



# Smart Vehicle Surveillance System for Road Accidents Detection

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**Abstract.** Every year many people die in road accidents. One of the reasons on the deaths caused by road accidents is the victims do not receive treatments within the golden hour. Hence, the detection of road accidents can help in reducing the number of deaths caused by road accidents. There are solutions to detect road accidents, such as implementation traffic management system, using sensors in smart phones and analyzing data from vehicle's sensors. In this project, Smart Vehicle Surveillance System (SVSS) is proposed to detect road accidents. Piezoelectric sensors play the role as vehicle's sensors in SVSS. Arduino Mega 2560 microcontroller serves as the control unit to receive and analyze signal. GPS module tracks the car's location, while GSM/GPRS module connects SVSS to mobile data network. Furthermore, Blynk IoT mobile application notifies the subscribers of SVSS if the occurrence of road accidents is identified and the driver needs help. This prototype is our initial idea in detection of road accidents. Industrial involvement can improve the practicality and implantable of SVSS in a car.

**Keywords:** Smart Vehicle · Crash Detection · Piezoelectric Sensors · Arduino · Internet of Things

## 1 Introduction

In the world, an average of 3,700 people die daily or 1.35 million people die yearly in car crashes [1]. On 13 January 2022, Dr. Bakri Zainal Abidin, the Assistant Director of Enforcement of the Bukit Aman Traffic Investigation and Enforcement Department, reported that 17 deaths occurred everyday due to road accidents in year 2019 in Malaysia [2]. A statistic shows that transport accidents is the forth principal cause of death in Malaysia for 2020. Besides, it is the principal cause of death for the Malaysia's population aged 0–40 years old [3].

From the medical point of view, the injured victims must receive treatments within an hour from the time of accident happens (the golden hour) to lower the risk of death [4]. However, some road accidents may not be known due to the road accidents occur at the rural areas or at night. In India, more deaths caused by road accident in rural areas is because ambulance cannot reach on time. Approximately 150,000 people die due to road accidents yearly in India and around 80% of them do not receive treatments within

the golden hour [5]. Apart from that, Albert and Baskara reported that the number of road accidents leading to death was more than minor and major injuries at 12 AM to 6 AM in Johor from the year 2011 to 2016 [6]. Hence, more valuable lives can be rescued if vehicles are equipped with a system that can detect the occurrence of road accidents and send an immediate rescue message to emergency response services when the road accidents happen.

In this project, the Smart Vehicle Surveillance System (SVSS) is proposed to detect the occurrence of a road accident and send the location of the accident through mobile data networks.

## 2 Literature Review

One of the solutions to assure the victims of the road accidents receive treatments within golden hours is monitor the road condition using traffic management system. Europe countries, United States, Japan and some developing countries in Eastern Asia used Intelligent Transport Systems (ITS) to monitor the traffic in real-time. ITS provides the services in responding to road accidents and other emergencies by dispatching ambulances, fire trucks, etc. [7]. However, implementation of ITS has deficiencies. Large number of traffic sensors has to be installed in every road. The cost of installation and maintenance of these sensors are high. Furthermore, the performance of traffic sensors is weather dependent [8]. The implementation of ITS also requires qualified personnel and technology [9].

In recent, smartphone is proposed to be used in detecting car crashes. Many mobile applications available in Apple's store claim they can detect car crash. For example, SOSmart, OpenRoad, CrashScan, etc. Meantime, Google's Pixel phones use motion sensors of the phone and capture sounds around the phone to speculate a road accident [10]. However, this technology has two major challenges: detect road accident using vehicle control unit; and prevent false detection [11].

The most common solution to detect road accidents is analyze data from the vehicle's sensors. For example, automatic crash notification (ACN) system, introduced by OnStar, detects the deployment of airbags, the changes in velocity and the vehicle's rollover using different sensors. The data from these sensors is analyzed to speculate a road accident [12]. Besides, some systems analyze video data and audio data from dashboard camera. Crash Catcher is the algorithm to train the system in identifying road accident through video clips that are captured using dashboard camera. To detect road accidents by analyzing audio data from dashboard camera, either audio features or audio spectrograms are extracted for analysis [13].

