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A framework for safer driving in Mauritius

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Abstract

According to the National Transport Authority (NTA), there were 493,081 registered vehicles in Mauritius in April 2016, which represents a 1.4% annual increase compared to 2015. Despite the sensitization campaigns and the series of measures setup by the Minister of Public Infrastructure and Land Transport, the number of road accidents continues to rise. The three main elements that contribute to accidents are: road infrastructure, vehicle and driver. The driver has the highest contribution in collisions. If the driver is given the right information (e.g. driving behaviour, accident-prone areas and vehicle status) at the right time, he/she can make better driving decisions and react promptly to critical situations. This paper proposes a framework for safer driving in Mauritius that uses an on-board car diagnostic module (OBDII) to collect data such as vehicle average speed, engine revolution and acceleration. This module relays the data to a cloud environment where an adaptive algorithm analyses the data and predicts driver behaviour in real-time. Based on driving behaviour, mobile alerts can be sent to the driver in the form of messages, voice commands or beeps. A survey was also carried out to evaluate the acceptance rate of such a framework by people of different age groups in Mauritius.

Keywords: Telematics; OBD; IoT; IBM Bluemix; Cloud

1. Introduction

Since the introduction of the first motor vehicles, transportation systems have advanced significantly and in the past few years, the sector has entered a new era where the traditional way to commute is steadily being replaced by technologically enhanced automotive systems. Nowadays, intelligent and quasi-autonomous systems are a reality. As a matter of fact, legislation is being revised in Europe and in the United States to accommodate for the specificities of Intelligent Transport Systems [1].

It has been noted that the motorization rate is quickly rising in many areas of the world, particularly in developing countries where the road networks are often inadequately planned and where the capacity of the physical infrastructure is not improving proportionately to the country's socio-economic growth [2,3]. Over the past few decades, quick urbanization as well as the population growth in developing countries has indirectly contributed to a surge in the number of on-road collisions, accident-related injuries and collateral human fatalities [4]. In fact, it has been estimated that over 90% of fatal

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crashes take place in low and middle-income countries [5]. Therefore, it is believed that technologically aided systems could assist in reducing the challenges faced in these particular regions such as accidents, major traffic delays, inefficient fuel consumption and financial losses due to prolonged traffic jams [6].

The use of technology to provide safety, elevate basic driving comfort and provide relevant information to drivers and authorities is crucial for the advancement of transportation systems. At the driver level, added security and safety while driving is required through systems that allow real-time communications to support en-route choice decisions [7]. Emerging vehicular technologies should be able to communicate crucial information to both authorities and drivers in order to alleviate traffic congestion and provide suitable responses to driving hazards independently of the implementation sites or the regional road configurations [8].

In December 2015, there were 486,144 vehicles on the road in Mauritius representing a 4.5% increase as compared to December 2014. Nearly, 50% of the vehicles consisted of cars, double cab pickup and dual-purpose vehicles [9]. In 2015, there was a 4.5% increase in the number of road accidents as compared to the previous year. Moreover, there was an increase of around 3.5% in the number of casualties as a result of road accidents [9]. Unfortunately, despite numerous sensitization campaigns, it can be noted that the number of road accidents and casualties are increasing every year.

This paper describes a framework for safe car driving in Mauritius that can be integrated in a cloud-based environment. The system can adapt to specific regions, road infrastructure, driver, vehicle, and time period in order to determine driver behaviour and provide alerts to the driver.

The rest of the paper is organized as follows: Section 2 describes some related works. Section 3 presents the OBD device to be used in the proposed architecture. Section 4 describes some vital parameters that can be monitored using the ODB device. Section 5 presents the proposed architecture while Sections 6 and 7 present the commercial applications and survey respectively. The work is finally concluded in Section 8.

