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# Classification in Machine Learning

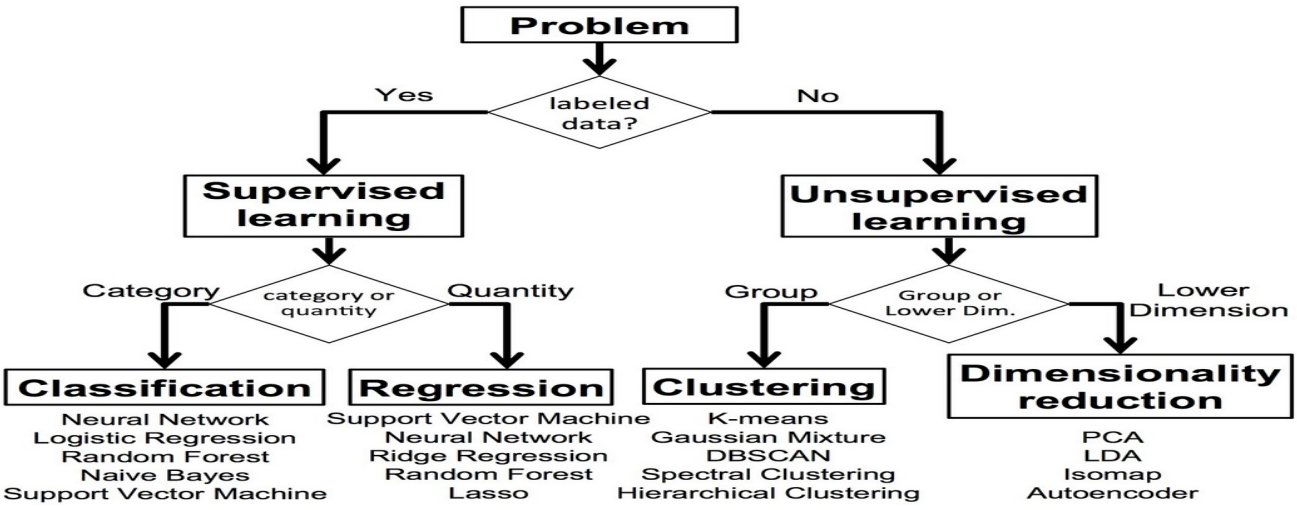
Better way of learning by researching and writing

## 1. Abstract

Classification is the technique to recognizing a object with it's pattern or classification is the task of learning a target function F that maps each attributes set x to one of the predefined class labels y.There are several classification techniques that can be used for classification purpose. In this paper, we present the basic classification method. This work is about my understanding. While doing this research I learned a lot, hopefully others will also learn something from here.

Keywords: Machine Learning , Clasification , Supervised Learning, Classification Techniques.

Fig:1



# 2. Introduction

Machine Learning (ML) is an application of Artificial intelligence that enables a system to learn and improve from expreiences without being explicity programmed automatically. Machine Learning is same like human learning. When we see something in the street with four legs one curved tail and pointed mouth, we say it a dog. Same like humans machine also learns from the features and patterns. Four leg curved tail and pointed mouth are called **features**.
Like we saw some one running with aggressive facial expression we can predict that he must be on hurry. Machine Learning does the same . It predicts future events on the basis of present and past activities.
Machine needs **algorithms** to learn which are man made algorithms.Humans have that algorithims inbuilt. Meachine needs a lots of data sets to classify a dog. like human have lots of years of experiences to classify a dog as a dog. I don't know how many years it took to human to classify a dog as a dog 😂.

