Methods and Developments in Machine Learning Approach – A Review

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Abstract: *The development in the area of machine learning is outlined in this paper. Machine learning has evolved as a new solution in outcome new and accurate decision in large data processing. The learning approach has a significant need in the upcoming applications, where a large learning data are to be processed in developing a decision. The field of automation in various applications ranging from data retrieval, medical application, military applications, security and authentication issues, astronomical data processing etc. was developing new interface and solutions for accurate and efficient mining. This paper outlines the development in the area of machine learning techniques using various learning approaches such as the neural network, classification approach, decision approach were presented. Machine learning approach is used as a mode of operation in developing solution based on training and testing process, where learning details such as the descriptive features and different predictive analysis algorithms in developing the best match decision. Wherein, evolution the area of machine learning has outcome with numerous approaches with the objective of faster and accurate learning system, the need of improvement in the monitoring factor is yet needed. The constraint of machine learning stand in two fold, wherein the complexity and data representation are to be kept lower, the demanded accuracy is higher. The evolution and constraint to the existing machine learning approaches were outlined in this paper.*

Index Term: Machine learning, Learning and decision system, review.

I. INTRODUCTION

Retrieval of information from a large dataset is a critical task in various automation applications. The demand of building the existing approach automated increases the effort on machine learning for present and future applications. The recent developments in the area of machine learning have developed in deep learning [1], Bayesian modeling [2], non parametric processing [3] etc. The increase in the volume of data in the registered data base has increase the demand for new machine learning approach, where a large signaling request and data accessing. With the evolution of machine learning, new techniques to make the process faster and efficient is been focused. With evolution of new architectures and network layout, the distribution of data is not confined to a specific location, but to maintain a large distribution of data units are distributed over a wide network communicating each other to deliver the data. In the evolution, new topology such as the cloud computing [4], distributed computing [5], heterogeneous network [6] have evolved. Machine Learning (ML) methods developed as a learning system in data interface, has shown a significant improvement in offered services and data performance, however these approaches has a constraint of high computing overhead, false decision under semantic conditions, and higher latency issue in data exchange [7].

Machine learning is developed as a synonym to human learning system. The approach predicts the observation and makes decision based on the past learning. The data acquisition and processing is a major part of a machine learning system. The development of machine learning system has a critical usage of data updation which can be developed online or

off line approach. In many applications, the approach of machine learning is developed based on area specific learning model.

As the observation continuous changes with time, the development of learning system based on the input observation are very complex. This approach finds difficulty in developing a decision under highly variant input environment. The effect of security and significance of data is a major concern. The developing approaches have a focus on developing new learning approaches under dynamic environment. The existing approaches of machine learning [8] are categorized as,

a. Supervised
b. Unsupervised, and
c. Semi-supervised learning

The categorization of the existing learning system is presented in figure 1 below.

