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RESEARCH ARTICLE

CLASSIFYING THE SUPERVISED MACHINE LEARNING AND COMPARING THE PERFORMANCES OF THE ALGORITHMS

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Abstract

Supervised Learning (SL), also recognized as SML, means Supervised Machine Learning. It's a subclass of AI (Artificial Intelligence) and Machine Learning (ML). It's defined by the conduct of entitled datasets for training algorithms that predict outcomes precisely or classify data. The input dataset is faded into the supervised Machine Learning model, which synthesizes its weights until the model has been fitted properly, which happens as a segment of the cross-validation process. Supervised learning machine assists organizations in solving different kinds of real-world problems. SML is searching for algorithms that externally outfitted the instances to produce common hypotheses, preparing predictions for future cases. The supervised Machine Learning (SML) classifications are frequently completed tasks by effective intelligent systems. This paper discusses different categories of Supervised Machine Learning classification technology, compares different categories of supervised learning algorithms and identifies the best effective classification algorithm based on some instances, data set and variables or features. This paper discusses eight different types of SML algorithms. Those were envisaging: Artificial Neural Network (ANN), Bayesian Networks, K-nearest Neighbor (KNN), Random Forest, Decision Tree (DT), Linear Regression, Support Vector Machine (SVM), and Logistic Regression. These eight algorithms develop in the python language. Using a sample dataset for every algorithm and justify the algorithm performance. Here, justify the algorithms based on three different outcomes: throughput, response time, and accuracy. The supervised learning method depends on pre-defined parameters. The performance metric has an important role in identifying the ability and capacity of any kind of machine learning algorithm. The outcomes show that Decision Tree is the best prediction performance in this paper and gives the best accuracy, response time and throughput. The next accurate algorithms in SML algorithms are Logistic Regression and SVM after the DT algorithm.

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Introduction:-

For a long time, various ML algorithms have been effectively used for creating predictive casts from the dataset. ML algorithms and data mining tools in expert-based disciplines are knowledge-intensive and data-rich. In the recent-day, the information society is growing rapidly. Computers affect all strategies in society, such as medical research and economy, and typically extrude the manner human function and penetrate new regions of practice. They look at recent statistics technology and its utility in specific regions resulting in the advent and improvement of contemporary-day programming languages and structures [1].

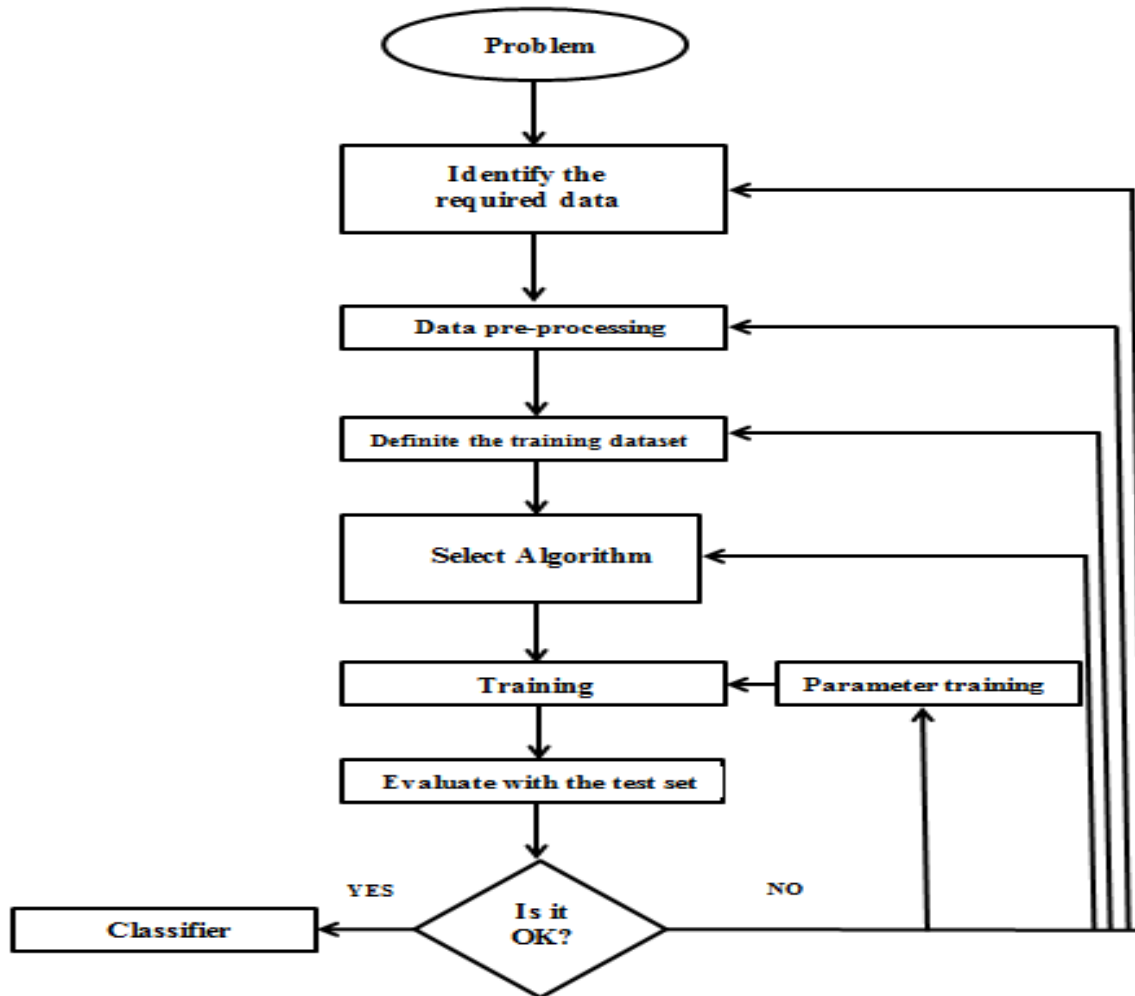


Figure 01:- The Method of SML [6].

In general, it was studied within the context of numerous disciplines — DM (data mining), IDA (intelligent data analysis), KDD (Knowledge discovery in databases), and ML (machine learning). In trend, KDD studies worry about the whole Knowledge invention process, such as data mining, pre-processing and post-processing. Contrariwise, ML studies have many opportunities--it researches the studying system and, in several, the automatic studying system.

Notwithstanding all four fields' making large developments in automatic information achievement from data, they've now no longer at once searched the labyrinth of ambit knowledge integration in another all of KD method. ML is the fastest developing computer science and engineering sector, with large-extending application programs. It means the self-acting discovery of significant swatches in a dataset. ML instruments are related to awarding projects which might adapt yet learned [2]. The ML method has formed on the mainframes of a principal portion of our existence, albeit usually hidden and Information technology. With the increasingly huge amount of data fitting available for the best reason, I believe that dataset analysis will happen more as an important component for technical systems.

Mobs are often apt to possibly build errors during analyses when attempting to set up relevance among multiple features [3]. Machine Learning and Data Mining are similar pairs where different sagacity can be evolved with accurate learning methods. New data creation makes ML methods more realistic from day today. It is used for individual methods for both unsupervised and supervised ML is rationally collective in the classification matters sod that the aim is to get the computational system to study the classification technique that we made [4]. Machine Learning is properly aimed at achieving accessibility invisible between large data.

