Camera calibration using roadside data

Automatic visual surveillance is useful in organization of traffic – for collecting statistical data, for immediate controlling of traffic signals, for law enforcement, etc. Existing systems typically require manual setup, often involving physical measurements in the scene of interest. Our goal is to process traffic data fully automatically, without any user input. This includes assessment of camera intrinsic parameters, extrinsic parameters in relation to the stream of traffic, and scale of the ground plane which allows for measurement in the real world units.

We automatically determine 3 orthogonal vanishing points, construct vehicle bounding boxes (left), and automatically determine the camera scale by knowing the statistics of vehicle dimensions. This allows us to measure dimensions and speed (middle) and analyze the traffic scene (right).

Our research

We propose a method for fully automatic calibration of traffic surveillance cameras. This method allows for calibration of the camera - including scale - without any user input, only from several minutes of input surveillance video. The targeted applications include speed measurement, measurement of vehicle dimensions, vehicle classification, etc.

The first step of our approach is camera calibration by determining three vanishing points defining the stream of vehicles. The second step is construction of 3D bounding boxes (Figure 1) of individual vehicles and their measurement up to scale. We propose to first construct the projection of the bounding boxes and then, by using the camera calibration obtained earlier, create their 3D representation. In the third step, we use the dimensions of the 3D bounding boxes for calibration of the scene scale.

The achieved mean accuracy of speed and distance measurement is below 2%. Our efficient C++ implementation runs in real time on a low-end processor (Core i3) with a safe margin even for full-HD videos.

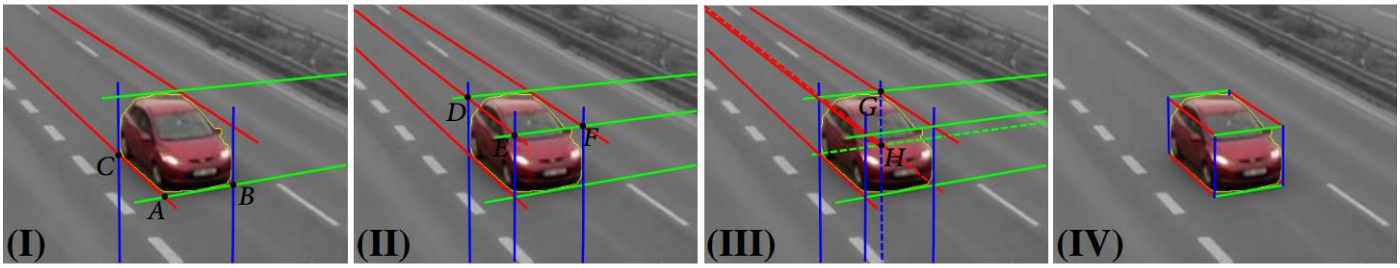

Figure 1: Construction of vehicle's 3D bounding box. (I) Tangent lines and their relevant intersections A,B,C. (II) Derived lines and their intersections E,D,F. (III) Derived lines and intersection H. (IV) Constructed bounding box.

Results

We proposed a method for understanding traffic scenes observed by stable roadside cameras. The method is fully automatic – no user input is required during the whole process. Experimental results show that the mean error of speed and distance measurement is below 2% (worst 5.6% for distance and 4.3% for speed). This outperforms existing approaches and provides sufficient accuracy for statistical traffic analysis. Besides measurement, our approach can facilitate other traffic analysis task, as traffic lane segmentation. The algorithm works in real time with a safe margin. Measurements show that the system is able to process 93 FPS of normal video input (854×480 px).

Figure 2: Different scenes with measured vehicle speed.

Figure 3: Cropped out vehicles with estimated dimensions.

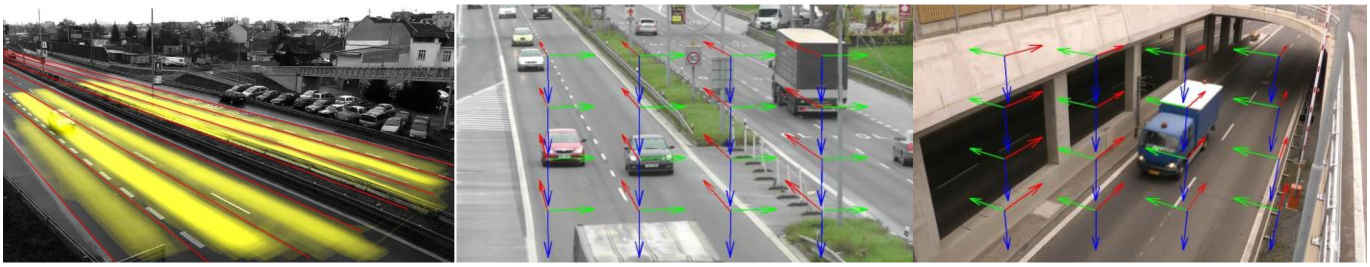

Figure 4: Different scene analyses (lanes and camera orientation).

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