2. Related works

The authors in paper [10] proposed a framework that would help to analyse data collected by OBDII, on the cloud. The analysis includes low emission levels, good engine performance, improving diagnostics, repair and maintenance, improving driving behaviour and thwarting vehicle thefts. The focus of the paper was mainly on the security, privacy issues concerned with the collection of the data.

Authors in [11] used CloudThink to analyse data from OBDII. The information about speed, RPM, fuel level, coolant temperature and average fuel consumption estimates were computed in real time using available engine data. CloudThink is a framework that has been designed based on a trade-off between security and flexibility to host applications.

Authors in [12] proposed a mobile application for monitoring inefficient and unsafe driving behaviour. OBDII reader had been used to capture vehicle data leading to evaluation of driving behaviour. Data was captured and displayed on the mobile phone in real time and feedback was also given to drivers to adjust their driving.

In [13], the authors implemented a mobile application that could evaluate a driver using the OBDII system. Parameters such as speed and turn signals are monitored and their values were periodically stored. These values were then evaluated and assigned scores using an algorithm. Drivers could view their scores and past performance graphically.

3. OBD

On-Board Diagnostics (OBD) systems are available in most vehicles that are on the road nowadays. OBDII, shown in Fig. 1, is an enhanced diagnostics monitor that has been in use since 1996 [14]. It reads data from the Electronic Control Unit (ECU), which controls nearly all of the systems of modern vehicles and gathers data from a range of in-vehicle sensors [15]. OBDII is a technology that allows a car owner or technician to monitor important engine data, diagnostics control network of the car and other information related to the chassis, body and accessory components.

The OBDII acts an early warning system and informs the driver of the need of potential repair and also provides in depth engine information to car enthusiasts or drivers who want to monitor the performance of their vehicles. Moreover, the system helps technicians to quickly and effectively repair vehicles as it accurately identifies problems and issues the appropriate diagnostic trouble codes (Fig. 2). OBDII Bluetooth or Wi-Fi connectors are now available on the market and can be used to interface the OBD system with smart phones. There are many mobile applications on the market that are able to read the information from the OBDII through the connector and displays meaningful data in a graphical way for easy interpretation.

Since nearly 50% of registered vehicles in Mauritius are cars and around 82% of cars are 15 years or less, the OBDII device can be used with most cars on Mauritian roads [9].

Fig. 1. OBDII module [16].

