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Smart airbag vest with integrated light turn signaling and location tracking

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ABSTRACT

Research on road safety is continuously developing with the applications of sensors and technologies. Another area that draws the attention of the developers for road safety are in the road accident response. As the number of riders and cyclists increase, so do the accidents particularly at night where visibility is limited. This study presents a method of integration of inflatable safety vests for riders with light emitting diode LED signaling strips embedded in its front and back, and sensors to send the location of the rider when an accident hap-pens. The LED strips are controlled using a wireless remote switch to make the rider more visible other than that embedded in the motorcycle or bicycle. The airbag will activate once an accident occurs and or the rider is detached from the motorcycle. A force-sensitive resistor (FSR) is used as a triggering device attached to the vest when an accident happens where a global positioning system (GPS) module will send the location and a map to a specific mobile number for response. Three trials were conducted to test the functionality of the LED lights for signaling. The device functioned well, that both the left, right, and standby mode were activated. The functionality of the location tracker is also tested in three different locations. The FSR was triggered and it gave the exact location by sending the coordinates and a link to view it on google maps with an average transmit and receive time of 3 seconds. It is recommended that the prototype be developed using light-weight materials and batteries.

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1. INTRODUCTION

Road safety and smart vest : several notable applications of smart safety vests are in aircrafts with traceability [1], and in water [2], paving the way for future applications for safety vests in general. Other than road signs, it is a must for vehicles to have signal lights for visibility for the safety of the riders [3]. Motorcycle accidents and fatalities have been recorded to have spiked in the 2020s [4] together with the increase of the use of motorcycles as a substitute to four-wheeled taxis because it can get away from the heavy traffic in the metro. Moreover, increase in bicycle usage also in-creased bicycle incidents during the pandemic. Smart vests were developed which are embedded with sensors to mitigate incidents or lessen injuries [5]–[8]. The addition of airbags [9]–[11] and brake lights [12], [13] to safety vests have also transformed the construct of smart safety vests. Through these technologies, the road accidents can be minimized.

Emergency response: it is quite a challenge to the rescuers to respond immediately when accidents or incidents occur. There could be more lives saved if the delay of sending and receiving information is fast. The emergency response is essential in all areas of accidents such as earthquakes, floods, and road accident response. Several researches and prototypes for locating people in distress conditions were done for quick response [14]–[16]. The utilization of global positioning system (GPS) and short message service (SMS) are still of great use in this regard [17]. The quick notification to the responders can be sent through the use of these technologies. Some concepts have been shown utilizing GSM and GSP for prompting rescuers as fast as possible [18]–[20]. However, a robust system that has proven working has to be displayed that could be used as a model for these applications.

In this work, a method of an integration of an inflatable rider vest and wireless signaling LEDs to increase rider visibility is done. The smart airbag vest is equipped with a force-sensitive resistor for triggering the GPS and GSM modules for sending the location of the rider when an accident occurs. This work will pave the way for a safe and a quicker transmit and receive of distress signal when a rider meets an accident. Its functionality is tested by triggering an force-sensitive resistor (FSR) embedded in the air vest when it is inflated.

2. METHOD

2.1. System setup

The overall system setup is presented in Figure 1. Two functions were highlighted in this setup: i) wireless signaling device; and ii) locating device when an incident or accident occurs. LED strips were embedded in the inflatable vest that are designed for left arrows (left turn), right arrows (right turn), LED off for stop or break, and blinking lights (FSR activation). In the test of the prototype, a domino 3-way switch will be used for switching left turn, right turn, or idling mode wire-lessly via NRF transducer. A relay is used in switching the LEDs with its compat-ible supply voltage.

