An IOT Design to Predict Mechanical Failure in Vehicles and Effective Replacement

S.S.Akilan, D.Kayathri Devi

Abstract:As there is an increasing need for monitoring the mechanical failures in the vehicle to ensure the high safety of the customers by avoiding possible accidents, researches have been going on using IoT. However, many failures occur on vehicles due to lots of reasons, here proposed an IoT based framework to address the way to quick and effective recovery from most of the common critical failures. In this work a set of sensors and microcontrollers (MC) are used to continuously monitor the critical factors of the vehicles, the data gathered by the sensors are mined to predict the possible future failure prediction. This research shows a positive outcome to predict the possibility of failures with higher accuracy.

Index Terms: Failure prediction,Vehicle Monitoring, Internet of Things (IoT),Data Mining.

I.INTRODUCTION

Failure prediction is an important research area in IoT. The efficient replacement of mechanical parts may increase the quality of service with cost efficiency. According to general survey lot of resources were spend in the manufacturing of replacement parts to support the customer needs, the major problem is that the manufacturer can't possibly know the exact amount of particular replacement part needed by the customer, then some series of replacement parts have been kept stored for longer time and it gets degraded in quality by itself. In other hands, the customers can't able to find some parts and had to look all over the showrooms for a particular series of a replacement part. This work focuses on all kinds of vehicles including the two-wheelers to monitor then predict and take precautions for most of the failure. Here with the help of existing network vehicular network may provide reliable data transfer. A lot of technologies has been combined to meet the entire requirement. That causes generation of an enormous amount of data so- called big data [1, 2,25]. To store and manage the big data, cloud [7] and machine learning algorithms are used as it helps things to understand the environment and take the decision of its own by communicating with other vehicles in the network [3]. The data from the vehicular network is sensitive as it holds all kind of information about the vehicle, to ensure security several kinds of research like cloud-based lightweight multi-layered protocol [5,6] has been done to encrypt data at real-time [4]. The key aspects of our work are.

- ✓ **Real time monitoring:**By using a set of sensors and microcontroller the vehicles are monitored to observe changes occurred in the system to analyze critical failure factors.
- ✓ **Data gathering:**With the help of microcontrollers serial monitoring, data from Arduino are stored in a query based database like MySQL etc.,
- ✓ **Failure prediction:**On further analysis, data mining algorithms are applied to analyze the data to identify the critical point of failure if any yet to happen.

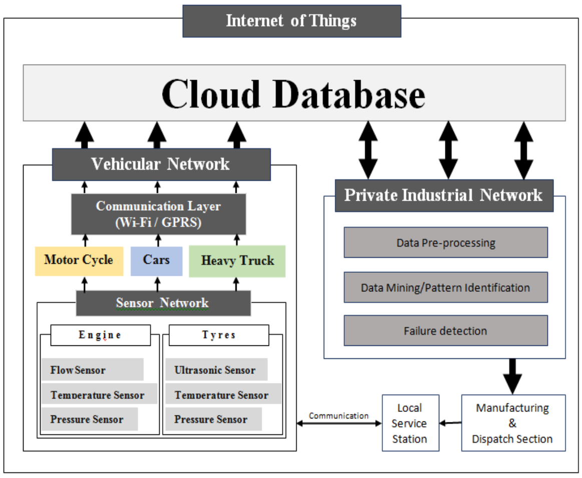

Figure 1. IoT based architecture diagram for failure detection.

The above figure 1 shows that the complete architecture of the IoT based failure prediction. Simply data is gathered from vehicles and stored in a cloud database then fetched by the manufacturer to be pre-processed and failure detection is carried out by using data mining technology. Here different and suitable technologies were used to plan and execute a task together [8,26]. The result shows that due to IoT based monitoring, control and replacement of the proposed system helps to increase the level of control over the vehicle[27,28]. Here also analyzed the engine temperature, vibration, and fuel level [9] etc., Then possible accident risks were also minimized.

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II. REAL TIME MONITORING

In real time monitoring instead of tracking vehicle location, the working status of the vehicle is monitored from remote location [10]. So that if any possibility of malfunction/failure is predicated on the system, the needed action is carried out immediately to avoid critical failures in real time. Real-time monitoring mainly focuses on critical places likes engine and wheels.