ML is appropriate for the angularity of monitoring through different data roots, yet the huge extent of values with huge amounts of data worried machine learning improves raising datasets. With the freedom from the lines of a particular level of study and concern, machine learning is cute to search out and display the models mystic in the dataset [5].

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Standard manufacture of SLM load is a classification matter: Learner is needed to study (probable the nature) a function that designs a vector with different classes by finding different input-outcome instances of functions. Inducing ML is a system of knowledge that is a part of laws from cases (training dataset), or moreover usually creating, telling a classifier which will be conducted to normalize from recent precedents. The system of enforcing SML in an actual problem is related in Figure 1. This work focuses on different types of machine learning methods and identifies the best efficient algorithm with strong accuracy, throughput, and response time.

The Supervised Machine Learning Algorithms Classification:-

Following [7], SML methods/algorithms are conducted much with the classification encircles due to Artificial Neural Networks, Bayesian Networks, Decision Tree, K-nearest Neighbor, Support Vector Machine, Random Forest, Linear Regression and Logistic Regression and others.

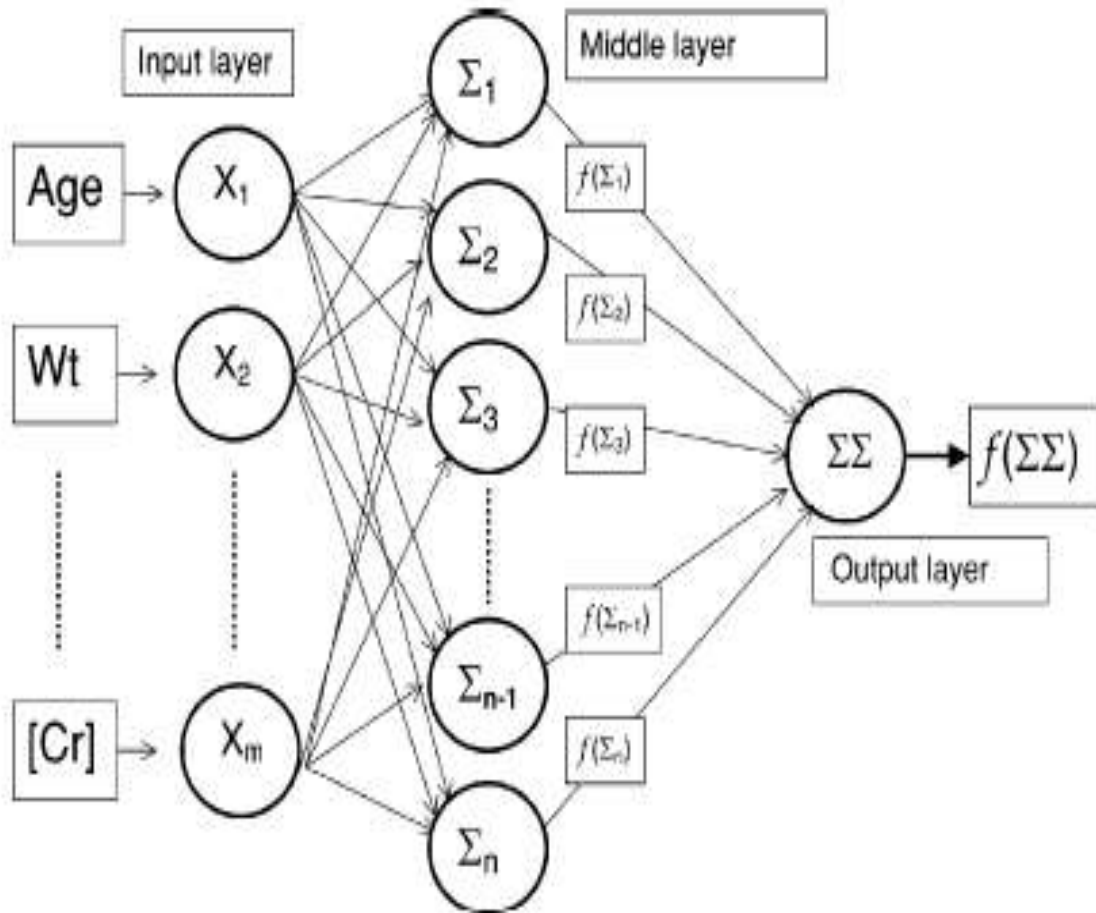


Figure 02:- Artificial neural network (ANN) architecture.

Artificial Neural Network (ANN):

Recently, a multitude of methodologies and ideas from individual disciplinary fields have increased in particularly attractive research field ANN [8]. A neuron is a basic unit for making the nervous networks which perform communication and computational methods. The ANN is the working repetition of the facilitated method of the biologic neuron. Yet, the aim is to reconstruct knowing data appraisal methods like classification, generalization, and pattern recognition using simple distributed and robust processing units named Processing Elements (PE) or artificial neurons [9]. A chief benefit of the ANN access is that the ambit learning gives shares in neurons. Data processing is brought to pass in a collateral distributed manner [10]. ANNs are exceptionally collateral data processing instruments able to learn the working dependencies of the dataset [8]. They have to be able to clearly categorize a high non-linear bearing yet, once trained, can categorize fresh datasets so much more swiftly than it should be probable by proving the structure logically. ANN formation is based on artificial neurons.

Every artificial neuron features a system node ('body') delineated by circles within the figure likewise as affiliations from ('dendrites') and affiliations to ('axons') alternative neurons that are shown as arrows sign in the figure 02. In the last step, the output neuron gets the weighted aggregate of inputs and dispenses the non-linear functionality to the weighted aggregate. The results of this function make the outcome for the complete ANN [11].

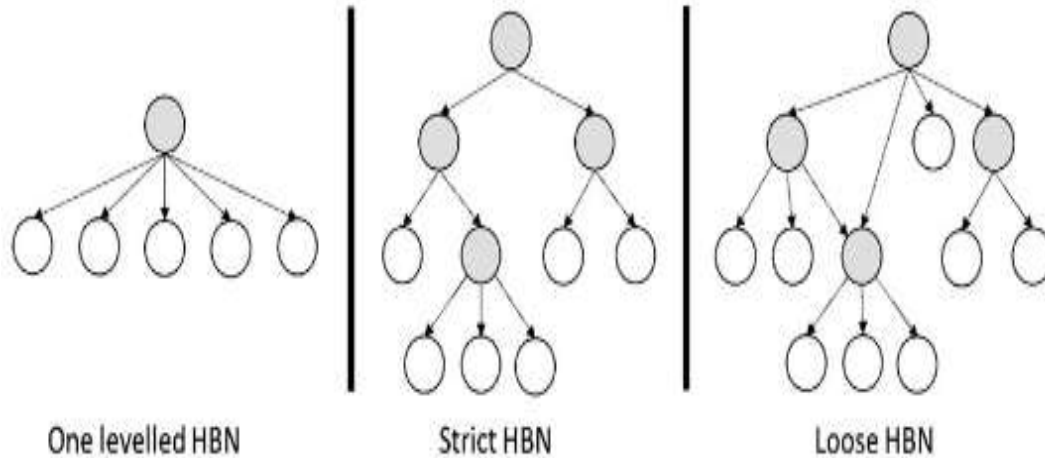


Figure 03:-Possible hierarchical Bayesian network structures. The gray-colored nodes represent the latent variables and the white-colored nodes represent the observed variables.

