Improving Satellite Image Processing Via Hybridization of Fusion, Feature Extraction & Neural Nets

Kavita Joshi, Dilip D Shah, Anupama A. Deshpande

Abstract: ***Satellite image classification is useful for many applications including but not limited to, crop classification, military equipment identification, movement tracking and forest cover detection. These applications involve image segmentation, feature extraction and application of a classifier to perform the final categorization task. This texts presents a hybrid approach which uses multispectral image fusion using brovey and principal component analysis methods, with the purpose of boosting the eminence of the image segmentation method, this when combined with hybrid feature extraction and classification process, tends to produce highly accurate classification results. We compare the classification accuracy of a standard support vector machine (SVM) with cascaded neural networks and observe that the neural network performs 20% better than SVM when applied to crop identification application***

Index Terms: ***brovey, fusion, hybrid, neural network, PCA, Satellite image classification.***

I. INTRODUCTION

Satellite image classification has emerged as a trending area for analyzing the type of land, forest cover, vegetation type and various other parameters of the image under consideration. The image classification process consists of the following steps,

- Image capture phase
- Denoising and pre-fusion
- Image fusion
- Extraction of useful regions
- Finding of features
- Selection of useful features
- Categorization

The image acquisition phase is of utmost importance. In this phase, the images are captured from the satellite image capturing device. Usually these images are multi spectral in nature, meaning they have more than 3 bands. Usually colored images have red, green and blue bands, but these images have separate bands for color and shape. The color bands assist in identification of color based features like green plantation, or brown soil, while the shape bands assist in identification of shape variations in the image. These shape variations include shadows, textures for mountains and other terrains.

The acquired images are given to the pre-processing block, where the unwanted noise from the images is reduced. Satellite image capture usually adds Gaussian noise to the image, which is removed using weiner and averaging filters. These noises can cause issues in the segmentation process, and must be removed before any further processing is done on the images. Furthermore, the de-noised images can be given to an image enhancement block, wherein any hidden regions can be enhanced in the image under test, so that better segmentation can be performed.

While pre-processing enhances the quality of the images, there is a need for combination of the multiple bands in the image. These multiple bands when used separately provide limited information in the image, and thus are needed to be combined by the process of band fusion in order to improve the information extraction from the image. Fusion methods include, but are not limited to brovey fusion, principal component analysis based fusion, and various others. These methods take the best parts from the image and combine them in order to get a fused image. The generated fused image is a culmination of both color and shape information as represented in the image.

Image fusion generates a post processed image, which is given to an image segmentation block. This block extracts only the required regions from the image and removes all the unwanted areas from the image. The design of image segmentation block usually depends on the application being developed. For example, for an application which processes plantation satellite samples, the segmentation block would be responsible for detecting and preserving the green region of the image, while removing the other regions with utmost accuracy. Methods for segmentation include thresholding, region growing, clustering, etc. These methods are selected based on the application being developed for the satellite image processing. Segmentation produces the image with regions of interest, these regions vary w.r.t. color, shape, texture and other parameters. The segmented regions are given to a feature extraction block, this block defines the features of the image, by which the color, texture and shape of the image are described. Feature extraction methods include, histogram evaluation, extended color maps, edge maps, texture maps and various others.

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These features are needed due to the fact that while classification, we cannot classify image pixels directly, because they might vary in size, color and texture for similar images, thus we need a constant sized feature vector, which can be used directly for the classification purpose.

Selection of features is generally an optional step in the process of satellite image processing. In this process, the extracted features are checked for repetition, and any other ambiguities. These ambiguities and repetitions are removed from the feature vector, and an optimized feature vector is produced at the output.

The classification process involves comparison of the extracted features against a pre-defined training set. This comparison is usually done with the help of neural networks, support vector machines, nearest neighbour classifier and naive bayes classifier. Via this comparison, the image and it's regions are classified as per the application. For example, for an application which identifies crop type, the classifier is trained such that it can detect the color and shape variations between various image blocks, and then each of the image block is given to the classifier and is categorized into a particular crop type as per the extracted features.

In our work, we are using color maps and shape maps for feature extraction, combined with brovey and PCA based fusion methods for image fusion. The extracted color and shape maps are given to a neural network and SVM classifier and comparison between the accuracies of these classifiers is done in order to select the best classifier for our application of crop type detection. The next section describes some state of the art methods for satellite image classification, followed by the methods used in this paper, and finally we conclude with some interesting observations from our results..

