Detection Systems for Improving the Citizen Security and Comfort from Urban and Vehicular Surveillance Technologies: An Overview

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Abstract. This paper presents emerging detection systems for improving the citizen security and comfort in vehicular and urban contexts. To this end, we firstly provide an overview of existing detection systems dealing with innovative citizen security and comfort functionalities based on vision technologies. Secondly, we expose two vision-based detection prototypes we developed for proposing services more specifically addressed to security agencies and to car drivers.

Keywords: Smart urban mobility · Citizen security and comfort · Urban monitoring · Embedded vision systems · Surveillance technologies

1 Introduction and Motivation

This paper presents an overview of detection systems for improving the citizen security and comfort in vehicular and urban contexts. More precisely, many surveillance sensors already equip urban infrastructures for security applications. However, their exploitations for the development of non-supervised security systems as well as for proposing comfort-related services remains relatively underused. In this paper, we present various emerging surveillance technologies as well as detection systems that are exploited in the literature for enhancing the security and the comfort of citizens. Additionally, we present experiments and results directly related to our designed detection and communication architectures and approaches which aim to support advanced police aid services as well as advanced driver assistance service.

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2 Related Surveillance, Detection and Communication Systems

This section presents some existing system architectures supporting urban and vehicular security and comfort developments (e.g.; surveillance services) through vision-based detection, computation and communication technologies.

2.1 Black Box Systems for Vehicles

Car black boxes are new trend products for car and motorcycle drivers. A black box for car is a camera with a storage system that is installed onto the windshield. Similar black box can be installed onto the helmets for motorcyclists (e.g.; dash cam). The acquisition device permits to collect videos of road environments corresponding to the vehicle displacements but can also be used to register videos inside the car. A black box often includes a looped recording functionality which save its video if an incident occurs. Additionally, the system can be equipped with a GPS sensor allowing to store different types of information related to the vehicle driving (e.g.; speed, direction, steering angles). For motorcyclists, it can be difficult to find low-cost systems, easy to install on helmets and integrating black box functionalities.

The collected video data are then exploited for clarifying the situations to the insurance companies in case of accidents. This can be done within the frame of insurance telematics which stands for the use of telecommunication technologies directly proposed by the insurance companies in order to remotely manage their customers. For more information about telematics insurance, we refer the reader to [6] which describes its advantages and drawbacks.

In this context, several works have been recently proposed which attempt to exploit black box systems in different innovative manners.

For instance, Prasad et al. [17] proposed to incorporate an automatic processing module into the black box system allowing an objective accident analysis. The module allows also to immediately send a short alert message to a predefined phone number in case of detected accident. To this end, they proposed their own black box prototype composed of 12 sensors regulated by a Raspberry Pi and an Arduino device.

Lee and Yoo [12] proposed to exploit the internal camera of the black box in order to monitor the driver tiredness through analysis of observed eye states (e.g.; open or closed).

Park [16] proposed a forensic analysis technique of the car black box. His work is motivated by the increasing number of insurance frauds caused by the deletion of data from the black box by the car driver following an accident. Indeed, in this latter case, the driver attempts to conceal his error. To fix this issue, the author proposed an investigation tool to restore deleted information while checking their originality and integrity. Similarly, Yi et al. [25] proposed a module to check recorded data integrity.

2.2 Vision-Based On-Board Systems Integrated to Vehicles

The next generation of vehicle is equipped with integrated vision-based systems (on-board systems). Some vision-based on-board systems of vehicles are dedicated to the analysis of outdoor scenes (road traffic) and include parking assistance systems [20], collision avoidance radar systems [24], traffic flow monitoring systems [14], traffic sign recognition systems [5] and can also be used as a car black box systems. Moreover, other vision-based on-board systems of vehicles are dedicated to the analysis of indoor scenes. Notably, they are oriented in direction of the driver for analyzing his behavior and triggering security-related alerts (e.g.; driver drowsiness detection systems [19], driver mirror-checking action detection system [13]). Additionally to the behavior analysis for security aspects, recent works have been undertaken for remotely controlling car functionality or comfort options through hand gesture recognition [23]. For instance, the driver can switch on/off the radio, the air conditional or answer a phone call by employing pre-determined hand gestures.