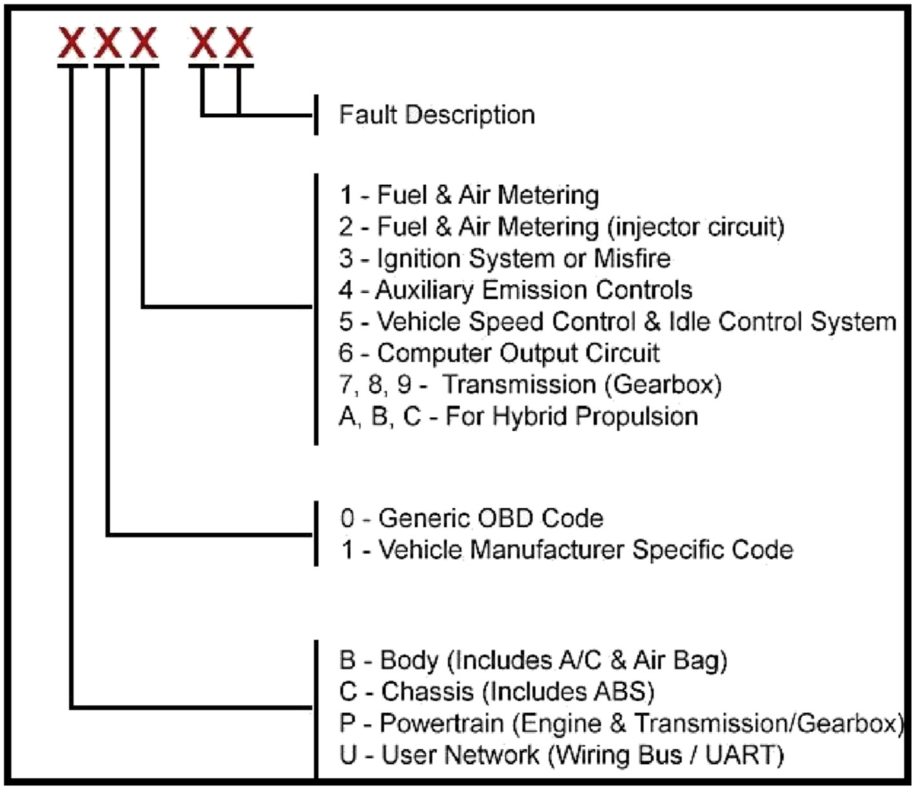


Fig. 2. OBDII Diagnostic codes [17].

4. Vital car parameters measured using OBDII modules

4.1. Battery

In this digital era, cars are loaded with computers and technology and the car battery plays an important role to make these devices function properly. Many cars that have a battery will still crank the vehicle but this can result in other problems. For instance, while starting the engine, the starter motor puts a huge load on the electrical system. The load of the starter can make the system voltage drop below normal if the battery is getting weak. The low voltage can cause issues with the modules that depend on a stable voltage in the car. Also there can be cases where the battery can be overcharged and hence will not work well or efficiently, as it should. Many cars can have symptoms of stalling, memory loss and anti-theft no start problem, which are related to a weak car battery.

The OBDII module can read the following data [18]:

- B1317 Battery Voltage High
- B1318 Battery Voltage Low

The sensors can help drivers in getting more timely and accurate information regarding their car battery, which is one of the most important devices in the car.

4.2. Tyre pressure

Tyre pressure is vital to ensure safety on the roads. Underinflated tyres lead to wastage of fuel, reduction in tyre lifetime and may cause accidents. There are two ways to monitor tyre pressure in vehicles and they are Direct TPMS (Tyre Pressure Monitoring System) and Indirect TPMS.

Direct TPMS utilizes sensors which are placed on each wheel of the vehicles and provide warning if there is a dangerous variation in the air pressure in one or more tyres. The information from the sensors are then transmitted to the ECU and displayed on the dashboard of some cars. Indirect TPMS monitors tyre pressure by using parameters such as rotational speed of the wheels and other data to calculate whether there is a change in tyre pressure [19].

The OBDII device can provide notifications for the following tyre pressure problems [18]:

- C1510 Right Front Wheel Pressure Reduction Performance Problem
- C1511 Left Front Wheel Pressure Reduction Performance Problem
- C1512 Right Rear Wheel Pressure Reduction Performance Problem
- C1513 Left rear Wheel Pressure Reduction Performance Problem

4.3. Revolution per minute

The RPM of a car measures the number of times the engine components are rotating per minute. RPM and the parameter torque can be used to calculate the amount of power that an engine produces. High RPM over a period of time can cause damage to the car engine.

Some of the OBDII codes related to RPM are listed below [18]:

- P0703 Torque Converter/Brake Switch B Circuit Malfunction
- P0719 Torque Converter/Brake Switch B Circuit Low
- P0724 Torque Converter/Brake Switch B Circuit High

4.4. Braking

Brakes are among one of the most important components of any vehicle and therefore require regular maintenance. Braking deficiencies such as misadjusted brakes, brake imbalance or incorrect brake calliper assembly may affect the ability of a vehicle to stop or require a greater distance in the event of an emergency situation. Catastrophic brake failures are rare but often fatal.

