VS^3: A Vehicular Surveillance and Sensing System for Security Applications

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***Abstract*—The *Vehicular Surveillance and Sensing System* (VS^3) is a 3G-based mobile device for car security applications. On the car side, it consists of a CO_2 sensor, a camera module, a 3G module, and a microprocessor. On the user side, only a 3G mobile phone is needed. VS^3 provides the following features: (i) it can be triggered by events detected on car, (ii) events can be abnormal air quality or potential burglary, and (iii) it supports text or multimedia interaction with users. Application scenarios include detecting an abnormal CO_2 level or potential car burglary, which triggers VS^3 to transmit SMS, MMS, or interactive video call to the vehicle owner, who can then monitor the car situation in return. VS^3 thus demonstrates a new car security and burglarproof prototype.**

Keywords: Burglarproof, IEEE 802.15.4, Surveillance, Vehicular Sensor Network, Wireless Network.

I. Introduction

The rapid progress of embedded micro-sensing MEMS and wireless communication technologies has made *vehicular sensor networks* (VSNs) possible. A VSN normally consists of a number of sensors placed on a vehicle to collect environment data and utilizes these sensed data for various purposes. Examples include vehicle tracking, crash prevention, and mobile surveillance [2], [3], [7].

In this work, we are interested in taking advantage of the current 3G or 3.5G mobile systems to enrich user interaction in a VSN. Our goal is to develop a surveillance and sensing system for car security applications. Traditional surveillance systems for vehicle protection rely on roadside cameras for video recording. There are two problems associated with such solutions. First, it requires huge efforts to distinguish targets from many other candidates. Second, since targets are not predefined, the recorded images are usually not clear enough. Further, the volume of videos could be huge, thus requiring a lot of labors.

We propose a 3G-enhanced VSN called *vehicular surveillance and sensing system* (VS^3). Only a 3G mobile phone is needed on the user side, whereas an integrated device with a CO_2 sensor, a camera module, a 3G module, and a microprocessor is need on the car side. The microprocessor is responsible for issuing commands and coordinating with other modules. VS^3 provides the following features: (i) it can be triggered by events detected on car, (ii) events can be abnormal air quality or potential burglary, and (iii) it supports text or multimedia interaction with users. Only when an event is dectected, the camera module is activated to capture images or record videos of that event. Thus, VS^3 can avoid recording unnecessary videos when nothing happens and improving image/video quality. Application scenarios include detecting an abnormal CO_2 level or potential car burglary, which triggers VS^3 to transmit SMS (short message service), MMS (multimedia message service), or interactive video call to the vehicle owner, who can then monitor the car situation in return. VS^3 thus demonstrates a new car security and burglarproof prototype.

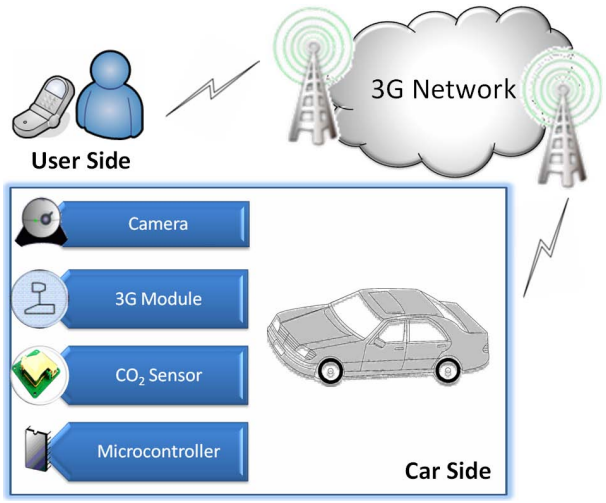

Fig. 1. System architecture of VS^3.

II. System Architecture

Fig. 1 shows the VS^3 architecture. On the car side, it consists of a CO_2 sensor, a camera module, a 3G module, and a microprocessor. On the user side, only a 3G mobile phone is needed. To illustrate how VS^3 works, we demonstrate a car security and a car burglarproof applications below. In

Y.-C. Tseng's research is co-sponsored by MoE ATU Plan, by NSC grants 96-2218-E-009-004, 97-3114-E-009-001, 97-2221-E-009-142-MY3, and 98-2219-E-009-005, by MOEA 98-EC-17-A-02-S2-0048 and 98-EC-17-A-19-S2-0052, and by ITRI, Taiwan.

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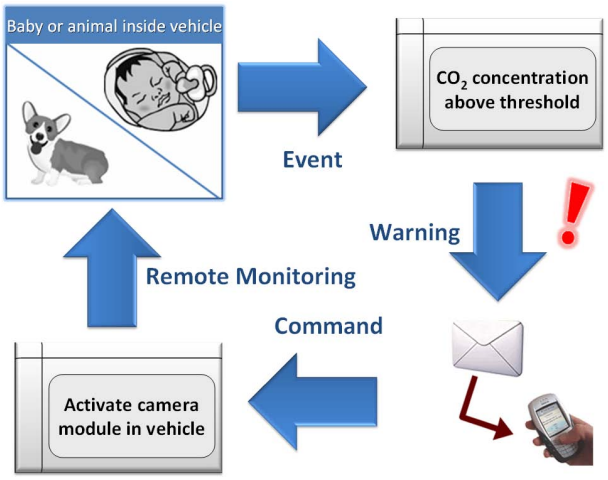

Fig. 2. A car security application.

