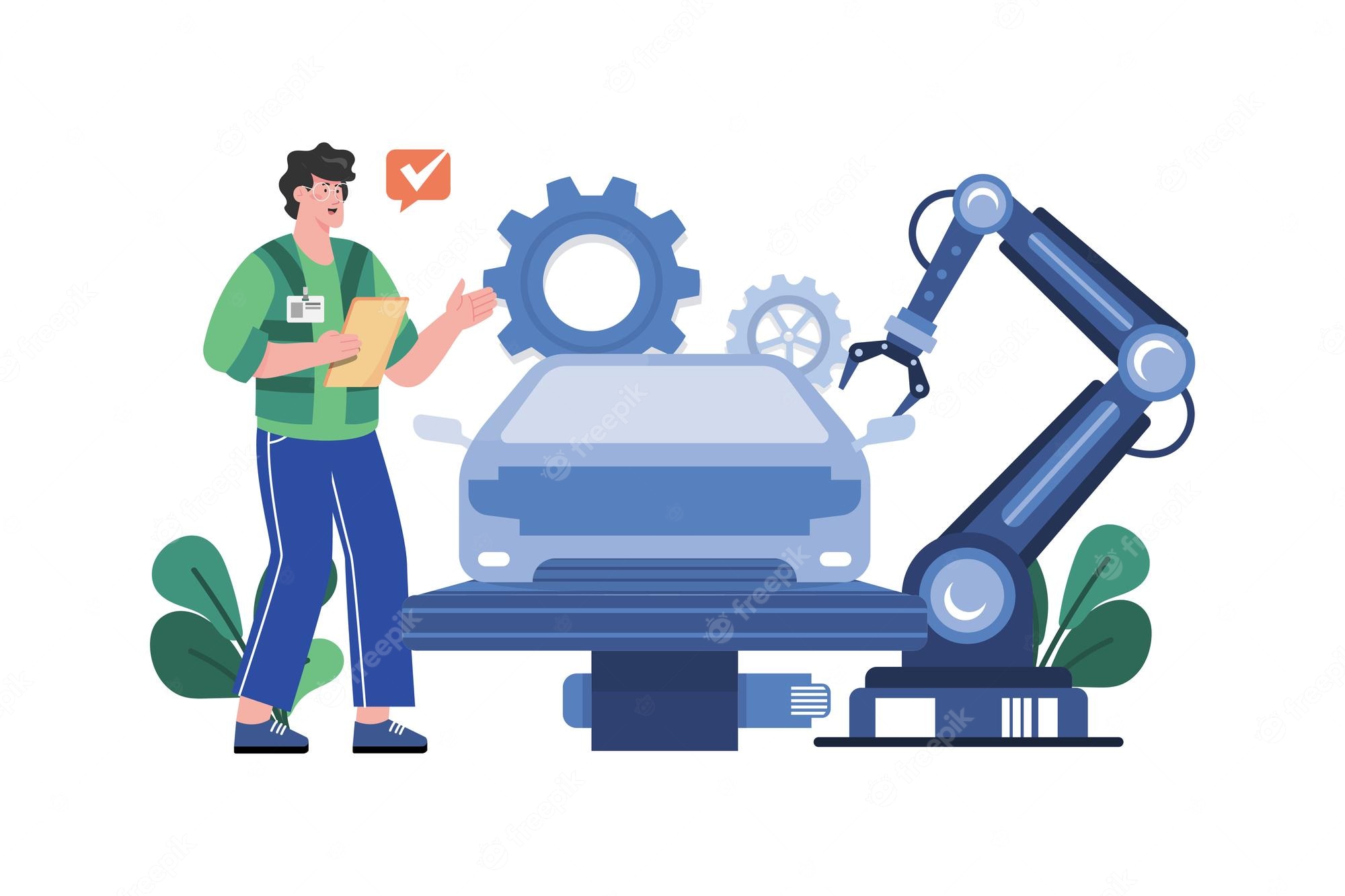
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***DEVELOPING A PREDICTIVE MAINTENANCE MODEL FOR AUTOMOTIVE ENGINES USING ML***

