Classification of Low Resolution Satellite Images Using Image Fusion and De-correlation Stretch

[1]Supraja Iyer, [2]Reetu Desai, [3]Smita Deore, [4]Stuti Ahuja

[1,2,3,4]Information Technology Department, SIES Graduate School of Technology, Nerul, Navi Mumbai, India.

[1]supraja.iyer@siesgst.ac.in, [2]reetu.desai@siesgst.ac.in, [3]smita.deore@siesgst.ac.in, [4]ahuja.stuti@siesgst.ac.in

Abstract: **Satellite images provide a lot of geographical information. Classification is one of the important step to use this information for various applications like glacier change detection, extracting mineral deposits, area under vegetation, disaster management etc. In proposed method, both high resolution and low resolution images will be classified. For the low resolution images, image fusion is carried out using IHS technique, one panchromatic image and its multispectral image is taken as input, geometric correction is performed on multispectral image relative to the panchromatic image, thus we obtain a high resolution image which is segmented and then classified. High resolution images are directly segmented and then classified. After comparing results for high resolution and low resolution images it is seen that, high resolution images directly given as input which are classified using proposed method are more accurate than low resolution images.**

***Keywords: Classification, IHS, Image fusion, Multispectral, Satellite Images, Semi Supervised Approach*.**

I. INTRODUCTION

A satellite image can be defined as an image of a part of location or an entire location on the surface of the earth, captured using artificial satellites from outer orbits of the earth. These images serve as input to a wide range of applications for extracting information and deriving conclusions like land cover, mineral detection, cartography, forest and agriculture status, urban sprawl etc. There are a number of satellites through which images are captured. The satellites which capture some of the best images are ASTER, Black Bridge, "EROS" satellites, INDOEX. The Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) is NASA's Earth Observing System (EOS) launched in December 1999. Satellite imagery can be classified into three main categories, namely, Visible Light Imagery, Water Vapor Imagery and Infrared Imagery. Visible Light Imagery (VIS) requires the presence of light for capturing images, as it uses the light from the sun to illuminate the object to be captured. Hence can only be used during the day, i.e. in the presence of sunlight. Water Vapor Imagery helps indicate the amount of moisture present in the upper layers of atmosphere. Since they focus on water vapor flow they are used in weather forecasting. An Infrared satellite image uses a channel recorded from infrared energy (typically the 10 to 11μm wavelength). It provides information about the temperature of an object. These satellite images serve different purpose according to its type. The satellite produced different types of images. The satellite imaging systems, depending on the number of spectral bands can be categorized as, Panchromatic Imaging System, Multispectral Imaging System and Hyperspectral Imaging System. Panchromatic Imaging Systems capture only black and white images. They fail to capture the spectral information i.e. color of image. Some of panchromatic imaging systems are IKONOS PAN, SPOT HRV-PAN etc. Multispectral Imaging Systems are spectral imaging systems that capture image beyond the visible light. They capture 2-10 spectral bands .i.e. multilayer image which contains both the brightness and spectral (color) information of the image. Some of multispectral imaging systems are LANDSAT MSS, LANDSAT TM, SPOT HRV-XS, IKONOS MS etc. Hyperspectral Imaging Systems are capable of acquiring images in hundreds of very narrow contiguous spectral bands. And thus can be used specific applications like precision agriculture (e.g. monitoring the types, health, moisture status and maturity of crops), coastal management (e.g. monitoring of phytoplanktons, pollution). Hyperion EO1 satellite is an example of Hyperspectral Imaging System.

A satellite image is an important tool which contains a huge amount of geographical information. The contained information in satellite images can be used for serving different purposes and applications which include Weather Forecasting, Conducting research, Remote sensing, Change detection, area under vegetation, navigation etc.

A number of techniques have been proposed for object recognition. One of them is by matching boundary signature. For this purpose, four boundary signatures: the Curvature Boundary Signature (SCB), the Direction Boundary Signature (SAB), the Distance Boundary Signature (SDB) and the Parameter Boundary Signature (SPB) are constructed by using boundary's local and global geometric shape attributes. This approach is based on the shape of the object. For shape of object, boundary of object is required to compute. But some objects don't have distinct boundaries. Soil, ecological zone are good examples that don't have distinct sharp boundaries. [2] Another methodology for characterizing satellite images that was based on the color and structure-based vocabularies. The drawback of this methodology is usage of larger vocabulary. Large vocabulary provides only small gain in accuracy but it requires a greater computation cost. [2]

Images acquired through sensors, radars and satellites are large in number. Remotely sensed satellite images contain huge amount of geographical information. Advances in technology have lead to improvement in quality of images, as well as the quantity of images captured has increased considerably. Each image having various objects. It is very tedious task to manually go through each and every image, extract objects and store useful patterns. An automatic mechanism is needed which will extract useful objects from the image and then do classification of the image. Our proposed system will do the classification of satellite image.

