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TERRAVISION

Synthetic Dataset Generation for Change Detection in Mining Areas Using Image Inpainting

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Change Detection

Change Detection is a fundamental problem in Remote Sensing and computer vision that involves identifying differences in the state of a geographic area over time.

INPUT → Two satellital images

OUTPUT → Binary change map

Use cases:

- Buildings (built-up areas)
- Roads (paved areas)
- Fields (cultivated areas)
- Forests (deforested areas)



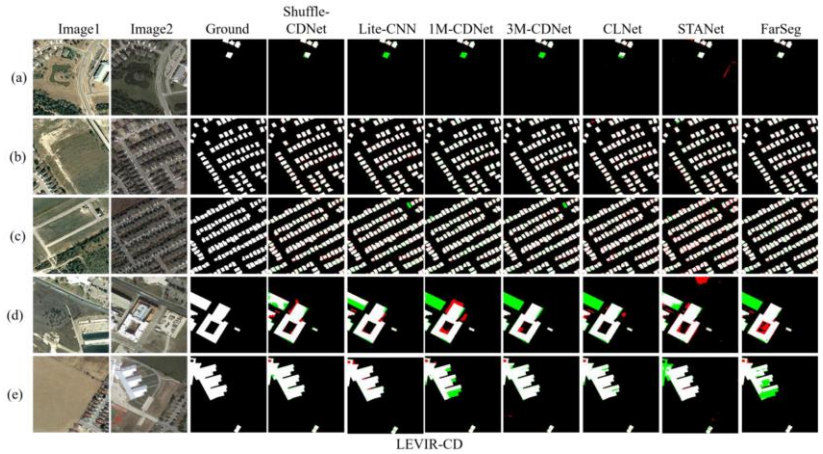
Change Detection

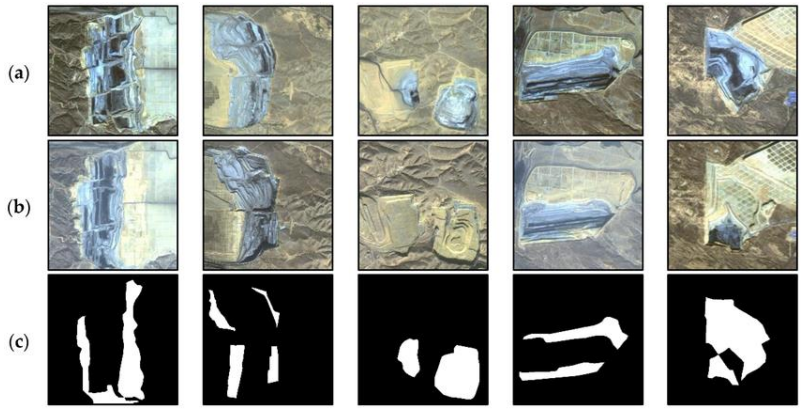
Objective: Train a LVLM (Large Vision-Language Model) capable of generating a mining activity change map from two satellite images of open-pit mines.

Problem:

- Scarcity of specialized models: very few models are suitable for such a specific use case.
- Domain mismatch: existing datasets are mostly focused on urban and forest changes.
- Model limitations: the few available models are too permissive (prone to false positives) and rely on aerial rather than satellite imagery.

LEVIR





OMCD

Change Detection

Solution: Given these limitations, we had to design a custom synthetic dataset for Change Detection using inpainting techniques and specifically focused on mining areas. Base images were acquired from the European Space Agency's (ESA) Sentinel-2 satellite constellation.

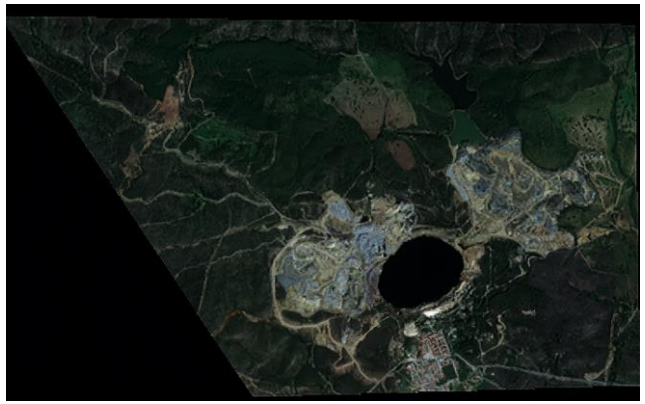
Considerations:

