GOLDEN AI DATA ACQUISITION AND PROCESSING PLATFORM FOR SAFE, SUSTAINABLE AND COST-EFFICIENT MINING OPERATIONS

Jari Havisto[1], Taras Matselyukh[2], Marko Paavola[1], Sanna Uusitalo[1], Marko Savolainen[1], Alfonso Sobrecueva González[3], Andreas Knobloch[4], Kamen Bogdanov[5]

[1]Optical Measurements, VTT Technical Research Centre of Finland Ltd, Oulu, Finland
[2]OPT/NET BV, Noord Holland, Netherlands
[3]Sitemark, Leuven, Belgium
[4]Beak Consultants GmbH, Freiberg, Germany
[5]Sofia University "St. Kliment Ohridski", Faculty of Geology and Geography, Sofia, Bulgaria

ABSTRACT

Improved use of Earth observation, sensor and positioning data can offer additional exploitation and environmental control and increase the productivity of mines. The EU-funded Goldeneye project develops a Golden AI platform to allow satellites, drones and in situ sensors to collect high-resolution data from an entire mine. This data will be processed and converted into actionable intelligence in new tools offering improved safety, environmental observation, exploitation and increased extraction in pilot mines. The project will combine remote sensing and positioning technologies to take advantage of Earth observation and Earth GNSS data together with data fusion and processing powered by data analytics and machine learning algorithms. The benefits of Golden AI platform will be demonstrated in mining pilots in Bulgaria, Finland, Germany, Kosovo and Romania.

Index Terms— Earth observation data, drone, Raman spectroscopy, active hyperspectral imaging, exploration, mining, environmental monitoring

1. INTRODUCTION

The modern societies, including the infrastructure and industrial production are dependent on raw materials and minerals. Although there is pressure to increase the use of recycled raw materials [1] to ensure sustainability, the excavation of minerals remains important as the need for raw materials is ever increasing [2]. The reason is that it is not possible to re-use all the waste due to ineffective and difficult separation processes and controversial environmental effects [3]. In some cases, the recycling process itself can consume excessive amounts of energy or release toxic chemicals. In addition, the quality of secondary materials is not always on the same level with virgin materials. Thus, the amount of circulated raw materials remains limited due to challenges in recycling. It is important to ensure the production capability of minerals now and in the future. This calls for not only locating new mineral deposits, but also social license to operate and attraction of workforce.

The European Commission has granted EUR 8.4 million to a three-year H2020 project, Goldeneye [4], which started on May 2020. Goldeneye consortium develops an artificial intelligence platform for the monitoring and analysis of mine sites across Europe to address the afore-mentioned production demands. The platform integrates information from satellite produced Earth Observation Data (EOD), drone overflight sensors and on-site recorded data. Its applications will improve safety, environmental impact and profitability of mines by employing automated data pre-processing fusion, AI and state-of-the-art visualisation methods [5].

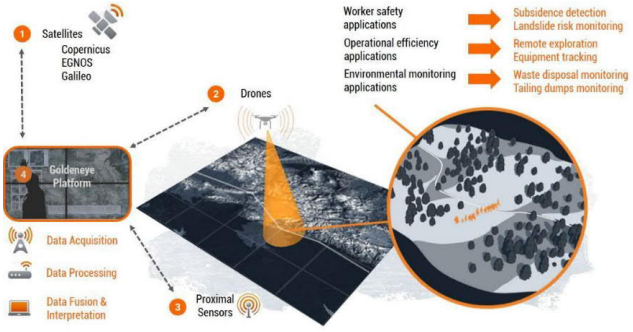

Figure 1. Goldeneye project combines data from satellites, drone missions and in-situ measurements.

The Goldeneye platform will be piloted on five mining sites across Europe. The use-cases of the Goldeneye platform address the different phases of the mine's life cycle from exploration to closure and post-closure. The applications developed in the project include mineral detection, safety monitoring, operational management, geo-