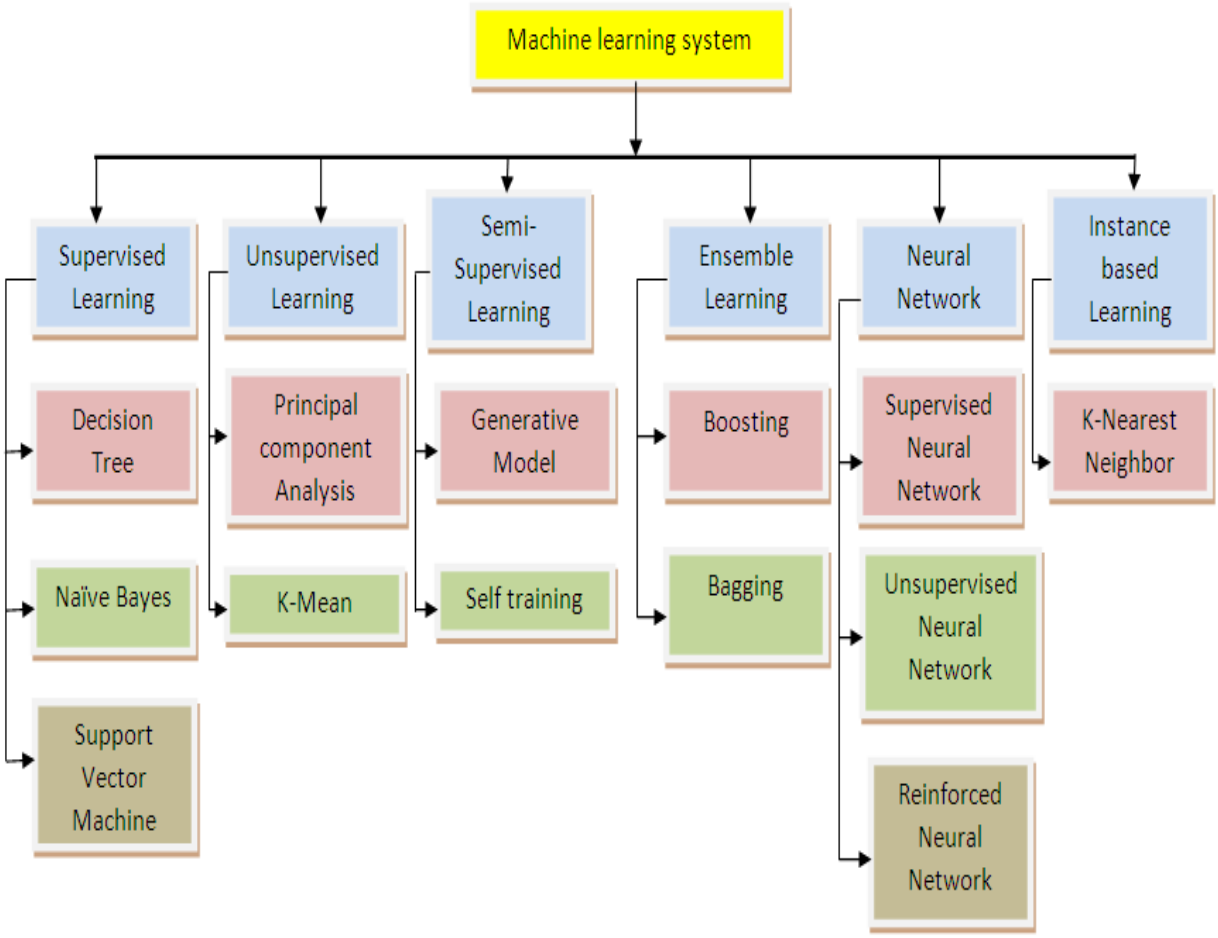

Figure 1- Machine learning hierarchy

The supervised learning uses a pre existing knowledge dataset in making a decision, an unsupervised learning does not follow any specific pattern for data type. The semi supervised [9] approach is a mixed approach of supervised and unsupervised approach. The unit of machine learning is developed as training, testing and classification unit. The process of training is developed as supervised or unsupervised model. The classification model is developed using clustering approach and decisions logic. The process of training in a machine learning approach is developed using supervised or unsupervised approach.

Supervised approach: this approach uses a linear model of prediction for a specified target based on the trained information. Methods such as linear modeling [10], SVM, random forest [11], Decision tree approach [12] etc. are examples of supervised learning approach. The supervised learning approach is a commonly used learning approach in machine learning. This approach maps the input and output variable, where the output is defined as a linear function of input. The supervised learning approach objective is to map the input to the accuracy of deriving output for best decision prediction.

Unsupervised approach: This approach is developed based on prediction and minimization of prediction error and makes decision based on cluster formation. Unsupervised approach is developed for the prediction of rules in order to obtain the suitable information in deriving an output. This approach is developed based on clustering and association rules [13,14], where the rules are derived to define the association of trained data to input data. Commonly approaches for unsupervised learning are the K-Mean approach [15], Apriorie approach [16] etc. Figure 2 illustrates the classification of machine learning approaches and the method involved in the classification process.