*7150CEM*

*DATA SCIENCE PROPOSAL*



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**ABSTRACT**

The aim of this research is to provide an analysis on the development of predictive maintenance models in automotive engines through the application of Machine Learning (ML). The model detects system abnormalities and predicts future failures using historical and real-time system data. To improve vehicle performance, reliability, and reduce costly repairs, construct predictive maintenance models for automotive engines using ML algorithms. In order to accurately estimate car maintenance based on engine faults and prevent unneeded repairs and expenses. Carrying out this proposal revealed some key insights into PdM and ML being used for automotive engines like it balances maintenance cost. However, gathered data in reviewing the literature offered insights into different facets of using PdM and ML in automotive engines. Additionally, this research will follow secondary qualitative method along with descriptive data analysis technique to provide accurate and effective information related to the topic.

# 1. INTRODUCTION

## 1.1 Background

Predictive Maintenance using Machine Learning (ML) is a powerful tool used in the automotive industry to predict failure of automotive engines and components. According to Kiangala and Wang (2020), the model helps in extracting both historical data and real-time system data, such as engine temperature, vibration, pressure and oil quality. ***Figure 1*** shows that the predictive maintenance industry generated $4.5 billion in 2020 and it will be $64.3 billion by 2030 (Statista, 2023). Therefore, the use of maintenance model is helpful for regression and classification algorithms, such as Random Forest and Support Vector Machine to detect anomalies in the system and predict future failures to optimise maintenance scheduling.

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***Figure 1: Global predictive market size***

(Source: Statista, 2023)

## 1.2 Problem statement and rationale

Predictive maintenance models in the automobile engines are employing Machine Learning algorithms for better product development. However, it has been observed that automotive industry facing major issues in their business operations such as accurately predict mechanical issues, dependability, and expensive repairs. In this context, the maintenance model precisely estimates vehicle maintenance requirements based on engine issues such as excessive oil consumption, fluid leaks before it harms the engine and its components. Thus, this study is beneficial as it will discuss the application of ML in the automobile sector for developing maintenance model.

## 1.3 Aims and objectives (Goals)

### 1.3.1 Aim

The aim of the study is to develop a predictive maintenance model using machine learning (ML) techniques to accurately predict the future state of an engine, allowing maintenance to be scheduled in advance and increase overall reliability of engines.

### 1.3.2 Objectives

* To develop a predictive model for automotive engines and predict potential failure of engine components.
* To evaluate the model’s accuracy and reliability to accurately predict engine failure.
* To determine the cost-effectiveness of predictive models for predicting and preventing engine failure.
* To compare different ML algorithms and their performance in predicting maintenance outcomes for automotive engines.

### 1.3.3 Dataset Link

<https://www.kaggle.com/datasets/parvmodi/automotive-vehicles-engine-health-dataset>

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# 2. LITERATURE REVIEW

## 2.1 Overview of predictive maintenance model and automotive engines

According to Montero Jimenez et al. (2020), predictive maintenance model is an effective model in order to run automated data processing. Additionally, this model encourages in allowing primitive corrective actions and safety compliances in order to enhance frequency and accuracy in minimal cost. As per Arena et al. (2022), predictive maintenance model plays an important role in order to prevent potential failure in the current sensor and network technological era. Consequently, this model is advantageous for the automotive engines in enhancing technical and economic benefits.

## 2.2 Use of Machine Learning (ML) in automotive engines

As per Martin-Diaz et al. (2018), Automotive industry nowadays is using ML in the operations to enhance economy, emissions, and performance. ML algorithms identify abnormalities and alter engine settings to adjust combustion chamber capacity and exhaust temperature. These algorithms may also recognise trends in real-time engine data to increase reaction times and accuracy. Intelligent driving assistance systems employ ML to recognise adjacent objects, people, and other risks.

