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An Analysis of Hybrid Layered Classification Algorithms for Object Recognition

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Abstract: *Several classification algorithms have been developed as there is potential growth in image data. Each classifier has its own strengths and shortcomings. Hybridization of classifiers with one another has the potential to combine the strengths and to overcome the shortcomings. This paper presents a study of various Hybrid Classification algorithms as KNN and SVM with Genetics Programming, Decision trees with Artificial Neural Network, Naïve Bayes with Decision Trees and Decision tree with K-means.*

Keywords*: Supervised classification, Soft classification, hard classification, genetics programming, NB trees.*

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I. Introduction

Image classification analyzes the numerical properties of various image features and organizes data into classes or themes. It is a process that converts image data into information. Image classification has gained potential popularity in recent years because there is exponential growth of image data but it is a complex process. Image classification can be categorized on the basis of following:

A. Learning Types:

1) Supervised Classification- Supervised classification is classification process in which an image analyst supervises the process of pixel classification, and then user specifies the pixel values such as the pixel represent the specific class or training sites. Algorithms have been developed to use these pixel values from these training sites for the classifying the whole image.
2) Unsupervised Classification- Unsupervised classification is a method that examines a large number of unknown pixels and divides it number of classes based on natural grouping present in image values. This process categorizes a digital image after processing it on the basis of image statistics without availability of training sites or a-priori knowledge of the area.

B. Assumptions on Data Distribution

1) Parametric Classification- A parametric model captures all its information about the data within its parameters, future data value of the model can be predicted by the current state of its parameters. This type of classification fits a parametric model to the training data and interpolates to classify test data with an assumption about the underlying distribution of data. Parametric methods require an intensive learning/training phase of the classifier for example: Support Vector Machines, Decision Trees, Artificial Neural Network etc. [41]. Parametric classifier is based on the statistical probability distribution of each class.
2) Non Parametric Classification- Nonparametric methods are good when you have a lot of data and no prior knowledge, and when you don't want to worry too much about choosing just the right features [15]. This approach has no explicit assumption is made about the form of the probability density. It performs density estimation separately for the class conditionals from labeled example sets and classifies new data according to the maximum posterior probability.

C. Number of outputs for each spatial unit

1) Hard Classification (Per-pixel Classification)-Pixel is the smallest addressable area of a display. Pixel is a term that represent picture element. The algorithm categorizes each input pixel into a spectral feature class based solely on its individual multispectral vector (signature) i.e. It creates square pixels and each pixel has a class. In per pixel classification, no context or neighborhood evaluation is involved. Per-pixel methods are most commonly used methods as it classifies pixels into various classes based individually on the spectral and contributory information intrinsic that pixel.
2) Soft Classification (Object-oriented classification)-The input pixels are grouped into spectral features (objects) using an image segmentation algorithm. These objects are characterized in both the raster and vector domains. The objects are classified using both spectral and spatial cues (metrics).The object-centered

classification prototype generally starts with the generation of segmented objects at multiple levels of scales as fundamental units for image analysis, instead of considering a per pixel basis at a single scale for classification. Object-oriented methods have identified the group pixels before classification based on spectral similarity and spatial proximity.

Different classifiers produce different classification results even when they are applied to the same image using the same training sets because classifiers have different capabilities and their performance depends on the application fields and image characteristics.

This paper presents a Hybrid Classification approach that combines per pixels classification and objects oriented classification. With the combination of the outputs of a set of classifiers it is possible to obtain a classification that is often more accurate than the individual classifications. Hybrid classification can be performed in two methods; first method performs the following steps:

- Pixel-based soft classification
- Computation of the classification uncertainty
- Development of rules to combine the soft classifications, which incorporate the information provided by the previous pixel-based classification and the results given by the uncertainty measure
- Image segmentation
- Object classification based on decision rules which include the results of the combined soft pixel-based classification and its uncertainty [20].

The second method does not take into consideration the output combination of pixel-based classifications and their uncertainty includes three steps:

- Pixel-based classification of the image;
- Image segmentation and
- Object classification based on decision rules [20].

