Institute of Automation

Master Thesis / Master Project

Active Learning for Obstacle Detection in Railways using CNN

Background: Obstacle detection (OD) and distance estimation is crucial for safety critical applications such as autonomous driving. As a result of developments in sensor technology and of Artificial Intelligence (AI), in recent years, there has been a rapid expansion in research and development of OD for road transport. Although railways are the other principal means of transport over land, research and development of OD in railways has to date lagged behind that for road transport. Currently, there is tendency to exploit the AI-based methods, in particular machine learning-based methods, developed for object detection in road transport for autonomous OD in railways. However, this is possible only up to some level due to specific challenges of autonomous OD in railways such as long-range distance estimation. Namely, due to high speeds of trains and the weight of rail vehichles, the stoping distances of trains are much larger of those of road vehicles so that there is a need for long-range on-board obstacle detection in railways. Because of this, datasets available for road transport are not suitable for railway applications as they mainly do not have annotated distant objects. This imposes the problem of available data for machine learning-based object detection in railways as, generally, these methods require a large amount of annotated data. Acquiring such annotated data is a tedious and expensive task. One way to conduct machine **learning with less annotated data is Active Learning,** which is a technique that aims at limiting the amount of annotated data by involving the learning algorithm in the selection of new training samples. The key idea behind active learning (Fig. 1) is that a machine learning algorithm can achieve greater accuracy with fewer labeled training instances if it is allowed to choose the training data from which it learns [1]. Active learning is an iterative process where a machine learning model is trained on an initial set of annotated data. With the trained model and selection criteria, new unannotated samples are identified and added to the current training set. The additional samples are annotated by an Oracle and the model retrains on the updated dataset. Generally, the Oracle is a human annotator that is presumed to always annotate samples correctly. The active learning loop is repeated until either all samples are used in the model or the model performs well enough A successful implementation of active learning achieves at least the same performance as random selection, but with fewer annotated training samples

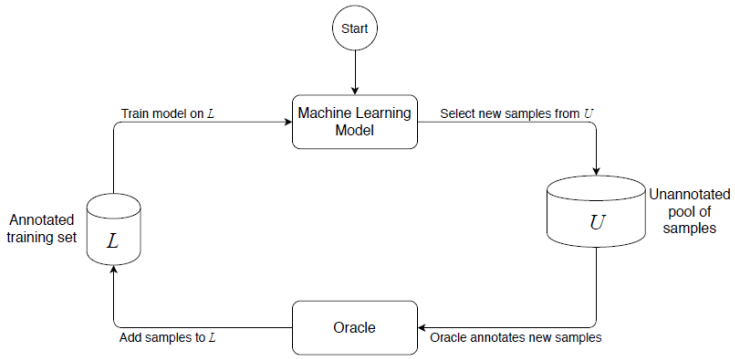

Fig. 1. Active learning loop. After training the model on the labeled training set L, the model select new samples from U, the Oracle annotate them and add them to the training set L [2]

Contact: Danijela Ristic-Durrant, ristic@iat.uni-bremen.de; Marten Franke, franke@iat.uni-bremen.de

The main goal of this thesis is to apply Active Learning to vision-based detection of objects in railway scenes. The starting point is OD CNN already used at the IAT, within project SMART2 [3] and existing annotated data from IAT railways dataset. The objective is to augment dataset using the Active Learning.

For the purpose of Master Thesis, two approaches are to be investigated. In the first one the samples having high confidence are picked-up during inference. These samples are annotated with the model's prediction, called a pseudo-label. In the following active learning iteration, these high confidence samples are treated as correctly annotated samples and are used for model re-training. In the second approach, in every active learning iteration, new samples are added to the training and validation sets and the model is then retrained. Samples are added by using a metric which ranks their informativity. Finding/implementing an effective and suitable informativity metric is one of the main tasks in the Thesis.

For the purpose of Master Project, only the first of above approaches is to be investigated and implemented.

Tasks:

- Literature search
- Concept development of the Active Learning framework for training the model for objsct detection in railway scenes
- Implement the Active Learning framework starting from the initial set of annotated data in IAT railway dataset (SMART and SMART2 projects) and using IAT existing model for object detection
- Evaluation of the OD model performance based on Active Learning data annotation.
- Augmentation of the IAT railway data set (SMART2 project) using the implemented Active Learning.

Requirements:

- Self-motivated, passionate about innovative applications comprising computer vision and machine learning.
- Understanding of machine learning and computer vision (sensor-based environment perception).
- Good programming skill in python.

References

1) Burr Settles, Active Learning Literature Survey. Computer Sciences Technical Report 1648, University of Wisconsin–Madison, 2009.
2) Sörsäter Michael, Active Learning for Road Segmentation using Convolutional Neural Networks, Linköping University, Department of Electrical Engineering, Computer Vision, 2018.
3) https://smart2rail-project.net/

Contact: Danijela Ristic-Durrant, ristic@iat.uni-bremen.de; Marten Franke, franke@iat.uni-bremen.de