II. LITEARTURE REVIEW

J. Shabnam et al., [11] presented administered satellite picture order strategy to characterize high goals satellite pictures into particular classes utilizing fluffy rationale. This technique groups satellite pictures into five noteworthy classes: shadow, vegetation, street, assembling and exposed land. This strategy utilizes picture division and fluffy strategies for satellite picture order. It applies two levels of division, first level division distinguishes and arranges shadow, vegetation and street. Second level division recognizes structures. Promote it utilizes relevant check to arrange unclassified sections and locales. Fluffy systems are utilized to enhance the arrangement exactness at the fringes of items. [12] Presents a managed satellite picture arrangement technique to decide water, urban and green arrive on satellite pictures. This strategy takes preparing set for each class and processes edge esteem utilizing k-means and LDA [13] strategies. The strategy separates low-level highlights from satellite pictures and applies k-implies calculation to aggregate into unlabeled bunches. Important names are appointed to the unlabeled classes by contrasting edge esteems and extricated highlights. [14] Describes philosophy based managed sea satellite picture grouping strategy. This technique outlines intensity of metaphysics in sea satellite picture characterization. The strategy removes low level highlights from sea satellite pictures and speak to in owl record design. This owl document is converged with area ontologies and naming standards. Naming guidelines, preparing rules, parallel choice tree tenets and master rules are speak to utilizing SWRL [15] dialect. The strategy produces characterization after effects of given sea satellite picture with the help of preparing, human master, choice help and naming guidelines. [14] Also gives an apparatus as module for protégé philosophy manager. The instrument underpins sea satellite pictures with the aid of definitive and exhaustive classification techniques related to area. Researchers [1] proposed an administered grouping of satellite picture by utilizing choice tree method. This strategy extricates highlights from satellite picture dependent on pixel shading and power. Removed highlights help to decide objects live in the satellite pictures. The techniques characterizes satellite pictures utilizing choice based tree by the support of recognized articles. [16] Offering a technique for the order of saellite pictures into different arrive cover classes which are already defined. This strategy is robotized and utilizations portion level order with the help of preparing set. The characterization techniques incorporates logical properties of predefined various classes to enhance the grouping precision. A. Selim [17] projected an order strategy utilizing Bayesian procedure. The strategy utilizes spatial data for grouping of high-goals satellite pictures. The technique achieves order in two stages. Stage 1: other worldly and textural highlights are separated for every pixel to prepare classifiers named Bayesian having non-parametric thickness models which are discrete in nature. Stage 2: split-and-consolidation having iterative calculations is utilized to change over the pixel level arrangement maps into adjoining districts. Isodata [9] system is utmost regular satellite order technique which is unsupervised in nature . It outperforms predefined number of unlabeled groups in a satellite picture. Later important names are relegated to the groups. Requirement of ISODATA parameter is few parameters which manages how many groups and cycles need to be run. In rare cases groups may cover pixels of various classes. In such circumstances ISODATA utilizes group busting [18] procedure to name the mind boggling classes. K-Means [10] is a mainstream insights and information mining procedure. It parcels n perceptions into k bunches dependent on Euclidean mean esteem. Favorable circumstances with the K-Means method are easy to process and quick performance. Confinement with this strategy is expert should know priori number of classes. Bolster Vector Machine (SVM) [19] is a unsupervised and non-parametric factual grouping technique. This technique can be utilized to extricate arrive utilize outline. SVM chips away at the supposition that there is no data on the most proficient method to disperse the general information. SVM diminishes satellite grouping cost, builds speed and enhances precision. Least separation [20] approach figures mean spectra of each predefined class and doles out the pixel to a gathering that has minimal separation to mean. It simple to execute and easy to process. However, least separation strategy thinks about just mean esteem. Mahalanobis remove technique [21] is fundamentally the same as least separation strategy. It utilizes measurements strategy covariance lattice for satellite picture order.