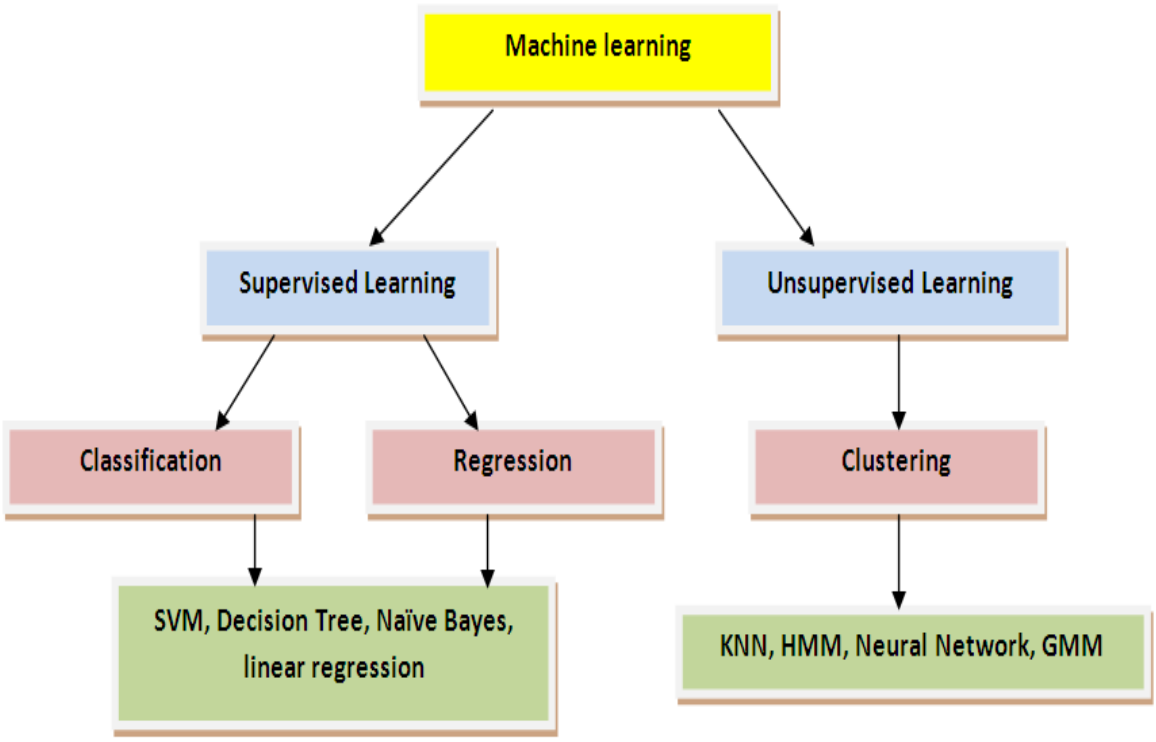

Figure 2 – Classification and methods in machine learning

The steps involved in Supervised learning are determining the training data set, gathering a training data set, determining learning function and to set up the learning algorithm for evaluating the accuracy of the algorithm by undergoing several test cases. The Unsupervised learning works on abnormal data patterns which is a complex task. In this approach the classifications are developed by two types – Binary and Multi class Classification [17]. If the predication of classification Algorithm results in two target classes, then it is a Binary Classification. If the predicate values results in more than two, then it is a Multi class Classification approach.

II. MODELING OF LEARNING SYSTEM

A Learning system is developed based on the past learning information's and the decision rules. The learning data updated into the database is termed as trained information. The learning data is stored in a remote location, such as a server and processed during testing phase. The machine learning system has a two phase operation [18] of training and testing phase. In this approach, the training phase develops a correlation with the testing input in giving a decision for classification. The common used supervised learning systems are as presented below.

1) Decision tree modeling: This approach is used as a tree modeling of different learned information in the database [19]. Decision tree are developed in the classification process, where the tree is represented by nodes and branches. The nodes in the tree represent the attributes of classification, whereas the branches represent the transition of the decision making algorithm to derive maximum correlation. The approach of decision are been used in various applications of machine learning.

