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Detection of the Mineral Presence and Its Effects on Different Tree Species Using Drone Photogrammetry and Remote Sensing Methods

Oyku ALKAN
Graduated Istanbul Technical University

Muntaha Kassım Hayder AL-ZUBADE
University of Technology

Mehmet Nurullah ALKAN
Hitit University

Abstract: It is expected that the vegetation, especially the tree roots, will be affected by the underground mines that may be discovered and have different spectral characteristics. In particular, it is possible for forest areas to be more frequent and stronger by being fed from metallic mines that are mineralized in a long process underground. For this purpose, the study was carried out in a mining area with a licensed gold and copper mineralization located in the west of Amasya province borders. Drone Photogrammetry has been studied to clearly classify the trees in the forest with dense and steep geography in the region. The spectral anomaly of tree species was investigated by using the ASTER satellite image with high spectral resolution of the region. With remote sensing methods such as SAVI, NDVI and supervised classification, satellite images were enriched to reach potential ore-intensive areas. The slope analysis was performed by creating a digital terrain model for the region, which geography is very rough and steep, and it was examined by considering tree height values from different angles. Tree species classified by the Spectral Correlation Mapping method were also evaluated together with their spectral signatures.

Keywords: Remote sensing, Drone photogrammetry, GIS

Introduction

Remote Sensing(RS) technology has become the indispensable methodology of multidisciplinary platforms and the dissemination of research in this direction is considered as an important innovation. With this method, whose importance is increasing day by day in the investigation of mineral deposits, powerful spectral analyzes can be made with the analyzes made with infrared and thermal bands of high spectral resolution satellite images. Little ore resources are used in the world and there are countless potentials waiting to be discovered (Alkan, 2019). Research with remote sensing methods is now considered indispensable in the world literature.

Analyzing systems that provide high-resolution images of mining areas are UVA tools. Drone-based mining exploration gains value when combined with remote sensing methods. Drones have quickly become one of the most cost-effective and efficient tools for collecting high-resolution data, aligning between larger-scale, lower-resolution satellite data collection and much more limited traditional terrestrial survey approaches (Hill, 2022).

A study conducted in Yankari Park in Nigeria used ASTER and Hyperion satellite data to identify alteration minerals. The algorithms used are based on Linear spectral separation and spectral angle mapping (Abubakar et al., 2017). Instead of the spectral angle mapper used in this study, the spectral correlation mapper, which is the corrected version of these methods, was preferred.

In another study conducted in the Sittampundi Anorthositic complex in South India; For thermal waters, VNIR and SWIR data from nine band high spectral resolution ASTER satellite data were examined. The usability of different multispectral satellite data and mineral ratio images for lithological differentiation has been investigated (Arivazhagan et al., 2017). A similar study was conducted in Oman to investigate the mineral mapping performance of ASTER satellite data in arid regions. ASTER bands for mineral mapping, band ratio literature was reviewed (Rajendran & Nasir, 2018).

In another study to determine the band ratio of hydrothermal alteration minerals, principal component analysis, Crosta technique and spectral angle mapper techniques were applied using ASTER satellite data. Spectroradiometry was used to extract the spectral signatures of the stone samples. (Yalçın et al., 2017). Different RS methods of ASTER bands were investigated to analyze potential mining fields in Çorum province. (Alkan et al., 2017).

Data obtained from satellites or Unmanned Aerial Vehicles (UAVs) makes these hard work equipped in a short time. Unmanned Aerial Vehicles (UAVs) or drones is a proven technology for some of these activities (Wyard, 2022). The diversity of remote sensing methods and high spatial resolution of drone data in the exploration of metallic minerals makes a great contribution to the studies. This study was carried out by combining effective methods to contribute to mineral exploration. For this purpose RS, UVA Drone and GIS processes were jointly used.

Method

Drone Photogrammetry and Remote Sensing

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. The digital elevation model of the region was prepared by taking drone images from different heights in difficult geographical conditions. Using the high spectral resolution of the ASTER, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined using merged data from drone and ASTER images. The samples obtained from the ground control points and the drilling for field-validated.

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. UAV-based study applied to clearly classify the trees in the forest with dense and steep geography in the region. The spectral anomaly of tree species was investigated by using the ASTER satellite image with high spectral resolution of the region. With remote sensing methods such as SAVI, NDVI and supervised classification, satellite images were enriched to reach potential ore-intensive areas.The slope analysis was performed by creating a digital terrain model for the region, which geography is very rough and steep, and it was examined by considering tree height values from different angles.Tree species classified by the Spectral Correlation Mapping method were also evaluated together with their spectral signatures.

Findings

Study Area

The study area was carried out in the Taşova district of Amasya, in the eastern part of the Central Black Sea Region. Projection is UTM, Datum WGS 84 and Zone 36 (Figure 1). A continuation of the significant parts of Central Anatolia Region in the Central Black Sea Region; the most part springs in the Yeşilırmak Basin (Gulersoy, 2013). Parallel to the tectonic development of Anatolia, Amasya province is located on a large area covered by metamorphic masses, conglomerates, limestones, and sandstones. In this geological formation, the probability of high temperature harboring of metamorphic belts is considered important in terms of investigating potential geothermal areas (Ongur, 2005). Classical local drilling activities were carried out in mining studies in the research area. No study has yet to be related Remote Sensing (RS) and Drone Photogrammetry (DP) adds high- value effects to this work. One of the lateral branches of the North Anatolian Fault (NAF) line extends to the study area. The vectorial density in the fault lines updated by the General Directorate of Mineral Research and Exploration (MTA) has been evaluated to indicate potential ore-dense areas in the region. The geography of the field is a rugged area where reaches up from 460 meters to 1130 meters in the forest many kinds of trees, the study which was applied in a license area where the tough geographical conditions.

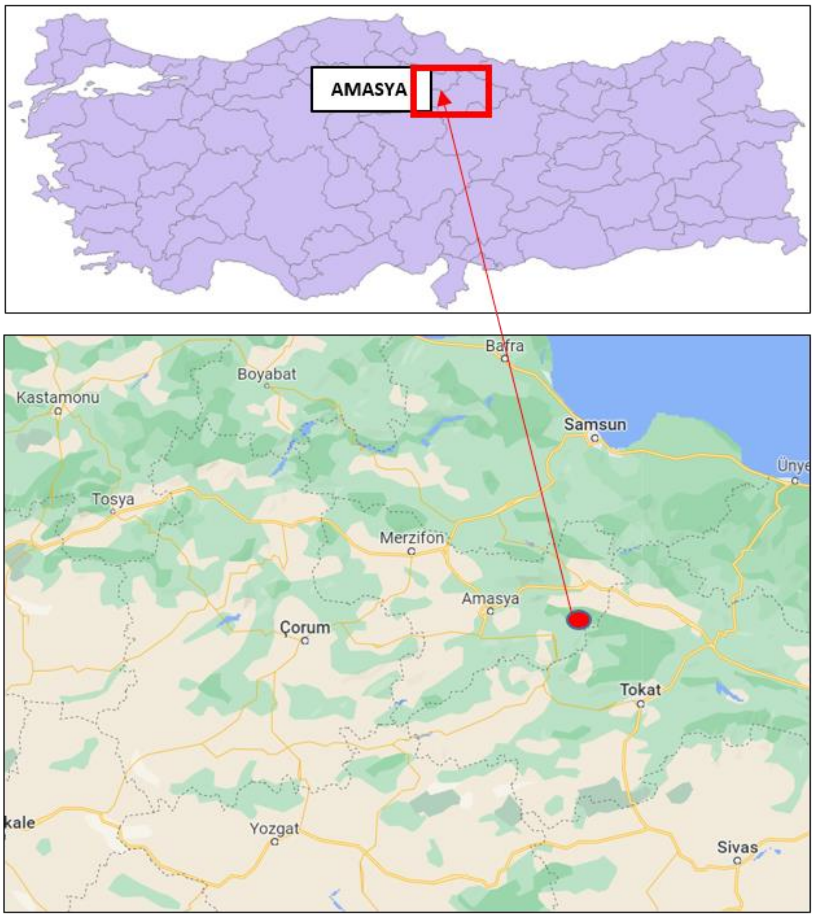

Figure 1. Study area

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area. In the first stage of the study, the digital elevation model of the region was prepared by taking drone images from different heights in difficult geographical conditions. In the second stage, using the high spectral resolution of the ASTER satellite data, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined with terrain maps created using data from drone and ASTER satellite images. For this purpose, unsupervised classification methods and band ratio techniques were used to extract the potential mineral distribution. The samples obtained from the ground control points taken as field-validated were evaluated.

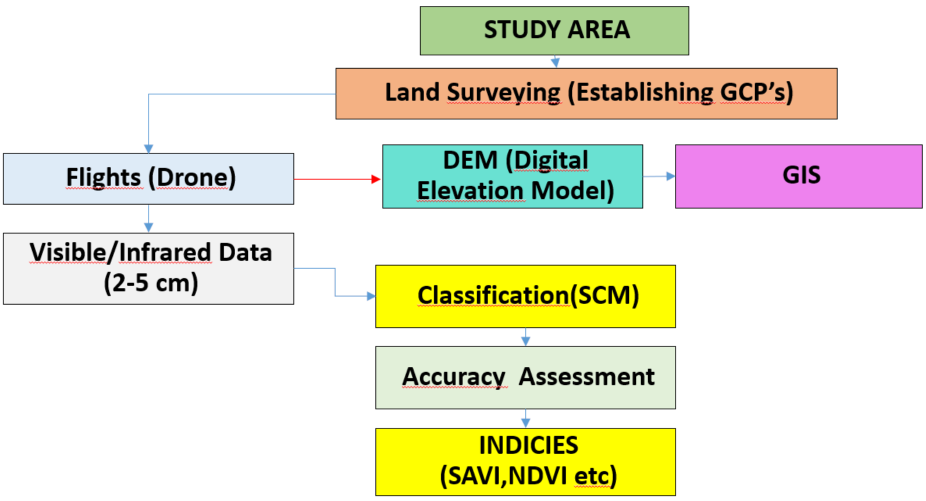

Figure 2. Flow chart

Ground sampling points were selected by using multi-spectral satellite data to be used in determining potential mineral areas in pre-classification. ASTER satellite multispectral bands are widely used in geological surveys. Separate field studies GPS measurements were carried out to determine the locations of soil classes in 4 different regions in the study area. By evaluating the spectral signatures of the samples by classification analysis, appropriate spectral ranges were determined and new test areas were created for the field study. The new samples analysis were completed by determining their positions with GPS were added to the spectral library inventory. Geometric and radiometric corrections have been applied to satellite data. Atmospheric corrections have been applied to visible, visible-infrared bands of ASTER satellite. The flow chart showing the working steps is shown in Figure 2.

Drone studies were carried out with a three planned flight by determining the ground control points. Due to the difficult geography, the flight altitude was realized as 75 m. The mosaic and DSM images obtained were combined using the data fusion method. In the first stage of the study, mosaic image and DSM image of the region was prepared by processing Pix4d software (Figure 3).

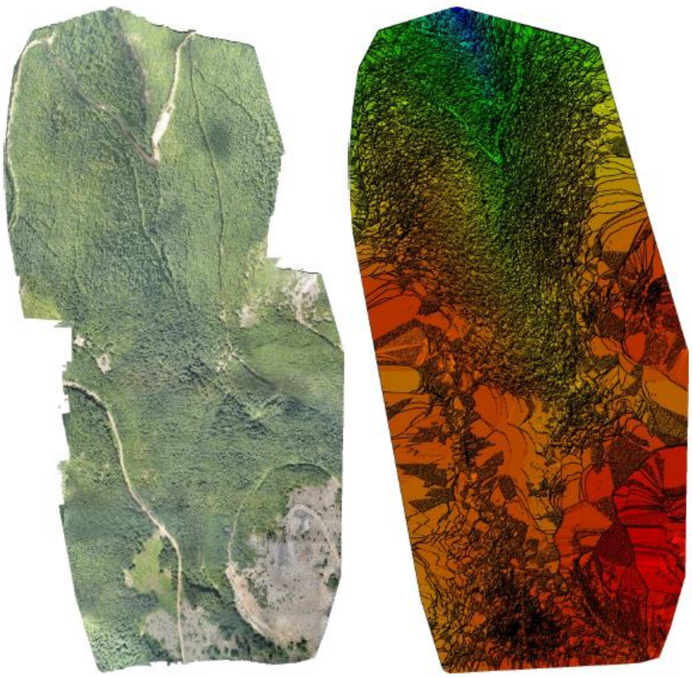

Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Figure 3. Ortomosaic and DSM images designed by UAV

The projection system is described in UTM and northern 36 segments. The location data of these points, Turkey national fixed satellite stations (TUSAGA-ACTIVE), is taken and converted into the national network based on the GPS coordinate system. One of the reasons for working with GPS was to test the positional accuracy of the sampling points on Google Earth, City Surf Globe and Orthophoto maps. Another was to compare the spatial accuracy of the ASTER satellite image with high spatial resolution images. It is aimed to increase the accuracy of image classification due to the ground accuracy of the samples by means of land measurements for sampling purposes (Alkan, 2019).

Drone photogrammetry and different remote sensing methods were used to investigate the metallic mines in this area.The digital elevation model of the region was generated by processing of the drone images from different heights in difficult geographical conditions. Using the high spectral resolution of the ASTER, different remote sensing methods were used and the mineral presence in the region was examined. Ore-dense areas were determined using merged data from drone and ASTER images. The samples obtained from the ground control points and the drilling for field-validated.

For the research, the measurement of ground control points with GPS was provided and sampling points were created for the classification process.. For this purpose, different algorithms were investigated for the selection of classification methods to be used and SCM (Spectral Correlation Mapper) algorithm was preferred because it is powerful in spectral analysis (Alkan 2019), (Figure 4).It has been tested in four different class classification processes and areas showing mineral density have been evaluated by taking into account previous drilling studies.

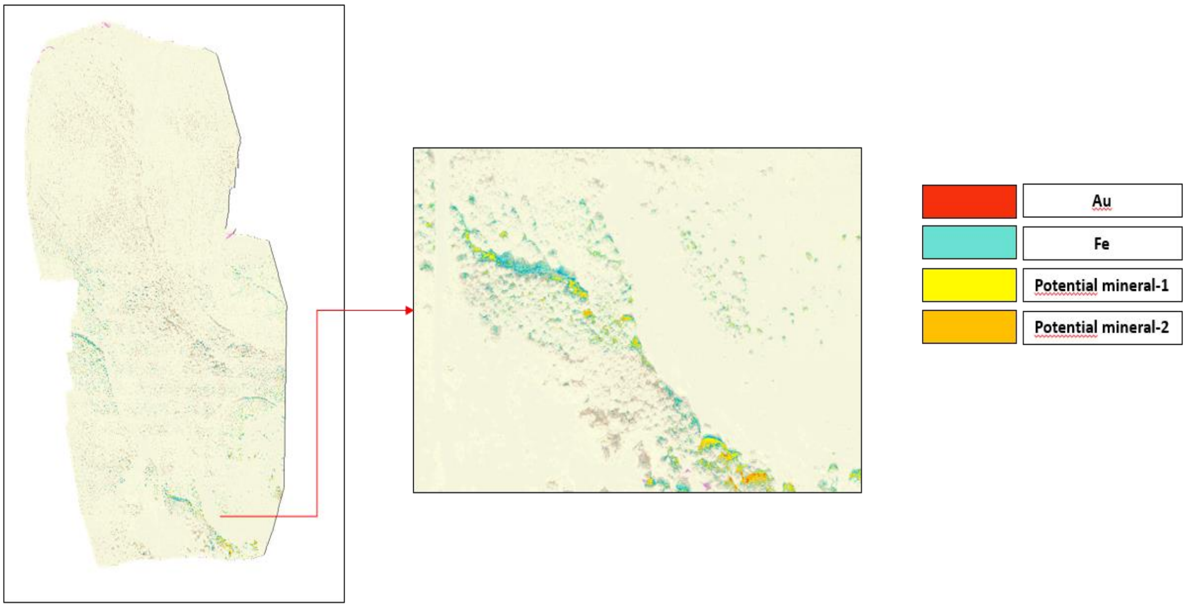

Figure 4. SCM image and sample classes

Considering the tree structure in the study area, three different ratios/indexes were studied in order to better perceive the symptoms that may occur on the surface (Figue 5). Iron-oxide ratio was studied in order to investigate the presence of gold composition in iron-intensive areas analyzed by previous drilling studies in the region. The NDVI index was studied to suppress vegetation and to better observe the spectral features in the region. NDVI and MSAVI indices were studied to suppress vegetation and to better observe the spectral features in the region.

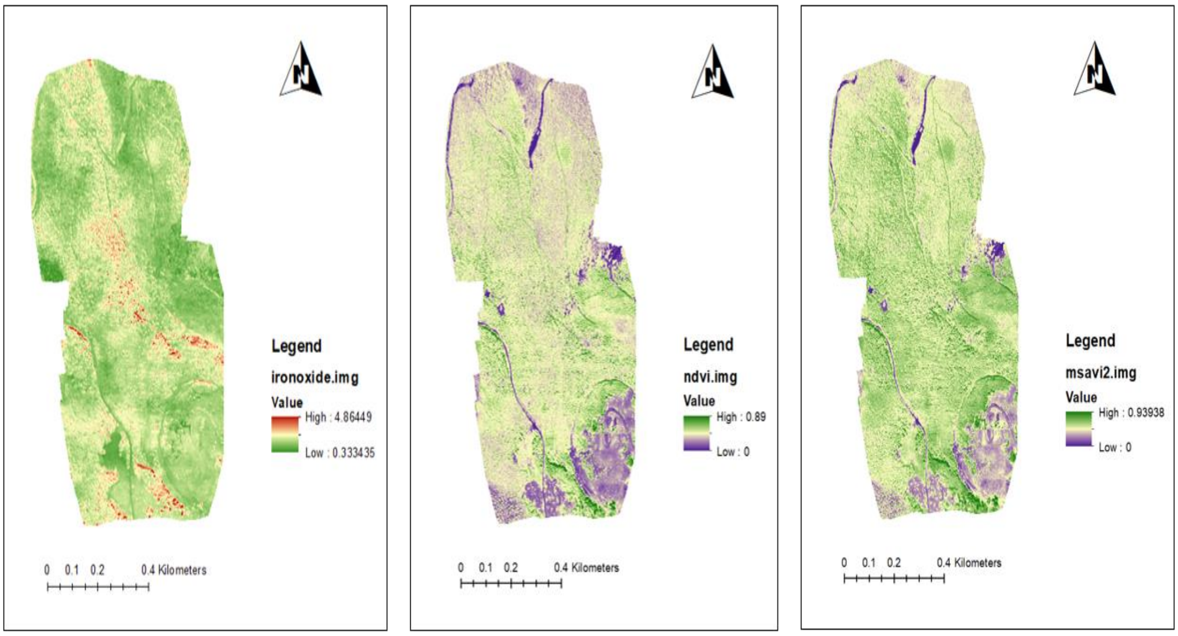

Figure 5 . Iron-Oxide, NDVI and MSAVI indexes applied the image.

DEM was generated by processing DSM image to achieve different elevations of the potential minerals for the study area (Figure 6).

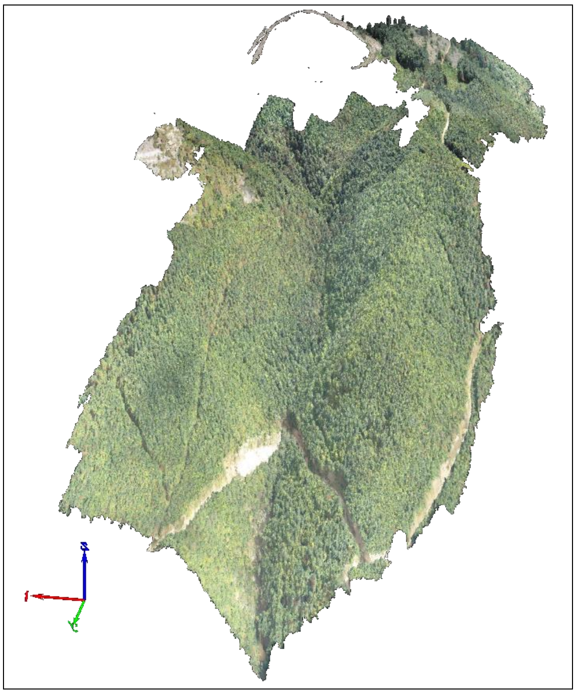

Figure 6 . DEM (Digital elevation model) generated by Pix4d

DEM study was performed with GIS to determine at which heights the potential mineral presence is located. With this study, it was aimed to contribute to the studies to be carried out in the steep and challenging conditions of the land geography (Figure 7).

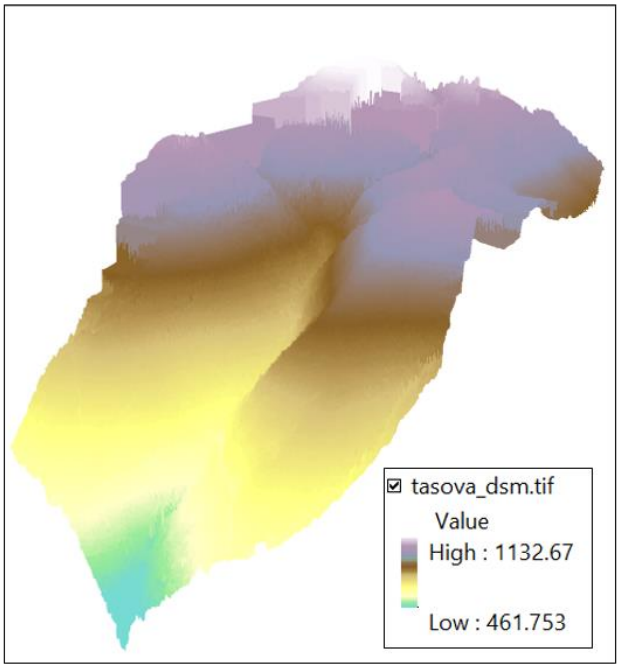

Figure 7. Distribution of the elevations of the study area generated by GIS

Accuracy analysis results were compared by using SCM classification methods for the investigation of potential mineral areas. Accuracy analysis result for SCM 0,94. The overall Kappa statistical values obtained for the 4 main classes in the SCM classifications results over 90%. Kappa, which mainly calculates the image classification accuracy, was obtained with the following formula.

In the formula, r = number of classes, xii = diagonal elements of error matrix, xi + = sum of rows; x+ i = column total, N = total number of pixels in error matrix.

$$\kappa = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r} x_{i+} * x_{+i}}{N^2 - \sum_{i=1}^{r} x_{i+} * x_{+i}}$$

Discussion

The aim of this study, which was carried out using RS and Drone photogrammetry methods, was to determine the presence of minerals.. For this purpose, the SCM performances of the classification method studied to evaluate and an accuracy of 94% was obtained. In the regression analysis for the estimated potential areas, 20 test points selected from ground-tested analysied by drilling activities were used in the classification procedures. The regression analysis and the relation of mineral elements expected to exist in the predicted potential mineral areas were investigated particularly focused on Copper (Cu) and the Gold (Au) surroundings.

In the regression analysis for estimated potential mine areas, 20 points selected from the drilling-tested points were used in the classification procedures for the histograms of mineral groups respectively. Drone photogrammetry and remote sensing methods can be used for the mine areas efficiently. High spatial resolution(UAV:2-5 cm) and high spectral resolution ASTER images effectivly used in data fusion method to explorate minerals.

Conclusion

The use of RS and drone-based photogrammetry methods in the preliminary studies of mining research is great importance in terms of the cost of drilling activities. RS methods which integrate topographic, geological and geomorphological features with the help of satellite images can be used in researches, surface symptoms can be examined and statistics and potential mineral fields can be reached. Determination of mine area with computer-aided of RS Satellite data which was carried out at every stage of the study using research-planning, application-analysis, evaluation-interpretation and accuracy analysis.

- Remotely sensed satellite data can be necessary to demonstrate the usability of different methods in mineral researchs
- Related potential mineral researchers and scientists can benefit from these data
- These data can be used in the development of ground-validation studies by using a combination of UAV-based data and satellite imagery.
- Spectral library can be obtained by field work will be an important data source in the future research

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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Author Information

Muntaha Kassım Hayder AL-ZUBADE
University of Technology,Baghdad,
Baghdad, Iraq
Contact e-mail: *muntahaalzubade@gmail.com*

Öykü ALKAN
Graduated Istanbul Technical University,
İstanbul, Turkey

Mehmet Nurullah ALKAN
Hitit University
Turkey

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