Final Report

On

Driver's Behavior Analysis using Android Phone

INTERNET OF THINGS

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Submitted by:

Driving Score Team

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Summary

Car accidents are one of the leading causes of death in US. The majority of car accidents could be prevented if the reckless, distracted or ignorant driver pays proper attention to the road and drives with reasonable care and awareness of the surrounding. To make the drivers more attentive to their surrounding and their driving activities, we have created an android application using various sensor data, speed and speed limit information of the road, the braking and turning activity of the driver as well as their approach to the acceleration and deceleration of the vehicle. To summarize this behavior analysis, this project intends to implement a system to analyze the driving behavior of a driver behind the wheel, interact with the driver to maintain their safety as well as the safety of the nearby driver and to share the driving information with other nearby drives in the road. We believe such as approach to analyze the driving pattern of a driver can help the driver to understand his safety level on the road as well as improve his driving habits for a safe driving environment.

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1. INTRODUCTION

In today's world, advancement in vehicular system and smart car has been so rapid lately that monitoring of the driver's behavior in a road has also taken pace to help the drivers to maintain a safe and sound driving condition. Monitoring the driver's behavior, recording their driving event and providing feedback based on those events can greatly enhance the driver safety and safety of other individuals in a road. Lately, most of the analysis has been done using the inbuilt sensors of smartphone devices due to the fact that most of the people already own smartphone built with wide varieties of sensors.

Similarly, in this project, we have used three sensors, accelerometer, gyroscope, and magnetometer to monitor the safe and unsafe acceleration and deceleration, right and left turn and lane changes. We have also used various other contributing factors such as speed, harsh brakes, weather conditions and safety condition of the road. We have implemented an algorithm to determine the score of the driver ranging from 0-10 and we have designed an android application to interact with the user to show the driver score, safe and unsafe drivers nearby and to provide feedback to the driver on unsafe events.

1.1 Factors Contributing to Accidents

a) Speed of the vehicle

b) Hard acceleration and sudden brakes

c) Turning angle during lane change and left/right turn

d) Weather conditions

e) Distracted driver (sleepiness, reckless)

f) Bad driving behavior of nearby drivers

1.2 Factors used in Analysis

a) Speed and speed limit of the vehicle

b) Number of brakes applied

c) Rainy and snowy weather condition

d) Harsh acceleration

e) Harsh turn and lane change

1.3 Smartphone Hardware Sensors

Sensor is a converter that measures a physical quantity and converts it into a signal, which can be read by an observer or by an instrument. There are various types of sensors which we have used to analyze the driver behavior.

a) Accelerometer. An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer. We obtain these values in m/s^2 in x, y, and z direction.

b) Gyroscope: Gyroscope detects the current orientation of the device, or changes in the orientation of the device. Orientation can be computed from the angular rate that is detected by the gyroscope. It basically works on the principle of angular momentum and it is expressed in rad/s on 3-axis, and denoted by pitch, yaw and roll.

c) Magnetometer: Magnetometers [4] are measurements instruments used for two general purposes-to measure the magnetization of a magnetic material like a Ferro magnet, or to measure the magnetic strength and the direction of the magnetic field at a point in space.

d) GPS: GPS is a satellite based Navigation tracking, often with a map showing where you have been. It gives us the value of longitude and latitude, which determines the point of location on earth.

2. Methodology

2.1 Data Collection

- Acceleration/Deceleration – determined using pitch angles obtained through sensor fusion and x-axis of accelerometer.
- Turn/Lane change – determined using yaw angles obtained through sensor fusion and y-axis of accelerometer.

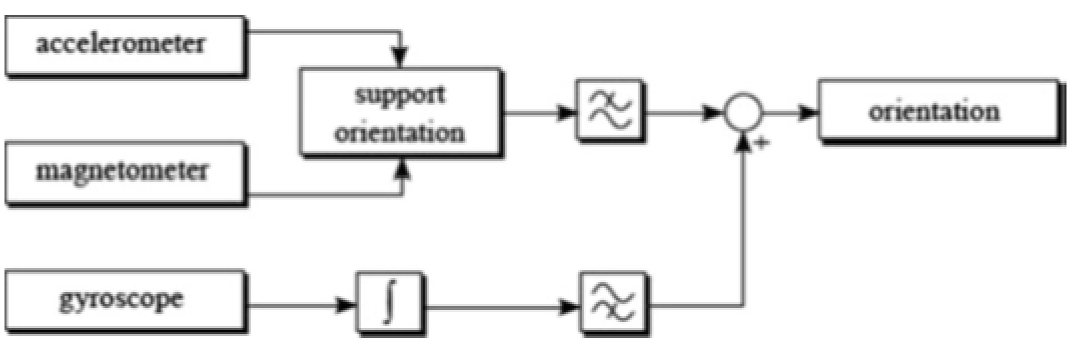
- Speed and speed limit – from Location API
- Brakes – determined by observing if user reduces his speed to more than 25 mph within 2 sec.
- Rainy and snowy condition – from DarkSky API