II. PROPOSED METHODOLOGY

Algorithm for classification

1) Input: Satellite image

2)

A. Low Resolution Satellite Image:

1. Perform geometric correction.

2. Apply IHS technique for image fusion

3. We get high resolution image.

4. Apply Decorrelation stretch to extract areas.

5. Reassign colors based on pixel value.

B. High Resolution Satellite Image:

1. Apply Decorrelation stretch to extract areas.

2. Reassign colors based on pixel value.

3) Output: Classified image for classes Greenery, Water, Rock/Soil and Urbanization.

The process of classification of images that is proposed is as follows:

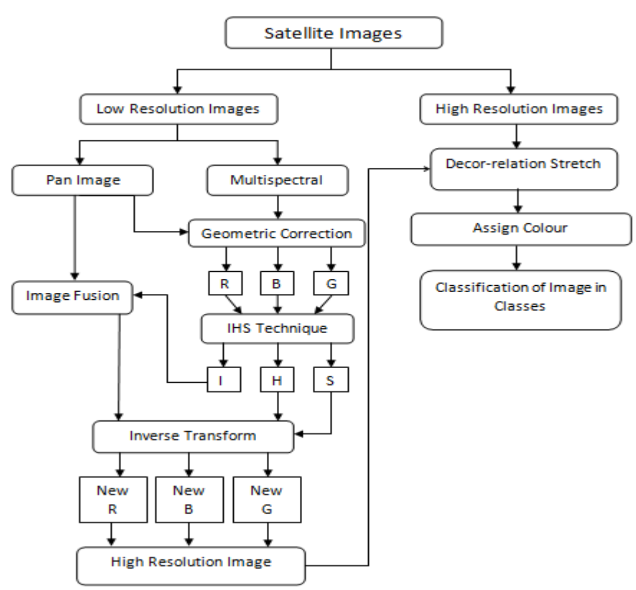


Fig 1. Proposed System

The proposed system considers high resolution as well as low resolution images for the purpose of classification. The low resolution images need to be converted to high resolution images before classification, for this purpose panchromatic and multispectral images are taken.

Panchromatic Images: The image which is collected in the broad visual wavelength range but the image is black and white.[1]

Multispectral Images: The image which are optically acquired in more than one spectral or wavelength interval. Each image is usually of the same physical area and scale but of different spectral band. [1]

For this conversion from low resolution to high resolution image, image fusion is carried out using IHS (Intensity Hue Saturation) technique, before image fusion can be applied the image should be corrected for geometric differences. This is called geometric correction, where one panchromatic image and its multispectral image is taken as input, geometric correction is performed on multispectral image relative to the panchromatic image.

Geometric Correction: Geometric correction or image registration is the process of aligning two images of the same scene. Geometric correction is used as a preliminary step in image fusion for satellite images. After registration we compare features in both images. The parameters of the transformation required to bring an image into alignment with another image are to be determined first by using ground control points (GCPs) in a pair of images that identify the same feature or landmark in the images. Then, a spatial mapping is inferred from the positions of these control points.

Steps in Geometric Correction-

1. Selection of GCPs (Ground Control Points) in both images: Choose one image, which is in proper geometric position, as reference image or base image and other image as input image for geometric correction.

2. Fine tune GCPs.

3. Perform Spatial Transformation on Input Image: Different transforms are applied on input image based on base image as: translation, rotation and scaling.

After applying transformations input image matches with base image.

Image Fusion: Image fusion is performed on the geometrically corrected image. The multispectral image is transformed band by band to its intensity, hue and saturation components. The intensity of the multispectral image is replaced with that of the panchromatic image. The replaced intensity from the panchromatic image and hue and saturation of the multispectral image is the fused image. Inverse transformation of this image gives the new RGB value which is a high resolution image. After obtaining a high resolution image using IHS technique, the path for high resolution image is followed i.e. segmentation using Decor-relation Stretch followed by reassigning color leading to classification.

Decorrelation Stretch: Decorrelation stretch enhances the image by applying Karhunen-Loeve Transform or Hotelling Transform on the principal components of the image. The original color values of the image are mapped to a new set of color values with a wider range. Followed by contrast stretching which uses feature discrimination to enhance the visual interpretation, which makes it easy to differentiate the different areas in the image. Inverse transformation maps the colors back to an approximation of that in original image. Thus, decorrelation stretch produces linear combination of the original bands which are uncorrelated.

Classification: The image obtained from decorrelation stretching is classified on the basis of pixel values in four classes, namely, Greenery, Water, Rock/Soil and Urbanization.

