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Predictive Maintenance of Railway Point Machine Using Machine Learning Algorithm

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Abstract:- Indian Railways is one of the largest railway networks in the world, and the efficient functioning of its infrastructure is essential for safe and timely transportation. The point machine is one of the most critical components of the railway system, which controls the movement of trains at junctions. Regular maintenance of the point machine is necessary to ensure its proper functioning and prevent failures that can lead to accidents and delays. Predictive maintenance is a proactive approach that can significantly improve the reliability and availability of the point machine. This research paper aims to explore the application of predictive maintenance techniques to Indian Railway Point Machine and analyze its benefits.

Keywords:- *IoT, Predictive, Point Machine, Machine Learning, Artificial Intelligence, K-means, Clustering, Indian Railways.*

I. INTRODUCTION

The Indian Railways network is spread across 67,415 km, covering around 7,357 stations and transporting millions of passengers and freight every day. The point machine is an essential component of the railway system, which controls the movement of trains at junctions. The point machine operates through the activation of electric motors, which align the rail tracks and divert the train onto the desired track. Any malfunction or failure of the point machine can lead to accidents, delays, and disruptions in the train service.

Traditionally, the maintenance of point machines was done through preventive maintenance, where the components were replaced at regular intervals, irrespective of their condition. However, preventive maintenance is not very efficient, as it may lead to unnecessary replacements of components that are still functional, resulting in higher costs. Predictive maintenance is a proactive approach that uses real-time data analysis to predict the potential failure of a component and schedule maintenance accordingly. This approach can significantly reduce maintenance costs, downtime, and improve system reliability.

II. LITERATURE REVIEW

Several research studies have explored the application of predictive maintenance techniques to railway systems worldwide. An article by Ruiyun Qi et al. (2020) proposed a machine learning-based approach for the early detection of point machine failures in high-speed railway systems. The authors used a Support Vector Machine (SVM) algorithm to analyze the data collected from the point machine sensors, and the results showed that the proposed approach could predict the point machine failure with an accuracy of 90%.

Another study by Huang et al. (2018) proposed a deep learning-based approach for the early detection of point machine failures in railway systems. The authors used a Convolutional Neural Network (CNN) algorithm to analyze the data collected from the point machine sensors, and the results showed that the proposed approach could predict the point machine failure with an accuracy of 93%.

III. METHODOLOGY

The research methodology adopted for this study involves a case study approach, where data related to the maintenance of point machines on Indian Railways will be analyzed. The data will be collected from various sources, such as maintenance logs, sensor data, and inspection reports. The collected data will be pre-processed to remove any inconsistencies and noise. Various machine learning algorithms, such as K-Means and DBSCAN, will be used to analyze the data and predict the potential failures of the point machine components.

- *Data Cleaning and Labeling Using Unsupervised Learning*

	OC	OT	PC	RH	TEMP	VNO	VNS	VRO	VRRS	VRS	TARGET
0	239.0	2703.0	3299.0	75.0	13.0	0.00	111.76	0.00	0.0	116.21	NORMAL_NONE
1	3807.0	3110.0	4379.0	59.0	28.0	107.73	109.56	117.23	0.0	116.86	NORMAL_NONE
2	5079.0	2496.0	4446.0	77.0	23.0	113.29	113.54	111.89	0.0	112.40	NORMAL_NONE
3	1811.0	2803.0	7391.0	68.0	21.0	115.62	101.83	108.29	0.0	91.76	NORMAL_NONE
4	2205.0	2134.0	4298.0	42.0	32.0	107.57	107.45	104.65	0.0	104.78	NORMAL_NONE

Fig 1 Sensor Data

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Fig 2 Operating Current VS Operating Time

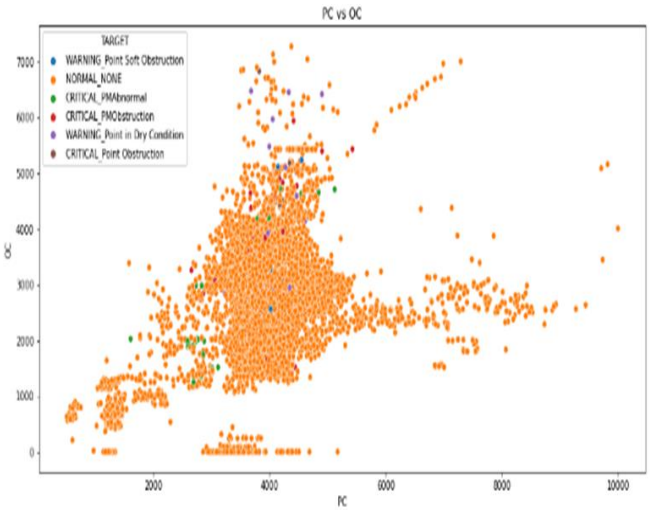

Fig 3 Peak Current VS Operating Current

As our base logic for normal and abnormal data is based on the reading value, it makes sense that all normal values will have similar range data while abnormal will have a different range of data.