2) Reinforcement Learning:
Reinforcement learning [20] is a kind of learning that build decisions based on events such that the result is improved to constructive decision. The Reinforcement Learning Model is developed as a learning approach based on the action model [21]. This approach developed a decision based on the action model of the testing system. This approach developed a decision based on the action to be made and the best suited decision is processed in retrieving the most accurate retrieval. This approach operates on a trial and error based estimation process. The test system provides a test input and the presented state of processing to the decision system. Here, the decision system develops the operational behavior of the test model based on predicted information from the database based on the query input. The best performing information is then processed as a decision for the given input. The learning system in this approach has a collaborative or independent processing for decisions making.

3) Ensemble Learning:
This learning approach is developed as a integrated processing of multiple learning approaches. Approach such as naïve Bayes approach [22], tree based modeling, neural network modeling etc. are used together in making a decision. The approach of ensemble learning is to develop more accuracy in making decision using multiple decisions in deriving a result. The approach though has a precision of decision making, the complexity and delay factor are highly effective in this approach.

4) Boosting: this form of ensemble learning [23], where the information are processed to minimize the bias and variance in decision making. The approach derive the data based on the strong a weaker learning model, where the collective data which are less correlative in decision making are classified and boosted for stronger learning. AdaBoost approach [24] is commonly used approach of boosting in machine learning applications. The interface of machine learning and flow of information in making decision is outlined in figure 3.

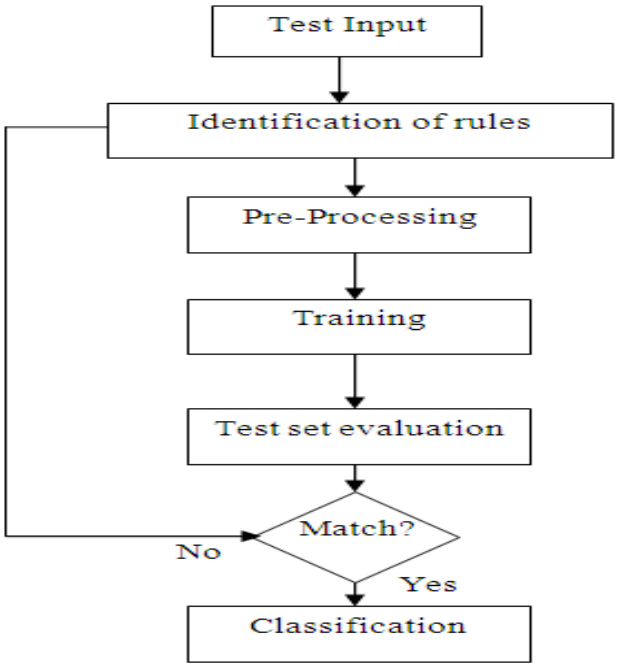

Figure 3- Flow diagram of machine learning approach

Most of the learning systems are processed as inductive or deductive [25]. Wherein inductive approach develops a computer program in developing decision based on the rules and patterns in the database. This approach takes the past processing examples and existing knowledge in developing a subclass of observation for improving the decision process. The deductive process develops a decision based on the learning algorithm passed and the based on the existing learning information to derive a updated information in decision making.

III. MACHINE LEARNING ALGORITHMS

Based on the approach of learning methods followed, the existing machine learning algorithms are classified as presented below.

1. Regression approach

This approach is developed based on the approach of relationship among the information and error predicted [26]. The regression approach predicts the variation of time variant details of the learning information in making decision. This approach is used in the prediction of price varying, temperature variation, natural monitoring parameters etc. The approach of regression models [27-30] developed in past are as listed;

- Linear regression.
- Logistic method
- Stepwise method
- Multivariate approach
- Least square method

2. Instance learning approach

This approach [31] is developed as a learning approach based on the current instance and decision approach for training and derive test model from the rules of learning and input information. The majorly used approaches [32,33] in this method are;

- Locally weighted approach
- Self organized mapping approach
- k-Nearest Neighbor (KNN) approach
- vector quantization approach

3. Decision tree based approach

This approach [34] is developed based on the categorization of dataset into small sub set and forming a tree like relation in building the decision. This approach is developed as a node and branch modeling where the attributes are grouped into set and interlinked as branches in

making the decision transition. The most commonly used methods [35,36] are;

- Chi squared approach
- Decision stump approach
- Regression tree approach
- Conditional decision tree modeling

