A COMPREHENSIVE SOLUTION TO ROAD TRAFFIC ACCIDENT DETECTION AND AMBULANCE MANAGEMENT

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ABSTRACT

Delay in providing Emergency Medical Services (EMS) is the cause of the high mortality rate in road traffic accidents in countries like India. There is delay involved in each and every stage of the process, right from reporting an accident to dispatching an ambulance, till the patient is safely handed over to the casualty. Minimizing this delay can help save lives. We propose a comprehensive solution to both accident detection and ambulance management. When the in–vehicle accident detection module reports an accident, the main server automatically dispatches the nearest ambulance to the accident spot. The android application used by the ambulance driver assists the driver to reach the location quickly and safely. Automation of accident detection and ambulance dispatch, along with providing guidance to the ambulance driver, is achieved here. This can save precious time and help standardize the whole process.

Index Terms**—** golden hour, EMS, accident detection, ambulance management

I. INTRODUCTION

Road traffic accidents account for more than 1.25 million deaths worldwide every year and more than two hundred thousand deaths in India alone in 2013, as reported by the World Health Organization[1]. The number has constantly been on the rise since 2007 in India. The primary reason for this is the inefficiency of prevailing Emergency Medical Services (EMS)[2]. If prompt medical care is not provided within one hour following a traumatic accident– the golden hour, death is most likely. This is exactly the case in some Indian states due to the poor condition of the state funded EMS systems[2].

The time interval between the occurrence of an accident and the arrival of an ambulance is critical in reducing the mortality rate. The victims of the accident may be in an unconscious state, and cannot be expected to place a call to the emergency services control room, when an accident happens. Hence, an in-vehicle accident detection module can be used[3]. Further, in a country like India, where the witnesses are expected to inform the emergency services control room when an accident occurs, a lot of delay can happen[4]. In India, it takes 30 seconds on an average for the Communications Officer to collect relevant information, and three minutes for the Dispatchment Officer to dispatch an ambulance to the location. Further, the ambulance driver needs to identify the accident location based on cues provided by the officer and sail through the heavy traffic. It takes another 48 hours after the accident to conduct a follow-up to check the impact of the care. A lot of delay arises in each and every stage due to the human element involved. In this paper, we propose a system that can intelligently detect accidents, and dispatch and guide the nearest ambulance to the accident location with minimal delay involved. Before moving into the details of the proposed method we briefly review the related literature.

I-A. Related work

Amin et al.[4] use GPS for measuring the speed of the vehicle every one second, and compare the acceleration to see if some external decelerating force has acted to cause an accident. But the GPS used is not reliable as dense foliage, caves, harsh weather, polluted air and "urban canyons" like high rise concrete buildings can sometimes cause system interference issues and can risk an accident going undetected in a long drive. GSM is used to alert the service center.

Works done by Kamijo et al.[5], and Yong-Kul Ki and Dong-Young Lee[6] suggest a vision based traffic accident detection system at intersections. This would be beneficial in determining the safety of intersections, but it is practically impossible to establish the system at each and every intersection. The system also neglects the accidents that happen on straight roads or off-roads. Acoustic detection of accidents, as done by Whitney et al.[7], does not guarantee accident detection due to variability in background noise and false alarms.

Zaldivar et al.[8] and Jules White et al[3] use costly smart phones for accident detection and for relaying the accident coordinates and hence, lacks a dedicated system for the same. The false alarm filter employed by Thompson et al.[9] in smart phone may not detect all accidents. Also, the smart phone sensors may have insufficient sampling rates. Wei and Hanbo[10] propose a dedicated module for accident detection but send accident coordinates through

GSM. Forgue et al.[11] speak of a better solution to accident detection, measuring the severity of accidents by considering both the magnitude and duration of the acceleration pulses using an on-board unit. But, the real–time integration of the acceleration function poses a computational over–head to the processor.

Several dynamic ambulance relocation models have been suggested[12][13][14] but there exists no comprehensive solution that addresses both road traffic accident detection and ambulance management to the fullest.