This paper is organized into 4 sections. Section I discusses about the introduction to Image Classification and different types of it followed by the related work in section II and finally section III covers the various Hybrid Classification Algorithms.

II. Related Work

In order to construct this analysis, we have downloaded almost 100 papers so that we could present a systematic technical analysis of the Hybrid Classification from various digital libraries which include IEEE Xplore, Science Direct, Google, Scholar, ACM and many more. We went through the paper title, abstract, introduction, experiment and future scope. We have identified most suitable papers for the review. The review of all selected 12 papers is presented in this section:Luisa M.S. Gonçalves[17], this paper presents a hybrid approach classification for the identification of Landscape Units that contain a variety of land cover objects using VHSR images. In this paper the author analyzes if the use of an output combination of a set of soft classifiers in a hybrid approach classification, can improve the accuracy of the results. This paper highlighted that a) the usefulness of the uncertainty information associated with the pixel-based soft classification for integrating the results of individual soft classifications; and b) the influence that the combined classification and the uncertainty information have in the classification of Landscape Units. This paper proved that the global accuracy of the classification of Mediterranean Landscape Unit class's increases by 11% when compared to a similar classification method that does not take combined classification and the ambiguity information into consideration.Sashikala Mishra[21] et al. gave a new meta heuristic Bat-inspired classification approach for microarray data. Many metaheuristics algorithms are present in data mining for classification. Bat algorithm is one of the metaheuristic which solves the multi objective engineering problems. The authors proposed a model which is inspired by bats. Functional link artificial neural network's weights were updated with the help of the proposed algorithm. The proposed model is compared with the PSO-FLANN and FLANN and found that it gave the good accuracy than other two approaches.Amira Sayed A et al. [27], In this article, a multi-layer hybrid machine learning intrusion detection system is designed and developed to achieve high efficiency and improve the detection and classification rate accuracy inspired by immune systems with negative selection approach. Authors proposed a multi-layers machine learning techniques for anomalies detection and classification system is composed of the following three layers: (1) Feature selection based on principal components analysis (2) Anomaly detection based on genetic algorithm with negative selection (3) Label the detected anomalies using several classifiers layer.Sarab Al Muhaideand et al. [34] proposed a hybrid meta-heuristic which consisted of two steps. The first step was ant colony optimization and the second step was genetic algorithm. In the ACO step, by using the different subsets of training data decision lists were made-up. Decision lists were constructed by AntMiner+ algorithm. The population of genetic algorithm was initialized to these decision lists. The genetic

algorithm worked for the optimization of these decision lists in term of classification accuracy and size. The proposed model gave the good results on the real world medical data sets.

