transition to remote work mode. Most organizations were unprepared for this new method of working, and many IT professionals first risked the security of the infrastructures they supported. As a result, ransomware developers found a way to resume development of one for the second most popular operating system – Linux, which is dominant in server infrastructures. Attacks up to now have tended to concentrate more on the end user, whereas ransomware developers now target the core of the organization, allowing for greater ransom demands to recover the data. Along with these, there have been increasing reports of new cryptoviruses for Linux in recent months. This concept is not new in 2015, the first ransomware for Linux was disclosed. The paper examines the evolution of cryptoviruses in Linux and demonstrates how to utilize a private cloud to recover data arrays after a ransomware infection in Linux.

Keywords: Ransomeware, Cyber security, Private cloud, Cryptovirus, Linux

Introduction

The situation with the Covid-19 pandemic, which occurred at the beginning of 2020, faced many business sectors with serious challenges. One of the serious challenges that most businesses have had to face is the rapid switch to remote working mode. Business, media, social interaction, education, etc. move onto platforms on the Internet. As a result, the amount and importance of information flowing through the digital landscape has increased exponentially (Sushruth et al., 2021). An increase with nearly 165 percent is the grow over the past five years, average bandwidth consumption (OpenVault, 2021). This has led to serious vulnerabilities in the cyber security of infrastructures and given a serious field for cyber criminals to appear. Proof of this is the serious increase in cyberattacks after the announcement of the pandemic, announced in numerous studies done in the field (Lallie et al., 2021).

The ransomware attacks mainly encrypts data from MS Windows, but is gradually spreading to machines with Linux-based operating systems as well. It demands a ransom from the user to decrypt the files, otherwise the hackers threaten to make the data public. This attack mostly uses infected email attachments or malicious websites. When it is compromised, companies fail to pay for the secret decryption key and therefore attackers can leak the stolen data. This trend has made it possible for cybercriminals to negotiate with victims, leading to extortionate data breaches (Tawalbeh et al., 2020).

The research describes an infection of Linux based machine with crypto-ransomware and proposes a method for data recovery after that. The study is organized as follows. First, we look at the vulnerabilities that are revealed

after the switch to remote working mode, as a result of which cyberattacks against users have increased tremendously. The next part is devoted to the main types of ransomware. The infection of the Linux-based machine and the recovery of the files are described in the last two sections.

Ignoring Cybersecurity by Organizations during Covid-19

Nowadays, the data that is stored online in an organization grows exponentially, and the financial value of the stored information repeatedly exceeds the one of the equipment which is needed for its storage (Hristev et al., 2021). The need to switch to remote working mode, due to the Covid-19 pandemic, has repeatedly accelerated the digitalization process in all sectors of the economy at a high pace. This has led many organizations to quickly change their established way of working, in remote working mode, as a significant part of them initially made compromises regarding the security of the infrastructure and the data stored in it.

The Zscaler's research: VPN Risk Report 2022 (Schulze, 2022) which was conducted among 351 IT professionals, shows that 95% of companies use VPNs for secure access to data stored in IT infrastructures, the share is increasing by 2% over the past year. A reference to Zero Day Exploits in CVE shows that since 1999, there have been 606 VPN-related vulnerabilities reported, with 34% of them whist is 206 as number have been announced since the beginning of the pandemic. For the second most common operating system – Linux, the values look similar, with 6,544 vulnerabilities announced since 1999 of which 1,400, or nearly 22% of all have been announced since the beginning of the pandemic.

The data shows that the process of digitization and the switching to remote working mode causes malware developers to focus more and more efforts on discovering vulnerabilities that they can use to compromise the integrity of data stored in IT infrastructures. 78% of the professionals who participated the Zscaler study are worried about ransomware attacks. Currently the data stored in the infrastructures does not use enough sufficiently protected methods. The most of specialists rely on the standard method of data protection - backup, which is not flexible enough. With an incorrect security policy and a successful ransomware attack, the backup also can be encrypted or the data from the last backup up to the time of infection can be lost. Many sources point to the 3-2-1 backup technique as the most successful. It includes:

- 3 archives;
- 2 different media;
- 1 different location.

Only about 31% of ransomware attacks are stopped before they encrypt part or all of the data. According to Sophos's research, The State of Ransomware in Retail 2022 (Sophos, 2022), the survey of 5,600 IT professionals from 31 countries around the world, 73% of businesses are dealing with the problem using backups, and 49% have had to pay back to the attacking organization. This means that not everyone who relies on backups was able to recover enough information and some of them had to pay a ransom for their data. Paying the ransom also does not guarantee data recovery, with only 5% of organizations claiming to have fully recovered their data.

After the appearance and popularization of RaaS (Ransomware as a Service), the number of attacks with crypto-ransomware has increased many times, and only in July this year, attacks against various organizations have increased by more than 40% compared to the previous month of the same year.

During the pandemic, many companies dramatically increased their enterprise IT budgets. There is a trend for small and medium-sized companies to invest more and more in technology, rather than security. Despite the fall of epidemic measures, a large number of companies adhere to and continue their development for a remote workplace to reduce costs. Securing computing equipment for employees working from home and connecting them to the work environment through a VPN tunnel is not enough to create a secure environment. As a result of the statistics from the various sources, we can conclude that the data stored in the organizations are vulnerable.

Undeniably a larger percentage of PCs run Windows, their users are undoubtedly a more common target for Ransomware attacks. As a result, the number of crypto-ransomware for Windows is significantly higher compared to Linux, but this is not a guarantee of security. Attempts for Ransomware attacks on the Linux operating system are not new. The first malicious crypto code for Linux appeared in late 2015 and was named Linux.Encoder. The main difference is that while Windows crypto-ransomware mainly look for user files, Linux

ones look to affect other types of files like .html, php, sql, java, class, etc. Thus, using the "double extortion" tactic, where a ransom is demanded in addition to decrypting the files, and not to publicly distribute the information that the malware developers have accessed, makes Linux users doubly vulnerable.

In one of our previous research (Hristev et al., 2022) we demonstrated the possibility of data recovery after Windows has been infected with Ransomware using a private cloud. The focus of the present study is on examining the possibilities of file recovery after infection of a Linux operating system with a crypto-ransomware.

The ability to recover data after a ransomware attack does not exclude the use of an alternative data storage option and does not negate the need to implement a backup policy. However, we must be careful and implement proper security policies due to the fact that our data can be put at risk by becoming public.

Ransomware Types

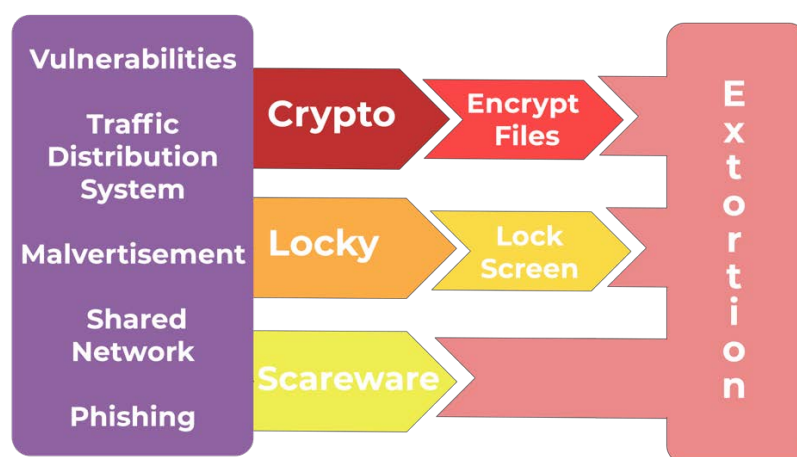There are basically three different types of ransomware as shown in the Figure 1.

Figure 1. Ransomware types

The first type of ransomware is called crypto-ransomware. This type of ransomware is considered very dangerous because it encrypts the victim's files, making them impossible to access without a valid decryption key. We classify crypto-ransomware as malware that demands a sum of money after limiting a user's ability to access their computer or files. The most often method used by crypto-ransomware to contact its victims is through files or links that are distributed in email message campaigns, called Phishing. The email message contains links to documents that have been saved online. The documents are executable programs. The emails have attachments that download crypto-ransomware to the device. Common file formats used to deliver crypto-ransomware include the following files: Microsoft Word (.doc or .docx), Microsoft XSL (.xsl or .xslx), XML document (.xml or .xslx), Archive folder, containing a JavaScript file (.zip file containing a .js file), Multiple file extensions (eg <PRINT#2106>.pdf.js).

Other often method used by crypto-ransomware to reach victims is malvertisement. This tactic direct the victim to a website hosting an exploit kit appearing on real websites. Also crypto-ransomware can be spreaded on the affected system, attacking any devices and computers on a shared network. Another well known practice is redirecting website traffic to a website that hosts an exploit kit that exposes the computer's weaknesses and the ransomware is installed with auto-download malware. These practices can be used by all three types ransomware that we consider.

Receiving of the email with the crypto-ransomware does not cause infection. User must download or open the attached or linked file. If the opened file is JavaScript, it will try to download and install the crypto-ransomware itself from a remote website or server. If the attached file is a Microsoft Word or Excel document, malicious code such as a macro is embedded in the file. Even if the user opens this file, the macro can only run if the macros are enabled in Word or Excel or user enables macros.

The attack starts after the malicious email attachment is downloaded and a ZIP file disguised as a PDF automatically launches and downloads the ransomware. It will be saved with a random name as a file in the root file system with the user's other applications. Once activated, the ransomware first establishes a connection to the attacker's control server. After connecting to an active server, the ransomware initiates a key exchange protocol using an encrypted public key. Requests and responses between the malware and the server are made using RSA encrypted HTTP POST commands. The ransomware already contains the server's 2048-bit RSA public key when it is downloaded. It uses this public key to encrypt a request for a unique for the machine encryption key which will be used later. Along with this request, the ransomware sends information about the machine it is running on. The information that is sent includes the malware version, system language, and a numeric identifier. After the server decrypts this message with its own 2048-bit RSA secret key, the server generates a key response. The response includes the victim's IP address and a unique RSA public key. Only then does encryption begin.

The malware starts looking for specific file types in directories and mapped network drives. There is a complex encryption process for every matching file found. First, the malware generates a new 256-bit key that uses AES (Advanced Encryption Standard) file encryption. AES is an encryption system using a symmetric key. The symmetric key encrypts much faster than 2048-bit RSA. The AES key is used to encrypt the contents of the files. Instead of storing the key somewhere else, the ransomware encrypts the AES key using the unique RSA public key obtained during the key exchange. Each RSA encrypted AES key as well as the AES encrypted file contents are written back to the file. The infected user must obtain the secret RSA key that corresponds to the user's unique private key to decrypt the contents of the file. Brute force decryption of the files without a decryptor is impossible due to the 2048-bit RSA encryption. After the payment with cryptocurrency is confirmed, the Ransomware Server searches for the corresponding secret key. It is unknown exactly how this process works, but it is clear that the server stores some information about the user's unique identifier and their public key in order to find the secret key. An automatic decryptor, which already contains the secret key is sent to the infected user by the server. The RSA secret key is used to decrypt the AES key stored in the file for every single file. The decrypted AES key is then used to decrypt the contents of the file. The decryptor automates this process for the infected system. The decryption process may take hours depending on the number of files in the system.

The crypto-ransomware displays a message containing the ransom demand once the encryption is complete. The amount varies depending on the particular ransomware, and payment is often only in Bitcoin or a similar digital cryptocurrency. The victim will receive the decryption key if choose to pay the ransom, although this is not guaranteed. And even if a decryption key is obtained, it is not guaranteed that it will work.

The second type of ransomware is called locker-ransomware. This type of ransomware locks the victim's system and displays a login page. The victim must pay a ransom to receive a password to unlock the system. Locker-ransomware is considered less dangerous because the attack can often be resolved by restarting the system in safe mode, followed by running anti-virus software.

Typically, a locked system allows only limited access, forcing the victim to interact only with the initiator of the attack. Keyboard sections may be locked or the mouse may be frozen, effectively only allowing the victim to respond to the ransomware's demands. Locker-ransomware usually does not penetrate the entire computer network and does not attack the files in the computer. This aspect makes it easier to find this type of ransomware and remove it without paying the ransom.

Locker-ransomware uses non-encrypting malware to lock the infected machine, whereas encryption ransomware uses encryption to lock the infected computer or device. As with crypto-ransomware, there is no guarantee that access to the computer or device will be restored after paying the ransom, even if the pop-up message says it will. On the contrary, many business owners who pay the ransom never get back access to their computer or device.

The third type, which does not carry such a danger compared to the discussed ones, is called scareware. This type of ransomware poses no real danger to its victim. Its main function is to scare the victim into paying the ransom. The cyberattack tactic of scareware ransomware is to scare people into visiting fake or infected websites or downloading malware. Scareware can take the form of pop-up ads that appear on a user's computer or spread through spam email attacks.

A scareware attack is often launched by pop-ups that appear on the user's screen, warning them that their computer or files are infected and then offering a "solution of the problem". This social engineering tactic is

intended to scare people into paying for software that supposedly provides a quick fix of the problem. However, instead of fixing a problem, scareware actually contains malware programmed to steal a user's personal data from their device. Scareware can also be spread through spam emails, through messages that trick people into buying useless items or services.

As the Linux operating system becomes more popular and more businesses than ever run on Linux now, Linux-oriented ransomware attacks are increasingly attacking Linux users and accumulating exorbitant profits. The Erebus ransomware affected about 3,400 of NAYANA's customers through advertisements containing malware. The Lilocked ransomware targeted Linux servers and gained root access to encrypt files with extensions like .php, .html, .css, etc. Victims were directed to the dark web to make a payment in Bitcoins to recover their files. Linux-targeted ransomware compared to ransomware targeting the Microsoft Windows operating system has not had a major impact on enterprises and individual users till soon. However, this situation is changing as ransomware producers are always driven by profits. It is inevitable that more companies and people in the industry will use Linux systems due to their security, stability, and open source, which will tremendously lead to the generation of a lot of ransomware targeting the Linux operating system. Due to the fact that crypto-ransomware are classified as the most dangerous of the three main types and the popularity of Linux as an operating system, the object of our research is to describe and prove an approach to recover files after GonnaCry infection in a Linux distribution of Debian is version 11.

Infecting Linux Based Machine with Crypto-Ransomware and Restoring User Files

Infection with crypto-ransomware is accomplished through a simple initial vector attack. We already discussed that the most widespread method for this is through phishing emails, you bet on the ignorance of the user, and mostly these attacks are aimed to users with Windows-based systems which are used significantly more for workstations. Analysis shows that for the Linux operating system, infections occur most often through old system vulnerabilities, key gaps in the provided services that make it easier to access and compromise the target system.

The simple example with GonnaCry Rasomware shows all the necessary characteristics for the effective execution and mass distribution of a piece of malicious code:

- Low memory consumption to avoid encryption overhead. This way, the user will find out that he has become a victim of an attack as late as possible.
- Ability to restore files only with the private key from the control server.
- Distribution and self-recovery plan when the encryption process of the target files stops.

The first stage of the attack is the analysis, which includes indexing all accessible files and trying to spread them, both locally on the already compromised machine and also on the local network. The major priority has the user files and the backups. Figure 2 illustrates the synchronization of user files with the cloud folder, in order to prove the proposed method for data recovery. Replication of the virus occurs at two levels, the first is local to the compromised machine, while at the same time the network is scanned for vulnerabilities through which the virus can penetrate other workstations in the organization.

After the analysis and compromise part of the maximum number of workstations is completed, encryption follows using a symmetric file encryption algorithm. For this purpose, GonnaCry uses an AES cipher, due to its high speed and efficiency. For each of the resources targeted by the attack, a public key, a private key and the location of the file to be encrypted are recorded. This list with information about the encrypted files is used to decrypt them when the ransom is paid. Once the file encryption process reaches a certain stage, depending on the virus that has penetrated the system, the original copies of the files are deleted. NextCloud support double delete functionality where deleted files are moved to "Deleted files" (Figure 3). To be deleted from the server, they must be deleted from there as well, and can be restored from the same place.

The file may be overwritten with zeros and then deleted depending on the crypto-ransomware. This action aims to avoid the possibility of data recovery with deep scan software for deleted files. Even if the file is not overwritten with zero, these types of software are not effective because of the large amount of data that is overwritten on the hard disk. In this situation, after restoring the file from "Deleted files", a previous version will need to be restored for each file.
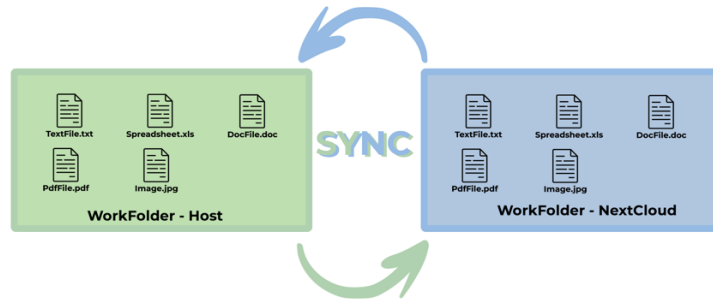
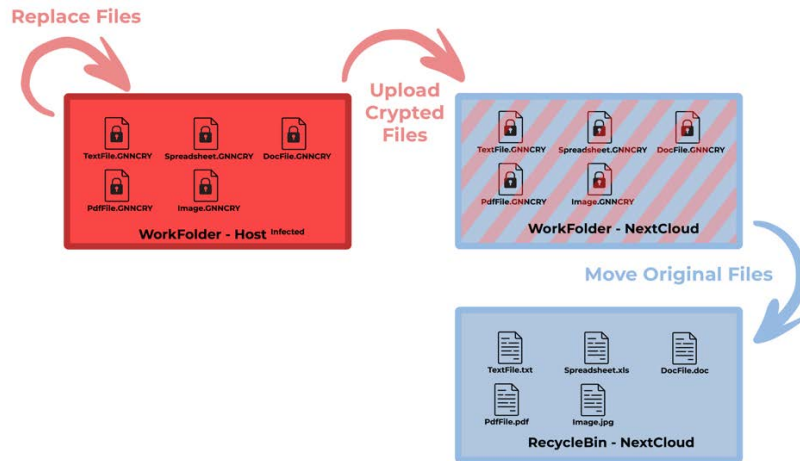Figure 2. Synchronizing local folder with cloud folder

Figure 3. Upload process of the corrupted data to the cloud.