I-B. This paper

In this paper, we address the problem of delay minimization, right from the detection of an accident till the victim is safely handed over to the casualty. The dedicated in–vehicle accident detection module automatically informs the server whenever an accident happens, as is discussed in section 2. The design of the main server, which tracks the ambulances and dispatches the nearest ambulance to the accident spot, is discussed in section 3. The android application, which guides the ambulance driver to the accident location, is discussed in section 4.

II. ACCIDENT DETECTION MODULE

The in–vehicle accident detection module comprises of the following components:

II-A. GPS receiver

SkyNav SKM53 series from Skylab M&C Co., a very high sensitivity GPS module with a tracking sensitivity of -165dBm is used. It has 22 tracking/aquisition–channel receiver which enables it to get a faster initial fix even in harsh GPS visibility environments like dense foliage and urban canyons. The acquisition time for cold start is <36s and for hot start, it is <1s. The output is provided in NMEA standards.

II-B. Accelerometer

MMA7260QT, a low cost triple–axis accelerometer from Freescale Semiconductor with a high sensitivity of 800mV/g is used to track the acceleration. It has a low operation current of 500μA and 1ms fast power supply. It has four selectable sensitivities from 1.5g/2g/4g/6g and is capable of keeping track of acceleration in all three directions. Output is obtained in I2C format every 0.01s. The accelerometer is directly mounted to the chassis of the vehicle so that it also experiences the same forces as that of the vehicle.

II-C. Raspberry Pi B+

A Raspberry Pi B+ with 512 MB of RAM keeps track of the accelerometer readings. If the reading goes above a preset threshold, the GPS coordinates are acquired over USB. An alarm is then sounded over a speaker. The user may switch it off in case of false alarms. If the user does not respond in 15s, he/she is assumed to be in an unconscious state and the accident is validated. The coordinates of the location are then sent to the main server as an HTTP POST request through the network connector connected to Pi.

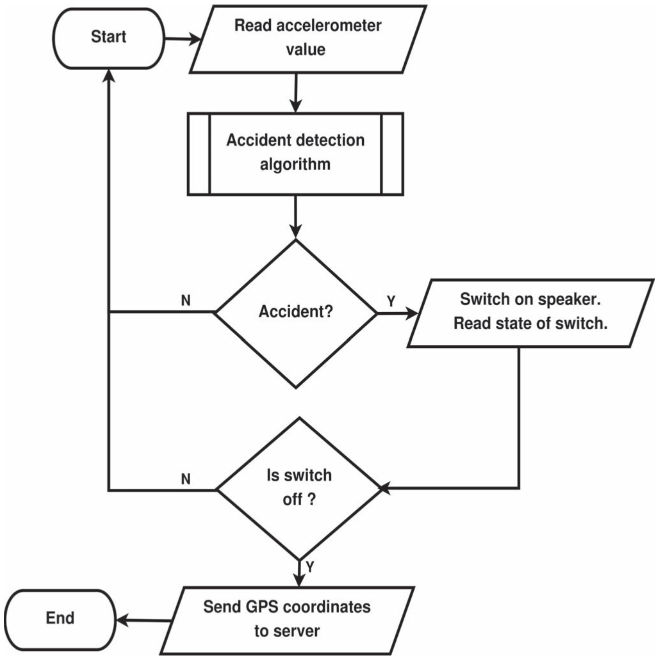

Fig. 1. Accident detection control flow

II-D. Accident detection algorithm

Both the pitch and roll angles are calculated every 30 seconds from the tri-axis accelerometer and if found above 45° for sufficient time, a vehicle rollover is detected and the alarm is sounded. If X,Y and Z are the accelerations in x,y and z axes respectively,

$$Pitch = arctan(\frac{X}{\sqrt{Y^2 + Z^2}})$$

$$Roll = arctan(\frac{Y}{\sqrt{X^2 + Z^2}})$$

If the acceleration value goes beyond 3g and the vehicle comes to a halt soon after that, then front, side or rear–end collisions are detected. This is a much simpler solution to accident detection.