Norma Monzón García et al. [23], this paper focuses on analysis and classification stage on pollen grains contour. Here, a classification approach using binarization of pollen grain images, contour and feature extraction to locate the pollen grain objects within the images is being proposed. A Hidden Markov Model classifier was used to classify 17 7genders and species from 11 different families of tropical honey bee's plants achieving a mean of 98.77% of success. This paper also proposed a taxonomical quantitative model, showing that the pollen grain contour classification system can simplify the features in the moment of its classification obtaining a sufficient discriminatory result.S. Shilaskar et al. [32], gave a model which contained the feature selection and the classification techniques. Three data sets from UCI namely Arrhythmia, SPECTF and Heart Disease were used. In this study, The SVM classifier was integrated with forward feature inclusion, back-elimination feature selection and forward feature selection. The results illustrated that there were reduction in the numbers of inputs and also improvement in the accuracy by using the feature selection. For the SPECTF, accuracy of SVM increased 3% and number of features reduced from 10 to 4.Shubham Goyal [40], In this paper, authors proposed a Data text mining and hybrid approach of KNN Algorithm and Naïve Bayes Algorithm to find the sentiments of Indian people on Tweeter. Authors concluded that the sentiments of tweets which are extracted from twitter using its API. We also implemented features like to find emotions, smileys, injections as they are recently become a huge part of internet.M.A. Jabbar et al. [30], proposed a combination of KNearest Neighbor and Genetic Algorithm for classification of Heart Disease. For pattern reorganization, the KNN is the simple, easily understood classification method in which the classification is done on the basis of class of their nearest neighbor. But to handle the large amount of data in the medical data set and for irrelevant and redundant data, authors proposed a model which was the combination of KNN and Genetic Algorithm. For global search in complex and large space and to find the optimal solution, genetic algorithm was used.Polat K. et al. [16], proposed a hybrid classification system based on a C4.5 decision tree classifier and a oneagainst-all method to improve the classification accuracy for multi-class classification problems. Their one-against-all method constructed M number of binary C4.5 decision tree classifiers, each of which separated one class from all of the rest. The ith C4.5 decision tree classifier was trained with all the training instances of the ith class with positive labels and all the others with negative labels. The performance of this hybrid classifier was tested using the classification accuracy, sensitivity-specificity analysis, and 10-fold cross validation on three datasets taken from the UCI machine learning repository.Pratiksha Y. Pawar et al. [24], this paper elaborates a comparative study on different types of approaches to text categorization. It describes different types of text categorization approaches as KNN, Rocchio's Algorithm, Decision Trees, Naïve Bayes, Back propagation Network and SVM. Several algorithms or combination of algorithms as hybrid approaches were proposed for the automatic classification of documents. Among these algorithms SVM, NB, kNN and their hybrid system with the combination of different other algorithms and feature selection techniques are shown most appropriate in the existing literature. Mitali Desai et al. [37], in this paper, authors proposed a novel Hybrid Classification Algorithm to classify engineering student's sentiments. The proposed hybrid classification algorithm classifies students' problems and perks shared on Twitter into various belonging categories rather than merely positive or negative. Thus, the proposed algorithm makes the sentiment analysis process descriptive, unlike traditional predictive sentiment analysis techniques; by incorporating qualitative analysis along with data mining techniques. The proposed algorithm makes the category generation process dynamic that eliminates the need to change the algorithm each time when new data is added that increase the accuracy of the classifier.Huijuan Lu et al. [39], in this paper, authors proposed a hybrid feature selection algorithm that combines the mutual information maximization (MIM) and the adaptive genetic algorithm (AGA). Experiments are performed to show that the proposing MIMAGA-Selection method significantly reduces the dimension of gene expression data and removes the redundancies for classification. Authors also applied four different classifiers namely the back propagation neural network, support vector machine (SVM), ELM and regularized extreme learning machine (RELM) to demonstrate the robustness of the proposed MIMAGA-Selection algorithm.

III. Hybrid Classification Algorithms

Hybrid classification algorithms are innovative, creative, and appropriate combination of several models for achieving a final common goal with a performance far better than traditional models based on single technology. These algorithms provide opportunity to take advantage of exclusive strengths of each technology and to overcome limitations of each technology. Numerous hybrid classification algorithms have been developed which are widely used for classifying the images. Some algorithms are described as below:

A. Knn With Genetics Programming

The purpose of kNN algorithm is to classify a new object based on attributes and training samples. This is best suited where prior knowledge about the distribution of the data is not available appropriately and this algorithm

can be used for both classification and regression predictive problems. Behavior of this algorithm depends on the value of K which is based on Euclidean distance in feature space (whereby k specifies the number of neighbors to be used.) But KNN has some limitations:

- Time to find the nearest neighbors in a large training set can be excessive.
- It is sensitive to noisy or irrelevant attributes.
- Performance of algorithms depends on number of dimensions used.
- Challenge was to select the appropriate features from the set of various numbers of features.