Parallelepiped executes dependent on parallelepiped-formed boxes for every class. Parallelepiped limits for every class are already-decided [20]. Pre-decided limits recognizes checks pixels of test pictures and decide class of the pixel. Technique having Parallelepiped process is quick and simple to run, yet cover may deliver incorrect outcomes. Most extreme probability [22] strategy is a factual managed approach for perceiving the examples. It distributes pixels to suitable classes dependent on likelihood estimations of the pixels. Most extreme probability is a proficient technique to group pixels of satellite picture. Crop and weed classification is carried out by using neural network[23][28] For segmenting image, while identifying cotton bug, hybridization of the fuzzy C means and the thresholding method had been implemented [32]

III. SVM AND NEURAL NETWORK BASED CLASSIFICATION ON SATELLITE IMAGES

In this work, we are using a combination of the following steps for classification of the input satellite images in order to detect the crop type in the captured satellite imagery,

A. Brovey and PCA fusion

The images are captured in sets of 2, where the first image is the panchromatic image (P) which consists of the shape information, and the second image is the Multispectral Image (M) which contains the color information. These 2 images are combined using brovey fusion. The formula for fusion of image using this method can be summarized using equation 1,

$$Fused = \frac{(k*P*M)}{\sum M} \quad (1)$$

where, k is the scaling constant (k=4 in our case, as we are having 4 bands, namely red, green, blue and panchromatic)

This steps gives the final fused image, which consists of both color and shape information due to the fact that the panchromatic image which contains the shape information is combined with the multispectral image which bears the color information in the image.

B. Color and shape map

Color map or extended histogram map is obtained by plotting the quantized color levels on X axis and the number of pixels matching the quantized color level on the Y axis. The obtained graph describes the color variation of the image and thus is used to describe the image during classification stage. The color map resembles to the gray level histogram of the image with one minor difference, that the color map quantizes the Red, Green and Blue constituents of the image before counting them, while the histogram directly counts the pixels belonging to a particular gray level and plots them. This ensures that all the color components of the image are taken into consideration by the descriptor. While color map describes the color of the image, the extended edge map describes the edge variation in the image. To find the edge map, the image is first converted into binary, and then canny edge detector is applied to it. The original RGB image is quantized same as in the color map. The locations of the edges are observed, and the probability of occurrence edge on a particular quantized image level is plotted against the quantized pixels in order to evaluate the edge map of the image. The edge map is used to define the shape variation in the image and is a very useful and distinctive feature for any image classification system. These 2 features combined together can describe the image in terms of color and shape

C. Neural Network Classifier

The neural network classifier is trained with more than 20 images. Each of the image is divided into 64 blocks, which gives a training set of 1280 feature vectors. These image blocks are segregated in terms of the crop type, and thus vary for each type of crop. The neural network layer has 278 neurons at the input layer that is one neuron per feature value, 1280 neurons in the hidden layer which is equal to the training set, and 3 neurons at the output layer as we are classifying the blocks into 3 different classes. The network training shows more than 90% accuracy, which is verified by the result analysis for the various test images.

D. Support Vector Machine Classifier

The classifier based on support vector machine is trained with the same 1280 feature vectors and 3 classes. Usually SVM is built to be a 2-class classifier, but in this case we are training strong 2-class classifiers of SVM and then aggregating their classification outputs in order to get the final class. Due to the strong 2-class based training of SVM, the results of classification are more accurate as compared to the SVM classifier used in 1vsAll SVM classification, due to the fact that the 1VsAll classifier weakly classifies the input features with each other and creates a support value for the test entry w.r.t. each trained entry, thus the classification rate is of our classifier is higher as compared to the 1VsAll based SVM classifier. The next section describes the obtained results for the various classifiers.

IV. RESULTS AND ANALYSIS

We compared the accuracy and delay needed for classification for both neural network and support vector machine for the same set of training and testing images. We trained nearly 1280 blocks of the image, and tested similar number of blocks in order evaluate the accuracy of the mentioned classifiers.

Table 1 shows the accuracy of both the classifiers,

Number of blocks trained	Accuracy (%) (SVM)	Accuracy (%) (NN)
50	75	77
80	78	81.5
120	79.5	86.4
250	81.2	90.2
500	82.3	91.5
750	82.4	93.6
900	82.6	93.9

1150	82.9	94.8
1280	83.4	95.2

Table 1 Accuracy v/s Number of blocks trained

As we can observe the accuracy of SVM is limited to nearly 83% and saturates after a certain number of training blocks, while the accuracy of the neural network classifier linearly increases and saturates near 95% as number of training blocks are increased. Figure 1 depicts the graphical comparison of these results,