In this project, the proposed SVSS is a system that detects road accidents using vehicle's sensors. Signal from piezoelectric sensors is analyzed to speculate a possible road accident. If a road accident is detected, a notification message is sent to a predefined recipient through mobile data network.

## 3 Research Methodology

The electronic components that used to build SVSS include Arduino Mega 2560 micro-controller, SIM800L GSM/GPRS Module, GY-NEO6MV2 GPS Module, 16 × 2 liquid

crystal display (LCD), buzzer and piezoelectric sensors. Figure 1 shows the system architecture of SVSS.

As shown in Fig. 1, SVSS system is divided into two parts: system and mobile application. In the system part, Arduino Mega 2560 microcontroller receives and analyzes input signal from piezoelectric sensors. It also receives the car's location continuously from GPS module. Furthermore, it will send out notification message to the subscribers of the system through GSM/GPRS module if a hit on the car is identified. At the same

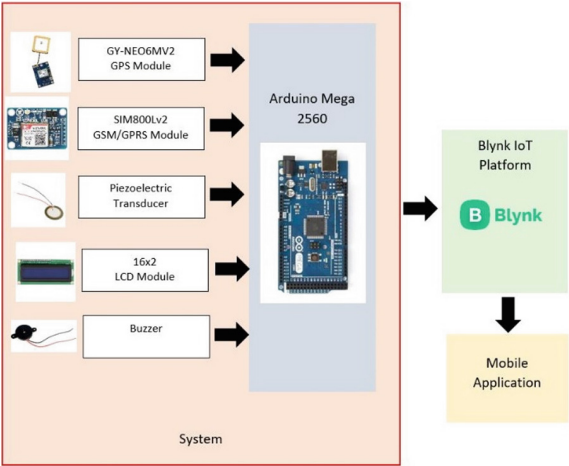


Fig. 1. The system architecture of SVSS.

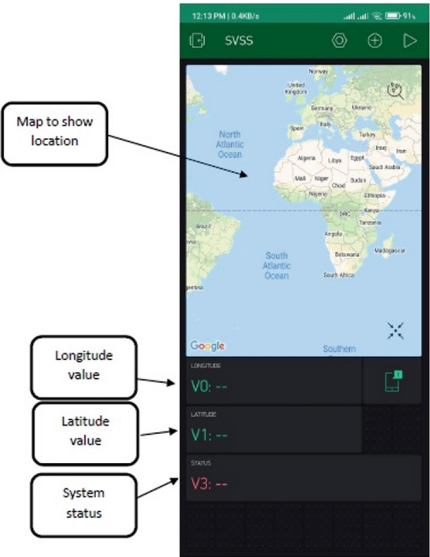
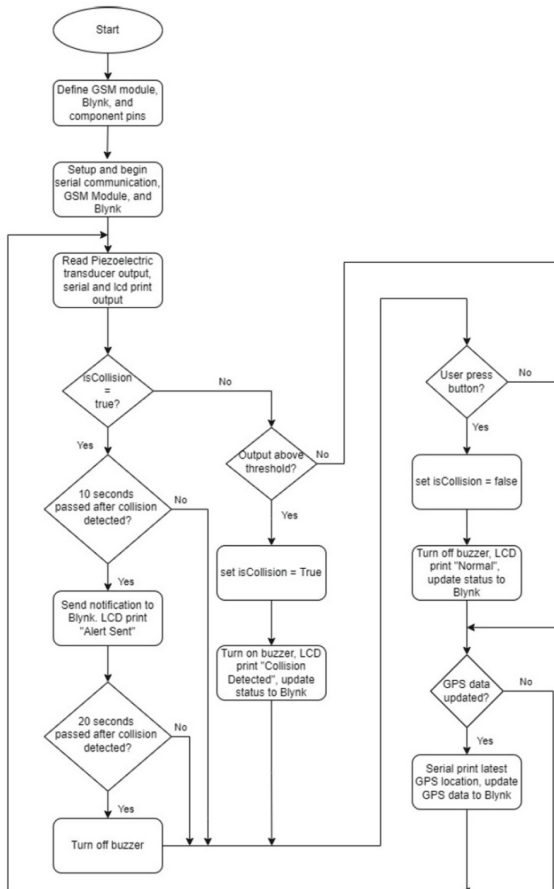


