Helmet-Mounted Display System of Motorcyclist with Collision Detecting and Navigation

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Abstract. This work presents an innovative motorcyclist assistance system that involves the helmet-mounted display and accelerometer integrated into a motorcycle helmet. The proposed system based on MCU AT89S52 can show driving information including speed and global positioning system (GPS) navigating message on face shield reflected from a 0.96-in. 96 × RGB × 64 AMOLED panel, which improve the safety of rider when riding the motorcycle. In addition, when the embedded 3-axis accelerometer detects an acceleration value exceeding 9.0 G in any direction caused by a traffic crash, the emergency short message service (SMS) will be sent after the buffer time of 10 s for possible rescue.

Keywords: Accelerometer · Driving assistance system
Head-Up Display (HUD) · Helmet-Mounted Display (HMD)
Motorcycle helmet

1 Introduction

The death of motorcyclists because of traffic crashes increases in recent years. According to statistics, there are almost three hundred thousand motorcyclists died in 2010 and 78% of deaths happened in Asia [1]. Since the helmet is required to be used by motorcyclists in most countries, it should be developed smarter and safer to decrease the casualty rate of motorcyclists. In order to improve the road safety, head-up display (HUD) is one of the solutions since it can eliminate the drivers' distraction while checking the dashboard. HUD was first developed for military aircraft, which can let pilots focus on flight and get state of plane at the same time. Nowadays, HUD is widely used as driving assistance system on automobiles. By projecting information on the windshield, drivers do not need to move their eyesight form road to dashboard for checking the state of their vehicles [2]. To make pilots turning their heads be able to see the display information, HUD that integrated with flight helmet is known as helmet-mounted display (HMD). HMD has been used as a navigation assistance system for helicopter pilots, which combines information into the vision of a pilot without interfering their view. A smart motorcycle helmet embedded with HMD can display

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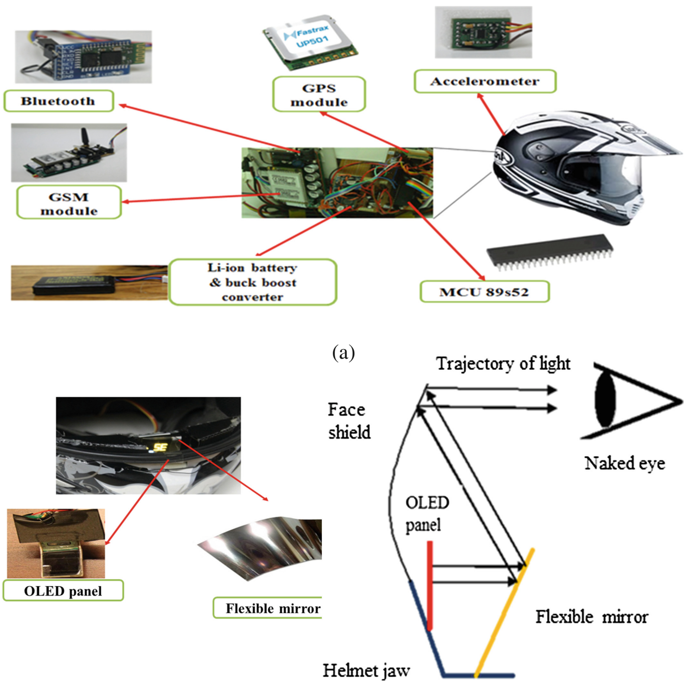
information of vehicle including speed, fuel, or GPS coordinates. With such helmet, motorcyclists do not need to check dashboard when riding so as to greatly improve their safety. However, an accident may still happens. To give motorcyclists immediate assistance when a car crash happened, an impact force sensor such as an accelerometer should be embedded in the helmet. Accelerometer is a type of micro electromechanical sensor that can sense the acceleration value in directions of 3-axis to detect gravity direction for motion capture [3] and force of impact [4]. Chang et al. proposes a HMD designed for motorcycle helmets with the see-through image display which has better image quality [5]. However, it only focuses on the optical design of display system and has no communicating function and sensors. Spelta et al. proposes a audio interface rider assistance system [6] connecting motorcycle's vehicle control unit (VCU) through bluetooth to get vehicle state. However, such system only supports few motorcycles with same VCU protocol.