2.3 Vision Systems of Existing Urban Infrastructures

Many urban infrastructures (building, parking, street poles) are already equipped with digital cameras for the surveillance of the road traffic (drivers, pedestrians). These cameras permit to acquire a huge amount of video at strategic locations and with various orientations. Foremost, these videos are exploited by public agencies for security reasons. In many cases, the acquired images are observed by a human operator. This makes the analysis tasks more or less fastidious and uncertain. For this reason, various vision algorithms have been proposed in the literature that exploit these existing raised cameras for automatically performing certain analysis tasks such as abnormal behavior detection [21,27] or monitoring the road traffic [4]. In France, such systems are employed in certain cases for automatically sending fines to drivers having done a detected infringement. This functionality is called "vidéo-verbalisation".

2.4 Vehicular Ad-Hoc Networks and Cloud Computing Systems

Vehicular Ad-Hoc Networks (VANETs) support the spontaneous creation of a wireless network for data exchange between mobile infrastructures [18]. They permit to carry out inter-vehicle communications. They also permit to communicate with urban infrastructures (e.g.; Road Side Units). VANETs can then be employed for exchanging video information between vehicular systems as well as with online platforms. Since vision-based on-board systems of vehicles can have limited computational resources, online platforms such as Cloud Computing services can be used for processing collected videos to extract relevant information [3].

In resume, such communication and processing technologies can then be used in conjunction with connected car black boxes or vision-based on-board systems of vehicles (mobile sensors) and/or with wireless cameras of urban infrastructures (static sensors) for constituting a wide-scale camera-based surveillance systems and cooperative detection systems aiming to enhance citizen security and comfort services [11]. In this sense, the next section presents our related designed and implemented detection and communication prototypes which have been undertaken for supporting advanced police aid services as well as advanced car parking assistance services.

3 Our Designed and Experimented Detection and Communication Systems

As previously mentioned, our first designed and implemented detection and communication system aims to develop advanced police aid services. The targeted services are focused on the improvement of the security for citizen. In particular, development complexities of these services lied in the statement of strategies for processing video acquired by on-board vehicular system and in the elaboration of a simulated communication architecture for exchanging on the processed data. Also, a complexity lied in combining these technologies of varied natures. Besides, our second designed and implemented experimental detection and communication architecture aims to develop a parking assistance system for drivers. The targeted service is focused on the improvement of the comfort for citizen. In particular, development complexities of this service lied in the elaboration of a car occupancy detection method from images acquired by a camera pole. These architectures are presented in more detail in next subsections.

3.1 Advanced Vision-Based Police Aid Systems

Police and security agencies need services for automatically recognizing searched individuals. In this sense, the studied architecture proposes to exploit vision-based on-board systems integrated to vehicles (such as those presented in Subsect. 2.1 and 2.2) for cooperatively enhancing the field of searches. More precisely, we assume at short term that a set of service vehicles (taxis, buses, police cars) will integrate connected camera systems. The flow of collected images tagged with associated GPS locations will be transferred on-the-fly to online computational machines such as cloud computing systems. Then, face detection systems already known for their efficiencies [22] will be applied in order to extract face sub-images of observed individuals for each collected image. These sub-images will be then rescaled and matched with identity photos of searched individuals obtained from reference databases of the police. Since the query sub-images are associated with their GPS locations, the matched sub-images will then provide the approximate location of the searched individual at a particular time and consequently will facilitate the security investigations.