III. EXPERIMENTATION AND RESULTS

For Low Resolution Images

An image of China Forest was taken. A low resolution image as well as a high resolution panchromatic image of the same place was taken. It was converted from low resolution to high resolution using the following steps:

Step 1: Geometric Correction: Fig. 2(b) is high resolution panchromatic image and geometrically better than Fig. 2(a), therefore Fig. 2(b) is taken as reference or base image and geometric correction is performed on Fig. 2(a). Control points are selected from both the images.

Step 2: HSI conversion: The RGB Image is divided into three bands R, G and B. It is then converted to HIS format using the following equations. Let *m* be the minimum value among the three.

$$I = (R + G + B)/3$$

$$S = 1 - m/I \text{ if } I > 0, \text{ or}$$

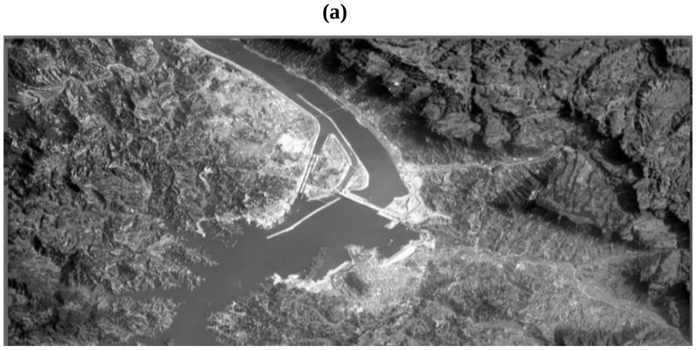
$$S = 0 \text{ if } I = 0.$$

$$H = \cos^{-1}[(R - ½G - ½B)/\sqrt{R^2 + G^2 + B^2 - RG - RB - GB}] \text{ if } G \geq B, \text{ or}$$

$$H = 360 - \cos^{-1}[(R - ½G - ½B)/\sqrt{R^2 + G^2 + B^2 - RG - RB - GB}] \text{ if } B > G,$$

Step 3: Create high resolution images from a low resolution image: The intensity band of HSI image is concatenated with the panchromatic image. Then, inverse transform is applied to get back a RGB image from an HSI image. The image obtained is a high resolution satellite image.

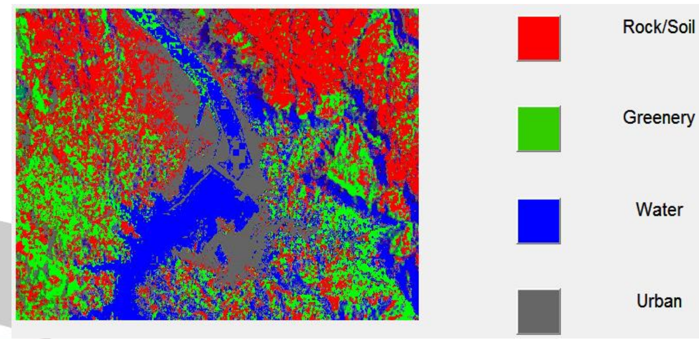
(a)



(b)

(c)

The further path for classification is the same as the one used for high resolution images.



(d)

Fig. 2 (a) Low resolution image of China forest (b) High resolution panchromatic image of China forest (c) New high resolution image of China forest (d) Classified image of China forest

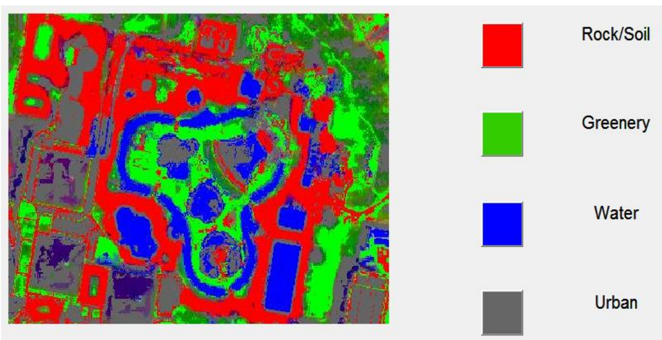
For High Resolution Images

An image of amusement park is taken. Following steps are to be applied to classify the image.

Step 1: Decorrelation stretch: The decorrelation stretch is applied on the high resolution RGB satellite image and true colour composite is obtained. Thus the image is now segmented by image enhancement.

Step 2: Classification of image: First the image is separated band by band. Masking is now applied on every band of the segmented image. Based on the value of each pixel obtained after decorrelation stretch, Color the given to each class. Green is the greenery, red is rock or soil, grey is for urban and blue is water. The colour is assigned on the individual value of every band of the segmented image. Lastly, all the three bands of the segmented image are concatenated to form a classified image.

