Unmanned Aerial Vehicle based Speeding and Tailgating Detection System

Sébastien Demmel[a], Mahrokh Khakzar[a], Grégoire S. Larue[a]

[a]Centre for Accident Research and Road Safety – Queensland, Queensland University of Technology

Abstract

Unmanned Aerial Vehicles (UAVs) offer a considerable potential for road safety stakeholders; they have been already used for tasks such as assisting first responders. This paper reports on a small-scale prototyping effort to use UAVs to measure speeding and tailgating on major urban roads. One hour of UAV footage was acquired and a custom vehicle detection system was programmed. From this, we developed methods to extract vehicles' speed and headways. Validation information was extracted from TMR induction loop present near the testing site.

Background

In recent years Unmanned Aerial Vehicles (UAVs) have become increasingly capable and affordable, to the point they are now a popular hobby for members of the public. For researchers and road safety stakeholders, they offer a large list of potential applications. A significant area of research in the ITS space using UAVs has been integrating them into communication architectures to support Cooperative-ITS (Zhou *et al.*, 2015; Oubbati *et al.*, 2017). Several reviews (Barmpounakis *et al.*, 2016; Menouar *et al.*, 2017) have identified remote sensing as a leading potential use for UAVs, stating that many challenges remain but that the effort required to solve them is worthy given the potential benefit. Barmpounakis *et al.* further noted that computer vision for processing UAV captured video footage is "*the cornerstone of success*" for UAVs. This paper presents research within this latter framework, aiming at developing a low-cost speeding and tailgating detection application.

Method

A video-processing application was developed to extract vehicles from the video captured by the UAV. This application used a HSV colour space transfer, binarisation, a series of morphological operations, and masking in order to extract the road at first, and then to detect vehicles. Kalman filtering was used to improve the tracking of vehicles movements between frames, as both the video frame itself and the vehicles would move. After vehicle detection, headway and speed were computed at first in pixel-space. Conversion to real-space units required data fusion of the drone's telemetry (altitude, speed) and further video-processing (surface features tracking). The post-processing system used the bearing and linear function fitting to estimate, respectively, direction of movement and lanes. Finally, validation of the UAV measurements was conducted with data from a TMR loop sensor located 500 m north of the data collection site was used to gather average speed and headways measured at similar times as the data collection (using 35,602 vehicle observations).

Results

One hour of UAV video footage was captured on 3 February 2017 at a data collection site on Nicklin Way, Sunshine Coast (QLD), using a DJI Phantom 3. The UAV performed five flights between 11:30 and 14:00, using different patterns of altitude (100-120 metres), speed (8-15 m/s), and behaviour (continuous flight, hovering at waypoints). Figure 1 shows a sample output of the vehicle detection application.

Figure 1. Output of the vehicle detection application (uncropped full frame)

About 73% of the vehicles present on the road were correctly detected. This detection rate could be improved by lowering the UAV's altitude. Indeed, despite the camera's HD resolution, we found that flying at altitudes above 100 metres still made vehicles too small for consistent detection. Unfortunately, it was not possible to fly at lower altitudes on the data collection day. The HD resolution also slowed down the processing considerably, preventing any real-time online processing. However, the application proved fairly robust against false-positives (e.g. detection of static objects), although we found palm trees on the median had a tendency to be often detected as vehicles. Those objects were filtered later in the post-processing using the UAV's movements. The average headway measured by the UAV was 3.01 seconds in the gazettal direction (northbound), and 4.66 seconds in the anti-gazettal direction. TMR loop data showed that the average headway measured between 11:00 and 14:00 on weekdays on this road was 4.66 and 4.62 seconds, respectively in the gazettal and anti-gazettal directions. UAV data measured that 41% of the vehicles were tailgating, while the loops gave 51%. Similarly, for speeds we measured average speeds of 55.6 and 52.5 km/h, while the loop yielded 58.5 and 56 km/h. While discrepancies remain, the margin of error is deemed reasonable given the preliminary state of this work. Further, note that the loop data contains many more vehicles than our video sample.

Conclusion

Our work has shown that it is possible to build a video-based sensor platform using UAVs for tracking speeding and unsafe following behaviours on the road. With further work, this could provide an additional way to collect on-road data for road safety research that is easy and quick to deploy. Future work will focus on improving the accuracy of the detection of vehicles using deep learning, investigate other patterns of data collection (e.g. lower flying altitudes), and optimise the application to improve processing time. On-line processing is a long-term goal.

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