Bayesian Networks (BNs):

An essential step for developing artificial sagacity is to qualify an engine to describe how the universe acts by constructing an interior model from a dataset. A very important view is studying the dependency diagram of BNs from a dataset. The motive defines learning the structure, is called NP-solid [12], and yet is chopping-edge research object acute. Shortly, it is knowledge of as selecting a diagram depends on a few candidates, mounting the argument all over the gathering of patterns of the format producing dataset. A wide review of remaining software instruments is also conferred [13]. The main argument in artificial intelligence is developing structures that enable generating a model narration of the ambit wisdom yet receiving within calculation the most probably structures will learn from the dataset.

BNs is a DAG (directed acyclic graph). Where conditional dependencies on edges and the random variables are represented by nodes. Now the Bayes' Theorem equation is:

$$P(H|E) = \frac{P(H) * P(E|H)}{P(E)}$$

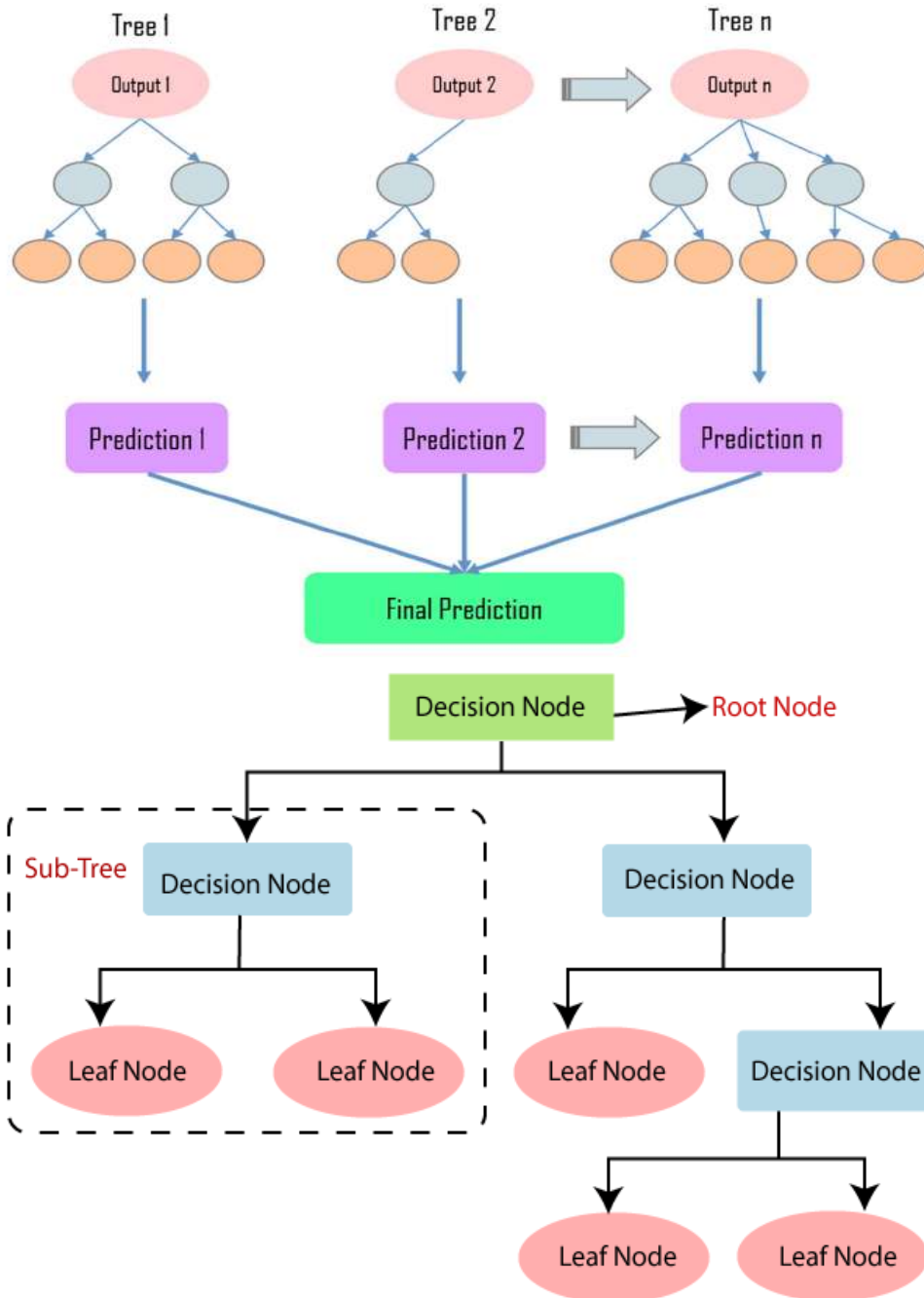
Here, $P(H|E)$ = Posterior probability of 'H' given the evidence; $P(H)$ = Prior Probability; $P(E|H)$ = Linklihood of the evidence 'E' if the Hypothesis 'H' is true; $P(E)$ =Prior probability that the evidence itself is true.

The strict HBN and loose HBN were received for supervised classification of instances and for designing of variables [14].

Decision Tree (DT):

DT is one of the significant technologies in machine learning. Several sectors applied the Decision Tree algorithm and applied it in several applications. Decision Tree has three different algorithms that are C4.5, CART and ID3 [15]. The ramification is the motive of offering objects to the class, which has various applications. A normal tree comprises roots, leaves and branches. It's a predictive structure applied in machine learning, data mining and statistics. In tree models, the destination variable can get a limited set of entities that are defined as classification trees; in the tree model, leaves represent the label of branches, and class represents the joins of fertilities that conduct with those labels of class. Decision trees can construct comparatively faster than any other method of classification [16].

Decision tree is similar to the tree. To construct a tree, uses the CART (Classification and Regression Tree algorithm). The structure of the decision tree:



A group of analysis used to analog the performance of every algorithm. This added the boosted/tuning DT Regression. Tuning/boosted DT regression is the algorithm applied to train model by performing with Multiple Additive Regression Trees (MART) algorithm. Every tree is devoted on prior trees that represents how to boost/tuning works shown in Figure 04[17].