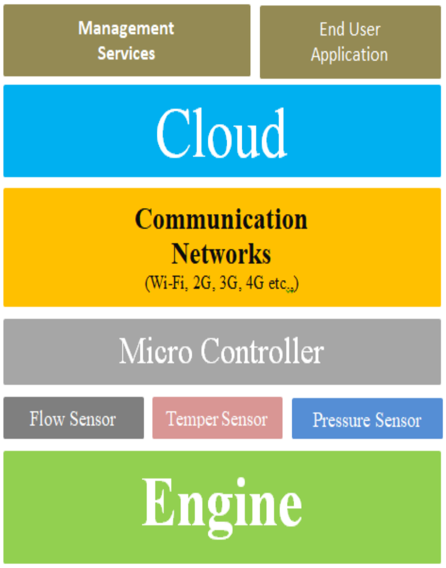

Figure 2. Real time failure detection.

Here the above figure 2 shows that the failure detection of tire thickness in real time the same can be implemented for engine failure and pressure drop etc.

A. Engine health monitoring

Speaking of the four-wheeler, most of the engine problems still occur due to heating issues caused by improper ventilation or overrunning beyond its ability. Malfunction[29] of cooling fans and insufficient coolant causes a heating problem. It is observed that cracks form in alloys due to improper stress and heat.

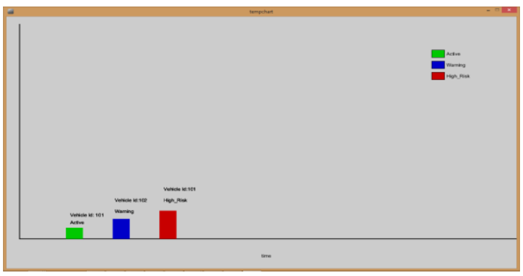

Figure 3. Engine Health Monitoring.

The above figure 3 shows that the layers of engine health monitoring system. Engine prognostic and health management helps to prevent engine failure and reduces the maintenance cost [11]. Crankshaft in the internal combustion engine that converts the displacement motion of the piston into rotary motion, most of the crankshaft are produced with forged steel because of its low voids and damage compared to other steel crankshafts [12]. To achieve rapid cooling and decrease the possible cracks in engine liquid nitrogen is used as a coolant. Here a set of temperature and flow sensor is used to analyze the engine temperature continuously, then based on a threshold value the flow sensor is triggered and the coolant is made to flow over the engine to dissipate the heat from the surface. In case of rapid cooling failure, an emergency shutdown mechanism is triggered by cutting off the fuel

supply to prevent the engine from causing fire or explosion[30,31]. Here used a dash controller to shut the engine down without causing any change in the air intake and it is an efficient way to hold the system in standby stage [13].

B. Wheel health monitoring and maintenance

Wheels are one of the critical parts in vehicles as most of the accidents happen due to improper wheel maintenance. In the case of the wheel, three different aspects such as pressure, thickness, and temperature were monitored to ensure transportation safety. The effective replacement of bolts and tires were carried out in need. For that, an effective inventory management system is proposed by kaanozbay et al [14]. In some researches, vehicular ad-hoc network-based accident prevention is used to alarm the driver [15].

C.Pressure maintenance

According to research 40% of drivers in the United States and Europe barely control the tire pressure and in Europe alone, more than 60% of passenger cars have low pressure resulting in the safety risk. When the tire pressure is low it causes sides to drop and uneven tire wear. Then causes the reduction in control over the vehicle [16]. The low-pressure tire also causes the high risk of understeering, oversteering, high risk of puncture and tire explosion etc., a research in Nigeria shows that 75.4% of tire replacement is because of the uneven tire wear pattern resulting from the effect of improper contact of the tire and the road [17].Thus research such as checklist to avoid accidents was also done to minimize the possibility of accidents in industrial campus [21, 23]. Then also injury prediction method was also implemented to improve health care services if the accident happens [22]. In some cases data mining techniques were aslo used to predict the accidents in prone locations[24].

To avoid this kind of situation a pressure sensor is placed inside the tire to monitor it continuously and data is transferred to the Arduino microcontroller. Then the data is processed and notification is triggered to instruct the driver. The below figure 4 shows that the notification message from the GSM (Global System for Mobile communication) module embedded in the vehicle.

