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VEHICLE LEAN ANGLE SENSING AND SOS SYSTEM

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Abstract: **Traffic accidents negatively affect the lives of human beings. Accidents may result in deaths, severe injuries, and loss of income to the impacted families. Accident detection and prevention is a keystone in improving road safety. In this paper, a system for detecting vehicle collision and rollover is presented. The proposed system includes three key phases. Data acquisition where accelerometer and gyroscope, integrated into MPU-6050 motion sensor are used to acquire 3-axis acceleration forces and rotation angles respectively. The complementary filter is used to enable the use of the gyroscope data on the short term because it is very precise and not susceptible to external forces. On the long term, the accelerometer data is used because it does not drift. An algorithm for acquiring data using sensors, filtering and analysing data, detecting collision and rollover is developed. Experiments are conducted to test the proposed system. Experiments show promising results.**

Keywords: - *Accident Detection; Vehicle collision; Vehicle rollover, Accelerometer, Gyroscope, SOS*

I INTRODUCTION

People around the world have become more dependent on transportation system. As a result of the growth of number of vehicles on roads, current transportation systems face several challenges such as traffic congestion, safety, mobility, and tremendous increase in traffic accidents especially in developing countries. Traffic accidents are one of the key causes of human death and injury in the world [1]. According to world health organization, Deaths from traffic injuries represent around 25% of deaths from all types of injury. Some of injured people during traffic accident live with permanent impairments. Average number of accidents in Egypt during 1990-2010 was 22733 accidents [2]. In Canada, 2013 statistics showed that the largest proportion of death cases and serious injuries was in vehicle drivers [3].Immediate detection of traffic accidents, identification of accident location, efficient notification of emergency services, and warning the following cars will contribute in (1) Minimizing number of fatalities and injuries, (2) Providing medical service fast, (3) Reducing number of vehicles involved in the accident, and (4) Avoiding potential accidents as a result of the initial accident. Moreover, every minute that passes without providing emergency medical care to traffic accident victims reduces their chances to survive. For example, the analysis showed that reducing the response time to accidents 1 minute increases the number of saved lives by 6% [1]. Automatic accident notification systems are based on using sensors embedded in vehicles to detect the occurrence of an accident. In fact, most vehicles except few luxury vehicles are not equipped with automatic accident detection and notification systems. A key obstacle of using the accident notification systems is the high cost of its installation in existing vehicles and the increase in the initial cost of new vehicles. This research aims at developing an effective and low cost system for accident prevention and detection as well as efficiently notifying emergency services and drivers to reduce number of fatalities, injured persons, and providing medical treatment fast. This could be achieved by reducing the time between the accident occurrence time and the dispatch time of the first responders, such as medical personnel, to the accident scene. This project particularly presents the overall proposed system including its key phases, hardware components, proposed algorithm, and how the proposed system works.

The paper also focuses on discussing how data are acquired using accelerometer and gyroscope sensors, how the acquired data are filtered using complementary filter, how the filtered data in terms of roll, pitch, and yaw angles are calculated and used to identify vehicle collision and rollover. The calculated results (e.g. roll angles) are compared with measurements of analog and digital inclinometers. The rest of the paper is structured as follows. Section II discusses related work. The proposed accident detection and prevention system is presented in Section III. In section IV, experimentation, system validation, and result discussion are presented. Finally, section V summarizes conclusions and future work.

II RELATED WORK

There are several research efforts related to accident detection and prevention and developing emergency notification systems. In [4], the sensor technologies and placement of sensors for accident detections with a focus on the rollover crash detection was reviewed. The paper also discussed sensor selection for particular crash detection based on sensors performance. The research presented in [5] aims at developing an engineering tool for evaluating technical and functional specifications of a forward looking automotive radar sensor and threat assessment algorithms for forward collision warning system. In [6], the implementation of a system which can automatically report vehicle crash to the emergency services was 2016 IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) 978-1-4673-8721-7/16/$31.00 ©2016 IEEE studied. The proposed system used fisheye lens camera which produces more detailed view inside the vehicle, Sensors, and Quad-Band GSM/GPRS SIM908-C module.

The objective of[7] was designing and developing an economical general purpose wireless emergency event notification system for vehicles that might roll over. The proposed system used wireless channels to send necessary information to emergency services. It did not discuss the detection of vehicle rollover. Another work [8] has discussed the use of magneto-resistive and sonar sensors for detecting imminent collision in cars. Basically, the magneto resistive sensors are used to measure the magnetic field from another vehicle in close proximity, to estimate relative position, velocity, and orientation of the vehicle from the measurements. The focus of [8] was on predicting vehicle crash not detecting it. The paper [9] described solutions to key challenges associated with using smart-phones to detect traffic accidents. It also presented the architecture of a Smartphone-based accident detection system prototype and discussed how Smartphone based accident detection system can reduce overall traffic congestion and increase the preparedness of emergency responders. In [9], the ability of the proposed system to resist false positives and its capabilities for accident reconstruction were empirically analyzed.

