XXIII Conference of PhD Students and Young Scientists

Interdisciplinary topics in Mining, Geology and Geomatics

MineCam: Application of Remote Sensing combined with Machine Learning for Mining Areas Monitoring

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ABSTRACT

We developed a solution that combines remote sensing and machine learning to continuously monitor surface transformations in mining areas like deforestation, infrastructure construction, excavation, and dumping. Our dataset contains over 2000 labeled satellite images, classifying over 10 components of mining areas. To accomplish the classification task, we evaluated different deep learning algorithms using various combinations of training data, including different image band combinations and truncated datasets focused on specific types of surface mines. Our final solution enables to (1) assess environmental impact in terms of land use, (2) detect illegal mining, (3) track the progres of mining operations and reclamation.

DATASET

The ML dataset was created using Earth Observation (EO) data from Sentinel satellites, including Sentinel-2 MSI L2A product with 12 spectral bands, as well as Sentinel-1 GRD scenes with dual-band cross-polarization. The data were resampled to 10 m spatial resolution and merged into a fused product of optical and radar data (Fig 1). Collected dataset of over 2000 images from 400 mining areas worldwide, differentiated by size, raw material type and cliatic zones

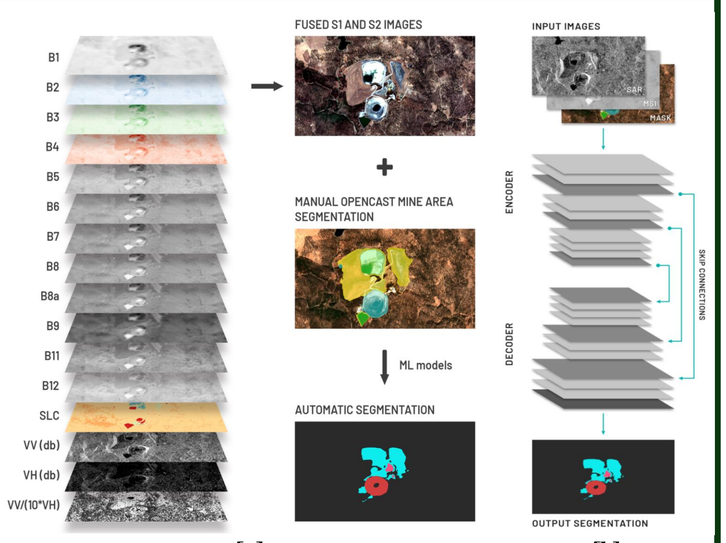

***Figure 1**. Data fusion in semantic segmentation task [a] and ilustration of encoder-decoder neural network for multidimensional satellite data*

Ground truth labels were manually annotated, compromising on certain definitions. A deep learning approach using an encoder-decoder architecture (Fig. 1) was employed for supervised image segmentation, with separate data subsets for training, validation and testing.

MATERIALS AND METHODS

Creation of pipeline for data download

Specific labels definition
← preparatory works, excavation, dumping ground, stockpile, settling pond, infrastructure, dam, tailings storage facility, outcrop, overburden, production slope, transport slope

Dataset creation
← Over 2000 satellite images of mining areas labeled using the CVAT (computer vision annotation tool) platform.

Creation of disjoint sets of labels (separate ML models)
← For instance: the dumping ground can be internal (inside the excavation), so the labels were assigned to different ML models. 5 models in total were decided, while the 5th one is to infer total transformed area.

Testing and choice of the best band combinations for individual models
← For all the models, we tested their performance after training only on specific band combinations. W tested: RGB, RGB+NIR, MSI, MSI+SAR, RGB+NIR+SAR

Testing for models optimization by splitting training datasets
← We checked the performance of models while training on truncated datasets. We had split dataset depending on surface mine type (open-pit, opencast, mountain-top) and extracted material type (coal&lignite, rock raw, metal ores).

Choice of the best models for process automation and implementation in our TerraEye application

To create the most reliable ML models we conducted several research tasks in order to optimize the results.

MINECAM

The research was conducted as part of the **MineCam** project. The main objective of the project was to develop a modern application for monitoring surface mining activities.

