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Predictive Maintenance Approach on Automobiles

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***Abstract*—** The main purpose of this paper is exploring the fact that how to use a machine learning model in order to perform predictive maintenance on Automobile. Maintenance and Care play a key role in the smooth and safe running of your motorcycle. The goal is to predict when the automobile require service or maintenance. If the model runs successfully, it gives us enough data about determining what the problem is and not only providing the necessary solutions but also ordering the parts and scheduling the people necessary to repair it. The innovative solutions of Predictive Maintenance recursively monitor, evaluates and report the component and system conditions in the vehicle. Various techniques are discussed and tested, such as linear and quantile regression. The primary aim of the system is to increase the vehicle's efficiency due to the observed and supervised driving behavior which is able to minimize the fuel consumptions and exhaust. Based on received data from the various connected vehicle and transmitting it to the cloud i.e. Azure where the processing of the data takes place, errors are predicted and fixed before time and with less damage of vehicle whereby reducing the overall cost of maintenance.

Keywords— Predictive maintenance, machine learning automobiles, 2-wheelers, Internet of Things, AZURE.

I. INTRODUCTION

If you Google, you would notice that India has the maximum number of motorcycles/mopeds in the world. While the economic growth of the industrial sector has grown rapidly due to the automobile, but it also comes with its own cons, such as high consumption of non-renewable resources like petroleum resulting in the emission of high pollutants in the atmosphere.

In this study, the aim is to find the major underlying features that affect the performance of the vehicle, by creating an object model for predictive maintenance. The obtained outcome can prove to be useful for vehicle manufacturers, two-wheelers to be more precise, as a reference on how to improve the performance by taking into account certain features that are determined to significantly affect vehicle's efficiency[1].

It is acknowledged that vehicle efficiency is influenced by a variety of features, including engine displacement, size of the vehicle, its total weight, aerodynamic performance. Real-world vehicle data, including vehicle characteristics and their corresponding performance efficiency, was utilized for analysis and modeling[2]. As a vehicle owner you must ensure that the correct operations of your motorcycle, mainly engine, breaks, and frame which is essential for a vehicle.

These components are subjected to a high level of mechanical stress and directly impact your day to day life[1]. 80% of the vehicle shutdowns are due to mechanical failures of these components which can cause their degradation and results in unplanned shutdown[3]. A faulty engine most commonly brings a mileage drop[4] as an early indication or a damaged frame will induce cavitation which may cause vibration and degradation of the bearings and coupling faults. Break damage is generally due leakage of oil of due to the overtime damage and other components are among the causes of accidents with serious consequences for the safety of you and your vehicle as well as the environment or the other people if these events are not detected in time they will increase and lead to the destruction of the equipment and the failure of your motorcycle it is commonly accepted that repairing faulty equipment is 50% more expensive than preventing a failure an incident on this equipment will always entail costly repairs security risks and loss of time what if you could detect these events early with 'OUR' predictive maintenance solutions you're able to diagnose these causes of failures simply and inexpensively[1][2] the detection of these events as soon as they appear will allow you to plan an intervention by limiting the costs and avoiding a full vehicle shutdown you can also quickly comply with changes necessary to keep you safe and your vehicle running, switching from a reactive mode to a predictive mode will allow you to increase the availability of your motorcycle

while reducing your maintenance budget other heavy vehicles like Volvo TRUCKS have already set up some sort monitoring solutions for their fleet and have achieved significant and measurable gains[3].

In this paper, various predictive maintenance techniques are discussed and their relevance to solving the problem. The paper in section II debriefs us about the maintenance and terminologies related with Azure later the various methodologies are discussed in section III. Section IV offers the features and advantages of using predictive maintenance, Cost saving is a big part of predictive maintenance and is elaborated in section V, and this the paper ends with a conclusion and relevant articles addressing the references and acknowledgement.

II. PREDICTIVE MAINTAINANCE

Predictive maintenance predicts failures, and the actions including corrective actions, the system's replacement. This can lead to cost effectiveness, high predictability, and increasing availability of the systems[5].
Predictive maintenance savings have majorly two forms:

- Avoid or minimize the unavailability: This will avoid a customer's anger, save capital, and sometimes save lives as well [5][6].
- Predictive maintenance avoids both the outliers and increases the use of its resources. Predictive maintenance will detect the divergence and failure patterns and provide early warnings which would enable efficient maintenance of the components [5][6].