2.2 Data Analysis

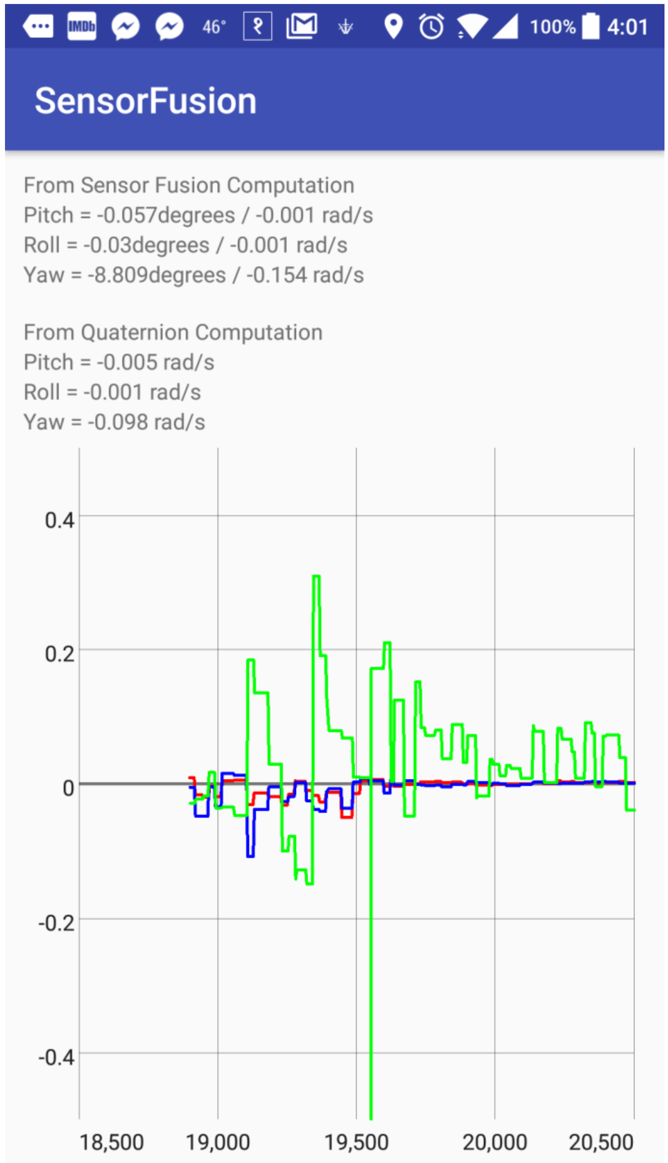
- Data from the sensor fusion to determine the accelerating behavior of a driver helps in determining whether the driver reduces his speed or accelerated too harshly or applies brakes too often.
- Data from the sensor fusion to determine the turn and lane changes helps in determining whether the drive made a harsh turn/lane change without lowering the speed in turns as well as the angle in which they made such lane change and turn.
- Speed of the vehicle is used to determine if the vehicle is under or over the speed limit. The speed and limit of the road is essential to categorize whether the driver is driving safely or over-speeding.
- Rain and weather data collected from the DarkSky API are also beneficial to suggest to the driver to maintain the safety condition in an unsafe road.

2.3 Sensor Fusion

We have combine the 3 sensors, accelerometer, gyroscope, and magnetometer to obtain an overall fused pitch, roll and yaw angles.



Furthermore, we have combined these overall sensor values with the quaternion values from the phone to get better estimate of the pitch, roll and yaw angles. We have used this pitch and yaw in our project to determine the acceleration and turn respectively.



In the above screenshot, we can see the background sensor computation on an instance. Yaw is represented by green lines, and the graph is implemented using GraphView in android

2.4 Calibration

We don't require calibration of sensor at the start as we have developed an algorithm to calibrate the sensor values at every instance based on the previous values. Our sensor provides us values at every 10 millisecond, and we deduct the value obtained at present with the value obtained 10 millisecond ago to obtain the calibrated value at every instance.