The final stage is when all files are encrypted and the file list contains the decryption data for each compromised file. This list is encrypted using the RSA algorithm for higher security and eliminating the possibility of decrypting the file itself. A file with the public key, as well as information about the requested ransom is shown to the user. Thanks to the public key, if the ransom is paid, a private key is obtained, which is kept by the attacking organization. The public key information and ransom payment instructions are usually in one of the following or similar files: READ_IT.txt, READ_ME.txt, info.txt, info.html, More.html, recover.txt, README.HTML, wallpaper. jpg, start.txt, Instructions.html, DECRYPTION.txt, ReadMe.txt, w.jpg, READ_ME.TXT, motd.txt, desk.jpg and others. Paying the ransom does not guarantee the receiving of a private key, nor does it guarantee the recovery of all data. The following figure (Figure 4) shows infected user files on the attacked machine.
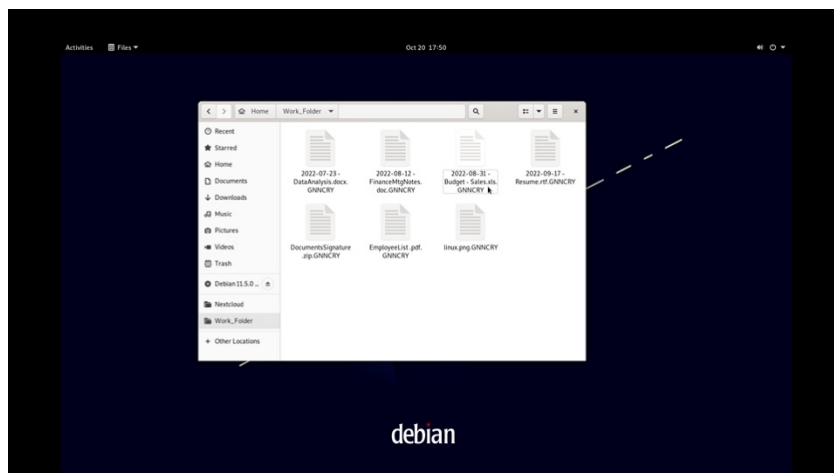

Figure 4. Corrupted files

Before proceeding to recovery, it is recommended to clean the infected device and then recover the deleted files, using NextCloud WEB from "Deleted Files" and restore previous versions for each file if it is necessary (Figure 6). The process is illustrated in Figure 5.
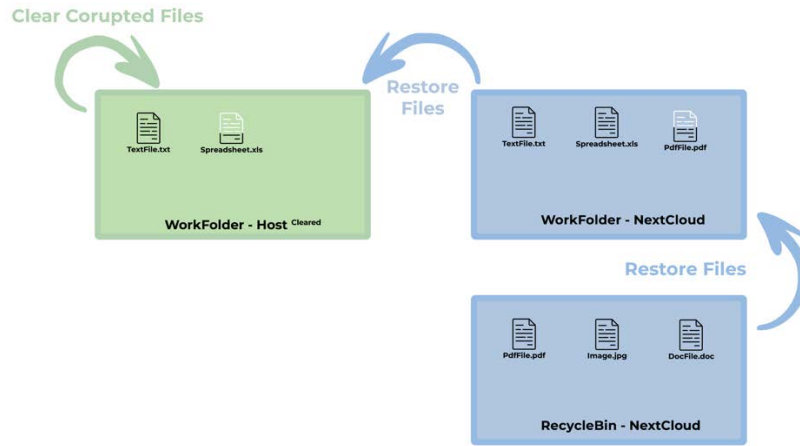
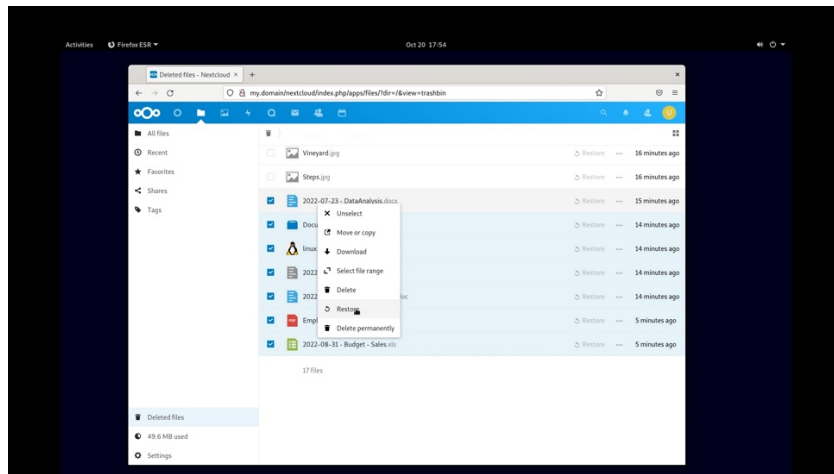Figure 5. Process of deleted data recovery from the cloud

Figure 6. NextCloud deleted files

Describing a Method for Data Recovery

The method we used to recover the files after infecting a Debian Linux operating system machine with GonnaCry crypto-ransomware is the same as shown in previous research (Hristev et al., 2022) in which we prove the possibility of recovering encrypted files with CERBER in Windows operating system crypto-ransomware system using NextCloud. As a result of the two studies, we can conclude that the described method works for Windows and Linux workstations after being infected with crypto-ransomware and we can recover user data as follows:

1.   Identifying the compromised departments in the infrastructure – First, it is necessary to discover how many workstations in the infrastructure have been compromised and infected with crypto-ransomware. Usually, it is one or a group of computers from a specific department, depending on the attack. There is a possibility that infected computers can be in more than one department.

2.   Isolation of Compromised Devices - Once infected computers have been identified they must be isolated. Skipping this step would introduce a loop in the method because after recovering the files through the private cloud, the compromised devices would re-encrypt the recovered files.

3.   Identifying and analyzing the breach - It is recommended to analyze how the crypto-ransomware penetrated the IT infrastructure and if it is possible establish policies and rules to limit the possibility of re-infection in the future.

4.   Cleaning a Compromised Devices - Compromised devices should be cleaned of the crypto-ransomware. Companies that develop anti-virus software are pouring more and more funds into updates to clean computer systems of such threats. Once the virus is identified, we can check the internet for products that can

detect the infection and clear it. If we can't find a tool to fix the problem, there is always the option of reinstalling the infected machines.

5.   Recovering of the files - Depending on the type of crypto-ransomware we are infected with, the NextCloud network offers two built-in options through which we can recover the files.

Most crypto-ransomwares, including GonnaCry for Linux based operating system and CERBER for Windows based operating system encrypt entire files by deleting the original copies of the files. In this situation, the data can be recovered thanks to the double deletion approach. Every deleted file is moved to the "Deleted files" in order to delete a file from the server, it must also be deleted from the recycle bin itself, and only then will it cease to exist.

If the attacking crypto-ransomware overwritten the file with zeros , we can restore it through Versioning Control of the private cloud. In this situation we need to restore each file to its previous version. Depending on the encryption algorithm that is used by the infected virus, an important feature is that the encrypted file is larger than the original one. In the general case, the encrypted file is about 30% larger than the uncompromised data. I.e. to ensure the safe storage of 100 GB of data, NextCloud must have more than 230 GB of free space. Thus, the first 100GB will be used to store the files before the encryption and the other 130GB will be for the encrypted files. We can install a Ransomware protection add-on on the NextCloud server. The add-on will not protect us from being infected with crypto-ransomware, but it will prevent uploading on the server encrypted files. The plugin tracks file extensions that users upload to the server. When we are using the add-on we must always keep it updated to the latest versions. Some of the crypto-ransomware extensions are not described by default and in this situation, the NextCloud server administrator needs to maintain the extensions manually. As new crypto-ransomware are constantly emerging which rename infected files with different extensions this is a difficult task (Hristev et al., 2022) and (Hristev et al., 2021).

When NextCloud works with shared files, it does not matter who is the owner of the original file. The deleted file must be searched for in the recycle bin of the user who deleted it or in the users that the compromised computers work with on the network.

6.   Deleting the files created by the crypto-ransomware - The last step that needs to be done before going back to normal operation mode is to delete the files that were encrypted by the crypto-ransomware. Encrypted files must be deleted from the directories and also must be deleted from Deleted files to cease to exist on the server.

Conclusion

The challenges facing consumers and industry in the 21st century as a result of the declaration of a pandemic bring with it even more difficulties than we can imagine. The situation gave cybercriminals the green light. More than 7 years after the first ransomware for Linux was disclosed, now machines with Linux-based operating systems became more and more attractive to cyber criminals. More massive attacks occurred targeting Linux appear recently. Every day, many users become victims to crypto-ransomware attacks more than ever. The study gives a method for data recovery on Linux-based operating system machine with Debian version 11 distribution after user files infection with crypto-ransomware. The user's data is stored on the private cloud and synchronized with a controlled workstation that is infected with GonnaCry. It is proved that the proposed approach can be used successfully for recovering data after crypto-ransomware attack.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements

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To cite this article:

Developing Music Recommendation System by Integrating an MGC with Deep Learning Techniques

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Abstract: In the modern scenario, everyone uses the internet to find music, movies, products, services and other commodities on a regular basis to make their lives easier. Because of a lot of data on millions of music, movie, products and services on websites, we need a recommender system very much to assist people in making decisions more quickly and easily. In this research study, we have developed an intelligent music recommendation system by integrating a Music Genre Classification (MGC) with different types of Deep Learning Techniques such as RNN-LSTM, GRU and CNN. We have used the GTZAN Genre dataset to training our system. We have extracted the features from GTZAN dataset by the help of Mel Frequency Cepstral Coefficients (MFCCs) then pass the MFCCs into our deep learning networks. After classifying the appropriate music genre, recommended the music from particular genre from the labelled database which has been classified by our system. From our proposed models the GRU, CNN and RNN-LSTM produced about 71%, 72% and 74% respectively in our testing accuracy. The RNN-LSTM has achieved the best accuracy result (74%) among all of our proposed models.

Keywords: Music recommendation system, MFCCs, CNN, GRU, RNN-LSTM

Introduction

With the widespread use of the internet, the music industry has seen tremendous change due to the internet, along with other types of development. Due to the development of music streaming services, consumers can now listen to music anytime, anywhere, and through a variety of platforms like Spotify, YouTube, Soundcloud, and many others. A major amount of the world's population now regularly downloads and buys music through online music stores. Users frequently categorize their tastes by genre, such as rock, metal, blues, hip hop, pop, or disco etc. But the majority of the songs that are now accessible are not automatically classified into genre. These systems are primarily focused on the classification of music genres for the purposes of mining music listening and music tagging, music recommendations to boost sales profits, and music copyright management for writers. Particularly through music streaming and broadcasting services like Spotify, last FM, Fizzy, etc., consumers have access to millions of songs at any time, from anywhere. Music Genre classification is crucial for organizing, searching, retrieving, and recommending music due to the huge amount of current collections.

Due to the gradual reduction in the complexity of music production in recent years, a large number of people now produce music and upload it to streaming services. People now spend a lot of time searching for particular music because of the massive music streaming industry. So, the ability to quickly classify musical genres is crucial in today's society. So, we want to build a Music Genre Classification System (MGCS) and its recommendation system so the music mining music listening and music tagging, music recommendations to boost sales profits, and music copyright management for writers.

So far, several researchers have built variety of Music Recommendation Systems in a variety of approaches. We are now going to discuss some of the researches about Music Recommendation System. An automated machine learning model that recommends potential candidate's resumes to the HR department based on the provided job description has been proposed by Roy et al. (2020). The suggested approach operated in two stages: first, it divided the resumes into various groups. Second, it suggests resumes based on how well their contents match the job description. The suggested method accurately captured resume insights and their semantics, and it produced a Linear SVM classifier accuracy of 78.53 % (Roy et al., 2020). Phaneendra et al. (2022) present a similarity metric that is simply based on raw audio content. Using this metric, songs that are similar to the user's collection are then recommended. A Siamese Neural Network (SNN) was trained on a dataset of similar and dissimilar song pairs to produce the similarity metric. To create a bitmap representation of each song, a Mel-Spectrogram was initially created. The Mel-Spectrogram bitmap of each song pair is sent to two identical CNNs that make up the SNN. The SNN gains the ability to function as a similarity metric between songs based on the raw audio information by being trained on this dataset of song picture pairs (Phaneendra et al., 2022). Using convolutional neural networks (CNN) as the foundation, Chang et al. (2018) offer the PMRS, or customized music recommendation system. The CNN method divides music into several genres based on the audio signal rhythms. The output of the CNN and the log files are combined in PMRS to create a collaborative filtering (CF) recommendation system that suggests music to the user. The history of each user who uses the PMRS is recorded in the log file. From the log file, the PMRS extracts the user's history and provides genre-specific music recommendations. They assess the PMRS using the million-song dataset (MSD). They created a mobile application to demonstrate how the PMRS functions (an Android version). To evaluate the effectiveness of the PMRS, they used the confidence score metrics for various musical genres(Chang et al., 2018). By examining the history records of user tracks in the data sets, Wang et al. (2018) technique RTCF (Tag-driven Collaborative Filtering Recommendation System) authors created a fair scoring system for users based on the training statistical language model (Good-Turing Estimate). Furthermore, they discovered that each tag has a linked count when describing a song or an artist, meaning that various tags can define the tracks and the artist's attributes to differing degrees. The tags work in conjunction with their analysis of each user's listening history to not only widen the music's content but also create individualized music recommendations for each user (Wang et al., 2018). A method for making branching playlists that allow music recommendations based on listener preferences is proposed. They discovered that branching playlists raised listeners' levels of contentment, familiarity, and interest by analyzing the method's efficacy. They also put the suggested technique into practice by implementing "reco.mu," a web-based music recommendation system. They discovered that while making a branching playlist, the creator is more aware of the recommender (Nonaka & Nakamura, 2021).

The key challenge is to recommend any things to users that they will enjoy and grade highly to match their expectations. Many researchers process of a recommender system makes use of data mining techniques like clustering to group related items together in order to find similarities between them when we choose an item as the centroid of the cluster or a user as the centroid of the cluster, as well as association rules to find hidden patterns and uncover new connections between products in order to boost sales as part of e-commerce. There are various methods used by recommender systems:

a) Content-based filtering: this type of filtering relies on examining the textual data's content and identifying patterns in the specifications of the items.
b) Collaborative filtering techniques: Depending on how similarly users rate products on the site, additional users may be recommended to like the person.
c) Hybrid collaborative filtering combines content-based filtering and collaborative filtering in order to maximize benefits and produce the best recommended items.

When Music Genre Classification (MGC) comes to human-machine interaction, it becomes a major topic. Due to the selection and extraction of appropriate audio elements, classifying music is considered as a very difficult process. While unlabeled data is readily available music tracks with appropriate genre tags is very less. Feature extraction and categorization are the two fundamental phases in the classification of musical genres. At 1st stage, the waveform is initially processed to extract various features. At 2nd stage, the features generated from the training data are used to construct a classifier. The features to be extracted from the music have been determined as zero crossing rate, spectral centroid, spectral contrast, spectral bandwidth, spectral rolloff and Mel-frequency Cepstral Coefficients-MFCC.

In this research study, it is aimed to develop an Intelligent Music Recommendation system by integrating a Music Genre Classification (MGC) with different types of Deep Learning Techniques such as RNN-LSTM (Recurrent Neural Networks-Long-Short Term Memory), GRU (Gated Recurrent Unit) & CNN (Convolutional

Neural Network) and we will also compare the experimental results for each of these from our experimentation. We are using the GTZAN Genre Dataset training our system based on genres.

Literature Review

An automated machine learning model that recommends potential candidate's resumes to the HR department based on the provided job description has been proposed by Roy et al. (2020). The suggested approach operated in two stages: first, it divided the resumes into various groups. Second, it suggests resumes based on how well their contents match the job description. The suggested method accurately captured resume insights and their semantics, and it produced a Linear SVM classifier accuracy of 78.53 %. Utilizing deep learning models such as Convolutional Neural Network, Recurrent Neural Network, Long-Short Term Memory, and others may improve the performance of the model. The proposed approach can be used to create an industry-specific model if a large number of resumes are provided by the industry. A more accurate model might be created by including domain experts like HR professionals, and the HR professional's feedback could then be used to iteratively enhance the model (Roy et al., 2020).

This study solves the problem of recommending new songs and artists by basing recommendations entirely on the audio content rather than extraneous metadata like the artist or genre or user listening histories. The authors Phaneendra et al. (2022) present a similarity metric that is simply based on raw audio content. Using this metric, songs that are similar to the user's collection are then recommended. A Siamese Neural Network (SNN) was trained on a dataset of similar and dissimilar song pairs to produce the similarity metric. To create a bitmap representation of each song, a Mel-Spectrogram was initially created. The Mel-Spectrogram bitmap of each song pair is sent to two identical CNNs that make up the SNN. The SNN gains the ability to function as a similarity metric between songs based on the raw audio information by being trained on this dataset of song picture pairs. On the test set, the SNN model scored 81.64 % accurate. It was built a query-by-multiple-examples based music recommendation system that uses the generated similarity metric to recommend music. A survey website was created to gauge how well their suggested system performed. Participants in the survey first compile a selection of music they enjoy, after which they score the suggestions. The user then reviews a single list of music that was generated using both the naive genre-based baseline system and the recommendations generated by both systems. Because the survey is a blind-use study, potential biases are reduced because participants are unaware that two systems are being utilized. The results revealed that more participants preferred the suggested system's choices, which also scored much higher than the baseline system even though it suggested less well-known songs than the baseline system did (Phaneendra et al., 2020).

Using convolutional neural networks (CNN) as the foundation, Chang et al. (2018) offer the PMRS, or customized music recommendation system. The CNN method divides music into several genres based on the audio signal rhythms. The output of the CNN and the log files are combined in PMRS to create a collaborative filtering (CF) recommendation system that suggests music to the user. The history of each user who uses the PMRS is recorded in the log file. From the log file, the PMRS extracts the user's history and provides genre-specific music recommendations. They assess the PMRS using the million-song dataset (MSD). They created a mobile application to demonstrate how the PMRS functions (an Android version). To evaluate the effectiveness of the PMRS, they used the confidence score metrics for various musical genres (Chang et al., 2018).

The melody, rhythm, timbre, and other significant aspects of music are challenging to extract and process; as a result, most personalized music recommendation systems for users do not fully take into account the content features of music itself, leaving them unsatisfied with the music recommendation. By examining the history records of user tracks in the data sets, Wang et al. (2018) proposed the technique RTCF (Tag-driven Collaborative Filtering Recommendation System) created a fair scoring system for users based on the training statistical language model (Good-Turing Estimate). Furthermore, they discovered that each tag has a linked count when describing a song or an artist, meaning that various tags can define the tracks and the artist's attributes to differing degrees. The tags work in conjunction with their analysis of each user's listening history to not only widen the music's content but also create individualized music recommendations for each user. Users' experimental findings on the tagged dataset suggest that our proposal method has a significant advantage over existing tag-based approaches for producing individualized recommended performance (Wang et al., 2018).

A method for making branching playlists that allow music recommendations based on listener preferences is proposed. They discovered that branching playlists raised listeners' levels of contentment, familiarity, and interest by analyzing the method's efficacy. They also put the suggested technique into practice by implementing

"reco.mu," a web-based music recommendation system. They discovered that while making a branching playlist, the creator is more aware of the recommender (Nonaka & Nakamura, 2021).

A mood-based music player is developed in the proposed system, which does real-time mood recognition and proposes songs in accordance with detected mood. This adds a new feature to the classic music player apps that are already pre-installed on our mobile devices. Customer satisfaction is a significant advantage of mood detection. This system aims to analyze a user's appearance, anticipate their facial expression, and provide music that fits their mood. Seven moods—anger, disgust, fear, joyful, sad, surprise, and neutral—can be correctly detected by their model, which has an accuracy rate of about 75%. Our Android application may then play music that is appropriate for the mood (Mahadik et al., 2018).

One of the top collaborative filtering-based neighbor algorithms is KNN. The KNN recommendation algorithm's error rate is higher when user ratings have changed, though. The shortcomings of the KNN algorithm, which are significantly impacted by the rating, are highlighted by Li and Zhang (2018) in this study. Then they suggest the KNN-Improved method, which is built on the KNN algorithm and uses the Baseline algorithm's mean value's concept, as well as increasing the rating's standard deviation. These steps can successfully lessen the effects of excessively high or excessively low user ratings, lower the algorithm's error rate, and produce better recommendation outcomes. Finally, performance of various recommendation algorithms is evaluated, and then improved algorithms are used (Li & Zhang, 2018).

This research focused on content-based music recommendation systems. The primary uniqueness of our study is the created recommender system's acoustic similarity-based approach to musical composition. This research examines two methods for developing a content-based music recommendation system. The first strategy, which makes use of auditory feature analysis, is highly popular. The second strategy uses computer vision and deep learning techniques to enhance the performance of the recommender system (Niyazov et al., 2021).

The sound browser's present implementation supports fundamental search and filtering features but lacks a method for sound discovery, such as a recommendation system. Users have generally chosen a limited range of high-frequency sounds as a result, which has resulted in less compositional diversity. In this study Smith et al. (2019) develop a recommendation system that uses audio attributes and collaborative filtering to suggest sounds for the EarSketch sound browser (Smith et al., 2019).

The usage of a content-based recommendation system that examines the rhythmic, melodic, and chordal aspects of the music will be extremely beneficial for classical music because these features help establish a user's musical taste. As a result, Cruz and Coronel (2020) describe a method for content-based recommendation that makes use of high-level musical qualities to compare classical music. The preliminary findings show that these features and methods can be used to build a content-based classical music recommender(Cruz & Coronel, 2020).

An information filtering technology called a music recommendation system (MRS) is used to manage the vast volume of digital music that is made available through online platforms. One of the most used methods in MRS is collaborative filtering (CF). The CF approaches are effective at recommending well-liked music but fall short of including less well-liked tunes. This essay tries to discuss longtail songs, or less well-known tunes. This research suggests an adaptive clustering method to include longtail tunes to recommendations. To find longtail tunes, the suggested approach is contrasted with user-based and item-based CF models. The metric called Tail-P has been proposed and contrasted with user-based and item-based CF models for the adaptive clustering approach. Results show that adaptive clustering outperformed CF models in terms of identifying longtail songs (Sunitha et al., 2022).

Due to the current world's quick expansion of music tracks both offline and online, greater access to automatically classify a song's genre and recommendations for related songs will affect the user's experience greatly. In order to perform genre categorization on the song, this study proposes a system that employs deep learning approach. Based on the results, the song will be recommended using word2vec. It's vital to compile a sizable collection for classification, index the songs according to their genres, and use the skip gram model to discover songs with comparable context that should be recommended. For a fantastic user experience, the proposed system functions as a whole music recommendation system (Budhrani et al., 2020).