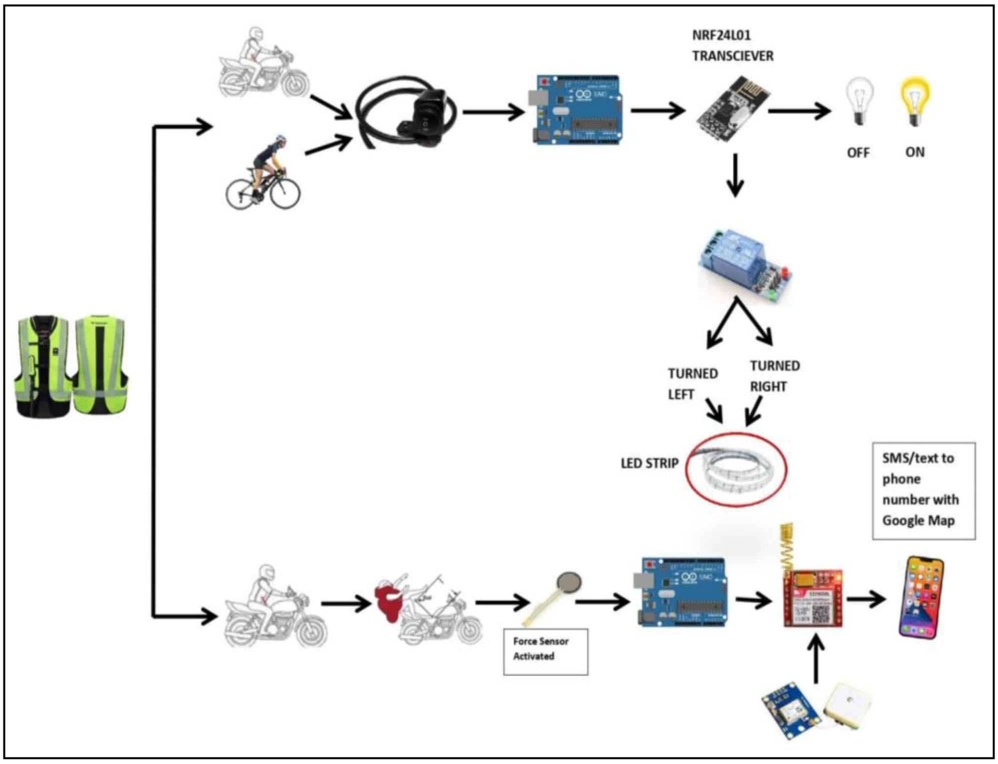


Figure 1. System setup for smart vest

For triggering the transmission of the location of the rider, an FSR is used. This setup is presented in Figure 2. The FSR is calibrated based on the pinch force (in kilogram per square meter) when the air vest is inflated. FSR is known for its sensitive functions when triggered [21]. It will automatically respond to transmit signals to the connected modules. A NEO 6M GPS and SIM800L GSM Modules module gets the location and sends a clickable link respectively to view the map in a smartphone [22]–[24]. The overall wiring diagram is presented in Figure 3. The enclosure for the components are fabricated using an FDM 3d printer.