2.5 Detecting Safe and Unsafe Events

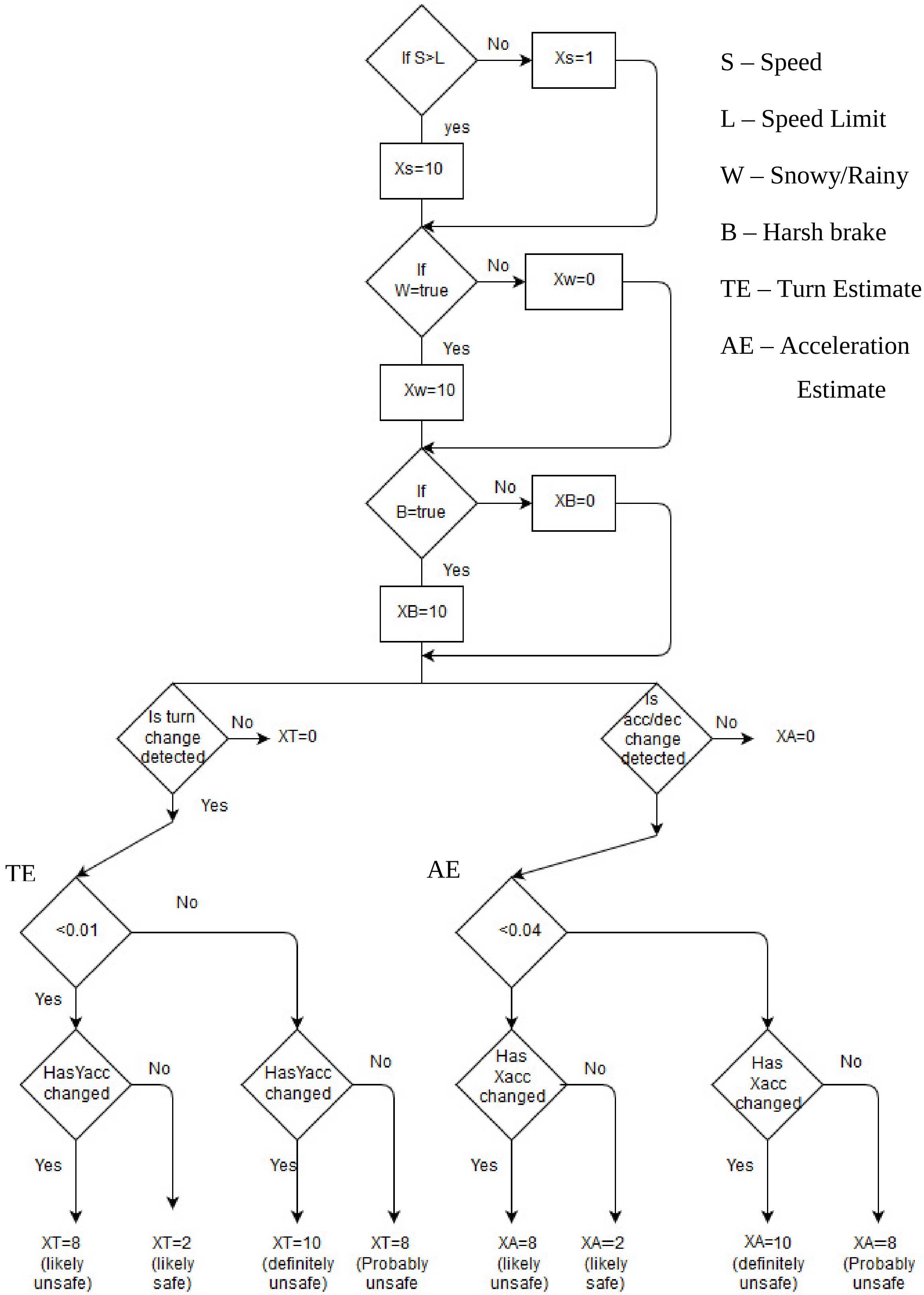
Based on the accelerometer and the sensor fusion values, we have used the following threshold to determine the unsafe and safe events.

