# Instant Accident Reporting and Crowdsourced Road Condition Analytics for Smart Cities

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**Summary.** The following report contains information about a proposed technology by the authors, which consists of a device that sits inside of a vehicle and constantly monitors car information. It can determine speed, g-force, and location. Using these data, the device can detect a car crash (or pothole). The data collected from the car is forwarded to a server to for more in depth analytics. If there is an accident, the server promptly contacts the emergency services with the location of the crash. The pothole information is used for analytics of road conditions.

## General Description

In recent years, the number of motor vehicle deaths has risen significantly. It is predicted that this trend will not slow down, especially with the growing population and the increased use of motor vehicles. Emergency vehicle response time plays a significant role in the event of these motor accidents. If emergency vehicles and response teams do not reach the scene of the accident in time, there could be devastating casualties. With the proposed technology, it is possible to reduce the response time of these emergency vehicles by eliminating the human factor in accident reporting, thus decreasing the amount of car accident fatalities. The proposed technology also brings to the city operators other benefits, such as crowdsourced live pothole detection, which is intended to improve the quality of roads. This is a beneficial feature, as recently research attention has also been directed toward roads condition monitoring (e.g. see [1]).

The proposed technology consists of a device that sits inside of a vehicle and constantly monitors car information while driving. It can determine speed, g-force, and location. Using these data, the device can detect a car crash or

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pothole. If the device detects a crash, it promptly reports it to the server. The server then contacts the emergency services with the location of the crash. In addition, all this data are stored locally by the device onto an SD card so there are two copies of the data. This allows for the device to also function as a "black box" commonly found on commercial vehicles. The pothole information is used for analytics of road conditions.

## Technical Solution and Project Details

The proposed accident reporting system can be divided into two modules/sub-systems. The first part is the Accident Detection Module (ADM) which is constantly monitoring acceleration and determines the moment a crash or pothole happens. It also continuously polls for GPS location and velocity. The second part is the Accident Reporting and Analysis Module (ARAM), which is a program and a web interface that has the online accidents reporting portal, analytics charts and the databases associated with the system. ARAM reports the accidents to Emergency organizations and calls the emergency contacts of the person(s) involved in accidents (see figure 1a). In the following subsections, we explain the two modules mentioned above.

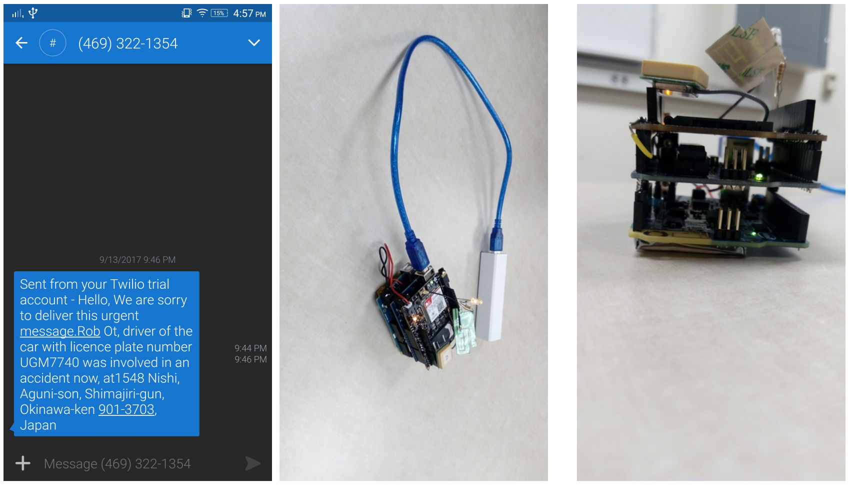
### Accident Detection Module (ADM)

To make the ADM, we have used multiple hardware components: Arduino Uno, SIM808 Module, SIM card, GPS Antenna, GSM Antenna, Arduino 101 (Intel Curie), LEDs, 220 Ohm resistors. ADM is implemented on two separate microcontrollers. It is implemented on the Intel Quark microprocessor on the Intel Curie module, using an Arduino 101 as a prototyping board. The location and communication system is implemented on an ATmega328 microcontroller, with the Arduino Uno as the prototyping board and a SIM808 GSM and GPS module attached to it. The final ADM device is shown in figures 1b and 1c.

The two microcontrollers act independently until there is a crash or pothole. The Arduino 101 sends an interrupt signal to the Arduino Uno and then promptly sends the crash data which includes the maximum axis of impact, the g-force enacted on that axis, and the total magnitude of all three axes as a percentage of the max value.