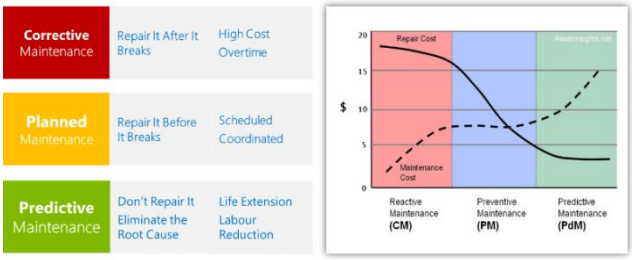

Figure 1. Comparision between different maintainance schemes.

Predictive maintenance (PdM) techniques are implemented in order to help detect the condition of in-service equipment to predict the time of performing maintenance. This approach is a cost saving or time-based preventive maintenance since tasks are performed only when warranted not else.

The major objective of predictive maintenance is to provide convenient scheduling corrective maintenance, and also to prevent unwanted component failure. The key is "the right information at the right time". By having a knowledge about which component needs maintenance, maintenance work can be well organized and planned and anything that would have been **unplanned stops** are converted into simpler and fewer **planned stops**, and hence improving the availability. Several potential advantages will include better component's lifespan, enhanced plant safety, lesser accidents with a negative impact on the environment, and providing an optimized way of handling spare parts.

Predictive maintenance differs from preventive maintenance, as it depends on the actual condition of the component[6], instead of average or approximated life statistics, for predicting when maintenance will be necessary.

Predictive Maintenance and the Internet of Things
With the advancements in networking of machines and production facilities in the Internet of Things[5], predictive maintenance has gained importance. Sensors provide easy monitoring of machine condition[2], cloud storage (AZURE) systems and databases enable a long-lasting catalogue and analysis of machine-based data for maintenance purposes.
By means of dynamic monitoring, a comprehensive data pool, and analytical methods, machine-specific break down can be predicted by 70 %. This helps the technicians to materialize in time in order to effectively prevent failures and also avoid unnecessary downtimes, measures, costs[1].
However, the advantages of the IoT and predictive maintenance are not limited to new facilities. Older machines with a lifespan of 50- 60 years can easily be integrated into predictive maintenance schemes by means of targeted retrofit measures this can be using the cloud technologies[7].

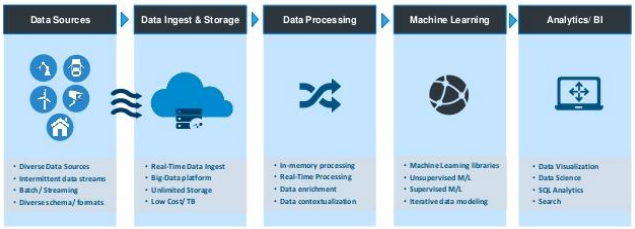

Figure 2. Predictive Maintenance – The Data Value Chain.

AZURE
Microsoft Azure is Microsoft's public cloud computing platform. It provides numerous cloud-based services for computing, analysing, storing and networking. Users have a variety of services and can choose these services for developing and scaling new applications, or also for running existing applications, in the public cloud.

Data storage - This service provides scalable cloud storage for structured as well as unstructured data and provides support for big data projects and persistent storage[7].

Analytics - This type of service provides distributed analytics and features for dynamic analytics, big data analytics, business intelligence (BI), internet of things, machine learning and data warehousing.

Internet of things - These services helps the user to capture, keep a track and analyse IoT data from sensors and devices. Services include notifying, analysing, monitoring and supporting coding and execution.

Development - This service helps application developer in sharing code, testing the applications and tracking potential issues[7]. Azure supports a wide range of application programming languages, like Node.js, JavaScript, .NET, Python, and tools in this category include support for Visual Studio, SDKs and Block Chaining.

Security - This product deals with authentication and authorization purpose and provides capabilities to identify and respond to threats related to cloud security, and also to manage encryption keys and other assets that are sensitive.

Artificial intelligence (AI) and machine learning - This is a wide range of services that are provided to the developer who can use to saturate machine learning, AI and cognitive computing capabilities into data sets and applications.

Containers - These provide facilities which help an enterprise to create, register and manage large volumes of containers in the Azure cloud, using platforms such as Kubernetes And Docker.

Databases - This category includes DBaaS (Database as a Service) offerings for NoSQL and SQL, as well as Azure Cosmos DB and Azure Database for PostgreSQL. It includes SQL Data Warehouse supporting, caching, and hybrid database integration features as well as migration features.

