

# Machine Learning and Its need In Mechanical Industry 4.0

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**Abstract-** Mechanical industry is facing more complex and dynamic behaviour. And for more efficient working we should use all the available aspects. Such efficient development can be achieved by using modern techniques. Machine learning is one of the emerging fields which is showing a great result for fulfilling such complex and challenging need of the industry. Machine learning is a subset of artificial intelligence. Machine learning is a study of statistical model and algorithms which is used by computer systems to perform task without any explicit instructions or reference. Machine learning focuses on prediction using computers. The machine learning is actually based on study of mathematical optimization. Machine learning is used in various sectors for solving and analysing critical problems. Machine learning helps in sectors such as medical, financial, energy, mechanical, and many more industry. The main aim of this study is to focus on the basic terms used in machine learning and the application of machine learning in mechanical industry. In mechanical industry machine learning is widely used in manufacturing, quality control, production areas.

**Keywords-** Machine learning, Supervised learning, Unsupervised learning, Semi-supervised learning, Machine learning Models, Mechanical Engineering.

## I. INTRODUCTION

Machine learning belongs to field of artificial intelligence. Although machine comes under area of study of computer science its approach is much different than traditional approaches. The basic working pattern of machine learning is to facilitate computer in building models from the given set of data in order to make decision automatically from the previous inputs and result. So due to this kind of approach we can use this technique in various field. In machine learning algorithms are used for solving the problems. This algorithm learns from experience. The algorithm understands the pattern from initially given data performed operations and after certain steps the algorithm itself generates the required input data and performs the further operation. The ML algorithm can be differentiated in the way they learn from the given data. Machine learning uses different types of algorithm which consist of different

approaches like supervised learning, unsupervised learning, semi-supervised learning, reinforcement learning, self-learning, etc. These approaches are helpful in improving the results of algorithm. From selection of proper approach we can get better result rather than using one specific approach. This algorithm with different approaches also uses different models. These models actually follow mathematical approaches for finding expected result from given algorithm. Neural network, Genetic algorithm, Decision tree, Support vector machine (SVM), K-Nearest neighbour, Naïve basin, Regression analysis are the various models used in different algorithms of machine learning. The data used in machine learning is the main parameter of all processing. The efficiency and result given by the machine learning algorithm totally depends on the data provided to algorithm. So necessary care should be taken while selecting data. Data which is given to the algorithm is always pre-processed according to need of algorithm. This technique is now rising in the field of mechanical also. In mechanical industry machine learning can be used in various sectors such as manufacturing, quality control and production area. Also in the industry 4.0 the complexity of data and challenges faced by the industry is increasing day by day. So for facing this challenges machine learning technique is very useful tool.

## II. LEARNING APPROACHES

There are various approaches used in machine learning algorithm.

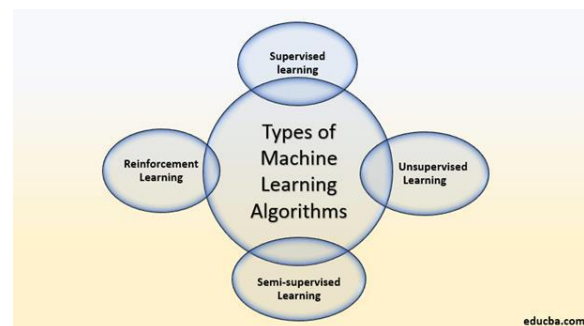


Fig 1 : Types of ML algorithm approaches

### 2.1 Supervised learning

Supervised learning algorithms build a mathematical model of a group of a knowledge which contains both inputs and desired outputs. The data which is taken for this purpose is called training data and it consists of a set of training examples. From the iterative optimization of given objective function supervised learning algorithms learn a function that can be used to predict output associated with new inputs. And the algorithm that improves the accuracy of the output or prediction over time is said to have learned to perform a task. The output can be obtained from two cases. The one of them is classification and another one is regression. Classification is mainly used for classifying input data and output we get by classification is in the form of class i.e. it does not specify any numerical value. But in case of regression we get a specific numerical value as the output. So in regression the output is real-world number.