In [11], a microcontroller based system with 3-axis accelerometer sensor and discarded cell phone model to warn drivers for abnormal conditions or unsafe driving, capturing images of occurred accidents, and sending multimedia and text messages to predetermined users was presented. In [12], a real Time traffic accident detection system (RTTADS) using wireless sensor network (WSN) and radio frequency identification (RFID) technologies was presented. It also explained the hardware prototype setup for the proposed system and the used algorithms. It is based on installing sensors in a vehicle to detect the accident location, the vehicle's speed just before the accident and the number of passengers in the vehicle. In [13], a vision-based real time traffic accident detection method is proposed. In this method, foreground and background from video shots using the Gaussian Mixture Model (GMM) are extracted to detect vehicles. The detected vehicles are tracked based on the mean shift algorithm. Then the three traffic accident parameters including the changes of the vehicle's position, acceleration, and the direction of the moving vehicles are gathered to make the final accident decision. In [14], accelerometer was used to detect dangerous driving, crash, or rollover. Another paper [1] describes how smartphones, such as the iPhone and Google Android platforms can be used to detect traffic accidents using accelerometers and acoustic data, immediately notify a central emergency dispatch server after an accident, and provide situational awareness through photographs, GPS coordinates, VOIP communication channels, and accident data recording. However, the proposed method may not able to detect all accidents such as vehicle rollover.

III PROPOSED SYSTEM

The key phases and hardware view of the proposed system are shown in Figures 1 and 2 respectively. The main idea is acquiring data from accelerometer and gyroscope sensors. Accelerometer is used to measure 3-axis acceleration forces. Vehicle crash will impact acceleration forces measured by accelerometer. The direction of the vehicle collision determines which acceleration force (i.e. X-axis, Y-axis, or Z-axis) is impacted. Large variation in acceleration forces particularly Xaxis and Y-axis within a very short time period means a possible vehicle collision.

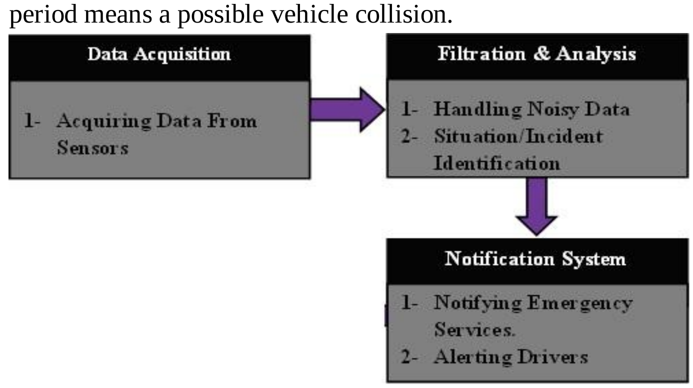

Figure 1: - Proposed System: Key Phase

However, gyroscope is used to measure 3-axis rotation angles:

(1) X-axis rotation angle called roll angle,
(2) Y-axis rotation angle called pitch angle, and
(3) Z-axis rotation angle called yaw angle.

Vehicle rollover can be identified by analyzing roll angles. The following subsections discuss the system phases with the focus on data acquisition, filtration, and analysis.

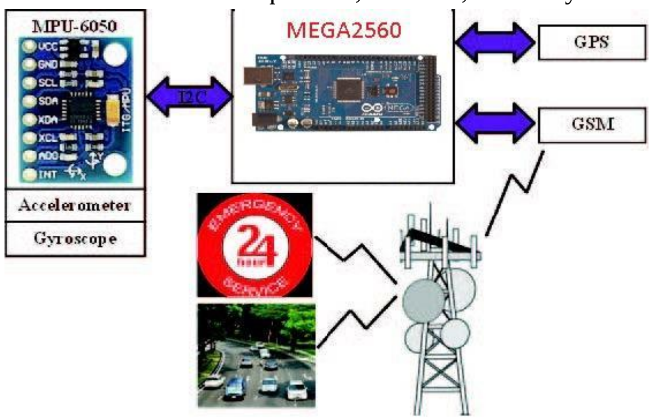

Figure 2: -. Proposed System: Hardware View

Data Acquisition

In this phase, a low cost MPU-6050 motion sensor and a low cost Atmega2560 microcontroller are used to acquire and process data. MPU-6050 combines Micro electro mechanical Systems (MEMS) accelerometer, gyroscope, and a digital motion processor. 3-axis acceleration forces data are acquired using the accelerometer. However, 3-axis rotation angles data are collected using the gyroscope. Moreover, Atmega2560 microcontroller applies the proposed algorithm to process the acquired data to determine the current incident (e.g. Vehicle collision or rollover). MPU-6050 and Atmega2560 are communicated using Inter-Integrated Circuit (I2C) communication protocol. Data acquisition includes three keys steps shown in Figure 3 and Figure 4 shows the designed hardware. Figure 5 shows the algorithm used in the proposed system.

