A Classification Approach for Satellite Images utilizing Support Vector Machine

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Abstract : ***Nowadays Satellite imagery importance is increasing, as the application utilizing satellite imagery has been developing more and more. The applications includes Land Identification, natural disaster managements, forest management, agriculturally purpose and more. In the field of remote sensing data, there is a high level requirement to locate an ideal picture classifier system that intend to classify the image because satellite images with spatial resolution less than 0.50m are not easily recognizable, its difficult to detect which image is it due to their high spatial resolution, therefore its very important to have such classification system that can accurately detect which category of physical scene or which area the particular image is depicting. However, Support Vector Machine (SVM) is presently thought to be one of the widely utilized classifier. It is a supervised machine learning strategy generally utilized for classification purpose. Machine learning is a logical processing control to naturally figure out how to perceive complex examples and settle on keen choices in view of the arrangement of training information. This research therefore presents a new classification mechanism for satellites captured images of spatial resolution under 0.50m, whose region cannot be easily determined without the help of a proper classification mechanism. In our work we have taken five physical scenes: Desert, mountain, residential, river and forest for classification. For implementing our proposed framework we mainly utilized these techniques: for image segmentation, Fuzzy C Means; for feature extraction, Gabor Filter and GLCM and for classification Support Vector Machine is utilized. And finally the accuracy of our system is measured with the help of confusion metrics. Our system has achieved overall accuracy of 91.66%.***

IndexTerms: Satellite images, classification, FCM, GLCM, Gabor filter, SVM.

I. INTRODUCTION

Remote sensing images are representations of parts of the earth surface as seen from space. The images may be analog or digital. Aerial photographs are examples of analog images while satellite images acquired using electronic sensors are examples of digital images.

Satellite images play a vital role in providing geographical information. It collects data at regular interval of time. Satellite imagery is predominantly pictures caught through various imaging satellites claimed by specific association or government. These pictures contain see distinctive piece of earth or other part of spaces and said to be the eye in the sky. The pictures caught by imaging satellites can be seen as unique portrayal as there is no way of mistake and these information or picture gave by satellites can be prepared as "direct". But the problem arises when the human manual processing is not that much able to retrieve the hidden treasures of information in the satellite images because human eyes are insensitive to understand the little changes in the parameters, for example, shading, surface and shape. So therefore, the processing of satellite images with digital computers are chosen as an optimal solution to extract and retrieve information from images. For this we need an efficient classification of the satellite images. By the term “classification” refers to the process of extricating information classes from an image or assigning an input image one label from a fixed arrangement of categories. The resulting information from an image classification can be used to detect the particular region and create thematic maps.

Satellite image classification is a technique for recognizing pixels in a satellite image of desired regions. It is a machine learning process with the capacity to learn automatically to recognize and make decisions from experiences without being expressly programmed or modified. The architecture of classification process include appointing an input picture one label from the fixed set of categories characterized for distinguishing region or a group of pixels from a satellite image which it resembles first, based on trained satellite images of different categories. Whatever the region or group of pixel it recognizes first from given satellite query image it will provide the result for recognized region.

The classification system involves preliminary steps such as pre-processing, segmentation, feature extraction of an image to be classified.

1. Pre-processing: key step in each image processing activity, commonly referred as abstraction at the lowest level. Objective is to create image appropriate for segmentation by suppressing the undesired distortion or enhancing some image features relevant for further processing.

2. Segmentation: It is the way of partitioning the computerized picture into various portion or clusters that is an arrangement of pixel. It is usually done to classify the pixel of an image accurately. Through segmentation we cluster the image so that similar pixels get into same class and dissimilar pixels into another and through this segmentation we get more number of efficient features from the image which makes our system our efficient.

3. Feature extraction: The term feature extraction also denoted as indexing in which feature are extracted from the image in the form of vector as feature vector. These features specify some computable property of object.

4. Classification: An important step in whole satellite image classification framework which classifies an image as one of the class in view of the classifier choice. Basically it’s the processes of assigning label to an image based on trained dataset.

The main focus of this paper is to provide an efficient classification system for satellite images of spatial resolution less than 0.50m with chosen classifier and techniques. This Paper is organized as follows. 2. Review of researches related to proposed technique is presented. 3. The Proposed method for classification of satellite images is presented 4. The experiment Results and discussion are given 5. Experimental results are shown in Section 6. Concludes this paper.