This article proposes an innovative 15 deep learning-based multi-criteria collaborative filtering model. Their approach consists of two parts: the first portion gets the features of the users and the items and feeds them into a deep neural network that predicts the criteria ratings. These criteria ratings serve as the input for the second component, a deep neural network that forecasts the overall rating. Our suggested model outperformed existing

state-of-the-art methods in experiments using real-world data, which offers 20 evidence that deep learning and multi-criteria techniques may be successfully applied in recommendation systems (Nassar et al., 2020).

This study introduces a system for recommending music to users based on their current moods, activities, and demographic data like age, gender, and ethnicity. Additionally, voice commands and hand gestures can be used to operate the device. In order to make music recommendations based on the user's emotions and demographic information, unsupervised learning techniques were applied. The crucial concept is to make music recommendations based on the entire user's information, including demographics, emotions, and activities. The overall system performance was manually tested and evaluated with a group of people, and the results showed a 70% satisfaction rate for the recommendation. In addition, supporting models like demographic identification, emotion identification, and hand gesture identification have a higher percentage of accuracy rates, which has contributed to the success of the research. Unlike other systems, ours makes music recommendations while taking into account the entire user's data (Wijekoon et al., 2021).

MRS has experienced a growth in recent years. Its primary goal is to provide appropriate, meaningful suggestions to people for particular things according on the user's mood and interest in such items. The two most well-liked recommendation systems are: Collaborative filtering and content-based filtering are two examples. The Content Based technique suggests music based on user data, whereas the Collaborative method uses user ratings and content sharing to suggest music. We use a content-based approach to examine subjective music qualities like speechiness, loudness, and acoustness in order to generate music recommendations. For new users, cold-start is the most typical issue. Users are suggested the most well-liked tracks to solve it here (Dutta & Vishwakarma, 2021).

In this paper, Yi et al. (2019) offer a deep matrix factorization (DMF) based collaborative filtering (CF) framework that can easily and efficiently incorporate any sort of side information. To immediately produce latent factors of users and items from a variety of input information, two feature transformation functions are included into the DMF. Implicit feedback embedding (IFE) is suggested for the implicit feedback that is frequently used as input for recommendation algorithms. IFE transforms the high-dimensional, sparse implicit feedback data into a low-dimensional, real-valued vector while preserving the essential characteristics. IFE might significantly minimize the scale of model parameters and improve the effectiveness of model training. In terms of quantitative evaluations, experimental results on five public databases show that the proposed method outperforms the most advanced DL-based recommendation algorithms in terms of accuracy and training effectiveness (Yi et al., 2019).

This research presents a feeling-based music recommendation system that incorporates a user's mood from signals obtained via wearable physiological sensors. In particular, a wearable figure device that includes a galvanic skin reaction (GSR) and photograph plethysmography (PPG) physiological sensor (OR) makes a customer's feeling more tasteful. Any community-focused or content-based suggestion engine receives this emotional data as vital input. In this way, this knowledge can be used to expand already-existing proposed motor exhibitions. Their suggested system for acknowledging feelings is viewed as an issue of excitement and valence forecast from multiple physiological signals. Depending on the user's mood, we'll automatically play some music (Lakshmi et al., 2019).

A hybrid recommendation method based on the profile expansion technique is proposed by Tahmasebi et.al. (2021) address the cold start issue in recommender systems. In order to improve the user base in the area, they also take into account demographic information about users (such as age, gender, and occupation) in addition to user ratings. In particular, two distinct tactics are employed to offer some more ratings to individuals in order to enhance their rating profiles. The performance of recommender systems can be significantly improved, especially when they are dealing with the cold start problem, thanks to the proposed rating profile expansion technique. This assertion is supported by the fact that the suggested mechanism adds some more ratings to the original user-item rating matrix, making it denser than the original one. Naturally, giving a target user a rating profile with additional ratings helps recommender systems avoid the cold start issue. To estimate user similarity and forecast items that haven't yet been seen, enlarged rating profiles are used. Experiment findings show that the suggested strategy performs better than the other recommendation methods in terms of accuracy and rate coverage measures (Tahmasebi et al., 2021).

In this study, Mohamed et al. (2020) develop two novel algorithms to address the recommendation system's sparsity, accuracy, and performance issues. First, they employed clustering along with association rule mining to uncover a hidden pattern, measure the number of songs played every transaction, and compute similarities through cosine vector similarity to give recommendations to consumers. Second, to decrease dimensionality,

improve efficiency, and address accuracy and sparsity issues, they combined K-means clustering techniques with SVD. Their experiments are conducted on recent FM music datasets and movie-lens datasets with implicit and explicit feedback. They compare their new algorithms with k-means collaborative filtering using RMSE (root mean square error) to demonstrate the performance and accuracy of movie lens and demonstrate the accuracy between the two new algorithms and basic collaborative filtering by measuring accuracy using precision, recall, and F-measure. This experiment demonstrates that when combined with SVD and fundamental collaborative filtering, association rule outperforms improved k-means. However, their new k-means plus SVD algorithm outperforms random collaborative filtering K-means in terms of performance (Mohamed et al., 2020).

The authors of this paper Dhahri et al. (2018) propose an autonomous and adaptive recommendation system that uses the user's mood and implicit feedback to suggest songs without knowing the user's preferences in advance. Their approach uses relationships between users, songs, users' moods, and song emotions to automatically create a latent factor model from the online data of numerous users (generic song map per mood). The basic song map for each mood is customized using a mix of the Page-Hinkley (PH) test and the Reinforcement Learning (RL) framework, taking into account the implicit rewards of the user. In order to demonstrate the impact of mood on music recommendation and how the suggested solution might outperform other traditional solutions over time in terms of hit rate and F1 score, the researchers conduct a number of tests using the LiveJournal two-million (LJ2M) dataset (Dhahri et al., 2018).

There are two significant drawbacks to the current content-based recommendation techniques. First, the recommendation outcomes are relatively limited as a result of the item flaws and user model matching algorithms. Second, the scenario is not given much thought therefore the suggestion algorithm is not context-aware. Enhancing user pleasure through superior suggestion is crucial. Two cutting-edge techniques are examined and expanded in this research in order to improve recommendation performance. The context-aware recommender, which incorporates context information into the suggestion process, is the first approach. The second approach uses a recommender system that uses semantic analysis and takes domain semantics into account. The challenge is to put them together in a way that will completely utilize their potential despite the fact that they are compatible. This research suggests an enhanced content-based model that incorporates semantics and context. Context-aware suggestion is used to increase context awareness. To solve the narrowness issue, semantic relevance-based instance similarity is computed. The suggested recommendation system is assessed using metrics (such as the recall meter) and contrasted with the existing content-based techniques. Results show that the proposed system is superior in terms of accuracy (Yang, 2018).

In this research, a system is shown for gathering user musical preferences and musical textual characteristics on YouTube, as well as for generating collaboratively filtered music suggestions. Additional attributes for the item are required because collaborative filtering suffers greatly from cold start and data sparsity. They provide a technique to boost YouTube recommendation performance by combining implicit feedback and textual features. The results of the experiments show that this system's recommended playlists meet both individual and group preferences (Wang et al., 2020).

This study outlines the topics that require attention and thought and covers the key concepts and techniques employed in contemporary recommendation systems. The study seeks to develop a directed tag-based personalized music recommendation system that can offer consumers basic music services and push them personalized music suggestion lists based on these algorithms, user history data information, and music data information currently available. Next, the tag-based collaborative filtering algorithm is shown. Typically, this method employs discrete tags and juxtaposes and levels user tags and music tags, which does not accurately reflect the significance and ranking order relationship of each tag or the cognitive sequence of users as they listen to and annotate music. The user-tag and music-tag data are associated through the tag sequence of tag and music-tag data are correlated and analytically modeled, and feature directed graphs are produced in order to solve this issue and improve recommendation accuracy (Huo, 2021).

This essay conducts a thorough and in-depth analysis of the qualities of music. A proposed intelligent recommendation algorithm for modern popular music is knowledge graph-based. In this study, user-defined tags are referred to as the free DNA of music, facilitating the analysis of user behavior and the identification of user interests. This algorithm's recommendation quality has been confirmed to be relatively high, and it offers a fresh development route for enhancing the speed of looking for health information services (Zhang, 2022).

Different filtering methods are applied in recommendation systems. Along with such filtering techniques, some soft computing techniques can be incorporated to improve its performance. This article provides a summary of evaluation criteria, stages, difficulties, and how soft computing approaches are combined with filtering

techniques. The popularity of various filtering approaches and soft computing methods employed in recommendation systems is also statistically analyzed in this research (Das et al., 2019).

This research suggests using latent variables to suggest a playlist of songs for a specific film. The suggestion is based on the proposed scoring function, which uses a weighted average of the latent elements for both the video and the music. Additionally, pairwise ranking is used to create the objective function, and stochastic gradient descent is used to optimize the suggested objective function. In the studies, they lay up two hypotheses and create a number of tests to evaluate the performance and efficacy of the suggested algorithm from several angles, such as accuracy, quantitative research, and qualitative research. The experimental findings show that the suggested model has promise for accuracy and quantitative analysis. Additionally, this paper offers a thorough analysis to look at whether the system's suggested background music is appropriate through subject interviews (Liu & Chen, 2018).

This study introduces a music recommendation system for offline song collections that uses reinforcement learning ideas to produce acceptable recommendations based on the many taken into account content-based characteristics. Parallel instances of single-play multi-arm bandit algorithms are maintained to gain insights into the efficacy of the provided recommendations. By assuming that the environment's reward-generating process is non-stationary and stochastic, the ideas of Bayesian learning are then considered to describe the user preferences. Within the limitations of the input data capabilities, the system is intended to be straightforward, straightforward to deploy, and at-par with user pleasure (Bharadwaj et al., 2022).

This work provides a customized music recommendation system based on multidimensional time-series analysis, which can enhance the effect of music suggestion by appropriately considering user midterm behavior. This approach represents the user's behavior as a multidimensional time series, analyzes the series to better forecast the usage of music users' behavior preferences, and then expresses each song as the probability of belonging to numerous hidden themes. Then, a method for recommending music is put forth that takes into account users' long-term, medium-term, and real-time behaviors as well as the dynamic adjustment of the influence weight of the three behaviors. This method makes use of advanced long short time memory (LSTM) technology and aims to further enhance the effect of music recommendation. The practicality of the suggested method is initially verified through the use of the prototype system (Shi, 2021).

This article proposes a system for product recommendations that makes use of an autoencoder built on a collaborative filtering technique. The findings section includes a comparison of this model with the Singular Value Decomposition. Given that the recommendations given to users are in line with their interests and are unaffected by the data sparsity problem because the datasets are extremely sparse, their experiment has a very low Root Mean Squared Error (RMSE) value, which is 0.996. The outcomes are very encouraging, with an RMSE value of 0.029 in the first dataset and 0.010 in the second (Ferreira et al., 2020).

Dataset

Description

For a very long time, experts have worked to understand sound and what makes one music different from another. How is sound visualized? How it makes one tone different from another? Hopefully, a suitable dataset will allow for the opportunity to do the study. The GTZAN dataset, which may be found in at least 100 published articles, is the most often used public dataset for analysis in machine listening research for music genre recognition (MGR). For train-up our Music Genre Classification (MGC) technology, we use the GTZAN Genre Dataset.

The most popular publicly available dataset for testing in machine listening research for music genre identification is the GTZAN dataset (MGR). The files were gathered between 2000 and 2001 from various sources, including as personal CDs, radio, and microphone recordings, in order to illustrate a range of recording situations.

A total of 1000 audio tracks with duration of 30 seconds are included in the GTZAN Genre Dataset. The dataset is organized into a total of 10 classes, each of which has 100 tracks and represents a different musical genre. The tracks are all 22050Hz Mono 16-bit.wav audio files.

GTZAN genre Dataset Structure

GTZAN genre Data Fields

- audio: a tensor containing audio.
- genre: a class label tensor to classify audios in 10 classes

GTZAN Genre Categories

The classes or genres are:

1) blues
2) classical
3) country
4) disco
5) hiphop
6) jazz
7) metal
8) pop
9) reggae
10) rock

GTZAN genre Data Splits

- GTZAN genre contains a single split with 10000 audio tracks

Data Pre-processing

Table 1. Audio pre-processing setting

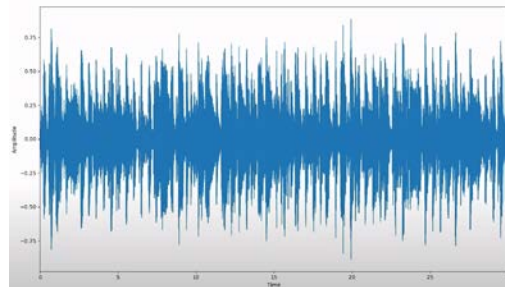| Hyperparameter	Value
Sample rate	22050 Hz
FFT	2048
Hop length	512
Number of segments	5
Number of MFCCs coefficients	13

Wave Form

Figure 1. 30 sec of a wave from GTZAN dataset

Each wave form audio tracks with a 30-second duration and 22050Hz Mono 16-bit audio files in .wav format. Here X axis as Time domain and Y axis is Amplitude in the Wave form.

FFT (Power Spectrum)

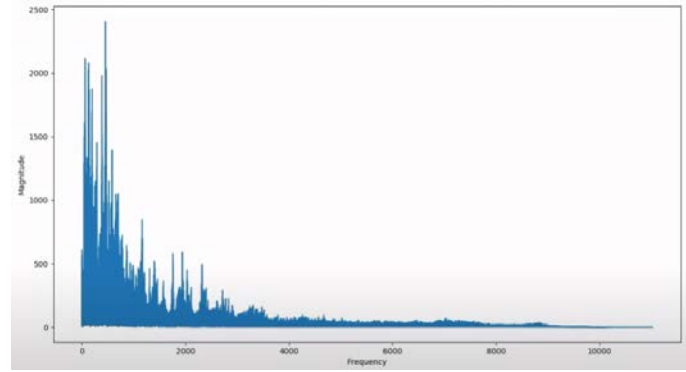In Fast Fourier Transform the normal wave are converted from Time to Frequency Domain and also Amplitude to Magnitude

Figure 2. Power spectrum

MFCCs (Mel-Frequency Cepstral Coefficients)

The modeling of audio sounds and music by other writers has also used MFCCs. For instance, Foote (1997) uses a cepstral representation of sounds to build a retrieval system. One of the aspects in the retrieval system described by Blum et al. (1999) includes MFCCs (Logan, 2000). There is a description of a system for summarizing music using cepstral features (Logan, 2000). However, these works do not thoroughly examine the assumptions given; they just use cepstral features because they have been so successful for voice recognition.

Mel Frequency Cepstral Coefficients (MFCCs) were initially employed in a number of audio or voice processing approaches, but as the area of Music Information Retrieval (MIR) advanced alongside machine learning, it was discovered that MFCCs could effectively represent tone. The following is the fundamental process for developing MFCCs:

- Divide signal into frame
- Convert from Hertz to Mel Scale
- Take logarithm of Mel representation of audio
- Take logarithmic magnitude and use Discrete Cosine Transformation
- This result creates a spectrum over Mel frequencies as opposed to time, thus creating MFCCs
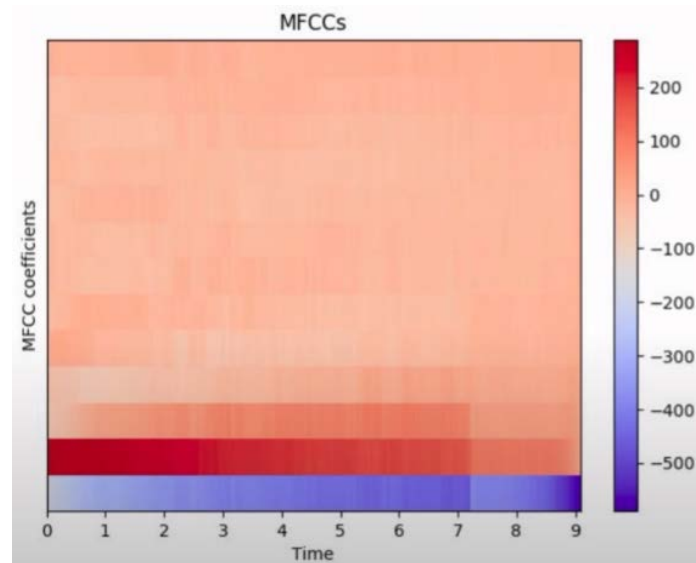

Figure 3. Visual representation of MFCCs

The GTZAN dataset which has 10 classes of music genre and 1000 of music wav files have been used in this system. Pre-process the audio data with the help of MFCCs to generate the features vectors. After extracted the features vectors using Mel Frequency Cepstral Coefficients, we pass the MFCCs into our deep learning networks.
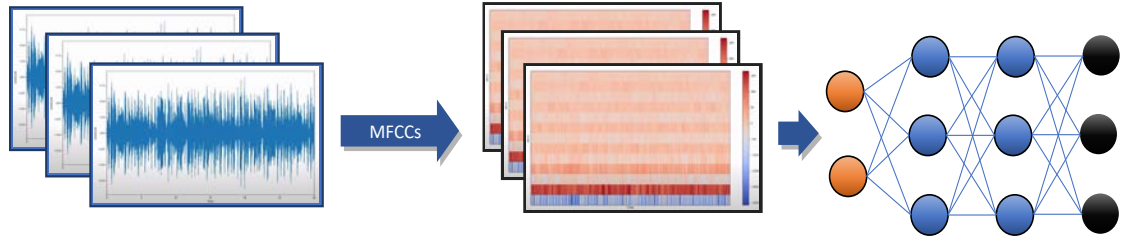
Figure 4. Pre-processing Pipeline

Methodology

Firstly, set the sample rate of music as 22050 Hz, set the window size or number of intervals for FFT as 2048 and hop length is 512. Here, the number of segments is 5 and the number of MFCC is 13. We have pre-processed the audio data by using the Mel Frequency Cepstral Coefficients (MFCCs) technique, then split the MFCCs feature data or Mel-Spectrogram for training & testing those data. Our network topology is a sequential model. Our network has 2 LSTM layers. In the 1st layer of LSTM, the input unit is 64 and the return sequence is True. That means it is a sequence-to-sequence layer. In the 2nd layer of LSTM, the input unit is also 64, set dropout and recurrent dropout is 0.4 (40%). This layer is a sequence to vector.
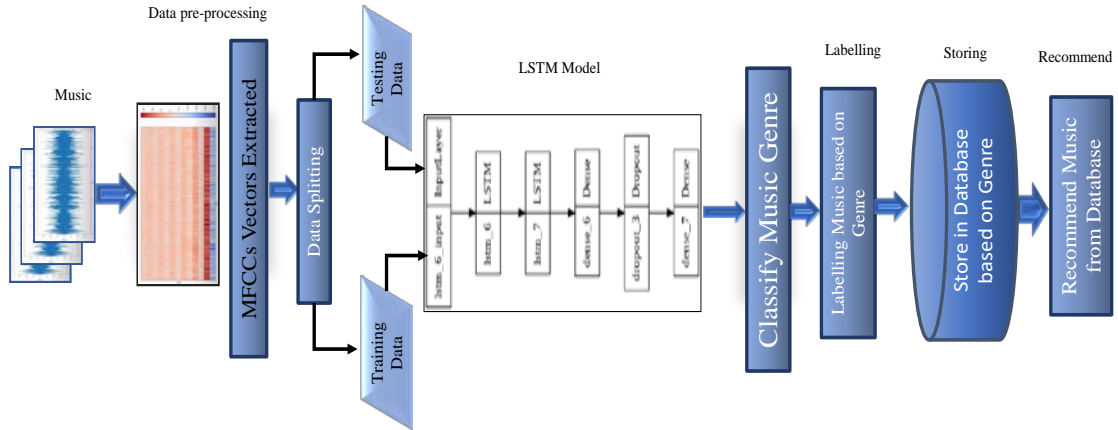

Figure 5. Methodology of music genre classification & recommendation

In the Dense Layer, the number of units is 64 and its activation function is Rectified Linear Unit (ReLU). In the Dropout Layer set dropout probability is 0.3 (30%) to avoid overfitting. In the Output Layer is set activation function as SoftMax which a classifier and set 10 neurons. Here 10 neurons represent the 10 Musical Genres such as blues, classical, country, disco, hip-hop, jazz, metal, pop, reggae and rock. This layer is finally classified the music genres. To compile the model, we use the Adam optimizer and the learning rate is 0.0001. We use 100 epochs and the batch size is 32 to train our model. After classifying the appropriate music genre, the particular audio gets labelled. Then labelled music are store in a database. Then finally, recommended music from particular genre from the labelled database which has been classified by our system.
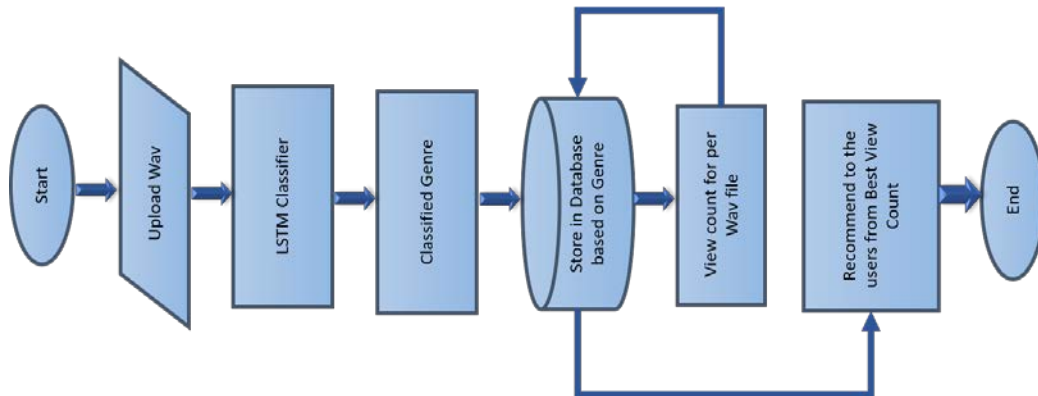

Figure 6. Flow chart of recommendation process

Steps of the flow chart of our recommendation system:

1) Start the process.
2) Upload Wav Music.
3) Classifying the Music Genre by Deep Learning   Model (RNN-LSTM/GRU/CNN)
4) Store the classified music in the database that has been categorized according to the genre.
5) Count the view of each wav file and also store the view count in the database in descending order.
6) Recommend the top 10 music (based on view count) from same categories genre from the database.