- Highly time consuming
- Hard-to-control changes
- Limited base image variety (four mines in Spain)

La Zarza (Huelva)



San Telmo (Huelva)



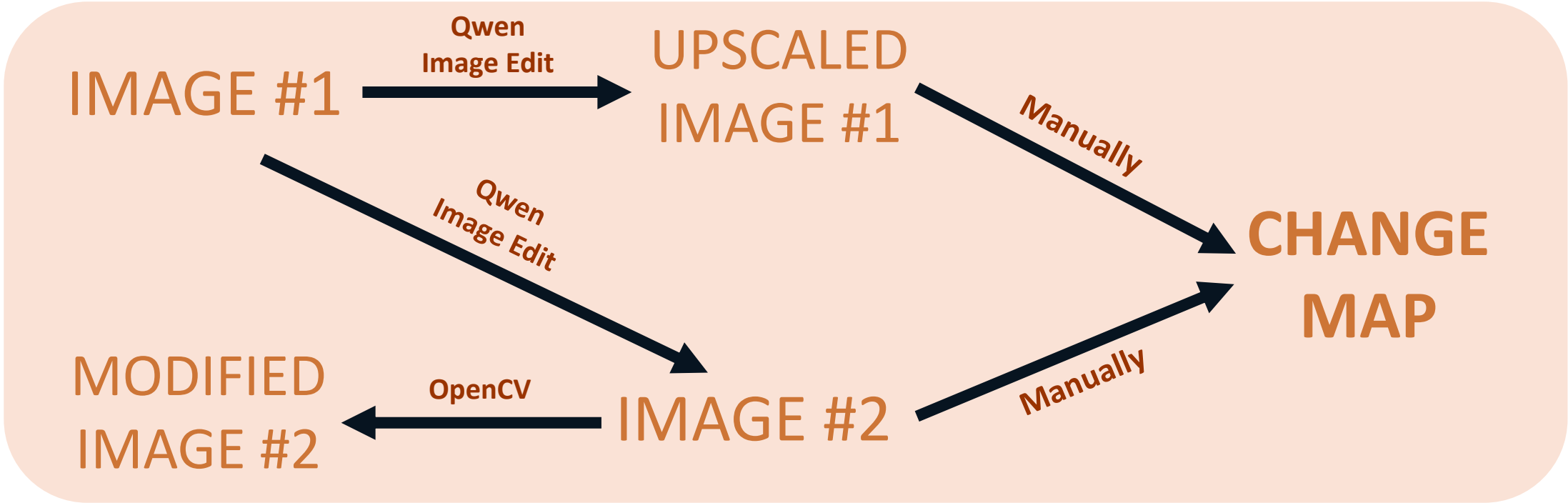
Tharsis (Huelva)



Canteras (Granada)



Synthetic Data



Final dataset structure: { UPSCALED IMAGE #1 , MODIFIED IMAGE #2 , CHANGE MAP }

Synthetic Data: Inpainting

To construct a sufficiently large dataset, inpainting techniques were applied to alter the base images and introduce specific variations.

Qwen Image Edit was used for this task, an image-to-image model that preserves context and proved fitting for mining activity modifications.

Frequent prompts included:

- *Add a small stockpile near the mining area.*
- *Increase the mining area / expand the mining activity.*
- *Add a small road or path near the mine.*
- *…*

Synthetic Data: Tweaking

Additional alterations were performed on each generated image to account for plausible changes due to the time of day or atmospheric conditions that occur in real-life scenarios.

Visual variability was carried out using **OpenCV**, altering lighting, hue, saturation and contrast.

