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Information Technology Essence of the Heuristic Model for SMART Management in a Medium-Sized Industrial Enterprise

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Abstract: This article presents the information and technological essence of a qualitatively new generated Heuristic model for SMART management in medium-sized industrial enterprises. A summary is made of the features of heuristics in the modern reality and of the prerequisites necessitating the implementation of heuristic and smart-based tools in a single and comprehensive software programme. The general framework of the mathematical model on which its architecture is based is also defined in order to make a comprehensive description of the structure and information and technological features of the software-based programme. The criterion for optimality, which is targeted in the Heuristic model for SMART management in a medium-sized industrial enterprise and its constituent engineering-technological, financial and production parameters, is presented. The main relationships, tools and approaches in the software programme itself are described. The main characteristics and connections of the software-based program of the Heuristic model for SMART management in the medium-sized industrial enterprise are presented.

Keywords: Information technology, Heuristic model, SMART management, Medium-sized industrial enterprise

Introduction

Today, the concept of heuristics has been repeatedly transformed in view of the challenges and requirements of information technology and artificial intelligence. The heuristic model in modern literature is understood in the context of logical thinking. In it, through heuristic methods, the reasoning process is observed or recreated by posing questions, drawing schemes and diagrams, building assumptions, examining the problem from different points of view. It is a kind of examination of directions however based on a specific logical framework. In this line of thought, a heuristic model is a study having its own structure and a defined space for discovering a solution to specific problems.

In modern smart information systems, heuristic models are not driven by psychology. They have a specific problem area, the solution to which requires the application of precisely defined heuristic methods and tools. The purpose of SMART heuristic models is to improve certain indicators, to provide information on the favourable elaboration of the problem embedded in the model.

Heuristic models are most often objectified when there is no precise and comprehensive algorithm for solving a specific case. In some situations, however, it is possible to apply heuristic techniques and models to a completely unknown problem, and their application often leads to reaching a solution based on an algorithm. Therefore, many authors (Michalewicz &Fogel, 2010; Polya &Conway, 2014; Pólya et al., 1995) consider that the terms «algorithm» and «heuristics» are different categories of concepts and that algorithms are not applicable in the study of new problems as the new cases are subject to examination by heuristics. An algorithm appears only when a successful solution to a particular task has been reached for the first time and the path to its

achievement is analysed. The term «heuristic search» is often used in the literature (Barr et al., 1981; Ernst & Newell, 1966; Noyes,1992; Winston, 1975) on intelligent systems – an attempt to formulate something that seems common to programmes integrating artificial intelligence. Therefore, heuristic search contributes to the construction of a unified approach leading to solving tasks based on a common paradigm (methodology and modelling) for solving problems.

In artificial intelligence programmes, based on clear rules for generating objects, heuristic search matches objects and rules for their generation, resulting in either a new object or an indication of non-matching. The generation of new objects, however, leads to the definition of a tree of objects, in which the heuristic search, defined by the initial situation and aimed at finding a way to the desired situation, should be implemented. The heuristic search is also about finding a solution „in the dark" in parallel with the search for a relevant outcome from a specific case study using a tree of objects. This is a search within a specific space in AI-based programmes based on a certain state of the object, based on heuristic decision-making processes.

Heuristic search within a tree of objects, as well as its algorithmic basis, lead to the introduction of plausible, but not always correct, procedures that are an integral part of computer programmes. On this basis, programming can be defined as a process of designing programmes based on a certain algorithm, in which procedures based on both partially verified and on absolutely valid, formal and informal reasoning rules are implanted. They may be the result of practical applied research or experiment, or they may derive from certain theories, concepts and laws. Some authors (Raphael, 1976) define them as carriers of "a certain degree of foreboding". In all cases, however, heuristic programming leads to a reduction in the amount of work required to arrive at the solution to a particular case study.

Information and Technological Features of the Heuristic Model for SMART Management in a Medium-Sized Industrial Enterprise

Preconditions

SMART programmes use two main methods to reach a solution to a problem:

- an algorithmic method – procedures that guarantee a solution to a defined case;
- a heuristic method – a set of empirical rules or strategies that operate in practice as a rule. (Solso, 1979)

The SMART based programme is a kind of performance improvement strategy. According to some scientists (Sampson, 1976), the heuristic programming approach to artificial intelligence is one of the most popular and productive approaches today. According to these researchers, however, this is in contrast to another major approach – the simulation of human thought, where the goal is to apply the characteristics of human intelligence.

A SMART-based programme is not a cyber-physical production system because it is not a "robotized model that is able, through a precisely described and machine-simulated algorithm, to analyse and evaluate the environment and to take actions that increase the possibility of achieving certain goals" (Temelkova, 2022). According to some authors, the cyber-physical production system is "an innovative type of human-machine-cyber device ecosystem" that has its real physical manifestation, but also its virtual duplicate corresponding to the real production system in terms of its structure, organization, resources, goal setting and strategy" (Temelkova, 2022).

