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Research paper



A Study of Connected Vehicle for Vehicle Maintenance

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Abstract

Connected Vehicle Maintenance System is a system that is developed to assist car owners from facing problems especially when there is a vehicle breakdown. Vehicles in Malaysia do not have any available platform system that can provide assistance, diagnostic and telematics services to car owners. As vehicles are connected with various components of vehicle control unit, huge number of data are generated. Gathering this data has become a part of the connected vehicle research scope. However, car owners do not understand raw vehicle data unless their vehicles are brought to a service center. Thus, enabling in-vehicle system to interpret and monitor this data is an advancement of technology and provides a convenient driving environment for car owners.

Keywords: *data; diagnostics; real time notification; maintenance system*

1. Introduction

The automotive industry is looking forward to conciliate the driver's necessity. The advancement of connected vehicles focuses on few key elements such as safety & security and maintenance & diagnostics. With technology advancement, innovation continues to accelerate, particularly in regards to the quality and time of service and repair. The connected vehicle is certainly at the stage to set telematics technology on an important phase. The potential of telematics ensures car owner able to know their vehicle condition.

In traditional maintenance, car owners are advised to take their vehicle for regular service and repair after a specific mileage or if there is, any faulty issue found in the vehicle. It is also advised to car owner, to take their vehicle for service and repair within three months of the last service date or have travelled more than specific kilometers [1]. Another example is that, if there is any breakdown or unavoidable malfunction in the vehicle, car owners can bring their vehicle to the nearby service center.

Although this is the method, which is being practiced ever since vehicles are on the road, there are some drawbacks of having a traditional maintenance. The most common one is the cost of service is high if the vehicle is required to be serviced or repaired based on a schedule [2]. For an example, if the vehicle parts are still in a good condition, and it has reach a specific mileage, the vehicle needs to go for a service and some of the parts will be replaced due to the procedure of common service and repair. Besides, there is no information known, if a vehicle parts are having issues and might result to breakdown. Thus, if there is vehicle breakdown, car owners has to spend more for the towing expenses and as well for the repair and service.

Taking the traditional process into a progression concept, rather than a vehicle getting serviced and repaired on scheduled, if there is a system that could analyze and transform vehicle condition data into a meaningful form, this will be a solution for the car owners and as well the automotive industry [3]. The system will act as a middleware to link vehicle condition data and human computer interaction (HCI). The development of the system should focus on understanding the data received from vehicle and to display the information to the car owner.

There are many research work carried out in the area of telematics, diagnostics and maintenance. In some of the work, the discussion is focused on how to read and collect data from vehicle. On the other hand, some work are using predictive maintenance techniques. However, in this paper, the development is focused in the context of Malaysia made vehicle. This research adapts the Internet of Things (IoT) technology to build a vehicle maintenance system, which provides a low cost platform for car owners to experience in driving environment.

2. Literature Review

From an overarching perspective, car-related data can be divided into two different data sources, which are operating data and historical data. Operating data is generated from a vehicle and its monitored sensors. Operating data excludes all kind of information that is brought into the vehicle by car owners. However, with advancement of technology, the number of connected and monitored working parts is continuously increasing, and subsequently leads to rising amounts of data [4].

Most interesting is information that contains suspicious issues related to parts that are stored in the form of a Diagnostic Trouble Code (DTC). Many DTCs have been diagnosed in the past and the solutions are stored with car manufacturers and service center. However, there is still a huge number of problems, which have not yet been clearly diagnosed. In this case, the code indicates which vehicle parts in particular are affected and should be examined. Typically, the code is read via the OBD-II interface. In this context, frequency, amount and type of data recorded [5].

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On the other hand, there is historical data about vehicles from car manufacturers and service centers. This information is expected to be quite structured compared to the real-time operating data. It relates to specifics of the vehicle, such as engine or fuel type. In addition, historical data, especially when combined from multiple service centers, contains useful information with regard to past issues. Hence, when a DTC is read out, the solution to this problem might already be apparent to the mechanic. It is obvious that the more structured and integrated data is available, the better is its utilization and incorporation in maintenance processes [6].

Geotab is a company that provides a web-based fleet management software. The fleet management software, MyGeotab, collects data and transforms it into useful information that businesses can utilize for making better decisions. For example, most customers of Geotab wants to understand how fuel consumption is impacted by driving habits, the time of day when driving (this sentence implies that different time of the day, like morning/evening/night affects fuel consumption differently), and the model of the vehicle. The software normalizes the data to a common measurement, such as U.S. gallons, imperial gallons, and liters, for easier understanding when managing one's fuel consumption [7].

