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Robust real-time pedestrians detection in urban environments with low-resolution cameras

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ABSTRACT

Detecting that pedestrians are present in front of a vehicle is highly desirable to avoid dangerous traffic situations. A novel vision-based system is presented to automatically detect far-away pedestrians with low-resolution cameras mounted in vehicles given the contributions of fixed cameras present in the scene.

Fixed cameras detect pedestrians by solving an inverse problem built upon a multi-class dictionary of atoms approximating the foreground silhouettes. A sparse-sensing strategy is proposed to extract the foreground silhouettes and classify them in real-time. Mobile cameras detect pedestrians given only their appearance in the fixed cameras. A cascade of compact binary strings is presented to model the appearance of pedestrians and match them across cameras.

The proposed system addresses the practical requirements of transportation systems: it runs in real-time with low memory loads and bandwidth consumption. We evaluate the performance of our system when extracted features are severely degraded and the sensing devices are of low quality. Experimental results demonstrate the feasibility of our collaborative vision-based system.

1. Introduction

Governmental agencies, car manufacturers, public transportation services, and many institutions are interested in detecting pedestrians in the surroundings of a vehicle to avoid dangerous traffic situations. In the United States, there are more than 69 000 pedestrians injured yearly and more than 4000 killed (numbers for 2011, Traffic safety facts, 2013). Many accidents originate from the momentary distraction of the drivers. A driver assistance system that detects potential collisions with pedestrians might reduce the number of pedestrians killed on the road (see Fig 1).

Over the past decades, progress in image and video processing algorithms has encouraged researchers to apply these techniques to transportation problems. Ali and Dagless (1990) presented a fully automatic system to detect and track pedestrians and vehicles. Several years ago, Velastin et al. (2006a) used optical flow to avoid potentially dangerous situations involving pedestrians in public transport. Chan et al. (2006) present an overview of existing technologies to detect pedestrians and illustrate the concepts of infrastructure-to-vehicle, vehicle-to-vehicle and vehicle-to-infrastructure operation. The increasing popularity of wireless networks in urban domains and the development of dedicated short-range communication (DSRC) enable the concept of vehicle-infrastructure integration. The United States Federal Communications Commission recently allocated radio frequencies for DSRC in the 5.9 GHz band. They propose to send alerts to the drivers by wifi using

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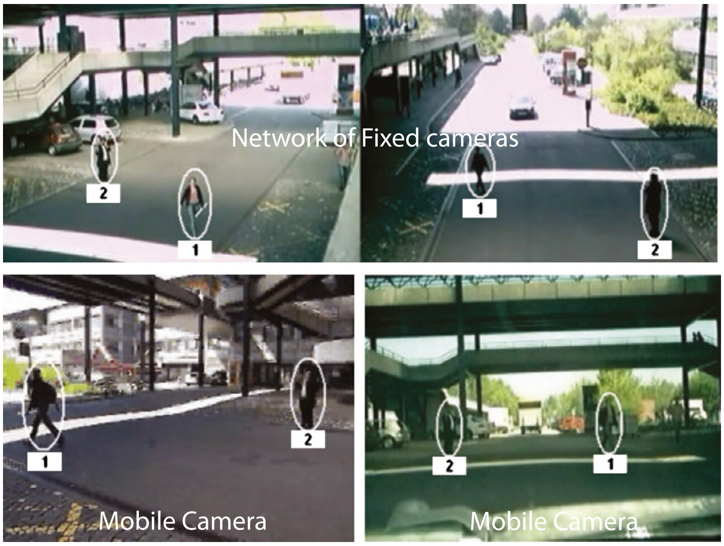

Fig. 1. Illustration of our proposed collaborative network of cameras where people are detected by the mobile cameras mounted in vehicles (bottom row) given their appearance in the fixed cameras (top row).

a set of ultrasonic sensors, and laser scanners which are cane become quite expensive. Note that, in public transportation, not all of the pedestrians around vehicles are leading to dangerous traffic situations. Mainly the pedestrians standing in front of the moving cars need to be avoided. That is why, current manufactures have started to mount sensors and more precisely cameras in front of their vehicles to detect pedestrians standing towards the direction of motion regardless the outside infrastructure. Cameras, as opposed to other sensors, increase the range of detection of pedestrians. However, the range is still limited and we will see in this paper how to further increase it if additional cameras outside of the vehicles are also used.

Dollar et al. (2012) point out in their survey on pedestrian detectors that current state-of-the-art detectors fail to detect low-resolution pedestrians occurring in transportation settings. As a consequence, far-away pedestrians are not correctly detected. Therefore, we present a framework to improve the performance of stand-alone pedestrian detection systems when additional priors, such as observations from fixed cameras exist. The detection information available from the fixed cameras is not enough to identify potential collisions since the relative positions of detected pedestrians with the vehicles are unknown. Fig. 2 illustrates our system.

This paper focuses on presenting a novel system to alert the drivers given a network of low-resolution cameras. A single camera is mounted in the vehicles and benefits from the network of fixed cameras present in urban areas to best detect dangerous situations. The underlying motivation is that nowadays, fixed cameras are installed at most urban intersections in major cities. Approximately four million fixed cameras were installed in the UK in 2002 (according to McCahill and Norris, 2002). The aim is to only detect pedestrians who are likely to lead to dangerous situations. Fixed cameras can detect pedestrians; however, they cannot determine if the endangered by a given vehicle. Therefore, the information detected by the

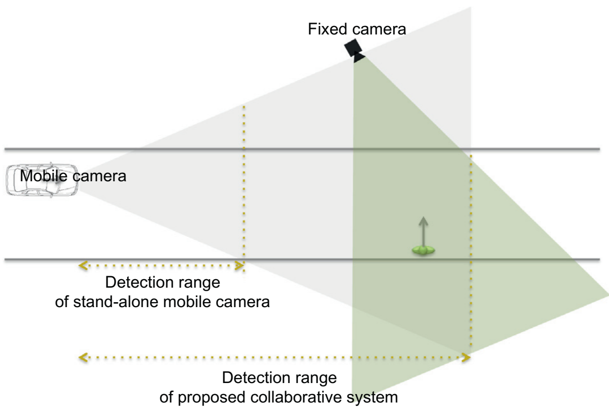

Fig. 2. Stand-alone pedestrian detector algorithms have a limited range of detection. We propose to increase the range by leveraging the observations from other available cameras on site.