Experiments

TensorFlow is an artificial intelligence framework created by Google, and Colaboratory is a development tool. Today Google has made Colaboratory free for the general public to use since 2017, and TensorFlow is open-sourced. Google Colab or just Colab are the current names for Collaboratory. We use google Colab environment in our all experimentation. Users can run Python programs through a browser easily through Colaboratory. For those who enjoy machine learning and data science, this is very handy. The best feature of Google Colab is the fact that it offers free access to powerful computing tools like GPUs and TPUs. It costs nothing to utilize Google Colab.

Our network topology is a sequential model. Our network has 2 LSTM layers. In the 1st layer of LSTM, the input unit is 64 and the return sequence is True. That means it is a sequence-to-sequence layer. In the 2nd layer of LSTM, the input unit is also 64, set dropout and recurrent dropout is 0.4 (40%). This layer is a sequence to vector. In the Dense Layer, the number of units is 64 and its activation function is Rectified Linear Unit (ReLU). In the Dropout Layer set dropout probability is 0.3 (30%) to avoid overfitting. In the Output Layer is set activation function as SoftMax which a classifier and set 10 neurons. Here 10 neurons represent the 10 Musical Genres such as blues, classical, country, disco, hip-hop, jazz, metal, pop, reggae and rock. This layer is finally classified the music genres. To compile the model, we use the Adam optimizer and the learning rate is 0.0001. We use 100 epochs and the batch size is 32 to train our model. After classifying the appropriate music genre, the particular audio gets labelled. Then labelled music are store in a database. Then finally, recommended music from particular genre from the labelled database which has been classified by our system

Experiments Results

In this research study of "Developing music recommendation system by integrating an MGC with Deep Learning Techniques", we have used 3 different Deep Learning Techniques in our system such as RNN-LSTM (Recurrent Neural Networks-Long-Short Term Memory), CNN (Convolutional Neural Network) and GRU (Gated Recurrent Unit) model. The accuracy that we have gained by using those 3 models are given in the below.
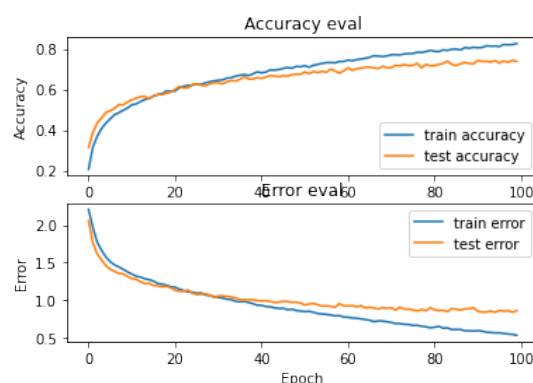
Table 2. Comparative analysis of accuracy of the baselines and proposed model on GTZAN dataset

Models	Accuracy
CNN	0.72
GRU	0.71
LSTM	0.74
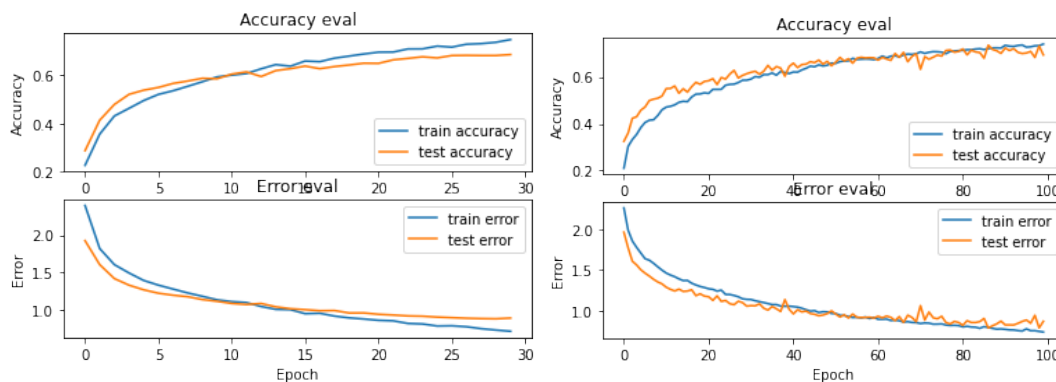
(1) CNN   (2) GRU

(3) LSTM

Figure 7. Train and test accuracy per epoch - CNN, GRU, LSTM model

By Gated Recurrent Unit (GRU) Model we have gained about 71% accuracy in our testing. On other hand, Convolutional Neural Network (CNN) have produced about 72% of accuracy in our testing which is 1% better than GRU Model. The Recurrent Neural Networks-Long-Short Term Memory (RNN-LSTM) have produced about 74% of accuracy in our testing experiment which is 2% better than CNN and 3% better than GRU Model. From all of our proposed models and experimentation, we see that the RNN-LSTM has achieved the best accuracy result (74%) among all of our proposed models.

Conclusion

Identifying a specific genre of music is a very challenging task, and the results depend on the accuracy of the feature and an appropriate model. In our research study, we have developed an Intelligent Music Recommendation System by integrating an MGC (Music Genre Classification) with Deep Learning Techniques such as CNN (Convolutional Neural Network), RNN-LSTM (Recurrent Neural Networks-Long-Short Term Memory), GRU (Gated Recurrent Unit) Model. We have used the GTZAN Dataset to training our system. We have extracted features by using of Mel Frequency Cepstral Coefficients (MFCCs) from GTZAN Dataset. Then pass the features into our neural networks. In our experiment, our neural networks GRU, CNN and RNN-LSTM models have gained the accuracy are about 71%, 72% and 74% respectively. From all of our proposed models and experimentation, the RNN-LSTM has achieved the best accuracy result (about 74%) among all of our proposed models. After classified music according to the genre, recommend the top 10 music (based on view count) from same categories genre music from the labelled database.

Recommendations

We will try to achieve more accuracy and try to reduce the classification time of music genre so that recommendation of music is shown quicker. Additionally, we will expand the dataset and integrate a variety of additional models into our system to improve accuracy and produce more precise results. We also develop an android Intelligent Music Player application with more accurate music recommendation system.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

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To cite this article:

Mathematical Doodles in Türkiye and the World

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Abstract: Google Doodles are special designs created by Google for special occasions and historical events. The math-themed doodles created and published by Google between 2000 and December 2022 were examined in this study, which was performed using the document analysis method. 39 math-themed doodles from Google's doodle database were examined. As a result of the content analysis, it was observed that 37 doodles were created to honour mathematicians, while two were created specifically for Pi Day. Two of the 16 Google Doodles in Türkiye that have a mathematical theme are tied to Pi Day, while 14 of them are about mathematicians. One of these mathematicians is from the Republican era, and the other is from the Turkish-Islamic era. The remaining 12 mathematicians come from various nations. However, while doodles honouring well-known Turkish-Islamic mathematicians such as Al-Biruni and Al-Rhazi were published in other countries, they were not published in Google Türkiye. Some suggestions have been developed in line with the results of the study.

Keywords: Google doodles, Mathematics, Mathematicians, Search engine, Mathematics campaign

Introduction

For many people, mathematics is seen as a scary problem that they will be saved as soon as they finish school. For some, mathematics has been a way to understand and love life (Sertöz, 1996). Although the science of mathematics is a serious business, it is not a grumpy and feared discipline, on the contrary, it is a fun, joyous and relaxing field like life (Dönmez, 2002). Bidwell (1993) states that "Mathematics is considered introverted, lifeless, unfeeling, and ultimately discovered… by students. However, including the history of mathematics in our lessons can help students understand that mathematics is open, living, emotional and always engaging." which emphasizes that the history of mathematics can change thoughts about mathematics (Karakuş, 2009). It is also seen that information about the history of mathematics is presented in the relevant parts of the mathematics textbooks within the scope of the renewal of the mathematics curriculum. It is seen that aims such as "encouraging learning by creating interest and curiosity about the history of mathematics" are emphasized in the examples of activities presented in the learning and sub-learning areas of the renewed secondary school mathematics curriculum (Uğurel & Bukova-Guzel, 2010). It will make students and society aware of the great mathematicians and their personalities, the role that mathematics has played in human history, its relation to our culture, and its place in our daily lives (Baki, 2008). Therefore, students can understand that mathematics is a human and sociological phenomenon by learning the history of mathematics. This may also affect their attitudes towards mathematics positively (Yenilmez, 2011). From this point of view, it can be understood how important the history of mathematics is.

The History of Mathematics is given particular importance within the scope of the "Mathematics Campaign" project, which was started in 2022 by the Ministry of National Education (MONE) in Türkiye (EBA, 2022). Thus, it is aimed to destroy prejudices by making mathematics popular. This situation, of course, should be tried to be popularized by using online applications and websites that have become the routine of life.

Google LLC is an American multinational corporation investing in internet search, online information distribution, advertising technologies, and search engines. It develops internet-based services and products. It gets most of its income from advertisements through the Google Ads program, formerly called AdWords. The company was founded by Larry Page and Sergey Brin while they were Ph.D. students at Stanford University (Wikipedia, 2015). The phrase "to google" has also become a verb that is widely used in various languages. The Google brand offers many services that dominate the market today, including its web browser, operating system, and smartphone product line. Google Earth, Google Drive, Google Voice, Adwords, and Gmail are just a few of them (Elmasoğlu, 2016).

Google Doodles are fun, surprising, and sometimes spontaneous changes to the Google logo to celebrate holidays and anniversaries, and honor famous artists, explorers, and scientists. The concept of the doodle first emerged in 1998, before the company was incorporated, when Google founders Larry and Sergey changed the corporate logo to indicate their attendance at the Burning Man festival in the Nevada desert. They placed a stick figure drawing behind the 2nd "o" in the word, Google. Their purpose was to tell Google users that the founders were "out of office" as a comical message. While the first doodle was relatively simple, the idea of decorating the company logo to celebrate significant events was born.
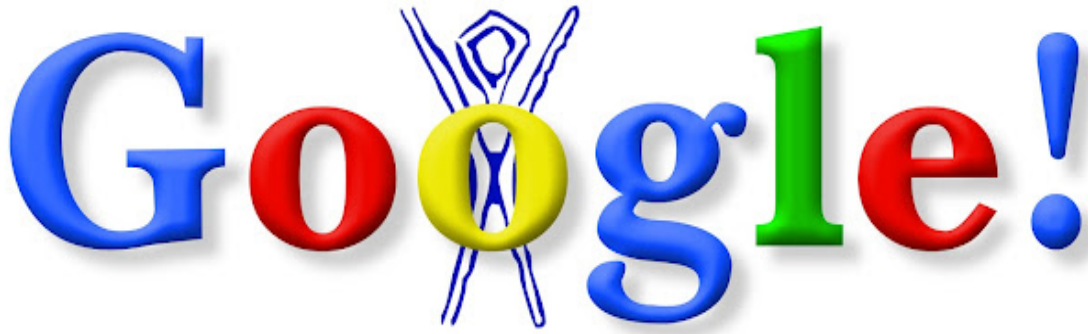

Figure 1. Burning man festival (Google, 1998)

Over time, the demand for doodles has increased in the US and other countries. For this reason, a team of special illustrators (doodlers) and engineers started to create doodles. According to Google, this team sees their task of creating doodles as a group effort to revive the Google homepage and make Google users around the world smile. (Google, 2013). Google has created more than 5,000 doodles for homepages around the world, including math-themed doodles. Maybe this team should have a goal of making Google users love mathematics as well as making them smile.

According to the statistics of 2021, Google is the most visited search engine and website in the world and in Türkiye (Similarweb, 2021). Many people see the Google logo first when they open their web browser. Google's great number of views and its easy reach to internet users can be seen as a very promising tool for the history of mathematics and therefore for the popularization of mathematics. Thus, considering the "Math campaign" project launched in our country, it is thought that Google Doodles can be used for this purpose. This study was carried out to see both the current status of the math-themed Google Doodles and how these doodles differ according to Türkiye and internationally.

Method

This study was carried out with the document analysis method, which is one of the qualitative research methods. This method includes the analysis of documents on the topics to be researched. A document can be defined as the recording of facts related to social life in the form of written texts. These written texts or documents consist of personal records or official documents such as diaries, letters, memories, and photographs (Hitchcock & Hughes, 1995). "Document analysis includes the analysis of written materials containing information about the facts and cases intended to be investigated" (Yıldırım & Şimşek, 2018). Considering the purpose of the study, it is seen that this method is appropriate for the study.

Data Collection Process and Data Analysis

The math-themed doodles created and published by Google between 2000 and December 2022 were examined in this study. During the research process, first the keywords "math", "mathematician" and "geometry" were searched in English, and then the words "matematik", "geometri" and "matematikçi" were searched in Turkish among the doodles indexed in the "Google Doodles" database. As a result of the first searches, 67 different doodles were found. Then, the related doodles were reviewed by two different researchers and it was decided to include 39 doodles related to mathematics in this study in line with the purpose of the study. According to the formula by Miles & Huberman (1994), the consistency rate between coders was found to be 97%.

Table 1. Doodles examined within the scope of the study, publishing dates and distribution of doodles published in Türkiye

Doodle	Year	Published in Google Türkiye
MC Escher's 105th Birthday	2003	x
Gaston Julia's 111th Birthday	2004	x
Percival Lowell's 151st Birthday	2006	x
Zu Chongzhi's Birthday	2009	
Chen Jingrun's Birthday	2009	
Christiaan Huygens' Birthday	2009	
Cahit Arf's 100th Birthday	2010	x
Pi Day	2010	x
Pierre de Fermat's 410th Birthday	2011	x
Hua Luogeng's 101st Birthday	2011	
Ada Lovelace's 197th Birthday	2012	x
Alan Turing's 100th Birthday	2012	x
Al-Biruni's Birthday	2012	
Omar Khayyam's 964th Birthday	2012	
Rhazes' 1147th Birthday	2012	
Grace Hopper's 107th Birthday	2013	x
Leonhard Euler's 306th Birthday	2013	x
Nicolaus Copernicus' 540th Birthday	2013	x
Mihailo Petrović Alas' 145th birthday	2013	
John Venn's 180th Birthday	2014	x
Sofia Kovalevskaya's 164th Birthday	2014	
Maria Gaetana Agnesi's 296th Birthday	2014	
Abu al-Wafa' al-Buzjani's 1075th Birthday	2015	
George Boole's 200th Birthday	2015	x
Emmy Noether's 133rd Birthday	2015	
Claude Shannon's 100th birthday	2016	x
Hertha Marks Ayrton's 162nd birthday	2016	
Hirotugu Akaike's 90th Birthday	2017	
Max Born's 135th Birthday	2017	
30th Anniversary of Pi Day!	2018	x
Johann Carl Friedrich Gauß's 241st Birthday	2018	
Gottfried Wilhelm Leibniz's 372nd Birthday	2018	
Omar Khayyam's 971st Birthday	2019	x
Olga Ladyzhenskaya's 97th Birthday	2019	
Benoit Mandelbrot's 96th Birthday	2020	
Émilie du Châtelet's 315th Birthday	2021	
Celebrating Satyendra Nath Bose	2022	
Julio Garavito's 157th Birthday	2022	
Celebrating Stefan Banach	2022	

Content analysis method was used to analyze the doodles discussed within the scope of the study. Content analysis is used in cases where it is necessary to systematize and digitize the information that was previously collected and organized for a purpose (Fraenkel & Wallen, 2000). Related doodles are classified according to whether they are published in Türkiye, their types and the cultures they belong to.

Results and Discussion

As a result of the content analysis on 39 Doodles that were included within the scope of the study, it was understood that 16 of these doodles were displayed on Google Türkiye. Distribution of doodles by types is presented in Figure 2.
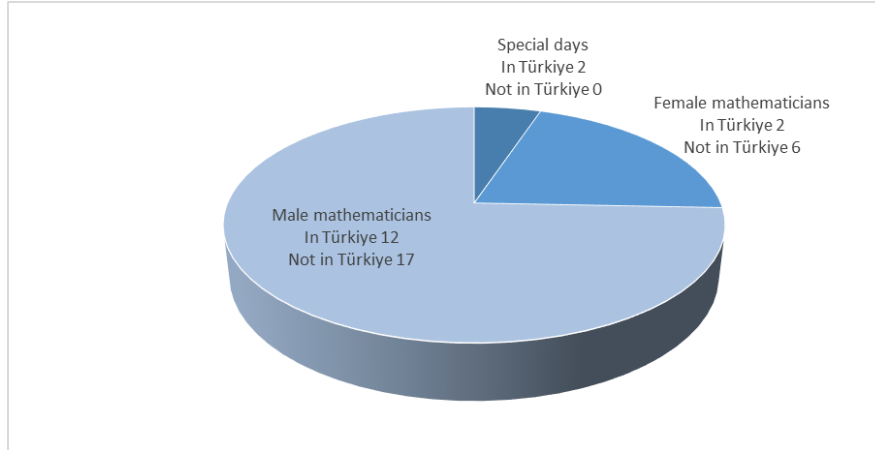

Figure 2. Doodle types examined within the scope of the study and data on their display in Google Türkiye

In the analysis of the data given in Figure 2, it is understood that two of the doodles published by Google were designed for Pi Day, 8 to commemorate female mathematicians and 29 to commemorate male mathematicians. Doodles for twelve male mathematicians and only two for the female mathematicians were published in Google Türkiye. Two doodles designed for Pi day were published in Türkiye as well as around the world. Figure 3 shows the doodle that coloured the Google Türkiye homepage named "30th Anniversary of Pi Day!" published on 14 March 2018.
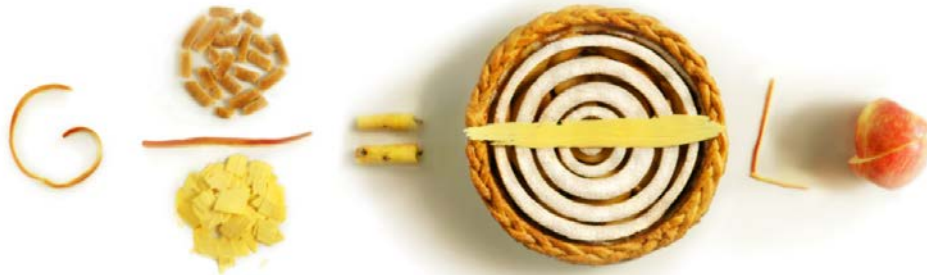
Figure 3. 30th Anniversary of Pi day (Google, 2018)
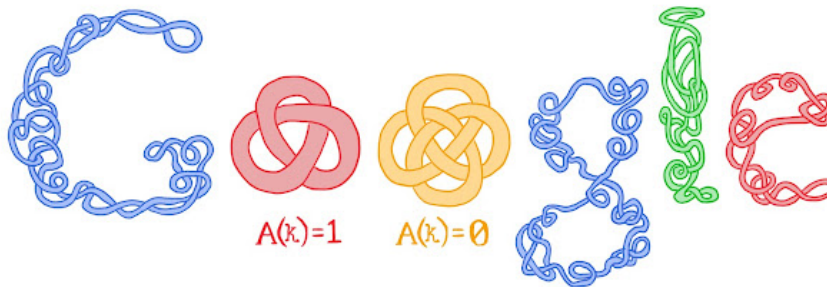

Figure 4. Cahit Arf's 100th birthday! (Google, 2010)

Considering the doodles published in Google Türkiye, it is seen that only one of them was published to commemorate Cahit Arf, one of the most famous and great mathematicians of the republican period. Figure 4 shows the doodle named "Cahit Arf's 100th Birthday!" which was published on the Google Türkiye homepage on 11 October 2010.