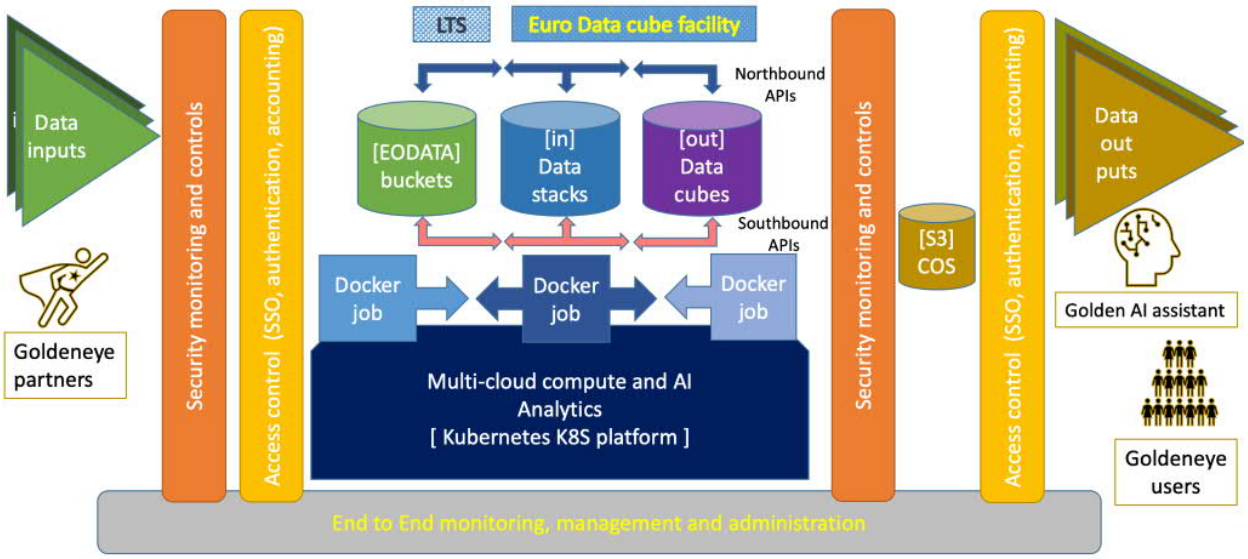

Figure 2. High-level architecture diagram of the Golden AI platform.

hazard monitoring, and environmental monitoring. For example, in the safety monitoring application the aim is to improve the safety of the mines by monitoring the mining sites for sudden slope and ground changes as well as analysing the environment of the mines to detect any mining water leakages from their indirect influence to the surrounding nature. End-users (mining site operators) will have visualized analytical maps in their use but need not to be concerned about how this data is collected and prepared. The required data pre-processing is provided automatically by the platform and the required AI tools are developed by the experts. The end-users can just communicate with the platform's AI assistant with natural human language and make use of the results.

2. GOLDEN AI PLATFORM

In future, the mines will be more and more automated with increased remote operational control. Automation will improve monitoring of mining activities such as employee location, mine slope stability, asset management and environmental control [6]. The monitoring can benefit from several data sources including satellite imagery, drone and aerial surveys as well as single sensors or instruments. Monitoring produces large amounts of data in the form of images and spectrographs. Therefore, there are challenges in fast and timely analysis of acquired data [7].

Working with a wide set of different types of data is time consuming and requires a lot of expertise. The Goldeneye consortium aims to develop an AI platform that enables novel uses of EOD in the mining industry. The Golden AI platform enables the fusing of satellite, drone and in-situ data with automated data pre-processing and state-of-the-art visualisation methods. The visualized analytical maps are accessible to the mining site operators with simplified end-user experience without the need for in-depth knowledge of how the data is collected and pre-processed.

Data fusion combines data from two or more sources, which provide data over the same area with comparable resolutions. Thus, creating data with improved information quality. Furthermore, data fusion can be beneficial for data with different spatial or temporal resolutions. For example, the temporal resolution of high-resolution and low-frequency satellite data can be improved by utilizing data from low-resolution and high-frequency sources. Data fusion can also combine data from different sources, *e.g.*, geophysical data from drone-missions and targeted in-situ Raman spectroscopy measurements or active hyperspectral imaging (AHSI). The data fusion products will be added to a stack of generated ARD (Analysis Ready Data) in the ESA (European Space Agency) Data Cube facility for reuse. Data cubes are formatted according to ESA Euro data cube and support ENVI format specifications. On-top visualisations will be based on COG (cloud optimized GeoTiff format).

As a summary, the generated Golden AI intelligence platform combines different data sources to provide next generation tools for mine safety, environmental monitoring and mineralogical mapping. Figure 2 shows the high-level architecture of the Golden AI architecture. This high-level architecture is the development-basis for a cost efficient, scalable and commercially viable solution. The design is flexible and updatable for novel technologies in the future.

