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Design and Development of Flash Rescue: Emergency Rescue System for the Road Accidents

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***Abstract*—The vehicles have become an absolute necessity in our daily life and with the rapid growth in population, the number of vehicles on the road has also increased. This in turn increases the number of road accidents causing a high loss of lives. One of the main reasons for more than half of the deaths due to accidents is the delay in receiving medical assistance on time. If immediate medical assistance is provided to the accident victims, then their chances of survival may increase. Nowadays, manufacturing companies are designing many accident prevention systems aiming to the reduction of the accidents or lessening its impact. But they still lack the facility of communicating with the emergency services if the vehicle is met with an accident. This paper proposes FlashRescue, a system that addresses these issues by equipping the vehicle with the technology of automatic accident detection and immediate notification to the emergency care services. It is developed using a camera, a GPS receiver, MPU 6050 accelerometer-gyroscope module all integrated with the Raspberry Pi. The system detects the accident using the sensors like accelerometer and gyroscope, finds total number of passengers, gets the location of the accident spot and informs the hospital and police station available nearest to the site of the accident using Google APIs and Twilio APIs. A testbed implementation and experimentation of FlasRescue shows that the system works without human intervention, is user friendly, compact and cost-efficient.**

***Index Terms*— Road accident, GPS, Automatic detection, MPU 6050, Raspberry Pi Camera.**

I. INTRODUCTION

While India's population growth has declined significantly over the last few years due to growing urbanization and rising education levels, it's still growing faster and is expected to be the most populous country in the world. With a growing population grows the need for the vehicles. The number of vehicles on road is increasing day by day. Consequently this results into increased congestion on the roads and road accidents. The road accidents cost India 3-5% of gross domestic product every year and are avoidable if some necessary precautionary measures are not taken [1]. India's young, productive population, aged between 18-45 years, is involved in 70% of the road accidents, according to data from a report published by the Ministry of Road Transport and Highways [1]. This is such a big loss to the country every year. Not only India but the whole world suffers from this problem. In one of the report of the World Health Organization (WHO), it is

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stated that around 1.25 million people die in a year because of road accidents, and millions more are injured [2]. In this respect, many devices and new methods to enhance road safety are being developed like roads and city planning, establishing communication between cars, improving car features like air bags and Anti-lock braking system (ABS)[3] that are more supportive of prevention of accidents, training its drivers better, enforcing traffic laws properly, monitoring through a camera, etc. Similar work is done in this paper to detect the accident and inform the medic services autonomously.

The rest of the paper is organized as follows. Section II discusses the previous work done. The details of design of FlashRescue system in terms of hardware and software is discussed in Section III and IV. This is followed by System implementation and the related results in Section V and VI respectively. Finally, the paper is concluded in Section VII.

II. Literature Review

Aloul et. al. [4] proposed a smartphone application based system that uses built-in accelerometer of mobile phone to continuously track and detect if there is any accident. After detecting the accident, it identifies the location of accident using built-in GPS of the mobile itself. After this, the system sends an SMS to emergency services and to the emergency contact fed in the system from before. This notifies them about accident occurrence, user's information and location of accident. Ahmed, Nazir, et. al. [5] proposed a system that takes values of acceleration, gyroscope and SIM808 which is processed by Arduino board to detect an accident. A buzzer is also made on upon detection. GPS traces the location of accident based on the decision and an SMS is sent to authorize number from the number which is already inserted in the system using GSM in SIM808 module. LCD Display is also there to depict each action taking place. Ki Ki, Yong-Kul, and Dong-Young Lee [6] designed a system that automatically detects and records accidents at the intersection of roads and reports them to authorities. It does this by cameras which are placed at the intersection of roads for surveillance. From videos these cameras first extract vehicles and among them continuously collects information of running vehicles on road like its speed, area, acceleration and direction. Based on above mentioned information the model then decides the occurrence of accident. But on the basis of only considering these parameters can give wrong triggering of accident. Also, this system only works at the intersections. Ali and Eid [7] propose a smartphone application based system for detection of accident. In this there is a programmed and built in decision support based on Mamdani Fuzzy Logic that helps in detecting accident by analyzing the data coming from sensors. It then informs an emergency contact, police or ambulance whose data is already there saved in the system. It also stores these processed data which is implemented as MySQL database for future use. It then informs an emergency contact, police or ambulance using already stored data. All the above-mentioned proposals do not provide multiple functionality needs of the system such as detection of accidents, identifying location of the accident, notifying the nearest possible emergency care services and creating a database consisting of related information to these accidents. To this end, this paper introduces the design of FlashRescue system that encompasses all of the above requirements of the system.