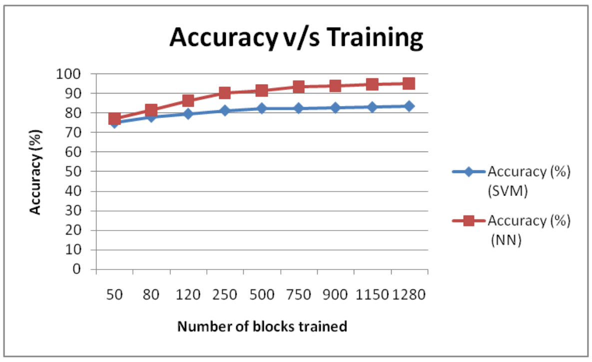

Figure 1 Accuracy Comparison

The table 2 shows the delay comparison of the algorithms. The delay is evaluated between the instance at which the image is given as an input to the classifier and the instance at which the output is obtained after classification,

Number of blocks trained	Delay (ms) (SVM)	Delay (ms) (NN)
50	12.5	15.6
80	15.8	16.2
120	28.3	17.8
250	37.4	19.6
500	48.2	21.4
750	62.8	25.7
900	79.2	29.4
1150	85.3	33.9
1280	104.6	37.4

Table 2 Delay comparison

As observed from the table, the delay of classification using neural network is initially high for less number of blocks, but reduces as the number of blocks increase, due to the fact that the neural network trains itself once the evaluates continuously, while the SVM block is needed to be trained and evaluated for each new entry in the database. Figure 2 depicts this with the help of a graphical comparison,

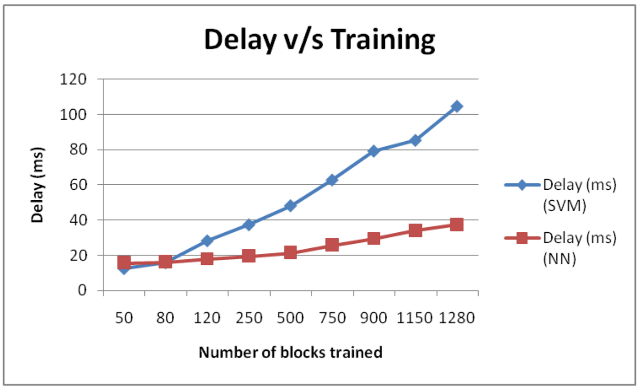

Figure 2 Delay comparison

From the observed results, it is imminent that neural network outperforms support vector machine when applied to crop region classification. Figures 3 and 4 indicate the simulation outputs for both the algorithms respectively,

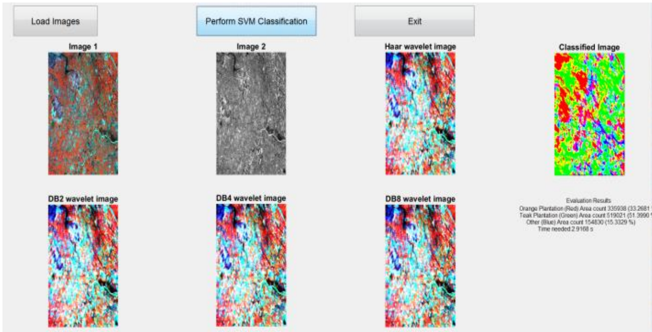

Figure 3 Output of SVM classification

From the output we can observe that the fused images have much better information representation as compared to the individual images, this is also inherent from the output of the neural classifier,

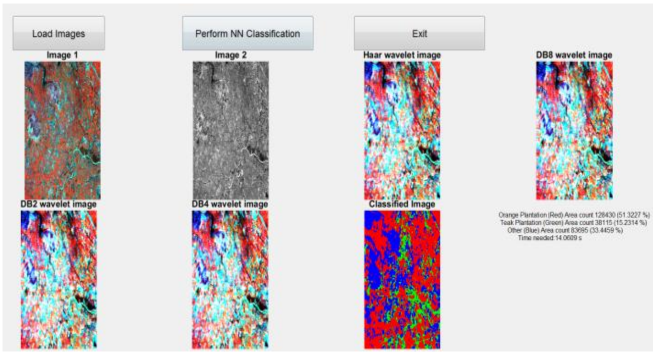

Figure 4. Output of neural network classification

Thus neural network performs better crop identification as compared to support vector machines.

V. CONCLUSION

From the results we observe that neural networks perform more than 20% better as compared to support vector machine based classifier in terms of accuracy and delay of the system.

The overall accuracy improvement is due to the error correction capability of the neural network, while the delay reduction is due to the one shot training of the classifier. In future, researchers can use advanced machine learning algorithms like Q-learning and deep nets in order to further improve the accuracy of the system

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