III. AMBULANCE MANAGEMENT

The server is responsible for keeping track of all the ambulances, identifying the accident locations, dispatching the nearest ambulance to the accident spot and finally, monitoring the performance of the ambulance driver. A Model–View–Controller (MVC) based Django framework is used here. The POST request method requests the server to accept and store the coordinates enclosed in the body of the request. A Django app (a group of related functionalities) is used for collecting all the accident as well as ambulance locations from POST request, applying reverse geocoding using Python's Geopy library and storing the corresponding geographical addresses in a form. The jurisdiction under which the accident has occurred is identified from the geographical address. This information on jurisdiction is later used while assigning an ambulance. Django internally uses sqlite3 for database. An admin log-in with multiple staff account facility is provided.

For monitoring purposes at the server, the Django project defines 2 views, one for displaying the location of ambulances and accidents, and another one for listing the accident details in a serial manner. URLconf maps the URLs to the above mentioned views. The template here is an HTML file which uses XMLHttpRequest object for AJAX (Asynchronous Javascript and XML). XMLHttpRequest is used for asynchronous communication and it constantly monitors the concerned port for any POST requests.

When an accident occurs, the server utilizes the Distance matrix service from Google Maps API web services to find the real map distances and transit times of nearby ambulances to the accident location. Only ambulances belonging to the same jurisdiction as that of the accident are considered for sorting. The "nearest" ambulance is found by using a simple insertion sort on the transit times. The term "nearest" is defined in terms of time required to reach the accident spot. It is to be noted that the transit time for each ambulance suggested by Google Maps API web services depends on the prevalent traffic conditions. Accident coordinates are then relayed to this "nearest" ambulance. Utilizing other functionalities of Google Maps API web services like transit time, it is possible to track and keep a check on the performance of the ambulance driver from a single terminal preferably at a control room.

IV. GUIDING THE AMBULANCE

It is important not only to relay the information to the nearest ambulance, but also to guide the ambulance driver to the accident location in order to minimize any delay that may occur. The android application developed uses Google Maps API web services like traffic layer, and enables the driver to choose a route with less traffic. The locations of the ambulances are constantly conveyed to the server through smart phone every 15 seconds. The ambulance driver should give a confirmation once the patient has been handed over safely to the casualty. The time when confirmation is received is noted down by the server for future reference.

V. EXPERIMENTAL SETUP

For testing the ambulance management system, the server was hosted in NITK, Surathkal. To simulate ambulances, three cars with drivers equipped with the android application connected to the server were placed as follows: first one in a busy section of the national highway three kilometers away from the accident spot, second one in a relatively free road

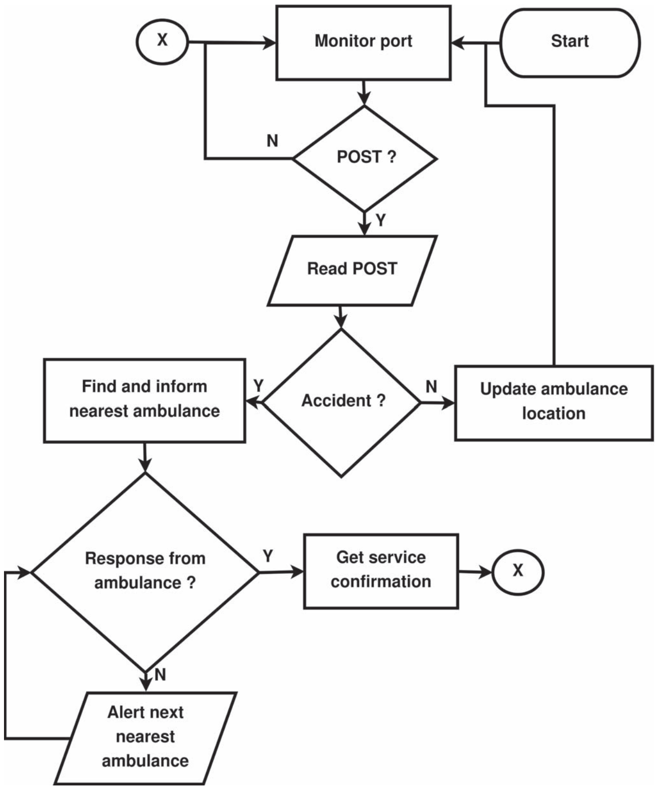

Fig. 2. Server control flow

three kilometers away, and third one in a remote village five kiolometers away. The three car drivers acting as ambulances were constantly monitoring the application for updates while the server was monitored from NITK.