A Simple Genetic Algorithm (SGA) is a computational concept of biological evolution that can be used to solve optimization problems [2]. The GA proposed by Holland, is a probabilistic optimal algorithm that is based on the evolutionary theories [J. Holland]. In this approach KNN is combined with genetics to overcome the limitations of KNN. GA is based on a population of chromosomes. Successive populations of possible solutions are generated in a stochastic manner following laws similar to that of natural selection [33]. GA uses crossover and mutation as search mechanism. The accuracy of kNN classifier is used as the fitness function for GA [11], [5]. The fitness function *fitness(x)* is defined as:

$$Fitness(x) = Accuracy(x)$$

Accuracy(x) is the test accuracy of testing data *x* in the kNN classifier which is built with the feature subset selection of training data. The classification accuracy of kNN is given as:

$$Accuracy(x) = (c/t)*100$$

Where c - Samples that are classified correctly in test data by kNN technique and *t* - Total number of Samples in test data.This algorithm hybridizes the classification power of KNN algorithms with the search and optimization power of the genetic algorithm. In this approach, for iteration, k-number of samples is selected and the accuracy of the classification is calculated as fitness.

B. Support Vector Machine and Genetics:

SVM is a supervised learning algorithm that analyzes data and recognizes patters which is applied for classification and regression analysis. The SVM can be characterized as a supervised learning algorithm capable of solving linear and non-linear binary classification problems [14]. It is derived from the statistical learning theory which is meant for classifying the data points into two disjoint half spaces. The main objective of SVM is to maximize the geometric error and minimize the empirical classification error, thus it is often called as Maximum Margin classifiers [knn and ga]. Limitations of SVM are:

- How to choose the optimal input feature subset for SVM
- How to set the best kernel parameters.

SVM provides a generic mechanism that fits the hyper plane surface to the training data using a kernel function. Genetic algorithm is a meta-heuristics algorithm that imitates the long-term optimization process of biological evolution for solving mathematical optimization problems [14]. Genetic algorithms have the potential to generate both the optimal feature subset and SVM parameters at the same time. This approach combines a GA and support vector machines, with the aim of classifying samples before selecting the minimum number of significant variables. Here, SVM is used as a fitness function of the genetic algorithm and for each individual, a training and validation set is created from the initial data. These sets will be applied to the SVM which, once the prediction is made, will yield a mean squared error (MSE) to be used as a scale to determine the fittest individual.

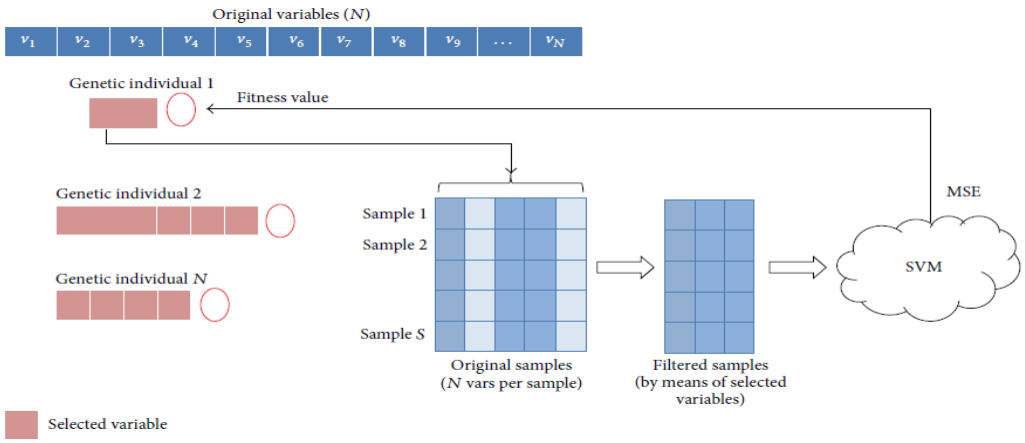

Fig 1: Evaluation of the genetic individuals [29]

C. Decision tree and Artificial Neural Network:

Decision tree algorithm is one of the classifier techniques which are in the form of tree structure and offers a structured way of decision making. A decision tree induces a hierarchical partitioning over the decision space. Starting with the root node, each of the successive internal nodes partitions its associated decision region into two half spaces, with the node decision function defining the dividing hyper plane [3]. Decision trees can be used in solving problems in which instances are expressed by attribute-value pairs, and the output of target function is discrete. They can describe the problem in a disjunctive way and can work with noisy data very well. But decision trees exhibit some deficiencies as:

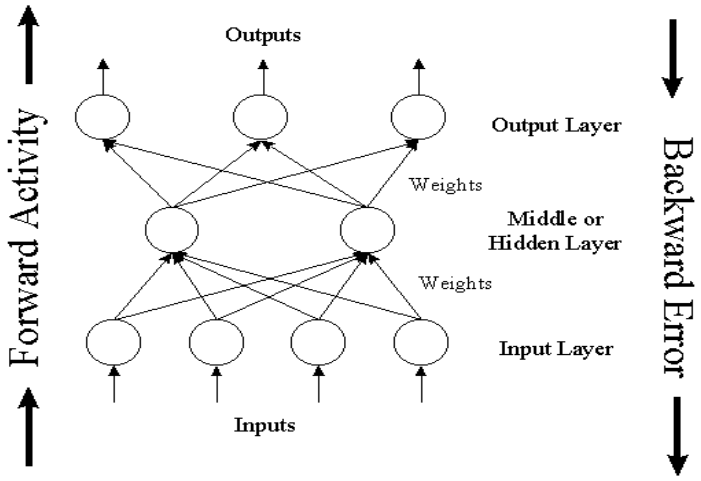

Fig 2: A typical Artificial Neural Network

- Rules set in decision nodes are usually based only on single attribute.
- Decision tree is not a global optimization method.
- The predictive ability of a decision tree depends on its size, the smaller the tree is, the better it can perform in classification, but it is hard to construct a tree which is small enough.

An artificial neural network is a biologically inspired computational model formed from hundreds of single units, artificial neurons, connected with coefficients (weights) which constitute the neural structure. Artificial Neural Networks were originally developed to imitate the human brain. Like the human brains, ANNs consist of processing units (artificial neurons) and connections (weights) between the units. ANNs can be used to interpret a set of data which we lack knowledge to understand fully but have ample amount of training data [36]. In this approach, key-point is to compose the decision tree and then based on the structure to compose the neural network. This means that the decision tree will be converted into the neural network. Sethi [3] composed a 3-layerd neural network using decision trees, where the neurons of the hidden layer were determined and constructed by the decision tree. Fig 2 depicts a typical artificial neural network.

D. Decision Tree and K-means:

A decision tree is a tree where the root and each internal node are labeled with a question. The arcs emanating from each node represent each possible answer to the associated question. Each leaf node represents a prediction of a solution to the problem under consideration. The basic algorithm for decision tree induction is a greedy algorithm that constructs decision trees in a top-down recursive divide-and-conquer manner [22]. But Decision Tree cannot deal with continuous attributes so they need to be converted into discrete ones. K-Means algorithm is said to be an unsupervised clustering algorithm. It works well for numerical data alone. The pixel-by-pixel image classification is possible by defining single and multiple thresholds. The method called k-means since each of the K clusters is represented by the mean of the objects within it. The K-means algorithm proceeds as follows. First, it randomly selects k of the objects, each of which initially represents a center. For each of the remaining objects, an object is assigned to the cluster to which it is the most similar, based on the distance between the object and the cluster. It then computes the new mean for each cluster. This process iterates until the criterion function converges.Combination of Decision tree and K-means is called Tree Bagging and Weighted Clustering. This approach uses C4.5 decision tree algorithm to generate decision trees for a classification problem and bagging improves the predictive performance of a classifier. This approach selects some important attributes and weights to them by using decision bagging[18] then weighted attributes are used to generate clusters for classifying a new instance. This approach enhances the accuracy of the classification process.