II. REVIEW OF RELATED WORK

A lot of research works have been carried out in the literature for Satellite image classification and some of them have motivated us to take up this research. Brief reviews of some of those recent significant researches are presented below:

Mr. S.V.S.Prasad *et al,* [6], have suggested an efficient method using cluster repulsion based kernel FCM for the classification of multispectral satellite images applying object segmentation and one-many Support Vector Machine (SVM) classifier into building area, road area and green area. It is carried out in three phases namely pre-processing phase, segmentation phase and at last classification phase. Focused at providing efficiency in classification of satellite images using object based image analysis and evaluated using satellite images and compared its accuracy with FCM based classification with neural network. The outcomes demonstrated that the proposed strategy has accomplished better outcomes.

Gandhimathi@usha *et al,* [9], have suggested an efficient classification technique for multispectral satellite images that differentiate images into land cover classes based on Gabor filter for texture feature extraction using fuzzy c means for clustering technique and SVM. It consist of five steps particularly pre-processing, feature extraction using Gabor filter, segmentation, training of SVM and classification using SVM. The proposed technique has been implemented on different dataset. The results guaranteed that the proposed classification technique is much better than the traditional technique.

Ruby bharti *et al,* [10], have presented the novel idea of detailed step-by-step classification method of high resolution satellite images and classified them into specific classes such as vegetation, building, roads, etc easily using fuzzy logic. Image classification semi-automatic method is suggested here. Using the same parameters, the produced results are compared to the results of existing classification. They have used different parameter of Gaussian membership function. The classification process described the percentage of accuracy in pattern recognition. The extracted feature are used for classification of the image database, that is pattern matching.

RupinderKaur *et al,* [11], have proposed a novel optimization algorithm for subdivision with the purpose of humanizing the segmentation in satellite images using support vector machine. Implemented Mar Hildreth Edge Detection Algorithm for detection of edges and segment satellite images using Fuzzy c means Clustering technique, the features are then extracted using Principle component analysis (PCA) and are optimized using Bacteria Foraging Algorithm and classification through Support Vector Machine (SVM) to execute the satellite picture classification. Accuracy of the planned approach in the satellite image organization is designed and the performance is compared with numerous clustering algorithms.

Anita Dixit *et al,* [12], have introduced classification system of satellite images, a textured based approach which can classify between the vegetation, soil and water bodies. Divided the work into three important phases that are pre-processing phase that denoises images, feature extraction phase that extracts multiple features using GLCM, LWT and first order, from which feature vector are formed and then finally SVM is utilized as a classifier to distinguish between vegetation, soil and water bodies. Then at last, in terms of accuracy, specificity and sensitivity performance of the proposed system is observed to be desirable.

By reviewing the above literature we come to realize the importance of satellite images and their classification. There is a requirement of efficient machine learning mechanism that can automatically detect the physical scene within the satellite images of spatial resolution less than 0.50m because we are continuously getting lots of remote sensing data from the thousands of satellites so it's very important to have efficient mechanism for classification of these satellite captured images because without it it is not possible to recognize those captured images.

III. PROPOSED METHODOLOGY

In this section, complete description of the proposed satellite image classification is given. Satellite image classification is an important task to generate classification maps as number of world observation satellites increasing day by day and these satellites contains different tools capable of capturing imagery time to time and utilized for a wide range of application. Thus, classification of satellite imagery has current area of researches and classification results can be used for different real-time application like in agriculture, forest department and so on. This paper proposed a novel approach for classification of five different categories forest, mountain, river, residential area and desert by utilizing satellite imagery. To achieve an effective satellite image classification framework this paper isolates its works in various stage; these phases are important to give the better classification accuracy and the next page described these phases in details.

3.1 Segmentation

It is the way of partitioning the computerized picture into various portion or clusters that is an arrangement of pixel. It is usually done to classify the pixel of an image accurately. Through segmentation we cluster the image so that similar pixels get into same class and dissimilar pixels into another and through this segmentation we get more number of efficient features from the image which makes our system our efficient. For segmentation of image we are using Fuzzy C means approach

One of the generally utilized clustering technique in the image segmentation is Fuzzy c-means (FCM). Created by Dunn in 1973 and upgraded by Bezdek in 1981, it is routinely used for clustering. Fuzzy based methodologies are most famous for segmentation of satellite images. Clustering of numerical information shapes the premise of numerous classification and framework demonstrating calculations. The motivation behind clustering is to distinguish normal groupings of information from an extensive informational index to produce a concise representation of a framework's conduct.