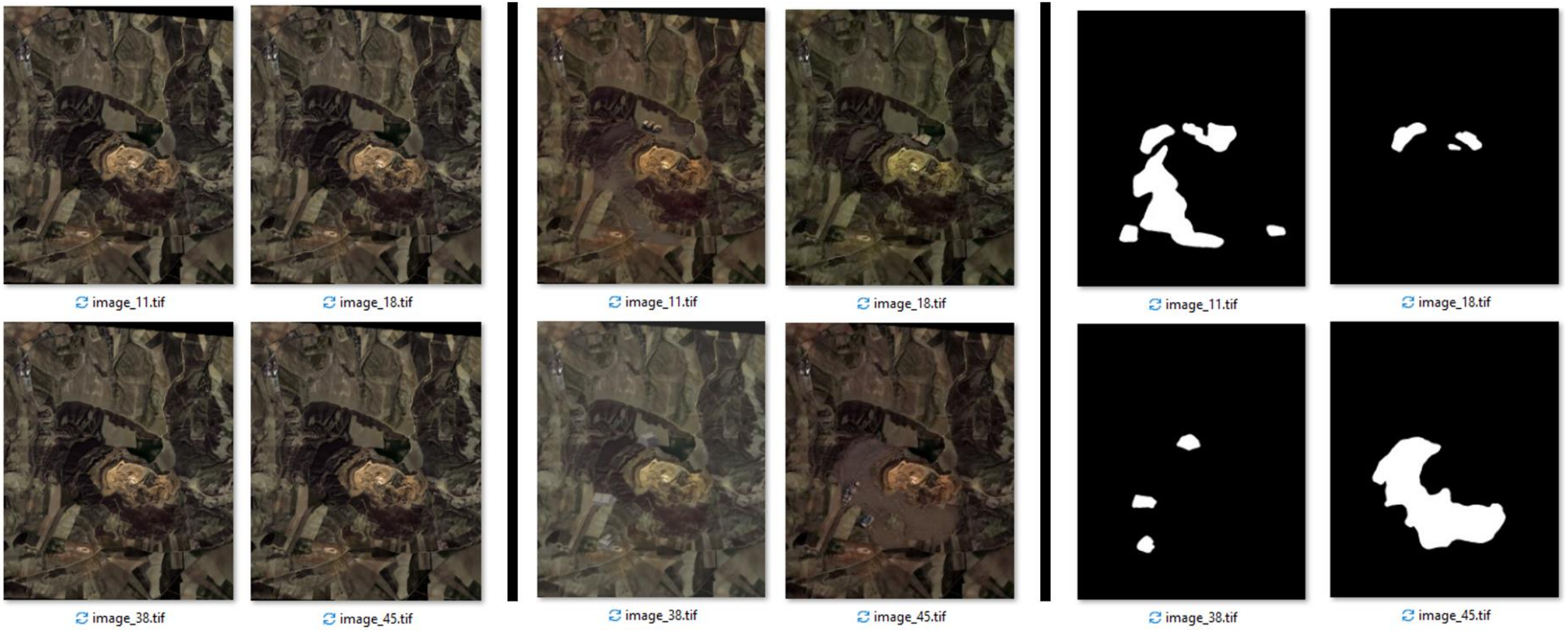


Synthetic Data: Ground truth generation

For ground truth generation, several approaches were considered. Ultimately, it was decided to manually draw the binary change maps, as this was the most reliable way to strictly control what should be classified as a change and what should not.

The primary drawback of this approach, however, is that it is highly time-consuming. **GIMP** was utilized as the main tool to generate the change maps, totaling over 900 images.