Advantages of supervised learning:

- Supervised data enables user to collect data and develop output from previous experience.
- It helps to optimize the performance criteria using experience.
- It provides help for solving real time problems.

Disadvantages of supervised learning:

- The boundary of decision can be over trained or might be unable to take decision because of improper training data (given data).
- User has to provide lot of good results or examples so that output obtained is more accurate.
- It is a time consuming approach.

## 2.2 Unsupervised learning:

Unsupervised learning algorithm consists of only inputs and it does not contain any output. It does not have any external reference. It contains data which is not classified. This kind of algorithms identifies common parameters in the data and responds on the presence or absence of such parameters in new data. As the supervision is removed in this kind of approach it can be more difficult as compared to supervised learning. The main target of unsupervised learning is to model the underlying structure or distribution in the data in order to understand and learn more about the data. Unsupervised learning problems are mainly classified as clustering and association problems. In Clustering problems algorithm have to discover inherent data group. In association problem the algorithm should discover the rule that describes large portion of available data. It mainly has disadvantages as compared to supervised learning.

Disadvantages of unsupervised learning:

- Precise sorting of data is not possible in case of unsupervised learning.
- The user need to spent time on interpreting and the labelling.
- As machine have to take the decision and no initial labelling is provided the accuracy gets compromised.

Although this approach has disadvantages as compared to supervised learning it can be more efficiently in some problems. Because it reduces the feature (characteristics) used in the specific approach.

## 2.3 Semi-supervised learning:

In this type of algorithm, some of the training examples are missing but they can be used to improve the quality. Semi supervised learning combines all the amount of labelled data with large amount of unlabeled data during training. In one approach, labeled data is used to learn class model and unlabeled data is used to decide the boundaries between the classes. This type of approach is used when problem is belonging to single class. For two classes problem one set of data is considered as positive and other is negative and using such kind of logic decisions are made. By using such approaches the available data is used.

## 2.4 Reinforcement learning:

Models are trained by reward and punishment in reinforcement learning. Every step is scored by assigning specific points. And the goal is to maximize the score. During training the trial and error method is used for generating new proposed solution which is continuously modified to improve the score. This algorithm reminiscent of human learning by praise and criticism so this is known as reinforcement learning.

## 2.5 Self learning:

It is system having only one input and only one output. There is no interference of environment and it is independent of explicit instruction. It works with the help of neural network for improvement of a algorithm.

For selecting a proper ML algorithm there should be specific approach. This approach for selecting ML algorithm is as follows.

- For selecting appropriate approach among supervised, unsupervised and RL the given data is analyzed and checked how it is described.
- The general applicability of available algorithm with regards to research problem requirements has to analyze. The focus should be on structure, datatypes and overall amount of available data which can be used for training and evaluation.
- Application of algorithm on previous similar kind of problem should be investigated in order to find suitable algorithm.

### III. MODELS

There are various models which are used in machine learning.

#### 3.1 Neural network:

Neural networks are a set of algorithms, modelled loosely after the human brain, that are designed to recognize patterns. They interpret sensory data through a kind of machine perception, labelling or clustering raw input. The patterns they recognize are numerical, contained in vectors, into which all real-world data, be it images, sound, text or time series, must be translated. It helps in grouping of unlabeled data according to similarities from the input data and they classify the data when they have trained labeled data set. Neural network are able to extract feature that they are fed to different algorithm for clustering and classification. There are three types of neural networks recognized as convolutional neural networks recurrent neural networks and artificial neural networks. Convolutional neural networks (CNNs) are mostly used for the tasks of image recognition and for classifying various types of images. Recurrent neural network (RNN) is used for building of sequential representations over period of time. These types of neural networks are very strong at recognizing past data or given examples. Artificial neural network (ANN) is used for solving regression problem and nonlinear classification.