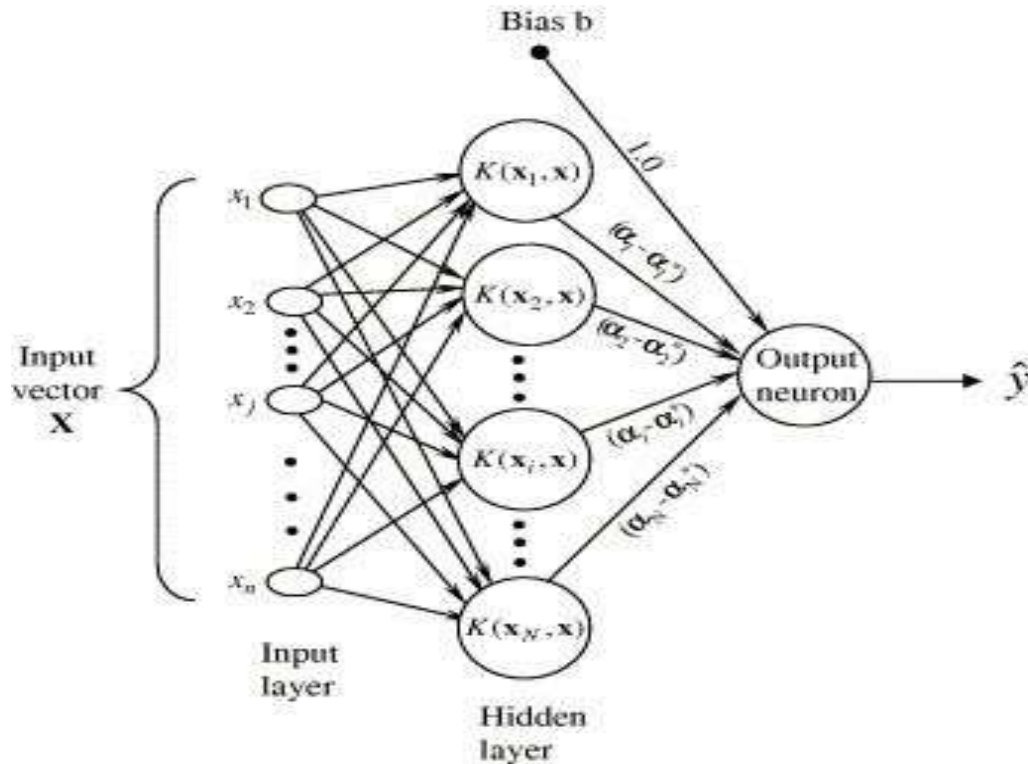


Figure 06:- Architecture of support vector machine.

D. Support Vector Machine (SVM):

SVM is the significant ML algorithm usually developed in pattern recognition problems, classifying the image processing and network traffic for recognition.

Too much research is working on skilling to develop Quality of Service (QoS) and indemnity aspects. Recent work in this sector has been solved by SVM. It acts more finely than any other classification network traffic for normalizing the difficulty. This research represents the aspect of SVM, its applications and its concepts overview [18]. SVM is the strong learning method applied in binary classification. The SVMs principle task is to search for the greatest hyper plane which can differentiate data properly into twice classes. [19]. Nowadays, multi-class classification was gained by mixing multiple binary support vector machines. The architecture of SVM is shown in figure. 06.

E.K-nearest Neighbor (KNN):

Distance-basis algorithms are broadly used for dataset classification difficulty. The KNN classification is the most exoteric distance-basis algorithm. Euclidean distance by this behavior of different datasets requires private resemblance measurement accommodated to the dataset features. [20] Alignment is the SML system that graphs on the input dataset, defining classes/groups. The main principle argument for investing an arrangement rein is that all of the dataset aims would be engaged to the groups and that every entity object would be engaged to a single group. Here, K use as an amount of the closest neighbors in KNN.

F. Linear Regression:

One of the maximum general, extensive statistical and ML algorithms is linear regression. It's applied to identify linear relationships within once or farther identifiers. Two types of linear regression: multiple regressions (MLR) and simple regression. Different researchers are researching polynomial, and linear regression yet compares their effectiveness using the accession to optimistic precision and prediction [21].

Machine learning [22-23] is generally conducted in diverse sectors to solve various problems that can't be smoothly composed depending on computer direction. Linear regression [24] is the mathematical experiment conducted for quantifying and evaluating the familiarity into the calculated attributes. Therefore, sketchy regression and correlation are experiments where a boffin in perception the bonding into two attributes to count the influence of

disorders [22, 25, and 26]. Linear regression [27] is generally conducted in mathematical techniques. It's likely to identify the prediction model yet affect the versus multiplex input attributes.

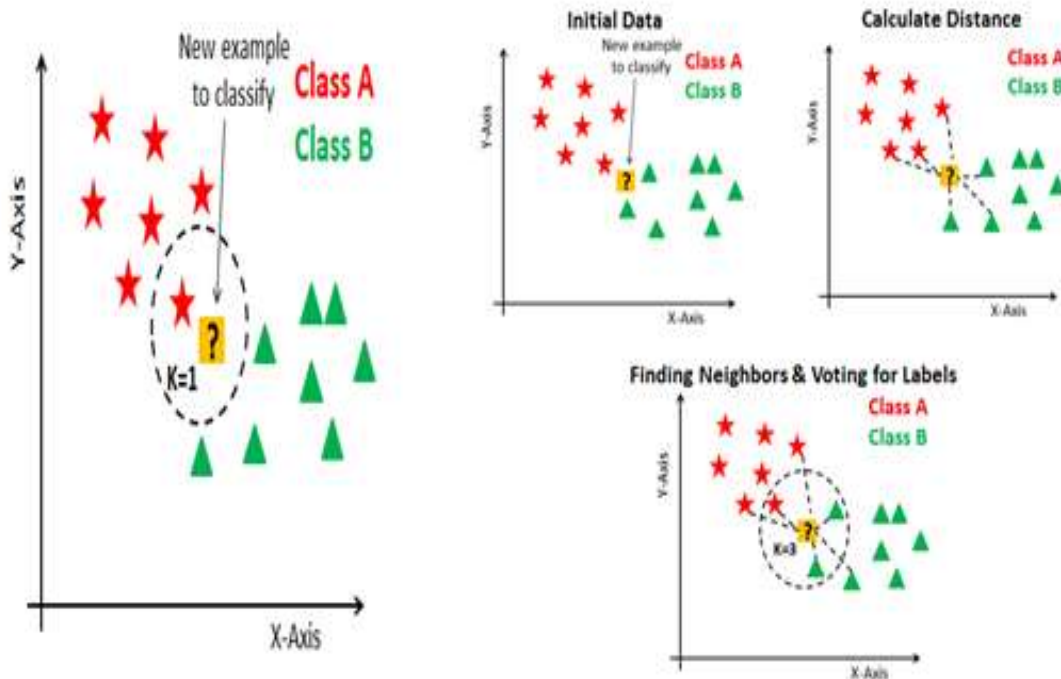


Figure 07:-K-nearest Neighbour (KNN) algorithm workflow.

Now consider Figure 8.1 an architecture model of the linear regression, as a forerunner of the neural network. Sum of the weighted is presented as computational unit. Here's a consecutive convention considering the favor as few specific weights, having the corresponding node as input and also constant noted value is +1[28]. The Linear regression has also been normalized to multi-variation linear regression. In this case, multiple variables y_1, \dots, y_p for prediction, as represented in Figure 8.2 (as an example, 3 prediction variables use y_1, y_2, y_3) [28].

