Autoliv Master Thesis Proposals Spring 2016

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Multi-class classification for object detection

A fundamental part of most object detectors is the classifier, determining whether a given image patch contains the object of interest or not. The basic binary classification problem tries to distinguish one type of objects (e.g., pedestrians, cars, traffic signs/lights) from all other types of objects or background. However, when increasing the number of object types that should be recognized, it becomes increasingly impractical and computationally expensive to use a separate binary classifier for each class. Instead, multi-class classification methods can be used, where similar object types - for instance pedestrians, cyclists, and motorcyclists - can share parts of the classification computations. The purpose of the master thesis is to investigate and implement one or several existing approaches, and to adapt them to the current classification software developed at Autoliv.

Deep learning for robust detection of lane markings

During the last three years, deep learning (deep neural networks) has proven to be the best approach for classification, especially if computational resources are not considered. During the spring of 2015, a paper called "An Empirical Evaluation of Deep Learning on Highway Driving" was published. It shows how a large convolutional neural network can be used for detection of lane markings and vehicles on highways. The results are impressive - the classifier is even able to detect lanes behind vehicles. However, it is not clear how performance is affected by road markings with low quality and/or bad weather.

The neural network developed in the article is open sourced. The goal of this master thesis is to see how good the detection performance can be if the open source code is adapted and trained on Autoliv's varied road marking database.

The student needs good knowledge about classification. Specific knowledge and experience on deep learning is highly meriting.

Multi-frame exposure for enhanced pedestrian detection during night time, using CMOS camera

CMOS camera sensors operating in daylight spectra typically have difficulties with capturing pedestrians which are not exposed to enough ambient light, vehicle lights or street lights. Safety systems for protecting pedestrians demand the usage of CMOS sensors which are capable of a very wide variety of functions which need to operate in all lighting conditions.

The objective is to investigate and develop an algorithm which combines several image frames to one final image frame where low contrast objects, like pedestrian night time, are clearly better visible than in any of the single frames used. The final frame should keep motion blur and other blur to a minimum and be suitable for object detection and classification. Both mono vision and stereo vision approaches should be considered, although it may be wise to choose one of the two for the thesis as main path.

Calibration of mono camera

Some ideas for camera calibration that could be implemented and evaluated are:

- By finding and tracking static features such as street lamps one should be able to estimate the orientation of the camera
- Alignment of rear lights of cars to estimate camera roll
- Use disparity and optical flow results to estimate pitch/roll and yaw
- The camera height above road level may vary due to e.g. different loading of the vehicle and mechanical wear of the suspensions. Evaluate methods to estimate the camera height using stereo image streams.

Superpixels for general object detection

Superpixels are a promising area of development for image boundary extraction and segmentation.

Evaluate one or more superpixel algorithms based on their use in a general object detection algorithm chain. Examples of potential uses are disparity image improvement (e.g. Depth SEEDS) and object segmentation as a preprocessing step both for general stereo object detection and mono classification.

Threat assessment for Autonomous Emergency Braking (AEB)

In order to apply automatic braking only in situations where it is relevant, a threat assessment must be performed for each detected object in the scene - vehicles, trucks, pedestrians, cyclists, stationary objects etc. The goal of this master thesis is to implement and evaluate different solutions to this problem.

As the amount of data available for making the threat assessment is high and complex, it is likely that a trained classifier can prove to be a generic and robust solution to the problem. Therefore it is required that the student has knowledge about classification and machine learning in general. Additionally, good knowledge of signal processing and programming in Matlab is required.

Object tracking in 3D using stixels

Autonomous driving is currently a very hot field in research. Vehicle manufacturers are also putting a considerable amount of resources into development in this area. Cameras have a central role in these kinds of systems and the requirements are very high on detecting and tracking arbitrary objects of any shape and form with high reliability.

One approach to do this is to utilize a concept called "stixels" (stick pixels), which are segments of pixels in the image shaped like vertical bars whose pixels have similar depth information. Using the depth map obtained from a stereo camera and optical flow from subsequent images, the goal is to track stixels over time and group them together to form objects. These objects can be moving, e.g. vehicles and pedestrians but also stationary like fences, buildings, guard rails etc.

The goal of this master thesis project is to develop a stixel tracking algorithm that can be used to track arbitrary objects over time that are observed through a stereo camera. The student needs to have good knowledge in signal processing, modeling dynamic systems, Kalman filtering with Matlab. Programming skills in C are meriting but not required.

Automatically controlled steering (Lane Keep)

Governments and companies around the world are currently discussing regulations for automatically controlled steering on larger roads. In only a few years, many cars will be able to steer automatically on such roads as long as the driver is still attentive.

Investigate different techniques for lane centering of a vehicle on roads with lane markings. The searched approach shall be able to handle curvy roads, resulting in a driving experience which feels comfortable for the driver. This means that also acceleration and braking must be performed. Transition between manual and automatic driving shall be smooth. In order to be able to perform this master thesis, the work must begin with the writing of a simple simulation framework (or, preferably, use open source if available) which can handle automatic and manual driving.

The student needs good knowledge in signal processing, modeling dynamic systems and Kalman filtering within Matlab.