On the other hand, Bosch focuses on predictive diagnostics, which could reliably prevent breakdowns of vehicles using vehicle data. Vehicle breakdowns are troublesome and can be quite costly. In many cases, vehicle failures can be avoided through proper maintenance of the vehicle. However, the components of a vehicle wears out gradually; it can be hard to determine when it is necessary to send a vehicle for maintenance. The innovative prevention diagnostics software solution from Bosch continuously monitors, evaluates and reports component and system conditions in the vehicle. Based on data from the connected vehicle as well as cloud information, faults can be predicted and fixed before a vehicle breakdown [8].

Continental has expanded its view on remote vehicle diagnostics (RVD). The RVD solution is a flexible platform that enables customers, partners, and service providers to establish diagnostic-centered services on the platform or integrate partial and full RVD functionalities into their own solution. The benefits of the RVD are, providing cloud-based platform to utilize diagnostic information in order to create comprehensive services and having predictive maintenance notifications and recommendations for better vehicular maintenance that also includes fault analysis with suggested solutions [9].

Similarly, Tech Mahindra has provided remote vehicle diagnostics solution that monitors the health of the vehicle, determines the root cause of the problems encountered and provides real time information of vehicle parameters to assess its performance against benchmarks. The system monitors the health of the electric vehicles, commercial vehicles, utility vehicles and provides insight to field support staff for determining the root cause of the problem. It also enables the customers to access information about the vehicle. Commercial/Utility vehicles that are being driven across the country extensively are in need of a diagnostic check, which is automated through the system [10].

Another automobile manufacturer, Chevrolet, has introduced the OnStar proactive alert system for maintenance issues. The predictive technology enables the vehicle to warn drivers about potential maintenance issues. The OnStar Proactive Alert system continuously monitors the condition of the vehicle's starter motor, fuel pump and 12-volt battery. If any of these parts are not functioning properly, OnStar notifies the driver to take their vehicle in for service. This new predictive technology works by collecting a small batch of the vehicle data. The collective information is monitored on an ongoing basis and will quickly identify any disturbances or changes in a particular component. The system identifies any potential maintenance issue and brings it to the driver's attention [11].

With all the advancement of technologies in automotive industry, our national cars are yet to align with the global vehicle standard. As seen from statistics, the number of people killed on Malaysian roads continues to rise each year, with driver behavior, environmental factors and vehicle conditions being identified as the main causes of accidents. Chief executive officer of Computerised Vehicle Inspection Centre (Puspakom), Mohammed Shukor Ismail, mentioned that out of the 7,152 deaths recorded in 2016, 20.8 per cent of them involved vehicles. He also added that the rate of road crashes increases each year, with 521,000 accidents recorded in the same year. The government has set a goal to reduce road deaths and severe injuries to half by 2020. Every driver plays an important role when it comes to road safety, and it should start with ensuring the safety and roadworthiness of their vehicles. Only then, accident rates, which are especially high during the festive seasons, can be decreased [12].

One of the important elements in preventing accidents is vehicle inspection, although it is the least contributing factor towards road crashes. Just like medical examinations, a vehicle needs regular inspection to ensure it is in a good state. Many people think sending their vehicles for regular maintenance is enough. This assumption is wrong because the aim of vehicle inspection is to ensure that their vehicles are road roadworthy by conforming to the Malaysian safety and environmental regulations. Vehicle inspection enables drivers to detect potential defects in their vehicle. Early detection followed by appropriate rectification and maintenance can enhance the roadworthiness of vehicles and prevent drivers from forking out huge amounts of money for major repair works caused by accidents. However, in Malaysia, technology of in-vehicle inspection is not available to all vehicles yet, as it is limited to premium vehicle brands only.

3. Proposed Study

In most of the cases, drivers refuse to take their vehicle to car service trying to avoid the cost it will take to service the car. However, the fear of the cost, which may lead to, interrupted scheduled services will result malfunctions in the car if seen for the long run. It still causes the newest car to face malfunction while on the go, for instance, dead batteries and flat tyres. It will cause double the malfunction to vehicles that are 10 years or older with difficulties finding for repair facilities.