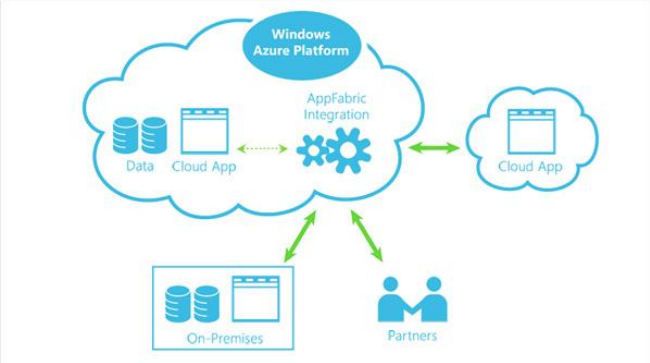

Figure 3. Azure Modules and Functioning.

III. METHODOLOGY

A. Decision Tree

The decision tree is a tree-like structure used for classification, based on the decisions as well as its consequences[6].

A decision tree majorly consists of three types of nodes

1. Decision nodes: It is represented by squares
2. Chance nodes: It is represented by circles
3. End nodes: It is represented by triangles

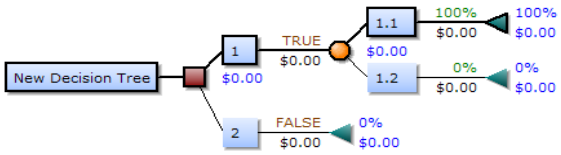

Figure 4. Decision tree.

Decision Rule

The decision tree can be converted into decision rules, where the outcome consists of the contents of the leaf node, and the conditions form conjunction(^) in the 'if' clause.

Syntax: *if condition1 and condition2 and condition3 then the outcome.*

Decision rules can be generated by using association rules with the target variable on the R.H.S called as consequent. They also denote causal or temporal relations.

Decision tree using flowchart symbols

A decision tree is drawn using a flowchart as it is easy to read and understand.

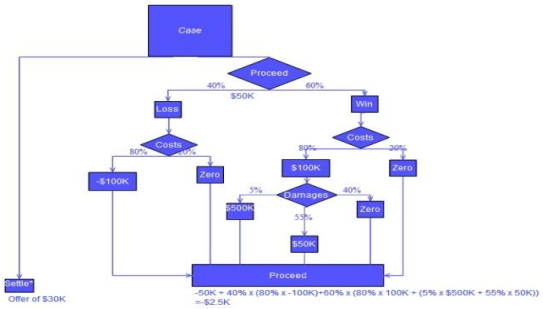

Figure 5. Decision tree flowchart.

B. Linear Regression

This provides the relationship between the dependent and independent variables.

Any linear relation can be defined as:

$$Y' = A + B * X \quad (1)$$

Let's see what these numbers mean.

Considering X is in our data, our IQ scores- we can determine the performances if we have the value of intercept (A) and the coefficient (B).

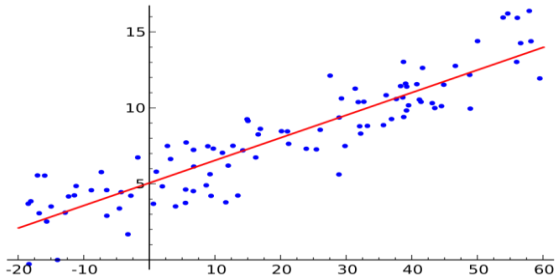

Figure 6. Linear Regeression

Least Square "Linear Regression" is a statistical method of regressing the data with the variable whose value is continuous (numeric) whereas independent variables having continuous or categorical (binary) values. To simplify this, "Linear Regression" is a method to predict the value of the dependent variable (Y) based on the values of independent variables (X)[4]. It can be used for the case which requires predicting some continuous quantity. E.g., Predicting traffic in a retail store, predicting a user's dwell time or the number of pages visited on Dezyre.com etc.

C. Quantile Regression

Ordinary least square regression is one of the most popular and commonly used statistical methods. It is a parametric model that is based on assumptions which are often false. Quantile regression has zero assumptions regarding the distribution of the residuals[8]. It allows you to explore various aspects of the dependent-independent variable's relationship.

Quantile regression aims at predicting either the conditional median or other quantiles of variables[4]. Basically, it is an extension of linear regression and we use it when the linear regression is not applicable.

One advantage of quantile regression over least squares regression is that the estimates are more robust against outliers.

In ecology, quantile regression has been proposed and used as a way of discovering more useful relationships between variables in scenarios where there is no relationship or only a weak relationship between the variables.