Therefore, this work presents a riding assistance system for motorcyclists that integrates a 0.96-in. organic light-emitting diode (OLED) HMD to display motorcycle state including speed and navigation information. A collision detecting system using 3-axis accelerometer is also embedded to record the value of impact force on helmet, and contact the emergency medical service after the buffer time of 10 s when a traffic crash happens. Therefore, this work effectively reduces the chances of car crashes by using HMD and also reduces fatality rate in a car crash by sending emergency cell phone short message.

2 System Hardware Architecture

Figure 1(a) shows the hardware block diagram of the proposed system, consisting of (1) a micro control unit (MCU): Atmel AT89S52, (2) global system for mobile communication (GSM) module: SIEMENS TC35, (3) GPS module: FASTRAX UP501, (4) 3-axis accelerometer: ANALOG DEVICES ADXL345, (5) HMD module, (6) bluetooth module: TI CC2540, and (7) power module. MCU AT89S52 is a low-power and high-performance 8-bit microcontroller to decode the strings from GPS module and bluetooth module for the speed and navigation information, and reads the value of 3-axis registers of accelerometer for determining to send the emergency text message or not. The whole system use single cell of Li-ion or Li-poly battery as power source which is regulated by buck-boost converters from 3.7 V to 12 V and 5 V to meet electric power requirement of GSM modules and the rest modules respectively. The system hardware excluding display module is fixed at the back of helmet. The helmet-mounted display module consists of a soft reflective plate and a 0.96-in. full color OLED panel connected with main MCU through 16 pin cable with a 8-bit parallel data bus across the helmet. Figure 1(b) and (c) shows the display hardware architecture and the corresponding image-projecting method. The whole display module is fitted in the jaw of a full face helmet to project a clear and transparent image of driving information on the face shield of the helmet.

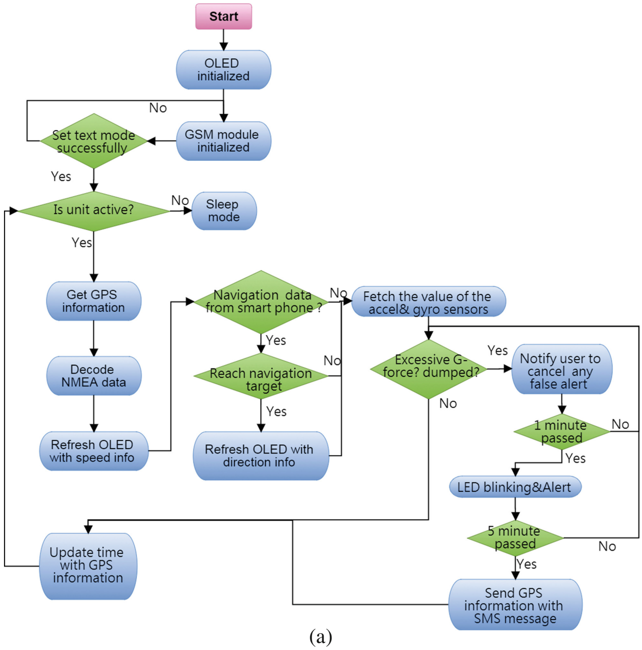


(b) (c)

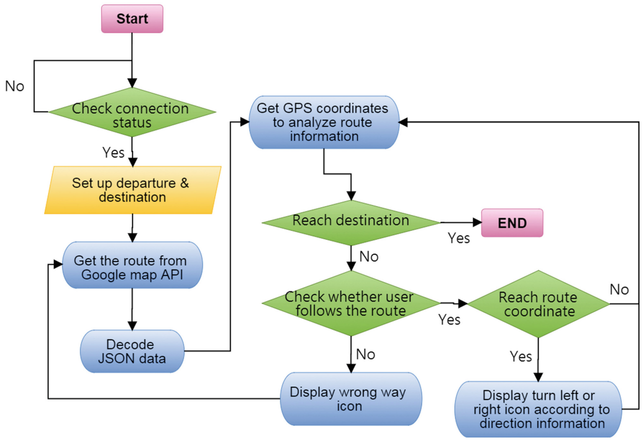
Fig. 1. (a) Block diagram of the proposed system (b) HMD display architecture and (c) image-projecting method.