The accident detection module was planted on a moving car and sudden brake was applied to stop the car repeatedly from speeds ranging from 10 to 80 kilometers per hour.'The MMA7260QT triple axis accelerometer was let to freely fall and hit in order to note the acceleration that may result from loose coupling with the rest of the module. These measures were taken to find an optimum accelerometer threshold for crash detection and, thereby, reduce false alarms. This car is then put to rest and an accident is simulated manually with the accelerometer. The accident detection module is connected by a network connector to a server responsible for ambulance management hosted in NITK campus.

VI. RESULTS

The acceleration for a hit from free fall of the accelerometer was found from various trials to be in between 1g and 2g and for sudden brake it was found to be between 2g and 3g for a range of speeds from 10 to 80 kilometers per hour. This suggests an optimum threshold of 3g for crash detection. In the experimental setup mentioned above, the server eliminated the third driver because he was very far from the accident spot. The server preferred the second ambulance

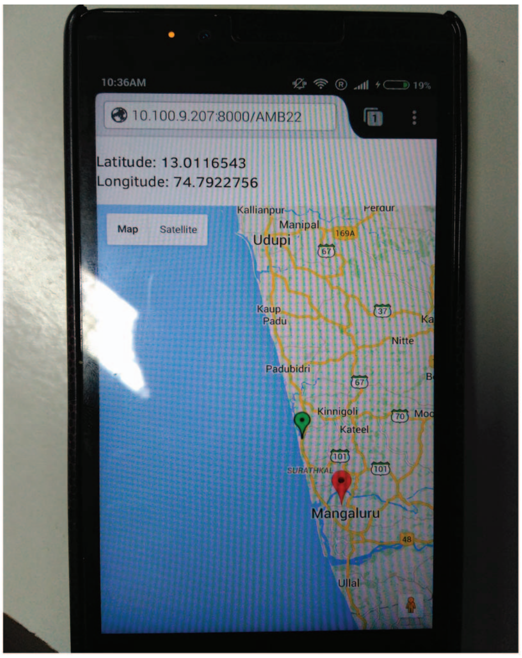

Fig. 3. Android application for ambulance guidance showing an accident call to the driver in green marker

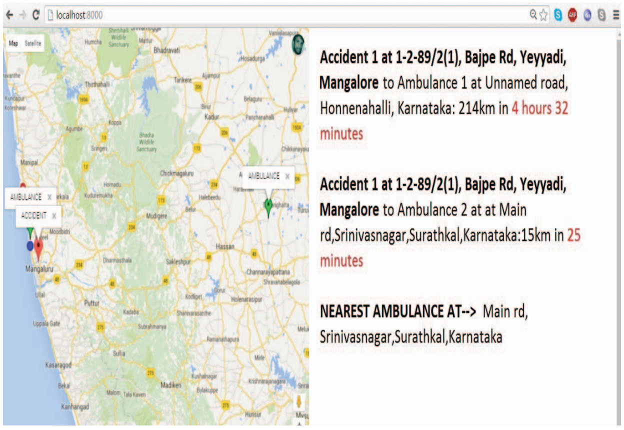

Fig. 4. Server selecting the nearest ambulance inside jurisdiction

driver located three kilometers away from the accident spot to the first one because of the prevalent traffic conditions. This validates that the Google traffic service is utilized. The second ambulance driver immediately received a notification on the phone from the server to reach the accident spot. The server takes into consideration only the ambulances inside the jurisdiction to avoid multiple assignments.

VII. CONCLUSION

The dedicated accident detection module can be directly retrofit to vehicles that do not have it when manufactured. The possibility of a false alarm is reduced with the help of a user input switch. The presence of a server with secured log–in for administration staff, lets us keep an eye on ambulance dispatch services for multiple accidents at the same time. It is easy to monitor the performance of ambulance drivers too. With the android application, navigating through the heavy traffic becomes easy for the ambulance driver, as routes with less traffic are automatically suggested.

The adoption of a comprehensive package for both road traffic accident detection and ambulance management helps save crucial time towards post traumatic medical care and reduce mortality rate. Standardization of service delivery process is achieved here with the involvement of less human element. A fully automated system like this can work wonders during natural disasters also.

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