The OBDII module can read the following data among others pertaining to brakes in a vehicle [18]:

- P1536 Parking Brake Switch Circuit Failure
- P1571 Brake Switch Malfunction
- P1572 Brake Pedal Switch Circuit Malfunction
- C1446 Brake Switch Circuit Failure
- C1940 Brake Pressure Switch Mechanical Failure
- C1960 Driver Brake Apply Circuit Fault

4.5. Engine coolant

Engine temperature is also an important indicator providing vital information on the status of a vehicle. Engine coolant normally absorbs heat from the engine and prevents the latter from overheating. Low levels of engine coolant may cause a dashboard warning light to illuminate. Several cases of vehicles catching fire have been reported in Mauritius and this may be explained by an overheating engine.

The OBDII module can read the following data among others pertaining to engine coolant in a vehicle [18]:

- P0115 Engine Coolant Temperature Circuit Malfunction
- P0116 Engine Coolant Temperature Circuit Range/Performance Problem
- P0117 Engine Coolant Temperature Circuit Low Input
- P0118 Engine Coolant Temperature Circuit High Input
- P0119 Engine Coolant Temperature Circuit Intermittent
- C1781 Engine Coolant Temperature Signal Missing/Fault

5. Proposed framework

The proposed framework consists of the following main components. These components interacts together as shown in Fig. 3.

- **OBDII module:** The module is connected to the ECU of the car. It reads vital vehicle parameters while the car is in motion and transmits the information to the driver's mobile phone via Bluetooth.
- **Mobile Application:** The mobile application can act as an interface between the car driver and the IBM Cloud Platform. This application reads vehicle parameters from the OBDII and transfers to the analytics platform. The driver receives alerts from the system or authorities via the mobile application. The alerts can be in audio format so as not to distract drivers from the road. Moreover, the driver can check his driving and vehicle statistics on the mobile application.
- **Website:** The website can primarily provide statistics about driving behaviour and traffic conditions. Other services may include generating reports on vehicle conditions and function as an integrated platform to broadcast alerts.
- **IBM Cloud Platform:** The platform receives car parameters from the mobile application. The data is transferred using the cellular 4G connection since the car is on the move. The platform processes and analyses these parameters in real-time. Analytics can also be performed to determine driving behaviour.

5.1. IBM Bluemix platform

IBM Bluemix is the latest cloud Platform as a Service (PaaS) developed by IBM. Bluemix provides mobile and web developers access to IBM software. It is secure and allows organizations to quickly build and manage mobile and web based application in the cloud. Bluemix is compatible with other cloud applications; hence it is easy to integrate enterprise level services. Bluemix brings together services, infrastructure and data to rapidly bring ideas to production [20]. The different solutions provided by Bluemix are listed in Table 1.

5.2. Analytics

Analytics is strongly related to the field of data analysis and involves the study of historical data to predict future trends. In the current business world, businesses that are progressing at high speed are using analytics as part of their decision making process. Analytics not only help businesses to make the right decisions but also help them generate more money since data is now being understood in new and meaningful ways.

Analytics is an important component of the safer driving framework as data analytics on driving behaviour may help road users improve safety. To examine driving behaviour, the mobile application can capture information such as speed, engine revolution, acceleration and braking. Static data such as speed limit, accident-prone areas, street information and dynamic data such as weather conditions can be uploaded to the cloud platform. Analytics applied on these data coupled with vehicle information can produce useful information, which can assist drivers to make better driving decisions. One such algorithm that can be applied to track driver behaviour is frequent pattern mining [22]. The IBM IoT Foundation is shown in Fig. 4.