The heuristic model for SMART management in the medium-sized industrial enterprise presented in this articles operates with several types of heuristics:

- practical – it is different from the theoretical assumption and derives from application;
- region-specific – it is characteristic of a precisely defined scientific field and is related to its characteristic features;
- ad hoc – it arose spontaneously or for a specific case;
- empirical – it establishes the presence of certain facts and trends through experience and practice.

The heuristic model for SMART management in the medium-sized industrial enterprise is based on analogies. It is a set of simplified representations that allow for differentiation of the more important aspects of intelligent management and the specifics of the medium-sized industrial entity. A complex, succinct presentation of the

main elements of the case study is achieved through the analogies. Thus, they appear as partial insights that could evoke new insights that give greater breadth to the studied problem.

The heuristic model for SMART management in a medium-sized industrial enterprise is a combination of theoretical and practical knowledge facilitating the performance of selection and evaluation. The modelling based on criteria, methods, principles, tools seeks to find a solution to a specific production-technical, financial, logistic or other case in the medium-sized industrial enterprise.

The heuristic model for SMART management in the medium-sized industrial enterprise is a complex compilation of procedures and has a hierarchical structure. It is composed of a set of rules for the applicable search strategies and functions regarding the selection and evaluation in the search process. Rules rank higher hierarchically than functions, and the model can also be defined as a strategy for retrospective selection of rules. At the same time, the heuristic model for SMART management in the medium-sized industrial enterprise handles multiple data, process principles, management functions, organizational and structural maps.

The synthesis of the main components serving as basis of the heuristic model for SMART management in the medium-sized industrial enterprise indicates that four fundamental elements should be its invariable part:

- heuristic search;
- algorithm based on artificial intelligence;
- heuristic programming;
- SMART based programme.

General Presentation of the Mathematical Model of the Heuristic Model for SMART Management in the Medium-Sized Industrial Enterprise

The heuristic model for SMART management in the medium-sized industrial enterprise seeks to solve the problems and cases in the industrial unit based on the achievement of optimality or a balanced compromise. This means that criteria that guarantee optimality or a combined compromise should be integrated as objective functions in the mathematical model of the Heuristic model for SMART management in the medium-sized industrial enterprise.

On the basis of the conducted research and the practical and applied developments, a conclusion has been reached that economic efficiency should be set as a target criterion in the Heuristic model for SMART management in the medium-sized industrial enterprise; economic efficiency is a relationship between the value of the utility achieved in the course of an economic activity and the value of the necessary production resources and all other costs incurred in the production and sale of a specific product of the j type. [11] In this respect efficiency is most clearly highlighted through the economic category of production costs per unit of manufactured product that is also used to estimate the economic effect. It is this category that forms the cost.

Therefore:

$$\mathrm{E} = \frac{\text{полезност}}{\text{себестойност}} \quad [1]$$

or:

$$\mathrm{E} = \frac{TR}{CP} \quad [2]$$

where:
TR – total revenue
CP – cost price

Therefore:

$$L = \frac{TR}{CP} \rightarrow \max/\text{compromise} \quad [3]$$

However, the constituent elements of the specified quotient can be expressed as follows:

$$TR = X_j \times P_p \quad [4]$$

$$X_j = \sum_{j=1}^{n} \frac{OH_{PSS}}{IPT} \quad [5]$$

$$CP = \sum_{j=1}^{n} \mathrm{TLTT_d} + \sum_{j=1}^{n} \mathrm{TCMR_{dg}} + \sum_{j=1}^{n} \mathrm{TEC_d} + \sum_{j=1}^{n} \mathrm{TLC_d} + \sum_{j=1}^{n} \mathrm{TCMAR_d} \quad [6]$$

where:

P_p – commodity price of the product formed in a previous production cycle

Therefore, the target criterion has the following mathematical expression:

$$L = \frac{\mathrm{Xj}.P_p}{\sum_{j=1}^{n} \mathrm{TLTT_d} + \sum_{j=1}^{n} \mathrm{TCMR_{dg}} + \sum_{j=1}^{n} \mathrm{TEC_d} + \sum_{j=1}^{n} \mathrm{TLC_d} + \sum_{j=1}^{n} \mathrm{TCMAR_d}} \rightarrow \max/\mathrm{compromise} \quad [7]$$

Information technology software-based programme of the Heuristic model for SMART management in the medium-sized industrial enterprise

The heuristic model for SMART management in the medium-sized industrial enterprise is based on a mathematical model in which multiple limiting conditions are described with limiting target values of certain production-technical and engineering-technological indicators, which derive from the initially set limits. They, in turn, are logical consequences of the limitations set at the stage of input. This facilitates the generation of a hypothesis about the unknown parameters which helps to increase the strength of the limitations and to synthesize new limiting conditions.When a contradiction is reached, the process loops back again to search for a new value of the unknown parameter or to reach a target state based on a sufficiently strong realization of the limiting conditions and satisfying the criterion for evaluation. The rules by which the limitations are distributed and the rules by which the hypotheses are made depend on the specifics of the medium-sized industrial enterprise and on the limiting conditions and evaluation criteria set in the assignment.

