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Performance Prediction of Machines Using Artificial Intelligence

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Abstract - *With the increase in the amount of data captured during the manufacturing process, monitoring and classifying the performance of the machines are becoming important factor in decision making. As the world is technologically advancing, the industries should also grow with the act of it, in the way of some sort of automation in decision making instead of manual work and 'Machine learning' is one of the advanced technologies to go for. This project is about developing an application to reduce the manual work on Machine Performance Analysis done by the use of traditional software like MS Excel and other Spread sheets. Data visualization has been done that helps us better understand the influencing features of Machine performance and the performance level of the machines are predicted by utilizing unsupervised machine learning algorithms.*

***KeyWords*: clustering methods, Machine learning, Unsupervised Learning**

1. INTRODUCTION

The ring spinning machine is used in the textile industry to simultaneously twist staple fibers into yarn and then wind it onto bobbins for storage..

It is important to monitor performance of spinning machines because; machine reliability and maintenance drastically affect the three key elements of competitiveness in yarn manufacturing textile industry: quality, cost and product lead time. Well-maintained machines hold tolerances better; help reduce scrap and rework, and raise consistency and quality of the product. They increase uptime and yields of good products, thereby cutting total production costs, and can also shorten lead times by reducing downtime and the need for rework.

The behavior of a spinning machine can be monitored and classified to predict the level of its performance. By doing this, maintenance personnel can perform early diagnostics and part replacement during regular daily maintenance hours. Therefore, the mean-time-between-failure can be extended to an unlimited length.

The existing performance analysis of machines is being done by developing pivot tables and charts using traditional software like MS Excel and other Spread sheets with the machine data collected from Data Lake.

In this project, we propose to analyze the performance of these machines by using the concepts of Data Visualization and Machine Learning using python. Data visualization is the discipline of trying to understand data by placing it in a visual context so that patterns, trends and correlations that might not otherwise be detected can be exposed.

Different Data Visualization charts [1] are developed to understand the performance features of the spinning machines and to find the highly correlated features that affect the machine performance with the help of correlation matrix construction. For further analysis of the spinning machines, we classified the machines using the unsupervised machine learning algorithm[13][14] 'K-means clustering' [2] to form clusters based on the performance data of machines.

2. PROPOSED WORK

First, the given dataset is visualized using various types of graph to get basic understanding of each and every spinning machine. Those graphs are deployed using python based matplotlib library function. The visualization of the data is continued with the deployment of heat map which is the visual representation of correlation values calculated using the features included in the given dataset.

Next, K-Means algorithm (unsupervised machine learning algorithm) is used to cluster the machines. Here the number of clusters is determined using the silhouette method (by finding average silhouette score).

2.1. DATA VISUALIZATION AND CORRELATION

A. Stacked Bar Graph

The stacked bar graph [1] depicts the overall performance of spinning machines by relating the machines (Machine names along x axis) with the major machine performance features (Production real, Production/h Real, Average count, OEE along y axis) as mentioned from the industry. This graph helps to find the high and low performing machines based on the required performance factors given to be related with.

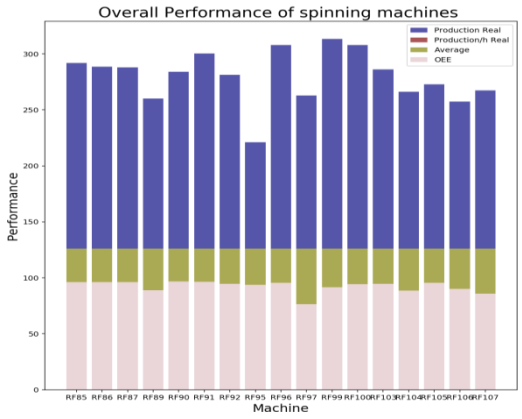

Fig. 1 Performance vs. Machine

B. Scatter Plot

The scatter plot [1] depicts the Working of Spinning Machines by relating the machines (Machine names along x axis) with the working time feature (Work time along y axis) as required from the industry. This graph helps to find the working time of the machines.