4. Bayesian Approach

This approach [37] is developed as a probabilistic modeling where data statistics are used in developing and quantifying the information based on Bayesian approach. The commonly used approach in the Bayesian approach [38,39] is;

- Bayesian belief network (BBN)modeling
- Naïve Bayes approach
- Gaussian naïve Bayes approach
- Average one-dependent estimator (AODE)

5. Clustering Based approach

This approach [40] is developed using a division of the training data into many small sub clusters based on the correlative property of the information. The clustering approach is developed as a categorized or hierarchal database. The commonly used clustering based approaches [41,42] are;

- Hierarchical cluster modeling
- K-Mean approach
- Expectation maximization approach
- K-Median clustering

6. Association Rule Based learning approach

This approach [43] is developed on multi dimensional database which are categorized in many sub clusters associated with learning algorithm. The association develops the relation of a variability factor for the database information. The commonly developed association rule based approaches [44,45] are;

- Apriori Rule approach
- Eclat Approach

7. Neural Network Approach

Neural network [46]are developed in reference to the biological neural modeling based on trained data. This network develops as a multi layer network with interface of input and output data. The two layers are interconnected with hidden layers which are developed based on the kernel functions. The mostly used neural network approaches [47,48] were;

- Feed forward back propagated neural network (FF)
- Back propagation model (BP)
- Radial basis function network (RBF)

8. Deep Learning Approach

This is improved approach of neural network [49], where the networks are trained to a finer level with complex neural network trained with large data size. The commonly used approaches[50,51] are;

- Convolution neural network (CNN)
- Deep Belief Network
- Deep Boltzmann Machine (DBM)

9. Dimensional Reduction Method

Dimensionality reduction [52] approach is developed for the minimization of feature data set in the training process. The large volume of feature representation builds a large overhead in storage and processing overhead. Dimensional reduction approach minimized the feature vectors which are of high significance. The approach of selectivity of the information vector defined the accuracy and complexity of learning approach. Most commonly seen approaches for dimensional reduction [53,54] are;

- Sammon Mapping approach
- Quadratic Discriminant Analysis (QDA)
- Linear Discriminant Analysis (LDA)
- Principal Component Analysis (PCA)
- Partial Least Squares Regression
- Mixture Discriminant Analysis (MDA)
- Flexible Discriminant Analysis (FDA)

10 Ensemble based approach

This is an unsupervised approach of learning [55]. This approach derive sub cluster representation from the trained data and builds a hypothesis by merging different learning approach in making a accuracy in decision. The commonly known approach for ensemble approach [56,57] is;

- Bootstrapped Aggregation
- AdaBoost
- Random Forest
- Gradient Boosted Regression Trees
- Boosting

11. Machine Learning Tools

The tools were developed with learning algorithm in making the interface of learning approach in coding and real time interface. The tools are developed in compatible to the applications and resources for coding. The commonly available tools for machine learning approaches [58] are;

- WEKA
- JSAT in Java.
- scikit-learn
- Panda

IV. CLASSIFICATION AND DECISION RULES IN MACHINE LEARNING

One of the core part of machine learning system is the decision unit. This is a classification unit where the system performs a predictive analysis from the trained information and performs a classification process in making a decision. The decision is developed for a current observation or a predictive observation for future. This approach is developed as a predictive model, descriptive model or a decision model [59].

a) **Predictive Unit:** This approach defines the relation of feature attributes of trained information. The approach clusters the information into similar groups based on the correlation property of the information and the clustering rules.
b) **Descriptive Unit:** This unit derives and predicts the relation based on the deviation among the information's of dataset. The approach derives the grouping of data based on the behavioral relation of attributes in trained database.
c) **Decision unit:** This unit performs a decision making based on the identified relation among the attributes and defined a rule of decision among the information for classification and categorization among the trained dataset. The attributes re categorized based on the decision tree modeling and process for the identification and prediction of the result on multiple inputs or feature vectors of the dataset.