The variables subject to optimization or a combined compromise between them are of essential importance in the Heuristic model for SMART management in the medium-sized industrial enterprise. These are, on the one hand, the costs forming the dynamic variable cost of production, and on the other hand, the ratio between the hours of operation of the production system and the ideal production time, determining the quantity produced in terms of in-kind value, which is a dynamic variable in the calculation of the total revenue. On this basis and based on the fact that the limiting conditions are related precisely to these dynamic variables, the information technology model emphasizes precisely on their description, integration and possibilities for implementing various options.

```
public abstract class BaseExpense implements Expense{
    private String name;
    private double time;
    private int reps;
    private double price;

    public BaseExpense(String name, double time, int reps, double price){
        setName(name);
        setTime(time);
        setReps(reps);
        setPrice(price);
    }

    private void setName(String name){
        if (name==null || name.trim().equals("")){
            throw new NullPointerException("Name cannot be empty.");
        }
        this.name = name;
    }

    private void setTime(double time){
        if(time<0){
            throw new IllegalArgumentException("Time cannot be negative number");
        }
        this.time = time;
    }

    private void setReps(int reps){
```

Figure 1. A software programme of the Heuristic Model for SMART Management in the medium-sized industrial enterprise (author's work)

For the purposes of conceptual modelling, the information technologies for the Heuristic Model for SMART management in the medium-sized industrial enterprise are provided on the basis of classes and objects. Thus, the digital counterpart of each expense in the medium-sized industrial enterprise in the model for SMART management based on information technology and heuristics is determined by the abstract class (Base expance). The logic for calculating the cash outlay by types is implemented in the class. All other expense types inherit Base expance – accordingly $TLTT_d$ (total losses of technological time), $TCMR_{dg}$ (total cost of material resources), TEC_d* (total energy costs), TLC_d (total labor costs), $TCMAR_d$ (total costs for machines, automata, robots), CP (cost price). Each of these expenses uses the constructor from Base expance, and the constructor expects a name, the time wjen the expense occurred, the recurrence of the expense, and its value (Figure 1.).

The expanceRepository class has a collection of the expance type as attributes. It does not accept information but initializes the collected data as a list. This class makes it possible to add, remove, find by name, and retrieve (use) all input data on a case-by-case basis. The other part of the efficiency formula – TR (total revenue) – is determined by the Quantity class. The constructor takes the total operating time of the production subsystem and the ideal production time and makes them part of the object of the programming.

The digital counterpart of the price is the Price class. Its constructor accepts a floating point number that represents the cost of the manufactured product. The interaction between the user and the application takes place through a graphical user interface developed on the basis of the Java fx library. The user interacts with the SceneBuilder class and interacts with the programme when entering data. After entering data and pressing a command button, the data is transferred to the Controller class. It has a repository of the expanceRepository type as attributes. In the Controller class all commands are executed, e.g. “save cost” – adds a cost to the cost repository, “delete cost” – removes a cost from the cost repository, “find by name” – finds a cost by keyword name, names are accepted as unique.

The information technology programme, integrating conceptual and heuristic modelling, meets the needs of the Heuristic Model for SMART management in the medium-sized industrial enterprise as it solves the set management tasks by providing an option to enter data by days. This makes possible the recording of trends and expands the possibilities of achieving an optimal solution or a combined compromise solution while at the same time it serves as a possible basis for the strategies for development of the studied economic entity.

```
public class CreateEfficiencyScreen {

    public static void createEfficiencyScreen(Group root, String efficiencyCalculated){
        Rectangle blueRectangle = new Rectangle();
        blueRectangle.setFill(Color.RED);
        blueRectangle.setX(50);
        blueRectangle.setY(0);
        blueRectangle.setWidth(900);
        blueRectangle.setHeight(50);
        root.getChildren().add(blueRectangle);
        Label efficiencyLabel = new Label(String.format("%s", efficiencyCalculated));
        efficiencyLabel.setScaleX(1.5);
        efficiencyLabel.setScaleY(1.5);
        efficiencyLabel.setTranslateY(25);
        efficiencyLabel.setTranslateX(450);
        root.getChildren().add(efficiencyLabel);
```

Figure 2. A software programme of the Heuristic Model for SMART Management in the average industrial enterprise (author’s work)

Results and Discussion

The heuristic model for SMART management in the medium-sized industrial enterprise, and hence its software image, integrates four main features:

- uncertainty;
- incomplete knowledge;

- improved performance;
- decision making guidelines.

