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Performance Analysis of Different Classifier for Remote Sensing Application

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Abstract: ***The classification of remotely sensed data on thematic map is a challenging task from very long time and it is also a goal of today's remote sensing because of complexity level of earth surface and selection of suitable classification technique. Hence selection of best classification technique in remote sensing will give better result. Classification of remotely sensed data is an important task within the domain of remote sensing and it is outlined as processing technique that uses a systematic approach to group the pixels into different classes. In this study, we have classified the multispectral data of Udupi district, Karnataka, India using different classifier including Support Vector Machine (SVM), Maximum Likelihood, Minimum Distance and Mahalanobis Distance classifier. The data of dimension 3980x3201 pixels are collected from a Landsat-3 satellite. Performance of the each classifier is compared by conducting accuracy assessment test and Kappa analysis. The obtained results shows that SVM will give accuracy of 95.35% and kappa value of 0.9408 respectively when compared other classifier, hence effectiveness of SVM is a good choice for classifying remotely sensed data.***

Keywords: Remote Sensing, Support Vector Machines, Pixel-based, Multispectral data.

I. INTRODUCTION

Remote Sensing (RS) is a technique for utilizing sensors or cameras at satellite stage to get a data about the earth surface. The classification of remotely sensed data for land cover application is the important task in remote sensing [1] [4]. Land cover classification is most useful in the fields of land resource planning, studies of environmental change, and Layout planning of cities. Normally selection of best classifier should be able classify the pixel into appropriate land cover classes and proper determination of the obtained training samples in to appropriate classes is ends up with the identification of the object in extracted information (knowledge) from RS data [2].

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From the last few decades, the majority of the remote sensing work has been carried out only on the natural atmosphere because of the medium and very low resolution images. Today, due to the advancements in technology of hardware and software, processing and classification of remotely sensed data is great interest among the RS community. The objective of this research work is to study an image classification technique that provides higher accuracy compared to conventional strategies. The overall classification accuracy can be increased by selecting suitable classification technique and using a multiple number of features from remotely sensed data. In broad classification technique may be classified into supervised and unsupervised, or parametric and non-parametric, or hard and soft (Fuzzy), or pixel and per field classification [3]. Non parametric classifiers such as decision tree classifier, neural network classifiers and fuzzy classifiers are very much essential classifier for multisource image classification. Maximum Likelihood Classification (MLC) and Artificial Neural Network (ANN) are frequently used classification for remotely sensed data but, there is some limitation in this classifier. Local minima and over fitting are the issues of ANN and required of large training samples for classification is the issue of MLC. Therefore, Support Vector Machines (SVM) is an explicit interest to choose as a classification technique for remote sensing application. The use of Support Vector Machines principle was increased from the last few years and this principle also extended to remotely sensed image classification, it has gained a major credit in applications of remote sensing [1] [4]. Hence, this work examines the quality of the classification issues wherever there is a requirement for extremely reliable and correct classification systems and algorithms.

II. OVERVIEW OF CLASSIFICATION METHODS

Multispectral image classification is one amongst the stringent method within the field of remote sensing image classification. Remotely sensed images generally engross a pixel element (picture element) having its characteristics recorded over many spectral channels. The output of a multispectral classification system could be a thematic map during which every pixel within the original image has been categorized into one amongst varied spectral categories. The key steps of image classification embrace (1) Defining an suitable classification system, (2) choosing, training samples, (3) image pre-processing, (4) post- classification process, and (5) accuracy assessment. The study space, classifier, and analyst's skills of user's are important factors that influence design of classification procedure and the quality of the classification result. The different classifier consider for this research work are discussed below.

A. Minimum Distance Classifier

The minimum distance classifier is used to classify the remotely sensed data into different classes. It requires to find the mean value of the each class called centroid, then compute Euclidean distance between the mean value of the classes and the unknown image pixel value. The pixel will be allocated to the corresponding classes based on the shortest distance between them. Implementation of this classifier is computationally simple and easy to use. The result of this classifier can be compared with computationally complex classifier to analyse its performance. Let us consider two unknown points a, b and applying the minimum distance classification between two points using Euclidean distance calculation is discussed below [8].