The learning rules developed in the decision making has an important role in developing machine learning system. The rules of learning defined the real time of training information and trained information in the dataset while training and define the relation of output to input in classification process. The rule defined the possible hypothesis in deriving the decision model of the learning system. There are two approaches of learning rules, Proportional and relational rules [60].

a) **Proportional rules:** Proportional rules are developed based on the input given and the instances of developing relational values among different attributes in the classification process. The process is developed as a IF-THEN condition rules, where the learning is developed as a hypothesis for conditional relation of input to output defining accuracy of the rules. The Proportional rules applied on a structured data set for classification.
b) **Relational rules:** this approach is processed over distributed dataset, where the information's are stored in different locations and a relational form of the database is used in making a decision. This approach performs the relation coding based on the transformation of learning approach based on reference entry mapping with other training data. This approach is also known as the inductive logic programming (ILP) approach.

The Commonly Used Machine Learning Models in the classification process is based on the regression modeling or the predictive modeling.

1. Regression Modeling

This approach [61] is developed based on the derivation of mathematical formulation of output to input for making a decision. The approaches of regression model used are;

1. **Linear model:** This approach develops a linear relation between the predicting value and the input value. This approach has a linear variation of output on the

changes on input data. The output (y) is derived from the relative linear function of input(x) defined as, y=f(x).

2. **Logistic model:** This is a two level decision model, where the decision has a probability of success or failure in detection. The value in this system is a binary variable.
3. **Stepwise model:** when the variables are multiple this approach is used. This approach predicts the best fit vale in a step manner. This approach achieves a maximum prediction with minimum predicators.
4. **Ridge Model:** This method is used in decision when the trained dataset information's are correlative in nature. This model uses a multi correlation property in deriving the decision among the learning dataset.

2. Predictive modeling

This modeling is used in the prediction of class among multiple class value. The prediction in this approach is fixed to a specified class attribute. The commonly used predictive models are;

1. **Support vector machine:** This approach is used in developing of relation and classification of complex pattern within the dataset [62]. They perform and detect best match value based on learning approach, also called as learning machine.
2. **Naïve Bayes approach:** wherein the predicators are high this approach is used. This approach performs the estimation based on the Bayes conditional probability [63].
3. **K-Nearest Neighbor Approach:** The approach develops a method for statistic prediction of pattern recognition based on both positive and negative values in the dataset [64].
4. **Random forest approach:** This is an ensemble type approach, were the decision is developed based on tree based modeling [65]. This approach performs a predictor decision based on the out-of-the bag error. This approach performs the classification based on subset of variables in dataset.

V. RECENT DEVELOPMENTS AND FUTURE PERSPECTIVE IN MACHINE LEARNING

In the process of improving learning approach under unsupervised learning approach various developments were made in recent past. A self-organizing neural architecture for active perception is presented in [66]. The unsupervised learning approach is developed based on the multimodal fusion approach. The approach is a tree based approach which map different modality among the attributes in dataset. The proposed architecture defines the collection of data into separable small group of information and performs sub learning using multiple learning models. Here each of the clusters is independent processed and a redundancy reduction using multi modality approach is proposed. This approach reduces the redundant entry in the learning phase hence improving the learning performance. However, the system is developed on a linear scale which has no consideration of past observation for data mapping. This limits the clustering decision to current observation hence resulting in lower efficiency. Towards developing a unsupervised learning and improving its learning efficiency in e-learning approach, a characteristic based approach is outlined in [67]. This approach developed an adaptive approach of learning based on the user characteristic of updation and the mode of mining process. This approach reads the log files of user access and develops a characteristic value for the user updation. An adaptive e-learning classification for creation of an efficient learning representation that symbolize the user characteristic is outlined. Observing the learning approach the adaptive E-learning scheme is developed to improve the learning procedure by providing modified data. A method to recognize the learning method

based on the present learners' characteristic and using web custom mining method and machine learning approach is outlined in [67]. The web custom mining method was used to pre-process the log file to find the learning conditions and observe the learners' pattern.