III. Hardware Design /details

The Fig. 1 shows the circuit diagram designed for the FlashRescue which is made using 'circuito.io' [8]. Fig. 2 depicts the overall block diagram of FlashRescue system. The Table I shows the list of components along with the power requirements. From this we can say that power required for operating the FlashRescue system can be operated using power generated by vehicle. The components used are discussed below.

A. MPU 6050

MPU-6050[9] is a 6-axis Motion Tracking device manufactured using a 3-axis accelerometer and 3 axis-gyroscope. It also comprises a temperature sensor embedded in the module. It is a micro-electrochemical system (MEMS) device which communicates with raspberry-pi using the I2C bus. It can communicate with other sensors like magnetometer, pressure sensor, etc. using its auxiliary I2C bus and can do processing on built-in Data Motion Processor. The gyroscope and accelerometer together are used for detecting the accident [9].

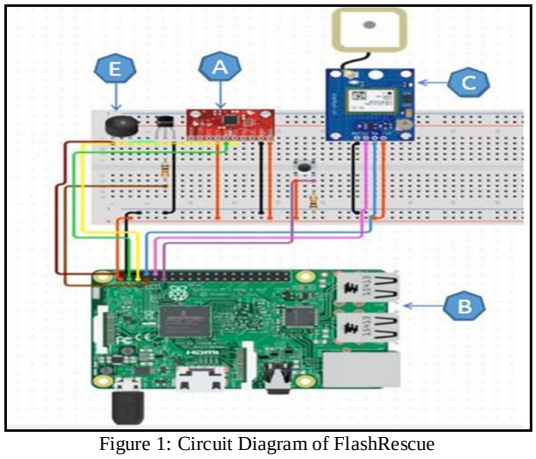

Figure 1: Circuit Diagram of FlashRescue

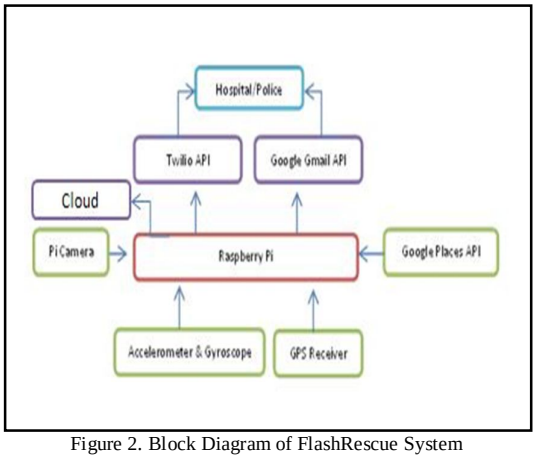

Figure 2. Block Diagram of FlashRescue System

B. Raspberry Pi

Raspberry Pi (RPi) 3 Model B [10], a single board computer is configured to be used as a processing unit for the whole system .Being a full-fledged computer in itself, it has faster and stronger processing capability, ability to multitask, Ethernet and internet connectivity. It runs on Broadcom BCM2837 SoC along with the ARM Cortex-A53 processor [11]. It comprises of 1GB of RAM. Its connectivity features comprise of 10/100 MB/s Ethernet port, 4 USB 2.0 connector, SD card slot, 3.5 mm audio, 15-pin MIPI camera interface connector, HDMI, 40 GPIO pins. For wireless connectivity, it is provided with Wi-Fi and Bluetooth facilities [10].

C. RPi camera module:

The RPi Camera Module is an official product from the Raspberry Pi Foundation. It can capture still photos and record videos in full HD (1080p) [11] and available in visible light and infrared versions. The picamera package consists of several modules that provide a pure Python interface to the RPi's camera module. It is used for capturing the inside view of the car after the accident to get the number of people inside car.

D. Neo-6M GPS module

The NEO-6M GPS module [12] is a complete GPS receiver with a built-in ceramic antenna. It provides a strong satellite search capability. It contains two indicators that show power and signal availability. It also has a special feature of data backup battery which can save data in case the main power supply shuts down [13].