The computation of the Euclidean distance between two points is described in (1)

$$Dist = \sqrt{\left(BV_{ijk} - \mu_{ck}\right)^2 + \left(BV_{ijl} - \mu_{cl}\right)^2} \quad (1)$$

where μ_{ck} and μ_{cl} are the mean vectors of class c measured in bands k and l.

The Euclidean distance calculation from point a to the class 1 mean in bands 4 and 5 measured is described in (2).

$$Dist_{a_{\ to\ class\ 1}} = \sqrt{\left(BV_{ij4} - \mu_{1,4}\right)^2 + \left(BV_{ij5} - \mu_{1,5}\right)^2} \quad (2)$$

The distance from mean of class 2 to the point 'a' in these same two bands would be as in (3).

$$Dist_{a_{\ to\ class\ 2}} = \sqrt{\left(BV_{ij4} - \mu_{2,4}\right)^2 + \left(BV_{ij5} - \mu_{2,5}\right)^2} \quad (3)$$

Subscript c in (1) increment from 1 to 2. Shortest distance can be determined by calculating Euclidean distance from point 'a' to the mean of all classes.

B. Maximum Likelihood Classifier

Maximum likelihood classification method works based on the principle of the pixels in each class training samples distributed in the multidimensional space. This classification method makes use of the mean and variance covariance of the class when assigning each pixel into one of the classes. A pixel is classified into the corresponding class when it maximum likelihood to that class. The probability function is the decision rule used in the maximum likelihood classifier [6].

The computed probability density functions for class w_i is described in (4).

$$\hat{p}(x \mid w_i) = \frac{1}{(2\pi)^{\frac{1}{2}} \hat{\sigma}_i} \exp\left[-\frac{1}{2}\frac{(x-\hat{\mu}_i)^2}{\hat{\sigma}_i^{\,2}}\right] \quad (4)$$

Brightness value of x-axis is denoted by x, mean value of the training class is denoted by $\hat{\mu}_i$, variance measurement of the class is denoted by $\hat{\sigma}_i^{\,2}$.

If the remotely sensed training data contains n number of bands for the classes of interest, then n-dimensional multivariate normal density function is described using (5)

$$p(X \mid w_i) = \frac{1}{(2\pi)^{\frac{n}{2}} |V_i|^{\frac{1}{2}}} \exp\left[-\frac{1}{2}(X - M_i)^T V_i^{-1} (X - M_i)\right] \quad (5)$$

Determinant of the covariance matrix is denoted by $|V_i|$, inverse of the covariance matrix denoted by V_i^{-1}, transpose of the vector $(X - M_i)$ is represented by $(X - M_i)^T$, M_i denotes mean vectors and V_i denotes covariance matrix of each classes calculated from training data.

C. Mahalanobis Distance Classifier

Mahalanobis Distance Classifier works similar to Minimum Distance Classification method to classify the data into different classes. In case of minimum distance classifier, need not find the covariance matrix for classification but it requires to obtain the covariance matrix in mahalanobis distance classifier [9]. Mahalanobis Distance Classifier is described in (6).

$$D_M(x) = \sqrt{(x-\mu)^T S^{-1} (x-\mu)} \quad (6)$$

Where x is the multivariate vector $x = (x_1, x_2, x_3, ..., x_N,)^T$, µ is the mean $\mu = (\mu_1, \mu_2, \mu_3, ..., \mu_N,)^T$, and S is the covariance matrix

