# Automated road detection in high resolution satellite imagery

*Assignment description for the University of Amsterdam course 'Leren en Beslissen'*
*version 02, 20181205*

## Assignment background

Earth Observation satellites provide the capability to acquire detailed imagery (up to 0.4m detail) of large areas anywhere in the world within a short period (although optical sensors are depending on cloud cover). This makes this type of data suited as a source for generation of actual maps. For example in cases where large changes occur due to vast economic or population developments, as a consequence of natural hazards, or in cases where detailed maps don't exist.

For the translation of satellite images to maps an analysis step is required to interpret the raster pixels to map features, mostly structured as vector elements. This translation or interpretation can be easily made by humans, but manual interpretation is a very laborious activity. Much effort has been made to automate the interpretation process. In the past many methods were developed that are based on analytical methods using spectral and morphological features in combination with physical models describing the object's characteristics. More recently Artificial Intelligence based methods made strong progress. They provide the possibility to include empirical knowledge by training systems based on a large number of offered situations. For image analysis Convolutional Neural Networks combined with Deep Learning shows promising results. Using Transfer Learning the training results from other networks (e.g. Google Inception) can be integrated to speed up the process and limit the required amount of training data. Extensive representative training data and sufficient processing power are required however.

## Assignment description

The assignment will focus on the detection of the road network in high resolution optical satellite imagery (0.8m). Objective is to detect the road elements and classify the different main road types. It would be very valuable if the network character of the roads can be taken in to account, so that the result can also be applied for route planning applications.

A dataset for part of the Netherlands is available, consisting of a TripleSat image and the road network from the Top10NL topographic map. A test area of about 20x20km around Amersfoort has been selected. It can be extended easily when required. The TripleSat image is a 0.8m resolution image with four colour bands. From the Top10NL all roads are selected for the test area and clustered into 11 different classes. The vector roads are rasterized in the same raster as the satellite image. See also the dataset examples in Annex-A.

We envision the following to take place. The student team will be provided with the data set. A method should be developed to detect the roads and classify them in the different types, and maybe correct the result for artifacts, so that a road network is obtained. A short inventory of results published in literature will be made. Based on this an approach will be defined and implemented. Possibly the method can be built up stepwise, introducing more complexity in several steps. An evaluation of the quality should take place. Recommendations related to operational implementation should be given (e.g. further quality enhancement, optimization of processing performance)

## Brief description of company and contact persons

**NLR** is the Netherlands Aerospace Centre for identifying, developing and applying advanced technological knowledge in the area of aerospace. Our activities are relevant to society, market-oriented and carried out on a non-profit basis. We thus strengthen the innovativeness, competitiveness and effectiveness of government and business. www.nlr.nl

Mark van Persie and Bas van de Kerkhof both work at the C4ISR (Command, Control, Communications Computers and Intelligence, Surveillance and Reconnaissance) and Space Utilization department at NLR. Mark is working on remote sensing applications, while Bas is doing a PhD on Machine Learning on inSAR elevation data.

## Information about the course and students

The assignment will be carried out in the framework of the University of Amsterdam College of Science Bachelor Artificial Intelligence course 'Leren en Beslissen'. A team of about four second year students will work on the assignment during four weeks in January 2019.

## Information about the expected working location

The student team is expected to find a working spot outside of NLR, except half a day per week where a meeting room at NLR and at least one of the contact persons will be available in person. During the week regular phone and e-mail contact will be possible for consultation and guidance from NLR side.

# Annex-A. Dataset description

## TripleSat satellite image

GeoTiff image with 0.8m pixelsize and 4 spectral bands. This image is the result of a resolution merge of a 0.8 meter panchromatic image and e 2.4m multi-spectral image. The colour bands of the image are Red, Green, Blue, Near Infra Red. The last colour band might be valuable to discriminate vegetation from non-vegetation. The colour information acquired in 12 bit and stored in 16 bit. The TripleSat images are acquired in stripes of about 25km wide. For this test an area of 20x20km within one stripe is selected. In case a larger area is required, two or more stripes will be mosaicked. The projection of the image is RD and the datum WGS84. For the assignment the image can be used as simple picture however. An impression of the TripleSat data is shown in Figure-1.