TABLE I. OPERATING VOLTAGE AND CURRENT DETAILS OF THE HARDWARE

Sr. No	Component	Operating Voltage	Operating Current
A	MPU 6050	2.38 V – 3.46 V	Gyroscope: 3.6mA Accelerometer: 500µA
B	Raspberry Pi B	5.1 V	500mA
C	Rpi Camera	Not Available	Not Available
D	Neo-6M GPS	2.7V- 3.6 V	45mA
E	Buzzer	12 V- 220 V	20mA

IV. SOFTWARE DESIGN

A. Google APIs

Google developed Google Application Programming Interfaces (APIs)[14] is a complete set of different APIs. These APIs enable the communication of services designed for any specific purpose by any developer or organization with the Google services. These APIs comprises of almost all the services provided by Google, like Gmail, Search, Translate, Map, Drive, and cloud service. Herein this system, specifically Google Places API [15] and Gmail API [16] are used. The Places API is used for extracting information about places marked on Google maps using HTTP requests. Additionally it provides information like

address, contact information, website, or reviews of the place provided by visitors. The Gmail API is used for automated sending of mail with gathered details of the accident and the picture captured by the camera.

B. Twilio API

Twilio is a cloud communication platform referred to as *communications platform as a service,* or CpaaS. It focuses on providing software developers to programmatically do messaging, voice calls and video calls in web and mobile applications [17]. In FlashRescue system the messaging service of Twilio API is used. It uses Twilio messaging service to send text alert messages to the hospital and other emergency cares. The user needs to take a token key available uniquely to individual users.

C. Face Detection using HAAR cascade classifiers algorithm

Face detection is done using the Haar Cascade classifier, an efficient object detection approach in machine learning [18].In this approach positive images (that contains desired objects) and negative images (devoid of object) are used to train a cascade function classifier. The features called haar features like edge features, line features; four-rectangle features that are similar to convolutional kernel are required to be extracted from it. A single valued feature is obtained by summing up the pixel intensities at each black and white regions of it and then subtracting the sum of white from black. A method of integral images has been introduced to make these calculations and process fast. It is required to have a large number of features to identify an object with required accuracy as a single haar feature is quite a weak classifier. But a large number of features aren't all applied on a window at one go, these are categorized into numerous stages of classifiers (i.e. cascade of classifiers) and applied one-by-one. Each stage is a collection of simple classifiers that are weak- learners and is trained by boosting technique Adaboost which takes the weighted average of weak learners and builds a highly accurate intermediate classifier. OpenCV [19] provides a training method (Cascade Classifier Training) or pre-trained models, that can be read using the cv :: CascadeClassifier::load method. The pre-trained models are located in the data folder in the OpenCV installation.

D. Google Firebase Realtime Database

Firebase is a special platform developed for mobile and web application by Firebase.Inc in 2011 which was later acquired by Google [20].It is a mix of Google's many services in the cloud, like instant messaging, real-time database, user authentication, storage, hosting, etc. Firebase real-time database stores all the data in it with JSON format. If any change is made on any of the connected platform, then at that instant only data is changed for all the other platforms.

V. WORKING OF THE SYSTEM

Based on activities, FlashRescue performance is divided into different sections. These sections are i) detection of the accident through sensors gyroscope and accelerometer, ii)collection and processing of relevant data using the on-board module, iii) the transmission of the emergency message to the relevant authorities to take care of it and the last iv) cloud platform that stores the gathered data at time of accident.

A. Detection of the Accident

In road accidents, there is a possibility of either a head-on collision with another vehicle or with a roadside entity or it may be a roll-over of the vehicle after any collision. In both cases, the accident has to be detected. As soon as a vehicle collides, its speed reduces drastically. This sudden decrement in speed can be measured by acceleration of the vehicle using a mounted accelerometer sensor as a part of MPU 6050 module. Similarly, the roll-over of the vehicle can be detected using the gyroscope sensor which is also a part MPU 6050 module. In these readings of angular position or angular velocity of the vehicle provides the information of a roll-over taking place resulting into accident [21]. The module MPU 6050 is initialized as soon as the vehicle starts and keeps on updating the data at a regular interval of time units. Until there is no accident detected, sensor data is not logged. For the detection, some threshold values are needed to be defined. Crossing this threshold values indicates the possibility of the accident [22]. For FlashRescue the threshold values are set as tilt of 45^{o} or collision with more than 4G of force.