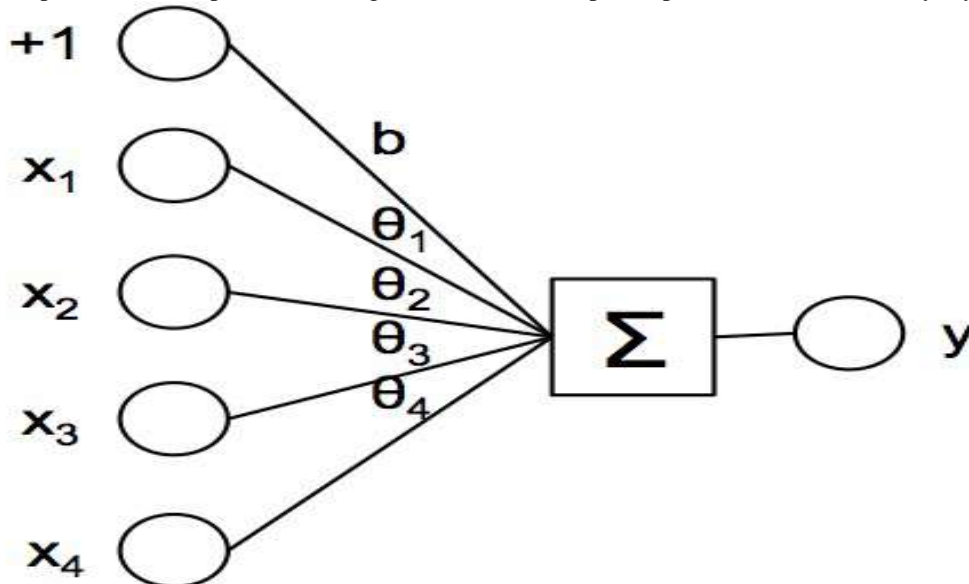


Figure 8.1:- Architectural model of linear regression.

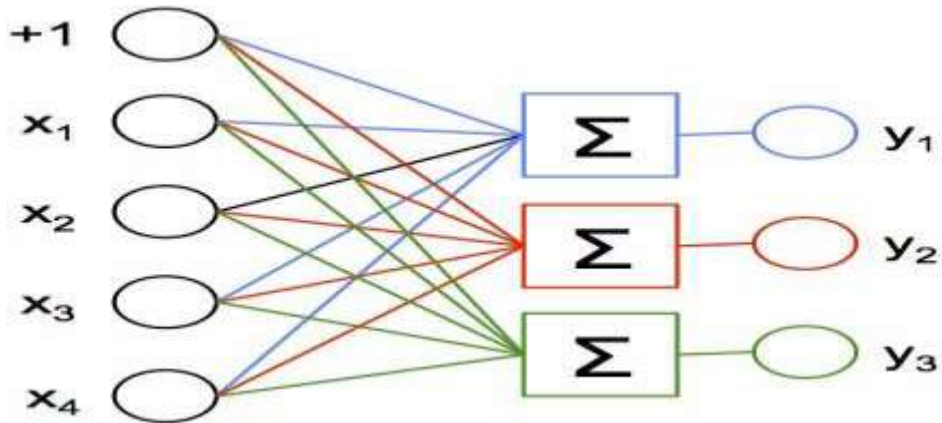


Figure 8.2:- Architectural model of multi-variation linear regression.

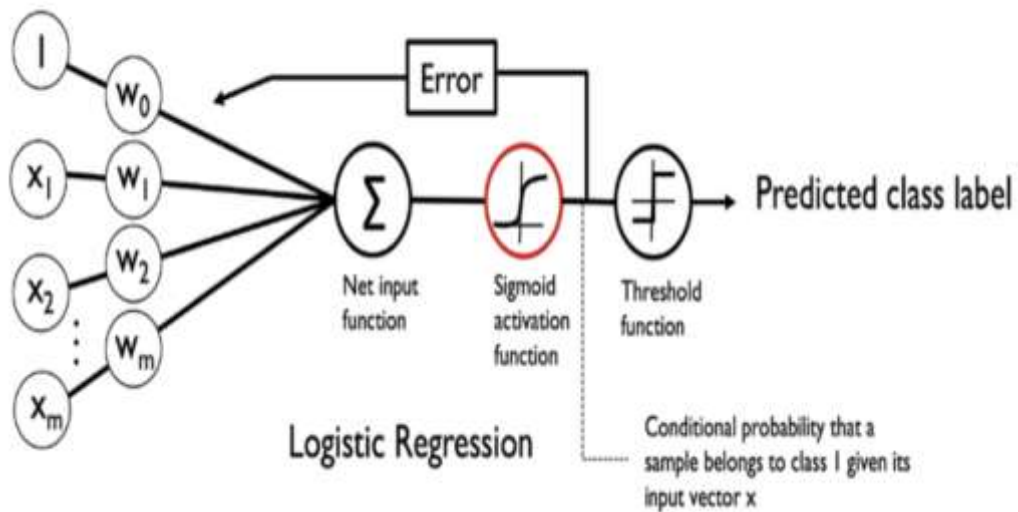


Figure 09:-Architecture of a Logistic Regression Model.

Logistic Regression:

Logistic regression has broadly applied to different fields of the experiment, such as hygiene science, to learn the risk factor attached to the illness. Some surveys depending on Health Survey and Demographic are made predicting mixed modeling i.e., multistage sampling, stratified and probabilistic with unbalanced magnification in the survey. These compound diagrams must hold to calculate faithful outcomes. Although it is a relevant general issue and not well analyzed in the literature [29].

It is the preferential probabilistic structure. This structure generates inferior probability formation $P(Y|X)$, ($Y =$ destination variable and $X =$ features). Given X , return to a probability formation over Y . In Figure 09 represents an architecture model of the logistic regression. Outcome of the sigmoid function is explained as probability of individual sample including to the positive class, in the binary classification crux. An example, $\phi(Z) = P(y = 1|x; w)$ ($Z =$ linear combination of the weights and the samples features $Z = w^T x$). This algorithm is broadly used for classification. This algorithm is broadly used for classification[30].

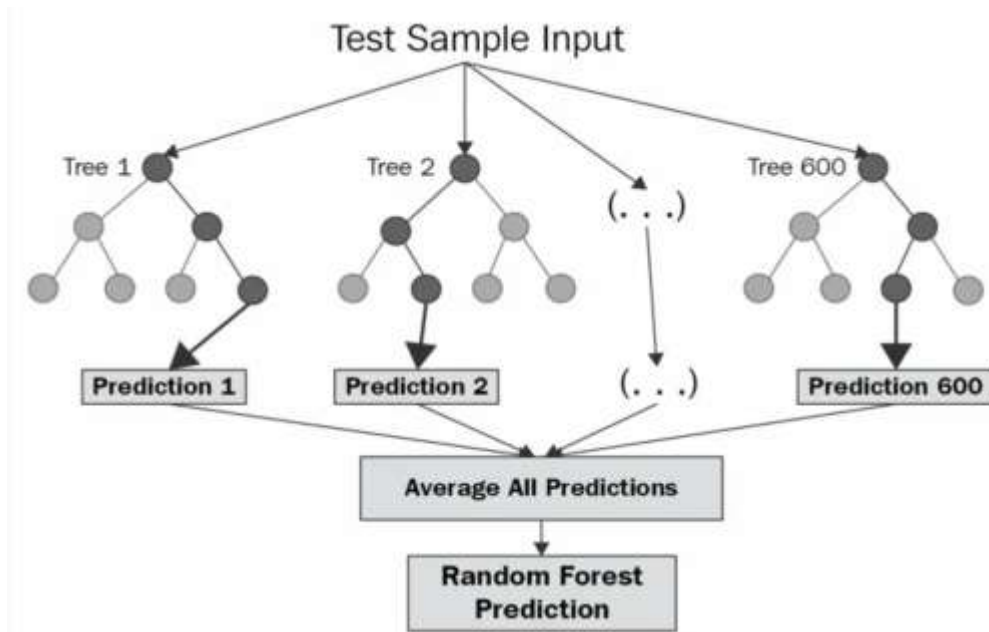


Figure 10:- Random forest Architecture.