The Golden AI platform demonstrator will benefit different users and stakeholders by providing tools and a platform for visualization, work, collaboration and reporting of various aspects in the mining site. The use cases include, asset tracking, automated calculation of stockpiles and detection of anomalies. The Golden AI

platform demonstrator will automate the recognition of known patterns in the fused data through the creation of specific AI Knowledge Packs (AKPs) developed for each use case. AKPs are language and development tool independent and therefore any AI tool can be used provided that its interface is compatible with the Goldeneye platform. Baseline for the data fusion algorithms are based on OPT/NET [8] products such as TSAR AI and MONITORED AI. – The products are proprietary commercial solutions which are being further developed and specialized in Golden AI platform. In addition, the solution is using a "commercial off the shelf" (COTS) IBM Watson Assistant [9] powered service for interactions with the human users in native human language and detecting intent and objects in the user queries. The platform supports a variety of common data standards: Input data in OGC, CEOS ARD (CARDL) or de-facto popular standard formats such as SAFE and ENVI for raster data and GeoJSON and KML for area shapes. The data outputs are in OGC compliant visualization maps (see Table 1).

Table 1. Data types and formats included in the Golden AI platform for different use cases.

Application	Data input/output formats
Multi- and hyperspectral satellite data processing	SAFE, ENVI
SAR satellite data (S1, TSX or equivalent)	SAFE, ENVI, CoSAR
RGB imaging with drones	8-bit RGB GeoTiff (orthomosaics) tiff/jpeg
Thermal Imaging with Drones	16-bit Geotiff (orthomosaics) tiff/rjpeg
Multi spectral imaging with Drones	16-bit Geotiff (orthomosaics) tiff
Electromagnetic sensing with drones	esri-ascii grid, geosoft grdgrid
Elevation sensing with drones	8-bit RGB (pseudocolor) GeoTiff (orthomosaics)
Raman - Mobile device	.csv and .txt files
Raman - Drilling device	.csv and .txt files
Active hyperspectral prototype development	tdms database file, Geotiff raster files
GNSS/GPS indoor navigation	N/A or GPS signals
GNSS/GPS outdoor navigation	NMEA
Platform for use cases	Multiple formats such as COGTiff, SAFE, CoSAR, ENVI, CARDL Euro Data cubes. API: S3 COS Access protocols: SCP, sFTP, NFS, HTTPS.

3. APPLICATIONS FOR EVERY STAGE OF THE LIFECYCLE

Goldeneye project has applications for different phases of the mine's life cycle from exploration to closure and post-closure. Use-cases vary from mineral detection, safety monitoring, operational management, geo-hazard monitoring, and environmental monitoring. The platform will be piloted on five mining sites across Europe. Pilots in Pyhäsalmi mine in Finland and Trepča Mines Complex in Kosovo will study the stability and environmental impact of the mines. GNSS location positioning and turn-by-turn navigation will also be tested at Pyhäsalmi. These technologies aim to improve the safety in underground mines by providing accurate location information and better mining activities tracking. Focus on Erzgebirge site at Bockau district in Germany and Panagyurishte district in Bulgaria trial sites will focus on mineralogical mapping. Satellite information will be calibrated using geophysical and in-situ Raman and AHSI sensing. In-situ measurements will also be used to teach AI algorithms. By improving the mapping of valuable mineral deposits using high-resolution imaging the efficiency of mineral exploration can be enhanced. Field trials in Roşia Poieni district in Romania will aim to improve profitability and support the local mining community by improved mineral predictions and fusing satellite imagery with drone-mission data.

Goldeneye project will also develop a novel mineralogical sensor solution for ore-drilling platforms. Sandvik drilling machines will be integrated with time-gated Raman sensor to analyse mineralogy during exploration drilling. The integrated sensor solution will increase the mineral extraction efficiency and can therefore increase the profitability of mines.

The Project will deliver four public demonstrators: 1) Data integration framework containing components for validation, feature detection and labelling, and anomaly detection. 2) Mineral application toolkit utilizing data fusion techniques. 3) Safety, geo-hazard and environmental monitoring application toolkit. 4) Other operational application toolkit for mine management optimization. Heterogeneous point-access to Goldeneye services is available for commercial users.

Figure 3. Goldeneye consortium consists of 16 European companies and research partners.

4. CONCLUSIONS

The consortium works together to develop a Golden AI platform, which brings together the work of sensing experts, solution providers and European mines. The aspiration is to create a general platform, which can flexibly endorse new mining applications during and after the Goldeneye project providing services and mine intelligence to different actors of the raw material sector. Project is coordinated by VTT Technical Research Centre of Finland. The consortium consists of 16 European companies and research partners: VTT, Beak Consultants, Cuprumin, Dares Technology, Earth Observing System, Galileo Satellite Navigation, OPT/NET BV, Radai, Sandvik Mining and Construction, Sinergise, Sitemark, AKG sh.p.k, Technical University of Cluj Napoca, Timegate Instruments, University of Oulu and Sofia University, Bulgaria (Figure 3).

5. ACKNOWLEDGEMENTS

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