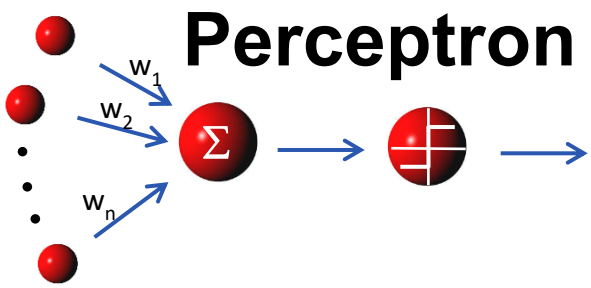
Volvo Highway Dataset



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The Perceptron Consortium

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Revision chart and history log

Version	Date	Reason
1.0	2019-08-01	First Draft
1.1	2021-01-11	Final Release public version

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Terminology

DNN: Deep Neural Networks

JSON: JavaScript Object Notation

1 Introduction

One of the main challenges in supervised learning [1] is the need of sufficient data to train the neural networks. Building a good dataset is an activity that requires a large investment in time and money. In the automotive area for example, the building of a dataset involve the need of a vehicle with the sensors required to collect the data. Additionally, after the data is acquired, the processing and annotation of this data requires a considerable amount of resources. To minimize this, there are several public datasets that can be used for training the networks. During the Perceptron project, we have used some of them, like MS COCO [2], PASCAL VOC [3], KITTI [4] and CITYSCAPES [5]. These public datasets can serve as a good starting point to perform a more general training of a network but it is often not enough for networks deployed in specific environments. For example some vehicles or some kind of lane markers are only present in some countries. Also these public datasets do not contain enough examples of different kinds of weather that are very prevalent in some countries, e.g. the snow in Sweden. It is also often the case that the public datasets have been created with sensors mounted on passenger cars. These sensor positions often differ from the sensor positions used for trucks, i.e. truck sensors are generally placed higher to get a better view. The need to have a more specialized dataset of the Swedish highways with high sensor positions is the motivation of this work.

In this project, we present a new image dataset containing exclusively Swedish highway data. The data is composed by images from different highways of Sweden, more specifically around Gothenburg. The dataset has been acquired during different seasons which has made it possible to capture different weather conditions. The aim of the dataset is to be used for object detection and classification, lane detection and classification and free-space detection.

To create this dataset, an initial study of the sensor configuration was needed. Then, the sensors were placed on a test truck and a plan for data collection was constructed. The data was continuously acquired during different seasons and then processed and sent for annotation. The annotation was performed by an external supplier Annotell [6]. The annotations were done manually to get more accurate results.

The Volvo Highway Dataset contains 29000 labeled images. The annotations include road objects, lane markings, road edges and free space. These annotations are divided in 7 classes of object vehicles, 3 classes of lanes markers and 4 classes of road edges. In addition, the dataset contains polygons for the object that can be used for semantic segmentation and object localization.

The next sections gives a detailed description of the data collection procedure and the dataset specifications.

2 Data Collection Description

This section describes how the data collection was performed and which locations and objects were selected to be included in the dataset.

2.1 Environment Selection

Environment selection when collecting data is an important factor since the performance of the neural network is highly dependent on it. Although there is a lot of public data available for training, to get a good performance of a neural network it should be trained on data that is similar to what it is expected to encounter in its operational design domain. This means that neural networks designed for specific conditions should be trained with data from these conditions.

The Perceptron project is focused on developing DNNs for highways in Sweden. Due to this, some of the national highways of Sweden were selected as the locations for the data collection. More specifically, the highways that pass through Gothenburg were selected since it is the base for the development of this project. These roads contain some scenarios that are only occurring in Sweden like 2+1 roads, and specific Swedish vehicles.

Figure 1 shows the stretch of highway selected for the data collection. More specifically, the roads are:

- E6, Gothenburg - Svinesund: This is the main highway connecting Gothenburg to Oslo along the coast. The data has been collected on 180 km of this road up to Svinesund.