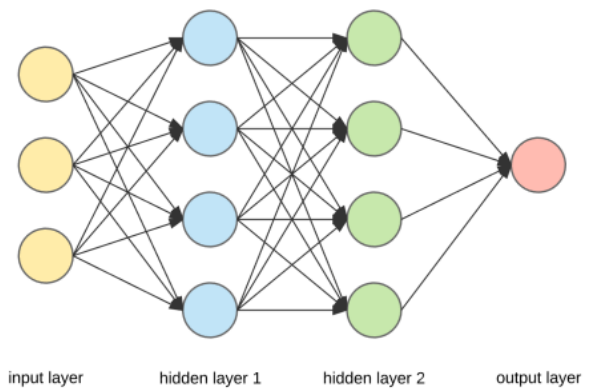


Fig 2. Neural network representation

#### 3.2 Decision tree:

Decision trees are type of supervised machine learning, where the data is continuously split according to certain parameter. The tree can be explained by two entities, namely decision nodes and leaves. The leaves are the decision or the final outcomes. And the decision nodes are where data is split. It starts with root node which is the feature with highest predicting power. With help of root node further decision are made and classified. Then this classified data is used for determining final result in the form of leaves. It is the way to display an algorithm that only contains conditional control statements. Decision trees in which the target variable is able to take values which are real number are called as regression trees.

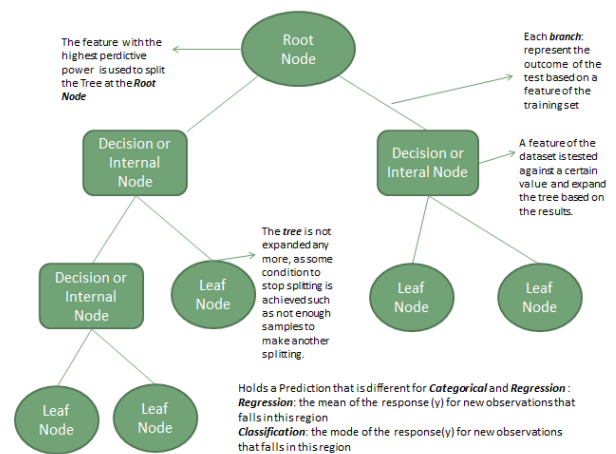


Fig 3. Representation of decision tree.

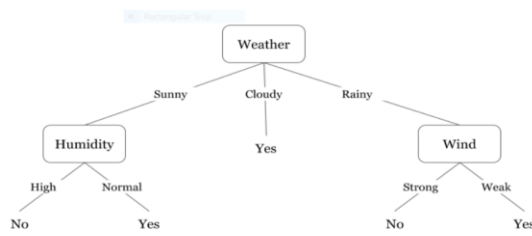


Fig 4. Example of decision tree

**3.3 Support vector machine:**

Support vector machine is a supervised machine learning algorithm which can be used for classification and regression challenges. It is mostly used in classification problems. In this type of algorithm, we plot each data item as a point in n-dimensional space (where n is number of available feature) with the value of each feature represents the value of particular co-ordinate. Then, we perform classification. It uses hyperplane and support vector for taking decision. From available numerous hyperplanes the plane with highest margin is selected for classifying two classes. Support vectors are data points which are closer to the hyperplane and responsible for the position and orientation of the hyperplane.

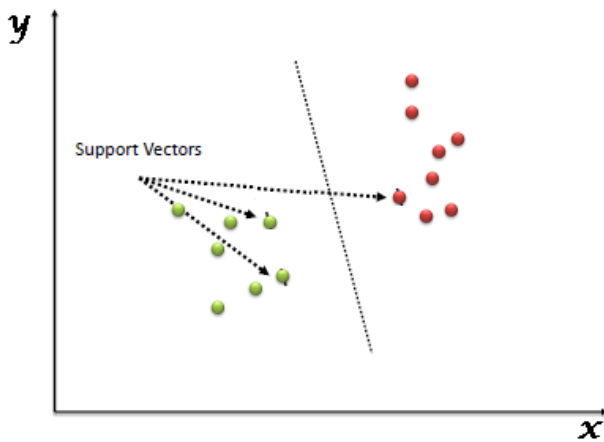


Fig 5. Graphical representation of SVM

**3.4 Regression analysis:**

Regression analysis consists of a set of machine learning methods that allows us to predict continuous outcome variable based on one or multiple predictor variables. The goal of regression model is to build a mathematical equation that defines outcome variable as function of predictor variables. This equation helps to predict the outcome variable value based on new values of predictor variables. The linear regression is the most simple and popular technique used for

predicting a continuous variable. It considers a linear relationship between the outcome and the predictor variables.