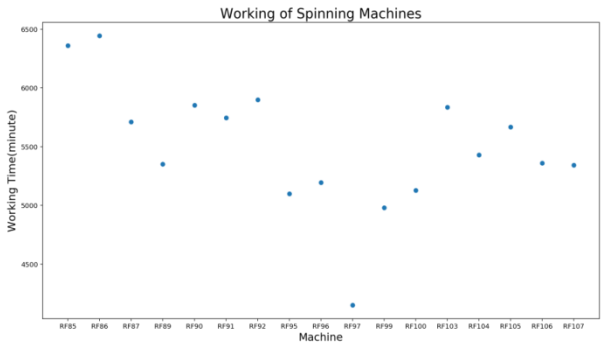

Fig. 2 Work time (seconds) vs. Machine

C. Correlation

Correlation is basically a statistical measure of how two or more variables are fluctuating together. Positive correlation is when two variables will see the parallel effects and changes and negative correlation indicates that when one value is increased and other is decreased. The correlation matrix is visualized using heat map [10]. Heat map is a way of graphical representation of the matrix values where the graph will be depicted using color and it has range of values from positive to negative. Large values will be represented in the lighter shade and smaller values will be using the darker shade in our graph. In the correlation matrix only either upper diagonal matrix or lower diagonal matrix is to be considered, because both the halves will depict the same information. Only one part of the matrix is considered to determine the correlation factor.

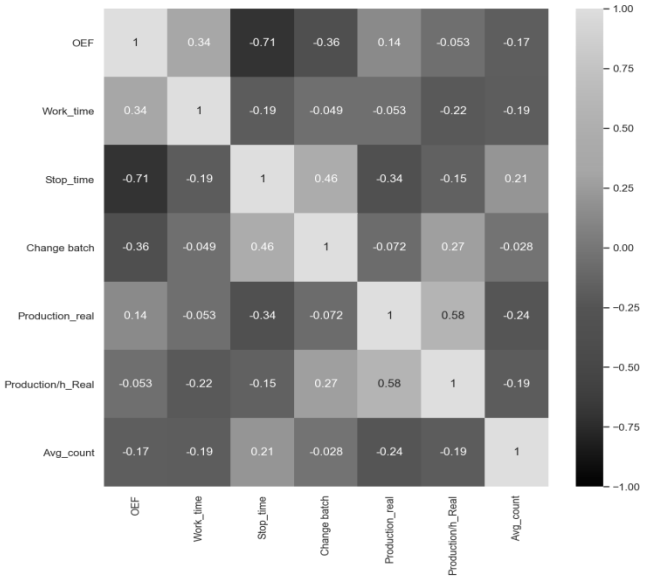

Fig. 3 Heatmap containing correlation factors of the features

2.2. MACHINE LEARNING CLASSIFIERS

K-means clustering

Clustering helps to get an intuition about the structure of the data (unsupervised). It can be defined as the task of identifying subgroups in the data such that data points in the same subgroup (cluster) are very similar while data points in different clusters are very different [3].

The number of clusters that is going to be used in the K-means algorithm is determined using the method called Silhouette method [11] [12].

If the Silhouette index value is high, the object is well-matched to its own cluster and poorly matched to neighboring clusters. The Silhouette Coefficient (S(i)) is calculated using the mean intra-cluster distance (a) and the mean nearest-cluster distance (b) for each sample. The Silhouette Coefficient is defined as –

$$S(i)=((b(i) - a(i)))/(\max \{ (a(i),b(i)) \})$$

Where, a (i) is the average dissimilarity of ith object to all other objects in the same cluster, b(i) is the average dissimilarity of ith object with all objects in the closest cluster [12].

For the given data set the average Silhouette Coefficient is found for the cluster size ranges from 2-6 .That optimal number of clusters for the given dataset is 5.

Each cluster is grouped among them and the mean value is found for each cluster. Based on the mean values the clusters are sorted (descending order) based upon the user's feature

interest which is selected from dropdown box containing the features from the dataset using ipywidgets library.

After sorting the clusters the cluster 0 is named as level 1(high performing machines) similarly following clusters are named till level 5(low performing machines) respectively. Then machines from the dataset which are already clustered are also replaced with its respective level numbers.

3. FUTURE WORKS

In future we can apply supervised machine learning algorithm to predict performance level of some other machines by training the dataset whose performance level is already determined.

4. CONCLUSION

We conclude that various spinning machines are grouped and classified based upon their performances. This could help the machine operators to get a better understanding of the machines. Thus appropriate machine can be chosen based upon the urgency of the product's order.

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