FCM is a clustering procedure which allows one piece of information to have a place with at least two clusters at any given moment i.e., the data point can belong to more than one cluster. It is the way of allotting every data points the membership levels with each cluster and after that utilizing them to assign data point to one or more cluster.

3.2 Feature extraction

The term feature extraction also denoted as indexing in which feature are extracted from the image in the form of vector as feature vector. These features specify some computable property of object. In general they are categorized as general features and global features. In our proposed method we are utilizing two technique for better feature extraction from the satellite images of different regions. We have used GLCM and Gbaor filter for feature extraction as they are efficient technique for extracting essential features from the images.

GLCM: technique standout amongst the most generally utilized technique for feature extraction in satellite image classification. The features extracted from this technique are called as harlick's features. In any image, particularly texture identification is accomplished by representing texture as a two-dimensional gray level variation. This two dimensional array is named as GLCM. It is an image evaluation technique that considers the spatial relationship of the pixels so as to evaluate image properties. It defines structural and spatial properties of an image.
GLCM can extract various features. When an image is formed into co-occurrence matrix, the neighboring pixels can be in any of the defined directions. Usually, 0^0, 45^0, 90^0, 135^0 are used. Features extracted from GLCM matrices are texture features. The span of the GLCM is decided by the quantity of gray levels in the image. The GLCM can reveal certain properties of the gray levels in the texture images. [5] For acquiring Gray co-occurrence Matrix, image is firstly converted into gray image and then the dx and dy displacement vector and direction θ are defined. Following parameters are sufficient to give good classification results:
Energy: This parameter measures the homogeneity (or uniformity) of the image, it is even larger than the image has strong transitions gray scale.
Contrast: It is the vividness measure of the texture pattern, CON measure the contrast of an image; it is even higher than the texture has a high contrast.
Variance: It describes the dispersion of the transitions between levels of gray. It increases when the gray levels differ from their average.
Entropy: It provides an indication of the disorder that texture may present. Unlike energy, entropy reached high values when the texture is completely random.
Mean: Mean calculates the intensity distribution average. It describes the average gray level for each region. Hence, the brightness level can be calculated of an image. Greater the mean value, brighter is the image and vice versa.
Standard Deviation: Standard deviation defines an image contrast of the gray level intensity. Hence, the lower standard deviation shows that the image is with lower contrast.
Skewness: Skewness denotes the skewed intensity. With respect to mean the intensity distribution is measured and the resultant value can either be positive or negative. The positive value shows that more intensity values lie on the left side of the mean and vice versa. When skewness value is zero, then the intensity values are equally scattered on both sides.
Kurtosis: Kurtosis measures the peak of intensity distribution around the mean value. This feature notifies about the data distribution with the sharp or blunt peak with respect to the mean.
Homogenity: Homogeneity is measure for uniformity of co-occurrence matrix. A dissimilarity measures how different the elements of the co-occurrence matrix are from each other, whose value is greater, when the gray level distribution is uniform.
Correlation: It provides the linear dependency of gray levels on those of neighboring pixels. It is the measure correlation of pixel to its adjacent pixel over the ROI.

GABOR FILTER: A Gabor filter is a linear filter whose impulse response is described by a harmonic function multiplied by a Gaussian function[2]. In perspective of the multiplication convolution property (Convolution theorem), the Fourier transform of a Gabor filter impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function. A Gabor filter is a sinusoidal plane of particular frequency and orientation, modulated by a 2-D Gaussian-molded function. As its name suggests, it is used to filter an image and extract everything that it is oriented in the same direction of the filtering. This is a component based approach, commonly used technique for edge identification. Before applying Gabor filter few parameters are considered such as extraction of the feature and Gabor filter bank. With different scales and orientations the Gabor filter bank is constructed. It decomposes image into components. Bringing about an alleged Gabor space the filters are convolved with the signal. In both frequency and spatial domain these filters have shown optimal localization properties. The set of scale channels can be configured to capture a specific band of frequency components from an image. The set of orientation channels are used to extract directional features. The number of filters is the product of number of scales and number of orientations.
[14]In image evaluation Gabor filter are for the most part utilized due to their temperament of orientation selectivity, spatial locality and frequency characteristic. By the alteration of suitable parameters it can be designed to have different shapes, data transfer capacities, center frequencies and orientations. A filter bank can be designed by varying these parameters, frequency *f*, standard deviation: σx, σy and orientation θ, that covers the frequency domain almost completely. The choice of these parameters is crucial. Simply, Gabor filters are detecting image gradients of a specific orientation. The convolution of image patches with a number of different scales and orientations allows for extraction and encoding of local texture information into a low dimensional feature vector, usable for generic classification.