Synthetic Data: Ground truth generation

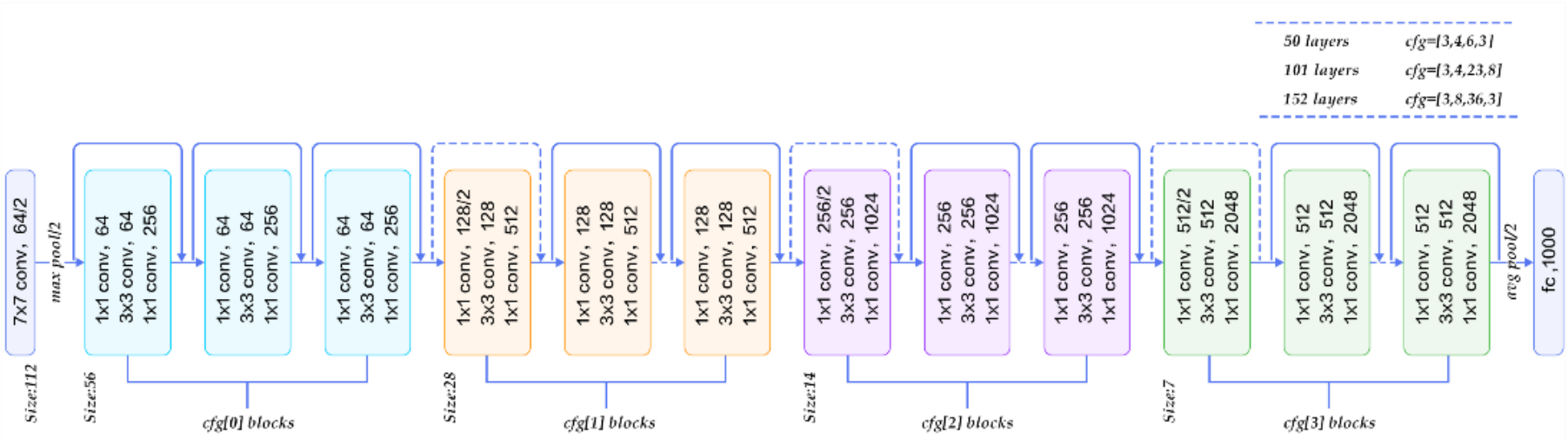


Model Fine-tuning: MineNetCD

MineNetCD is a Deep Learning framework for Change Detection using Remote Sensing imagery in mining environments. It is part of a benchmark that includes a large-scale dataset and a unified framework for evaluating Change Detection methods.

It offers several architectures:

- *Swin_Diff_B*
- *ResNet_Diff_50*
- *VSSM_T_ST_Diff*



Model Fine-tuning: MineNetCD

Dataset splitting

To follow the standard practices for data distribution in these scenarios, the dataset was partitioned into 70% for training, 20% for validation, and 10% for testing.

Model configuration

Both the ResNet and Swin architectures were fine-tuned using the synthetic dataset. Hyperparameter tuning focused on learning rate schedules, batch sizes, and optimization algorithms to identify the optimal configuration.

Evaluation

Model	Precision	Recall	F1	IoU
ResNet_5e-5_50	0.861488	0.871294	0.866363	0.764322
ResNet_5e-5_100	0.89229	0.838944	0.864795	0.761796
ResNet_5e-5_150	0.909873	0.836687	0.871747	0.772652
ResNet_1e-4_CM_50	**0.919595**	**0.836247**	**0.875943**	**0.779269**
ResNet_1e-4_CM_100	0.916919	0.83362	0.873288	0.775076
ResNet_1e-4_CM_150	0.912393	0.83678	0.872952	0.774547
SWIN_5e-5_50	0.903834	0.84793	0.87499	0.777762
SWIN_5e-5_100	0.884263	0.84518	0.86428	0.760997