- E45, Gothenburg - Trollhättan: the road between these cities is about 78 km and it was sometimes selected as an alternative route to the previous section of the E6 to increase the variability of the data.

- E6, Gothenburg - Malmö: this is the main highway going to the south from Gothenburg. The data has been collected on 280 km of this road up to Malmö.

- E4, Gothenburg - Linköping: this highway goes to Stockholm through Linköping and the data has been collected on 280 km.

- E20, Gothenburg - Örebro: This is the alterative highway going to Stockholm. The data has been collected on 290 km of this road up to Örebro.

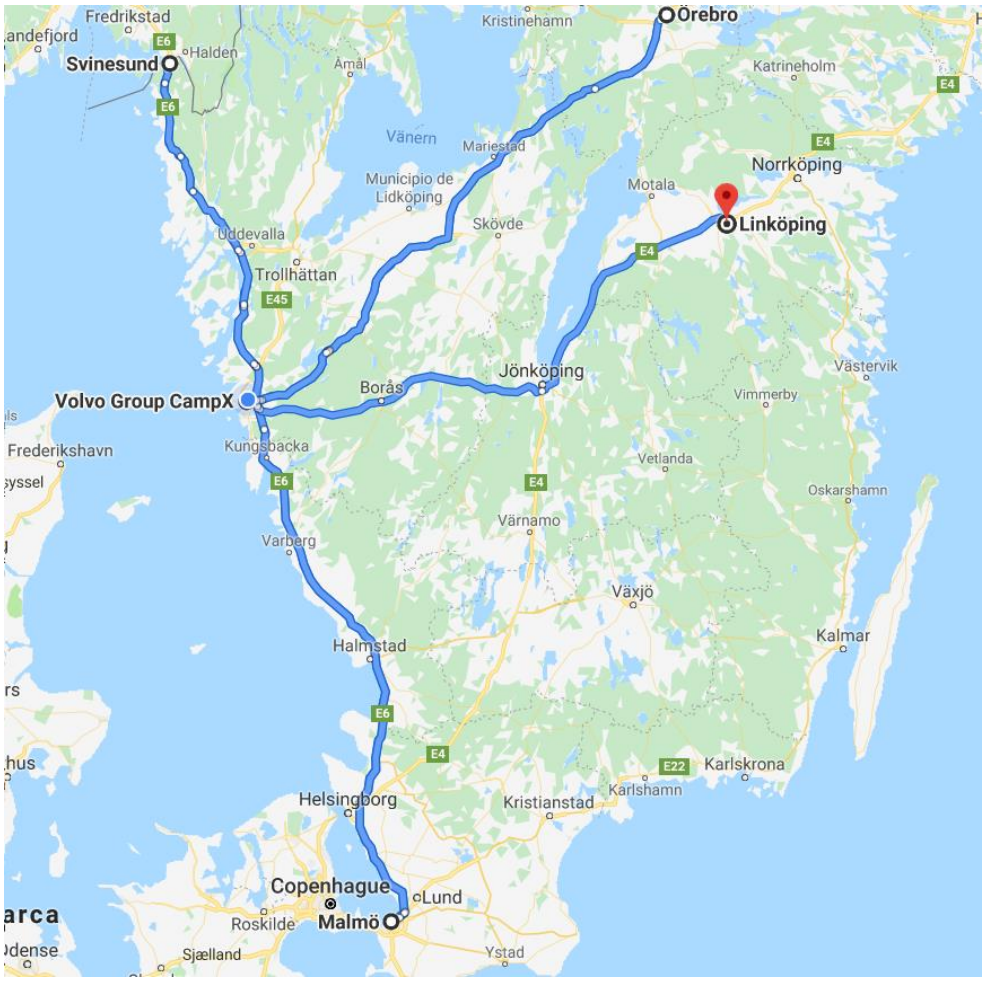

Figure 1: Map containing the highway sections for the data collection.