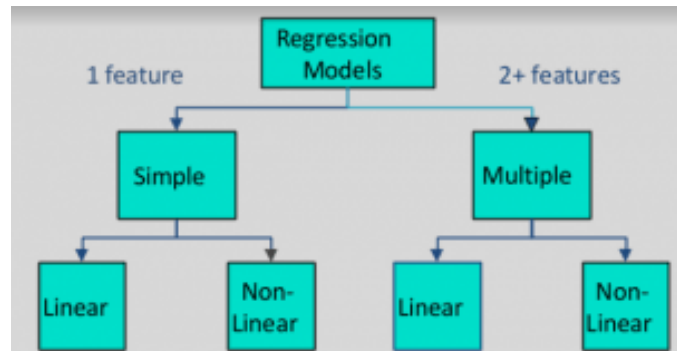


Fig 6. Regression analysis.

**3.5 Genetic algorithms:**

Genetic algorithms are used for developing high quality solutions to optimization and problems by depending on biologically inspired operator. They are based on the mechanics of population genetics and selection. The main solutions are encoded as ‘genes’ — strings of characters from some alphabet. New solutions can be produced by ‘mutating’ members of current population, and by ‘mating’ two solutions together to form a new solution. During each successive generation, a portion of existing population is selected to breed new generation.

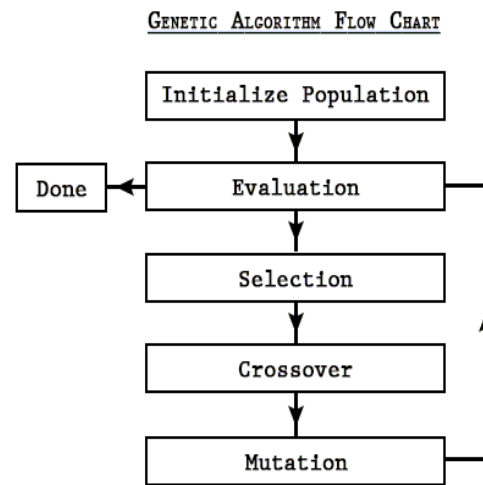


FIGURE 2

Fig 7. Flowchart of genetic algorithm

**3.6 Naïve basien :**

It is algorithm which consists of an acyclic graph. Acyclic graphs of NB model consist of only one parent and multiple children. The parent represents the unobserved node and the children are observed nodes. Naive Basien is useful

for problems related to classification, regression and clustering. Also, it requires little storage space during both stages i.e. training and classification. It has ability to learn in short time and another perk is it can deal with big, fuzzy data with faster speed.

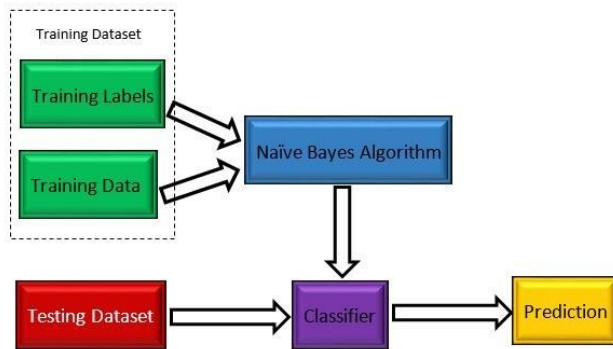


Fig 8. Naïve basien representation

There are various tools which we can use in machine learning but we have to pair them with proper processes and tools for optimum results. It's necessary to maintain overall data quality and management, and for quick reliable results easy model deployment should be present. Also for betterment of process, best performers should be evaluated through automated ensemble model. Graphical user interfaces are developed for creating process flows and building models. Along with these main techniques, there are several techniques which are used. They are mapping the nearest neighbor, boosting and bagging gradient, self-organizing maps, SEO, etc.