Driving event	Data used (accelerometer)	Threshold	Data used (sensor fusion)	Threshold
Safe acceleration	X-axis data	$1.3\ m/s^2$ to $2.5\ m/s^2$	Pitch	−0.08 to −0.12 rad/s
Safe deceleration	X-axis data	−1.3 to $-2.5\ m/s^2$	Pitch	0.08 to 0.12 rad/s
Safe left turn	Y-axis data	−1.8 to $-3.0\ m/s^2$	Yaw	0.10 to 0.30 rad/s
Safe right turn	Y-axis data	1.8 to $3.0\ m/s^2$	Yaw	−0.10 to −0.30 rad/s
Hard acceleration	X-axis data	$>2.5\ m/s^2$	Pitch	<−0.12 rad/s
Hard deceleration	X-axis data	$<-2.5\ m/s^2$	Pitch	>0.12 rad/s
Sharp left turn	Y-axis data	$<-3.0\ m/s^2$	Yaw	>0.30 rad/s
Sharp right turn	Y-axis data	$>3.0\ m/s^2$	Yaw	<−0.30 rad/s

Reference: Based on the analysis done by the author in the Book "Beyond the Internet of Things Everything Interconnected"

Note that as calibration takes place at every instance, the values will always be close to 0 at safe events, also, when a unsafe event takes place, the values might go from –ve to +ve or vice versa, so we might get more than 5 values above the threshold in such events. The counter 5 only means that 5 values were recorded on such unsafe condition, and doesn't mean that 5 such unsafe events has occurred.

2.6 Flowchart for analysis



Here, Xs, XB, Xw, XT, XA are the factors obtained as shown in the above flowchart during each events, and values are assigned depending on the safe and unsafe events.

TE and AE are the Turn Estimate and Acceleration Estimate respectively, these are the values obtained based on the sensor values in the last 30 seconds. TE is obtained by dividing the number of counter of yaw that has crossed the threshold values in the last 30 second upon the total number of sensor values recorded in the last 30 seconds. Similarly, AE is obtained by dividing the number of counter of pitch that has crossed the threshold value in the last 30 sec upon the total number of sensor values recorded in the last 30 seconds.

2.7 Final Score

The unsafe score is calculated as follows:

Unsafe Level = 0.3*speed_factor (Xs) + 0.2 *weather_factor (Xw) + 0.2 * brake_factor (XB) + 0.2 * Turn_factor (XT) + 0.2 * Acceleration_factor (XA)

Then the safe score is calculated by reducing the unsafe score from 10, since we have assigned factors for each event from 0 to 10 in the above analysis.

if (Unsafe Level < 10)

Safe score = 10 – Unsafe Level

Else

Safe Score = 0*

* highly unsafe scenario, this condition theoretically means an accident has occur. For examples, currently its raining, the speed of the driver is above the limit, the driver turn and acceleration is unsafe, and he applies a harsh brake decreasing his speed by 25 mph in 2 seconds. Such case would give the driver a score of 0 (based on unsafe level, he will cross 10 which is highest).

