Highly accurate vehicle speed measurement using stereo camera

V3C

Abstract

We have developed a method for vehicle speed measurement with high accuracy using a stereo camera. The method consists of three steps: calibration, speed estimation and refinement. This method has been successfully tested on dataset with 100 car passages.

Abstrakt

Vyvinuli jsme metodu pro měření rychlosti projíždějících vozidel pomocí stereo kamer. Metoda se skládá ze tří kroků: kalibrace, odhadu rychlosti a zpřesnění změřených výsledků pomocí série kalibračních průjezdů. Funkčnost metody byla úspěšně ověřena na datasetu, který obsahuje sto průjezdů aut.

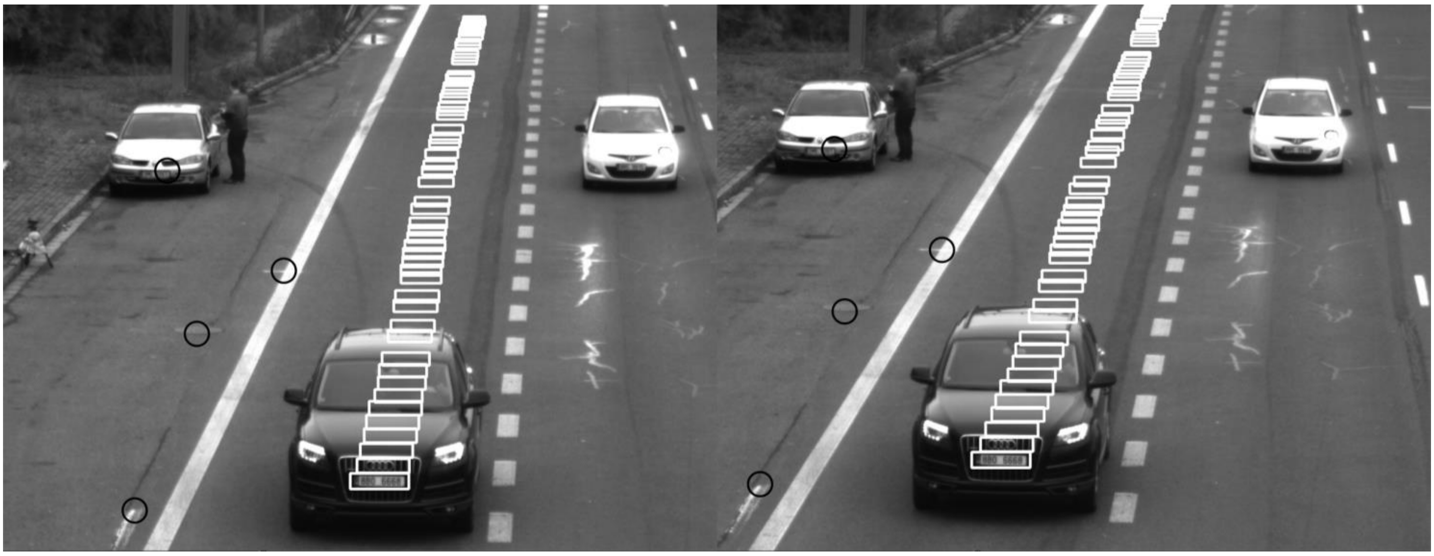

Figure1: Left and right camera images with license plate detector output and highlighted calibration points.

Traffic safety is one of the most discussed topic for the last decade. There are several methods how to increase it. One of them is speed measurement. It was designed for monitoring, but special checks in critical locations, especially in the cities, can increase traffic safety. We have several methods, which can be used for speed measurement. One of them is using inductive loops in the road. It is simple and accurate method which can be easily used in newly built roads. More difficult is to add these loops into existing roads especially on the main roads. Next method is to use a radar which is a very expensive device. On the other hand, it is reliable and weather-independent. Another approach is to use a camera. Single camera setup is possible to use, but there is a big problem with methodological requirements and standards. Solution to this problem could be a stereo camera setup. It should be more accurate and robust.

Our Research

Subject of our research is to define high precision and stable method for speed measurement based on a stereo camera setup. The setup consists of two custom made cameras with known intrinsic parameters. The proposed method consists of three steps. In the first step we use manually measured calibration points in a scene to estimate external parameters. The estimated camera parameters are used in the second step to measure the speed of passing vehicles. Final step of our method involves refining the measured speeds using data from several car passages with known speed. The last step aims to reduce the measurement error caused by imprecise calibration.

