Towards a Challenge-Ready Cartography: Enhancing Road Network Mapping Using AI and Satellite Imagery

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Who I am?

- Educational Background:
  - BS in Geomatics Engineering by UPV
  - MSc in Geomatics Engineering and Geoinformation by HKA
- Professional Experience:
  - 2+ years as a GIS Back-End Engineer
  - Currently Geomatics Engineer at the Geographic Institute (since 2023)

What we do?

- Produce, maintain and serve the transport network cartography
- Focus on official attributes and rural areas

Which problems do we face?

- Autonomous vehicle
- Climate change
- BIM

Need for detailed characterization and faster updating

Solution proposed

The PNOA (National Plan for Aerial Orthophotography) service provides high-quality satellite imagery with a resolution of 0.15 meters.

Using high-resolution PNOA images, we perform data extraction to automatically update our geometries and properly characterize them.

The models

- Roadways semantic segmentation
- Roadway lines semantic segmentation
- Road markings object detection
- Arrows oriented object detection
- Roundabouts detection
- Bridges detection

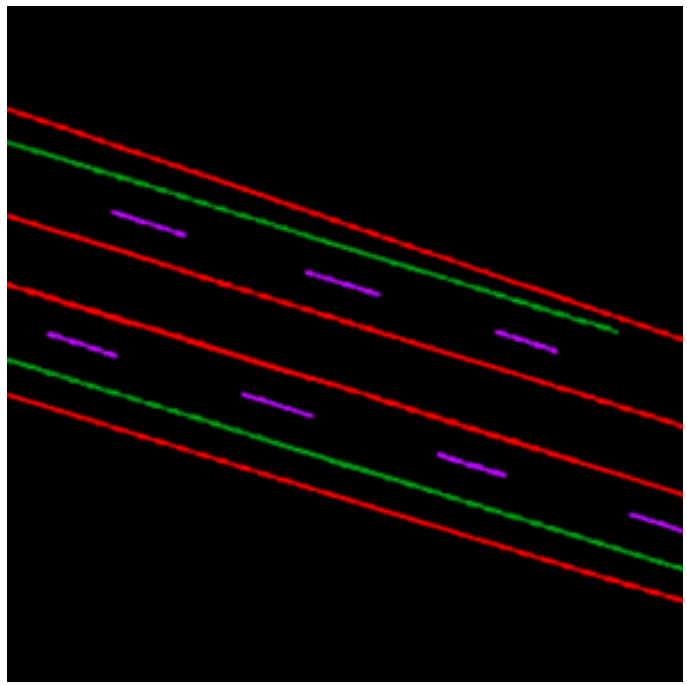
Roadways

Binary semantic segmentation based on a ResNet encoder and Unet decoder architecture using PyTorch.

The aim of this model is to restrict the areas where we run the rest of the models, enable change detection, produce BIM models, and delimit parcels in urban areas.

Roadway lines

We use FPN architecture based model and Tensorflow. Up to 3 classes.



This model aims to extract attributes, such as the number of lanes.

Road markings

Use Yolov5 to both train and predict up to 19 road marks classes.

With this model we aim to increase the attributes of our cartography for the autonomous vehicle. Stop signs, yield signs, pedestrian crosswalks, etc.

Arrows

Yolov8 to detect up to 9 classes.

With this model we aim to obtain the driving direction of each lines, the allowed turns, forbidden turns, etc.

Roundabouts

Use of Yolov5, to detect up to 3 different classes.

Automatically classify the geometries as roundabouts and assign the same driving direction.

Bridges

Yolov8. 3 classes.

With this model we aim to assign the elevation of each road segment for an proper topology in the network.

Phases of the project

- Training phase
  - Dataset generation: Semi-automatic produced (100.000 tiles)
  - Metrics analysis
- Prediction phase
  - Output: classified images/(o)bbox
- Post-process phase
  - From raster/(o)bbox to geometries in the db

The stack

- Dataset generation
  - LabelImg (bbox)
  - LabelMe (obbox)
  - QGIS
- Modeling and processing
  - Pytorch
  - Tensorflow
  - YOLO
  - Segmentation models
  - GDAL
- DevOps
  - Docker
  - GitHub

Problems and difficulties along the path

- Training data: Time-consuming to produce. If done automatically, the results are suboptimal
- Learning new tools
- Managing team expectations (AI projects often generate too much hype, which may not always be satisfied)
- Handling large amounts of data

Next steps

- Seamlessly integrate the ML models into our workflow
- Set up a proper production environment
- Implement a CI/CD strategy
- Ensure easy access to the application
- Fine-tune the models
- Develop data warehouse solutions
- Add or migrate to a more frequently updated image provider (PNOA currently updates every 2-3 years)

Thank you!

Any question?

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