B. Processing of Collected Data

As soon as the accident is detected by the on-board MPU-6050 sensor module, the processing unit gets activated and starts acquiring the relevant data and process it to generate the rescue message. First of all, the Rpi camera mounted on the dashboard gets activated and after few seconds it captures a scene picture of the

inside view of vehicle. The captured image is then processed on the RPi to find the no of persons inside the car and this number is also sent in the message so that the first responder can send the medical assistance according to the number of people involved. To determine the number of people inside the car during accident, the face detection algorithm - Haar cascade classifier is used here. Along with the camera module GPS module NEO 6M also gets activated to get the location (latitude & longitude) of the accident spot and is saved for further processing. As soon as the location of the accident is received another process that is of searching of the possible nearest rescue unit starts. After that, using the data of latitude and longitude provided by GPS, the FlashRescue system starts searching for the nearest hospital, police station and fire brigade. For this purpose, Google places API is called upon. Google Places API connects to google servers using Wi-Fi of a smartphone which gets connected to the FlashRescue system as soon as it starts. After getting the list of nearest located emergency services, it collects the contact details like mobile number and email id of these services.

C. Transmission of Emergency Message

After all the data like location of accident in form of latitude and longitude, number of person involved, time of accident, and details of the nearest emergency care to spot is processed and collected, then a message is to be generated to inform the emergency services about these accident details. The message consists of all the above mentioned data which is processed while accident and the data already pre-cached from before that is related to the vehicle and owner which can be accessed during accident. Hence a message generated will have location of the accident i.e., latitude and longitude, vehicle number, owner name, owner number, another emergency number related to owner, all possible blood groups of people that could have been involved in the accident. For the transmission of the message, Twilio API is used which can send a message or call to the respective authorities for e.g. hospital. The contact details consisting of phone numbers, mailing address of the nearest emergency care where the accident has to be reported is collected using Google Places API. Also the same message is sent to same emergency care through Gmail API which along with that data, attaches the captured image of inside view of car taken while accident. Additionally another similar message is generated and sent through the Twilio API to the person whose contact number is already saved as an emergency contact number in the module. That contact receives the alert message of the accident, owner name, and location of the accident, name and contact information of the hospital /emergency care which has been informed about the accident in the message. Sometimes it may be possible that there is some false detection of accident that cause the system to initiate the process of the rescue while there is no accident occurrence in real so to avoid such a situation, at last confirmation is kept in user control. An alert is given to the user after the accident detection which raises alarm for 15 seconds. If in 15 seconds the user presses the switch confirming no occurrence of the accident, then the total system gets reset and further steps are prevented from execution. If not interrupted by the user, the system goes with the programmed process and transmits the alert message to the above-mentioned authorities.

D. Cloud Platform

After all this, the last part of the job that the FlashRescue system has to perform is to store all the relevant data collected during accident from the sensors along with number of injured people, accident time, date of the accident, accident location, Hospital information, vehicle registration number, vehicle model, owner number, owner name, etc. These are stored on Firebase real time database. The data gets uploaded on the cloud simultaneously after FlashRescue module completes its processing after accident detection. All these information stored on the cloud can be further used in the future for study which may help authorities in visualizing and analysing data of road accidents to determine various parameters like most accident-prone area and their prominent reasons. This may help in reducing the number of accidents in the coming future.

VI. RESULTS

Fig. 3 shows the experimental prototype prepared for the system where the sensor module GPS, MPU-6050 and RPi camera are placed in it. The threshold for the topple is set at an angle of 45^{o} and for collision detection, 4G force is considered as a threshold limit above which, the accident gets detected as shown in Fig. 4. The camera module as seen in the figure is initialized as soon as any of the above thresholds are crossed, and it click picture thereafter as shown in Fig 4.

Figure 3. Testbed Setup of FlashRescue

From the captured picture as shown in Fig. 4, number of the passengers sitting in the car is detected. Simultaneously, the GPS receiver gets the location of the accident and passes it to Google places API which generates the list of hospital in the vicinity of the accident. Fig 5 shows the list of the hospitals generated along with their contact and address using Places API.