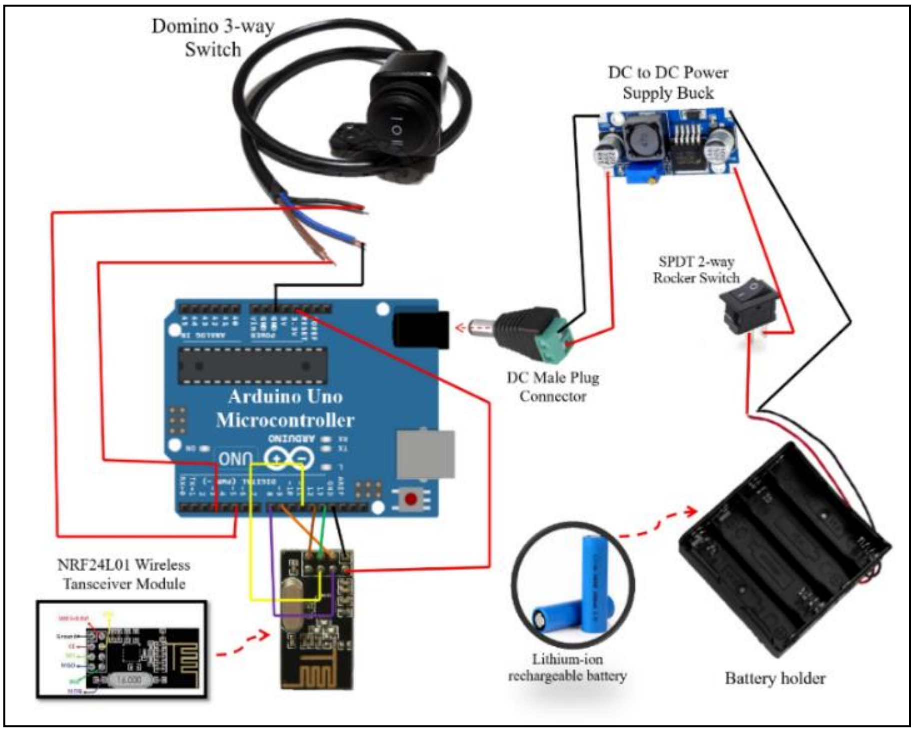


Figure 2. Schematic diagram for the wireless module

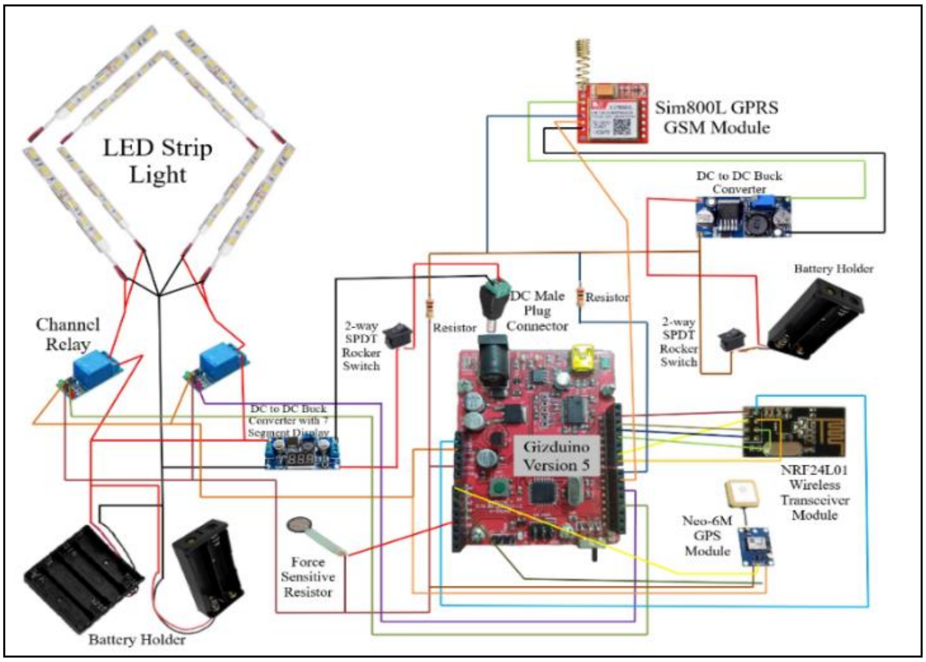


Figure 3. Wiring diagram for the wireless switching of the LED strip

2.2. Test and evaluation

The wireless switching of the LED strip for signaling is tested in 3 trials. The triggering of the GPS and GSM module tested with a calibrated FSR based on the pinch force when the airbag is inflated. The GSM module is excellent for sending text messages, in this case, location of the rider without the use of internet connection [25]. Three trials were conducted for each of the three different locations. Triggering the FSR is an actual assumption that the air vest is inflated when an accident occurs as presented in Figure 4. The airbag vest is CO2 gas operated and has a reusable cartridge. All these data are confirmed through the Arduino IDE and through the smartphone interface.