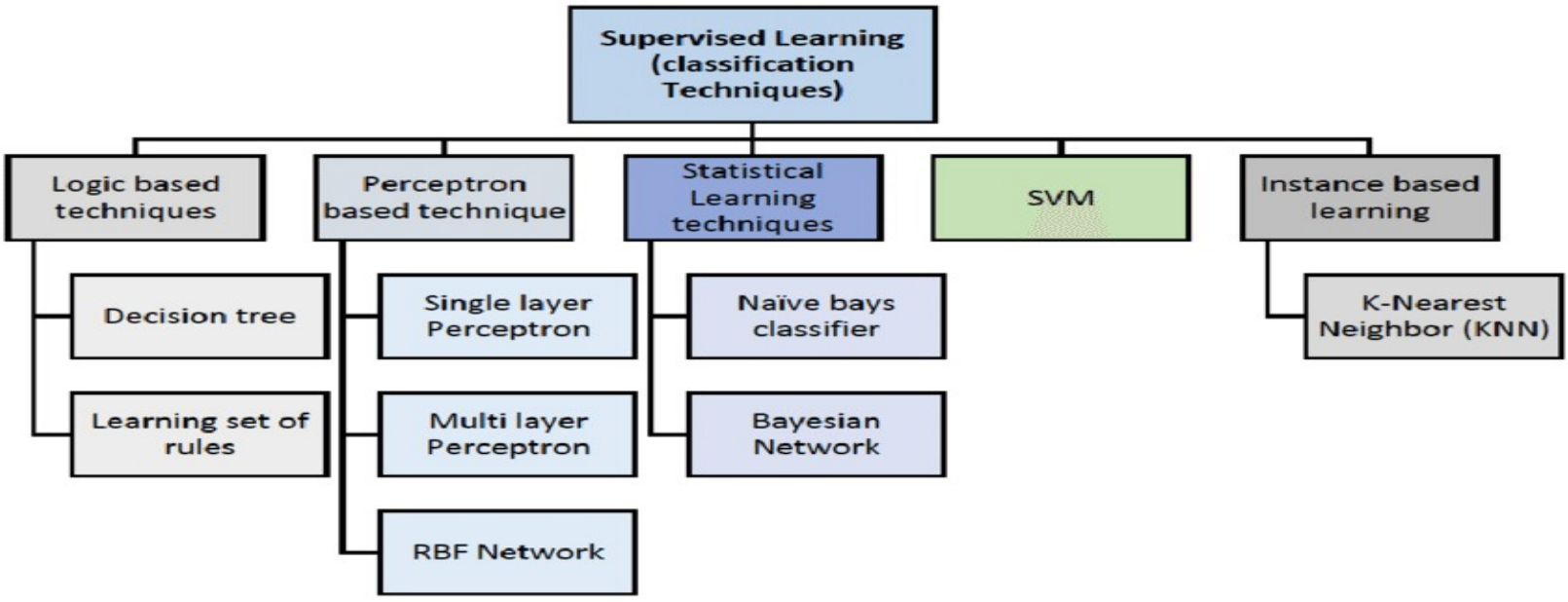
Machine Learning can mainly classified into board categories includes **Supervised Meachine Learning**, **Unsupervised Meachine Learning** and **semi-supervised machine Learning**.

Unsupervised Meachine Learning means the machine is left on it's own with a pile of animal photos and a task to find ot who's who. Data not labeled, There is no teacher machine is trying to find any problems on it's own.

In Supervised Machine Learning the machine has a "supervisior" or a "teacher" who gives the machine all the answer, like wether it's a cat in the

picture or dog. The teacher has already divided (**labeled**) the data into cats and dogs. Supervised Learning further classified into two main categories **Classification** and **Regression** . Some Regression examples are House price prediction, Gold price prediction, weather forecasting e.t.c.It gives output in numeric value. While in classification output variables takes class labels.

Classification predicts a discrete target label Y. Classification is the problem of assigning new observation to thr class to which they most likely belong based on a classification model built from labeled training data. E.g Is this mail spam or not. Is this cat or dog etc.
The **accuracy** of your classification will depends on the effectivness of algorithm you choose, how to apply it, and how much usefull tranning data you have. There are various algorithms for classification as shown in the figure. We will discuss it later on classification technique[3].



Although classification Is well known technique in machine learning but it has issues like handling missing data, ***overfitting***, ***underfitting*** etc. Data problem can be overcome by approacches like, Data miners can over look the omitting data.

Underfitting means high ***bias*** and over fitting means high ***variance***. Low bias and low variance is just perfect while training model.The other thing we used in machine learning to minimize loss is ***Gradient descent.***Gradient descent will come over and over again especially in neural networks. Machine learning libaries like ***Scikit-learn Tensorflow*** use it in the background. The goal of gradient descent is to find the minimum of our model's loss function by iteratively getting a better and better approximation of it.

In this work we will focus only on some selected classification methods.This paper organized as following: In section 2 methodology of review is presented. Section 3 is divided into five subsection in which selected classification techniques has been discused and in last there are some tables of application issue and solution of classification techniques.

## 3. Methodology

A literature search was performed for the articles by using database include google scholar and various webpages. The keywords used for lietratue search include Machine learning, classcification technique on machine learning, classification algorithms. These keywords were used alone and in combination for the initial collection of research material. Only those article that contains relevent data about classification techniques applications, challenges and solutions were include in this review. It is difficult to provide exhaustive review of all supervised meachine learning classification methods in a single article, therefore I focoused only on commonly used classification techniques include **Decission Tree, Bayesin**

**Network ,Logistic Regression, K-Nearest Neighbours, Support Vector Machine(SVMs).** Application of different classification techniques are presented in table I and issue of classification techniques with their sollutions are presented in table II.

# 4. Classification Techniques

Major classification techniques has been discussed in this section with their basic working advantages and disadvantages.

## 4.1 Logistic Regression

"logistic regression is a method of classification. The model outputs the probability of a categorical target variable Y belonging to a certain class. We use logistic regression for binary classification as well as for multiple classification.