3.3 Classification

An important step in whole satellite image classification framework which classifies an image as one of the class in view of the classifier choice. Basically it's the processes of assigning label to a pixel or an image based on trained dataset.
Execution of Proposed System. Its architecture is shown in fig.1.
Step 1: - Load Image
One satellite image is chosen as an input for classification.
Step 2: - Image Pre-processing
Gaussian filter is used to filter the unnecessary information and remove various types of noises from the images using image processing. Gaussian filter utilizing its Gaussian function alters the input images. Gaussian filters mostly used in image processing for noise removal and it also improve the image signal. This pre-processing step makes satellite image more useable for classification process.
Step 3: - Image Segmentation
Segmentation can be defined as important attribute in any image processing phase. The goal of this phase is to alter the image such that the representation of image is more meaningful and usually locate the specific objects or boundaries. In this paper image segmentation is

performed utilizing FCM, which help in the feature extraction phase. After this step the satellite image is segmented into different segments containing every pixel with similar statistical characteristics thus, image regions will strongly interrelated to feature of interest or objects.

Step 4: - Feature Extraction

GLCM & Gabor Filter extracts feature vectors from input satellite pictures. Feature are extracted from the input satellite image. The GLCM functions characterize these texture feature of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image. The texture features utilized most widely includes –homogeneity, correlation and entropy which provides more accurate outcomes. After this phase a feature vector is generated utilizing extracted features.

Step 6: - Training and testing framework

Support Vector Machine algorithm utilizes these extracted vectors to prepare and train our proposed structure. Out of 200 images, including 40 images for each category, 100 images are taken for training and 100 for testing. The features of 100 images taken for training are extracted for training purpose and are labeled using matrix. In light of these stored vector, this proposed structure using SVM will classify the input satellite pictures into one of the five classes which include desert, mountain, residential area, river and forest. For the effective classification of the images, various distance metrics are used to measure similarities of features. Here, similarity evaluation using SVM classifiers achieved between the features of the Query Image and the features of the database trained images. The SVM classifier then classify the input image as one category.

Let A and B be the two datasets, A as input and B is output.

$$B = f(A, \alpha)$$

Here, A is the trained dataset contains feature vectors and α is parameter for SVM kernel function contains features of input satellite image that need to be tuned for better classification accuracy. Here a kernel function, radial basis function is used for calculating satellite image classification.

Step 7: - Classified Image

Input image is classified as either from five categories or other than these five categories.

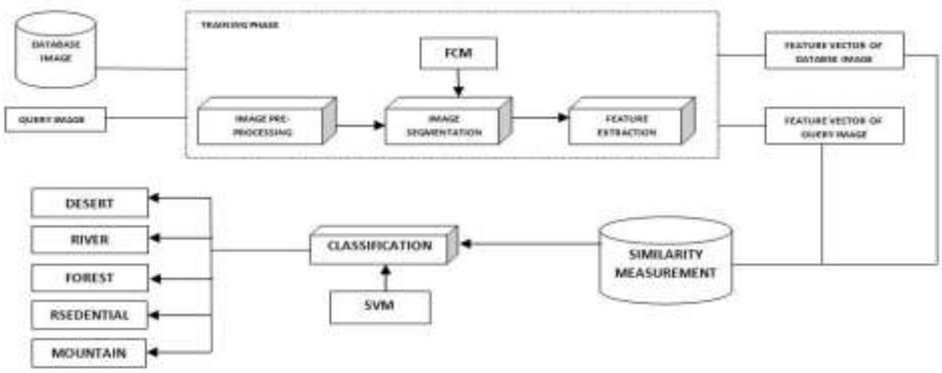

Figure.1 Proposed Architecture

IV. RESULTS AND DISCUSSION

In this section result analysis of proposed work is described. This paper presented results of classification process in terms of precision, specificity, sensitivity, F1 measure and accuracy. The accurate classification depends upon how effectively the image features extracted and every classification algorithm relies on a good accuracy. The proposed framework is trained and tested with of total 200 satellite images in which 100 images is taken for testing purpose and 100 images is used to trained framework, 20 images for each category. The dataset is generated from taking images from Google earth satellite[15]. This work is implemented in MATLAB Simulink 2016a. some sample images are shown in Fig.2.