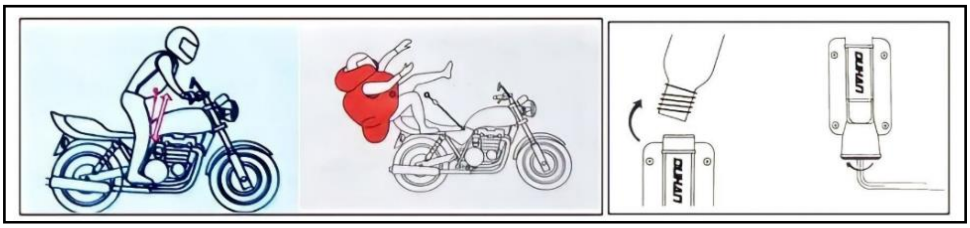


Figure 4. Air vest triggering (photo provided in courtesy of the supplier)

3. RESULTS AND DISCUSSION

3.1. Fabrication

The air vests installed with LED strips are presented in Figure 5. The circuit com-ponents are housed in a 3d printed enclosure as presented in Figure 5 where the relays, GPS and GSM module, microcontroller unit, and wireless modules are placed. The test results summary is presented in Table 1, where 3 trials for each of the conditions were successfully done. The battery pack is placed beneath the enclosure. Figure 6 presents the actual results, where Figure 6(a) and Figure 6(b) are the front and back side of the vest, Figure 6(c) is the image with embedded LED strips, Figure 6(d) and Figure 6(e) are the triggered left and right turn respectively captured in the evening for visibility test. The LED strips are wear-resistant but not water-proof. The airbag vest can inflate in 30-kg tension when the ball valve is pulled for inflation.

Figure 5. Electrical and electronic components in a 3D printed enclosure

Table 1. Test results for wireless remote control and LED system

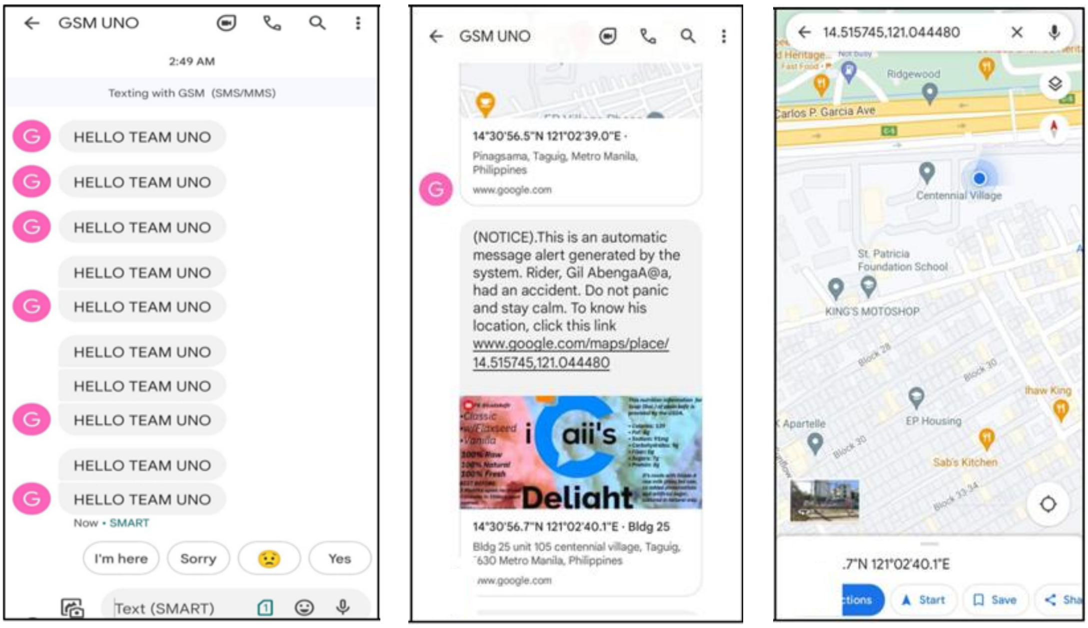
LED signal options	Trial 1	Trial 2	Trial 3
Left	Yes	Yes	Yes
Off	Yes	Yes	Yes
Right	Yes	Yes	Yes

(a) (b) (c) (d) (e)