The heuristic model for SMART management in the medium-sized industrial enterprise is a unique compilation of:

- subjective uncertainty regarding the success in solving a particular problem arising from the problem's heuristic nature;
- objective security based on the algorithms in the model.

The uncertainty in the model is related to a real practical case that needs to be solved while the algorithms are applied to abstract and theoretical tasks. They provide safe, reliable and good solutions based on the mechanical application of certain logical postulates. However, the search for a solution to a practical assignment cannot be achieved only on a theoretical basis. This is not inherently a heuristic strategy.

The model for SMART management in the medium-sized industrial enterprise is heuristic because there is no guarantee that it is practically optimal for finding optimal options within a space of states. However, the fact that every task finds its optimal solution in the long run should not be overlooked. Therefore, the heuristics in the software-based model for SMART management in the medium-sized industrial enterprise is only possible if it is based on practical problems and integrates practical algorithms on this basis.

When a case is property set the algorithm in the information technology software model offers an exact step-by-step procedure that leads to a solution to the task, using a certain set and amount of resources, or points to the impossibility to solve the task. However, finding a solution to any problem is always related to scarcity of resources – the limitation of the required resources compared to the growing needs for them. Time, space and technological limitations are among the most important resources, but also among the most variable factors for providing a certain solution. It is this uncertainty, influenced by the dynamics of the environment, that introduces uncertainty into every process in the medium-sized industrial enterprise. This also means that there is a need for a heuristic model for its SMART management, because in the conditions of dynamic external and internal organizational factors, guaranteeing a secure, reliable, efficient and optimal solution seems illogical. In reality, the uncertainty in the case of strong variability of the environment factors does not even guarantee a correct solution of the constituent problems of the decomposed case that is the object of solution. This justifies the conclusion that in the heuristic model, and consequently in its software-based programme, the rules that condition the combined compromise decision have an essential place.

Conclusion

The information technology features of the Heuristic Model for SMART management in the medium-sized industrial enterprise are integrated into a software-based programme, in which the following fundamental elements also stand out:

- presence of an unsolved problem, case or assignment;
- a SMART based programme integrating:
  - an algorithm based on artificial intelligence;
  - heuristics based on practice, specificity, empiricism, expertise, or spontaneity;
  - heuristic programming (code);
- an optimal or combined compromise solution, conclusion or inference.

In the software-based programme algorithms and heuristics are integrated by means of code into a single system, and the relations between them are semantically adjusted. They are used to achieve optimality or a combined compromise of the problems, cases or assignments initially defined.

The algorithms in the software programme of the Heuristic Model for SMART Management in the medium-sized industrial enterprise represent a sequence of commands that are performed in order to solve a given task. They are based on:

- artificial intelligence in the form of conditionals;
- cloud servers performing the calculations submitted by the equipment and returning them to the investigated fundamental plane;
- a filter and analysis of large data sets;

- The Internet of Things, interactively connecting every physical element with its digital counterpart;
- additive manufacturing obtained on the basis of a created digital counterpart and a method set for the production of a given physical object.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

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References

Barr, A., Feigenbaum, E. A., & Cohen, P. R. (1981). *The handbook of artificial intelligence*. USA: William Kaufmann.

Ernst, G. W., & Newell, A. (1966). *Generality and generality and problem solving.* Carnegie Institute of Technology.

Michalewicz, Z., & Fogel, D. B. (2010). *How to solve it: Modern heuristics*. Berlin – Heidelberg: Springer

Мирчев, А. (1996). *Производствен мениджмънт.* Princeps.

Noyes, J. (1992). *Artificial intelligence with common lisp: Fundamentals of symbolic and numeric processing*. USA: Heath and Company

Polya, G., & Conway, J. H. (2014). *How to solve it: A new aspect of mathematical method*. Princeton University Press.

Pólya, G., Roquette, P., & Behnke, E. (1995). *Schule des denkens: Vom losen mathematischer probleme*. Bern, Francke, A.

Raphael, B. (1976). *The thinking computer: Mind inside matter*. W. H. Freeman.

Sampson, J. R. (1976). *Adaptive information processing*. New York, NY: Springer.

Solso, R. L. (1979). *Cognitive psychology*. NewYork, NY: Harcourt Brace Jovanovich

Temelkova, M. (2022). Model for the organization of a cyber-physical production system. *Intelligent Sustainable Systems - Selected Papers of WorldS42022,* (Vol. 1, pp 703–718).

Temelkova, M. (2022). Model for the organization of a cyber-physical production system. *Intelligent Sustainable Systems - Selected Papers of WorldS42022,* (Vol. 1, pp 785–794).

Winston, P. (1975). *The psychology of computer vision*. NewYork, NY: McGraw-Hill.

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