The Arduino Uno with the SIM808 module constantly polls for GPS latitude, longitude, and speed. The results are stored in respective variables and the variables are updated each time a new coordinate or speed is read. This is the main job of the Arduino Uno. While it does that, the Arduino Uno waits for an interrupt signal sent by the Arduino 101, which signifies a car crash. The operation of Arduino Uno is depicted in the figure 2.

The presence of a car accident can be detected by measuring a sharp change in acceleration, or impulse. This can be achieved using the accelerometer on the Intel Curie module on the Arduino 101. The accelerometer measures the



9/13/2017 9:46 PM

Sent from your Twilio trial account - Hello, We are sorry to deliver this urgent message.Rob Ot, driver of the car with licence plate number UGM7740 was involved in an accident now, at1548 Nishi, Aguni-son, Shimajiri-gun, Okinawa-ken 901-3703, Japan

9:44 PM
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(a) (b) (c)

Fig. 1: (a) Emergency contact of the person who is involved in an accident gets a text message from the system. (b)(c) ADM device

acceleration along the x, y, and z axis in three-dimensional space. By dividing the measured values of acceleration in each axis by the acceleration due to gravity, the g-force enacted on each axis can be determined. The g-force value for all three axes are constantly polled and a car crash is declared when the g-force for any axis exceeds 12 G. The device determines whether the accident was a T-bone or a head-on collision based on whether the x or y axis of the accelerometer is negative or positive.

When a car crash has been determined by the Arduino 101, an interrupt signal is sent to the Arduino Uno. The Arduino Uno then retrieves the axis with the maximum g-force enacted upon it, the g-force value on that axis, and the total magnitude of the shock as a percentage of the max. The Arduino Uno now has the GPS coordinates of the device, the last known speed before the crash, and the crash data. It compiles all of this information, appending a driverID to the end of all the data. The data are sent to the Accident Reporting and Analysis Module. The operation of Arduino 101 is shown in the figure 3.

### Accident Reporting and Analysis Module (ARAM)

ARAM is implemented on Amazon AWS cloud IaaS, and acts as a server and a portal for the whole system. This module is implemented using the following technologies: JAVA, JavaScript, NodeJS, MySQL, JDBC, and Twilio, and it consists of three major components: server, events and drivers database, and

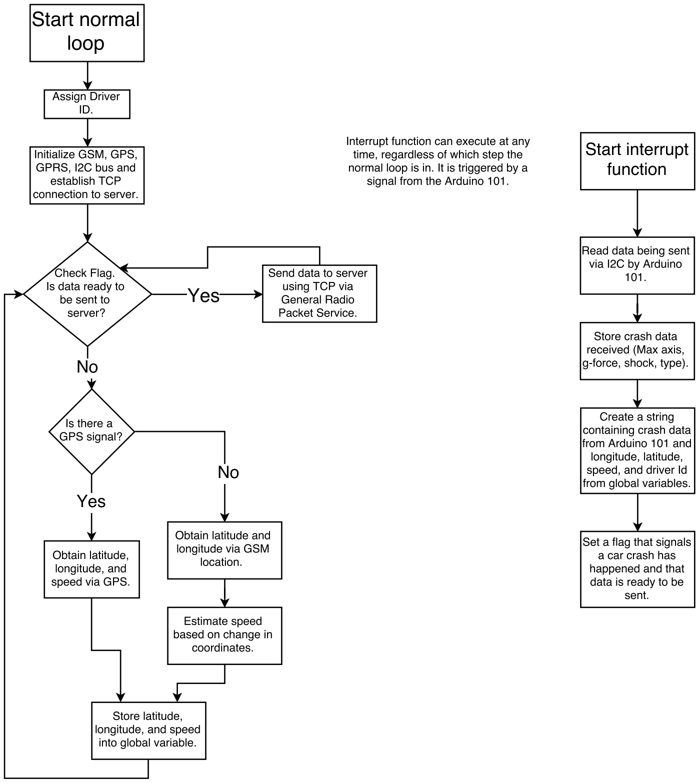

Start normal loop
Assign Driver ID.
Initialize GSM, GPS, GPRS, I2C bus and establish TCP connection to server.
Check Flag. Is data ready to be sent to server?
Yes
Send data to server using TCP via General Radio Packet Service.
No
Is there a GPS signal?
No
Yes
Obtain latitude, longitude, and speed via GPS.
Obtain latitude and longitude via GSM location.
Estimate speed based on change in coordinates.
Store latitude, longitude, and speed into global variable.
Interrupt function can execute at any time, regardless of which step the normal loop is in. It is triggered by a signal from the Arduino 101.
Start interrupt function
Read data being sent via I2C by Arduino 101.
Store crash data received (Max axis, g-force, shock, type).
Create a string containing crash data from Arduino 101 and longitude, latitude, speed, and driver Id from global variables.
Set a flag that signals a car crash has happened and that data is ready to be sent.