In the same way, vehicle license plates detection systems already known for their efficiencies [26] will be applied onto the flow of collected images in order to extract the license plate characters of vehicles; notably by using Optical Character Recognition Systems (OCRs) [15]. The extracted characters of vehicle license

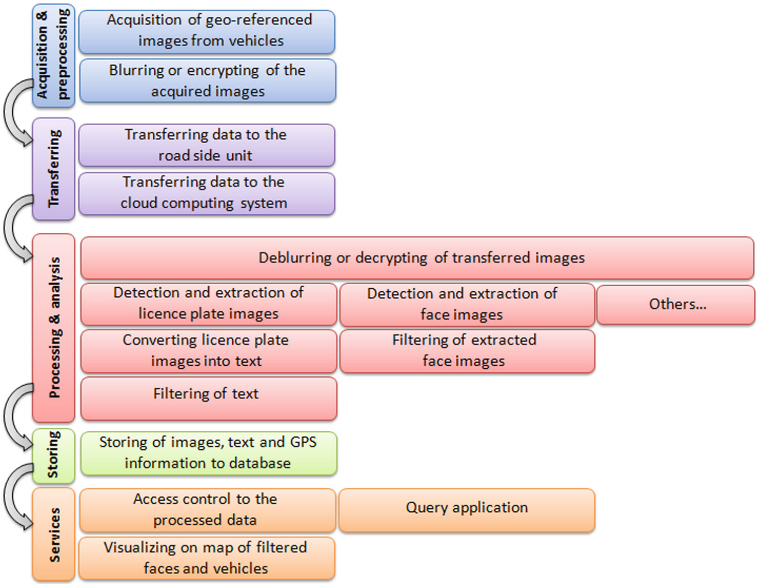

Fig. 1. Global Data-flow diagram to develop varied vehicle-based services with vision-based systems.

plates are then matched with those of stolen vehicles obtained from reference database of the police. Similarly to the previous application, GPS locations associated to the license plate characters extracted on-the-fly will permit then to immediately determine the approximate location of searched vehicles in case of matching between license plate characters.

Figure 1 illustrates a data-flow diagram shared by our two presented systems. This data-flow diagram exposes a generalized bottom-up representation of the employed major stages that can help to the development of other high-level services from vision-based feature detection systems. Moreover, an architecture (based on technologies presented in Subsect. 2.4) we designed for supporting the experiments of the two presented systems is described in more details in [9].

3.2 Advanced Vision-Based Parking Occupancy Detection

The traffic flows are more and more important in urban environments. This makes the finding of available parking slots particularly difficult during daily driving. For this reason, we developed a parking slot occupancy detection system that can exploit camera systems of existing urban infrastructures such as described in Subsect. 2.3 and we assume that the camera is imaging a car parking. More specifically, an image of an empty parking is captured from a camera pole. This image (reference) will be used for detecting changes by comparison with the flow of images acquired in real-time from the same camera pole. Then, a human operator will manually delineate visible footprints of parking slots in

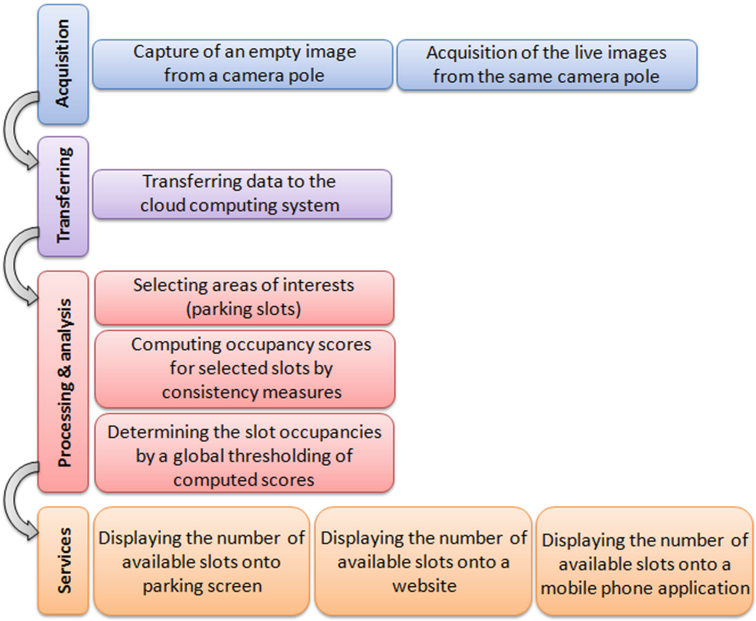

Fig. 2. Data-flow diagram of a parking occupancy detection service developed for camera pole of parkings.