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Reference speed values of passing vehicles were obtained from a pair of experimental setups, containing a LIDAR, GPS module (high precision synchronization) and a PC. These were placed on the side of the road perpendicular to the direction of traffic flow at a defined distance between them. The sampling rate is 1 kHz and maximal measurement range is 300 m.

Our dataset consists of 100 vehicles with speeds in range from 53 to 91 km/h. Graph with our results can be found on figure 2. There are two series of data. Blue one shows the calculated speed error without any compensation. Mean absolute percentage error is 5.54 % with maximum absolute percentage error of 7.44 %. The red series shows the calculated speed error after compensation by a calibration passes. Mean absolute percentage error for this series is 0.46 % and the maximum absolute percentage error is 1.83 %.

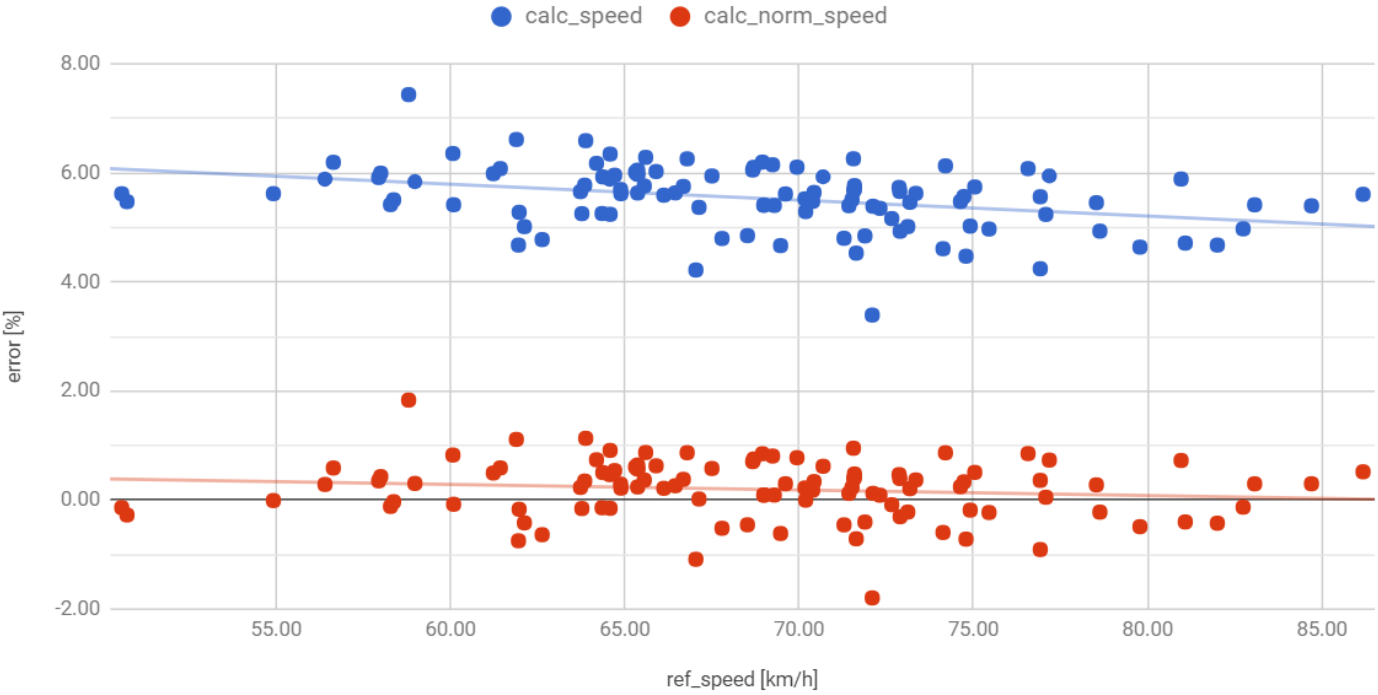

Figure 2: Speed measurement percentage error with respect to ground truth speed. Blue series - without refinement. Red series - with refinement.

Applications

The primary focus of our method is on speed measurement. Other possible applications of stereo cameras in traffic surveillance could involve vehicle dimensions measurements, classification or counting number of cars in tunnels.

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