The doodle in Figure 4 was only displayed on the Google Türkiye homepage and was not published in any country other than Türkiye. Also, within the scope of the doodles reviewed, it is seen that only one doodle (Omar Khayyam's 971st Birthday) from the Turkish-Islamic period coloured the Google Türkiye homepage on 18 May 2019.

Figure 5. Omar Khayyam's 971st birthday (Google, 2019)

It is seen that the other 14 doodles published in Google Türkiye belong to mathematicians from various countries and nationalities. However, when the doodles included in the study are examined, it is seen that the doodles such as "Al-Biruni's Birthday, Abu al-Wafa' al-Buzjani's 1075th Birthday, Omar Khayyam's 964th Birthday, Rhazes' 1147th Birthday" related to the Turkish-Islamic period are not included in Google Türkiye.
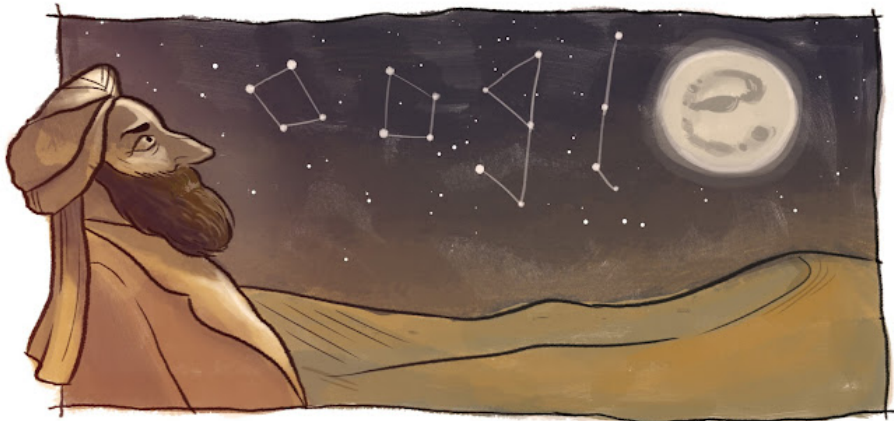

Figure 6. Al-Biruni's birthday (Google Doodles, 2012)

Many of the Chinese, Russian, Indian and South American mathematicians covered in the study were published only on the Google homepages of their own countries. However, European and North American mathematicians enlivened the Google homepages of many countries

Conclusion and Recommendations

The results of the study showed that the majority of the mathematicians commemorated with Google Doodles are male. Although men have been at the forefront in mathematics, as in many other fields, due to the male-dominated culture throughout history, mathematics is a common product of humanity, regardless of religion, language, race and gender. It is of great importance to show people and students that women mathematicians have also made significant contributions to the development process of mathematics, and the lives and scientific studies of women mathematicians who spent extraordinary efforts to reach knowledge (Yıldız & Hacısalihoğlu-Karadeniz, 2017). Thus, students can realize that mathematics is not only a profession developed under the

influence of male mathematicians but also has a structure that grows by being provided by female mathematicians from different languages, religions and races.

Two of the 16 doodles published in Google Türkiye were designed for Pi Day and were published in Türkiye along with the majority of the world. Another interesting result of the study is that out of 14 doodles published on Google Türkiye to commemorate mathematicians, only two of them, one from the Republican period and the other from the Turkish-Islamic period, are culturally related to Türkiye. Although mathematics is a universal profession that does not discriminate against religion, language and race, the fact that all the remaining 12 doodles are from the western world can be considered a reflection of the classical western approach (Sezgin, 1985; Yıldız, 2020). However, the contributions of the medieval Islamic world to mathematics are undeniable. Another interesting issue is that some of the Turkish-Islamic mathematicians are not covered on the Google Türkiye homepage. Mathematicians from the Turkish-Islamic world such as Abu al-Wafa, Al Biruni and Al Rhaze are well known in Türkiye and it is known that Al-Biruni is a Turk (Leaman, 2015; 39). It can be said that not including mathematicians from our own culture is the result of the condescending approach of the west. This applies to Indian, Russian, Balkan and Far Eastern mathematicians as well. Many of the Chinese, Russian, Indian and South American mathematicians covered in the study were published only on the Google pages of their own countries. However, doodles for European and North American mathematicians have been published on Google homepages of many countries.

It is obvious that Google Doodles is also very important in terms of advertising and promotion (Elmasoğlu, 2016). Mathematics can be popularized with the cooperation of MONE with the Google Türkiye office within the scope of the mathematical campaign initiated in Türkiye. For example, Google organizes a competition called 'Google 4 Doodle', created according to certain themes, for elementary school students in many countries every year. As a result of this competition, the most successful logo is published on the Google homepage logo for one day. It is seen that Google is mostly targeting elementary school children between the ages of 6-14 with this competition (Elmasoğlu, 2016). Because the use of various elements such as cartoon characters, animations or child actors to attract the attention of the target audience is the right approach to draw the attention of children to the product in an advertisement about a product that children will use (Elden, Ulukök, & Yeygel, 2009; 105). Math-themed competitions can be organized for mathematics to be considered a product and to attract the attention of certain age groups. Also, in cooperation with the Google Türkiye office, doodles with Mathematics themes and the number of doodles focusing on Turkish mathematicians can be increased.

Acknowledgements

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To cite this article:

Impact of Information and Communication Technology on the Secondary Schools' Efficiency in Barisal Division of Bangladesh: Teachers' Preference and Perceptions

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Abstract: This study assess the efficiency and identify the factors causing responsible for school inefficiency of Barisal division in Bangladesh using stochastic frontier analysis. Multiple regression analysis was used to investigate the impact of teachers' preference and use of ICT on their knowledge and motivated factors in teaching and learning. The determinants of factors affecting to secondary school efficiency were investigated by Tobit regression analysis. Through the likelihood-ratio test, Translog model was found an appropriate than Cobb-Douglas model. The number of students, the number of class rooms and teaching ability of the teachers had a positive and significant contribution to improve the efficiency. The ICT lab, teacher's preference of ICT tools like multimedia projector used played a contributor role in increasing the school efficiency. The urban secondary schools performed better than the rural secondary schools. Barisal district was found comparatively better for urban secondary schools and Jhalokhati district was for rural secondary schools. Both medium and high level ICT teaching ability have positive and significant influence on the secondary school efficiency. Government should take necessary steps to improve the teaching and learning system in Barisal division by improving the teacher-student ratio, rural school and conventional teaching method in secondary school.

Keywords: Efficiency of secondary schools, ICT, Stochastic frontier analysis, Tobit regression analysis, Bangladesh

Introduction

Effective teaching and learning in education relies on the performance and teaching-learning methodological development of the teachers and students. Quality education, teaching, learning achievement and reduction of dropout in Bangladesh has not yet made breakthrough. Information Communication Technology (ICT) has the latent to transform the teachers' design work, the roles of students and teachers in the learning process and learning environment etc. Studying the issues and challenges incidental to to ICT use in teaching and learning can help teachers in overcoming the impediment of ICT integration in schools. The value of quality education at the secondary level is a vital implement for the facilitated economic development Bangladesh. In setting the students for the digital epoch, teachers are the primal participant in using ICT in the classrooms. Schools in the countries like Netherland, United Kingdom and Malta acknowledged the value of technical aid to assist teachers to usage ICT in the classroom (Yang & Wang, 2012). Lack of adequate ICT equipment and internet entree is the fundamental question that schools narrowly in rural areas are lining now. Former researches established that use of ICT in teaching will intensify the learning process and maximizes the students' quality in learning (Finger & Trinidad, 2002; Jorge et al., 2003; Young, 2003; Jamieson-Procter et al., 2013).

Teachers' preparedness and acquisition in using ICT are acting indispensable role in the use of ICT in education. According to Winzenried, Dalgarno and Tinkler (2010) teachers went through ICT course that is more effectual in teaching as opposing to those that have no knowledge in ICT. A school in Ireland reported that teachers who did not create adequate assurance using ICT. Related case occurred in Canada, a few teachers admitted they were loath ICT users because they disquieted they might acquire abashed that the students knew more about the ICT than they did (Hennessy et al., 2005).

According to Warwick and Kershner (2008) the importance and benefits of ICT should be best-known by teachers to deal a substantive pedagogy through ICT. ICT assists students to create new intelligent acquisitions which may transfer to various situations which may necessitate investigation and understanding accomplishment, and accordingly captious acquisition improvement (Al Hudhaifi & Al Dughaim, 2005), exploration and identification of the barriers that affected the implementation of ICT in the Bangladesh education system (Khan et al., 2012; Mou, 2016). This is a need for this study to look into the role of ICT in advancing a synergistic learning state of affairs. In a Bangladesh circumstance there has been a fast alteration in the function of the teacher in new years. There is another new modification and situation that teachers face, and are needed to accommodate to. However, there is a little research which focuses on the role of ICT in creating and boosting an synergistic educational situation, as the part of teaching and learning.

The efficiency of schools studies have been conducted by many researchers. A good school plan of action can result the cognitive acquisition of students, can change productiveness, social quality and the legal status rights in the society. Hence the increasing involvement in measuring the efficiency of acquisition of the students, of the acquisition acquired and of the knowledge of ICT use in everyday life (Hanushek & Woessmann, 2010). The study by Sengupta and Sfeir (1986) made an beginning point for the survey of frontier efficiency measuring method in education. Sengupta (1987) ended that the frontier method seemed to be more better than non-frontier method, particularly in case of inputs variation. Chakraborty (2009) calculated the efficiency of public school education using a stochastic frontier analysis (SFA) and an inefficiency effect function that controls the socio-economic and environmental factors. Again, Scippacerola and D'ambra (2014) utilized a SFA in Campania to measure the school relative efficiency and a Tobit regression model was utilized to evaluate the factors affecting efficiency.

Due to lack of study on secondary school educational efficiency by ICT integration in Bangladesh, it is supposed to develop a suitable stochastic frontier secondary schools efficiency model by ICT intervention and to find the responsible factors for secondary school inefficiency in Barisal division that could be the essential facts for the educationist of Bangladesh. This type of unresolved problem in ICT integration in secondary schools may fill up the current gap between teachers and students. So, it is essential to analyze the impact of ICT and measure how teachers comprehend ICT innovation and its effectiveness in teaching-learning process.

Method

Study Areas

The quantitative data were collected from both urban and rural secondary schools selected from six districts namely Barisal, Bhola, Patuakhali, Pirojpur, Barguna and Jhalokati under Barisal division in Bangladesh through structured questionnaire on the use of ICT and preference, teachers' qualification, teachers' knowledge of ICT, experience regarding the ICT application etc.

The study sites of this study are as follows: Barishal is a administrative division which is the south-central part of Bangladesh, it has an area of 13,644.85 km^2 (5,268.31 sq mi), located in between 21°48' and 22°29' north latitudes and in between 89°52' and 90°22' east longitudes. In particular, it is delimited by Gopalganj, Madaripur, and Shariatpur districts on the north, Bay of Bengal on the south, Lakshampur and Noakhali districts on the east, Bagerhat district on the west, and a population of 8,325,666 at the 2011 Census. It lies in the Padma river delta on an offshoot of the Arial khan river. Barishal division is criss-crossed by many rivers that attained it the nickname *Dhan-Nodi-Khal, Ei tin-e Borishal* (rice, river and canal built Barishal). This study covered the six districts under Barishal division presented in Figure 1.

Sampling Design for Quantitative Component

Six districts namely Barisal, Bhola, Patuakhali, Pirojpur, Barguna and Jhalokati were selected under Barisal division in Bangladesh. Both urban and rural secondary schools were selected from the selected districts of Barisal division. The questionnaire in size of 240 were distributed to different stakeholders like non-trained teachers, trained teachers, head teachers and students over the 12 secondary schools. The secondary schools were selected based on both urban and rural context, and the questionnaires apportioned are not equal in numbers where teachers from urban secondary schools predominate the total population as compared to teachers from rural secondary schools.

Figure 1. Description of the study areas (Barisal, Bhola, Patuakhali, Pirojpur, Barguna and Jhalokati districts) in Barisal division.

Table 1. Variable names and the description of the variables

Variables	Symbol / Variable description
Dependent variable	
Percentage of the students passed in SSC	Y
Input variables	
Number of teachers	X_1
Number of students	X_2
Number of class rooms	X_3
Teaching ability of the teachers	X_4
Explanatory variables	
Teacher-student ratio	ϕ_1
Teaching experience	Teaching experience defined into different categories: 0-2 years (Ref.), 2-5 years (ϕ_2), 5-10 years (ϕ_3), and 10 years above (ϕ_4)
School type	Secondary schools are three types: Government (Ref.), Non-government (ϕ_5), and MPO (ϕ_6)
School location	Location of the school are semi-urban (Ref.) and rural (ϕ_7)
Preference of teaching methods	Teaching methods are modern (Ref.) and conventional (ϕ_8)
ICT teaching ability	Teaching ability in ICT are three types: Low (Ref.), medium (ϕ_9), and high (ϕ_{10})
ICT variables	
ICT lab of the secondary schools	Z_1
Online class of the secondary schools	Z_2
Multimedia project used always in the secondary schools	Z_3
Multimedia project used often in the secondary schools	Z_4
Multimedia project used sometimes in the secondary schools	Z_5
Multimedia project used rarely in the secondary schools	Z_6
Multimedia project used never in the secondary schools	Z_7

Data Sources and Variable Description

The data on non-trained teachers, trained teachers, head teachers and students were obtained from the secondary schools of Barisal division in Bangladesh through the structured questionnaire in the year of 2021. This data collection is carried out on teachers and students of secondary schools in the selected study area. The data collection has been done reference point to fitting the objectives using a questionnaire. The questionnaire admit segments on (i) background characteristics of the teachers and students of secondary schools (ii) Teacher's preference of ICT use in teaching and learning (iii) Effectiveness of ICT integration for student's learning (iv) Challenges for Teacher in using ICT in teaching and learning. The associated both teacher's and student's data set are described in Table 1.

Empirical Cobb-Douglas Stochastic Frontier Secondary School Model

The empirical specification of Cobb-Douglas stochastic frontier secondary school model for Barisal division can be expressed as follows:

$$lnY_i = \beta_0 + \beta_1 \ln(X_{1i}) + \beta_2 \ln(X_{2i}) + \beta_3 \ln(X_{3i}) + \beta_4 \ln(X_{4i}) + V_i - U_i \qquad (1)$$

where, ln = Natural logarithm; Y_i = the percentage of the students passed in SSC in i-th secondary school; X_{1i} = the number of teachers in i-th secondary school; X_{2i} = the number of students in i-th secondary school; X_{3i} = the number of class rooms in i-th secondary school; X_{4i} = teaching ability of the teachers in i-th secondary school; β_i = The unknown parameters (i=1,2,3,4) to be estimated. The systematic error component V_i, which is assumed to be independently and identically distributed as $V_i \sim NID(0, \sigma_v^2)$ independent of U_i which measure the technical efficiency relative to the stochastic frontier.

Empirical Translog Stochastic Frontier Secondary School Model

The specification of Translog stochastic frontier secondary school model for Barisal division is given by

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(X_{1i}) + \beta_2 \ln(X_{2i}) + \beta_3 \ln(X_{3i}) + \beta_4 \ln(X_{4i})$$
$$+ \frac{1}{2}[\beta_{11} \ln(X_{1i}^2) + \beta_{22} \ln(X_{2i}^2) + \beta_{33} \ln(X_{3i}^2) + \beta_{44} \ln(X_{4i}^2)]$$
$$+ \beta_{12} \ln(X_{1i}) * \ln(X_{2i}) + \beta_{13} \ln(X_{1i}) * \ln(X_{3i}) + \beta_{14} \ln(X_{1i}) * \ln(X_{4i})$$
$$+ \beta_{23} \ln(X_{2i}) * \ln(X_{3i}) + \beta_{24} \ln(X_{2i}) * \ln(X_{4i}) + \beta_{34} \ln(X_{3i}) * \ln(X_{4i}) + V_i - U_i \qquad (2)$$

where Y_i = the percentage of the students passed in SSC; X_1 = the number of teachers; X_2 = the number of students; X_3 = the number of class rooms; X_4 = teaching ability of the teachers; β_i (i = 1,2,3,4), β_{ij} (i < j) = the unknown parameters to be estimated.

Empirical Technical Inefficiency Effect Model

The specification of the technical inefficiency effects model U_i for Barisal division is defined as

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + W_i \qquad (3)$$

where U_i's are the technical inefficiency effect for the i-th secondary schools, assumed non-negative random variables and independently distributed, U_i, were estimated by truncation of normal distribution with mean zero and variance, σ_i^2 such that Z_{1i} = the ICT lab in the i-th secondary school; Z_{2i} = the online class in the i-th secondary school; Z_{3i} = the multimedia project used always i-th secondary school; Z_{4i} = the multimedia project used often i-th secondary school; Z_{5i} = the multimedia project used sometimes i-th secondary school; Z_{6i} = the

multimedia project used rarely i-th secondary school; $Z_{7i=}$ the multimedia project used never i-th secondary school, $\delta_0, \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \delta_6, and\ \delta_7$ are parameters to be estimated. W_i are the disturbance terms, assumed independently distributed, estimated by truncation of normal distribution with mean zero and variance, σ_i^2. The variances are stated in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\gamma = \frac{\sigma_u^2}{\sigma^2}$, γ is the ratio of variance of education output efficiency to the total variance of output and bounded by zero and one. All parameters of the inefficiency effects model were calculated by using the Maximum Likelihood (ML) method.

Likelihood Ratio Test for an Appropriate Model for Barisal Division

The likelihood ratio test helps us to determine whether Cobb-Douglas or Translog production function is better or not. It is measured as follows:

$$\lambda = -2\{\ln[L(H_0)/L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}. \tag{4}$$

where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypothesis (note that this statistic has a mixed chi-square distribution). The null hypothesis is rejected when $\lambda_{LR} > \chi_c^2$.

Empirical Tobit Regression Model

The specification of the Tobit regression model for Barisal division is defined as

$$\begin{aligned}
E_i &= \phi_0 + \phi_1 TSR_i + \phi_2 TE(2-5)_i + \phi_3 TE(5-10)_i + \phi_4 TE(10+)_i \\
&+ \phi_5 STNG_i + \phi_6 STMPO_i + \phi_7 SLR_i + \phi_8 PTMC_i \\
&+ \phi_9 ICTTAM_i + \phi_{10} ICTTAH_i + \xi_i. \tag{5}
\end{aligned}$$

where E_i is defined the efficiencies based on Stochastic frontier Cobb-douglas, Translog with Battese and Coelli (1992,1995) in the i-th secondary schools; TSR_i is the teacher-student ratio of the i-th secondary school; TE_i is the teaching experience (0-2 years, 2-5 years, 5-10 years, and 10 years above) of the i-th secondary school; ST_i is the school type (government, non-government, MPO) of the i-th secondary school; SL_i is the school location (semi-urban, rural) of the i-th secondary school; PTM_i is the preference of teaching methods (modern, conventional) of the i-th secondary school; $ICT\text{-}TA_i$ is the ICT teaching ability (low, medium, high) of the i-th secondary school. ξ_i is the error term.

Results and Discussion

Results of the Secondary Schools for Barisal Division in Bangladesh

Results on Frequency Distribution of the Secondary Schools in Barisal Division

The frequency distribution of the secondary schools of Barisal division is represented by the Table 2 and it is observed from the data set that teaching experience of the teachers those who have more than 1 to 5 years is found highest, the second highest is 6 to 10 years (30.51%), the teaching experiences for those who have less than 1 year and above 10 years are recorded almost similar in Barisal division. According to sample data set, the number of MPO type schools are found highest (71.23%), second highest is Non-government type schools (21.92%) and government type schools are found lowest (6.65%). The data set covered both urban and rural school where the 64.38% of urban schools and 35.62% of rural schools. From the sample data set it is found that 79.45% of teachers who have preference of teaching style is 'modern' and the 20.55% teachers still prefer conventional method for their teaching to the students in the class.

The highest number of teachers those who have education level is found 'HSC' (45.21%) and second highest is noticed 'Graduation' (27.40%) while the 'SSC' is 16.44% and the 'Post-graduation' is found lowest (10.96%).