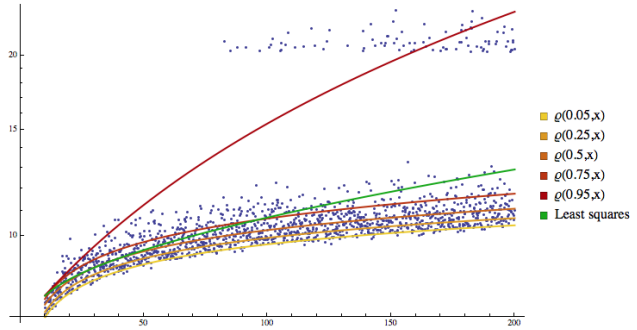

Figure 7. Quantile Regeression

D. Gaussian Process Regression:

A Gaussian process uses lazy learning approach and similarity measures between points in order to predict the value for an unseen point from the training dataset[6]. The prediction isn't just an estimate for that point, but also contains uncertainty information it is a one-dimensional Gaussian distribution[7].

When concerned with general Gaussian process regression problem, it is assumed that for a Gaussian process f observed at coordinates a, the vector of values **f(a)** is just a single sample from the multivariate Gaussian distribution of dimension which is equal to the number of observed coordinates **n**.

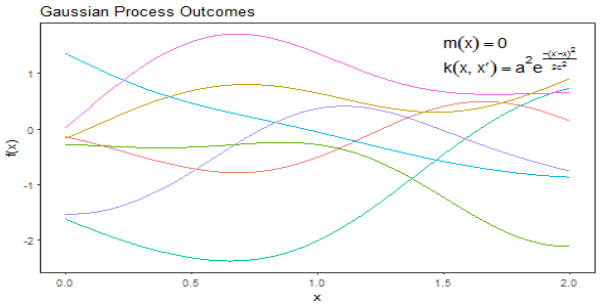

Figure 8. Gaussion Regeression

IV. Features and Advantagesss

Reduction in maintenance costs and services, as only those parts which need to be replaced/serviced are replaced/serviced.

Real-time alerts of possible failures of various parts, and hence avoiding breakdown of the vehicle and costs associated with its outages.

Analytics and reporting dashboards can be utilized to view the performance of the bike,

over the period of time and at numerous locations.

- Optimizing the vehicle's availability by avoiding unforeseen failures.
- Satisfaction of customer through innovative services that are proactive and also providing significantly fewer breakdowns.

Starting with data which provides the description of our system in a wide range of healthy as well as faulty conditions, we develop a prediction model (for prognostics). Development of such a model has requirement of identifying appropriate condition indicators and training the model to interpret it. The process is most likely to be iterative, as we try various condition indicators and variety of models till the time we find the best model for our application. Ultimately, we deploy and integrate the algorithm into our system for monitoring and maintenance of the machine.

V. Cost Saving and Difference

- As far as the cost of maintenance is concerned, preventive maintenance cost per annum is higher as compared to predictive maintenance costs per annum, making predictive maintenance a convenient and cheaper option.
- Also, provided that preventive maintenance sometimes requires the parts to be replaced even when there is no need, also if the technician/mechanic happens to damage the machine during an unneeded service call, unnecessary maintenance can result in increasing the overall cost.
- But with predictive maintenance, several cost savings ranging from minimizing the time when equipment is not working to lowering down the cost of spare parts and its supplies.

• While the initial investment into installing a predictive maintenance program can prove to be costly, it results in reducing the maintenance cost and downtime.
• Other examples, predictive maintenance can often be used for wind turbines, as wind farms often have high operational costs. And field service software can be integrated starting with data which provides the description of our system in a wide range of healthy as well as faulty conditions, we develop a prediction model (for prognostics). Development of such a model has requirement of identifying appropriate condition indicators and training the model to interpret it. The process is most likely to be iterative; as we try various condition indicators and variety of models till the time we find the best model for our application. Ultimately, we deploy and integrate the algorithm into our system for monitoring and maintenance of the machine with predictive maintenance tools to assure that your machine keeps running efficiently.

VI. CONCLUSION AND FUTURE SCOPE

Several regression methods effective on the dataset, including Linear Regression, partial least squares, Quantile regression (QR), Gaussian process regression (GPR), support vector regression (SVR) are utilized for training the model.
The major contribution of the study is to determine the characteristics that affect vehicle performance efficiency significantly and also to accurately predict the efficiency performance from specific automobile attributes via various effective regression techniques.
To achieve the following goal, future work may include exploration of different techniques for imbalanced data classification. Machine Learning highly depend on data if we have suffice data then the model can be build without over fitting and more accurate results can be obtained.
This work will be very beneficial for both vechicle owner and manufacturers more senors maybe implanted to gather even high quality data .

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