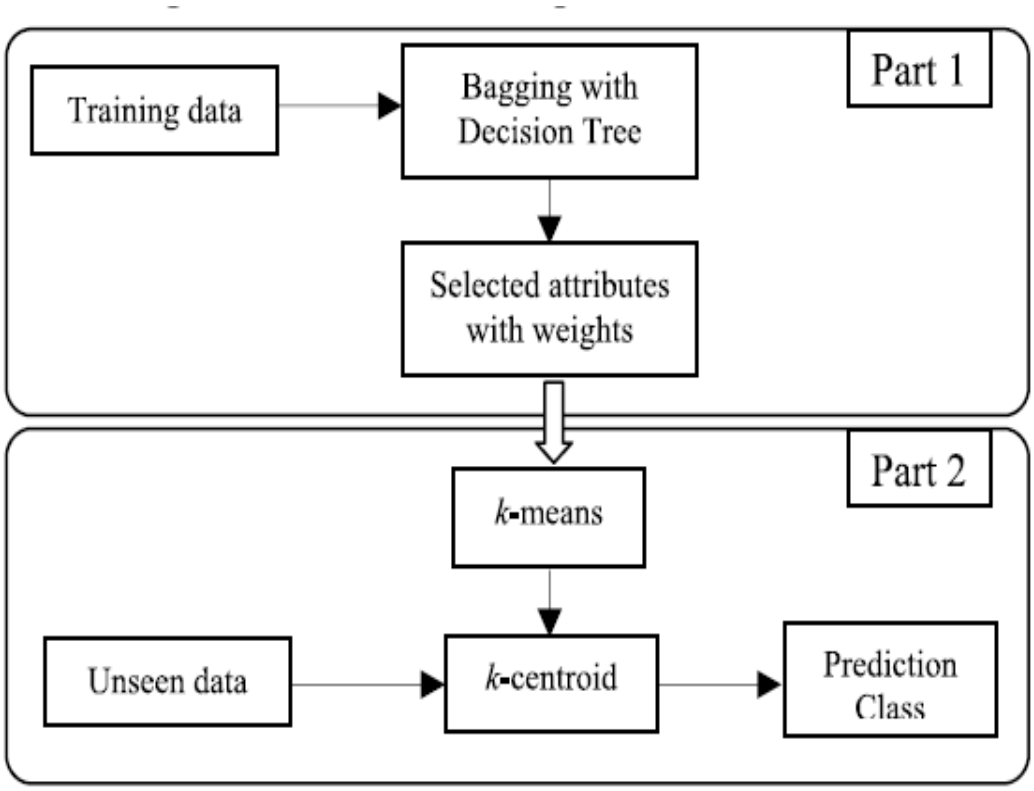

Fig 3: Tree Bagging and Weighted Process[18]

This hybrid approach consists of two main steps: a) attribute selection and b) classifying a new instance. For attribute selection step, bagging with C4.5 decision tree is used to select and weight attributes. Then K-means algorithm is applied to assign a class label to a new instance [18].

E. Naïve Bayes and Decision Tree:

The Naive-Bayes classifier uses Bayes rule to compute the probability of each class given an instance, assuming attributes are conditionally independent given a label. The unseen data can be easily predicted by characterizing the problem in naïve Bayes method. During the construction time and prediction time this algorithm separates the attributes value. The probability of each attributes in isolation process needs only the enough data. But if the data has high correlated features the performance will be degraded. It provides a flexible way for dealing with any number of attributes or classes, and is based on probability theory. It is the asymptotically fastest learning algorithm that examines all its training input. The proposed hybrid (also called as NB Tree) scheme solves the problem of poor naïve Bayes performance in a domain with dependent attributes, and the memory consumption problem of the decision tree. The Hybrid approach tries to capture the desirable properties of both the Naive Bayes and the Decision Tree based classifiers as it combines the Decision Tree Classifier's feature to separate out dependent attributes, and the effective classification by the Naïve Bayes Classifier on independent attributes. It takes advantages of both decision trees (i.e., segmentation) and Naive-Bayes (evidence accumulation from multiple attributes) [6]. The two techniques are combined by learning a decision tree using pruning methods, and including a Naïve Bayes model at the leaf nodes, consisting of the remaining attributes that have not been branched upon. This method takes advantage of the speed of the naïve Bayes approach, and uses the decision tree in order to break as many dependencies as possible in order to suit the data to the naïve Bayes assumption of attribute independence [10]. The NB-Tree classifier includes a Decision-Tree structure having Zero or more decision-nodes and one or more leaf nodes. At each decision-node, a test is performed based on one or more attributes. At each leaf node, a classifier based on Bayes Rule classifies the records. The NB Tree also provides a system and a method of inducing the hybrid classifier from a set of labeled instances. Each instance has a plurality of attributes. The hybrid classifier has a decision-tree structure With Zero or more decision-nodes and one or more leaf-nodes. There is one root-node that may either be a decision-node or a leaf-node [7]. Following figure represents the working of NB Tree algorithm.

