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Studies on Predictive Maintenance System for Automotive Braking Using Artificial Intelligence Techniques

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ABSTRACT

In automobile, brake system is an essential part responsible for control of the vehicle. Any failure in the brake system impacts the vehicle's motion. It will generate frequent catastrophic effects on the vehicle cum passenger's safety. Thus the brake system plays a vital role in an automobile and hence condition monitoring of the brake system is essential. Vibration based condition monitoring using machine learning techniques are gaining momentum. This study is one of attempt to formulate an approach & methodology for identifying predictive maintenance requirements of hydraulic brake system. In this research, the various condition based monitoring algorithm will be studied & compared. A detailed study will be performed on Clonal Selection Classification Algorithm (CSCA) improvement and practical application. A hydraulic brake system test rig will be fabricated. Under good and faulty conditions of a brake system, the various signals will be acquired. The statistical parameters will be extracted from the signal. Base algorithm will be established based on the maximum accuracy for the fault diagnosis of a hydraulic brake system. An attempt will be made to develop self-learning model, in order to fine tune base algorithm based on driving conditions & patterns. The Digital Twin of hydraulic brake system will be developed. The On-Board Diagnostic (OBD) data will be used to test & validate the Digital Twin. Finally a predictive maintenance application will be developed to alert driver on current health of brake system & upcoming maintenance requirements.

Keywords: Millennials, Talent Management, Retention, Retention Strategies.

I. INTRODUCTION

Brakes are the most important control components in automobile. Every automobile shall be equipped with an efficient brake system which ensures the stability of the vehicle. An efficient brake system should bring the vehicle to rest within a reasonable distance. The brake system must promote the highest degree of safety on the road not alone for the person driving but also for the others moving on the road. Since there are moving components involved, they are bound to get faulty due to various reasons, viz. wearing, air leak, fade, etc. When such things occur, the effectiveness of the brake system reduces resulting in accidents. It is essential that the brake system and brake components should be monitored all the time and diagnosed when faults occur. Hence maintenance of the brake system plays a vital role in terms of safety.

The malfunction of the brake system can be identified through its symptoms or some warning sign; since the faults in the brake system are not fairly noticeable. Monitoring of a brake system is not an easy job. This can be performed using intelligent techniques called fault diagnosis through machine learning. Such analysis will provide the information required to make a

decision about when intervention is required for maintenance. The results of such analysis can be used for failure analysis in order to determine the original cause of the fault. Combining these results with engineering and manufacturing data of brake system, can be used to predict the health of brake system & identify the maintenance needs.

II. PROBLEM STATEMENT

In many industries inclusive of automotive vehicle industry, predictive maintenance has become more important. It is hard to diagnose failure in advance in the vehicle industry because of the limited availability of sensors and some of the designing exertions. The research in predictive maintenance and prognostics in the automotive industry is small. In particular to Braking System, only a few different methods have been presented so far with no or limited practical application. Thereby, industry is lacking a proven approach & robust methodology to develop predictive maintenance systems for braking system.

III. LITERATURE SURVEY

Following is the partial list of relevant literature to justify research on this topic.

From the literature one can understand that many algorithms have been used for classifying the faults in various machine elements. In order to suggest strongly that a particular algorithm is better, a detailed study needs to be conducted. One such detailed study [1] suggests that the Clonal Selection Classification Algorithm (CSCA) performs better and gives the maximum classification accuracy (96%) for the fault diagnosis of a hydraulic brake system. From the study, one can confidently say that CSC algorithms were found to be good contender and it can be used for practical applications of fault diagnosis of the hydraulic brake system. Hence, a further research work is required to improve classification accuracy of CSCA for practical applications.

To model the fault diagnosis problem as a machine learning problem, a large number of vibration signals are required for each condition considered for study. It may be possible to acquire any number of vibration signals for good condition; however, it is very difficult to acquire signals of different faulty conditions. A detailed study [2] had been performed to determine minimum sample size. This study can be leveraged to determine # of training data set for base algorithm.