Fig. 1: Use Case of Car Service Process

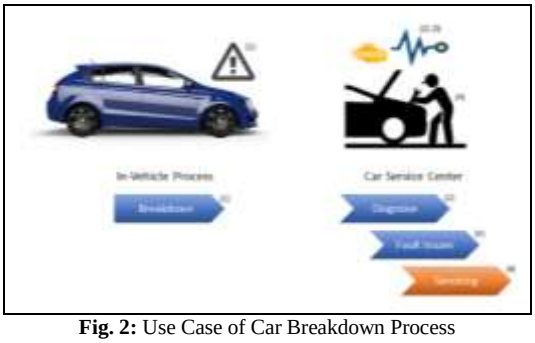

Fig. 2: Use Case of Car Breakdown Process

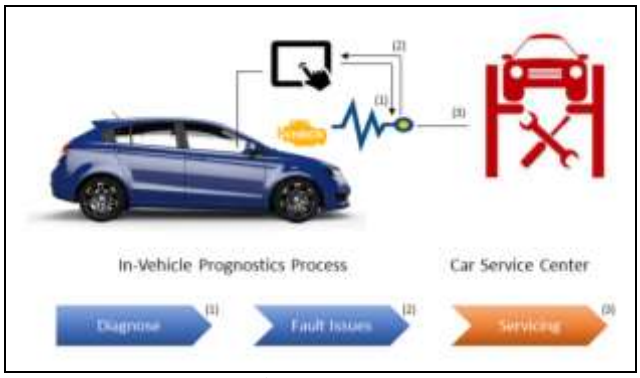

Fig. 3: Use Case of Proposed Maintenance Process

For an example, in a traditional maintenance, the car owner drives their vehicle to service center. Based on Fig.1 and Fig.2, the vehicle will be then diagnosed to find the faulty issues. Based on the issues whether it is ordinary service or breakdown, it is then repaired and service. In contrast to that, the proposed process of maintenance will diagnose the vehicle through an in-vehicle platform system. If there is a faulty issue, the data is recorded in the system and displayed to the car owner as shown in Fig.3. If the fault issue triggers to be an important vehicle problem, it will prompt an alert to the car owner to proceed for a service or repair. As soon as the car owners drives the vehicle to the service center, the person in charge of the service center will extract the data that has be diagnosed and proceed with the service and repair. This will reduce the manual work of diagnose first, fault identified and then service.

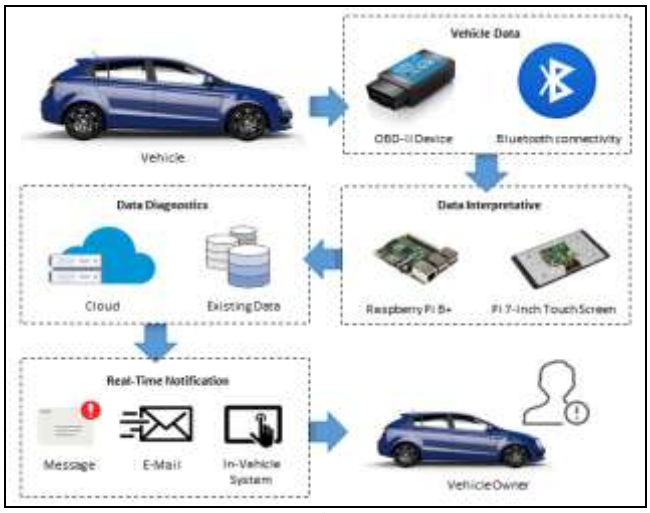

Fig. 4: Framework of Maintenance System

The framework of the system is shown in Fig.4. As soon as the engine is turned on, the OBD-II starts collecting data constantly. At that point, the system analyzes and refines the data in the vehicles. It will then display information of the vehicle's condition to the car owner. In the event that the information shows a specific part has some fault, the system will subsequently send the car owner a real time notification through either the in-vehicle system display, text messages or email.

Vehicle Data

As the engine is turned on, the OBD-II is connected to vehicle through a Bluetooth connection. It will the initiate a process to receive raw data constantly.

Data Interpretative

The raw data is processed to ensure the system is able to display the information to the car owners through the Dashboard Interface.

Data Diagnostics

The processed data is analyzed to ensure if there is any issues in the vehicle. If there is any information that could result to faulty issues. The data is then send to the cloud for existing data comparison.