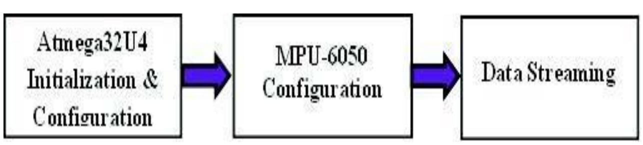

Figure 3: - Data Acquisition Steps

IV EXPERIMENTS

Identifying whether the incident is a vehicle collision or rollover depends on the validity of roll, pitch, and yaw angles calculations. A number of experiments have been conducted to test the designed hardware system and proposed algorithm.These experiment had the following objective: Confirming the validity of calculating roll, pitch, and yaw angles using the designed system.

V RESULTS AND DISCUSSION

In experiment, the angles, calculated by the proposed algorithm, are visualized using MATLAB. They System detects lean angle and sends SOS with GPS latitute and Longitude if a vehicle fall is detected. The systems waits for 20s after detecting a fall before sending a SOS so that the rider can deactivate the system is he has regained control of the vehicle. A Google maps link of the current location is send to assigned phone or Emergency Service as Shown in Fig No. 5. Thus with the help of this link we were able to locate the riders location. Fig No. 4 shows the MATLAB Visualization of the system through which we carried out our experiment. Following are the Screenshot of results shown in Fig No. 4 & 5.

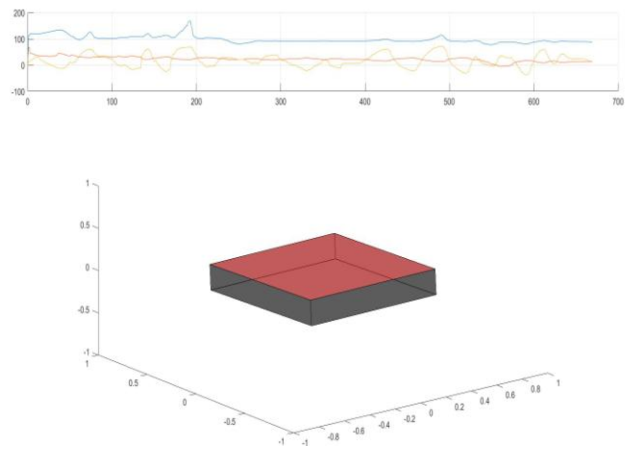

Figure 4: - MATLAB Visualization of MPU6050 data

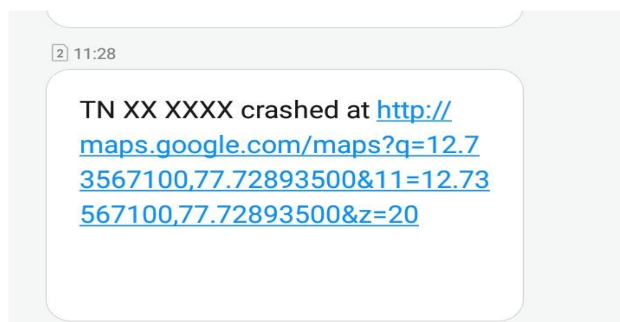

Figure 5: -SOS from Device

VI CONCLUSIONS

In this project, we proposed a system for detecting vehicle collision and rollover. Detecting vehicle rollover and collision and immediate notification of emergency services will facilitate fast assistance to injured occupants. The proposed system consists of three phases:

(1) Data Acquisition,

(2) Data Filtration and analysis,

(3) Notification.

A hardware system and algorithm have been designed to implement the intended functionality of the proposed system. Experimentation with the proposed system shows promising results.

VII FUTURE WORK

1- Expanding the functionality of the proposed system to avoid the occurrence of an accident and detect dangerous driving.

2- Modeling and simulating vehicle collision and rollover incidents and using the developed model to test and assess the performance of the proposed system.

3- Testing and evaluating the performance of the proposed system in a realistic environment.

4- Developing a mobile-based notification system that is able to report an occurrence of traffic incident to emergency services and warn drivers in case of careless driving.

5- Designing the historical database with the ability to record traffic incident information and post-incident assistance. Moreover, investigating how vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication can be used to expand and facilitate the communication between vehicles in the accident scene and emergency services.

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