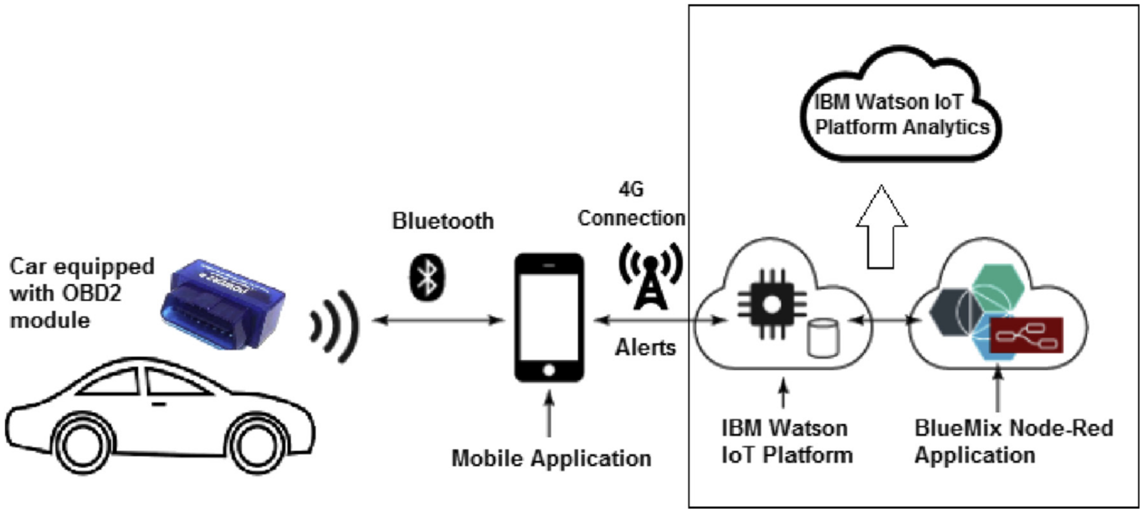


Fig. 3. Proposed architecture for safer driving in Mauritius.

Table 1
IBM Bluemix solutions [21].

Analytics	Description
Geospatial Analytics service	≻Track when devices enter or leave defined regions ≻Monitor device locations in real-time ≻Control region monitoring using the geospatial API
Node-RED for analytics	≻Visual tool for wiring up devices, sensors and online services ≻Store data and Perform additional logic ≻Send notifications
Watson analytics	≻Data exploration, predictive analytics, dashboards and infographics ≻Text-to-speech/Speech-to-text
Watson	≻Analyse and interpret data ≻Data can include unstructured text, images, audio and video.

The IBM IoT Platform Analytics service provides a set of facilities to support the proposed framework. A few possible services available on IBM Cloud are summarised in Table 2.

5.3. Mobile phone, application and website features

The features that can be provided by the mobile phone, mobile application and website are detailed in Table 3.

5.4. Privacy

Nowadays, data is continuously being gathered and shared on network; hence it is mandatory to preserve the privacy of data. In this framework, sensitive data about drivers and traffic

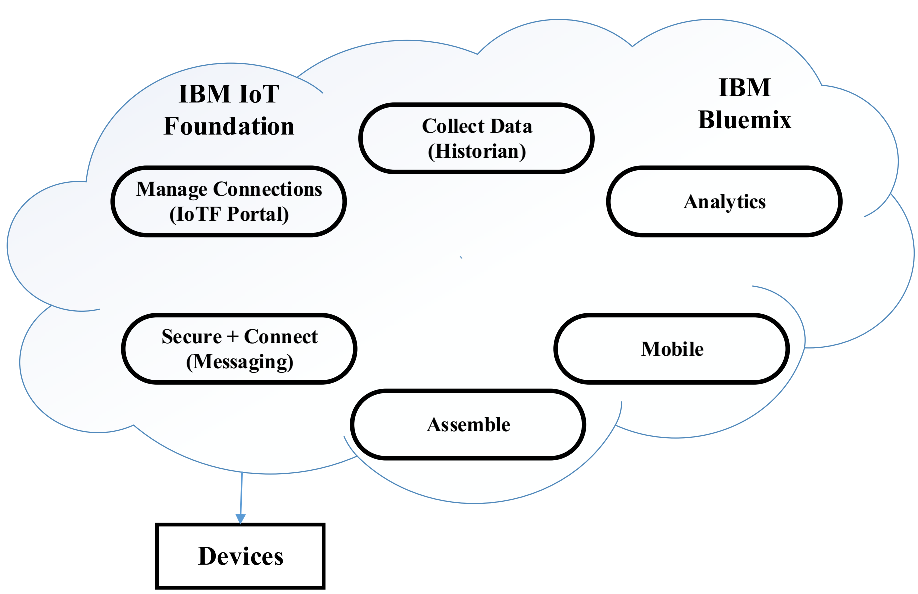


Fig. 4. IBM IoT foundation [23].