Real-Time Notification

If the analyzed data confronts there is a fault issue in the vehicle. The system will alert car owners through either the in-vehicle system display, email or text message. This ensures the car owner aware of their vehicle condition.

4. Result and Discussion

The integration of the Raspberry Pi 3 is initiated with pairing the OBD-II device. The connection is established through Bluetooth connection. As soon as the connection is successful, the raw data is generated from the vehicle itself to the system. In Fig.5 shows the startup of raspberry pi 3. The raw data that is generated from the engine control unit (ECU) is refined through a backend development code to ensure the Dashboard Interface is updated with six universal maintenance information, such as engine status, battery level, tyre pressure, oil pressure, engine rpm and timing. As this development is a proof of concept, only selected data are defined through the backend development code. In Fig.6 shows the Dashboard Interface of the vehicle maintenance system.



Fig. 5: Raspberry Pi Start Up

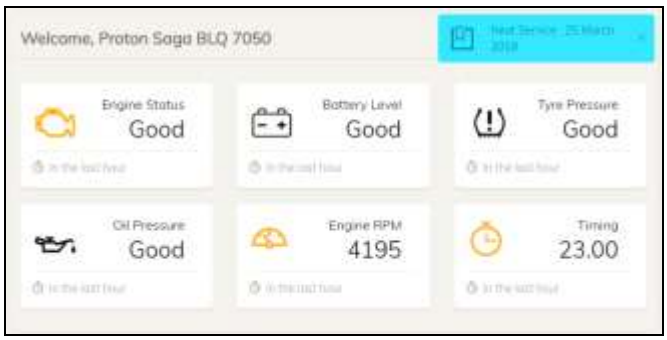

Fig. 6: Dashboard Interface of Vehicle Maintenance System

Based on the generated raw data, the system will also send the data to the cloud to compare with existing data for fault issues consideration. If the data is present in the existing data, the system will automatically alert the car owners of potential fault issues through in-vehicle system, email or text message. In Fig.7 shows the data that has been retrieved and stored in the Firebase Firestore.

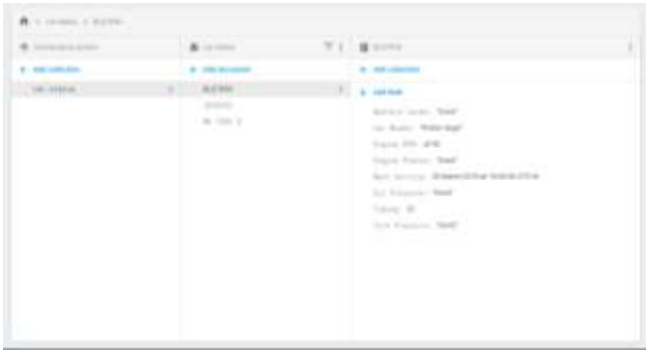

Fig. 7: Firebase Firestore Maintenance System Data

There are benefits that the proposed system can provide; however, its implementation still faces certain challenges. The maintenance system eases the issues of traditional maintenance by reducing the diagnostic work and time. It also provides certain decrease in service and repair costs, as all parts are only repaired or replaced when necessary. A real time notification of possible faulty parts is crucial, as it is able to alert the car owners about potential issues with the vehicle before it breaks down. The vehicle data can be utilized to see how vehicles perform over timeframes and in various areas. This will better connect the car owners with the car manufacturers and service centers. In contrast, imposing maintenance system in automotive industry is quite challenging. Some of the challenges are regulatory policies and deciding on what sort of data can be exchanged.

5. Conclusion

"Connected vehicle" is a term that is becoming more prevalent in the automotive industry these days. Emerging into the era of autonomous domination in the domain of connected vehicles, Internet of Things (IoT) plays a huge role in the progression of technologies related to said domain. Advantages of the proposed maintenance system over a traditional maintenance include reduced cost, ensures the vehicles are systematically analyzed and enables car owners to better understand their vehicle condition.

A possible future feature for the proposed system is to adapt to data generated from new vehicle models. The data received by the proposed system is sent to the cloud for analytics purposes. By storing the data in the cloud, even if the vehicle were heavily damaged in an accident, the data would still be intact and can be used to better understand the cause of the accident. The data gathered by the system can be utilized to decide whether the vehicle has been subjected to regular maintenance. Besides, the driving behavior of the driver can be inferred using certain features of the data such as RPM and speed of the vehicles. Based on the data analysis, drivers can be categorized into different behaviors such as careful or reckless.

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