Fig. 2. Mobile user interface of Blynk IoT mobile application for SVSS.

time, the buzzer and LCD are triggered to notify the car's driver that the SVSS system has identified a hit. The subscribers of SVSS can track the car's location through Blynk Internet of Things (IoT) mobile application. Furthermore, they can check the status of the car through the mobile application. Figure 2 shows the mobile user interface of Blynk IoT mobile application for SVSS.

As shown in Fig. 3, the SVSS continuously update the car's location to Blynk IoT mobile application if no hit on the car is detected. When a hit on the car is detected, *isCollision* is set to TRUE if the signal from piezoelectric sensors is higher than a pre-defined threshold value. At this moment, the buzzer is turned on; "Collision Detected" is shown on LCD; and the status is updated to Blynk IoT mobile application. The car's driver has 10 s to press a button to notify the system that the hit is a false alarm. If there is no response from car's driver within 10 s, a notification message is shown in Blynk IoT mobile application that the car's driver needs help in this road accident. The car's



**Fig. 3.** The coding flowchart of SVSS in Arduino Mega 2560 microcontroller.

driver can turn off the buzzer and change the status to “Normal” when the driver presses the button.

## 4 Results and Discussions

In this project, the signals of a piezoelectric sensor are measured when a 0.1 kg object is dropped freely on it. Table 1 shows that a higher value of signal is generated when the object is dropped freely at a higher height. At higher height, an object has higher gravitational potential energy. According to the law of energy conversion, the gravitational potential energy is converted into kinetic energy when the object is dropped freely. Hence, higher gravitational potential energy means higher kinetic energy is generated. As a result, higher signal is generated by the piezoelectric sensor when the object is dropped at higher height due to higher kinetic energy. Piezoelectric sensor is also sensitive to vibrational kinetic energy from its surrounding environment. In this project, the mean value of signal for the vibrational kinetic energy from the surrounding environment is 32.6. Based on the observation, the pre-defined threshold value of SVSS is set to 150 to identify a hit on the car.

When SVSS is turned on, the GSM modem is initiated. The server of Blynk IoT mobile application is connected after the initiation of GSM modem succeed. The connection can be viewed from the serial monitor in Arduino integrated development environment (IDE) as shown in Fig. 4.

The signal from piezoelectric sensors is updated continuously in SVSS. Furthermore, the car’s location is updated continuously through GPS module. The data can be viewed from the serial monitor in Arduino IDE as shown in Fig. 5.

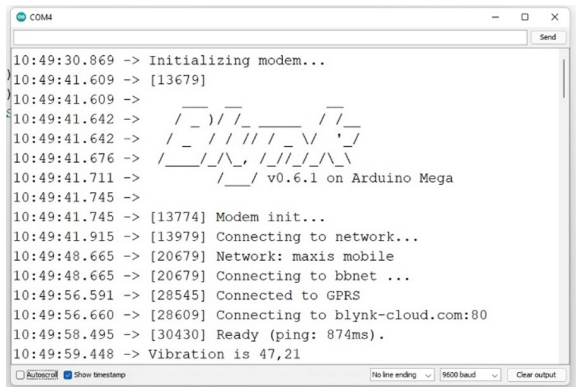
In this project, a prototype of SVSS is built. The installation of prototype on the dashboard in a car is demonstrated in Fig. 6.