3 System Firmware and Software Principle

According to the flow chart of the proposed system in Fig. 2(a), at first the MCU initializes the parameters of all modules, then starts to receive and decode NMEA GPS protocol from GPS module to get speed and position. MCU also checks the navigation command sent from mobile devices application program through bluetooth and determines which riding direction icon (left, right, or wrong way) should be displayed. Consequently, the OLED module updates and displays the information of the driving speed and navigation path to notify motorcyclists. Simultaneously, MCU loads the value of acceleration stored in the 3axis registers of accelerometer to detect the magnitude of impact on the helmet. If the impact value exceeds the threshold value that a human body can withstand, 9.0 G is setting herein, and the motorcyclists doesn't press the reset bottom after 10 s, the system will enter emergency state and MCU automatically sends short message to emergency medical services through GSM module. The emergency short message contains the magnitude of impact and the GPS coordinate to indicate the location where the accident happens. If the impact value is under threshold value, system will ignore this event and proceed to another firmware loop.



(a)



(b)

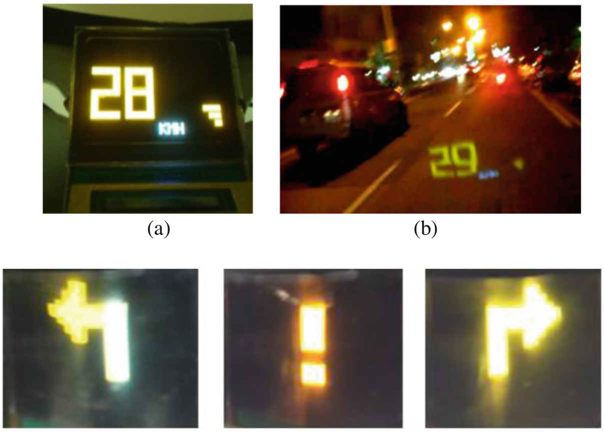
Fig. 2. (a) Firmware flowchart and (b) APP flowchart of proposed system.

This work develops an Android smart phone application program and establishes a bluetooth connection between helmet and smart phone to achieve the GPS navigation function, as shown in Fig. 2(b). Google map API is embedded in this application and the user can manually set the desired destination. When the application detects current position nears a waypoint, it sends a command through bluetooth to helmet.

4 System Presentation

To render graphic with limited memory in MCU, this work uses draw command that can form simple number and icon to present speed and navigation information. The OLED panel can project a clear view of speed information on helmet face shield compared to traditional LCD panel for back light unit because the self-emission characteristic of OLED achieves much higher contrast ratio. Figure 3(a) shows actual operation of the helmet-mounted display. Figure 3(b) and (c) demonstrates the on-road driving speed of 29 km/hr, and the navigation icons including “turn left”, “wrong way”, and “turn right”, respectively.

A 3-axis accelerometer (ADXL345) is embedded as the impact force sensor to detect whether a car accident has happened. To obtain the max acceleration value in the instant of impact, the acceleration sensor module has its own controller to record input acceleration value continuously and store the max value in register to send to MCU of system. When MCU detects the acceleration value exceeding the threshold value, MCU enters emergency alert state. Figure 4 shows the measurement of real time raw



(a) (b)

(c)

Fig. 3. (a) Practical OLED panel operation. (b) Projection images including driving speed and (c) navigation information.

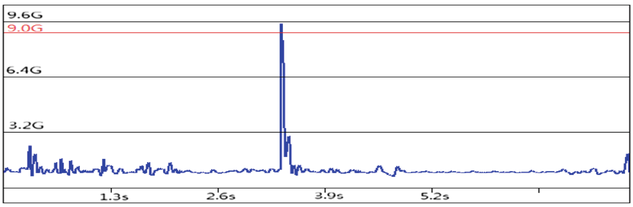


Fig. 4. Real time recording of acceleration value, and a detection of receiving impact which has value of around 9.5 G.

acceleration value when helmet receives impact with the maximum impact value of 9.5 G, which exceeds the threshold value of 9.0 G. The experiment verifies the feasibility of the proposed system to provide the emergency arrangement promptly when a traffic crash happens.

5 Conclusion

This work presents an advanced rider assistance system that improves convenience and safety. The proposed system is developed to have capability of showing the timely information on the HMD, and matches up with our mobile devices. When the accident happened, it can detect the impact and send the emergency message. By reducing traffic crash chances and contacting emergency service when accident happens, this work can greatly reduce the casualty rate of motorcyclists.

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