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Using Convolutional Neural Networks for Cycling Infrastructure Classification

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1 INTRODUCTION

Information on the used infrastructure of cyclists, e.g. bicycle lane or road, is relevant for different applications. Naturalistic cycling studies often analyze the use of infrastructure to infer additional information. Therefor the recorded sensor and video data is manually annotated with infrastructure usage in a time consuming process [1]. Furthermore, future smart-bikes or intelligent assistance systems might rely on infrastructure data gained in real-time.

Due to deficient GPS accuracy and outdated or unavailable maps including cycling infrastructure, automated retrieval of infrastructure data is a non-trivial problem. This work presents a state-of-the-art approach to classify infrastructure by image data using convolutional neural networks. The resulting trained network allows automated data annotation as well as real-time classification using portable devices.

2 METHODOLOGY

Machine learning and especially CNNs have been in focus for a while, due to the success in different fields. From image classification [2] to end-to-end learning for steering autonomous vehicles [3], the field of application is vast. This paper proves that CNNs are also capable of classifying cycling infrastructure offering sufficient accuracy with a manageable demand for training data.

The data for training the classifier was captured from a front facing camera mounted on a bicycle handlebar while riding through the city of Berlin. Different districts of the city were covered to ensure a wide inter-class variety of infrastructure categories. The videos were taken at varying lighting and weather conditions and were annotated manually. Four categories of infrastructure are present in the data: roads, bicycle paths, bicycle lanes and sidewalks (Figure 1). Other categories, e.g. forest paths or parking facilities, were not considered.

Different model architectures were evaluated. Already existing models designed for processing front facing vehicle camera images to perform different tasks [3] were compared to a model designed by the authors. Furthermore, training the models on open source datasets containing road images and fine-tuning them on bicycle data was compared to training the model only on the recorded bicycle data.

Figure 1: Example images for the four infrastructure categories

3 FINDINGS AND CONCLUSION

Results show that existing model architectures that are designed to perform tasks based on road images also perform well for classifying bicycle infrastructure. The recorded, in comparison to other publications, small dataset allows us to achieve reasonable accuracy. Due to the fact that not all possible environmental conditions are present in the recorded dataset (e.g. heavy rain, snow) and the diverse appearance of the different infrastructure categories in other cities/countries, the classifier is not able to generalize in these cases.

Considering the results, annotating a large amount of video data by hand takes more effort and is less cost effective than creating a diverse and localized dataset to train a CNN. Furthermore, several annotated naturalistic cycling datasets already exist and might be used for training purposes, if the local infrastructure design is similar to the one represented in the dataset. Additionally, future intelligent bicycle assistance systems that require infrastructure data may use a similar classifier on portable devices for real-time usage.

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