D. Support Vector Machine

Support Vector Machines (SVM) are one of the interesting classification technique supported by kernel ways that have been well-tried terribly effective in determination of complicated classification issues in various application domains. The use of Support Vector Machines principle has increased from the last few years and this principle also extended to remotely sensed image classification, it has gained a major credit in applications of remote sensing. The scientist Gualtieri was the first to utilize SVM principle to classification of remotely sensed images later, many investigators that evaluate the theoretical properties and the performances of support vector machines by applying to different types of classification issues. The effectiveness of SVM is excellent when compared with traditional classifiers because which gives better classification result and overall accuracy by using the structural risk minimization principle. The SVM principle will effectively resolve the issues of classification in non-linear separable by dividing the data into large dimensional area and separate with linear function.
The aim of Support Vector Machine is separating the information with hyperplane and increasing the boundaries of non-linear hyperplane using kernel principle [5]. SVM tends to see that the goal is to properly classify all the data.

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SVM is described by using following mathematical expressions,

$$(x_i) = \begin{cases} 1 & if\ w.x_i + b \geq 1 \\ -1 & if\ w.x_i + b \leq -1 \end{cases} \quad (7)$$

Overall accuracy of the SVM classification will be depending on the selection of hyperplane. The hyperplane which gives maximum margin between the data set is the best solution for classification data.

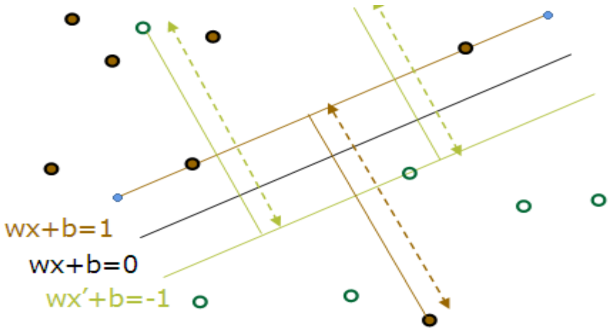

Fig. 1. SVM Principle of Operation [5].

III. STUDY AREA

The multispectral remotely sensed data consider for this study is area around the Udupi district. The collected data is the area between the points 13° 96'N 74° 43'E / 13° 97'N 75°21'E is shown in Fig. 2. The dimension of obtained data contains space of 3980x3201 pixels. The study area has combination of different classes with several features of land cover.

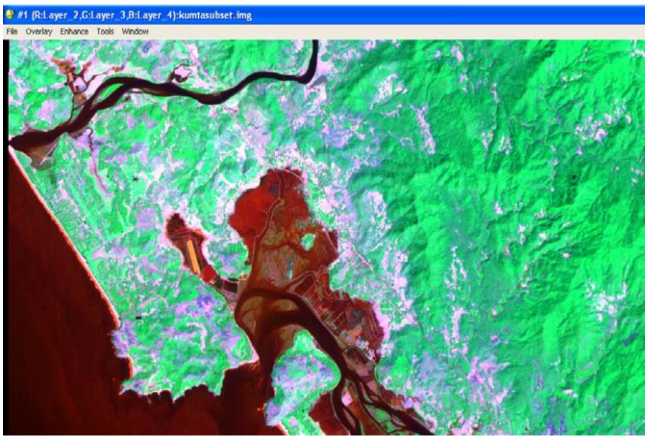

Fig. 2. Study Area

IV. RESULTS AND DISCUSSION

To evaluate the accuracy assessment of different classifier, nine classes have been considered they are Ghats, Barren Land, Shallow Sea Water, River Water, Fields, Salt Reservoir, Submerged Land, Light Vegetation, and Sea Water. Assigned colors for each class are given in Table-1.