The teaching ability of the teachers in ICT is recorded 'high' (72.60%), 'medium' (12.33%), and 'low' (15.07%) respectively. The secondary school having ICT lab in is satisfactory (91.78%) and 8.22% of the secondary school don't have ICT lab in Barisal division.

Table 2. Frequency distribution of the secondary schools in Barisal division

Variables		Frequency	Percentage
Teaching Experience	<1 Year	6	8.22
	1-5 Years	33	45.21
	6-10 Years	23	31.51
	>10 Years	8	10.96
School Type	Government	5	6.85
	Non-government	16	21.92
	MPO	52	71.23
School location	Urban	47	64.38
	Rural	26	35.62
Preference of teaching style	Modern	58	79.45
	Conventional	15	20.55
Education	SSC	12	16.44
	HSC	33	45.21
	Graduation	20	27.40
	Post-graduation	8	10.96
ICT in teaching ability	Low	11	15.07
	Medium	9	12.33
	High	53	72.60
ICT lab	Yes	67	91.78
	No	6	8.22

Table 3. Maximum Likelihood Estimates (MLE) of Cobb Douglas frontier secondary school model with Battese & Coelli (1992) for Barisal Division

Variables	Parameters	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	β_0	4.152688	0.212962	19.4997	<2.20E-16***
X_1	β_1	0.374649	0.088486	4.234	2.30E-05***
X_2	β_2	-0.06649	0.045357	-1.4659	0.14267
X_3	β_3	-0.07369	0.048143	-1.5307	0.12585
X_4	β_4	0.080255	0.032969	2.4342	0.01492
		Variance Parameters			
sigmaSq	σ^2	0.040178	0.008798	4.567	4.95E-06***
gamma	γ	0.957263	0.038677	24.7499	<2.20E-16***

*, **, *** Significance level at 1, 5, and 10%, respectively, @ indicates insignificant.

Results of Secondary School Efficiency with Cobb-Douglas Model based on Battese & Coelli (1992) for Barisal Division

The estimated parameters of secondary school efficiency model were presented in the Table 3. In this model, a positive coefficient shows the advance of efficiency and vice-versa. The variables like the number of teachers and teaching ability have straight causation to gain the efficiency where the number of teachers played a role to improve the secondary school efficiency significantly. Both the number of students and the number of class rooms have influence to decrease the level of efficiency.

The negative coefficient of the number of students and the number of class rooms were indicated that these might be the cause of decreasing secondary school efficiency. The value of γ was positive and significant indicating that 95.72 percent of random variation around in secondary school outcome due to inefficiency. The estimated value of σ was found different from zero and significant, indicated a good fit.

Results of Cobb-Douglas Secondary School Inefficiency Effects Model with Battese & Coelli (1995) for Barisal Division

The estimated parameters of secondary school inefficiency effects model based on Battese & Coelli (1995) were reported in Table 4. The number of teachers and teaching ability have straightforward determinant to change the efficiency while both the number of students and the number of class rooms are the cause of decreasing secondary school efficiency. In inefficiency effects model, a positive coefficient points the decrement of efficiency and vice-versa. Both the coefficient of ICT lab and online class had no direct influence to improve secondary school efficiency. Both ICT lab and online class in secondary school were found increasing the level of inefficiency. The coefficients of ICT tools that is multimedia projector used always, often, sometimes, rarely, and never in teaching and learning were found negative which indicated that multimedia projector use play positive role in decreasing the school inefficiency. The estimated value of σ was found other than zero, point a fit. The value of γ (1.00) was positive and significant, interpreted that 100% random fluctuation in secondary school outcomes due to inefficiency.

Table 4. MLE of Cobb Douglas frontier secondary school inefficiency effects model with Battese & Coelli (1995) for Barisal division

Variables	Parameters	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	β_0	4.39E+00	1.48E-01	29.6459	<2.20E-16***
X_1	β_1	3.80E-01	6.89E-02	5.5172	3.44E-08
X_2	β_2	-1.09E-01	3.06E-02	-3.5459	0.000391
X_3	β_3	-8.14E-02	3.77E-02	-2.1604	0.030738
X_4	β_4	6.15E-02	2.65E-02	2.3199	0.020345
Estimation of Inefficiency Effects Model					
Z_1	δ_1	4.50E+01	1.07E+02	0.423	0.672317
Z_2	δ_2	2.21E+01	5.10E+01	0.4328	0.665159
Z_3	δ_3	-7.48E+02	1.78E+03	-0.4203	0.674247
Z_4	δ_4	-2.54E+02	5.96E+02	-0.4261	0.670057
Z_5	δ_5	-2.06E+02	4.88E+02	-0.4223	0.672809
Z_6	δ_6	-4.94E+02	1.18E+03	-0.4194	0.674941
Z_7	δ_7	-1.95E+02	4.59E+02	-0.4253	0.670635
Variance Parameters					
sigmaSq	σ^2	1.19E+01	2.81E+01	0.4247	0.67104
gamma	γ	1.00E+00	8.30E-04	1203.82	<2.20E-16***

*, **, *** Significance level at 1, 5, and 10%, respectively, @ indicates insignificant.

Table 5. MLE of translog stochastic frontier secondary school model based on Battese & Coelli (1992) for Barisal division

Variables	Parameters	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	β_0	-0.06377	0.96663	-0.066	0.947405
X_1	β_1	-3.0000	0.945688	-3.1723	0.001512**
X_2	β_2	1.139749	0.565578	2.0152	0.043884*
X_3	β_3	3.383784	0.937686	3.6087	0.000308***
X_4	β_4	0.913261	0.982752	0.9293	0.352739
X_1^2	β_1^2	-0.03711	0.928759	-0.04	0.968126
X_2^2	β_2^2	-0.10959	0.179147	-0.6117	0.540735
X_3^2	β_3^2	0.468403	0.845511	0.554	0.579587
X_4^2	β_4^2	0.517098	0.911567	0.5673	0.570535
$X_1 X_2$	$\beta_1\beta_2$	0.498826	0.35566	1.4025	0.160755
$X_1 X_3$	$\beta_1\beta_3$	0.055493	0.670956	0.0827	0.934084
$X_1 X_4$	$\beta_1\beta_4$	0.155277	0.947201	0.1639	0.869784
$X_2 X_3$	$\beta_2\beta_3$	-0.69512	0.309235	-2.2479	0.024585*
$X_2 X_4$	$\beta_2\beta_4$	-0.1178	0.467457	-0.252	0.801034
$X_3 X_4$	$\beta_3\beta_4$	-0.27961	0.941009	-0.2971	0.766365
Variance Parameters					
sigmaSq	σ^2	0.029747	0.072586	0.4098	0.681943
gamma	γ	0.979259	0.961305	1.0187	0.308357

*, **, *** Significance level at 1, 5, and 10%, respectively, @ indicates insignificant.

Results of Secondary School Efficiency with Translog Model based on Battese & Coelli (1992) for Barisal Division

MLE of the parameters was reported in the context of secondary school efficiency in Barisal division of Bangladesh followed by Translog stochastic frontier model presented in Table 5. The coefficients of students, class rooms and teaching ability of the teachers in secondary school have had a positive and significant contribution to improve the school efficiency. Again, the coefficient of the number of teachers was observed negative and significant. Both the square effects of the number of class rooms and teaching ability have had positive effect in increasing secondary school efficiency while both the square effects of the number teachers and the number of students have had negative effect in decreasing secondary school efficiency of Barisal division in Bangladesh. The interaction effects of the number of teachers along with the number of students, number of class rooms and teaching ability were found positive in improving the school efficiency. The interaction effects of the number of students along with the number of class rooms and teaching ability of the teachers played role to decrease the school efficiency. These two interaction effects have reversely effect on secondary school efficiency of Barisal division in Bangladesh. The estimated value of σ was different from zero, indicate a good fit. The value of γ was positive and it showed that 97.9 percent of random variation around in secondary school outcomes due to inefficiency.

Table 6. MLE of translog stochastic frontier secondary school inefficiency effects model based on Battese & Coelli (1995) for Barisal division

Variables	Parameters	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	β_0	-0.24606	0.941141	-0.2615	0.793744
X_1	β_1	-3.37322	0.743082	-4.5395	5.64E-06***
X_2	β_2	1.220791	0.400539	3.0479	0.002305**
X_3	β_3	3.860197	0.824975	4.6792	2.88E-06***
X_4	β_4	0.501341	0.646967	0.7749	0.438393
X_1^2	β_1^2	-0.05703	0.823535	-0.0692	0.944793
X_2^2	β_2^2	-0.10718	0.101187	-1.0592	0.289517
X_3^2	β_3^2	-0.2258	0.36076	-0.6259	0.531382
X_4^2	β_4^2	0.002993	0.282557	0.0106	0.991549
$X_1 X_2$	$\beta_1\beta_2$	0.434356	0.161262	2.6935	0.007071**
$X_1 X_3$	$\beta_1\beta_3$	0.559359	0.420545	1.3301	0.183492
$X_1 X_4$	$\beta_1\beta_4$	-0.4973	0.299074	-1.6628	0.09635.
$X_2 X_3$	$\beta_2\beta_3$	-0.72682	0.138808	-5.2362	1.64E-07***
$X_2 X_4$	$\beta_2\beta_4$	0.058787	0.203106	0.2894	0.772245
$X_3 X_4$	$\beta_3\beta_4$	0.162539	0.335548	0.4844	0.628104
Estimation of Inefficiency Effects Model					
Z_1	δ_1	-0.0896	0.12539	-0.7146	0.474862
Z_2	δ_2	0.276774	0.177718	1.5574	0.11938
Z_3	δ_3	-0.34244	0.552236	-0.6201	0.5352
Z_4	δ_4	-0.14233	0.360711	-0.3946	0.693146
Z_5	δ_5	-0.13125	0.406127	-0.3232	0.746556
Z_6	δ_6	-0.38576	0.378693	-1.0187	0.308368
Z_7	δ_7	-0.21849	0.477283	-0.4578	0.647108
Variance Parameters					
sigmaSq	σ^2	0.019072	0.01131	1.6862	0.091754
gamma	γ	0.997001	0.03559	28.0133	<2.20E-16***

*, **, *** Significance level at 1, 5, and 10%, respectively, @ indicates insignificant.

Results of Secondary School with Translog Inefficiency Effects Model based on Battese & Coelli (1995)

MLE of the parameters was reported in the context of Translog stochastic frontier secondary school efficiency model with Battese & Coelli (1995) for Barisal division in Bangladesh presented in Table 6. The coefficient of the number of students, class rooms and teaching ability were found to be positive values where the number of students and class rooms were recorded significant. It implies that these have had direct impact to improve efficiency of secondary school. The square effects of the number of teachers, the number of students, class rooms have had reversely effect on secondary school efficiency of Barisal division in Bangladesh. The coefficient of squared effect of teaching ability of the teachers has positive effect in the secondary school efficiency. The interaction effects of the number of teachers and the number of students was recorded positively significant. The interaction effects of the number of teachers and class rooms, the number of students and

teaching ability of the teachers, and class rooms and teaching ability of the teachers have had positively impact to increase the secondary school efficiency. The interaction effects of the number of teachers and teaching ability of the teachers, and the number of students and the number of class rooms have had reversely effect on secondary school efficiency of Barisal division in Bangladesh. The coefficients of all explanatory variables except online class variable were recorded negative, indicated that the ICT lab, teacher's preference ICT tools for example multimedia projector used variables have direct influence to decrease secondary school inefficiency. The explanatory variables those were found negative hence decreasing the level of inefficiency. The online class in school was found increasing the level of inefficiency. The technical efficiency level tended increasing due to the cause of effect on multimedia projector used in teaching and learning in secondary school. The value of γ was positive and significant, interpreted that 99.7 percent of random variation exists in secondary school through inefficiency. The estimate of sigma was found significant and positive, indicated that the estimated factors are perfectly fitted to this model.

Results on the Choice of Appropriate Model for Barisal Division with Battese & Coelli (1992, 1995)

The results of likelihood ratio test for an appropriate model for Barisal division with Battese & Coelli (1992, 1995) is represented in Table 7. The likelihood values of Translog and Cobb-Douglas models with Battese & Coelli (1992) were found 65.604 and 53.813 respectively. The chi-square value was recorded 23.582 and significant. Based on the likelihood values that Translog model is an appropriate than Cobb-Douglas model. Again, the likelihood values of Translog and Cobb-Douglas models were found 80.648 and 63.924 respectively. The chi-square value was recorded 33.45 and significant. So it can be concluded that Translog model is an appropriate than Cobb-Douglas model in case of Battese & Coelli (1995).

Table 7. Results of likelihood ratio test for an appropriate model for Battese & Coelli (1992, 1995)

Model	Log Likelihood Value	Degrees of freedom	Chisq	Pr(>Chisq)
Trans_Barisal_92	65.604	17		
CD_Barisal_92	53.813	7	23.582	0.00879[**]
Trans_Barisal_95	80.648	24		
CD_Barisal_95	63.924	14	33.45	0.000229[***]

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

District-Wise Efficiency Results of Secondary Schools (Urban & Rural) in Barisal Division

From the results, it was presented in Table 8 that both Cobb-Douglas and Translog stochastic frontier models (Battese & Coelli, 1995) performed better compare to (Battese & Coelli, 1992) models in determining the district-wise average efficiency of both urban and rural secondary schools in Barisal division. Again, Translog frontier model (Battese & Coelli, 1995) performed better than Cobb-Douglas frontier model (Battese & Coelli, 1992) in measuring the average efficiency of urban secondary schools. Again, Cobb-Douglas frontier model (Battese & Coelli, 1995) performed better than Cobb-Douglas frontier model (Battese & Coelli, 1992) in determining the average efficiency of rural secondary schools in Barisal division.

Table 8. District-wise average efficiency score of secondary schools (Urban & Rural) in Barisal division

District	Urban				Rural			
	TL 92	TL 95	CD 92	CD 95	TL 92	TL 95	CD 92	CD 95
Barisal	0.92246	0.96612	0.90188	0.95611	0.84205	0.85087	0.85529	0.89739
Bhola	0.92245	0.92463	0.93282	0.96648	0.88854	0.90805	0.85807	0.90569
Patuakhali	0.82694	0.93716	0.88998	0.96424	0.84990	0.86368	0.84384	0.90132
Pirojpur	0.92201	0.93173	0.89914	0.94846	0.81180	0.80506	0.75050	0.76773
Barguna	0.86461	0.86771	0.85663	0.91503	0.86952	0.89374	0.86016	0.91144
Jhalokati	0.80201	0.89834	0.87175	0.97924	0.92298	0.91792	0.93090	0.95431
Overall Mean	0.87675	0.92094	0.89203	0.95492	0.86413	0.87322	0.84979	0.88964

The overall urban mean efficiency was observed 92.09% while it was recorded 87.32% for rural secondary schools in case of Translog (1995) model. Again, for Cobb-Douglas (1995) model, the overall mean efficiency of urban secondary schools was found 95.49% while it was observed 88.96% for rural secondary schools. These showed that the urban secondary schools performed better than the rural secondary schools in Barisal division. On an average the urban secondary schools of Bhola district are comparatively better than other districts when Cobb-Douglas stochastic frontier (1995) model were used and on an average the urban secondary schools of

Barisal district are found comparatively better than other districts when Translog stochastic frontier (1995) model were used. Again, on an average the rural secondary schools of Jhalokhati district are comparatively better than other districts in case of both Cobb-Douglas and Translog stochastic frontier models (1995).

Results of Tobit Regression Model with Secondary School Efficiency for Barisal Division

Table 9 represents the results of the factors affecting to secondary school efficiency derived from both stochastic Cobb-Douglas and Translog frontier models for Barisal division. As regards the explanatory variables, by Tobit regression with inefficiency, in case of Translog model with (Battese & Coelli,1992, 1995) the teacher student ratio was found negative and significant, implying that the teacher-student ratio had a negative impact on the secondary school efficiency. In case of Translog model with (Battese & Coelli,1992, 1995) the teaching experiences those who have 6 to 10 years was observed negative and highly significant implying that has negative influence on the secondary school efficiency. Non-government school type, and school location (rural) were notice negative but significant and these had a negative influence on the secondary school efficiency. Again, both medium and high level ICT teaching ability were recorded positive and significant for both Cobb-Douglas and Translog models indicating that this had a positive influence to increase the secondary school efficiency.

Table 9. Determinants of factors affecting to secondary school efficiency of Barisal division

Variables		Parameters	Tobit Regression Model			
			TL_1992	TL_1995	CD_1992	CD_1995
Intercept		ϕ_0	0.966***	0.908***	0.845***	0.857***
Teacher Student Ratio		ϕ_1	-0.003**	-0.0009	0.001	0.0004
Teaching	< 1 Years					
Experience	1-5 Years	ϕ_2	-0.006	-0.058	-0.061*	0.002
	6-10 Years	ϕ_3	-0.062	-0.118***	-0.095***	-0.101***
	> 10 Years	ϕ_4	-0.006	0.016	0.040	0.025
School Type	Government					
	Non-government	ϕ_5	-0.008	-0.071***	-0.077***	-0.037
	MPO	ϕ_6	0.049*	0.008	-0.013	0.021
School Location	Urban					
	Rural	ϕ_7	-0.065***	-0.019	-0.011	-0.047**
Preference of	Modern					
Teaching Methods	Conventional	ϕ_8	-0.032	-0.014	0.002	-0.018
ICT Teaching	Low					
Ability	Medium	ϕ_9	0.062***	0.069***	0.047**	0.085***
	High	ϕ_{10}	0.134***	0.152***	0.115***	0.186***
Log likelihood	58.994					
Sigma	0.038					

*, ** . *** means significant at 10%, 5% and 1% level

Conclusion

This study developed an appropriate model to estimate the secondary school efficiency and in this context Translog stochastic frontier model was found an appropriate than Cobb-Douglas model for Barisal division in Bangladesh. The Stochastic frontier models were applied to estimate secondary school efficiency of Barisal division and Tobit regression was utilized to look into the grounds of secondary school efficiency. The study is contrary from the earlier as it adopted a two-stage (Tobit) regression to analyze the effects of the secondary school efficiency of Barisal division in Bangladesh.

In measuring the average efficiency of urban secondary schools for Barisal division, Translog model (Battese & Coelli, 1995) performed better than Cobb-Douglas (Battese & Coelli, 1992). While Cobb-Douglas model (Battese & Coelli, 1995) performed better than Cobb-Douglas model (Battese & Coelli, 1992) in case of rural secondary school's efficiency. The number of students, the number of class rooms, the teaching ability of the teachers were found positive and significant which indicated that these have straight determinant to gain the secondary school efficiency. The interaction effects of the number of teachers with the number of students, number of class rooms and teaching ability were found positive which implied that these have positive impacts to increase the secondary school efficiency of Barisal division.

The explanatory variables such as ICT lab, and teacher's preference ICT tools like multimedia projector were found positive indicated that these played significantly contributor role in increasing the secondary school efficiency. The urban secondary schools performed better than the rural secondary schools. In specific, on an average the rural secondary schools of Jhalokhati district was found comparatively better than other districts of Barisal division. In case of Tobit regression, both medium and high ICT teaching ability of the teachers were recorded positive and significant which implied that these variables had a positive influence towards the secondary school efficiency of Barisal division in Bangladesh.

Scientific Ethics Declaration

The authors declare that they are responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgement

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To cite this article:

Technology Integration and SkELL: A Novelty in English Foreign Language Teaching and Learning

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Abstract: The development of technology and its web-applicative tools in reference a variety of fields of contemporary interest, has flourished even the horizons of education. Due to the necessity of the rapid growth of Technology, its integration was considered as a solution to the covid-19 pandemic worldwide situation that caught humanity unskilled on such frequent and easy-to-follow use of 'learning by doing' when dealing with knowledge. On purpose, the present study introduces the implementation of SkELL (Sketch Engine for Language Learning) in English Foreign Language (EFL) learning and teaching as a rich source of free online linguistic data, provided the use of authentic texts (hereby to corpus data). All of these constituents autonomously yield both sides: learners and teachers to learner-learner interaction, learner-teacher interaction. Throughout the exploitation of its various web-applicative tools such as: Word Sketch, Thesaurus, Wordlist, Concordance, and Visualization among a range of others made possible and available EFL learning, and assisted teaching during the hard educational situation. It consequently may serve as a pre-requisite for language practitioners, curriculum designers to facilitate overall EFL teaching and learning process.

Keywords: Technology integration, SkELL, EFL, Corpus linguistics, Web-applicative tools.