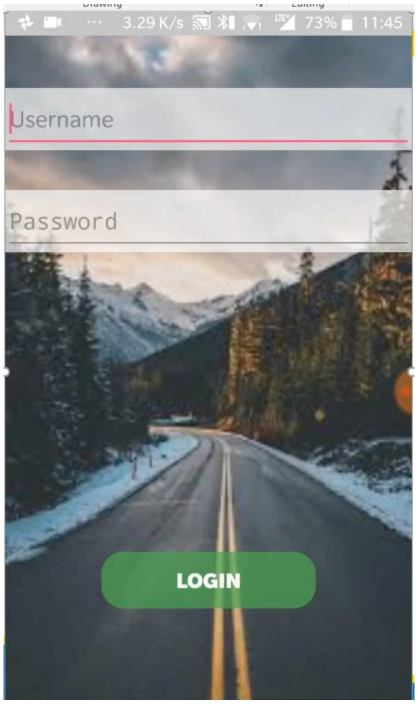
3. PROJECT DEPLOYMENT

3.1 User Authentication:

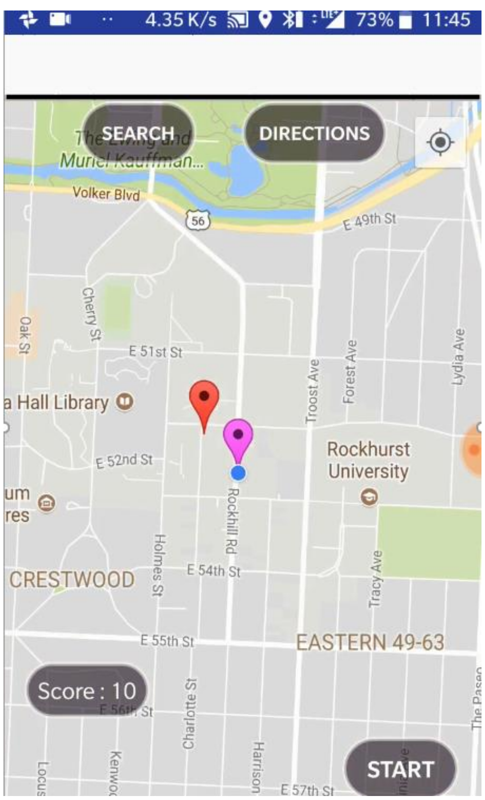
- Authentication has been implemented using Google Firebase API.
- Users are required to register an account to keep track of users on road while driving.
- Users driving score are stored on Firebase API database to share the driving behavior with other users.

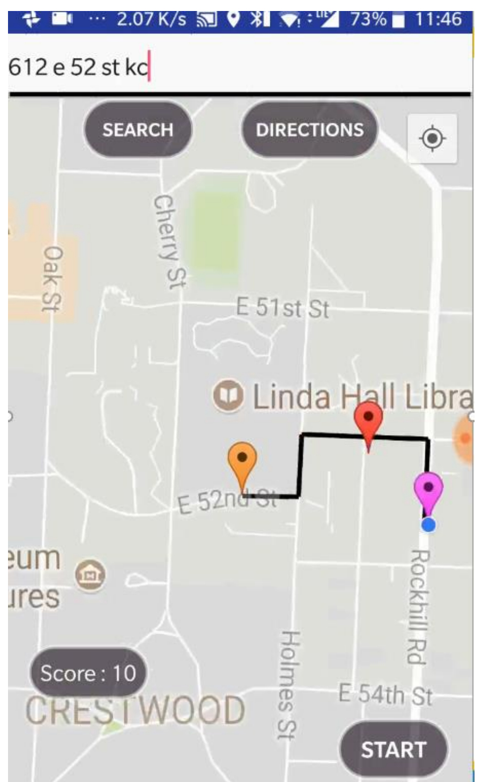
3.2 Home Page

The Log In Page and the Home Page of the app in the screenshot below:

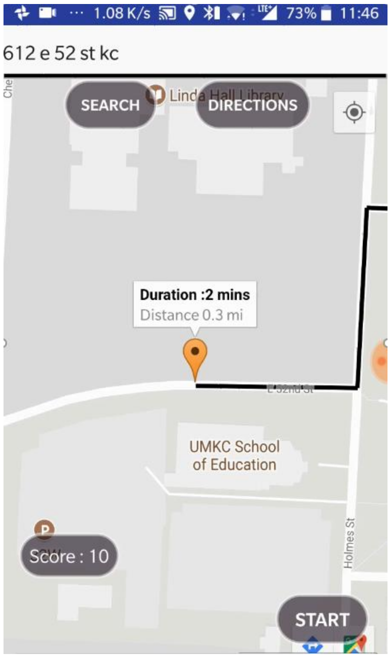


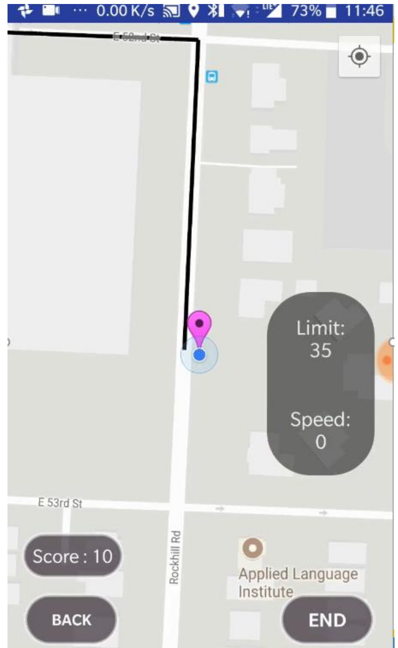
The Maps within the app to navigate the driver to their destination and the score displayed on the left bottom.