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RESULTS

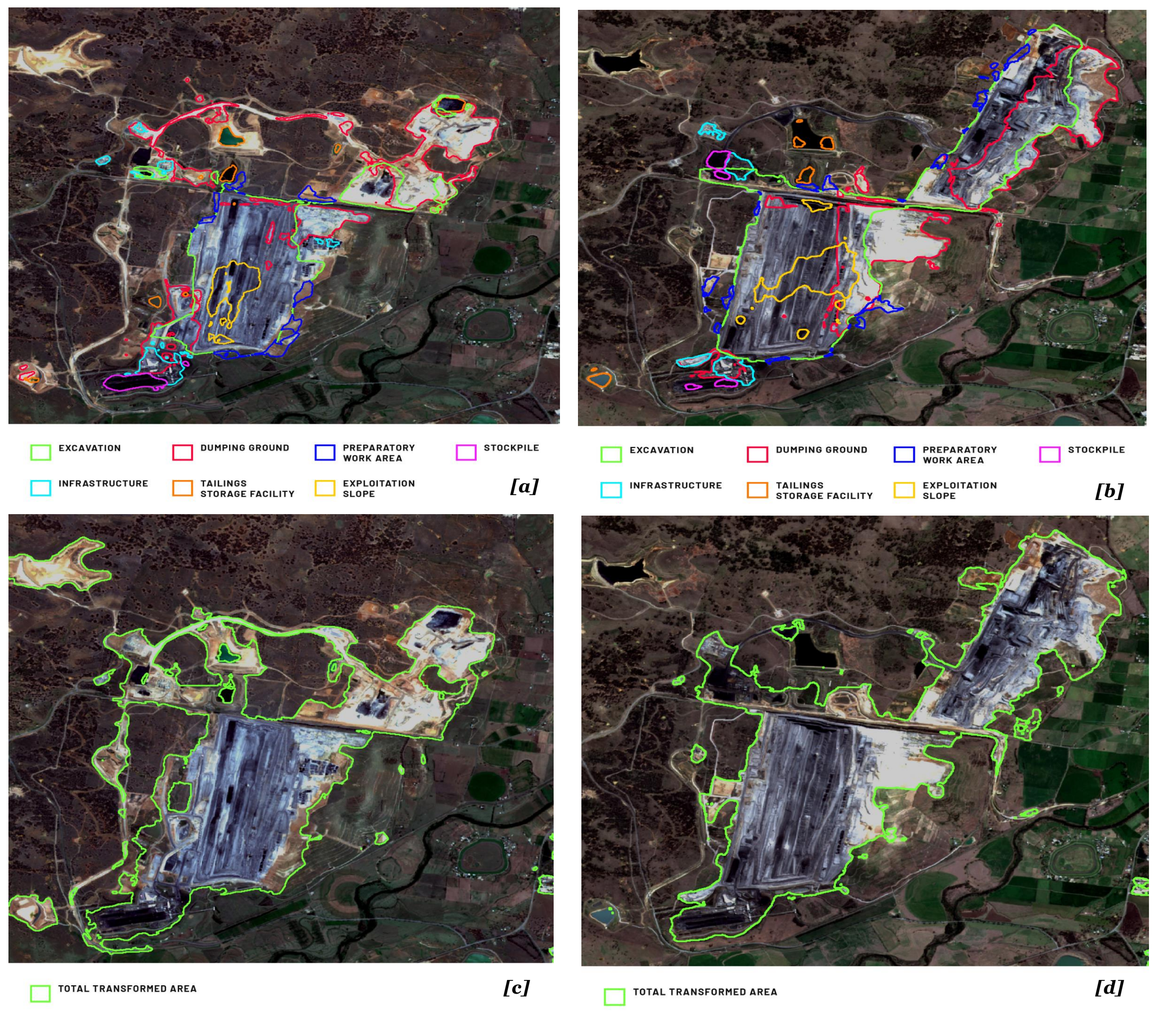

***Figure 2**. Bengala Coal Mine (Australia): example predictions of four ML for 2019 and 2021 [a, b]; example predictions of „total transformed area" ML model for 2019 and 2021 [c, d].*

DISCUSSIONS

- We find our best ML models able to automatically recognize components of mining areas from satellite images; track the progress of mining, track environmental impact in terms of land use, as well as detect illegal mining activities;
- Finding a balance between heterogeneity of mining area components and the number of defined land cover classes (and therefore the number of ML models) is crucial in our opinion;
- Splitting of training datasets by mine type and mineral type, did not significantly improve model metrics in our research, however, we find the testing dataset too small to draw overall conclusions; further tests are necessary;
- We find the models to provide more accurate results than the ground truth masks in some cases since the data labeling might have been subjective on 10x10 satellite data;
- We believe that the results and the possibilities of using the models would be much better if the dataset was constructed from high-resolution satellite images

ACKNOWLEDGMENTS

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REMOTE SENSING BUSINESS SOLUTIONS

RSBS is a company that deals with the processing of remote sensing data with ML and AI algorithms in order to extract business value. RSBS provides a set of digital tools for the detection, classification, and assessment of objects and phenomena in satellite imagery.

TerraEye is a web-based app dedicated to the mining industry for all the stages of the mining cycle, enabling near-real-time monitoring through automated data processing pipelines, as well as analyses based on archival data. It enables users to semi-automated generation of reports.

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