Introduction

Foreign language learning and teaching has undergone significant changes as the result of the today's demands that all kinds of social, cultural, economic, political, technological developments are evolving during the past decades. Crucially it has become a necessity in today's educational system majoring various general, vocational learning and teaching of human endeavor. Technology integration especially in the field of education has affected overall learning and has empowered positively students' outcomes in terms of: raising the dependent variables' efficacy especially in foreign language learning: motivation, engagement, skills, proficiency. Technology integration clearly explained from the website Edutopia (http://www.edutopia.org/), refers to the use of technology resources such as: PCs, mobile devices like smartphones and tablets, social media platforms and networks like Goggle classroom, Moodle, Microsoft Teams, software applications to implement in language learning like Wordsmith, Compleat Lextutor, Academic Word List, SKELL, the internet, … etc, and all of these serving the scope of enriching our daily classroom practices and scaffolding the so called "skills of the 21st century". In addition, Friginal (2018) embraces the view that successful technology integration depends on the cases when technology: a) has become routine and transparent b) is accessible and readily available for the task at hand, and c) is supporting curricular goals and helping teachers/learners effectively reach their goals (Frignal, 2018, p.30). Yet what he puts emphasis more, is the fact that a well-integrated use of technology equipment and resources requires well-trained teachers to adopt all of these constituents to gain as the final outcome well-prepared students. In essence this view reports to be utopic in underlying that technology integration can cot lead to unified outcomes due to the varied tools, practices, relationships, curriculum goals and constructs and in dependency to teachers' and learners' involvement and willingness to embrace change in this ongoing process.

As technology continues to evolve it requires continual learning and shifts in paradigm from both teachers and learners. According to the Brookings Institute (1916) research, technology integration in education especially at higher education improves academic achievement. Yet the prerequisites that ought to be followed are: the real-time use, personalized instruction, and mastery-based progression. Grounded on these determining elements to

yield to progression in the final outcomes, our study builds on the research statement that technology once incorporated with deliberate skill from the language instructors it will allow the latter to customize language learning by creating varying levels of scaffolding support from the students involved in the process. Specifically, the present study constructs on the factual incorporation of Corpus Linguistics and its wide range of relevant applications to foreign language teaching and learning. Specifically, McEnery & Hardie (2012) confine this approach in SLA which focuses upon a set of procedures, or methods, for studying language. It has the potential to reorient our entire approach to the study of language by refining and defining a range of theories of language that we may construct for a better understanding and adequate use of the latter from attested language use and findings drawn from it. Corpus linguistics can be reasonably defined as dealing with some set of machine-readable texts deemed to give possible answers to a specific set of research questions. Yet it is not a consensually agreed set of methods and procedures for the exploration of foreign language. This underpins McEnery & Hardie's (2012) the statement that corpus linguistics is a heterogeneous field in which differences prevail due to the varying approaches that may be applied to the use of corpus data. Typical of the corpus analysis are the generalizations inferred from the large scale.

Methodology

The advancement of technology has made possible its extension in use and extent via internet, regardless space and time limits. The more it advances, the greater the users will add and considerable benefits would be gained in all spheres of human activities. Moreover, its influence is notably encountered in the field of education especially during the pandemic period which found educators and students unskilled and lacking the most essential means of technology: computer, devices and internet to fill the long gap created from the physical interruption learning process. In various developed countries technology integration was viewed as a counterproductive means of transmitting knowledge, service, and information prior the pandemic, during and long after it. It has reported to be a variable that became an integral part of the learning process and as such positively impacted student learning. Del Vecchio & Loughney (2006) define E-learning throughout technological devises as beneficial to education since it applied to all types of learners due to its flexibility features i.e. saves time, informs learners regardless space, assists them share information and activities, and fulfills commitments in cases of in-class physical absences, and above all it produces measurable, reliable and prompt results for each learner. It allows both parts: learners and teachers to record, view, analyze, correct and seek for improvements in the overall learning commitments so as to meet the demands that the today's speed of developments require.

Yet, despite the benefits we all obtain, the limitation to technology integration underlies in the fact that learners need to have computer skills starting from basic to proceed to more advanced level. The latter is acquired to deal especially with word processing programs, internet browsers, web sites that provide contemporary tools to analyse language and/or information data. They need to gradually pass in a self-paced style from basic inquiry to more conceptual, analytic inquiry vs. learning outcomes. It is the teacher's main objective to fit the triangle: learner - technology – learning to support what Fitriah's (2018) statement that E-learning, is a denominator in increasing learner's engagement and as such it promotes the improvement of the memorizing concepts and better performance in terms of results. The above-stated triangle corresponds to the same components of English language pedagogy that Chappelle & Jamieson (2009) connect with technology as part of the curriculum: teacher, learner and English (or the content of teaching). All these components move upwards and downwards centering technology to all kinds of classroom technologies but with a major impetus on corpus-based technology. Specifically, in the domain of Corpus Linguistics (CL) this model highlights the potential strengths and weaknesses of CL tools when applied in the EFL classroom. It makes the teachers responsible and sensitive in deciding how corpus-based technology in association to web-applicative tools would fit into their teaching philosophy. When all the components of this triangle are considered as complimentary constituents and if effectively integrated into the curriculum, corpus-based technology will no doubt influence English Foreign Language learning and teaching in powerful and novel ways.

SkELL (Sketch Engine for Language Learning)

Grounded on Corpus Linguistics, corpora, corpus data, the present study highlights the use of free online web-applicative tools that these huge bodies of electronic texts offer for teachers, learners and researchers to conduct all kinds of linguistic analysis of the authentic corpus-based data. Provided the fact that they are free and online it is worth using new approaches especially to English Foreign Language teaching and learning. This is made possible by implementing their direct use so as to attribute to the process the benefits that Friginal (2018) cites

from Leech 1997's study outlining the use of computers, internet, and online tools in language learning which aligned with Computer-Assisted Language Learning (CALL) principles of:

1) automatic searching, sorting and scoring;
2) promoting a learner-centered approach;
3) open-ended supply of language data; and as such enabling the learners to be tailored.

To the time of being introduced the benefits of them were not so satisfactorily in classroom use provided that computers were large, the language data they stored was moderately accounting thousands of word usages, and internet access was limited to certain areas for restricted operational use. Today the rapid development of technology and its sophisticated devices has made possible the application of corpus-based tools and materials to which virtually all kinds of learners have global access. Moreover, hardware and software have become accessible online as it is the case of examining linguistic variation in the broader exploration of lexico-syntactic characteristics of spoken and written language through SkELL (Sketch Engine for Language Learning). Being a tool to show how words are used by real speakers of the language, it supports more than 95 languages aiming to assist linguists, translators, interpreters, lexicographers, dictionary companies and more currently is used by language teachers and students as well. Users can even build their own specialized language database (text corpora) and analyze the latter by means of built-in text analysis tools such as Word Sketch, Thesaurus, Wordlist, Concordance, and Visualization.

Implementing web-applicative tools in EFL teaching and learning: Word Sketch, Thesaurus, Wordlist, Concordance, and Visualization. Sketch Engine is the ultimate tool to explore how language works. Its algorithms analyze authentic texts of billions of words as corpora lines display to identify instantly what is more typical in a language and what is rare, unusual or recently and developmentally emerging in use. Pavel Rychlý is a computer scientist and researcher in natural language processing. Since his PhD on indexing text corpora, he has turned to efficient large-scale text processing. Pavel is the main software architect of Sketch Engine and the original author of many of its components, mainly the Manatee corpus indexing system.

Michael Rundell is a linguist and lexicographer. As a dictionary editor since 1980, he has designed and managed numerous dictionary projects. He is a leader in the field of pedagogical English dictionaries. He is currently Editor-in-Chief of macmillandictionary.com, having started a dictionary development programme at Macmillan in the late 1990s. He has been involved in the Sketch Engine development since its very beginning as a consultant and nowadays his main responsibility is running the Lexicom training courses.

Sketch engine is free and easy to use and the initial steps you need to follow are: 1) register so as to have free access of the search for 30 days 2) start by (Figure 1) logging in and switch to the new interface 3) select the English language among a range of others to proceed with the language exploration. If not properly competent in using it, click on the right side of the page on the quick start tutorial (Figure 2) to observe how to start using the program.
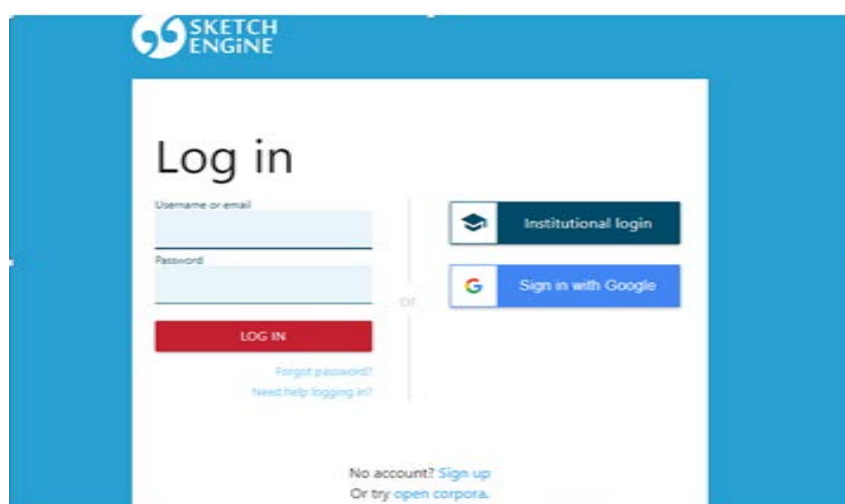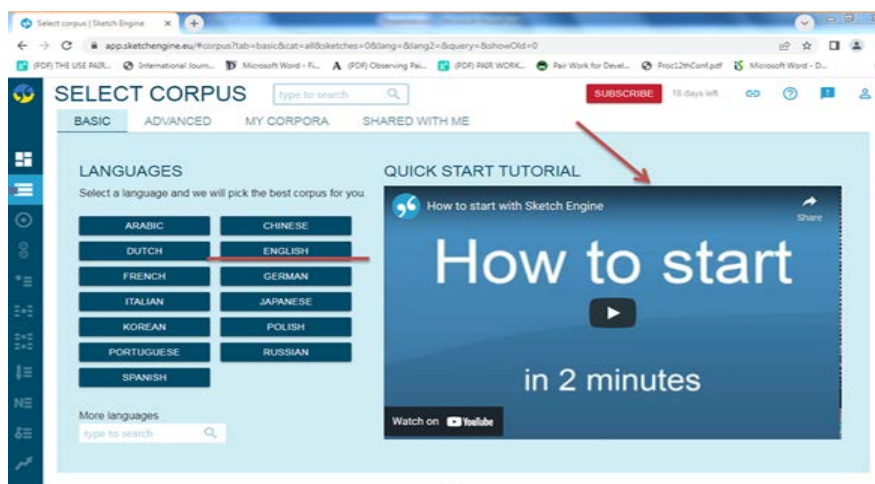

Figure 1. SkELL log in interface

Figure 2. Language and tutorial display

Once you log in, Sketch Engine interface displays in the gadget that you use for language learning. A range of innovative tools (Figure 3) appear to assist all kinds of language learners in exploring corpora, authentic texts, language behavior output from native speakers of English product of various social communicative texts across different registers. It boosts the learners' interest in exploring the site itself and its web-applicative tools. Moreover, it fosters autonomous learning and web-based inquiry of any encountering linguistic ambiguity or language hypothesis that goes beyond the disconnected lines of concordance text.
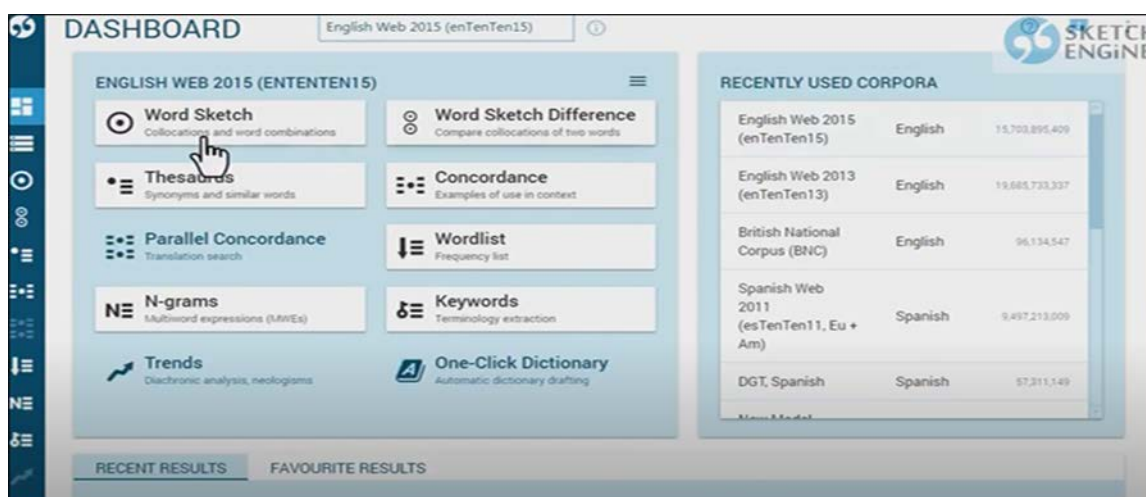
Figure. 3 Sketch engine tool interface

The selected tools from the SkELL resulted as novelty in our EFL and ELT Master students' classes. They provided a considerable number of linguistic data that demanded the students' attention on what linguistic analysis to initially pursue in terms of vocabulary and grammar. The following tools, figures of illustration are a clear evidence of the actual and novel web-tasks that were generated by exploring and later on implementing this corpus search website in English language classrooms. For ease of application and understanding the targeted search word 'opinion' was applied in the search icon box with each respective tool so to apprehend the linguistic use, significance and insights this very word can gain in reference semantics, morphology, grammar and syntax as well.

Word Sketch

This tool furnishes language users with a variety of linguistic information (morphological, semantic, syntactic) viewing the word's searched variance in terms of contextual collocations, frequency use across registers, and semantic use by having a concrete display of it in a larger and authentic use in concordance lines.

Figure 4. Word sketch interface

The specific and useful information that we get from this tool all in one try and in one interface is considerable provided the modifying use of the given word example "opinion" and the dozens of examples it gives for a clear understanding of it attributed in different parts of speech in contextual use. For instance, as modifiers of 'opinion' we notice the various collocations such as:

Adjective + opinion: the majority opinion, expert opinion, humble opinion, dissenting opinion …etc providing so connotative meanings and use of how and in what communicative occurrences 'opinion' can be.
Opinion + Noun: opinion polls, opinion piece, opinion formers, opinion editorials, opinion column.
Verb + opinion: express/ voice/ differ / form / reflect / issue / share opinion.

The semantic meaning, we specifically get from this type of collocation is that throughout the contextual examples we get informed for the formal use of the word "opinion" and its associate verbs in this register. If we replace the informal counterpart meaning of "opinion" with the informal "thought" we notice other verbs (few in numbers) to collocate with it such as: have / think/ clarify/ collect/ give a thought.

In the third and fourth column we may also note the use of the word "opinion" having various syntactic collocations as displayed in the Figure 4. as subject and as object to modify a specific verb in such different functions. For instance: reflect/concur opinion *versus* the opinion polls; opinions vary ... etc

Thesaurus

Thesaurus in Sketch Engine is an automatically generated list of synonyms or words belonging to the same category (semantic field). The list is produced on the exact context in which the words appear in the selected corpus. Only nouns, adjectives, verbs and adverbs are supported in most corpora. Provided the following Figures 5&6 of Thesaurus interface, the information you get in an instant is of great learning assistance. It gives learners the possibility of observing all the synonyms of the searched word without carrying any kind of dictionary or thesaurus to deal with such linguistic inquiry. Moreover, it is suitable to both types of language learners: Basic or Advanced. In the given example of the searched word "opinion" we are provided by a range of synonyms such as: belief, statement, comment, thought, view, advice, decision, perspective, argument, knowledge .., etc. The score given for each synonym indicates the percentage of shared collocates. For a better comprehension of a word's contextual implication you can use the local menu at the Change View Option to see the examples of real text use, in addition to the collocations, listed number of synonyms, clusters, counts of use in the discourse of the key word with other content words. The obtained metadata is instantly elicited in terms of frequency, similarity to indicate that the scores given for each synonym indicate the percentage of shared collocates.

As viewed, thesauri are a good tool in English language learning as it assists learners in expanding, enriching and reinforcing vocabulary. For the most it is easily and freely used on the web because no manual work and no reference book are involved. The list of synonyms generated from this simple search provides a sufficient number of authentic native occurrences found in any targeted corpus.
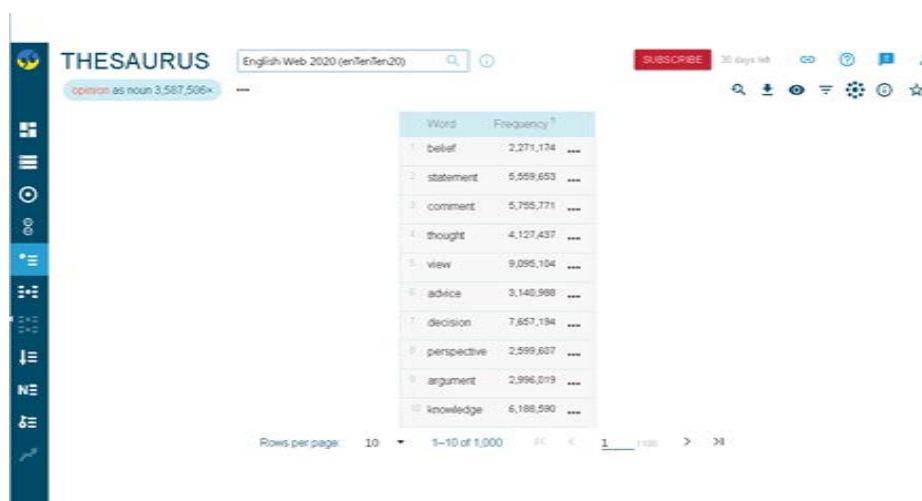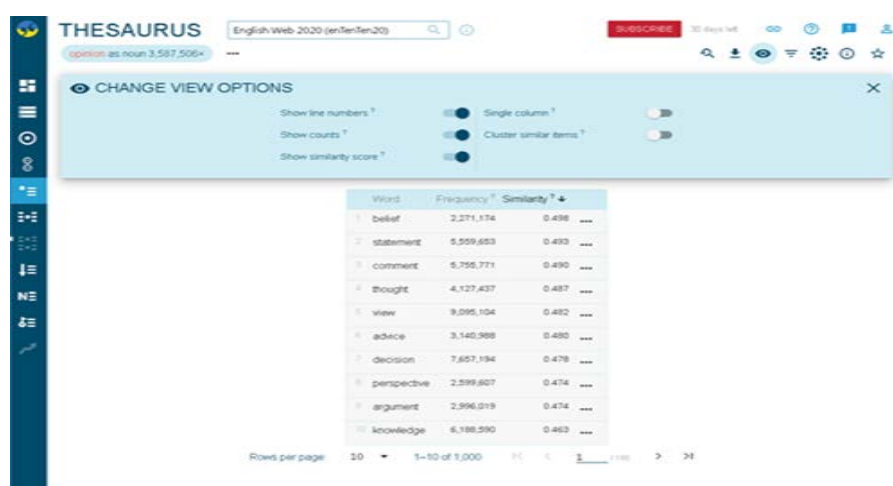
Figure 5. Thesaurus interface

Figure 6. Change view options of 'opinion'

Wordlist

The Wordlist tool is used to generate frequency lists of all kinds: lists of words, lemmas, nouns, verbs, tags, words containing or not containing certain characters etc. Word lists typically enable the searcher to examine the frequency of a word or a phrase in different contexts as an important part of its description. Various word lists that are based to some degree on word frequency in a corpus exist especially in the English language teaching (ELT) context. Word lists are a good starting point for subsequent searches of individual items at concordance level and can be useful in the comparison of different corpora. Moreover, they can be generated to account for individual items or for recurrent sequences of two or more items. Lemmatized frequency lists (Figure 7.) all group together words from the same lemma. For example, McEnery & Hardie (2012) define the meaning of lemma as a group of word forms that are related by being inflectional forms of the same base or term throughout a simple example of the English words: destroy, destroys, destroying and destroyed as part of the verb lemma 'destroy'; each of which will automatically be counted separately in annotated texts. It should be noted that other derivate words of the stem word belonging to various parts of speech such as: destruction, destructive are both considered as separate lemmas. These are related to the stem lemma 'destroy' by derivational rather than inflectional processes. Lemmatization can be done manually using an alphabetical frequency list, or in an automated way.

