Pedestrian sensing for increased traffic safety and efficiency at signalized intersections

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Abstract

The control of signalized intersection plays an important role in the safety and efficiency of urban traffic. The last decades a lot of resources were spent on ITS for the detection of vehicles at traffic lights. Today not only the efficiency of traffic is of interest but also the safety of pedestrians is becoming a priority. To respond to this need two new traffic video sensors are proposed specifically designed for the detection of pedestrians in an urban setting.

1. Introduction

Every year, over half a million pedestrians die worldwide in automobile accidents – a harrowing figure that represents 65% of the total automobile-related fatalities. In North America alone, there were 4,654 pedestrian fatalities in 2007. As well as the devastating loss of life, pedestrian accidents cost countries financially – the level of injuries affects global GDP by up to 3%. In low- and middle-income countries, road traffic accidents can cost US$64.5 billion per year. The number of fatalities is highest in urban areas, which is logical, as urban areas are where the numbers of pedestrians are higher and more concentrated. And although many pedestrian deaths occur at locations where vehicle speeds tend to be fairly high (for instance, freeways) and drivers are not expecting to stop, there are a significant amount of crashes at intersections [1], [2], [3].

Pedestrians are notoriously disobliging when it comes to waiting for the green phase or using the push buttons. They push buttons, then walk off and are prone to set off when the lights are about to change. Today green times for pedestrians are calculated based on average walking speeds. Depending on the real walking speed and the density of pedestrians the optimal green time needed can be significantly different. When the green time is too short there is a safety issue, when it is too long there is an efficiency issue.

There are two main drivers for infrastructure based pedestrian detection at signalized intersections namely pedestrian safety and traffic efficiency. From a practical point of view this can be translated into the following points:

- Traffic efficiency:
  - Only initiate a green phase when people are actually waiting to cross.
  - Reduce the green time to the minimum i.e. there is no need to extend the green time when no people are on the crosswalk.
- Pedestrian safety: Extend the green time as long as there are people on the crosswalk.

The above problem therefore boils down to detecting people waiting to cross and people actually crossing the street. Fig. 2 illustrates these two scenarios.

Fig. 1: The main applications of urban pedestrian detection are the detection of waiting people and the detection of people crossing the street.

In this paper we present two new video sensors for the detection of pedestrians (see Fig. 2). The first sensor can detect people crossing the street and uses a single camera. The second sensor is a stereo sensor and is used to detect people waiting on the sidewalk to cross the street.
2. DETECTION OF CROSSING PEDESTRIANS

Video analysis techniques for surveillance and more specifically the detection of human activity had a lot of attention both in the research community as from a commercial point of view. Countless algorithms for person recognition both in indoor and outdoor situations have been described. Many products have been released on the market trying to valorize these techniques mainly for security applications. Intrusion detection is a common application in many surveillance applications. Today we can state that technology has reached a level of maturity in order to be able to deploy such commercial products without too much problems. In many cases the setting of these applications is also relatively easy because the zone to be observed is not densely crowded since by definition it is an intrusion application.

The case of the detecting crossing pedestrians is fundamentally different because the scene can be very crowded not only with people but also vehicles driving around. Indeed, only people should be detected while suppressing vehicles and other disturbing factors. There is also a directional constraint: only people actually crossing the street should be detected. Further the urban environment of crosswalks is often very challenging due to the presence of trees and other objects casting long and moving shadows. Finally, since human lives are at stake, the system should work under all situations meaning day, night, snow, rain, etc.

3. DETECTION OF WAITING PEDESTRIANS

The problem of detecting pedestrians waiting to cross the street is different from the detection of crossing pedestrians. Waiting people are more stationary which makes that motion information can not be used. SafeWalk combines stereovision technology together with intelligent image processing technology. By using two CMOS cameras in parallel, SafeWalk converts two-dimensional images into three-dimensional information. Such three-dimensional information is useful and necessary as it enables to distinguish between real objects and irrelevant background information (shadows, reflections). Based now on this 3D information, embedded and field-proven Traficon algorithms are able to analyze more ‘in depth’;
delivering accurate information on pedestrian presence and pedestrian behavior. Through this unique approach, reliable and high-level information about the monitored pedestrian area is now more than ever a fact. A drawback of stereovision is that there is a limit on the maximum distance objects can be detected. This distance is proportional to the baseline, i.e. the distance between the two cameras. Because the size of the sensor is also important a baseline of 15cm was chosen. A further factor of importance is a good detection during night time situations. A minimum of 10 Lux is needed on the ground otherwise an external IR light source is needed.

4. DETECTION PERFORMANCE TESTING

Quality control of the pedestrian sensors is crucial. Especially the detection must be very good and not only work on some ideal video sequences but under all conditions. To achieve this Traficon has set up a system so that the performance of the algorithm can be easily tested on prerecorded video sequences. These video sequences are stored in a library that contains tens of video clips of crossing and waiting pedestrians. In case a problem occurs in the practice a recording is made and added to the performance test. Each time a modification is made to the video processing algorithms the performance tests is repeated. This is an automated process that can be done in a matter of some hours.

5. DEVELOPMENT

For the development of the above pedestrian sensors Traficon has worked together with different research centers with expertise in the field of image and video processing. To avoid problems of intellectual property rights Traficon has made available a Development Kit version of several of its video sensors. For a 3rd party this is an extremely easy way to port video processing software on a real vision platform that can be used and tested in outdoor environments. Another advantage is that there is no need to share source code avoiding tedious negotiations of Intellectual Property Rights (IPR). Also for Traficon it is interesting because the effort to port the video algorithm to the Traficon sensors is done by the partner.

The Development Kit basically consists of the same hardware as the existing commercial sensor but with different software running on it. This software avoids that the user has to bother with accessing the low level system components such as control of the video sensor, Mpeg4 video compressing, RTSP streaming, Ethernet communication, hardware interrupts, etc. All these things are pre-integrated and delivered with the product as precompiled libraries. The software also contains a dummy video processing algorithm that can be used as an example by the user. This allows him to know how the video images can be accessed for further processing or how information can be written on the video output screen.

Fig. 5: Images from the stereo sensor. By combining the left and the right image it is possible to accurately detect people. Shadows and other objects that are irrelevant can be suppressed.

Fig. 6: In order to facilitate cooperation with 3rd parties Traficon has a Development Kit version of their video sensors. This allows others to easily port and integrate video processing algorithms on an embedded platform.

6. CONCLUSIONS

In this paper we have presented two new traffic sensors for the detection of pedestrians at signalized intersections. The first sensor is a mono vision sensor for detecting crossing pedestrians while the other sensor is a stereo sensor for the detection of waiting people. These sensors provide an answer to the need to increase pedestrian safety and traffic efficiency at signalized intersections. The sensors were
developed in cooperation with several research institutions for which a special development platform was made to simplify the cooperation and integration of 3rd party algorithms. During the design of the pedestrian sensors special attention was paid to the specific environment of urban intersections caused by vehicle traffic, shadows and other factors that make it a particularly challenging problem.

7. REFERENCES

