Intelligent Image Classification Using Supervised and Unsupervised Classification: A Survey

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***Abstract*— Image processing and classification is huge research area with large number of applications like SAR imaging, medical diagnosis etc. The image classification helps in analysing the captured image and finding hidden information from it. This paper reviewed supervised and unsupervised image classification approaches in image classification.**

***Keywords*— Supervised classification, Unsupervised classification, SVM, KNN, Random Forest, Maximum Likehood, K Means clustering, Hierarchical clustering, Isodata, SOM.**

I. INTRODUCTION

The image processing is one of the huge fields in current research trends. Since many decades the researchers are working in it but still it is not fully explored yet. This field is so important because of its application in real life problems. The applications like SAR imaging, surveillance, medical informatics and diagnosis, character recognition etc. This list is increasing day by day [1]. The accurate medical diagnosis of many in vivo diseases is possible because of ultrasound and X-ray imaging which produces images of human body structure which helps medical practitioner to diagnose disease. There is a valuable contribution in cancer, brain tumour, cardiac, paediatric analysis etc. The image processing also contributes in video compression, 3D reconstruction and augmented reality. The fig 1 represents stepwise process of image processing for any application in real life.

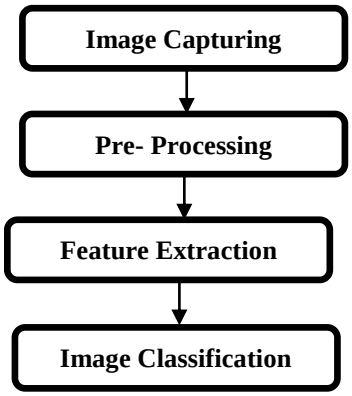

Fig. 1 Basic steps in image processing

The images are captures by X-ray imaging, ultrasound imaging or camera for various applications. These images are pre-processed like de-noising, compression, some morphological operations. The image classification is very important step in this process which actually helps to draw conclusion from the processed images. These algorithms classify information presented in images into different categories like man, vehicle, building in case of traffic surveillance or infected area, non-infected area in medical diagnostics or forest, water reservoir etc. in satellite surveillance applications. However these mentioned applications of image processing generates large amount of data in the form of images. These images are processed to draw necessary conclusion. But it very difficult to process such large amount of database by using simple image classification techniques like color based, shape classification etc. The processing time and accuracy are the key requirements in real life applications. This is achieved by advanced image classification algorithms like supervised and unsupervised classification. It basically works on pixel values and their positions in image hence they are part of spatial domain analysis techniques.

The remaining paper is organized as follows. The section II gives insight of image classification, section III elaborates supervised classification, section IV elaborates unsupervised classification, section V comparison of various techniques and section VI concludes the paper.

II. IMAGE CLASSIFICATION

Image classification is used to extract information from the input images by clustering all the pixels in image into various categories. The image classification dependent on prior knowledge of various classes in the image is known as supervised classification whereas the classification process which is independent of prior information about classes in image is known as unsupervised classification. Fig.2 shows two main steps in classification process.

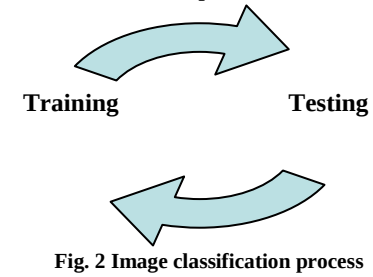

Fig. 2 Image classification process

The training step image features are organized into different classes which are known as training classes. In the testing step these classes are applied on the images to classify pixels.

III. SUPERVISED CLASSIFICATION

The supervised classification is clustering of image pixels based on training input given by the user. The clustered pixels are then assigned in different classes. Training can be any bit matrix which represents the details of classes in an image to be classified. The figure 3 shows types of supervised classification.

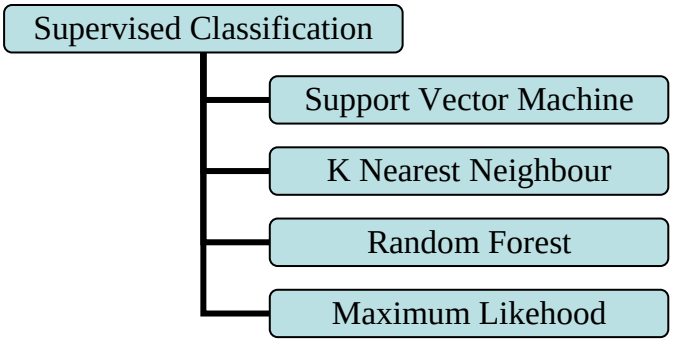

Fig. 3 Types of supervise image classification

A. *Support Vector Machine*

Support vector machine is widely used classification technique under supervised classification. It is a representation of classes as points in space which are mapped so that separate categories are done by clear gap between the two different classes. It draws a hyperplane or a set of hyperplane on image pixels and divides the image pixels into separate classes. The hyperplanes are not always linear sometimes they are nonlinear also. There are two types of SVM namely linear and nonlinear SVM which are shown in fig 4 a) and b).