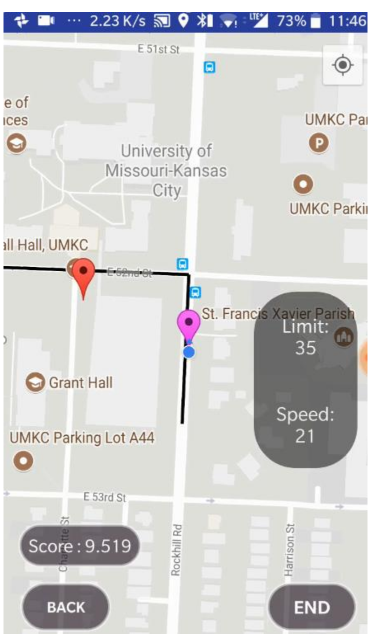


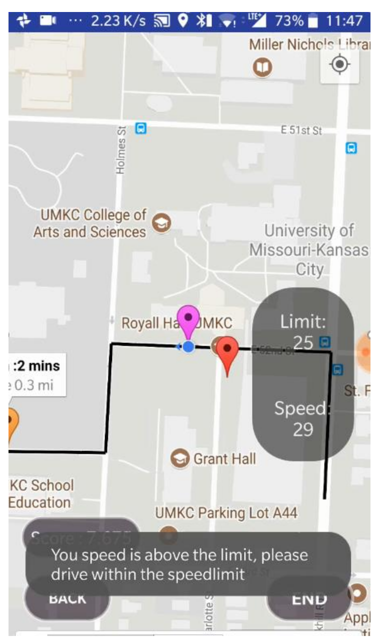
Starting the navigation, the score will remain 0 if the app doesn't detect any acceleration of the vehicle.





Once the vehicle is in motion, the speed can be seen on the right side, and the score will start decreasing from 10. The score is updated on every 2 sec based on the sensor values in the last 30 sec. If the speed goes over the limit, the score will drop, and the user is notified and advised to decrease his speed.

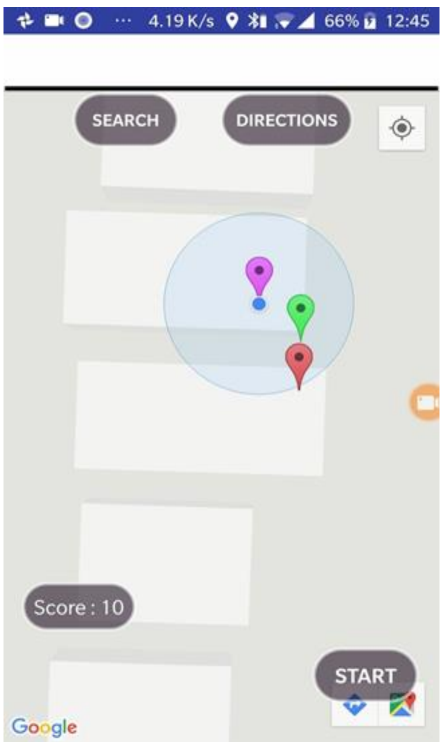




At the end of the trip, the average score of the trip is displayed to the user. Also, various instructions to drive safely in any unsafe events are advised to the users through the notification in the app.

3.3 Location sharing:

- Implemented using Maps and by storing the location of a user in the Firebase Database.
- Unsafe drivers are identified by red color marker and safe drivers using green marker.



4. CHALLENGES

- Analysis – integration of factors such as yaw, pitch and accelerometer values was a major issue due to the fact that we relied on the references for the analysis and threshold of sensor values.
- Algorithm – assigning the weightage for the different factors such as speed, brakes and so on was an issue as one factor alone can be responsible for the accident.

- Interpretation of sensor values – sensor values such as pitch and yaw might not reflect accuracy due to problems with calibration and electromagnetic interference.

5. FUTURE ENHANCEMENT

- Algorithm used for analysis can be improved through more analysis on the sensor values and real testing on different scenarios.
- Navigation can be improved by implementing more features of google maps. Like advanced searching, rerouting, voice commands etc.

6. CONCLUSION

We hope that our analysis and implementation to determine the safe score of the driver will help in the future work to create a bigger platform to analyze the overall driving behavior of the registered driver and can be an indicator for insurance company to determine the insurance cost for drivers.

7. CODE

Coding was done on Android Studio using Java Programming language, and can be found on the following link on GitHub.

https://github.com/yashwanthmanchikatla/Driver_behaviour

8. REFERENCES

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EBook: Beyond the Internet of Things Everything Interconnected