The different logging sessions have also been placed in time in such way to allow us to capture the different seasons of the year. Because of this, the dataset contains all kind of weather conditions like, snow, rain and fog which can be used to make the networks more robust in handling these weather conditions. Figure 2 contains example of images captured in different seasons.

Figure 2: Pictures from the dataset from different seasons.

2.2 Data Collection Specification

The data collection for the dataset started in autumn 2017 and was finished in summer 2019. Most of the data was recorded in 2019 when the hardware for the logging was more stable and the agreement with the annotation company was set-up. In total, around 50 hours of video were recorded during the different seasons. Figure 3 shows a breakdown of the hours recorded during the selected months.

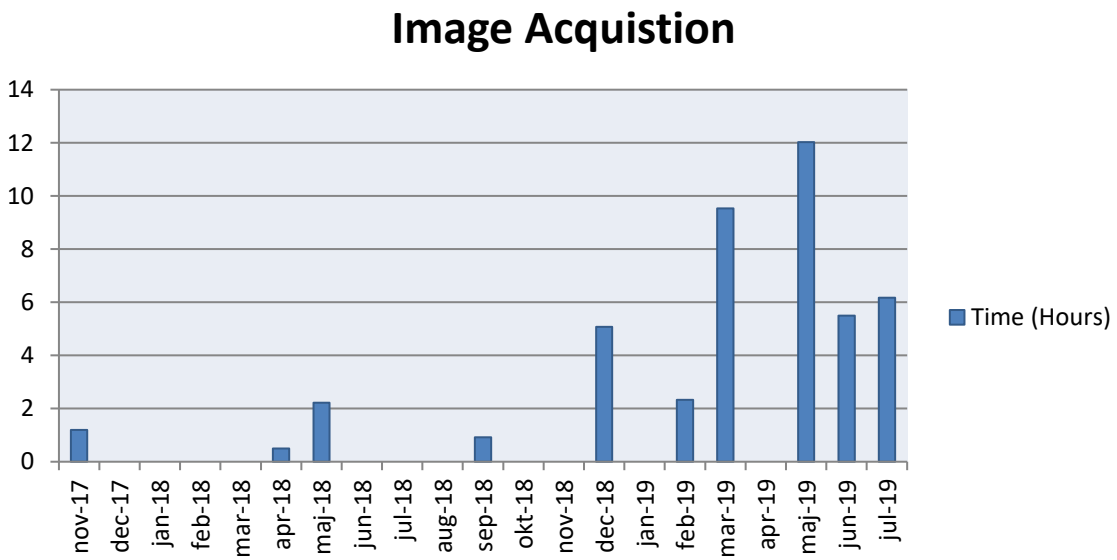

Figure 3: Quantity of hours of image data collection from 2017 until 2019.

The data was recorded mostly in raw format to avoid the loss of quality by compressing the images but around 10% of the data was compressed into jpg format to have the possibility of investigating how the compression affected the performance of the networks.

For the resolution, two sizes were selected, full resolution of 1920x1208 and a smaller resolution of 960x604. In this case around 95% of the dataset was recorded with full resolution and a small portion was recorded with the lower resolution for testing purposes.

Regarding the fps, around 95% of the hours were recorded at 15 fps to avoid saturation of the devices during the recording. A small portion of the data was recorded using 30 fps, which was possible by disabling other sensors to avoid saturation. The camera used had some problems with the auto exposure function so the fps was not completely stable and some of the videos were recorded with between 9 and 15 fps. This is very visible in the videos with more shiny illumination like the ones recorded during summer.