Figure 6. Airbag vest; (a) front, (b) back, (c) installed with LED strips (d) left turn LED, and (e) right turn LED

3.2. Functionality test result

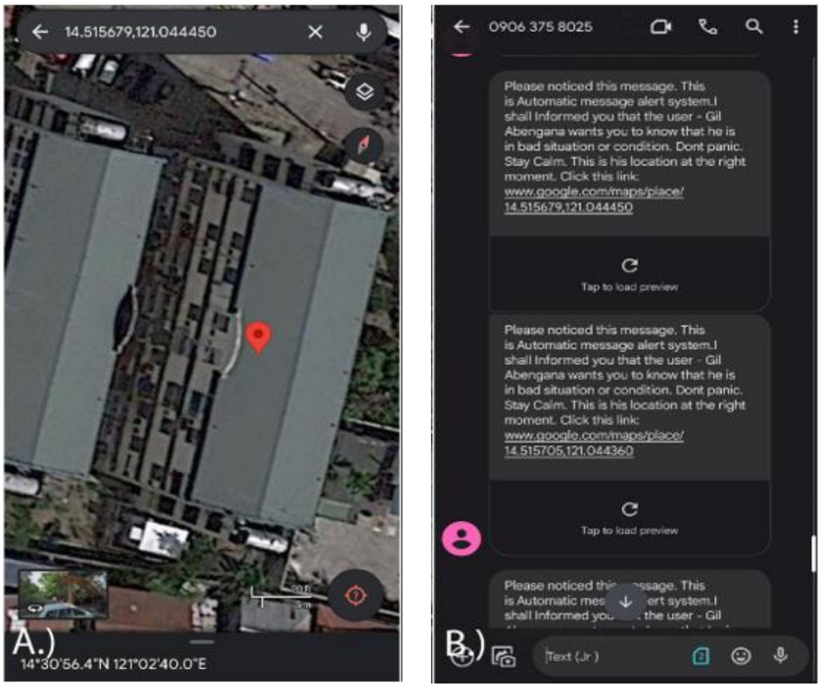
The GSM and the GPS module was successfully set up as presented in Figure 7, where a text message is received as programmed in the microcontroller unit. Figure 7(a) is a test for SMS notification, while Figure 7(b) and Figure 7(c) presents the successful reception of the GPS location and a location map displayed when the link is clicked. It must be noted that the map will only be possibly displayed when there is a mobile data or internet connection. The FSR is calibrated at a force of 20.6 kN based on the conversion of the analog reading in the microcon-troller unit. Triggering of FSR is done in 3 different locations in taguig city philippines which successfully have sent the location to the registered SIM card. An average of 3 seconds was recorded for the transmit and receive time of the text message. This result may vary depending on the strength of the mobile network for transmission and reception of messages. When in use, the lithium ion batter-ies can last for 5-7 hours.



(a) (b) (c)

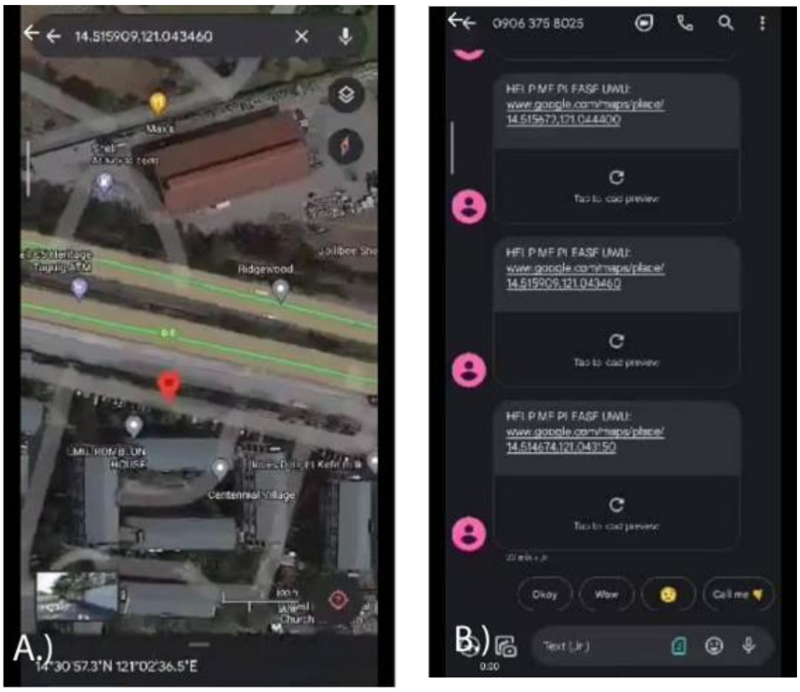
Figure 7. GSM and GPS test result; (a) GSM test, (b) a sample received message with GPS location and map and (c) map display