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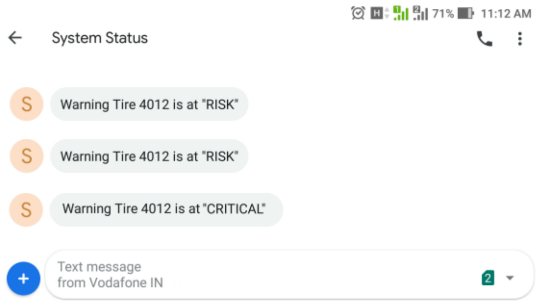
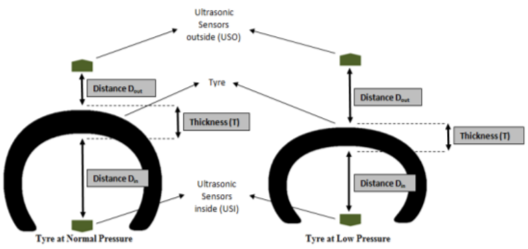


Figure 4. Tyre Pressure Alert system.

The alert messages have also been sending to the person in charge using the GSM shield. With the help of these systems, the tires can be replaced effectively at right time. The above Figure 4 shows that the message alert system. The modules used are GSM shield, ultrasonic sensor and temperature sensor.

D. Thickness Measurement



Short Message Service (SMS) to the manufacturer using GSM shield through 2G network

E.Temperature maintenance

Another cause of an accident is rapid heating of wheel rim in heavy load vehicles. Here the wheel rim will overheat rapidly due to the pressure and load then causes bolt thrown off while running. To avoid this kind of critical situations the rim temperature is continuously monitored with the help of the thermostat (temperature sensor) connected to the MC then an alarm is triggered when the temperature reaches its threshold.

Figure 6. Temperature maintenance of a tyre

The above figure 6 shows set up for both the temperature and tire thickness maintenance system. A scooter tire was used for the experimental purpose. The tire chosen is with the varying thickness. A temperature sensor is fixed inside the rim and Ultrasonic sensor is fixed at fender in scooter part.

III.DATA GATHERING

In IoT data gathering from sensors is an important aspect. Here data from the sensors were gathered using a developed module and transferred to the cloud using ESP Wi-Fi module. Data transferred by the devices is received using Wi-Fi then stored in SQL (Structured Query Language) based database on the cloud using Processing engine

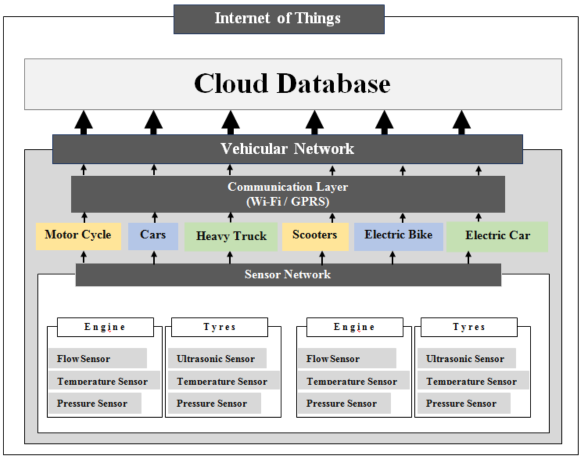


Figure 7. Data gathering and storage in cloud

The above figure 7 shows that the data flow from bottom to top level in the architecture diagram. As shown in the figure the ultrasonic, temperature, pressure and flow sensor lies under the sensor network where all the sensors and its controllers are interconnected to each other to form a strong network in a single vehicle. The data from the vehicle is transmitted from the vehicular network to cloud using Wi-Fi at the service station or petrol bunk in absence of regular network otherwise data transmission is done using standard mobile GPRS (General Packet Radio Services) connection. Here with the help of the communication technologies a private virtual network and a temporary end to end connection is established [18]. As the objects in the vehicular network move from one place to another the dynamic routing protocol is used [19].

IV.FAILURE PREDICTION AND ENHANCEMENT

The below table 1 shows the data observed from ultrasonic and temperature sensor to track the working condition of the vehicle tire for every certain interval of time. The key work Ultra_Active denotes that there is no issue in tire thickness and Ultra_HighRisk denotes that the thickness of tire is lower than the threshold value. Similarly, Temp_Active denotes the temperature of tire bolts are at acceptable and Temp_HighRisk denotes that the temperature of bolts is higher than the threshold value.