There are serious challenges when we deal with prognostic maintenance. Prognostic maintenance copes with onboard data. Development cost of on-board diagnostic is limited in vehicle, which results in limited number of sensors. These sensors produce thousands of signals or data streams when vehicle is on the move. With the increasing trend of smart phones and wireless communication, it has become feasible to use these technologies for real time solutions. Despite limited resources, these technologies are being used along with machine learning approaches to solve big problems in automotive industry. A novel vehicle monitoring and fault predicting system is presented in this paper [3] including VMMS. A further research is needed for practical application.

The research in predictive maintenance and prognostics using on-board data streams in the automotive industry is small. Only a few different methods have so far been presented. Two approaches to predict vehicle maintenance is put forward in this thesis [4]. The first one, presents an unsupervised self-learning method for predictive maintenance based on streaming on-board data. It specifically aims at tackling the bottleneck of manually crafted predictive algorithms by using life-long learning of upcoming failures. The second approach relies on off-board data sources for maintenance predictions and uses supervised classification to predict the future maintenance of vehicles. Notably, no method is found which utilises both historical and real-time

data, and this leaves room for further research in this area.

IV. METHODOLOGY

This study will adopt Digital Twin based methodology and attempt to design, develop and validate Digital Twin (Fig 1.0) for hydraulic brake system.

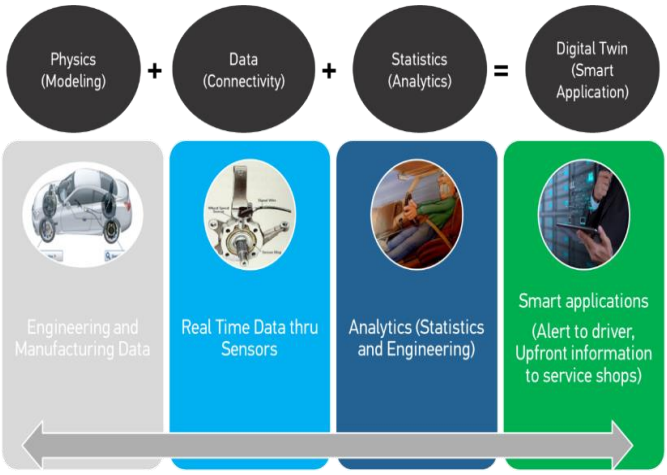

Fig: Digital Twin: Preliminary Architecture

Below section describe the preliminary steps to follow:

Comparative Study of Condition Based Monitoring (CBM) Algorithms

Detailed Study of CSCA & Establish Improvement Approach

Define Data Acquisition System Architecture and Analysis Approach

Learn from Offboard/Historic Data

Setup System Test Infrastructure

Establish Base Algorithm via Supervised Learning Techniques

Learn from Onboard Diagnostic

Deploy Edge Analytics

Fine Tuning of Base Algorithm via Unsupervised Learning Techniques

Design, Develop and Validate Digital Twin for Test Rig

Generalization of Digital Twin for Hydraulic Brake System

Develop & Validate Application to Predict Maintenance Requirement

Conclude Approach and Methodology to identify predictive maintenance requirements for Brake System

V. EXPECTED OUTCOME OF THE RESEARCH

As a result of this study, an approach & methodology will be established, which will enable predictability (>99.999%) in identification of maintenance requirements for hydraulic brake system.

VI. CONCLUSION

In many industries inclusive of automotive vehicle industry, predictive maintenance has become more important. It is hard to diagnose failure in advance in the vehicle industry because of the limited availability of sensors and some of the designing exertions. However with the great development in automotive industry, it looks feasible today to analyze sensor's data along with machine learning techniques for failure prediction. In this study, an approach & methodology will be developed for predictive maintenance of hydraulic brake system with the end goal of expanding vehicle up-time and safety on-the-road.

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