3 Data Set Description

The Volvo Highway Dataset is composed by 28778 images. During the project, 75% of the dataset was used for training and validation and 20% as a test dataset. The dataset contains the images in .PNG format and an annotation file for each image. The annotation file contains the annotations in the format GeoJSON [7], a special format to organize geometries in a JSON format. The annotations are separated in four categories, road objects, lane markers, road edges and free space. These categories will be explained separately in the next sections:

3.1 Road Objects Annotations

The road object annotations indicate mainly the presence of vehicles in the road. The dataset contains 98592 annotations for road objects. These annotations are divided into 7 classes, car, van, Truck, Motorcycle, Bus, other vehicle and unidentified road object like for example the presence of an animal in the scene. Both objects in the ego road and in the oncoming road are annotated.

In addition to the classes, each annotation contain the bounding polygon for each class so it can be used for semantic segmentation or object detection problems in addition to the classification. Figure 4 contains an example of images with a mask and with bounding boxes taken from the annotations. Figure 5 contains the class distribution for the road annotated objects.

Figure 4. : Annotation for Object Detection. The left image contains the mask for object segmentation and the right image contains the bounding boxes for the objects and the object classification.

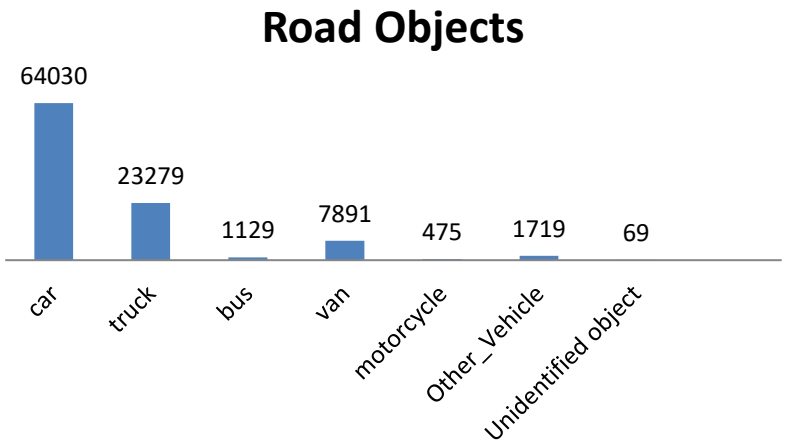

Figure 5: Class distribution for the road objects.

3.2 Lane Markers Annotations

The lane marking annotations are used to identify the presence of different lanes in the road. The dataset contains 99856 annotations for lane markers. The annotation for each lane contains several segments that are classified as either solid, dashed or implied. This way a lane can contain several segments with different classes, e.g. a lane changing from solid to dashed. The implied segment type is a very rare case which means that there should be a lane marker, but in practice no physical marker has been drawn on the road, e.g. an exit of the highway where the lane is cut. Figure 6 shows an example of lane markings annotation. Figure 7 contains the class distribution for the lane markings.