#### IV. STEPS FOR FORMATION OF ALGORITHM

1. Data Collection: Collect the data that the algorithm will learn from.
2. Data Preparation: Format and engineer the data into the optimal format, extracting important features and performing dimensionality reduction.
3. Training: Also known as the fitting stage, this is where the Machine Learning algorithm actually learns by showing it the data that has been collected and prepared.
4. Evaluation: Test the model to see how well it performs.
5. Tuning: Fine tune the model to maximize its performance.

#### V. CASE STUDY

Industry 4.0 depends on the increment of available data sets especially big data which cannot be processed by using conventional technologies. ML is capable to achieve higher level requirements than human. ML has to utilize the different techniques and algorithms to achieve optimum

benefits from data. The supervised learning, unsupervised learning, semi-supervised learning and reinforcement learning are the methods which are used for processing. In manufacturing process algorithms and models are used such as support vector machine, decision tree, nearest Neighbor, rule based learners, Navien-bayesian, neural network, etc. Machine learning techniques helps for improvement in environment. In manufacturing industry ML is beneficial for development and predicting future behavior of system by taking reference of current behavior and establishing relation between data. . The ML techniques decision trees, neural networks, helps in various manufacturing applications such as LEAN manufacturing. In LEAN manufacturing by using JIT and KANBAN tool. We can achieve more transparency and can also reduce complexity of results by using ML. But the ML technique is still a young scientific field which has to face many challenges ahead of them. The big data and its availability and its complex nature, also requirement of high dimensionality, variety are these main challenges in manufacturing industry. And in order to overcome these challenges ML techniques and algorithm are used. But the irrelevant, missing and redundant information can affect the performance of machine learning capabilities. Misuse of data in manufacturing as well as in entire industry because of wireless remote control of physical device and finding human experts in data science and optimization of scientific fields having in mind that different skills are major challenges. The aim of use of machine learning technique is to improvement in terms of quality, lead time, cost, flexibility. ML can be used in different sectors of production. In quality management ML can be used to monitor or sometimes to predict the quality of product. From maintenance point of view ML can give the optimum maintenance time for tools and machines by estimating its condition. Also fault diagnosis, job shop scheduling, energy management ML techniques are useful. The required data in production includes data from product field and control devices, stations, work Centre's, the own enterprises up to suppliers and customers also. There are several processes which uses ML techniques. ML can be used in various mechanical process foundries. It is use real – time quality prediction. In casting process also ML approaches are used. ML is applied for defect prediction in metal forming process. ML is employed for anomaly detection in press hardening process. In large scale production of automotive suppliers no. of various unpredictable disturbance variables can affect production system. For reducing the defect percentage and increasing the accuracy, it is necessary to filter on may variable combination of various techniques such as unsupervised learning methods, supervised methods such as decision trees are used which helps in enhancing efficiency of process. However, research on application of ML must be promoted because it is not yet widespread. Machine learning

has been adapted across various industries. In the sector of packaging also ML can be used effectively. Because the efforts and complexity for logistic and packaging planning has increased dramatically. Packaging is separated into two categories which are primary packaging and secondary packaging. ML techniques can be used for primary packaging process. The two main decision points in this process are selecting certain packaging and calculating filling rate. Execution of ML in this process is done 3 steps. In first step data understanding is done which includes separation of data by considering various characteristics, features and categories are considered. For e.g. shape, dimensions, weight, etc. In second step, data preparation is done. It aims to process data and prepare it for introducing to ML algorithm. For this particular application supervised learning is used. Features are considered as input data and labels represent outcome of model. These labels are nothing but the filling rate which is needed. After this, invalid data has to clean. In last step modelling is done, in which formulation of input feature is done for classification of feature and packaging label for training. By using regression model, classification of feature has to be done. Along with this various algorithm selection has to be done for different sub-processes. This is initial approach of research and future research is required on this. But as per study this model gives accuracy up to 84.4%. Along with ML other techniques can also be combined to get optimum result.

## VI. CONCLUSION

This report gives an overview on basic parameters and processes used in formation and development of ML algorithm. It also gives literature overview on the wide application of ML used in mechanical industry. It also discuss about the challenges and advantages of ML and provides information of ML. It describes need of ML in mechanical industry. ML is the tool which will be helpful in upcoming development which will increase productivity, efficiency and production speed.

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