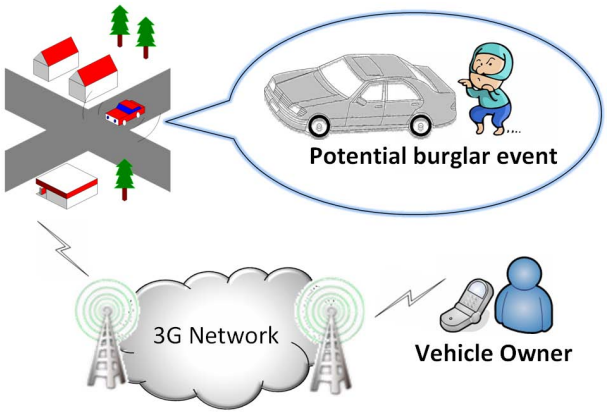

Fig. 3. A car burglarproof application.

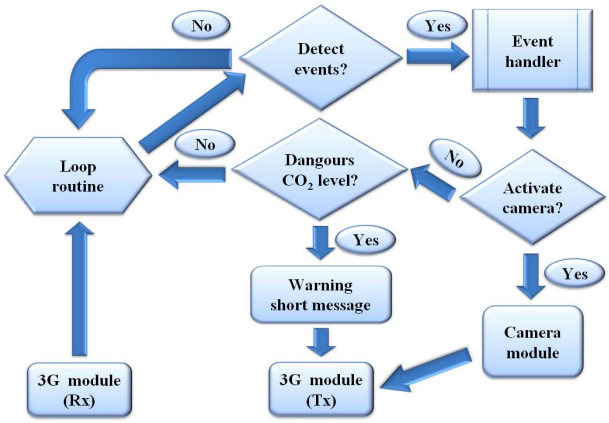

Fig. 4. Flowchart of VS^3.

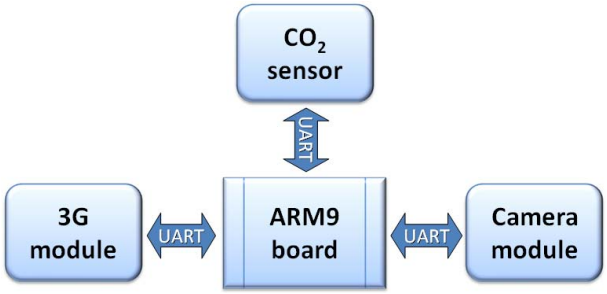

Fig. 5. Building blocks of the car unit.

the car security application in Fig. 2, after the driver parks the vehicle and activates the car unit, VS^3 will continuously check the CO_2 concentration in the vehicle for a predefined period. During this period, when it is found that the CO_2 concentration is beyond a dangerous threshold, VS^3 will send a short message to notify the predefined phone number (user unit). On receipt of the warning message, the owner can return a command short message to VS^3. According to the command, VS^3 activates the camera module and initiates a video call to the owner. Through the live video call, the user can monitor possible abnormal events (such as baby or animal forgotten in the vehicle) by his/her 3G phone. Therefore, lives can be saved in time by the help of VS^3.

In the car burglarproof application in Fig. 3, VS^3 notifies the owner as a potential burglar event is detected (such as door open). 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 to catch the thief. Fig. 4 shows the VS^3 flowchart.

Fig. 6. Mini2440 development board with a 3.5" TFT LCD.

Fig. 7. H-550EV CO_2 sensor integrated with JN5139.

Fig. 8. Wavecom Q2403A module.

III. Implementation Details

Fig. 5 shows the building blocks of the car unit. The microprocessor in the car unit is an ARM9 board (Mini2440 [4]) with a 3.5" TFT LCD as shown in Fig. 6, which has a 400MHz 32-bit RISC integer processor (ARM920T [1]), 64MB SDRAM, 64MB Nand Flash, 2MB Nor Flash with BIOS, three serial ports, and a 10/100M Ethernet RJ-45. In particular, Mini2440 can run embedded Linux and WinCE to develop diverse applications.

The CO_2 module has an H-550EV CO_2 sensor [5] integrated with Jennic JN5139 [6], which is mounted to Mini2440 via an UART interface. Our prototype is shown in Fig. 7. The CO_2 sensor module has 0$\sim$5,000ppm measurement range and $\pm$30ppm accuracy. JN5139 has a 16MIPs 32-bit RISC processor, a 2.4GHz IEEE 802.15.4-compliant transceiver, 192kB of ROM, and 96kB of RAM. In particular, JN5139 allows the flexibility of supporting mesh networking and packet routing inside a vehicle.

The 3G module is currently implemented by a Wavecom Q2403A GSM/GPRS/CDMA module as shown in Fig. 8, which is controlled by Mini2440 via AT commands. It performs SMS, MMS, and video calls as instructed by the ARM9 board.

Fig. 9. CAM130 camera module.

The camera module is implemented by CAM130 as shown in Fig. 9. It is a CMOS optical sensor. Mini2440 can send a snapshot (record) command to CAM130. In return, a full-resolution, single-frame still picture (video) will be transferred to Mini2440 through the serial port.

In the CO_2 monitoring application, the concentration threshold is set to 1500ppm. We use AT commands to trigger the 3G module to send short messages. The car owner can return a short message with a specific command to ask the ARM9 board to initiate a video call back.

In the burglarproof application, besides a warning short message, a video clip is sent to the car owner as a multimedia message. The clip can be provided to polices as evidence in the future when needed.

IV. Conclusion

VS^3 integrates 3G communication and CO_2 sensing into surveillance technologies to support intelligent car security applications. The vehicle owner can be informed immediately as unusual events are detected on car. At the same time, the owner can remotely monitor the situation inside vehicle and then take proper actions if necessary. VS^3 can prevent vehicles form burglar or keep evidences to catch the thief. Furthermore, The baby or animal forgetfully left in the vehicle can be rescued in time by the assistance of VS^3. The future extension of VS^3 could be equipped more various sensors and form a VS^3 network to investigate cooperation issues and develop novel applications.

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