We have used precision, specificity, sensitivity and F1 measure to evaluate the classification accuracy.

4.1 Precision

We use precision for the classification process. Precision is the ratio between measurements of number of relevant classified image to sum of relevant classified image and irrelevant classified image. The precision can be calculated as:

$$Precision = \frac{\text{TP}}{\text{TP+FP}} \times 100 \qquad \text{(I)}$$

Sensitivity and specificity are other important measures that could rate the performance of the classification algorithm.

4.2 Sensitivity

It is the measure which is the rate of correctly classified images to the sum of images that are correctly classified as positive and wrongly classified as negative. Also called as Recall.

The sensitivity is represented as follows:

$$SENSrate = \frac{\text{TP}}{\text{TP+FN}} \times 100 \qquad \text{(II)}$$

TP is the count of images that are correctly classified with respect to the class. FN are the count of images that are misclassified as the images do not belong to a specific class.

4.3 Specificity

It is measured by the ratio of the sum of images that are correctly classified as negative to the sum of images that are incorrectly classified as positive and correctly as negative. The specificity is represented as follows:

$$SPECrate = \frac{\text{TN}}{\text{FP+TN}} \times 100 \qquad \text{(III)}$$

TN is the count of images that are correctly classified as these images do not belong to a particular class. FP is the count of images that are wrongly classified as these images belong to a particular class.

4.4 F1 Score

The F1 score is the harmonic mean of precision and recall taking both metrics into account for getting the optimal blend of precision and recall F1 metrics can be used. It is calculated as:

$$F1 = 2 * \frac{\text{Precision} * \text{Sensitivity}}{\text{Precision} + \text{Sensitivity}} \times 100 \qquad \text{(IV)}$$

To create a balanced classification model with the optimal balance of recall and precision, we try to maximize the F1 score.

4.5 Accuracy

For any classification algorithm the most important parameter is classification accuracy. The efficiency depends upon effectiveness of the feature being extracted. Classification accuracy is measured by this following equation

$$acrate = \frac{\text{TP+TN}}{\text{TP+TN+FP+FN}} \times 100 \qquad \text{(V)}$$

In eqn. (1) TP and TN are the true positive and true negative rates respectively. Similarly, FP and FN are false positive and false negative rates respectively.

Going from the confusion matrix to all the above parameters requires finding the respective values in the matrix and applying the above equations. The Confusion matrix in itself is not a performance measure as such, but almost all of the performance metrics are based on Confusion Matrix and the numbers inside it.