Different forms of the same lemma tend to vary significantly in terms of their overall frequency, with one particular form tending to be more frequent than others. The wordlist works on the token level. The default settings will produce a list of words because non-words are excluded automatically. The wordlist can also be limited by frequency, by setting the minimum and maximum limit.
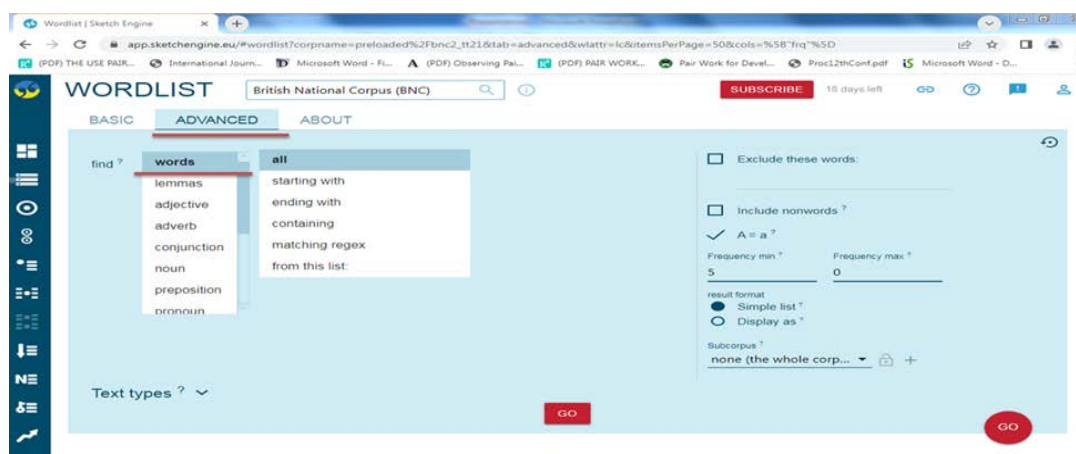
Figure 7. Interface of wordlist tool

Frequencies can be obtained for a list of concrete words. Use the: *from this list*: option on the advanced tab and input the items for which frequencies should be calculated from the selected corpus. Regular expressions can be used to define complex criteria for the words that should be included in the frequency list. For a more concrete and contextual understanding, let us try to find corpus authentic uses (Figure 8) of the word "opinion" by using the Wordlist tool and selecting another corpus for linguistic analysis such as The British National Corpus (BNC).
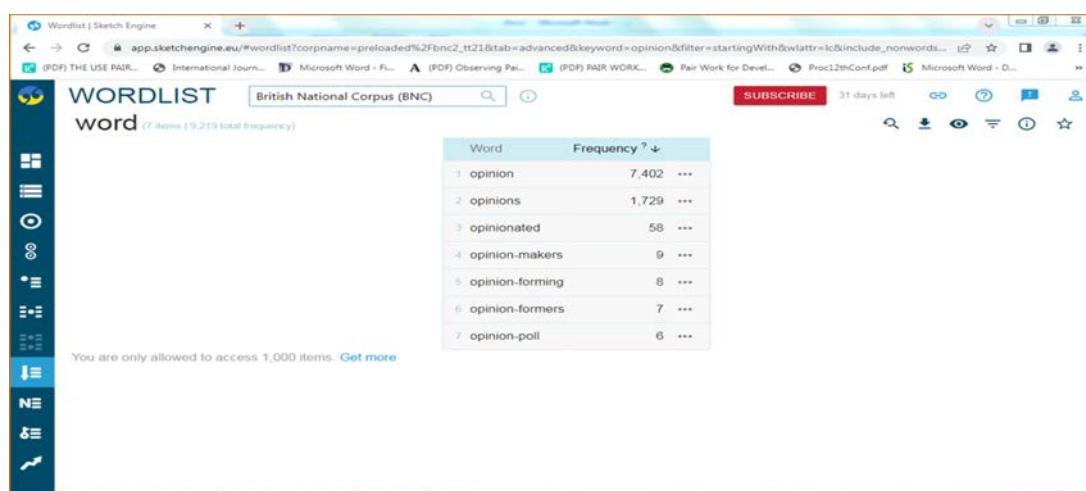
Figure 8. Lemmatized frequency list of 'opinion'

Concordance

Concordance may be considered as the most powerful tool as it consists of a variety of search options. Throughout its search option we can find and elicit words, phrases, documents, text types or corpus structures all of this linguistic data displayed in the form of a concordance (Figure.9). As Friginal (2018) defines concordances are reference books comprised in alphabetical listings of all significant content words such as: prepositions, articles, adverbial phrases. Besides they can add to the primary list from the source text, a secondary list of words that co-occur before or after the primary word in association to the text enabling searchers to understand the contextual meanings of each word as extracted from the genuine source of its occurrence. Concordances derived from digital text files of actual language in oral and written discourse can provide comparative and quantitative linguistic data useful in characterizing the shared meanings that refer to a specific group of people involved in communicative settings. Specifically, concordances can be utilized to identify the different usages and frequency of a content word, examine word collocations, and explore key words in context indexes to define the subtle nuances and the semantic meanings intended by the speakers or writers of the texts.
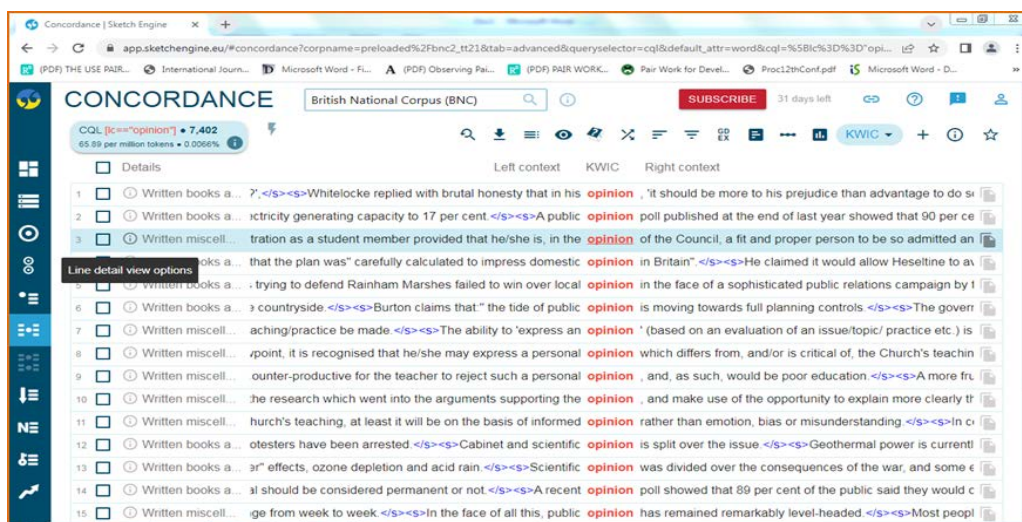
Figure 9. Concordance interface

We may further use view options (Figure 10) for tags and other attributes. Here we can see the frequency of the word "opinion" in different websites. If the concordance is very large you can work with smaller numbers of randomly selected lines. A random sample with the same number of lines from the same concordance will always produce exactly the same concordance lines. This corpus-based data behavior is intentional so that different users (e.g. students) do not get confused when examining such huge amount of data. It is advisable to follow the same steps and consequently arrive at the same result.
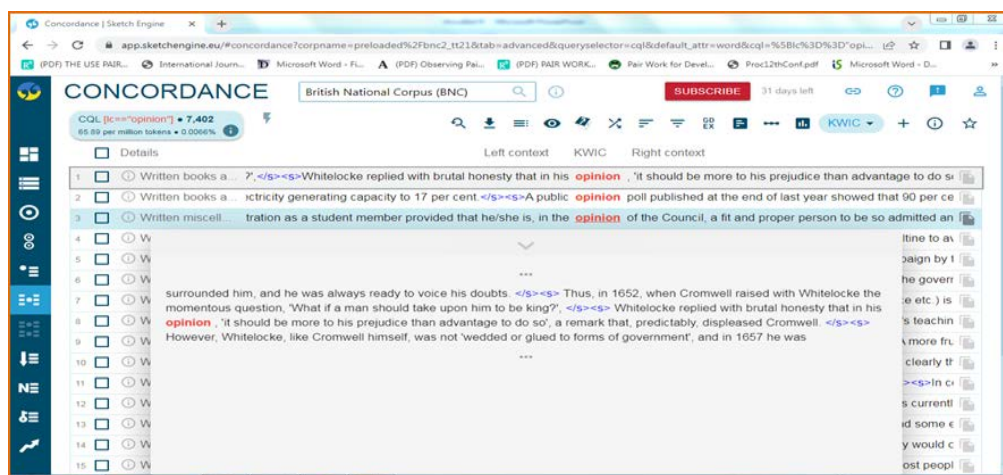
Figure 10. View options: Concordance 'opinion'

Provided the various intentional commands we give on the search icon box, we generate a different sample for each attempt with different scores in dependency to frequency which is the base measure to examine whether the targeted word is frequent or infrequent in use.

We can order the lines by the command to yield to:

- the standard KWIC view that easily enables the context/s observation to the right and left;
- a rather advanced research by eliciting linguisitic corpus-data for the token that comes before KWIC which is the left context or after it which is the right text.
As viewed from the (Figure 11) the concordance can be sorted, filtered, counted and processed further to obtain the desired result. Despite being the most powerful tool, the concordance used with large corpora may find so many results that it can tedious to analyze and interpret them.
The view options allow displaying additional information such as lemmas, tags and other attributes, text types (metadata) or corpus structures. Yet such careful decisions should be made so that introduce the new concepts and tasks in the lanaguage classroom fstarting from basic to more advanced tasks in English language classroom.
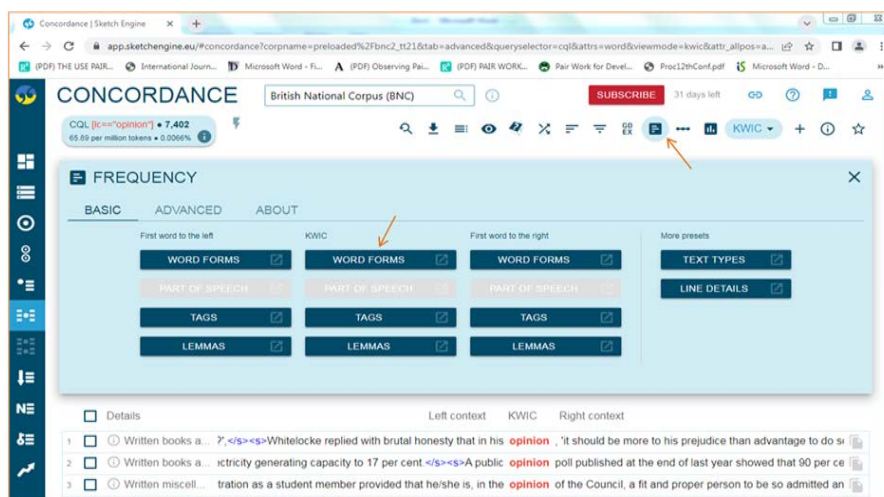
Figure 11. Frequency data word forms

Visualization

The SkELL allows English foreign learners to provide word distributions obtained from the Visualization icon (Figure 12) to get a better understanding of the range of synonyms or similar words that the targeted word may have and all of them are identified automatically. Notably, as displayed from (Figure 13.) a list of the synonyms of the word "opinion" is orderly obtained in a raw coming one after another in terms of proximity of semantic meaning as well as frequency use.
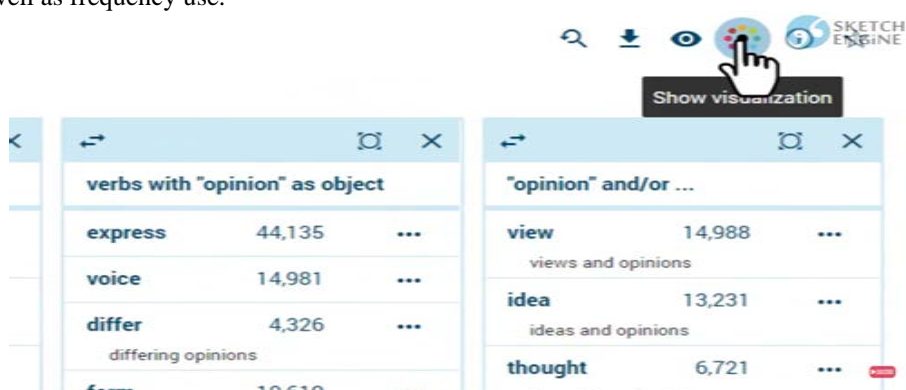
Figure 12. Interface of visualization icon

Figure 13. Visualization sample of the word 'opinion'

The adequate explanation is based on the theory of distributional semantics which states that in a nutshell, words occurring in similar contexts are also similar in meaning. The visualization display as seen from the (Figure 13.) gives the list of words in reference the targeted word 'opinion' in terms of synonyms and common similar words. Precisely the semantic meaning of the presented words (such as: idea, view, decision, belief, statement…etc) both in lines and through graphical image presenting them in various font sizes with the

implication of the highest sematic meaning and use of the possible synonyms of the word 'opinion'. To continue with the five least similar words in reference, and as consequently presented at the last lines such as: issue, review, evidence, research, rule, discussion and that visualized in small font size letters when compared to the large font visualization of the strongest synonyms in use of it.

Further visualizations (Figure.14) can be obtained if interested in eliciting the uses of each of the synonyms presented throughout corpus examples, with the use of the latter as different parts of speech and behaving in contextualized examples with various functions.
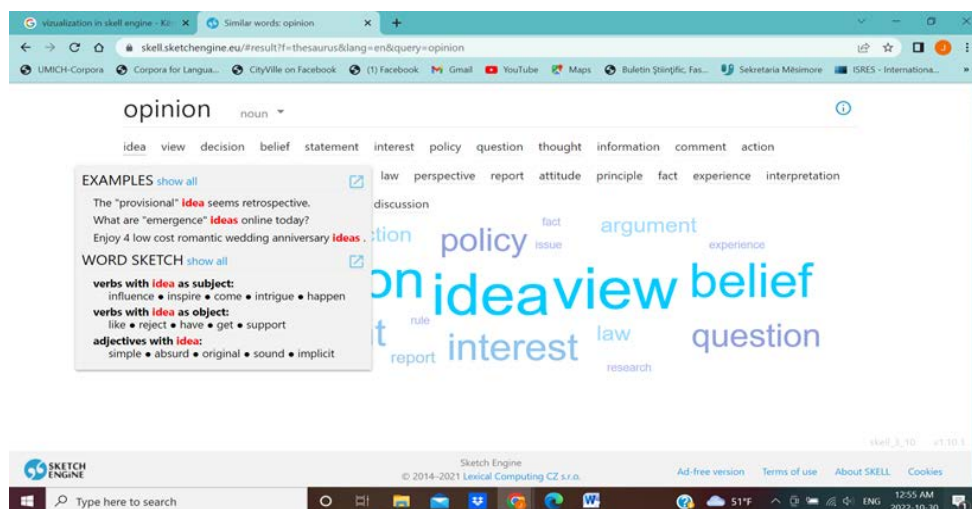

Figure 14. Sample of sketch engine word's synonym feature

Conclusion

The consecutive and affect-like constituents: the development of technology, technology integration, corpora, corpus data and various issue-specific web-applicative tools whose connection and interaction in the researcher's English teaching classes was due to the covid-19 pandemic worldwide situation especially in the field of education. The main impetus of the present study is to reveal that their implication in EFL classes can overcome and facilitate teaching and learning no matter how unpredictable the educational settings or conditions may be. The main focus of the present study concerned vocabulary instruction in a modern, real and virtual learning environment for the solid reason that the knowledge of a word goes beyond the knowledge of its dictionary definition as it embraces knowing the word's spelling, parts of speech (POS), morphology, variant meanings (Semantics), collocations, and specific uses across registers and genres (Corino & Onesti, 2019).

Indeed corpora and the implementation of SkELL (Sketch Engine for Language Learning) assisted the present study's ELT Master students to exploit and master different aspects in EFL language learning and teaching: lexical information, patterns of textualization (viewing the targeted word in larger contexts), with the intent on noticing the genre-structuring features of the words selected for linguistic investigation. All of these relevant tasks and activities were introduced and guided under considerable information to the foreign language learner regarding the appropriateness and acceptability of particular linguistic choices to foster autonomous learner-teacher interaction and learner-learner interaction in individual genres. As Leech (1997) argues, by learning to interact with corpora, "students find themselves learning a great deal about language, and how to study language. They learn about the kind of query questions that can be usefully put forward and answered by reference to corpus data" (Leech,1997, p. 23). Notably, some pieces of information are not to be found either in paper or in e-dictionaries (tools that almost all learners have been using and still do so far), whereas more detailed information on lexico-grammatical features such as: syntactical markedness, annotation and nuances in meaning of similar or common synonyms is made possible through the use of corpus linguistics and the plethora of corpora consisting of a range of corpus-based tools to process linguistic data for text authentication and native-like assimilation of the English language.

Among the current, efficient, available 'ready-to-use' corpora with a teaching and learning purpose, SkELL is certainly a good source of information, a fine center of online language instructor that promotes Data Language Learning (DDL) on the web, a term coined for the first time by Johns (1991) in the field of Second Language Acquisition. Johns describes microcomputer-based approach as an incentive to foster the learners to "discover"

the foreign language under the provision of authentic texts from the language teacher so that lead the learners towards autonomous developing strategies vs discovery strategies through which they can "learn how to learn".(Johns,1986,1988). This kind of search uses a special algorithm to select occurrences from a large multi-billion samples of text, providing good KWIC (Key Word in Context) examples of the word or phrase useful for language learners especially of English, German, Italian, Czech, and Russian (Johns, 1991).

Moreover, the present study puts to practicality and highlights the importance in EFL learning and teaching the statement of Thomas task-based study on Sketch Engine (2015) that DDL is based on the principle of "cutting out the middle man" with the insinuation of learning from the genuine language rather than from mediated resources such as textbooks, grammars or dictionaries. It is exactly the case as in our study that language users have just to type the word they want to investigate in any of the selected tools: Word Sketch, Thesaurus, Wordlist, Concordance and Visualization among a range of others and the software returns a set of occurrences, the word sketch with POS (Parts of Speech) relationships to other words, and the synonyms or semantically related words. The frequency of a word or phrase in different contexts is an important part of its description. Various word lists that are based on word frequency, a measure of corpus data exist especially in ELT context. They can be generated to account for individual items or for recurrent sequences of two or more items. Yet it is to be stressed that the larger the corpora the better the results obtained for linguistic analysis and in compiling in-classroom corpus-based tasks. Corpora consisting of oral and written version of the stored and displayed texts make it possible to develop and integrate the necessary 21st skills in a multi-modal DDL practice, thus answering and strongly supporting the Cobb & Boulton (2015) question when they speculate on "multi-modal or multimedia corpora can bring to the table and their impact on speaking and listening skills.

All in all Corpus Linguistics being a new discipline in SLA acquisition is already known from the current EFL students but not from all language educators. On this point, it is worth recalling what Hutter et al. (2009) label teacher education as an 'interface of theory and practice', suggesting training future teachers, in-service EFL teachers and practitioners to work with corpora. Continuously being under the exert of technological developments, it is the time that these language educators deal with corpus texts and tools within an applied corpus-based/corpus-driven linguistics framework so to make way for them mediate and gain new insights on the course of exploration to English language teaching and learning practice. The implication of the above-mentioned tools of Sketch Engine search software resulted to the present ELT Master students in a consciousness-raising outcome, leading them to a long-term global assessment of English. The fact of using technological tools, devices and integrating technology in English foreign language education stimulated group work and crafted the collaborative problem-solving and understanding, affected student inclusion in corpus linguistic query and increased their motivation and involvement to gain ownership of the overall English foreign language learning.

Recommendations

The implementation of SkELL in EFL classes at university level reported to be a rich resource, suiting student's level either Basic or Advanced when exploring and learning language on the web. The present study revealed the impact it exerted on both sides of the SLA process. It was targeted to show the richness of knowledge, additional linguistic explanation they gained while thinking critically to go beyond the hidden lines of corpora texts and gain insights in vocabulary transformations and context-like occurrences that words may suffer by implementing the right tools for autonomous inquiry. The tools it presented in real course endeavors were moderate in number when compared to the range that the search itself consists of. Further implications and insights to facilitate teaching and learning and make it globally unique among English language learners is to address other tools for classroom implications. It is of great importance in dealing not only with vocabulary matters but further exploiting and disseminating grammar by using structure strategies for self-discovery of corpus-data regularities when compared to the students' irregularities in oral/and or written expression in English. The crucial focus of future case-specific study would be to investigate upon the inductive strategies the EFL learners employ to induce patterns or rules from the authentication of English in corpora lines.

Scientific Ethics Declaration

The author declares that she is solely responsible for the scientific, ethical, and legal aspects of the paper published in EPSTEM.

Acknowledgements or Notes

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To cite this article: