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APPLICATION OF THE GOLDENRAM AI PLATFORM FOR MONITORING MINING ACTIVITIES USING EARTH OBSERVATION DATA

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Abstract. *This paper analyzes the potential of Earth remote sensing data and artificial intelligence for monitoring mining sites. The study investigates the remote assessment of the value of the deposit using multispectral imagery, time-series data, and digital elevation models. Particular attention is paid to the GoldenRAM platform, which ensures synergy between satellite data, GIS, and machine learning for automated change detection. The core innovation of this study lies in the implementation of the Artificial Intelligence Knowledge Processors (AIKP) approach, which serves as a modular foundation for a fundamental system development architecture. This methodology enables seamless integration of AI-assisted development and advanced geospatial analytics, producing a reliable framework for cross-domain monitoring. Integrating these technologies facilitates continuous remote monitoring, dynamic quarry assessment, and verification of extraction volumes. The proposed approach is highly relevant for monitoring areas with limited physical access and can be adapted for environmental analysis systems in industrial regions of Ukraine.*

Keywords. *Remote sensing, satellite data, artificial intelligence, mining industry, AI platform, GoldenRAM.*

Introduction. Ukraine possesses significant mineral and raw material potential and ranks among the leading European countries in terms of proven mineral reserves. Its territory is home to tens of thousands of deposits, which form a strategically important resource base for the metallurgical, energy, and engineering industries. Ukraine's mining sector is one of the key elements of the national economy and is of considerable importance to the European mineral resources market. However, the intensive exploitation of these resources is associated with significant anthropogenic impacts on the environment and requires systematic monitoring. The rapid development of the mining industry leads to significant transformations of the

natural environment, particularly the degradation of land resources and the alteration of natural landscapes [1].

Effective resource management requires continuous monitoring of industrial areas. Traditional ground-based methods are resource-intensive and often cannot be applied to hard-to-reach areas. In the current context, the situation is complicated by the fact that a significant proportion of deposits is located in regions affected by hostilities. Damaged infrastructure and the risk of landmines limit the ability to conduct field surveys. In such circumstances, remote sensing technologies become particularly relevant, enabling the acquisition of verified information on changes on the Earth's surface [2].

Main section. Modern satellite observation systems provide regularly high-resolution data on Earth's surface. The use of remote sensing data enables the systematic monitoring of industrial sites and the collection of objective information on landscape changes. Optical satellite imagery enables the analysis of surface morphology, the delineation of open-pit and waste-dump boundaries, and the assessment of changes in site area over time.

The use of Synthetic Aperture Radar (SAR) systems significantly expands monitoring capabilities, ensuring data acquisition regardless of weather conditions. SAR data is widely used to analyse structural changes in surface and ground deformation. The combination of optical and radar data enhances the reliability of scientific results. Further technological development involves implementing artificial intelligence (AI) methods to automate the interpretation of geospatial data. Computer vision algorithms enable the automatic identification of mining sites and the analysis of their dynamics [3-4].

An example of the implementation of such technologies is the European GoldenRAM project (Grant Agreement No. 101138153), whose architecture is based on the use of specialised Artificial Intelligence Knowledge Processors (AIKPs) distributed across three application domains [5]:

- exploration applications AIKPs: modules for geological exploration and mineralogical mapping.
- production, safety, and operations AIKPs: a module for monitoring the stability of open-pit scope and tailings dams, and for detecting volumetric changes.

- environmental applications AIKPs: components for environmental monitoring, including vegetation and water quality and acid mine drainage.

The AIKP workflow covers all stages from defining the area of interest to the final visualisation via a web interface. A key focus of the analysis within the Volume Change Monitoring module is the assessment of mining activity using Digital Elevation Models (DEMs). Analysis of differences in DEM time series enables elevation changes to be recorded, which correlate with the volumes of extracted material. The calculation of volumetric changes serves as an objective indicator of the intensity of mining processes.

An important aspect of the analysis corresponding to the Volume Change Monitoring module is the assessment of mineral extraction activity. To achieve this, DEMs are used to analyze morphometric changes in topography and evaluate the volumetric characteristics of mining operations. The GoldenRAM platform implements a suite of specialised AIKP analytical components designed for the intelligent processing of DEMs. Using this toolkit, relief models are visualised, time-series data are generated, and differential models (elevation differences) are calculated [5].

Analysis of differences between DEMs allows detection of changes in surface elevation, which directly correlate with rock extraction processes or the stockpiling of industrial waste. Based on the generated stacks, time series of topographic transformation are generated, enabling the assessment of quarry development rates and the determination of volumetric changes in mining workings. Calculating volumetric changes enables estimating the approximate volumes of extracted rock, which serves as an objective indicator of the intensity of mining operations.

Integration of satellite data, digital elevation models, and artificial intelligence algorithms within the GoldenRAM platform forms a toolkit for remote analysis of mining operations. The application of such technologies enables monitoring through regular observations and the generation of objective indicators of mining activity, especially for areas with limited or hazardous access [5].

Conclusions. This study examines the potential of using remote sensing satellite data and artificial intelligence methods for systematic monitoring of mining activities. It has been demonstrated that the convergence of satellite data,

geoinformation technologies, and machine learning algorithms enables the automation of landscape transformation analysis, the assessment of subsoil exploitation intensity, and the remote monitoring of industrial sites. Experience from implementing the European GoldenRAM project confirms the potential to develop integrated platforms for comprehensive analysis of the mining sector based on remote sensing data. For Ukraine, implementing such intelligent solutions is extremely relevant, given the need to monitor deposits in areas with restricted access due to military operations. The use of remote methods ensures the acquisition of verified information on the condition of industrial areas. It could become a fundamental tool for the rational management of natural resources and for strategic planning to restore the country's mining infrastructure.

ЛІТЕРАТУРА / REFERENCE

1. Weng, Q. Remote sensing for environmental monitoring and analysis. 1st Edition. CRC Press, Boca Raton, 2020. 452 p.
2. European Space Agency. Earth Observation Applications in Mining and Environmental Monitoring. ESA Special Publication, 2022. 84 p.
3. Copernicus Programme. Sentinel satellite missions for Earth observation. European Space Agency, Special Report, 2023. 112 p.
4. Asner, G.P., Tupayachi, R. Accelerating environmental monitoring of mining regions using satellite data. Remote Sensing of Environment. 2017. Vol. 201. P. 243–251. <https://doi.org/10.1016/j.rse.2017.09.015>.
5. European Commission. GoldenRAM Project: Digital platform for raw materials monitoring. Horizon Europe Research and Innovation Action. Grant Agreement No. 101138153, 2024.

ЗАСТОСУВАННЯ АІ-ПЛАТФОРМИ GOLDENRAM ДЛЯ МОНІТОРИНГУ ГІРНИЧОДОБУВНОЇ ДІЯЛЬНОСТІ З ВИКОРИСТАННЯМ ДАНИХ ДИСТАНЦІЙНОГО ЗОНДУВАННЯ ЗЕМЛІ

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***Анотація.** У статті аналізується потенціал даних дистанційного зондування Землі та штучного інтелекту для моніторингу гірничодобувних об'єктів. Досліджено дистанційну оцінку інтенсивності видобутку корисних копалин за допомогою мультиспектральних знімків, часових рядів та цифрових моделей рельєфу. Особливу увагу приділено платформі GoldenRAM, що забезпечує синергію між супутниковими даними, ГІС та машинним навчанням для автоматичного виявлення змін. Основна інновація цього дослідження полягає у впровадженні підходу «Процесори знань штучного інтелекту» (АІКР), який слугує модульною*

основою для архітектури розробки системи. Ця методологія забезпечує безперервну інтеграцію AI-розробки та передової геопросторової аналітики, створюючи надійну основу для міжгалузевго моніторингу. Інтеграція цих технологій сприяє постійному дистанційному контролю, динамічній оцінці кар'єрів та верифікації обсягів видобутку. Запропонований підхід є актуальним для моніторингу територій із обмеженим фізичним доступом і може бути адаптований для систем екологічного аналізу в промислових регіонах України.

Ключові слова. *Дистанційне зондування Землі, супутникові дані, штучний інтелект, гірничодобувна промисловість, AI-платформа, GoldenRAM.*