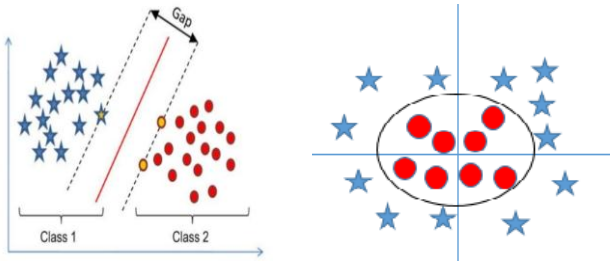

Fig. 4 a) Linear SVM b) Non Linear SVM

SVM is useful in text and hypertext classification, hand written character classification etc. It provides significant accuracy in classification when input data is labelled. Classification is not possible when training is not provided [2].

B. *K Nearest Neighbour*

KNN is a non-parametric image classification method whose output is a class membership based on distance between K neighbours and members to be classified. It is one of the simplest algorithms. It can handle complex problems though it is simple and less complex. The KNN is also called Lazy algorithm because it requires minimal training dataset. The KNN algorithm is explained in fig.4

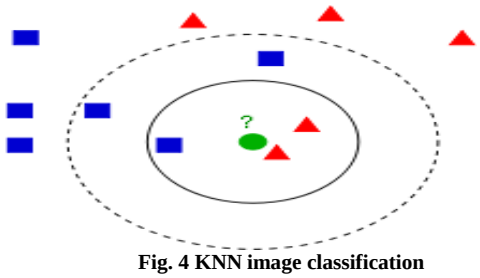

Fig. 4 KNN image classification

The green circle is to be classified in one of two classes Red triangle or Blue rectangle. The classification is done by drawing circle with specified value of K. Green circle will be categorised in Red triangle class because majority of objects present in circle are of that category. This algorithm is easy to implement and takes less time in classification [3].

C. *Random Forest*

Random forest is extension of decision trees algorithm. It grows multiple decision trees to classify new object into pre specified class based on training data inputs[4]. The fig.5 shows example of random forest algorithm.

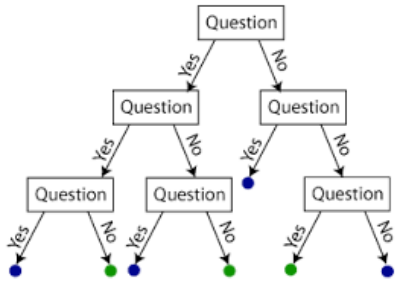

Fig. 5 Random forest image classification

Random forest algorithm can handle large and complex databases. It performs classification based on input given by users at each decision making node as shown in fig.5. It provides highest possible accuracy. But it becomes computationally slow when sufficient training is not provided to it.

D. *Maximum Likehood*

Maximum Likehood is one of the most popular classifications in remote sensing applications. The pixel is classified in a class with maximum likehood probability. This algorithm assumes that statistics in each class are normally distributed and probability of pixel to be classified is calculated. The fig.5 shows methodology of maximum likehood classification.

Maximum likehood classification produces most accurate classification. It also handles the complex cases very well [5]. Maximum likehood classification is computationally slow.

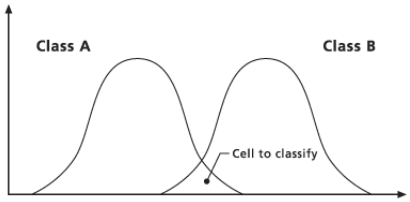

Fig. 6 Maximum likehood classification

IV. UNSUPERVISED CLASSIFICATION

The image classification which is independent of prior knowledge of various classes in image is known as unsupervised image classification. Unsupervised classification algorithm examines the pixels present in image and classifies them into different classes based upon their natural grouping. These algorithms do not require training. The fig.7 shows different types of unsupervised classification.

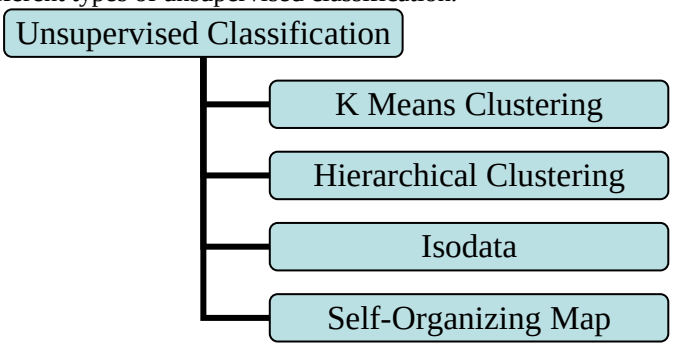

Fig. 7 Types of unsupervised image classification

A. K-Means Clustering Classification

K Means clustering algorithm divides the input image into K clusters. This is iterative algorithm which marks centroid for each cluster and the classification is done by measuring the distance between pixel to be classified and different centroids[6]. The pixel is assigned with a class of centroid at the shortest distance. The fig.8 represents K means clustering.