Fig. 2: The flowchart of Arduino Uno operation

web portal. The server is mainly responsible to receive, process and store the accident and pothole information that it receives from the ADMs of all cars. The events and drivers database contains information about drivers, their cars, and their emergency contacts; and events, such as accidents and pothole readings. The web portal visualizes the accidents and potholes (both live and over time), and also has analytics charts for the city operators.

The server is a multi-threaded program that listens and receives pothole and accident data from the installed ADMs on cars. When the server receives pothole information, it simply stores them in the events and drivers database, and also sends it to the web portal for live view. On the other hand, when the server receives accident reporting from an ADM, it first stores the information into the database, then it performs the emergency contacting. It does so by calling 911 and playing a auto-generated message, which consists of the name of the person(s) involved in accident, location of accident, and license plate of the car(s). The server also calls and texts the emergency contact of the person involved in the accident, with an appropriate message about the accident and

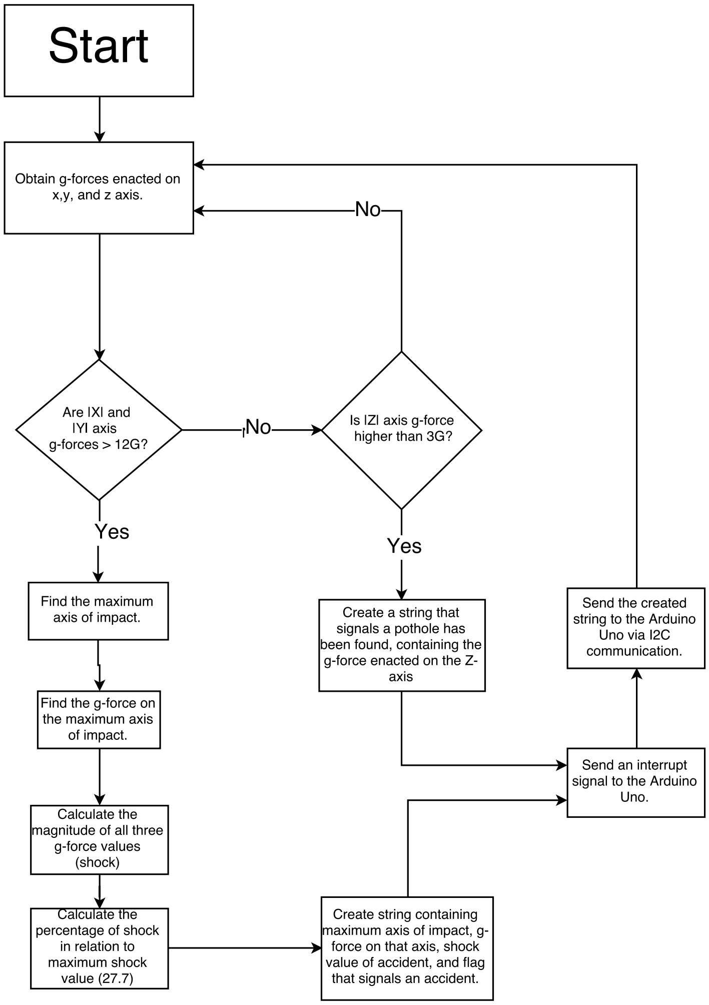
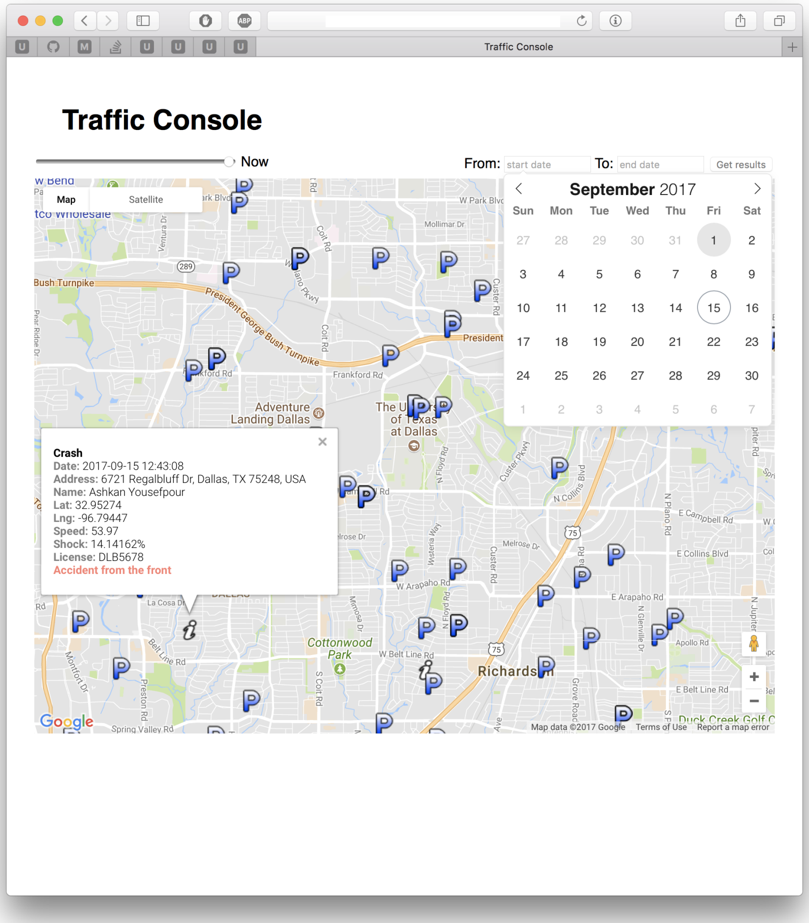