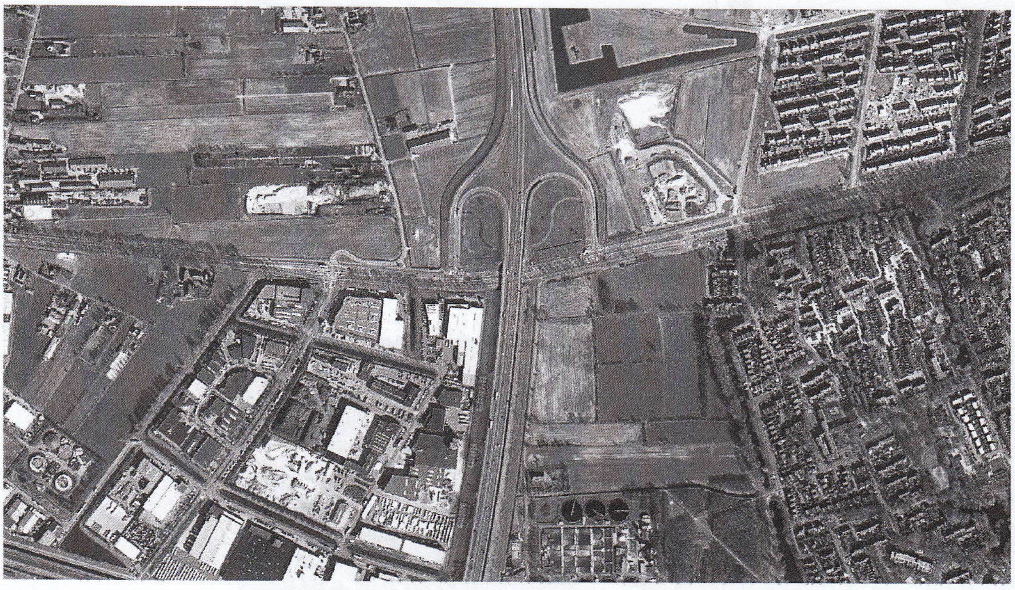

*Figure-1. Impression of the TripleSat data.*

## Top10NL rasterized roadmap

Top10NL is a 1:10.000 vector map produced by The Cadastre of The Netherlands. All road elements are selected and classified in 11 classes. The resulting vector file is clipped to the same area as the TripleSat file and rasterized with the same raster pixel size and projection (0.8m, RD, GeoTiff). The pixel values represent the class numbers from 1-11 (background value 0) and are stored in byte. An overview of the road classes is given in Table-1. An impression of the Top10NL road data is shown in Figure-2 and a combination of both datasets in Figure-3.

*Table-1. Overview of the road classes.*

| Class | Road type | Class | Road type |
|---|---|---|---|
| 0 | background | 6 | biking lane |
| 1 | highway | 7 | sidewalk |
| 2 | main road | 8 | parking |
| 3 | regional road | 9 | others |
| 4 | local road | 10 | half hardened |
| 5 | street | 11 | not hardened |

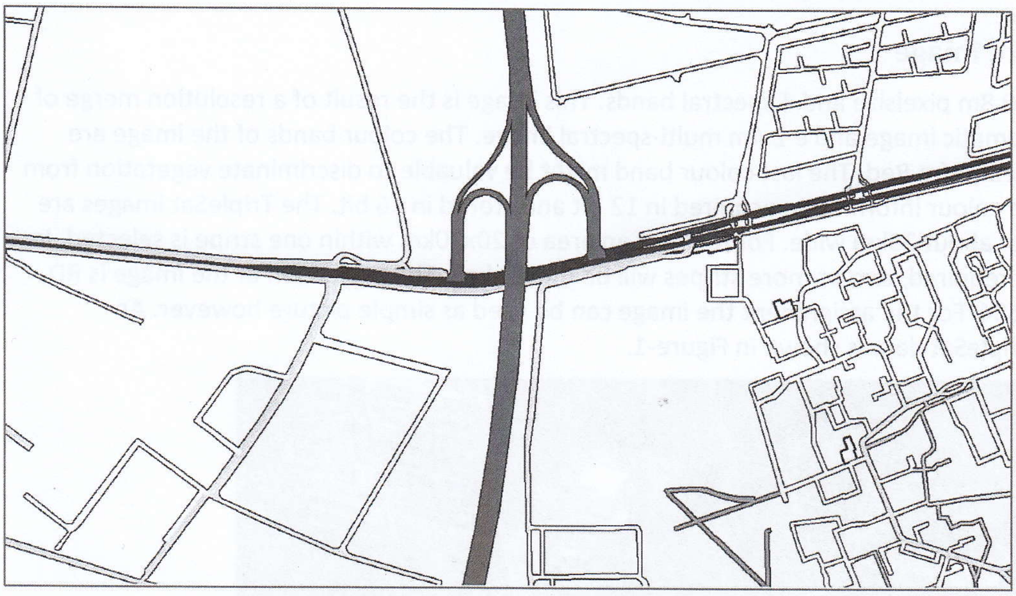

*Figure-2. Impression of the Top10NL road data.*

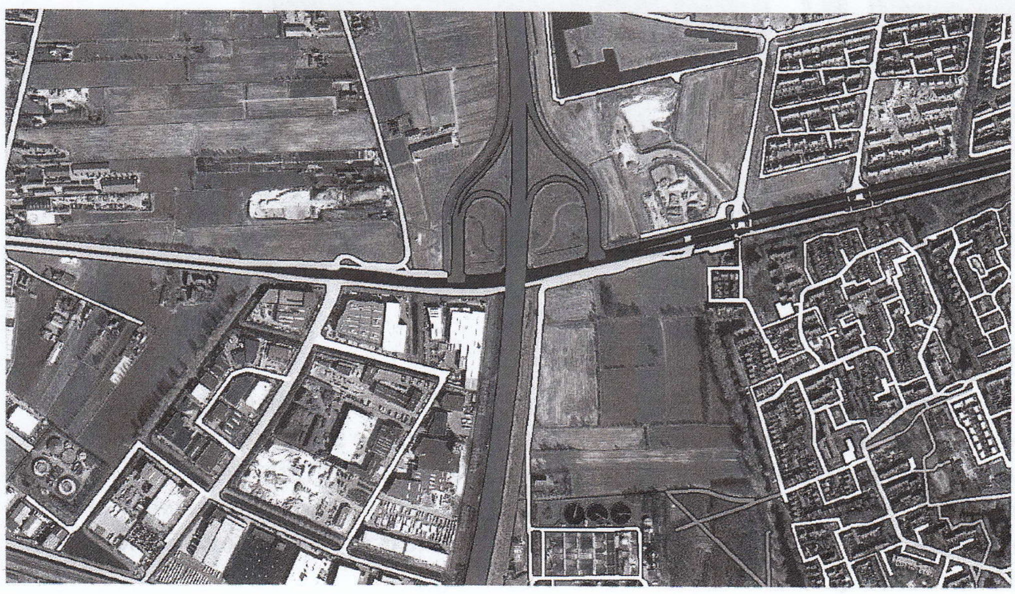

*Figure-3. Combination of TripleSat and Top10NL road data.*