## 2.3 Significance of predictive maintenance for automotive engines using ML

According to Arena et al. (2022), a predictive maintenance model (PdM) allows an engine-maker to obtain the best compromise between costs induced in repairing and costs needed in preventing the same. Theissler et al. (2021), commented that PdM is a crucial approach, which ensures the functional safety over the lifecycle of a product when it comes to limiting maintenance costs. Additionally, Theissler et al. (2021), stated that limiting the maintenance costs has already become a core challenge for the automotive industry, thus, to bring this industry out of this challenging scenario, ML and PdM work together at their best. Figure (2), showcases maintenance-benefit and complexity are classified into three categories named in the circular form, benefits increase when complexity increases. Therefore, it is found that predictive maintenance model is important for automotive engines because it along with ML helps automakers to balance their cost-burden between repairing and maintenance including prevention.

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***Figure 2: Relationship between complexity and maintenance***

(Source: Theissler et al., 2021)

## 2.4 Challenges in developing predictive maintenance models.

Predictive maintenance models strive to reduce expenses to enhance the ability of business to compete. However, there are a few challenges associated with the development of predictive models which can cause issues in automotive engines. Florian et al., (2021) commented that the rise in maintenance costs of predictive maintenance models due to rise in labour rates thereby impacting heavily on the production. On the other hand, absence of a highly skilled team can be counted as another challenge as it is highly important to employ a skilled and trained team to develop predictive maintenance models. Besides, providing skills training to employees can also be a time-consuming process.

## 2.5 Requirements for predictive maintenance model for an ML-based automotive engines

In accordance with Sang et al. (2021), requirements such as acquiring data from various multiple sources, flexibility, knowledge of batch and real-time data processing, skills to use tools such as wear detection and others, get involved in a predictive maintenance model. On the other hand, according to Tyagi et al. (2021), better user experience, cost-effective and lower downtime are the core requirements needed to develop a predictive maintenance model.

# 3. METHODOLOGY

## 3.1 Research philosophy

In this research, the ***positivism research philosophy*** will be undertaken for the further progress of the study on developing predictive maintenance models. According to Park et al. (2020), positivism research philosophy is based on the knowledge associated with a particular phenomenon which is observed and measured to acquire useful findings.

## 3.2 Research Approach and design

The ***deductive research approach*** will be selected to support the findings of the study. As per the study of Azungah (2018), deductive approach in research is linked to scientific investigation. Through this approach, a researcher analyses existing theories of a specific phenomenon and draws new insights from it (***Refers to figure 3***). In addition to this, the research will be performed through the ***exploratory research design***. According to Olubayo et al. (2020), exploratory designs are performed only where there is a limited number of studies on a specific phenomenon. Therefore, the mentioned approach and design will be helpful for the present study in acquiring detailed understanding about the development of predictive maintenance models in automotive engines using ML.

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***Figure 3: Deductive research approach***

## 3.3 Data Collection Method

As this research will follow a ***secondary quantitative method***, therefore, this research will gather data and information from dataset on vehicle or automobile industry, company data, annual reports. Additionally, this study has also focused on numerical data from journals which provide accurate information related to the topic. According to Archibald et al. (2019), data collection methods play a significant part in collecting information in order to achieve goals effectively within the meantime. Thus, this study will primarily focus on numerical data related to automobile industries which help in providing in-depth and conceptual knowledge of dependent and independent variables of the research topic.

## 3.4 Data Analysis technique

Based on the above discussion, it has been clear that this study will choose a secondary quantitative method, therefore, this research will select ***descriptive analysis*** as a data analysis technique. In order to gather reliable, accurate data and avoid statistical error, descriptive analysis helps in a perfect distribution of data and identifying the similar variables on the research topic ***(Refers to figure 4)***.

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***Figure 4: Descriptive analysis technique***

# 4. CONCLUSION AND FURTHER RESEARCH

After analysing the overall study, it can be concluded that expected findings of this study can offer key insights into a tactic to develop a well predictive maintenance model helping automakers to balance between repair costs and prevention costs. As per the above analysis, a secondary quantitative approach can help in developing a dataset from various annual reports of the UK automobile companies. Therefore, analysing quantitative data such as costs induced in maintenance of their automotive engines can help this study achieve its aim of developing a PdM for automotive engines using ML. In future, certain improvement is required for the study where both the primary and secondary data will be gathered and contracted for more in-depth analysis on the topic. Additionally, the future research may also focus on other advanced technologies and specific firms from the automotive sector to get more detailed data which can help in the development of maintenance models.

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