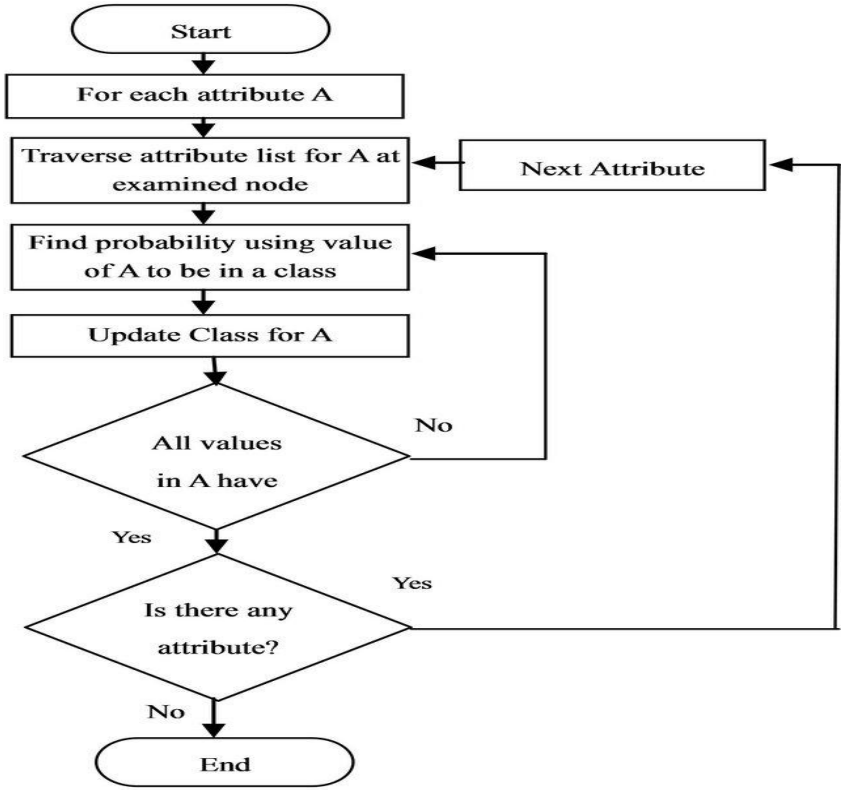

Fig 4: Flowchart of NB Tree Algorithm [28]

IV. Conclusion

This paper attempts to throw light and provides a brief knowledge about the different hybrid image classification approaches and different classification methods which help in the efficient decision making process. This paper presents the most common approaches for image classification can be categories as supervised and unsupervised, or parametric and nonparametric or object-oriented, sub-pixel, per-pixel and per-field or spectral classifiers, contextual classifiers and spectral-contextual classifiers or hard and soft classification. This paper discusses various hybrid algorithms as KNN and Genetics, SVM and Genetics, DT and Artificial Neural network, DT and K-Means and Naïve Bayes and DT etc. that give the better result as compared to the single classification techniques. Each algorithm has its own strengths and weaknesses. Several researches had been conducted in order to use multiple remote-sensing features, including spectral, spatial, multi temporal, and multi sensor information in different fields. This survey gives theoretical knowledge about different classification methods and provides the advantages and disadvantages of various classification methods.

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