Table- 1: Colors Assigned For Each Class

SL. No.	Classes	Assigned Colour
1	Ghats	Green
2	Barren Land	Yellow
3	Shallow Sea Water	Aquamarine
4	River Water	Black
5	Fields	Coral
6	Salt Reservoir	Orchid
7	Submerged Land	Maroon
8	Light Vegetation	Sea Green
9	Deep Sea Water	Blue

The results of any classification process must be quantitatively assessed in order to determine its accuracy. In RS data analysis, in order to express the degree of correctness of classification the term accuracy is used. The error in classification refers to some variation observed between the situations expressed in a thematic map to the real world. The accuracy assessment involves comparison of an area on a map against the reference information (ground truth) of the same area. Assumption made is that, the reference data is correct. The reference data are also called test data or validate data. Image classification is incomplete unless an accuracy assessment is performed on the classified image to quantify the performance of the algorithm. The most commonly employed traditional accuracy measures are Overall Classification Accuracy (OCA) and the Kappa statistics computed from the error matrix. The accuracy analysis also considers the accuracy of each class, measured as producer's accuracy and user's accuracy. Statistical analysis is also carried out for classes and layers. For statistical analysis, mean and standard deviations are considered. The dataset subjected for classification belongs to the area surrounding Udupi district. Once classification is performed, an error matrix is generated which gives the description about the classification performance. Since qualitative (visual) analysis cannot identify the image with the best classification accuracy, hence accuracy assessment is to be carried out. Accuracy assessment was carried out in ERDAS IMAGINE v9.1 RS image processing software. Accuracy assessment was carried out considering different sets of points (validation points) on the classified data image and for each set of data, overall classification accuracy and Kappa statistics are calculated. As the numbers of validation points considered in the RS data for accuracy assessment changes, overall classification accuracy as well as the Kappa value changes. Table- 2 indicate the average values of both overall classification accuracy (OCA) and Kappa statistics of different classification methods.

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Table -2 Comparison of Different Classifier

Classification Method	Overall Classification Accuracy	Overall Kappa Statistics
Maximum Likelihood	91.78%	0.8188
Minimum Distance	88.43%	0.7805
Mahalanobis Distance	92.19%	0.8763
Support Vector Machine	95.35%	0.9408

The results of Maximum Likelihood Classifier for 9 classes per pixel are shown in Fig. 3. Area of each class colour shown as per the Table-1

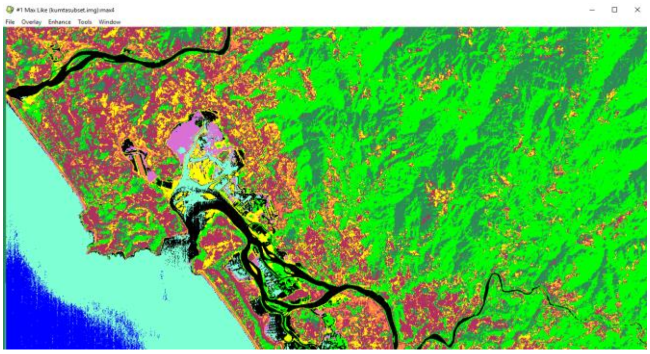

Fig. 3. Classified Image of Maximum Likelihood Classifier

The results of Minimum Distance Classifier for 9 classes per pixel are shown in Fig. 4. Area of each class colour shown as per the Table-1

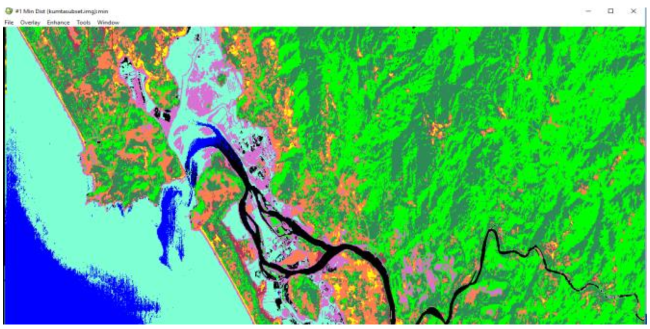

Fig. 4. Classified Image of Minimum Distance Classifier

The results of Mahalanobis Distance Classifier for 9 classes per pixel are shown in Fig. 5. Area of each class colour shown as per the Table-1