the reference image in order to initialize the system. Once done, the reference image as well as the acquired live images are transferred to a remote machine for computing a dissimilarity score between reference slots and live images of slots. Next to this stage, a global thresholding of computed scores is applied to determine the occupancy status of selected parking slots. By this way, we can determine the number of available parking slots and transmit this information to drivers located into a surrounding perimeter. This can be done by displaying this information on dispatched parking screens, on a dedicated website or via a dedicated application for mobile phone. Figure 2 illustrates a data-flow diagram of these major stages.

Besides, two strategies were experimented for automatically measuring in real-time the consistency of parking slot images and taking a slot occupancy decision. The first one was based on a Canny edge detector (e.g.; see [1]) and considered the rate of contour points detected into each slots. The second one was based on robust image-based metrics such as Sum of Absolute Differences (SAD), Sum of Squared Differences (SSD), Zero-mean Sum of Squared Differences (ZSSD) (e.g.; [2]) and exploited a dynamical thresholding mechanism. Both experimented strategies was based on a global threshold. Figure 3 gives an overview of the developed detection system as well as occupancy results automatically computed in real-time. Details on the computational mechanisms of this system are described in [7,8,10].

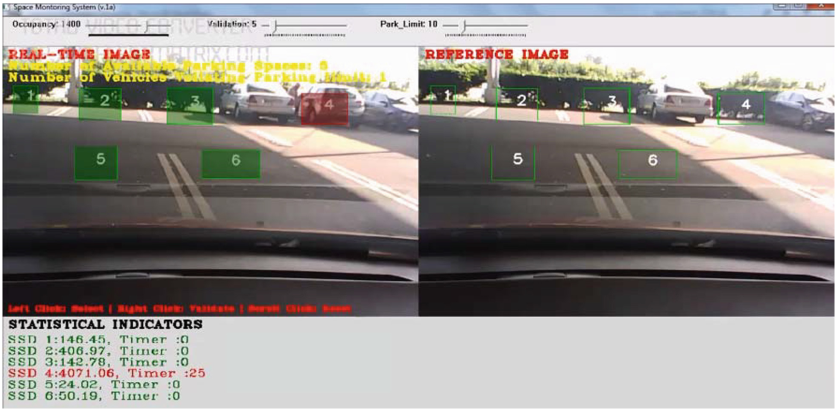

Fig. 3. System developed for the automatic detection of available parking slots in real-time [7,8,10]. Slots colorized in green and red represents detected vacant and occupied slots, respectively (color figure online).

4 Contributions and Conclusion

This paper proposes an overview of detection systems for improving the citizen security and comfort from urban and vehicular surveillance technologies. Indeed, a large variety of surveillance, detection and communication technologies are presented through the description of diverse use cases with black box systems for vehicles, vision-based on-boards systems integrated to vehicles, camera systems of existing urban infrastructures as well as with Vehicular Ad-Hoc Networks and Cloud Computing Systems.

Moreover, two vision-based detection prototypes we developed are described in more details and covers both security and comfort aspects. The developed security system exploits efficient vision-based detectors already intensively exploited in the literature. A complexity of the services lie in the combined action of heterogeneous systems (mobile and static systems, vision-based systems, communication and computation systems) for cooperatively supporting these services. The service descriptions stress a generalized data-flow diagram of the different stages assigned to each system. The developed car parking assistance system deals with analysis from static cameras. The description is focused on the elaboration of the proposed parking slot occupancy detection system. By this way, we hope that the highlighted detection systems as well as technological possibilities will foster the enhancement of new security and comfort services for the citizens.

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