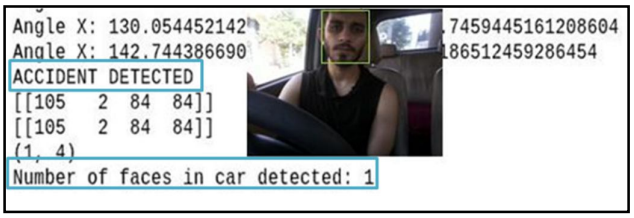

Figure 4. Result of Face Detection

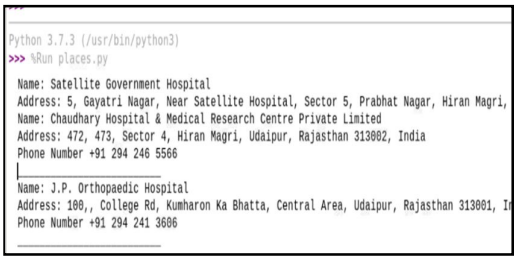

Figure 5. Result of Hospital Search

After that, the generated message containing location, name of owner, vehicle number, number of people, and name of hospital is received as text message on mobile as shown in Fig. 6 and subsequently Fig. 7 shows received Email by the emergency care.

Figure 6. Received Text Message

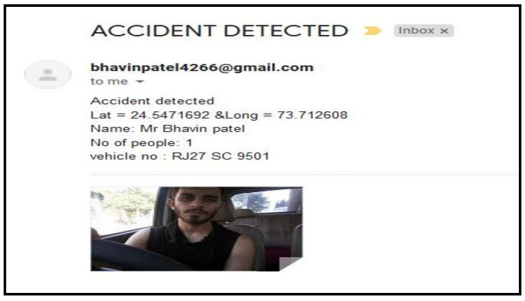

Figure 7. Received Email

Along with this, all the data which is being simultaneously sent to Firebase database is depicted in Fig. 8 can be used in future for finding accident prone areas. Finally Table II gives timing analysis for the testbed system. Change in the angle measured by MPU 6050 is continuously monitored and visualized as shown in Fig. 9. The Table II shows the total time taken by each stage to complete its process. The face detection takes maximum 20 sec to detect the number of people, simultaneously Places API gives list of hospital in about 15 seconds. Then within 15 seconds message and mail is sent to the nearest searched hospital. In total, it takes only a minute to complete the whole process.

Figure 8. Firebase database for accident data storage

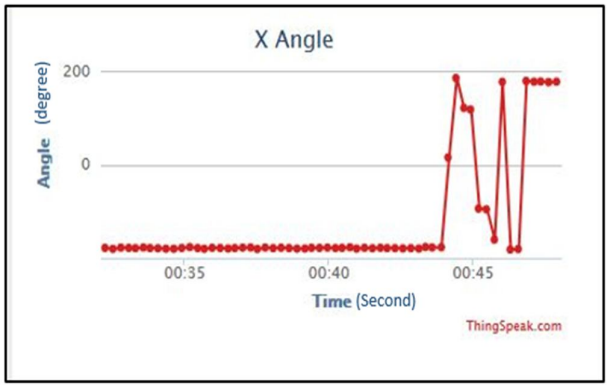

Figure 9. Visualization of MPU 6050 gyroscope data- change in angle(in degree) with respect to time.

TABLE II. TIMING ANALYSIS OF FLASHRESCUE

Sr. No	Parameter	Time requirement
1	Accident Detection	< 1sec
2	Location fetching	< 1 sec
2	Face detection	10 to 20 sec
3	Nearest Hospital search result	10 to 15 sec
4	Twilio message	<10 sec
5	Gmail mail transmission	<15 sec

VII. CONCLUSIONS

The design of a fully automated emergency rescue system for the road accident is proposed in this paper. It was tested and was able to complete the whole process within 1 minute. FlashRescue is compact and can be easily installed in two wheelers and four wheelers. It has the ability of automatically detecting the accident, locating the spot of the accident, finding number of passengers inside using the camera, searching the nearest hospital and police station available and informing them about the accident using SMS and email service. The data regarding accidents on cloud database stored area wise for a city can help government authorities to take necessary actions of planning accordingly as per location. This may help analyse and improve both risks of accident and quality of services. The system can be further made fail-safe and reliable in accident detection by interfacing sound sensor, fire sensor, pulse sensor, glass break sensor etc. that further increases the logic and checking involved in accident detection.

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