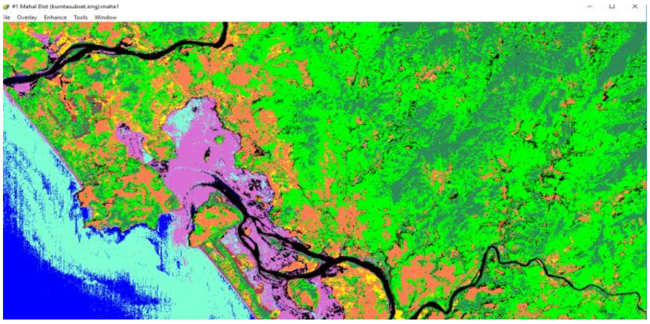

Fig. 5. Classified Image of Mahalanobis Distance Classifier

The results of Support Vector Machine for 9 classes per pixel are shown in Fig. 6. Area of each class colour shown as per the Table-1

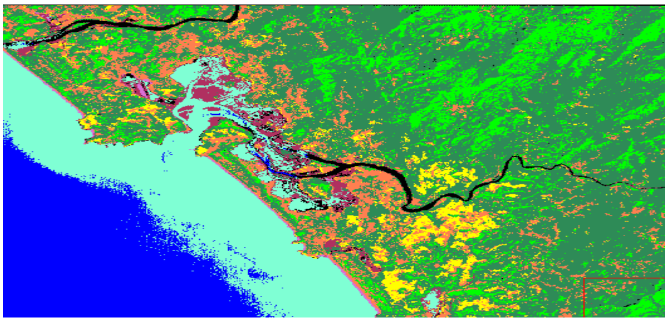

Fig. 6. Classified Image of Support Vector Machine

The Fig. 7 to Fig. 14 indicates the Gray scale images of each class in classified image. The bright pixels indicate area covered by corresponding class.

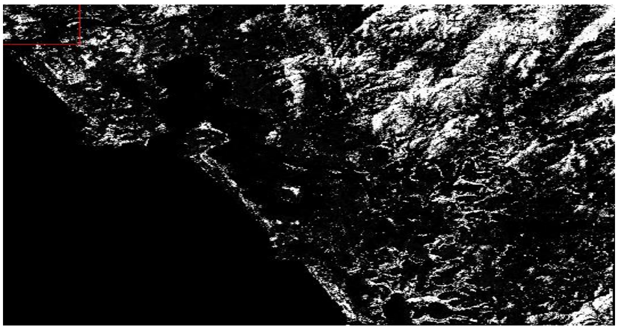

Fig. 7. Area of Ghats.

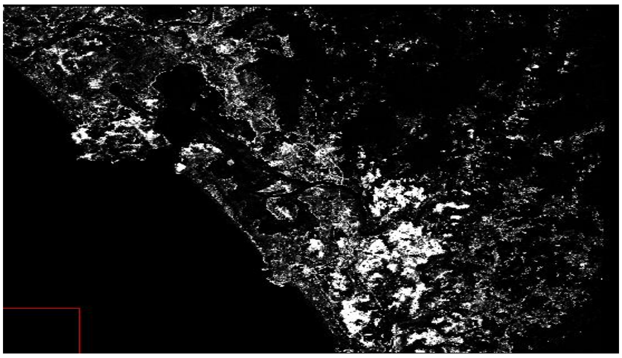

Fig. 8. Area of Barren Land.

Fig. 9. Area of Shallow Sea Water.

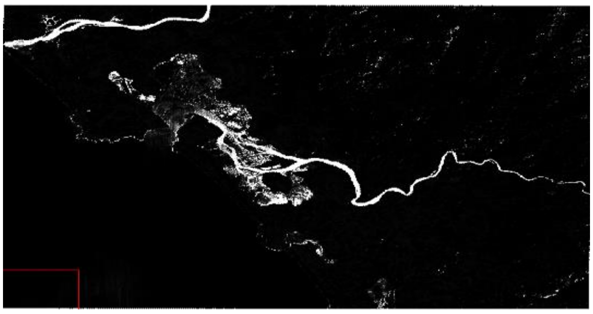

Fig. 9. Area of River Water.