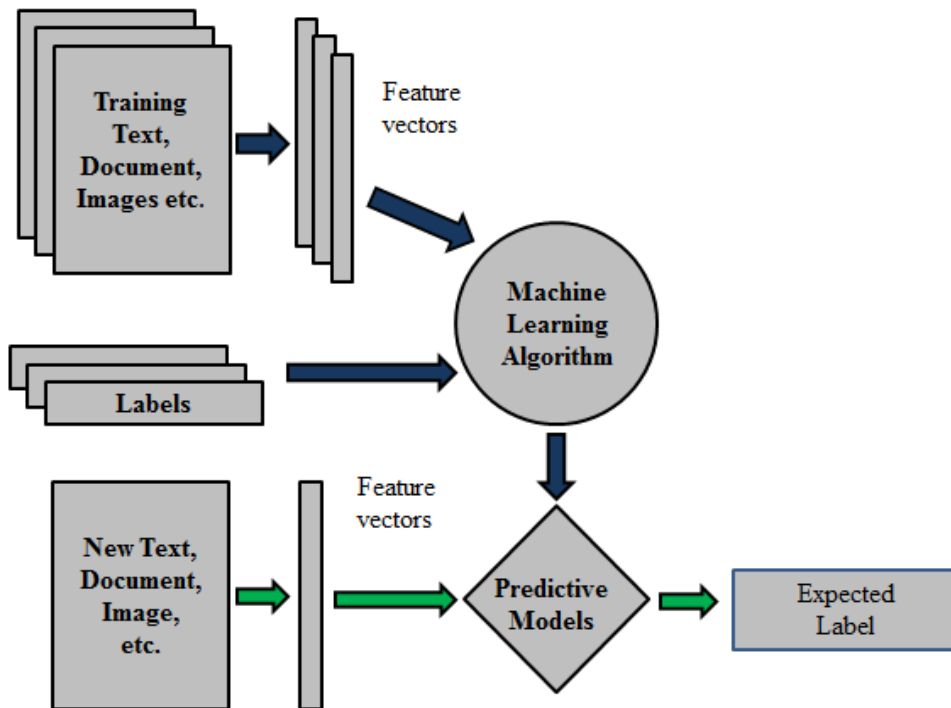


Figure 11:- Features of the SML Model [34].

H. Random Forest (RF):

Random Forest algorithm is an assemble method which combined the outcomes of various randomly built classification tree. Two elements of randomness are proposed into the building of the several trees. At Frist, every tree is built using the random bootstrapped form of training dataset. Prediction contracts for unobserved dataset by getting a majority view of the individual trees. Random Forest packages in python used for implementation [31]. In RF for constructing a tree uses random dataset. Figure 10 shows the Random Forest model architecture. Random forest is generated the prediction result by the average all sub-tree predictions.

Features of supervised Machine Learning Algorithms:

SML methods are contextual to mass ambits. Some ML dispensation oriented researchers can get in [32], [33]. In general, neural networks and SVMs bend to deduct better, however, conduct with continuous features and multi-tasking. However, other sites' logic-basic methods bend to enact so well, conducting with definite characteristics. For SVMs and ANN models a huge pattern is needed in sequence to gain its maximal accuracy count where Naive Bayes can require a comparatively little dataset.

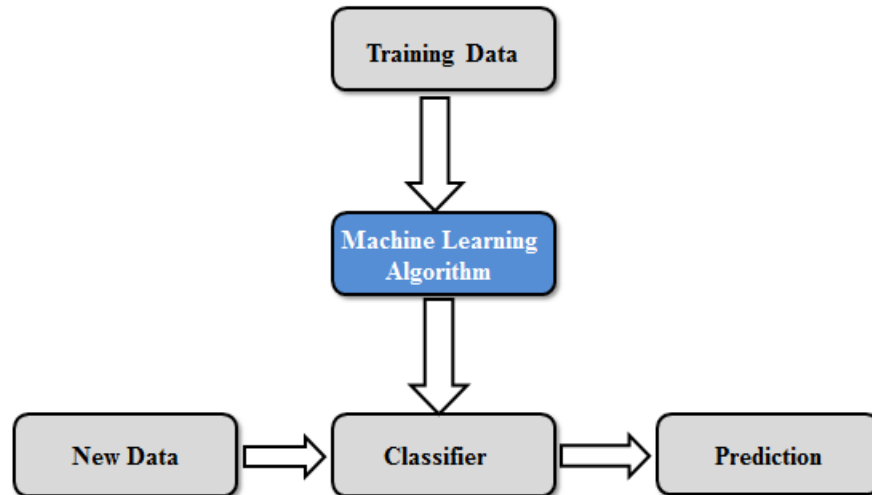


Figure 12:- SML working process [36].

Related Works:-

An SML model has two portions: one is the training part and another is the testing part. In the training part, sample datasets are taken into training as input. Which characteristics are realized by the learner or which learning algorithm constructs the learning model [35]. On the other hand, the testing part, the learning structure, conducts the redaction engine, making the count for producing or testing data. Tied datasets are the model's main outcome, which generates the ultimate classified /prediction data.

The SML process (figure 12) is a common method in classification matters, although the machine aims to learn about the classification model we have constructed.

In the classification, the entities are abstract, in regression, the label is continual. In this research data was reached from BMI calculation chart. This dataset was selecting because of its accuracy and has also been anonym zed (de-identified), therefore confidentiality is ensured.

In this research number of Columns 4 and number of row 1128 .So number of 4512 instance for using as a datasets.

In the four columns are height, weight, BMI, and outcome a result which is depends on another three columns instance. Here uses the height as a centimeter scale and weight data gets in pound scale. This height and weight are integer type's data and BMI is floating type's data. But on the other hand, the outcome result or the destination result columns are String type datasets. For getting proper outcomes iterates every models 100 times and takes the average outcome result as the final result.

Proposed Efficient Model:-

In this research have two vital objectives: At first, makes a compare of some supervised machine algorithms: Random Forest, Support Vector Machines, Naive Bayes, K-near Neighbor (KNN), Logistic Regression, Linear Regression, Artificial Neural Networks (ANN) and Decision Trees. And other important goal is improve the accuracy of final results using hyper parameter tuning and cross validation. The architecture of the proposed approach can be seen in Figure no. 13.

(i) Comparison of Methods

This paper discus about eight supervised machine algorithms performance based on the algorithms accuracy, Response time and Throughput. We target an algorithm is best which accuracy and throughput is high and response

time is low. In this research we get significant outcome on throughput, response time and accuracy from different supervised machine learning algorithm.

(ii). Proposed Model

In this research analytical part we find vital outcome on accuracy, response time and throughput. Different supervised machine learning algorithms gives different kind of performance which based on throughput, response time and accuracy. In this research, two different algorithms Random Forest and Decision Tree generates best outcomes. It's to be noted that, Random Forest generated accuracy is high that is near about 93.36% but its response time and throughput performances are low. On the other hand, Decision Tree generates second higher accuracy is near about 90.71% and its response time and throughput performances are high.

