A Vehicular Surveillance and Sensing System for Car Security and Tracking Applications

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ABSTRACT

In this paper, we propose a *Vehicular Surveillance and Sensing System* (VS^3), which targets at car security and tracking applications. VS^3 can be triggered by events detected inside or outside a car, such as abnormal air quality, potential burglary, and identification of some target vehicles (such as stolen cars). Via a 3G module, a user can interact with VS^3 via multimedia communications. For security applications, we show how VS^3 detects an abnormal CO_2 level or potential car burglary, notifies the vehicle owner, and then interacts with the owner. For tracking applications, we show how VS^3 identifies potential stolen vehicles, transmits reports to the police department, and get neighboring cars involved to cooperatively track suspicious vehicles. This paper demonstrates our current prototype.

Categories and Subject Descriptors: C.2.1 [Network Architecture and Design]: Distributed networks

General Terms: Algorithms, Design, Management

Keywords: Burglarproof, Surveillance, Vehicle Tracking

1. INTRODUCTION

The rapid development of micro-sensing MEMS and wireless communication technologies has made *vehicular sensor networks* (VSNs) possible. In a VSN, vehicles carry sensors to collect surroundings data and they cooperate with each other to utilize these sensed data for various purposes, such as crash prevention, surroundings monitoring, and mobile surveillance.

On the other hand, 3G/3.5G mobile systems are quickly developing. This would greatly enrich the interaction among users and vehicles. For example, a burglarproof system can provide video calls between a user and an on-board unit. As another example, traditional surveillance systems for vehicle monitoring rely on roadside cameras for video recording. However, it requires a lot of labors to go through these videos and huge efforts to distinguish targets from other irrelevant vehicles. With the cooperation of 3G/3.5G systems and VSNs, such video-recording work can be done in an on-demand manner via on-street vehicles.

In this work, we propose a 3G-enhanced VSN called *vehicular surveillance and sensing system* (VS^3). VS^3 can be triggered by events detected by a car. We will show how events of abnormal air quality, potential burglary, and identification of some suspicious vehicles (such as those stolen cars identified by the police department) trigger the surveillance module of VS^3 in an on-demand manner. Thus, VS^3 can avoid recording unnecessary videos. Alternatively, for simpler events, VS^3 can transmit SMS (short message service) or MMS (multimedia message service) to vehicle owners, who can then decide whether to initiate a video call. This paper demonstrates our current prototype.

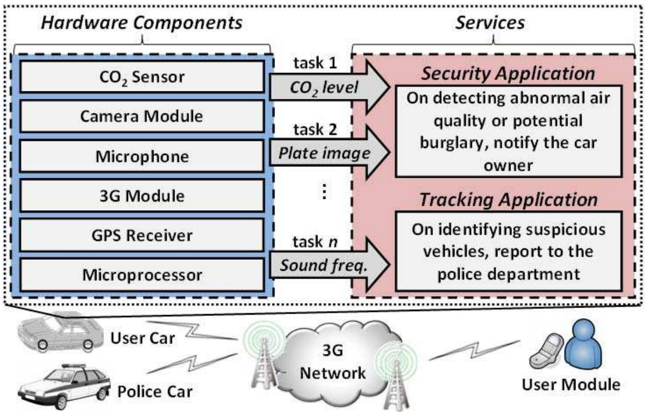

Figure 1: System architecture of VS^3.

2. SYSTEM ARCHITECTURE

Fig. 1 shows the architecture of VS^3. On the car side, it consists of a CO_2 sensor for detecting the CO_2 level inside the vehicle, a microphone for detecting unusual sound frequencies inside the vehicle, a GPS receiver, camera modules for taking photos or recording videos inside and outside the vehicle, a 3G module for making SMS, MMS, or interactive video calls, and a microprocessor for controlling all these components. On the user side, only a 3G mobile phone is needed to receive warning short messages, pictures, video clips, or interactive video calls from the on-board unit.

VS^3 targets two types of vehicular applications: security and tracking. In the security part, we propose two scenarios in Fig. 2(a) and Fig. 2(b). In Fig. 2(a), after a vehicle is parked, VS^3 will continuously check the CO_2 concentration in the vehicle for a predefined period. During this period, if there is no abnormal CO_2 concentration, it implies there is no baby or animal in the car. So the CO_2 sensor can be shut down to save energy. If it find that the CO_2 concentra-

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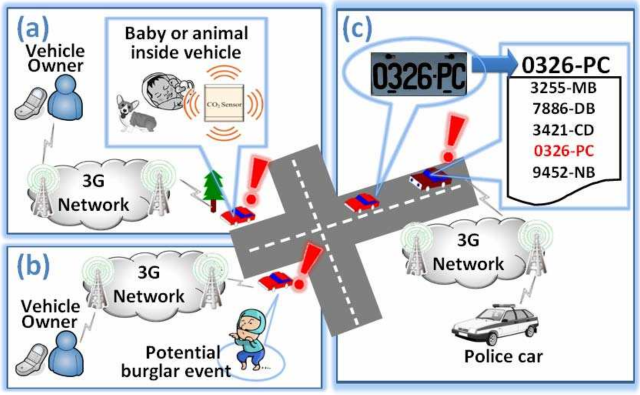

Figure 2: Scenarios of security and tracking applications.