However, the characteristic developed for the user is mapped as a isolated observation in learning process. This resulted in isolation of observation in learning and leads to misclassification. In the classification process, a critical process of the system is to cluster the information as accurate as possible to have maximum accuracy in classification. Towards clustering process, in [68] Quantum information based coding is proposed. The clustering process is developed based on the quantum machine learning approach. A q-mean approach is presented which is developed by a k-mean approach developed for a faster convergence in decision making. This clustering approach developed a higher precession in clustering process however, the data clustering has no validation on the information gain in cluster formation. Table 1 present a summary of the past developments in machine learning methods with application, advantages and limitation to the machine learning system.

Table 1: Approaches of machine learning advantages and limitation

Method	Application	Advantages	Limitations
Neural Network (NN) Method [1, 22, 46,47,38,49, 50,51,66]	Operational testing in industrial application Functional analysis of large system Data security and risk management applications Sales and market forecasting, etc.	Adaptive in nature: The network adapt to the decision process based on the input and the trained data given to the network. Self organizing: The approach creates and updates the representation of data during learning process based on the input given. Practical usage: This approach is developed and used in usage of many real time practical applications, which show a benefit of adaption to variation with course of time variation.	The issue of over fitting leads to a large computational effort. The relation of input to output is derived by the defined rules which would lead to false mapping under dynamic condition. The accuracy of this network is based on the size of data given in learning, which is has to be large in making accurate decision.
Case Based Reasoning	Auto help desk interface. Effort estimation in software applications.	This system does not require any expert learning system. It works on the prediction model and process in	The interface for the learning and decision is hard. The case data are limited to the

(CBR) Approach [69-71]	Decision making based on knowledge based application	handling of case failures. The system has a minimum maintenance.	application and hence has a constraint of low predication.
Classification and Regression Trees (CART) Approach [12,19,22, 34-36, 56,57,59,65,66]	Used in customer relationship management in financial sector. Precision of effort such as COCOMO model	This is a non parametric approach, where the data are clustered based on exhaustive search of all possible operations. This approach has the feasibility of handling missing variables in the learning process. It is an automated learning system, which can predict varying parameters.	This is a new approach and the complexity of the coding is variant with applications. The approach has less expert analysis for evaluation. This approach would lead to a large unstable decision trees and the clusters are developed with a single variation.
Rule based coding [43, 44,45,59,60-64]	Used in accounts and loan credit system. Applied for transformer protection in electrical application. Applied for classification of mechanical devices	The input interface in simple and the rules defined are easy in understanding and depiction.	The rules are to be accurate to improve classification performance. Estimation of rules in dynamic condition is a difficult task and the system has to process on complex rules.
Adaptive Coding [67,72]	Applied in scientific research such as biological evolution. Used in genomic processing. Used in various tools on economic process.	This approach is simpler in computation, and results in accurate value based on the convergence. The approach is based on the standards of fittest survival.	The computation resource requirement is large. The process takes a large processing time in deriving a decision. The decision is relatively similar for many combinations in genetic processing.

The past developments and the limitations outlined, focus on developing a new processing interface for data retrieval in wide distributed domain offering high security, reliability, throughput, low resource consumption, accuracy and integrity of data using an advanced machine learning approach which is to be faster and accurate in processing. To minimize the learning and updating overhead, approach using input characteristic and feedback of learning system could be used. This method would reduce the learning process overhead, and minimize the delay in data exchange. In the updation process of machine learning, each of the observed data passed for learning is randomly stored. This updation results in large search overhead during decision making, resulting in delay of allocation. A new data semantic approach based on input updation rate, characteristic of input variation and

maximization of expectation parameter could be made for dynamic input updation in the learning process. The enhancement of clustering approach could lead to better accuracy in the decision performance. A new clustering approach based on information gain could be proposed for optimal clustering in machine learning.

VI. CONCLUSION

The evolution of machine learning and its application to practical applications has outcome with the need of developing new approaches in machine learning approach. Various past modeling and operational approach for machine learning are outlined in this paper. The process of machine learning system and its working model gives an approach of evolution of the operation units in machine learning. The existing method, applications and limitations concludes in the need of developing new approaches for machine learning. This paper presented the approach of working methods of classification, clustering and decision making in machine learning system. An attempt to outline the methods and operational outline of Classification, Regression, and Clustering in concerns to ML Algorithms is presented. The recent developments and the future perspective in development of machine learning system are outlined.

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