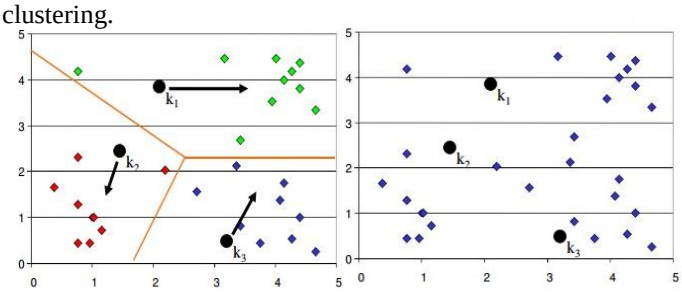

Fig. 8 K-Means Clustering Classification

K Means is an iterative approach. If there are only two classes it will perform the classification again separately in each cluster individually. This approach is time consuming for complex image inputs.

B. Hierarchical Clustering Classification

Hierarchical clustering classification creates binary tree of image pixels by iterative processing. It is extended version of K means clustering. This algorithm seeks natural order in image pixel data. There are types approaches top down approach and bottom up approach. The fig 9 shows hierarchical clustering.

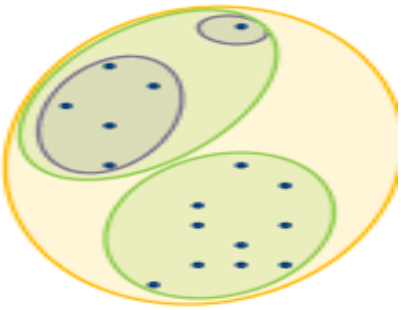

Fig. 9 Hierarchical clustering classification

Hierarchical clustering is an iterative approach. There is no limitation on number clusters in an image. The similar clusters are merged into each other[7]. It takes more time and large memory for classification.

C. Isodata Classification

The Iterative Self Organizing Data Analysis Technique (ISODATA) is improved version of K Means clustering. In the image pixels are classified into different clusters. In the first stage few random centroids are permitted. In second stage the image pixels are classified into different clusters. In the third stage the pixels classified into clusters are analysed to calculate distance between pixel and centroid. If this distance exceeds the pre-defined value then clustering is reassigned to the pixels[8].

This is also iterative approach hence time consumed is more in this approach. It is complex to design and accurate than K means because it can merge two similar pixels together whereas It can split single cluster into more than pre-specified number of pixels.

D. Self-Organizing Map Classification

Self-organizing map is the data reduction technique. It is used to cluster the image pixel data into groups of similar properties. It comprises of two nodes namely input nodes and computational nodes. It operates in two modes training and testing. The values of input variables are adjusted by providing information about input. The data entered into the algorithm is classified by using trained neurons. The classification is done by taking random sample vectors and map of weight vector is searched to find best match[9].

This whole process is repeated many times to find suitable classification of image pixels. The fig 10 shows SOM classification.

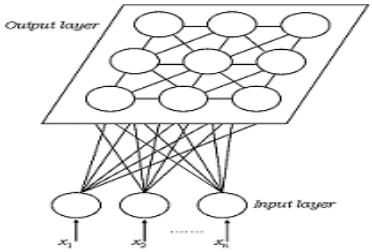

Fig. 10 SOM classification

V. CONCLUSIONS

A. *Comparison of Supervised Classification Algorithms*

The table 1 shows comparison of various supervised classification algorithms on the basis of various parameters.

TABLE I
COMPARISON OF SUPERVISED ALGORITHMS

Parameter	Support Vector Machine	K-Nearest Neighbour	Random Forest	Maximun Likehood
Training	More	Minimal	More	More
Accuracy	Medium	Less	More	Most
Time	Medium	Less	More	More
Complexity	More	Less	Most	Less
Memory	More	Less	More	Medium

According to the Table 1 K nearest neighbour classification is the less time consuming, less complex algorithm. It also requires less memory for implementing it. However accuracy of KNN algorithm is lees hence it cannot handle complex databases. In such cases the random forest and maximum likehood can be used. The SVM is the optimum among them for image classification with satellite images.

B. *Comparison of Un-Supervised Classification Algorithms*

The table 1 shows comparison of various supervised classification algorithms on the basis of various parameters.

TABLE III
COMPARISON OF UNSUPERVISED ALGORITHMS

Parameter	K- Means Clustering	Hierarchical Clustering	Isodata	Self-Organizing Maps
Accuracy	Less	More	More	Most
Time	Less	Medium	More	Medium
Complexity	Less	Less	Medium	More
Memory	Less	Less	More	Medium

According to the Table 2 K means clustering classification is the less time consuming, less complex algorithm. It also requires less memory for implementing it. However accuracy of K means algorithm is lees hence it cannot handle complex databases. In such cases Isodata and Self organizing maps can be used. The Hierarchical clustering is the optimum algorithm.

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