The testing of the location tracking feature included in the system of the smart vest is demonstrated in Figures 8-10. Figure 8(a) is the first point at which the demonstration result was conducted, located inside the house, and Figure 8(b) is the exact longitude and latitude coordinates to the location of the subject. Figure 9(a) is located outside of the compartment building in centennial village, and Figure 9(b) is the coordinates to the location of the subject. The last point of the demonstration location tracking is in Figure 10(a), which is also located outside of the building but in a different location, and Figure 10(b) shows the coordinates of the exact position and location of the subject.



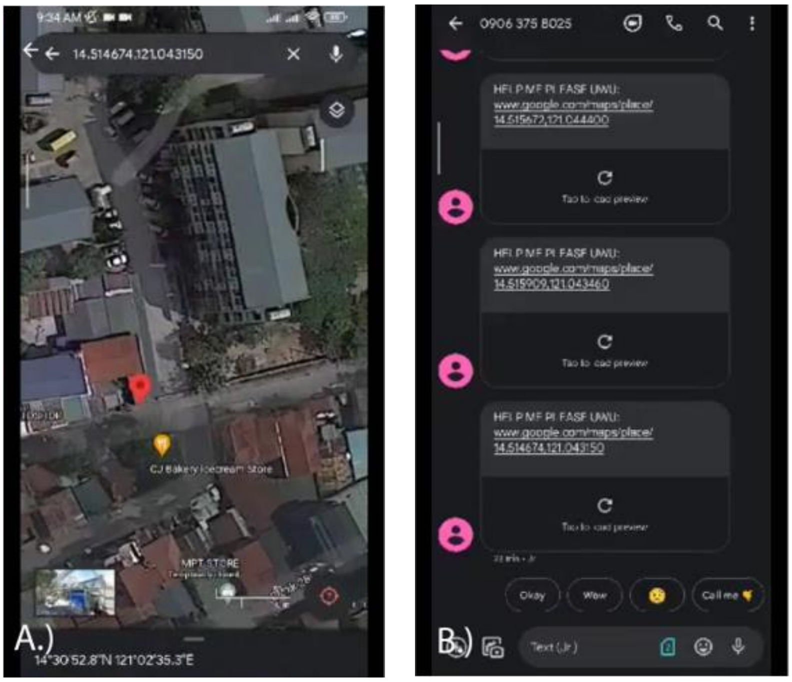
(a) (b)

Figure 8. First point (a) coordinates in google map and (b) message with google map link



(a) (b)

Figure 9. Second point (a) coordinates in google map and (b) message with google map link



(a) (b)

Figure 10. Third point (a) coordinates in google map and (b) message with google map link

4. CONCLUSION

This study has successfully integrated wireless signaling LED lights in an inflata-ble vest which gives better visibility to motorists and mitigates accidents on the road. All of the signaling conditions have been met. The vest was installed with a force-sensitive resistor to automatically send a notification when triggered, to the emergency response contact with its coordinates and google-map link using GPS and GSM system. The results of the tests in three different locations indicate that the coordinates and google-map link are accurate and precise with an average transmit and receive time of 3 seconds. This model is recommended for further development of a prototype with lighter weight materials. As some models include live video broadcast, it is recommended that an alternative power source will be searched for these applications.

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