When the signal from piezoelectric sensors is higher than a pre-defined threshold, SVSS identifies the signal as a hit on the car. As shown in Fig. 7, the message of “Collision Detect” is displayed on LCD to notify the car’s driver. Besides, “Collison, Waiting Response” is updated on the Blynk IoT mobile application to notify the subscribers of SVSS.

If the car’s driver does not press the button to confirm the hit is a false alarm, “Alert Sent” is displayed on LCD. At the same time, a notification message of “Collision Detected, Need Help” is updated on the Blynk IoT mobile application. The response of SVSS and Blynk IoT mobile application are shown in Fig. 8.

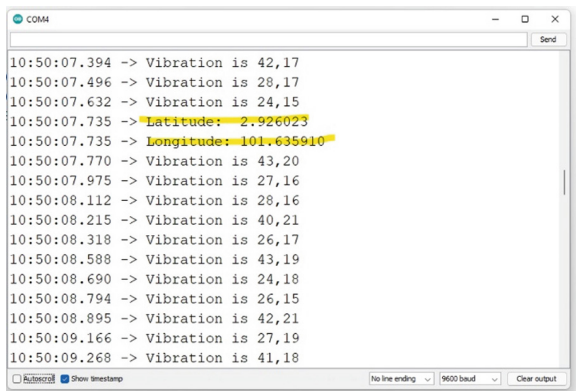
**Table 1.** Mean value of signal of a piezoelectric sensor when a 0.1 kg object is dropped freely at different heights

Height	Gravitational Potential Energy	Mean Value of Signal of Piezoelectric Sensor
0.1 m	0.098 J	72.4
0.2 m	0.196 J	155.0
0.3 m	0.294 J	258.0



```
10:49:30.869 -> Initializing modem...
10:49:41.609 -> [13679]
10:49:41.609 ->
10:49:41.642 -> / _ _ ) / / _ _ _ / / _ _
10:49:41.642 -> / _ _ / / / / / / _ _ \ / _ _
10:49:41.676 -> / _ _ / \ _ _ / / / _ _ \ \ _ _
10:49:41.711 -> / _ _ / v0.6.1 on Arduino Mega
10:49:41.745 ->
10:49:41.745 -> [13774] Modem init...
10:49:41.915 -> [13979] Connecting to network...
10:49:48.665 -> [20679] Network: maxis mobile
10:49:48.665 -> [20679] Connecting to bbnet ...
10:49:56.591 -> [28545] Connected to GPRS
10:49:56.660 -> [28609] Connecting to blynk-cloud.com:80
10:49:58.495 -> [30430] Ready (ping: 874ms).
10:49:59.448 -> Vibration is 47,21
```

**Fig. 4.** Output from the serial monitor in Arduino IDE when SVSS is connected to Blynk IoT mobile application.

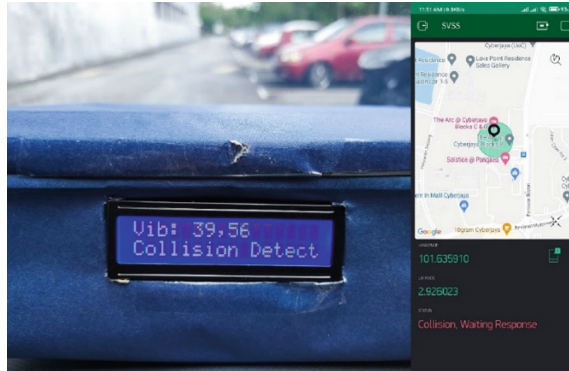


```
10:50:07.394 -> Vibration is 42,17
10:50:07.496 -> Vibration is 28,17
10:50:07.632 -> Vibration is 24,15
10:50:07.735 -> Latitude: 2.926023
10:50:07.735 -> Longitude: 101.635910
10:50:07.770 -> Vibration is 43,20
10:50:07.975 -> Vibration is 27,16
10:50:08.112 -> Vibration is 28,16
10:50:08.215 -> Vibration is 40,21
10:50:08.318 -> Vibration is 26,17
10:50:08.588 -> Vibration is 43,19
10:50:08.690 -> Vibration is 24,18
10:50:08.794 -> Vibration is 26,15
10:50:08.895 -> Vibration is 42,21
10:50:09.166 -> Vibration is 27,19
10:50:09.268 -> Vibration is 41,18
```