Start
Obtain g-forces enacted on x,y, and z axis.
Are |X| and |Y| axis g-forces > 12G?
No
Is |Z| axis g-force higher than 3G?
No
Yes
Yes
Find the maximum axis of impact.
Find the g-force on the maximum axis of impact.
Calculate the magnitude of all three g-force values (shock)
Calculate the percentage of shock in relation to maximum shock value (27.7)
Create a string that signals a pothole has been found, containing the g-force enacted on the Z-axis
Create string containing maximum axis of impact, g-force on that axis, shock value of accident, and flag that signals an accident.
Send an interrupt signal to the Arduino Uno.
Send the created string to the Arduino Uno via I2C communication.

Fig. 3: The flowchart of Arduino 101 operation

the its location. The server uses Google Reverse Geocoding library to get the human readable address of the accident from GPS latitude and longitude.

The events table store the events generated in the system, i.e. potholes and accidents. It keeps track of events by storing latitude, longitude, speed, shock, type, and driver ID. The drivers table simply stores information about drivers, including their car, license plate of the car, and drivers emergency contact information.

The web portal shows real time data of traffic accidents and potholes using NodeJS. The web portal obtains data from the database and displays the data in a console webpage and analytics webpage (figure 4). In the console webpage,



September 2017

| Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|
| 27 | 28 | 29 | 30 | 31 | 1 | 2 |
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| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

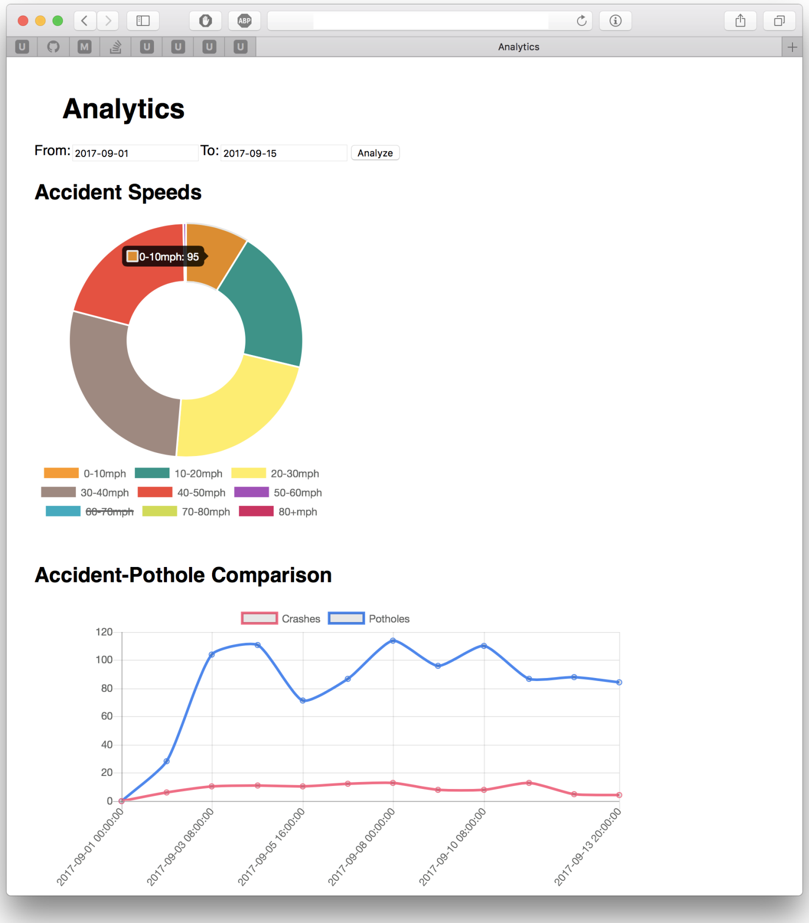
**Crash**
**Date:** 2017-09-15 12:43:08
**Address:** 6721 Regalbluff Dr, Dallas, TX 75248, USA
**Name:** Ashkan Yousefpour
**Lat:** 32.95274
**Lng:** -96.79447
**Speed:** 53.97
**Shock:** 14.14162%
**License:** DLB5678
**Accident from the front**