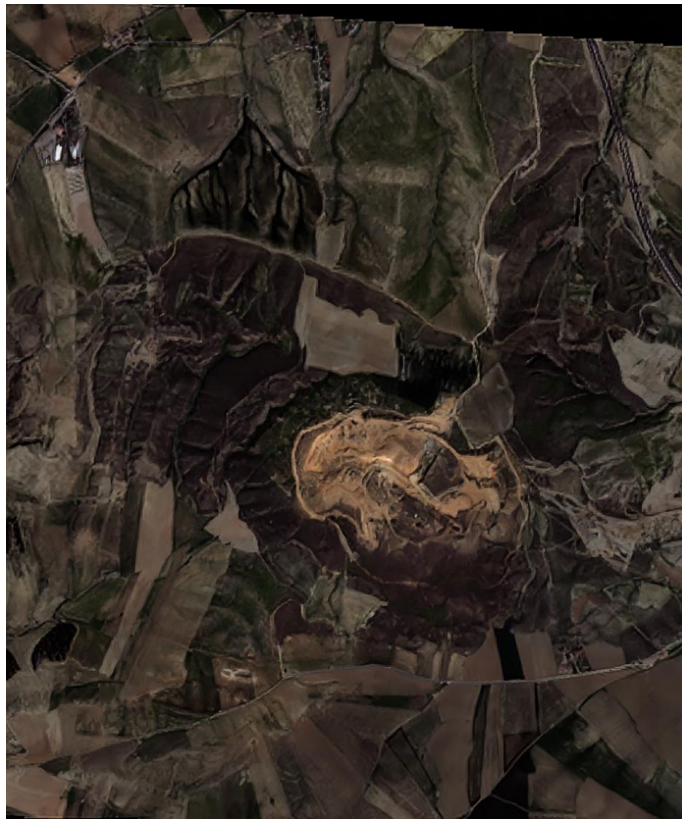
Metrics

- Precision
- Recall
- F1-Score
- Intersection over Union

Results: Canteras



2017



2024

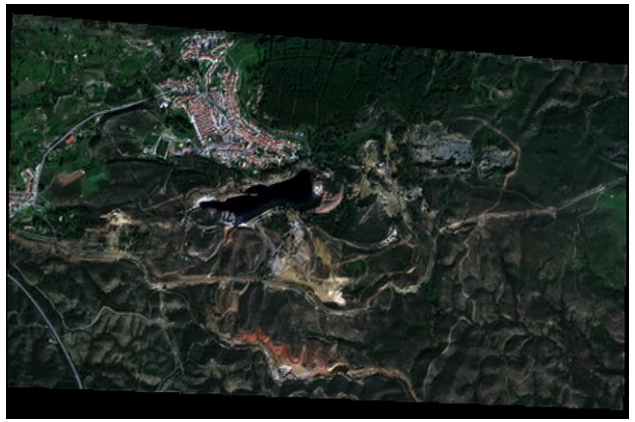


Change map

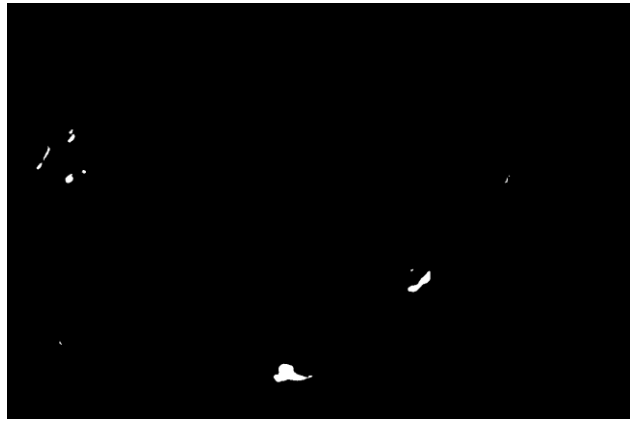
Results: La Zarza & San Telmo



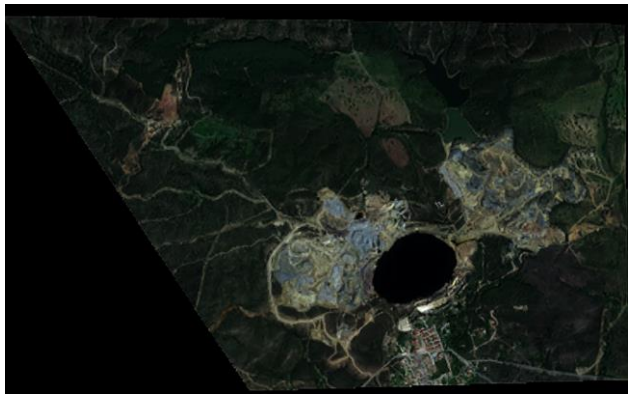
2017



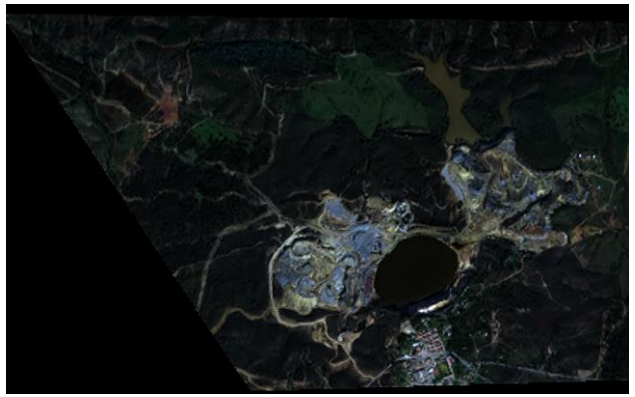
2025



Change map



2017



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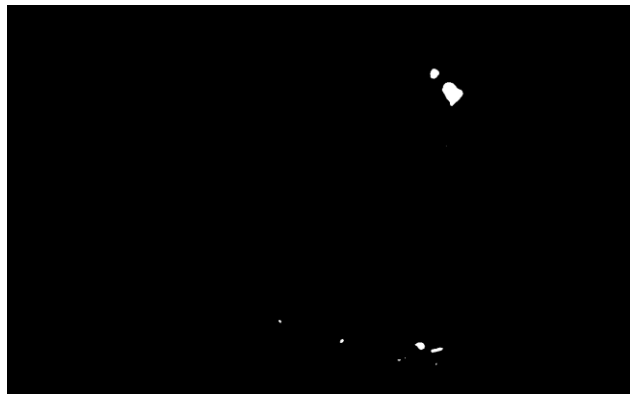

Change map

Questions & Contact

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