*Why don't we use linear regression and use Logistic regression?*
*For linear regression we have to make best fit line every time based in change of data points, so we use logistic regression.*
*Linear regression cannot go beyond greater than 1 and smaller than 0, so logistic uses sigmoid function to divided it and make it error free.*

Logistic regression is applied where it can be **linearly seperable** (it can be divided with a straight line or best fit line )

**Cost Function = $\Sigma^{n}_{i=1}\ y_i = w^{T}_{i}\ x_i$**

We need to update $w^{T}_{i}$ or coffeicent to get best fit line. The main aim of logistic regression is to find the maximum cost function. There we encounter some error while finding best fit line and finding maximum cost function because of some **outliers.** Outlieres may be encounter in that case we do use sigmoid function. Sigmoid function makes sure that the value must be under 0 to 1. while doing this process **sigmoid function** remove affect of outliers.

For multiple classification from logistic regression we use **One-Vs-Rest** concept '**OVR**'

## 4.2 Support Vector Machine

SVMs typically solves the same problem as logistic regression. Classifcation with two classes and yeilds similar performance few examples of the problems SVMs can solve are:

- *Is this image of dog or cat?*
- *Is this review positive or negative?*
- *Are the dots in the 2D plane red or blue?*

There are two types of datas linearly seperable and non-linearly seperable datas.The distance between hyperplane and margin is called **marginal distance**. **Hyperplane** is slope or tanzent which seperate the data. **Margin** is the line which passes touching the nearest point to the hyperplane. The nearest point which touches margin and nearest to hyperplane is called **support vectors**. Marginal distance must be maximum . Maximum margined distance is selected to train model. For non linearly seperable datas we cannot use hyperplane directly to seperate data. Datas are not managed so frist we have to managed those data by using technique called **SVM kernel**. We have to do hyperparameter tuning. It converts low dimensions into higher dimensions. Types of SVM kernel are :

- **Polynomial kernel**
- **RBF kernel**
- **sigmoid kernel**

The main advantage of SVM is its capability to deal with wide variety of classification problems includes high dimensional and not linearly separable problems. One of the major drawback of SVM that it requires number of key parameters to set correctly to attain excellent classification results.

# 4.3 K-Nearest Neighbour

"you are the average of K closest friends"

K-NN seems almost too simple ti be a machine learning algorithm.The idea is to lable a test data point x by finding the mean (or mode) of the K-closest data points labels. Some examples of where we can use KNN are fraud detection , house price prediction , Immputing missing training data.
In frist step KNN algorithm select the **K-value** (nearest neighbour) and it calculate the distance of that K-value or its nearest neighbour. If there is two category in datasets. It finds how many nearest neighbour belongs to category 1 and category 2. If most of its nearest beighbour belongs to 1 it says 1 if 2 it says 2.

For calculating distance it uses 2 methods. **Eucledion distance** and **manhatten distance.** The most straight forward measure is Eucledion distance (a straight line). Another manhatten distance is liking working blocks. Manhatten is more usefull in a model involving fare calculations. Manhatten distance uses the pythagores theorem for finding the length of hypotenuse of a right triangle and Eucledion distance uses distance formula

$$\mathbf{D=\sqrt{(x_1-x_2)^2+(y_1-y_2)^2}.}$$

However it is a simple and mostly used algorithm it get impacted by unbalanced datasets. It also get impacted by outliers.One of the main advantages of KNN techniques is that, it is effective for large training data and robust to noissy training data. Two important obstacles with nearest neighbours based classifiers are highlighted in the link below in refrences, that includes space requirements and it's classification time. Different methods have been introduce to overcome space requirement issue. **K-Nearest Mean Classifiers (K-NNMC)**. K-NNMC independently search K nearest neighbours for every training patterns class and calculate mean for all given K-neighbours.

## 4.4 Navie Bayes Classifiers

Navie Bayes methods are a set of supervised learning algorithms based on applying Baye's theorem with the "navie" assupmption of conditional independence between everypair of features given the value of the class variables. Bayes theorem states the following relationship

$$\mathbf{p(A|B)=p(B|A) * p(A)/p(B)}$$

Bayes' theorem finds the probability of an event occuring given the probability of another event that has already occurred. Basically, we are trying to find probability of event A given that event B is true. Event B is also termed as evidence . p(A) is the prior of (A) (The prior probability i.e. probaility of event before eveidence is seen). The evidence is an attribute value of an unknown instance (There it is event B) . P(A|B) is a posterior probability of B i.e. (Here it is event B). P(A|B) is a posterior probability of B i.e. probability of event after evidence is seen. We need to create a classifier model. For this we find the probability of given set of inputs for all posible values of the class variables Y and pick up the output with maximmum probabilty. This can be expressed mathmatically as

$$\mathbf{y=argmax_y\ p(y)\ \pi^n_{i=1}\ p(x_i \mid y)}$$

p(y) is also called class probability and $p(x_i \mid y)$ is called conditional probability . The difference navie bayes classifers differ mainly by the assumption regarding the distribution of $p(x_i \mid y)$ . The different navie bayes classifiers are Gussains Navie's Bayes Classifiers, Multi Navie Bayes, Bernouli Navie Bayes for more you can visit the link below on reference.