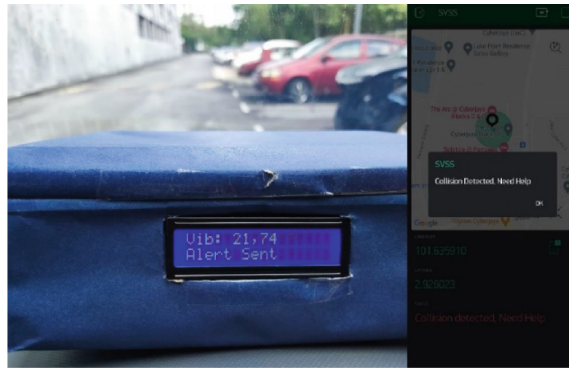
**Fig. 5.** Output from the serial monitor in Arduino IDE shows the signal from piezoelectric sensors and the car's location from GPS module (highlighted in yellow) are updated continuously.



**Fig. 6.** Installation of SVSS in a car.



**Fig. 7.** Response of SVSS and Blynk IoT mobile application once a hit on car is detected.



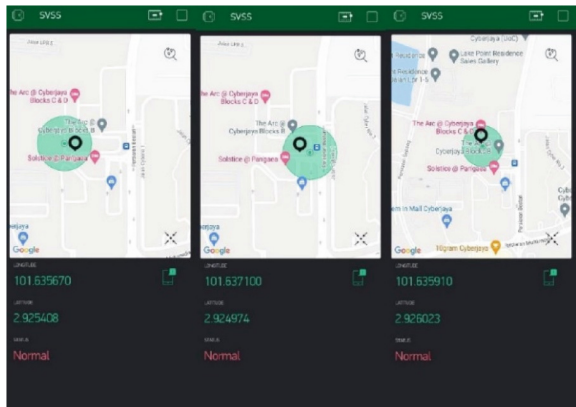
**Fig. 8.** Response of SVSS and Blynk IoT mobile application if no response from the car's driver for 10 s after the hit on car is detected.



**Fig. 9.** Response of SVSS and Blynk IoT mobile application after the car's driver presses the button.

Lastly, the status on SVSS and Blynk IoT mobile application are returned to "Normal" if the car's driver presses the button. The responses are shown in Fig. 9.





**Fig. 10.** Mobile user interface of Blynk IoT mobile application when car is moving.

If SVSS does not detect a hit on the car, SVSS can work as a location tracker. Figure 10 show the mobile user interface of Blynk IoT mobile application for a driving car moves in a parking area.

### 5 Conclusion

As a conclusion, a prototype of SVSS is built in this project to detect a road accident. In this system, piezoelectric sensors play the role as vehicle’s sensors. Arduino Mega 2560 microcontroller serves as the control unit to receive and analyze signal. GPS module tracks the car’s location, while GSM/GPRS module connects SVSS to mobile data network. Blynk IoT mobile application is the IoT platform for SVSS. This prototype is our initial idea on the detection of road accidents. We believe the concept can be improved by involving other vehicle’s sensors. Furthermore, industrial involvement is important to make the project more practical and implementable.

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**Authors’ Contributions.** Yew-Keong Sin, Chin-Hean Law and Ming-Yue Tan conceived and planned the experiments to build the SVSS. Yew-Keong Sin wrote the manuscript with support from Chin-Hean Law and Ming-Yue Tan. Chin-Hean Law and Ming-Yue Tan designed and performed the experiments, built and test the prototype and analyzed the data.