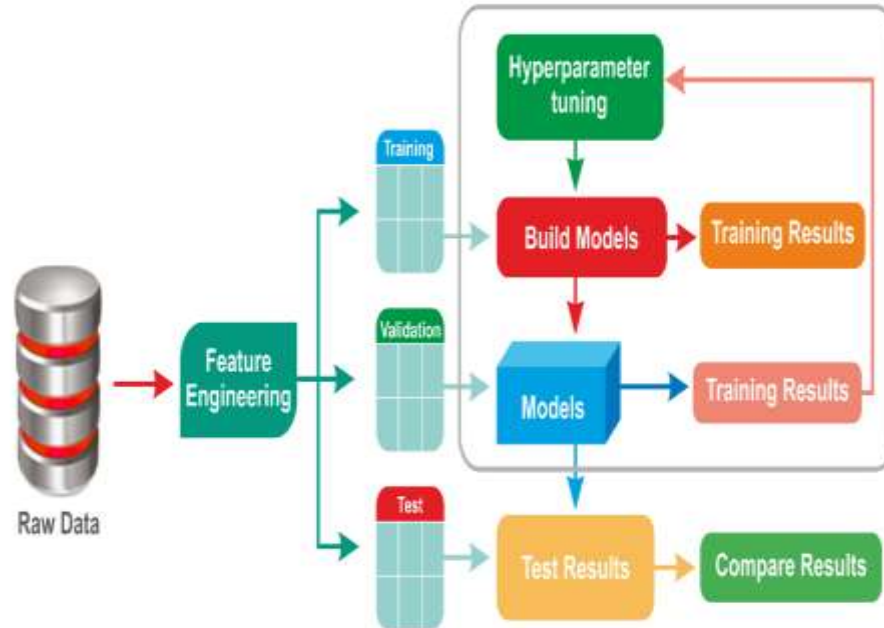


Figure 13:- Proposed Model using hyperparameter tuning.

In this situation, we used proposed methods for getting a best algorithm form those supervised machine learning algorithms. Now focus on two algorithms Decision Tree and Random Forest. The Random Forest accuracy is high but its response time and throughput performances are low. On other hand, the Decision Tree generates second higher accuracy and its response time and throughput performances are high. So at this moment, we want improve the Decision Tree accuracy using hyperparameter tuning and cross validation Model.

Hyperparameter tuning and cross validation for an algorithm is normal method that uses for increasing algorithm performances. Hyperparameters are naturally adjusted before the real training method begins.

It's done by engaging various values for that hyperparameters, training model, and improving accuracy of ours targeted algorithms. The tuning of hyperparameter is a method for selecting the particular combination of the hyperparameters depends on the performance of current data. It's a fundamental necessity for getting accurate and meaningful outcomes from machine learning algorithms. Following figure no. 13 represents things to consider, the model tuning method, and workflow.

Rotation estimation is also known as Cross-validation (CV). It is the model validation method for measuring the efficiency of the results and statistical analysis. The aim is to create the model normalized toward a random test set. It helps to estimate which way model can predict and it will perform accurately in machine learning application. Using cross-validation method, a model is normally trained with dataset of a acquainted type. Moreover, it's tested a dataset which is unknown variant. In this aim, CV helps to narrate a dataset testing the model in training stage using validation set.

Hyper-parameters are a significant sector for model performance analysis which set appropriate values to improve model efficiency. These research hyper-parameters use GridSearchCV to find out optimal values for getting the model's best performance.

GridSearchCV is a method of executing hyper-parameter tuning for identifying optimal values for selecting the model. In GridSearchCV checks, all types of combos of values arrived at the dictionary so that estimate the algorithm for every combo using the Cross-Validation technique. Using this technique get loss/accuracy for each combo of the hyper-parameters and choose the best performance generating optimal combo values.

The model's parameters configuration is native to the model. Prediction needs to use these parameters. Those are guessed or specified when the method trains up. It's an internal part of a model. It's set and learned by the model.

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On the other site, hyper-parameters are that parameters are explicitly controlled and specified in the training method.

This research finds the optimal values using the GridSearchCV method for hyper-parameters tuning to get the best performance of our model.

Evaluation of methods results and Efficiency Analysis:-

Results:-

Table 1:- Eight Supervised Learning Method and Proposed Model performances table on a sample dataset.

No.	Algorithm's Name	Throughput	Response Time(millisecond)	Accuracy (100%)
1	Proposed Model	110874.5251	0.001990	95.13%
2.	Decision Tree	112873.6251	0.001993	90.71%
3.	Random Forest	11886.35081	0.018929	93.36%
4.	Support Vector Machine(SVM)	12546.826	0.017933	90.27%
5.	K-near Neighbor (KNN)	14116.13683	0.015939	88.05%
6.	Logistic Regression	75621.27675	0.002975	84.51%
7.	Naive Bayes	15055.07527	0.014945	79.65%
8.	Linear Regression	75284.94194	0.002989	57.96%
9.	Artificial Neural Networks(ANN)	3893.936746	0.057782	53.10%

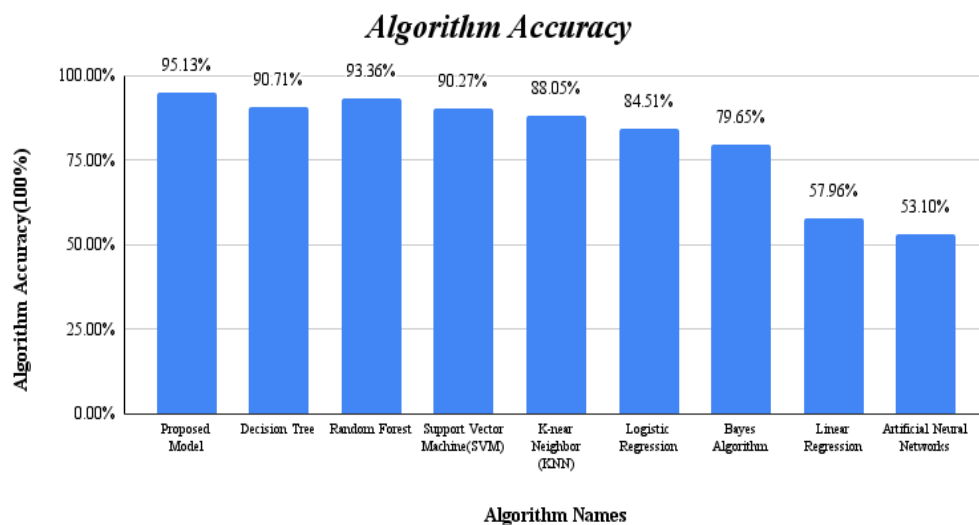


Figure 14:-Eight supervised learning methods and proposed model accuracy graph.

Accuracy

Accuracy directs to the sanctification of an individual measurement. Accuracy is destined by assimilating the measurement versus the accepted or true value. The accurate measurement is closer to the truth value.