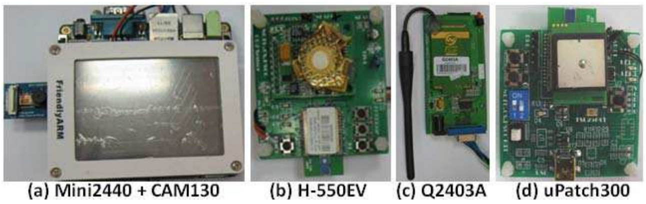

Figure 3: VS^3 hardware components.

tion is beyond a dangerous threshold, VS^3 will send a short message to a predefined phone number. The user can then activate MMS or video call with the car unit. In Fig. 2(b), we demonstrate a burglarproof application. When a potential burglar event is detected (such as doors being opened), VS^3 will send the owner a short message. Since an immediate action is needed, VS^3 will directly record a video clip and send it to the owner via MMS. More importantly, the video clip is a critical clue and evidence in a lawsuit.

In the tracking part, Fig. 2(c) shows a surveillance scenario. Through its camera, VS^3 will continuously take snapshots on neighboring vehicles. VS^3 will retrieve these license plate numbers and compare them against a database of suspicious plate numbers provided by the police department (through the Internet or nearby police cars). When a suspicious vehicle is identified, the on-board unit can transmit a report message to the police department via 3G networks. The police department then can take further actions. In addition, the on-board unit can broadcast this message to neighboring vehicles by vehicle-to-vehicle (V2V) communications (through IEEE 802.11p [1] interfaces). Thus, the traces of suspicious vehicles can be continuously logged, which are valuable clues to the police department. This brings up a new challenge of how to conduct cooperative tracking by general vehicles on the street.

3. PROTOTYPE IMPLEMENTATION

We have developed a prototype of VS^3. The microprocessor in the car unit is an ARM9 Mini2440 [2] with a 3.5" TFT LCD, as shown in Fig. 3(a). It is equipped with a CAM130 camera, which has a 400MHz 32-bit RISC integer processor (ARM920T [3]), 64MB SDRAM, 64MB Nand Flash, Camera Interface, three serial ports, and a 10/100M Ethernet RJ-45. Mini 2440 can issue snapshot commands to

Figure 4: Prototyping demonstration.

CAM130 for taking full-resolution pictures. To output the captured video data to an image file, the jpeg library, *libjpeg*, is linked to the executable program. The CO_2 module is a H-550EV CO_2 sensor [4] integrated with Jennic JN5139 [5] as shown in Fig. 3(b), which has 0$\sim$5,000 ppm measurement range and $\pm$30 ppm accuracy. The 3G module is the Wavecom Q2403A GSM/GPRS/CDMA module as shown in Fig. 3(c), which is controlled by Mini2440 via AT commands. The GPS module is implemented by uPatch300 [6], as shown in Fig. 3(d), which follows the NMEA (National Marine Electronics Association) 0183 protocol.

For *license plate recognition* (LPR), we integrate a software with the following functions: plate localization, plate orientation and sizing, normalization and edge detection, character segmentation, and optical character recognition. For car security, we demonstrate a door-trigger scenario as shown in Fig. 4(a) and a CO_2-monitoring scenario in a model car as shown in Fig. 4(b). For car tracking demonstrations, Fig. 4(c) and Fig. 4(d) show our prototyping system set up in a real car and a suspicious vehicle tracking scenario, respectively.

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5. REFERENCES

[1] IEEE std. 802.11p/D4.0, Draft Amendment for Wireless Access in Vehicular Environments (WAVE). Mar. 2008.
[2] FriendlyARM, Mini2440. http://www.friendlyarm.net.
[3] ARM, ARM920T. http://www.arm.com/products/CPUs/ARM920T.html.
[4] H-550EV CO_2 Sensor Module. http://www.co2sensor.co.kr/new/eng/ndir-co2-sensor-module-h550ev.htm.
[5] Jennic, JN5139. http://www.jennic.com.
[6] Fastrax, uPatch300. http://www.fastrax.fi.