(a)



(b)

Fig. 3 (a) High resolution of an amusement park (b) Classified image of an amusement park

IV. PERFORMANCE EVALUATION

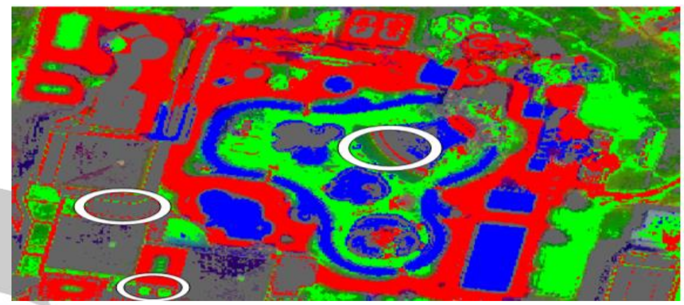
For the purpose of testing the accuracy of the system, we have used K-means alongside of Decorrelation Stretch to classify the satellite images.

The K-means method makes four clusters in the image given to it as input. Depending on the similarity of the objects in the given image these four clusters are made. These four clusters correspond to the four classes of the proposed system. Comparison is made between the image classified by the proposed system into four classes with that of the image classified by K-means into four clusters for measuring the accuracy.

Comparing Fig. 4(b) and Fig. 4(c), the differences in the classification methods can be seen. The former image classifies the swimming pool and its adjacent area into three classes namely water urban and greenery. The latter image using k-means fails to do so.

Thus the proposed system can classify images whose variation in classes is visible providing classification of minute details, whereas K-means does random classification.

(a)

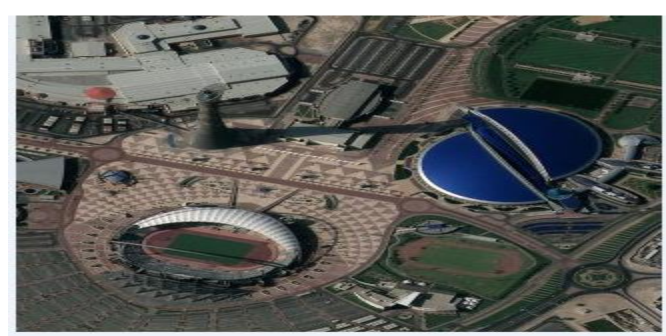


(b)

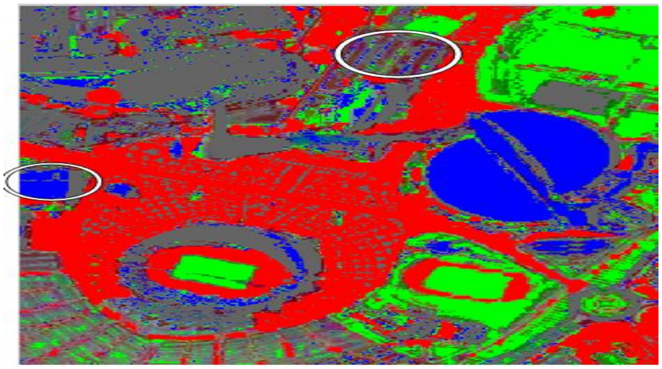
(c)

Comparing Fig. 4(e) and Fig. 4(f), the differences in the classification methods can be seen. The former image misclassifies some part of the urban area into water whereas the latter image does it correctly.

Thus the proposed system misclassifies images where there is variation in urban area.



(d)



(e)

(f)

Fig. 4 (a) Image of an amusement park (b) Classified image of an amusement park using Proposed System (c) Classified image of an amusement park using K-means (d) Image of a Stadium (e) Classified image of a Stadium using Proposed System (f) Classified image of a Stadium using K-means

V. Conclusions

The method implemented is simple yet effective to identify classes from any satellite image. Also, this method is used for converting low resolution satellite image to high resolution satellite image. This conversion method requires the panchromatic high resolution and the multispectral low resolution image to be geometrically corrected with respect to each other, after which IHS (Intensity Hue Saturation) image fusion technique is applied to obtain a single high resolution multispectral satellite image. The image obtained using image fusions as well as originally high resolution images are classified using decorrelation stretch. For the purpose of classification the test classes taken into consideration are water, soil, greenery and urban. Conventional ground methods of classification are labor intensive, time consuming and are done less frequently. Hence this method is semi-supervised and training is performed which provides higher accuracy. The accuracy is relatively less when the proposed method is used to classify only urban areas. Also, after comparing results for high resolution and low resolution images it is seen that, high resolution images directly given as input which are classified using proposed method are more accurate than low resolution images.

References

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