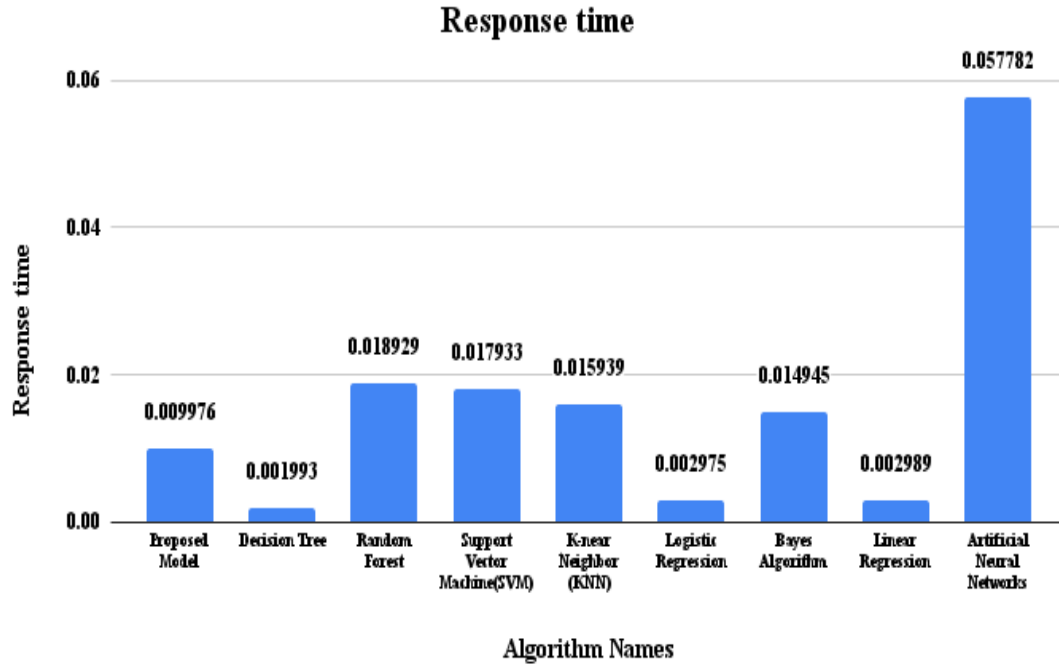


Figure 15:- Eight supervised learning methods and proposed model Response time graph.

Response time

The time season between a marginal operator's depletion of an investigation and the getting a response. The response time involves the time taken to send the inquiry yet process it by the methods and send the feedback to the marginal. The response time is usually used for measuring the reduction of interactive algorithms.

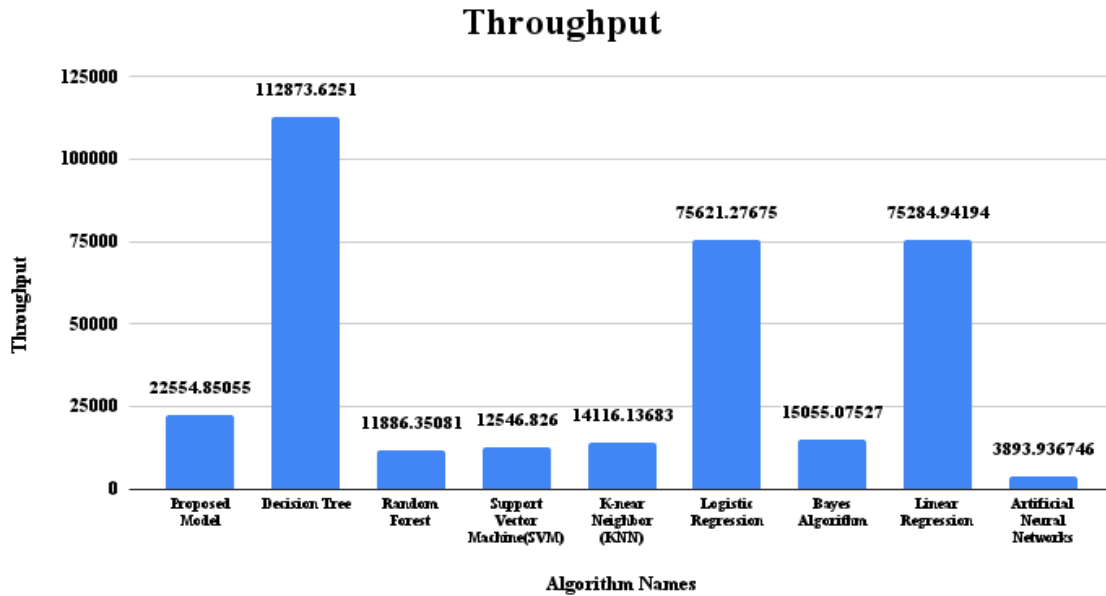


Figure 16:- Eight supervised learning methods and proposed model throughput graph.

Throughput

Throughput is the calculation of how much data a method can process in a given number of times. Connected calculation of algorithm productivity comprises the speed across which few tangible workloads can be fulfilled. The response time is the extent of time into an individual interactive user desire and getting the response times.

Discussion:-

In table. 01, we see eight (08) supervised learning methods (ANN, Bayesian Networks, DT, KNN, SVM, Random Forest, Linear Regression and Logistic Regression) and proposed model. A sample dataset and implement python coding to notify eight supervised learning methods and proposed model. We determine all supervised learning method throughput, the Response time (millisecond), and accuracy (100%) through the process. Every supervised learning method gives its individual operation performance, providing our perfect outcome. By this performance analysis, we get proposed model method is best among eight methods. In figure no. 14, the graph shows that the best accuracy is proposed model about 95.13%. Secondly high accuracy is Random Forest that is about 93.36% and the worst accuracy is ANN – 53.10%. For getting best accuracy we use hyper-parameter tuning with Cross-validation technique. At the final outcome, we get that proposed model gives the best result in our dataset.

Conclusion and Future Work:-

Machine learning ramification needs detail subtle to the constants and, at that time, a large number of cases for the dataset. There is no problem constructing the structure for any method but the right classification. However, a better learning method for a special dataset doesn't gaze at accuracy, throughput and response time for another dataset whose characteristics are logically varied from others. Although the main point when we are in contact with Machine Learning classification isn't in the case, a learning method is excellent for another. Still, an individual model can significantly outcome from any other definite application matter beneath those situations. Meta-learning is passing the way, trying to search functions that are designed with the dataset for algorithm execution. At last, it uses several attributes defined as meta-attributes to display the behavior of studying works while finding the interrelations among these attributes yet the learning algorithms reduction. Some behaviors of the learning works are: the ratio of categorical attributes, total count of instances, entropy of classes, a ratio of missing values, etc.

Providing a comprehensive chart of statistical yet information calculates for datasets. Considering the limitations yet strengths of every technique, the probability of perfecting two or extra methods simultaneously to prove matters would be researched. The purpose is to improve the powers of one model to multiplier the debilitation of another. If we focus on the best feasible classification on the accuracy, it is impossible and difficult to identify a singular classifier that fulfills the best classification ensemble. SVM, DT and Logistic Regression algorithm can give upper accuracy, response time and throughput of many data and attributes instances. ML algorithm requires the best accuracy, minimum response time, and maximum throughput to have supervised machine learning.

This paper recommends a few sample datasets and predicts the target values in different supervised machine learning algorithms. In the future, we have to work with different varieties of huge datasets and analyze the performance of the SML algorithms that also depend on other different parameters.

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