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The automated detection of different trucks in orthophotos with ArcGIS Pro

Project Goal

The aim of this project was to be able to recognise different trucks on the basis of orthophotos (raster images). For this purpose, the trucks had to be classified into the following classes according to their length. Three vehicle types were distinguished: single truck, semi-trailer truck and multi-trailer truck.

Dataset Used

Digital orthophotos of North Rhine-Westphalia from OpenGeodata.NRW.de were used for this project. These images were 4-band images (red, green, blue, infrared) with a resolution of 10cm and an image size of 1000m × 1000m (10000pixel × 10000pixel). The NRW orthophotos were divided into 100m × 100m images and 2400 were selected from them. Of this number, 2148 were labelled for training and validation of the truck detection model.

Challanges

Model training requires a large amount of training data to achieve optimal results. For better results and analysis, more training data and better data resolution would have been necessary. For example, the model occasionally recognised cars with trailers (and in rare cases house walls) as trucks. Furthermore, it was difficult to differentiate between two vehicles parked close to each other, as they can be perceived as one vehicle.

Applied Methods

A deep learning model was trained for automated recognition and differentiation of the different vehicle types. A pre-trained TernausNet-16 model was used for this purpose. Training data was first created from 1747 images by manual labelling and used for training the model. TernausNet-16 is a U-Net16 with VGG11 encoder pre-trained on ImageNet for image segmentation. The U-Net architecture consists of a contracting path with typical convolutional network architecture and varied convolution and pooling.

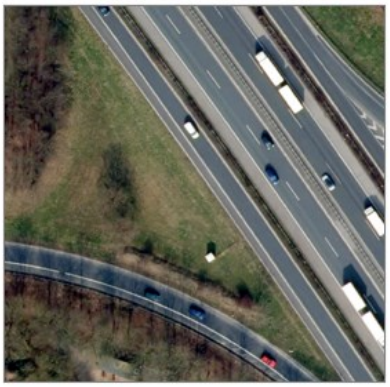
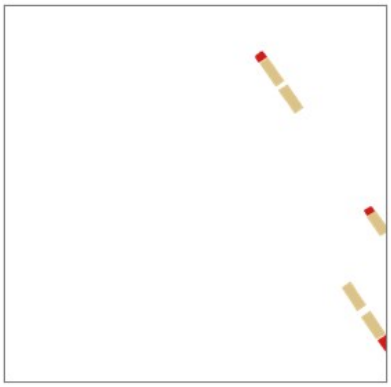


Image from OpenGeodata.NRW.de



Labelled trucks

ArcGIS

The output of the model is a pixel mask with a predicted class for each pixel. In the case of vehicle detection and classification, the output of the model consists of pixels belonging to the classes background, trailer and cabin. Subsequently, the trained model was evaluated based on the detected trucks, using validation data consisting of 437 images. The detected trucks were then divided into 3 classes based on the length of the truck calculated from the rotated minimum bounding box. Subsequently, the trained model and truck classification was implemented in ArcGIS Pro through an inference function and a specific esri model definition file.

Project Outcome

The model resulted overall with good and reliable accuracy, precision and recall. Over 99% of the trucks were recognised by the model. Less than 10% of the detected trucks were classified in the wrong class.

In some exceptional cases, the model provided incomplete recognition with missing parts of cab or trailer. In 5% of the cases, the model classified background as a truck.

Further fine-tuning of the model, with additional training data of different framework conditions, can make the model even more robust and solve all the problems mentioned above.

	ACCURACY (%)	PRECISION (%)	RECALL (%)
Single truck	93.15	90.34	98.82
Semi-trailer truck	92.46	91.76	95.12
Multi-trailer truck	95.20	99.17	95.24

Input grid

Output grid with classification

ArcGIS