One of the problem with Navie Bayesian Network clsssifiers is that it usually requries continious attributes to be discretized. These issue may include noise, missing information.The other method of of Bayesn network classifier in which continous attribrute does not converted into disceret attributes, needs valuation of the attributes conditionaly density.
To overcome the problem of conditional density estimulation of attributes , in Gussain kernel function with stable constraints for evaluation of attributes density was used.

# 4.5 Decision Tree Induction

A Decision Tree is a flow chart like tree structure, where each internal node (non leaf node) denotes a test on an attribute each branch represent an outcome of the test and leaf node (terminal node) holds a class label.

Decision Tree used in both Regression and classification. It is mostly used for classification. Decision tree provides an easily understandable modling technique and it is also simplified the classification process. The decision tree is transparent mechanism it facilitate users to follow a tree structure easily in order to see how the decision is made. Two keywords mostly used in decision trees is **Entropy** and **information gain**. Entropy refers to the common way to measures the randomness or impurity. In the decisions tree it measure the randomness or impurity in datasets. Information gain refers to the decline in entropy after the datasets is split. It is also **called entropy reduction**. Bulding a decission tree is all about discovering attributes that returns the highest data gain. There are two main decission tree algorithm **ID3** and **C4.5**.

ID3 (**iterative Dichotomiser 3**) decision tree algorithm was introduced in 1986. It is one of the widely used algorithm in the area of data minning and machine learning due to its effectiveness and smplicity. The ID3 algorithm is based on information gain.

C4.5 is a famous algorithm for decission trees production it is an expanssion of the ID3 algorithm and it minimize the drawbacks caused by ID3. In pruning phase C4.5 tries to ultimate the uncomfort branches by swapping them with leaf nodes by going back through the tree once it has been generated. It can deal with missing value and it deals with both discrete and continous features but it is not suitable for small data sets.

| Classification Techniques | Applications |
|---|---|
| ID3 | predicting student performance<br>land capability classification<br>tolerance related knowledge acquisition<br>computer crime forensics<br>fraud detection application |
| C4.5 | Decision making of loan application by debtor<br>Predicting Software Defects<br>Thrombosis collagen diseases<br>Electricity price prediction<br>coal logistics customer analysis<br>Selecting Question Pools |
| Bayesian Network | automatic and interactive mode for Image Segmentation<br>traffic incident detection<br>signature verification<br>efficient patrolling of nurses<br>examine dental pain<br>telecommunication and internet networks |
| K- Nearest neighbor | Microarray data classification<br>Phoneme Prediction<br>Face recognition<br>Agarwood oil quality grading<br>Classification of nuclear receptors and their subfamilies<br>Short-term traffic flow forecasting<br>Plant Leaf Recognition |
| SVM | Scene classification<br>Predict corporate financial distress<br>Induction motors fault diagnosis<br>Analog circuit fault diagnosis<br>enterprise market competition |

***Fig 3: classification techniques andi its Application***

| Classification Approach | Issue | Solution/technique |
|---|---|---|
| Decision tree (ID3 and C4.5) | multi valued attributes<br>Complex information entropy and attribute with more values<br>Noisy data classification | Algorithm by combining ID3 and association function(AF)<br>modification to the attribute selection methods, pre pruning strategy and rainforest approach<br>Enhanced algorithm with Taylor formula<br>Credal-C4.5 tree |
| Bayesian Network | Attributes conditional density estimation<br>Inference (large domain discrete and continuous variables)<br>Multi-dimensional data | Gaussian kernel function<br>decision-tree structured conditional probability<br>greedy learning algorithm |
| K nearest neighbor | space requirement<br>time requirement<br>KNN scaling over multimedia dataset | Prototype selection<br>feature selection and extraction methods<br>finding R-Tree index<br>multimedia KNN query processing system |
| SVM | controlling the false positive rate<br>low sparse SVM classifier<br>multi-label classification | Risk Area SVM (RA-SVM)<br>Cluster Support Vector Machine (CLSVM)<br>fuzzy SVMs (FSVMs) |

***Fig 4 : classification techniques issue and solution technique***

# 5. Conclusion

In this paper various popular classification mtechniques of machine learning has been discussed with their basic working mechanisms, some drawbacks and importance. The potential application and issue with their available solutions have also been highlighted. The discussed classification techniques can be implemented on different type of data sets. Every technique has it own advantages and disadvantages. For more you can check references linked below. This paper has small simple and basic understanding of classification techniques

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