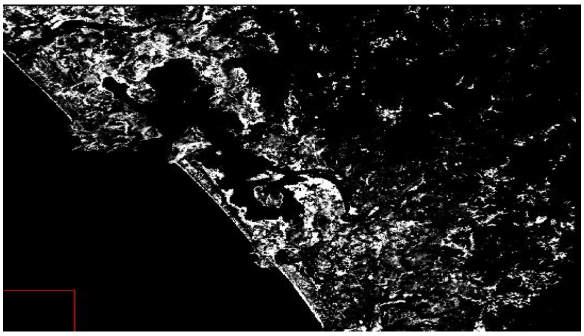

Fig.10. Area of Fields.

Fig. 11. Area of Salt Reservoir.

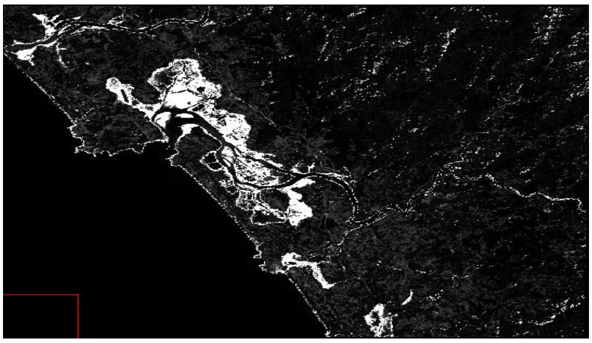

Fig. 12. Area of Submerged Land.

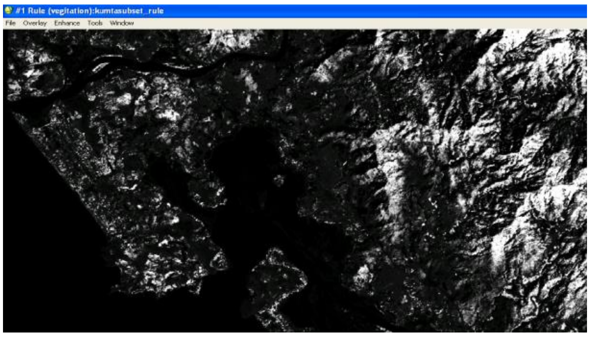

Fig. 13. Area of Light Vegetation.

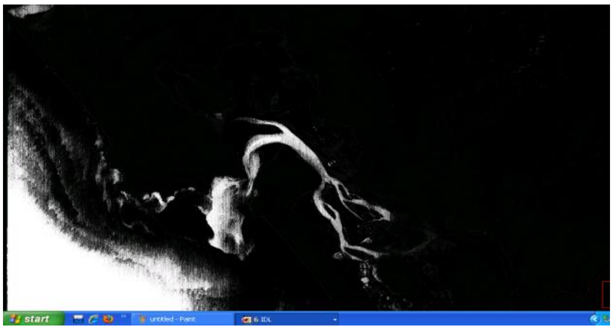

Fig. 14. Area of Deep Sea Water.

V. CONCLUSION

In this paper performance of various classifiers were studied in the field of remote sensing. The study area consider for this work is surroundings of Udupi district, Karnataka state, India. Study area around the region is well cultivated and thickly vegetated, hence it is great interest to classify the obtained data. The land region contains water bodies, land and tree cover crop. The water body contains both Arabian Sea and rivers. This research work is to analyze the performance of the different classifiers in the field of remote sensing by classifying the multispectral remotely sensed data. The obtained results of this work helps in choosing the appropriate classification method in the field of remote sensing. This study shows that SVM is a best choice in remote sensing field to classify the remotely sensed data.

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