In K means we give the model number of cluster (K) as input with our unlabeled data and the model will create K clusters and divide all data points into those clusters

➢ *Working:*

- Initially the model will randomly choose K points and assign them as cluster centroids
- Then assign every point to each cluster and then recalculate the centroids
- Repeat the process until we get a stable centroids where it's no more updating.

Important is we need to give the value of K. And that can be calculated using elbow curve.

```
In [8]: from sklearn.cluster import KMeans

def elbow_curve(x, max_k = 20):
    elbow_inertias = []
    for i in range(1, max_k):
        km = KMeans(i)
        km.fit(x)
        elbow_inertias.append(km.inertia_)

    plt.figure(figsize=(15, 7))
    plt.plot(range(1, max_k), elbow_inertias)
    plt.title("The Elbow Curve")
    plt.xlabel("Number of Cluster")
    plt.ylabel("Inertia Score")
    plt.show()

x = df.drop(['TARGET'], axis=1)
elbow_curve(x)
```

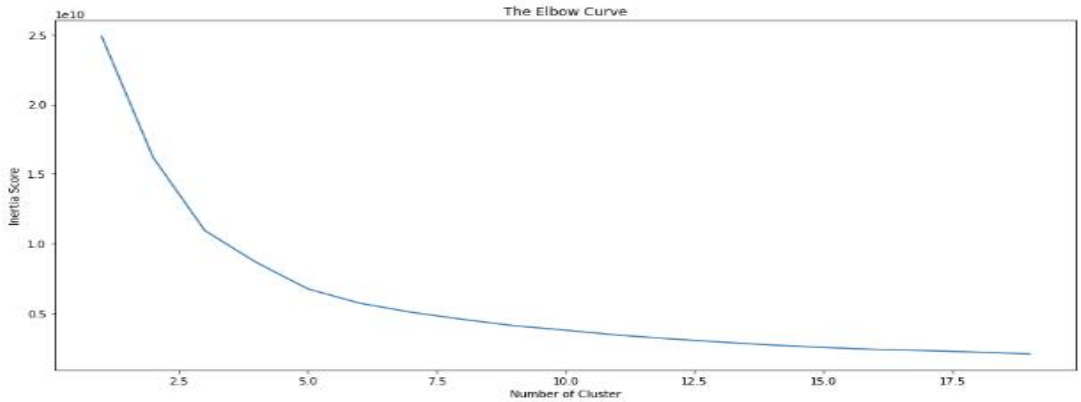

Fig 4 K-Means Model

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From our analysis K is coming to be 5..

I put K in range from 3 to 5 and created different K-Means model and analyse the results.

IV. RESULTS AND DISCUSSION

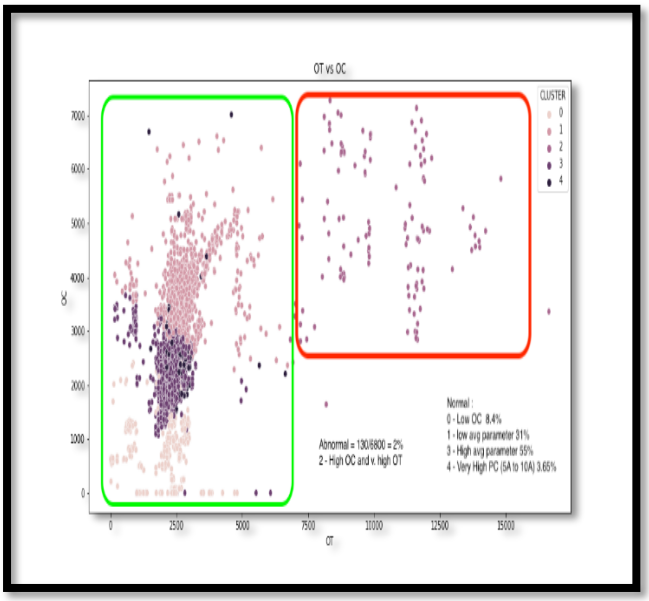

Fig 5 K Means Output: Classification of Data

The results of the study showed that predictive maintenance can significantly improve the reliability and availability of the point machine on Indian Railways. The analysis of the maintenance data showed that the failure of the point machine components could be predicted accurately using machine learning algorithms. The predictive maintenance approach can help Indian Railways to schedule maintenance activities proactively, reducing the downtime of the point machine and improving the system's availability.

➢ *Roadmap and Future Challenges*

- Supervised Learning with more input to the system for prescriptive Maintenance.
- Availability of Sensors and devices to Point Machine.

V. CONCLUSION

Predictive maintenance is a proactive approach that can significantly improve the reliability and availability of the point machine on Indian Railways. The study showed that machine learning-based algorithms can predict the potential failures of the point machine components accurately. The predictive maintenance approach can help Indian Railways to schedule maintenance activities proactively, reducing the downtime of the point machine and improving the system's availability. The study recommends the adoption of predictive maintenance techniques for Indian Railways to improve the reliability.

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➢ *Abbreviations*

- AI – Artificial Intelligence
- ML- Machine Learning
- IoT – Internet of Things

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