Table 2
IBM IoT platform analytics [23].

Solution	Description
Mobile	Build a powerful backend in the cloud for your next mobile app
IoT	Build apps that leverage data streams from sensors and other components
Cognitive	Discover how your app can learn, grow, and simulate expertise
Hybrid Cloud	Deploy apps across public and private clouds based on your security and performance needs
Open Architecture	Run apps on a wide variety of open source architectures, natively on the platform

Table 3
Mobile phone, application and website features.

Mobile Phone and Application Features	
• Management of OBD Data	≻Capture data: The application is designed to read real time data (acceleration, speed of vehicle, mileage, fuel consumption and cost, driving time, Detection of Safety Equipment Issues, Detection of Mechanical Issues and emission, among others) through the OBD port ≻Measure Data: Real time data is sent to cloud based system for processing and analysis
• Warning/Notification	≻Provide real time feedback through alerts (beep sound or voice) based on processed data, to enable the driver to adjust his or her driving style to be safer, smoother, and more efficient.
• Emergency Alerts	≻Receive emergency alerts by authorities to inform driver of possible road network issues in the vicinity of his current location.
• Statistics	≻Allow drivers to view the data in form of graphs to allow them to evaluate their driving.
• Logs and historic views	≻All alerts, notifications received are logged and can be managed.
Website features	
• Statistics	≻Provide statistics to authorities (police, NTA, insurance, etc.) on driver behaviour in form of graphs or charts ≻Provide indication on accident-prone areas related to driving behaviour ≻Provide details on driver behaviour during peak/off-peak hours
• Vehicle status	≻Provide real-time status on vehicle condition ≻Reports on vehicles which are not in good condition can also be generated
• Emergency alerts	≻Allow authorities to broadcast emergency alerts to all vehicles in a particular location

data is collected and processed. All entities involved in this process have to comply with relevant legislation including the Data Protection Act. In Mauritius, the Data Protection Act 2004 provides the legal infrastructure to certify that private information is collected and used appropriately [24]. All companies dealing with confidential information have to abide to the Data Protection Act [25]. Hence, the gathering and use of any personal and sensitive data collected using the proposed framework shall remain private.

6. Commercial potential

6.1. Local authorities

Numerous studies have confirmed the rapid adoption of mobile devices by consumers. The proposed framework can be of interest to local authorities such as the National Transport Authority and the Traffic Management and Road Safety Unit (TMRSU). In general, these service-oriented departments are responsible for the regulation, control of road transport and movement of traffic in Mauritius including Rodrigues. One of their main objectives is to reduce the number and severity of road accidents. The local authorities may therefore use this framework to achieve the following [26,27]:

- Ensure that vehicles are fit for our roads.
- Monitoring, collecting and analysing of driving behaviour and accident data.
- Collection and management of data on traffic volumes along heavily trafficked routes.
- Reviewing existing legislation and propose new regulations related to road safety and driving behaviour.
- Changing road user behaviour through education and training.