Fig. 4: Live Traffic Console (live accident and pothole monitoring)

users can view past accidents and potholes for the past 24 hours or select a date range. In the analytics webpage (figure 5), users can view a comparison of accident speeds within a date range. They can also view a comparison of accidents to potholes over a time period that they input.

## Social Impact

According to the National Highway Traffic Safety Administration, in the United States, there were 35,092 reported traffic accident fatalities in the



Analytics

From: 2017-09-01 To: 2017-09-15 Analyze

Accident Speeds

Accident-Pothole Comparison

Fig. 5: Live Traffic Console (live accident and pothole monitoring)

year 2015. To put in perspective, traffic accident fatalities in the year 2015 averages to 97 deaths per day from car accidents. The year 2015 saw the largest percent rise in car accident fatalities in 50 years at the rate 7.2%. In 2016, the following year, motor vehicle deaths increased by 6% [2],[3]. Traffic accident fatalities are increasing at an alarming rate.

The proposed device aims to mitigate motor vehicle fatalities by alerting emergency services to the exact location of a vehicle accident the exact moment it happens. Studies have shown that the survival rate of motor accidents increases if the response time of emergency vehicles does not exceed five minutes [4]. With such a short response time, every second is crucial, and that is the main motivation for the proposed technology.

With the current method of accident reporting, the reporter would first have to assess the severity of the accident. The reporter must then dial 911 and then relay the information to the dispatcher. This can take several minutes. For extremely severe crashes, the reporter would have to be a bystander not involved in the crash. This would further delay the time which the accident is reported since there may be no bystander at the moment of the accident. With our proposed scheme, this whole process can be reduced to an instant so that an emergency vehicle can be dispatched immediately. The system also contacts the emergency contacts of the person involved in the accident, so that they are informed of the accident. In many cases, when the emergency contact becomes present, many hospital-related procedures could be done faster, leading to a faster and more accurate medical care.

## Implementation Status and Code

We have finished the implementation for all the components, including Arduino, server, database, and web portal. The code is available on a GitLab directory at *https://gitlab.com/ANRL_UTD/IEEE-ComSoc-Competition-17*. The project is in working state, and we have tested it by shaking the ADM to simulate running over potholes. We have also tested the accident functionalities, such as calling emergency contacts, by generating accident reports from ADM. Nevertheless, installing the ADM in a car, and testing the system in an actual crash is not done yet, since it is difficult to make a car crash, only for the purpose of testing our product.

## References

1. S. Basudan, X. Lin, and K. Sankaranarayanan, "A privacy-preserving vehicular crowdsensing based road surface condition monitoring system using fog computing," *IEEE Internet of Things Journal*, 2017.
2. "Nsc motor vehicle fatality estimates," *Statistics Department, National Safety Council*, vol. 2016, pp. 1–2, 2016.
3. "2015 motor vehicle crashes: overview," *Traffic safety facts research note, US National Highway Traffic Safety Administration*, vol. 2016, pp. 1–9, 2016.
4. T. H. Blackwell and J. S. Kaufman, "Response time effectiveness: comparison of response time and survival in an urban emergency medical services system," *Academic Emergency Medicine*, vol. 9, no. 4, pp. 288–295, 2002.