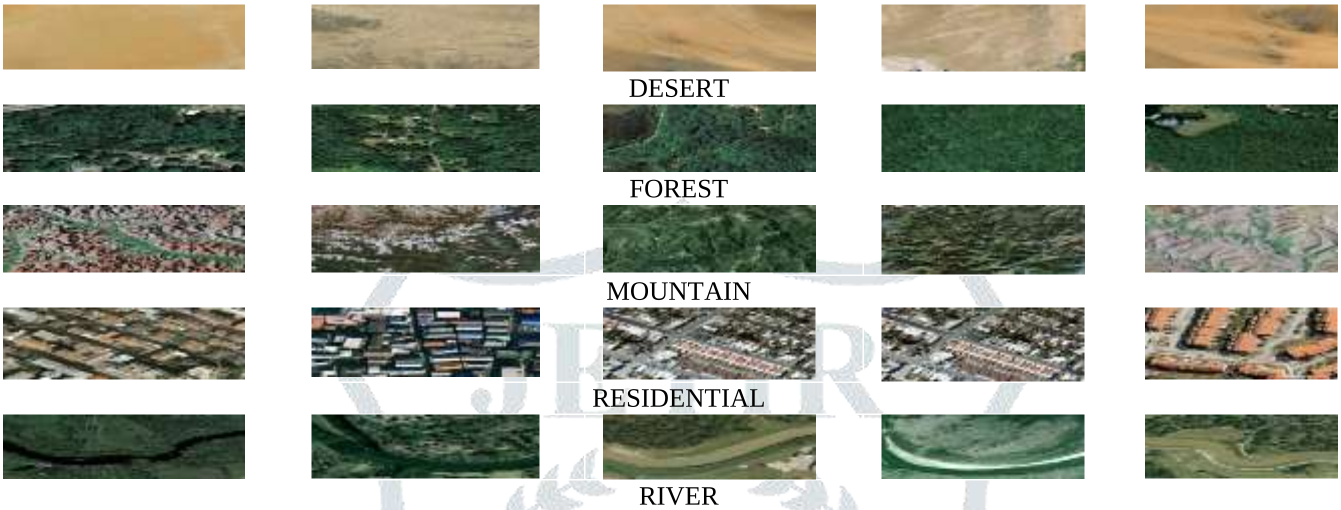

Fig. 2 sample images for proposed system

We have performed our proposed work on MATLAB and calculated the confusion matrix which is shown in table 5.1. we have taken 20 images for each category for testing.

Below table 5.1 demonstrates the confusion matrix for our proposed work.

INPUT IMAGES (N)=20	DESERT	FOREST	MOUNTAIN	RESIDENTIAL	RIVER
DESERT	19	0	1	0	0
FOREST	0	16	4	0	0
MOUNTAIN	0	0	19	0	1
RESIDENTIAL	0	0	7	13	0
RIVER	0	4	0	2	14

Based on this above computed confusion matrix the performance metrics are calculated such as precision, specificity, sensitivity, F1 Score and Accuracy.

Below table 5.2 demonstrates the results of performance metrics calculated from proposed classification technique in %.

Performance metrics (%)	DESERT	FOREST	MOUNTAIN	RESIDENTIAL	RIVER
Precision	100	80	61.2	86.6	93.3
Sensitivity	95	80	95	65	70
Specificity	100	94	83.7	97.1	98.5
F1 Score	97.4	80	74.5	74.2	80
Accuracy	98.7	91	86.1	90	92

After execution of our proposed framework Table 5.2 clearly demonstrates that our system achieved good results with overall accuracy of 91.66%. The execution results demonstrate the effectiveness of our proposed framework in satellite image classification application.

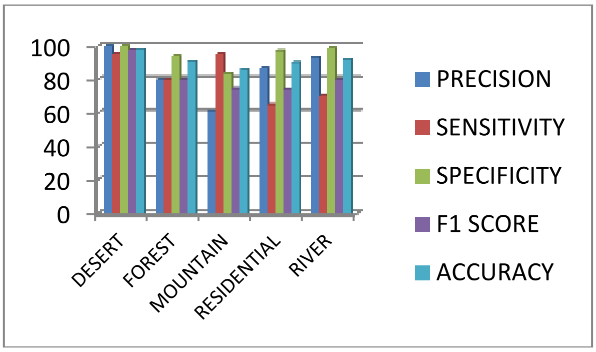

Figure 5.1 overall graph of our classification technique

V. CONCLUSION

This paper proposed a hybrid approach for classification of satellite images with spectral resolution less than 0.50m taken from[15], which classify input satellite image into either of the five categories which are residential, River, desert, mountain and Forest. This classification approach for satellite image undergo some initial steps similar to digital image processing before going straight forward to classification step. These initial steps include image segmentation and image feature extraction. This approach is utilizing Fuzzy C Means for image segmentation that segments images, give the desired segment which can give the most relevant results with highest number of pixels and useful in making accurate classification results. Then for feature extraction, GLCM & Gabor Filter techniques are used, which are most appropriate for extracting the features, also for feature representation.

This classification approach is carried out in two phases i.e., training and testing phase. The training phase involved storing features extracted from the dataset images taken for training and assigning them category to which they belong. The testing phase involved observing the classification result for query image and this is carried out using the classification technique. The features are extracted from the query image and are compared with the features of trained dataset features matrix and based on that it classify the query image that category of matched image feature as the result. Support Vector Machine (SVM) is used here for performing the classification of input satellite images. Further execution of proposed framework shows that one can be certain of high classification results utilizing the proposed approach and the framework yields better classification accuracies. Our proposed system showed overall accuracy of 91.66%.