6.2. Insurance sector

Customers are also moving towards mobile services. Another area where the proposed framework can be of great interest is the car insurance sector. In the event of an accident, the insurance companies sometimes have to bear the cost of reckless drivers since in some situations, it cannot be determined with certainty the exact causes of the accident. This framework can help insurance companies in the following ways:

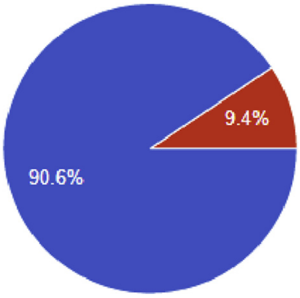
- Determine the profile and driving style of drivers. The premium to be paid next year can be calculated in function of how the driver is behaving on the road. Someone who drives carefully may be entitled to a discounted insurance rate.
- When an accident occurs, insurance companies can easily determine the state (speed, engine revolution, etc.) of the car involved in the accident. These evidences will be readily available and will speed up the process to refund the parties involved.
- Generate statistics on drivers, for example which age group is more prone to accidents. These statistics can then be used for formulating personalised insurance packages.

6.3. Fleet management

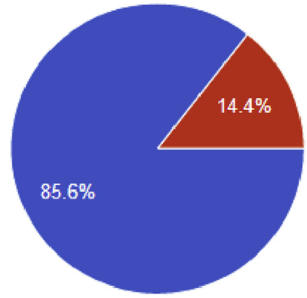
Vehicle fleet management systems are being adopted by more and more companies to monitor a range of parameters such as vehicle maintenance, driver behaviour and fuel management. The proposed framework can be used by

Table 4
Survey results.

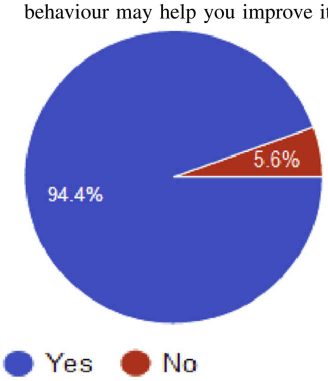
Would you like to get real time information about your driving pattern/practices in your vehicle while you are driving?



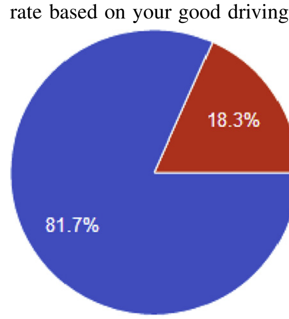
Would you like driving information to be relayed to you by voice commands or audio alerts on your mobile phone?



Do you believe that getting to know your driving behaviour may help you improve it?



Will you be agreeable to share your driving information? For example, to obtain a discounted insurance premium rate based on your good driving skills?



companies for fleet management purposes. Information from the OBDII devices from the vehicles in the fleet can be displayed on a dashboard and monitored in real time. The system can be used for remote diagnostics of vehicles therefore allowing maintenance and repairs to be scheduled at the earliest. The proposed framework can also provide information on driver behaviour such as maximum speed, rapid acceleration and harsh braking. Fuel use, trip duration and trip distance can also be tracked.

7. Survey

An online survey was carried out to evaluate the acceptance rate of the proposed framework. One hundred and eighty people responded to the survey among which 52.8% were in the age group of 18–25, 26.7% were in the age group of 26–35, 15.6% were in the age group 36–45 and 4.9% were in the age group above 46.

81.6% of the respondents were using the Android platform, 11.5% were using the iOS platform, 4% were using the Windows platform and the remaining 2.9% were using the Symbian and Blackberry platform. Respondents were also asked about the type of communication that their mobile phone support and 95% of respondents phone had Bluetooth connectivity and GPRS/4G/5G communications. Table 4 below summarizes the result of the other questions in the survey.

8. Conclusion

In this paper, a framework for safer car driving in Mauritius has been proposed using OBDII module and a mobile device. Data obtained from cars can be relayed to the IBM Cloud Platform where analytics is applied on historical data to provide useful alerts to the driver. One of the main objectives of the system is to model driver behaviour based on specific regions, road infrastructure and vehicle condition. The framework can therefore help drivers to adjust their driving skills and avoid accidents. This framework can also be used by local authorities and insurance companies and any other organisation dealing with fleet management. The survey carried out also confirmed the feasibility of the proposed framework where more than 80% of respondents have shown their interest in using this type of system.

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