### References

1. Ministry of Transport Malaysia, “Malaysia Road Fatalities Index,” Ministry of Transport Malaysia Official Portal. [Online]. Available: <https://www.mot.gov.my/en/land/safety/malaysia-road-fatalities-index> [Accessed: 26-Apr-2022].



2. J. Ramachandran, "One death every 84 minutes in rising road accidents, say cops," *freemalaysiatoday.com*, 13-Jan-2022. [Online]. Available: <https://www.freemalaysiatoday.com/category/nation/2022/01/13/one-death-every-84-minutes-in-rising-road-accidents-say-cops/>. [Accessed: 27-Apr-2022].
3. M. U. Mahidin, "Statistics on causes of death, Malaysia, 2021.," Department of Statistics Malaysia Official Portal, 16-Nov-2021. [Online]. Available: [https://www.dosm.gov.my/v1/index.php?r=column%2FcthemByCat&cat=401&bul\\_id=R3VrRUhwSXZDN2k4SGN6akRhTStwQT09&menu\\_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09](https://www.dosm.gov.my/v1/index.php?r=column%2FcthemByCat&cat=401&bul_id=R3VrRUhwSXZDN2k4SGN6akRhTStwQT09&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09). [Accessed: 27-Apr-2022].
4. M. D. Pallavi Suyog Uttekar, "What is the golden hour in medicine?," *MedicineNet*, 26-Feb-2021. [Online]. Available: [https://www.medicinenet.com/what\\_is\\_the\\_golden\\_hour\\_in\\_medicine/article.htm#golden\\_hour\\_in\\_road\\_traffic\\_accidents](https://www.medicinenet.com/what_is_the_golden_hour_in_medicine/article.htm#golden_hour_in_road_traffic_accidents). [Accessed: 27-Apr-2022].
5. A. Sharma, P. Panchal, and S. Suman, "Smart traffic accident monitoring system," *International Journal of Recent Technology and Engineering (IJRTE)*, vol. 9, no. 1, pp. 823–828, May 2020. DOI: <https://doi.org/10.35940/ijrte.A1962.059120>
6. Albert and S. N. Baskara, "Accident severity analysis in Johor," *INTI Journal*, vol. 2020, no. 53, Dec. 2020.
7. T. Yokota, "ITS for Developing Countries," *World Bank*, 2004.
8. H. M. Ali and Z. S. Alwan, "Car accident detection and notification system using smartphone," *Journal of Computer Science and Mobile Computing*, vol. 4, no. 4, pp. 620–635, Apr. 2015.
9. W. Ackaah, "Exploring the use of advanced traffic information system to manage traffic congestion in developing countries," *Scientific African*, vol. 4, p. e00079, Jul. 2019. DOI: <https://doi.org/10.1016/j.sciaf.2019.e00079>
10. S. Brodsky, "Smartphones could save lives by monitoring car crashes," *Lifewire*, 04-Nov-2021. [Online]. Available: <https://www.lifewire.com/smartphones-could-save-lives-by-monitoring-car-crashes-5208490>. [Accessed: 29-Apr-2022].
11. C. Thompson, J. White, B. Dougherty, A. Albright, D. C. Schmidt, "Using smartphones to detect car accidents and provide situational awareness to emergency responders," in *Mobile Wireless Middleware, Operating Systems, and Applications: Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, vol. 48, Y. Cai, T. Magedanz, M. Li, J. Xia, C. Giannelli, Ed. Berlin, Heidelberg: Springer, 2010, pp. 29–42.
12. M. K. Verma, R. C. Lange, D. C. McGarry, "A Study of US crash statistics from automated crash notification data," 2007.
13. J. G. Choi, C. W. Kong, G. Kim, and S. Lim, "Car crash detection using ensemble deep learning and multimodal data from Dashboard Cameras," *Expert Systems with Applications*, vol. 183, p. 115400, Nov. 2021.

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