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Extraction of vehicle kinematics from traffic videos

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1. Introduction

Nowadays, road transportation has become such an integral part of our lives that our daily routine would be unimaginable without it. Describing the phenomena that occur in traffic is an important step in order to better understand and improve the operation of traffic. The aim of this work was to create a video processing algorithm that is suitable for monitoring moving vehicles, determining the velocities of vehicles, counting traffic and providing measurement data for fitting the parameters of dynamic equations describing individual traffic participants based on a recording of the traffic even with a smartphone.

2. Vehicle detection via image processing

Fig. 1. Detected vehicles can be seen in a selected frame of a measurement recording. The numbers indicate the speeds of the vehicles measured in [km/h].

In order to identify vehicle kinematics based on roadside or aerial view of road traffic (see Fig. 1), a classical image processing algorithm was constructed. First, videos were recorded about traffic situations from tall buildings. Then, the region of interest was defined for each of the videos, and the background was separated. The perspectival distortion was compensated through the help of fitting a plane on suitable reference points. Following the preparatory steps, the background is subtracted from each frame, by which, the moving objects are separated. Vehicles are identified as these moving objects via the size and position data (see Fig. 2). Tracking and data recording has been implemented for these detected vehicles. Using the whole data-set it is possible to calculate the speed of every vehicle through differentiation and filtering the discrete positions. The flow chart of the image processing method is shown in Fig. 3.

Fig. 2. The detected areas are for one frame and the detected vehicles based on this result.

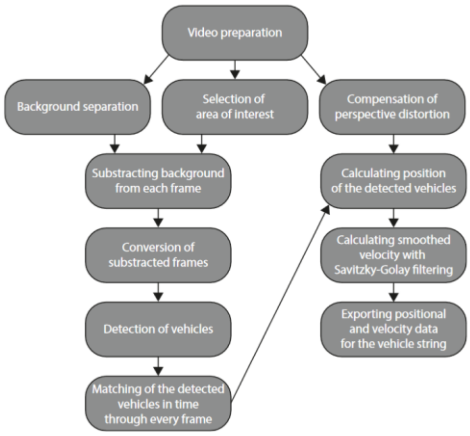

Fig. 3. Flowchart of the processing algorithm. On the left hand side the process is an iteration through each frame, while on the right hand side the post processing of the recorded data is shown.

In our study, we captured approximately 8 hours of traffic footage, which were analyzed by the above described image processing algorithm.

3. Vehicle kinematics

To illustrate the capabilities of the constructed image processing algoritm, here we present a stop-and-go siutation at a traffic light. Fig. 4 shows the distances traveled by the vehicles. The location of the vehicles with the colored rectangles can also be seen on the original camera image in accordance with the colors of the time histories. It is worth to observe the differences within the shape of the time histories that are related to the different driving behaviours (maximal deceleration/acceleration, etc.). The wave propagation can also be identified clearly originated in the reaction time of drivers.

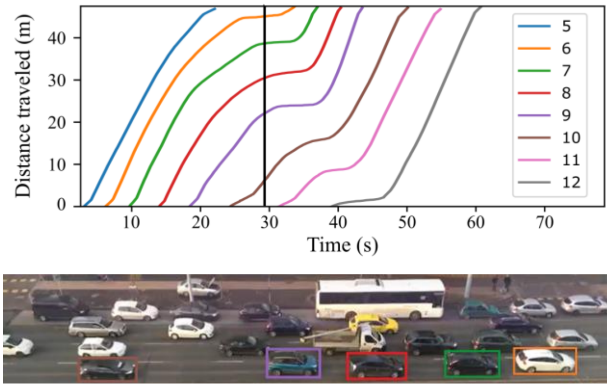

Fig. 4 Top: Distance traveled by vehicles with different identification numbers (marked with different colors). Bottom: The detected vehicles for the marked (black line) time instance on the recording. Colored accordingly.

We can also receive information about the statistical characteristics of traffic. The algorithm is suitable for counting vehicles over time, see Fig. 5. Thus, fluctuations in traffic density can also be observed. In addition, the distribution of the maximum and average speed of the examined vehicles can also be analysed, see Fig. 6.

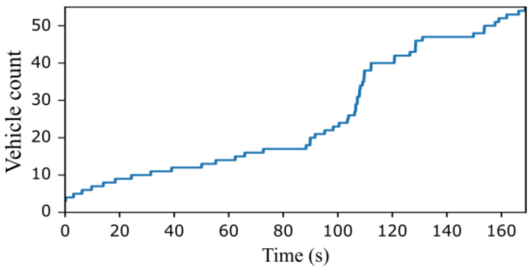

Fig. 5. Count of detected vehicles over time. Steeper incline means a higher flow of traffic. The change in the slope is indicating the fluctuation of the traffic flow.

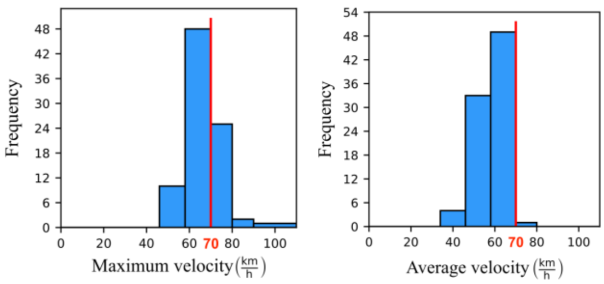

Fig. 6. Left hand side: Representation of the distribution of maximum velocity. Right hand side: Shows the distribution of the average velocity of each examined vehicle. The red line indicates the speed limit.

4. Conclusions

The main objective of this project was to create a simple, however sufficient, methodological approach for analyzing different dynamic situations in traffic through video recordings. A classical image processing algorithm was developed to achieve these goals.

Stop-and-go traffic situation were analyzed by this algorithm. Vehicle position and speed data were used to investigate the dynamics of the traffic, moreover, to identify the driver behaviors. The classical driver model of the literature [1][2] can be parametrized and improved in order to use them in the prediction of urban traffic flow.

In recent years, the convolutional neural network (CNN) solutions became very popular in the image-based vehicle detection [3][4]. They can provide data in real-time but they also introduce unwanted uncertainty in the processed data. Thus, in our future work, our method will be combined with CNNs to achieve better accuracy in real-time vehicle detection.

Acknowledgments

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