Table 1. Failure detection data for vehicle tyre

Vehicle ID	Thickness	Temperature	Thickness Status	Temperature Status
101	60	24	Ultra_Active	Temp_Active
102	60	24	Ultra_Active	Temp_Active
103	60	24	Ultra_Active	Temp_Active
104	44	34	Ultra_High Risk	Temp_High Risk
105	60	34	Ultra_Active	Temp_High Risk
106	42	24	Ultra_High Risk	Temp_Active
107	60	24	Ultra_Active	Temp_Active
108	60	24	Ultra_Active	Temp_Active
109	53	24	Ultra_Warning	Temp_Active

In failure prediction, the data will be monitored to attain details about the wheels to get the failure, the probability of failure is calculated to handle product quality on a certain factory at a certain time. In a lot of cases, failures occur due the environment changes thus environment worthiness is also measured. So those vehicles and its electronic hardware is enhanced to withstand on harsh condition [20]. To achieve better enhancement environment stress analysis is carried out with boundary prediction.

Table 2 below shows the categorization of the vehicle depends on the observed sensor value. Here vehicles are categorized in three different categories and prioritized depend on it. Thus, manufacturers can extend their deadlines and increase service quality.On the customer side, they are provided with service over internet facility so they can view the status of their registered vehicle and place the order manually or automatically. The service is also designed to be configured. So, depending on the configuration defined, priority will be provided for better utilization of resources.

Table 2. categorization of vehicle based on sensor value

Vehicle ID	Sensor Status	Category
101	Ustatus="Ultra_Active" &&tempstatus ="Temp_Active"	Best
102	Ustatus="Ultra_Active" &&tempstatus ="Temp_warning"	Best
103	Ustatus="Ultra_Active" &&tempstatus ="Temp_High_Risk"	Worst
104	Ustatus="Ultra_warning" &&tempstatus ="Temp_Active"	Better
105	Ustatus="Ultra_warning" &&tempstatus ="Temp_warning"	Better
106	Ustatus="Ultra_warning" &&tempstatus ="Temp_High_Risk "	Worst
107	Ustatus="Ultra_High_Risk" &&tempstatus ="Temp_Active "	Worst

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108	Ustatus="Ultra_High_Risk" &&tempstatus ="Temp_warning "	Worst
109	Ustatus="Ultra_High_Risk" &&tempstatus ="Temp_High_Risk "	Worst

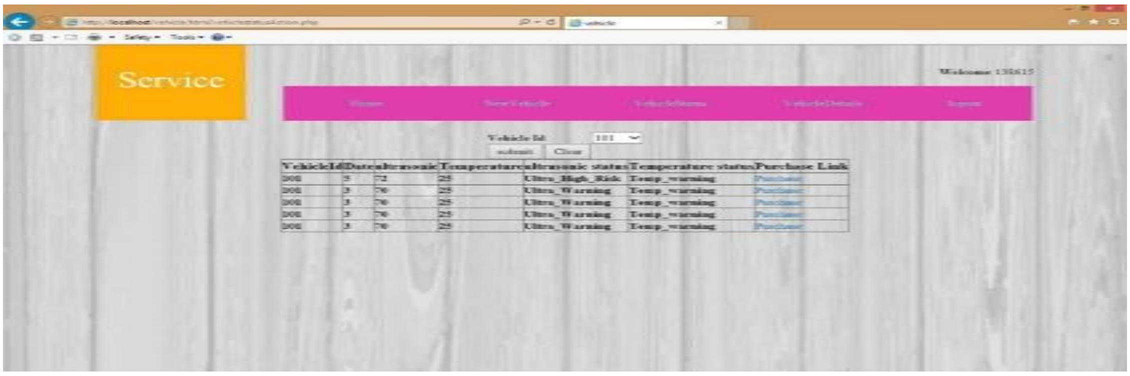

Figure 8. Service Interface for End User

The above figure 8 shows that the end user service interfaces so that the user may place and manage their order then able to keep track of their vehicle status in detail.

V. CONCLUSION

With the help of IoT based framework for vehicular failure prediction, the order placement may be improved with the fastest replacement than ever. Using this service, the following key aspects were achieved.

1. Future device failure is identified before it occurs.
2. The manufacturer can able to predict the quality of their products based on replacement rate.
3. Increase in product production rate is predicted early.
4. Predict product lifetime for certain manufacturing plant.

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