REFERENCES

[1] Guofeng Sheng, Wen Yang, Lijun Chen, Hong Sun, **"Satellite image classification using sparse codes of multiple features",** Signal Processing (ICSP), 2010 IEEE 10th International Conference, 03 December 2010, DOI: 10.1109/ICOSP.2010.5655718, ISBN: 978-1-4244-5897-4,

[2] Jin-Tsong Hwang, Kuan-Tsung Chang, Hun-Chin Chiang, **"Satellite image classification based on Gabor texture features and SVM",** Geoinformatics, 2011 19th International Conference, 12 August 2011, ISSN: 2161-024X, DOI: 10.1109/GeoInformatics.2011.5980774,

[3] S.Manthira Moorthi, Indranil Misra, **"Kernel based learning approach for satellite image classification using support vector machine",** Recent Advances in Intelligent Computational Systems (RAICS), 2011 IEEE, DOI: 10.1109/RAICS.2011.6069282, ISBN: 978-1-4244-9478-1, 03 November 2011,

[4] Rosniza Roslan, Nursuriati Jamil, **"Texture feature extraction using 2-D Gabor Filters",** Computer Applications and Industrial Electronics (ISCAIE), 2012 IEEE Symposium, 21 March 2013, ISBN: 978-1-4673-3032-9, DOI: 10.1109/ISCAIE.2012.6482091, pp.: 173-178,

[5] Fardin Mirzapour, Hassan Ghassemian, **"Using GLCM and Gabor Filters for Classification of PAN Images",** 978-1-4673-5634-3/13/$31.00 ©2013 IEEE

[6] Mr. S.V.S.Prasad, Dr. T. Satyasavithri, Dr.Iyyanki V. Murali Krishna, **"Object Classification of Satellite Images Using Cluster Repulsion Based Kernel Fcm and Svm Classifier",** IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735. Volume 7, Issue 3 (Sep. - Oct. 2013), PP 25-35

[7] P. Ganesan, K. Palanivel, B. S. Sathish, V. Kalist, KhamarBashaShaik, **"Performance of fuzzy based clustering algorithms for the segmentation of satellite images - A comparative study",** Computing, Communication and Information Systems (NCCCIS), 2015 IEEE Seventh National Conference, 12 October 2015, ISBN: 978-1-4799-8990-4, DOI: 10.1109/NCCCIS.2015.7295906,

[8] Panpan Yang; ZhitingHou; Xiaolong Liu; Zhengtao Shi, **"Texture feature extraction of mountain economic forest using high spatial resolution remote sensing images",** Geoscience and Remote Sensing Symposium (IGARSS), 2016 IEEE International, 03 November 2016, ISSN: 2153-7003, DOI: 10.1109/IGARSS.2016.7729816,

[9] Gandhimathi@usha, AN.Valliyappan **"Gabor features based classification of multispectral images using clustering with SVM classifier"** International journals for trends in engineering and technology, VOLUME 13 ISSUE 1 – MAY 2016 - ISSN: 2349 – 9303(2016)

[10] Ruby bharti, JitentraKurmi, **"Satellite High Resolution Image Classification Using Fuzzy Logic"**, Advances in Computational Sciences and Technology, ISSN 0973-6107 Volume 10, Number 5 (2017) pp. 1427-1437,

[11] RupinderKaur, Dolly Sharma, AmitVerma, **"Enhance satellite image classification based on fuzzy clustering and Marr-Hildreth algorithm",** Signal Processing, Computing and Control (ISPCC), 2017 4th International Conference, 25 January 2018, DOI: 10.1109/ISPCC.2017.8269663, ISBN: 978-1-5090-5838-9

[12] Anita Dixit, Dr. Nagaratna Hedge, Dr. B. Eswar Reddy, **"Texture Feature Based Satellite Image Classification Scheme Using SVM",** International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 13 (2017) pp. 3996-4003

[13] J. Krishna Chaithanya, MISTE, Dr. T. Rama Shri, MISTE, **"Feature Extraction of Satellite Images Using 2D Phase Congruency Measure",** International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013

[14] Urszula Marmol, **"USE OF GABOR FILTERS FOR TEXTURE CLASSIFICATION OF AIRBORNE IMAGES AND LIDAR DATA",** Archives of Photogrammetry, Cartography and Remote Sensing, Vol. 22, 2011

[15] http://www.xinhua-fluid.com/people/yangwen/WHU-RS19.html