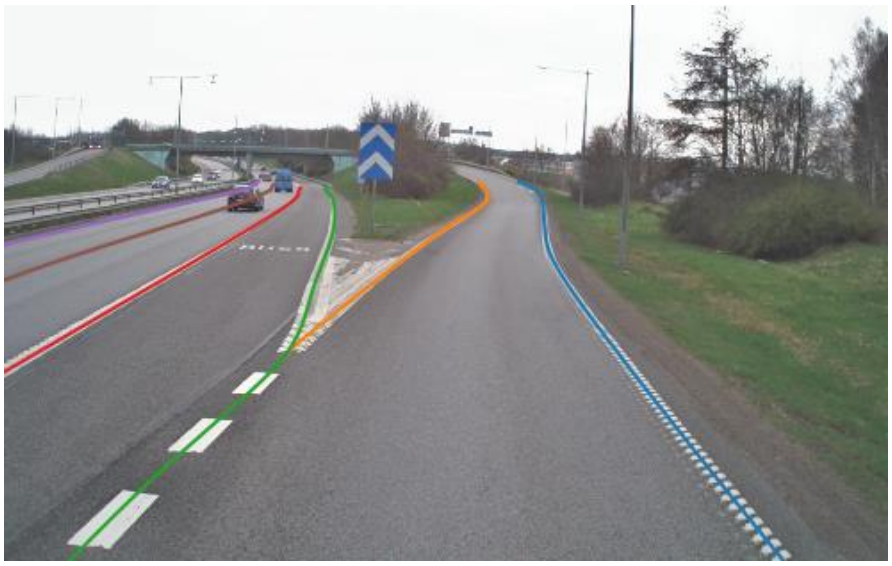

Figure 6: Image from lane marking annotations with some example or dashed and not dashed segment lanes.

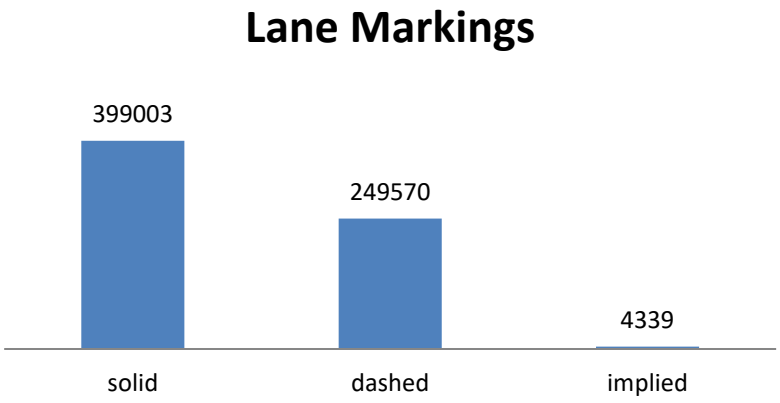

Figure 7: Class distribution for the segments of the different lane markings.

3.3 Road Edges Annotations

The road edges annotations are used to detect the limits of the road. The dataset contains 126997 annotation for road edges in the ego road. Again, the edges are formed by several segments. These segments are divided into three classes: guard rail, asphalt and jersey barrier. There is an extra class of segment called connect, that was used to compute the free space, so it is not relevant for the road edge detection. This way a road edge can

contain several segments with different classes. Figure 8 shows an example of the road edges annotations. Figure 9 shows the class distribution of the dataset for the segments that form the road edges.

Figure 8: Annotation for road edges with asphalt segments.

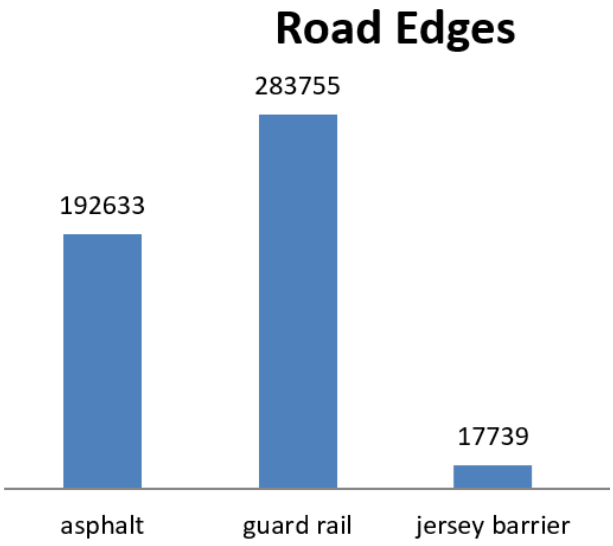

Figure 9: Class distribution for segments of the annotated road edges.

3.4 Free Space Annotations

The free space annotations contain the part of the ego road that is drivable space. Each image of the dataset contains an annotation for the free space which is indicated by a polygon enclosing the drivable space. The number of polygons in the dataset is 36577. Figure 10 shows an example of a free space annotation.

Figure 10: Free space annotation example.

4 References

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