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Automatic Change Detection for High Resolution Satellite Images Based On Spatial and Spectral Features

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***Abstract*—The main objective of this paper is to develop a fully automated system for change detection of high resolution satellite imagery. In existing literature manual inspection was performed in a newly collected imagery to identify changes on the surface of the earth. It provides inaccurate results. In order to address this issue a new Geospatial Change Detection and Exploitation system is introduced. Image misregistration is a major factor impacting the development of fully automated change detection algorithm. To increase the registration accuracy pansharpening is introduced. Pan sharpened imagery have enhanced spatial resolution. The panchromatic and multispectral imagery is processed and higher level features are extracted to capture additional information. Change detection is done in three stages. Initially in the preprocessing step the images are cataloged and prepared for subsequent processing. In second stage, features like spectral and spatial features are extracted from the imagery. They are Principal Component Analysis, Independent Component Analysis, Differential Morphological Profiles, Gray Level Co-occurrence Matrix and Urban Complexity Index. It overcomes the shortcomings due to pixel based change detection method. Then the supervised classification is used to classify the changes in the remote sensed images. The supervised classifier is used. In this approach change information of objects is concerned, shading effects are reduced and the accuracy of Natural disasters assessment is improved.**

***Index Terms*—Classification, Change Detection, Support vector machine, Classifier, Feature extraction, Supervised classification**

I. INTRODUCTION

Remote Sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites. Remote sensors collect data by detecting the energy that is reflected from Earth. These sensors can be on satellites or mounted on aircraft. Remote sensors provide high resolution earth observation data in both the spectral and spatial domains. This type of high resolution imagery contains detailed ground information in both the spectral and spatial domains. The classification of high resolution images suffers from uncertainty of the spectral information. Remote Sensing Applications used in the following areas like Forest Monitoring, Environment Management, Precision Agriculture, Security, Defense issues.

Remote sensing has a wide range of applications in many different fields. One important application area is Coastal applications. Monitor shoreline changes, track sediment transport, and map coastal features. Data can be used for coastal mapping and erosion prevention. The next important application area is Ocean applications-Monitor ocean circulation and current systems, measure ocean temperature and wave heights, and track sea ice. Data can be used to better understand the oceans and how to best manage ocean resources. The next important application area is Hazard assessment-Track hurricanes, earthquakes, erosion, and flooding. Data can be used to assess the impacts of a natural disaster and create preparedness strategies to be used before and after a hazardous event. The next important application area is Natural resource management-Monitor land use, map wetlands, and chart wildlife habitats. Data can be used to minimize the damage that urban growth has on the environment and help decide how to best protect natural resources.

By summarizing the existing literature, it can be found that they have used either spectral feature extraction or spatial feature extraction. Different spatial feature extraction and classification methods were implemented, including differential MPs (DMPs)[1],[2], gray level co-occurance matrix (GLCM)[10], Urban Complexity Index (UCI)[1]. The drawbacks of the existing methods are lower accuracy, Uncertainty of spectral information and Calculation of the spatial features, such as the GLCM,DMP in most cases leads to hyper dimensional feature space since spatial features refer to different parameters such as sizes, scales, and directions.

In this context we proposed an SVM-based multi classifier system with both spectral and feature extraction for high resolution image classification. Automated change detection is introduced in the proposed system. A simple scheme of the processing steps implemented in this approach is as follows.

A feature extraction procedure is applied to the data to reduce the dimensionality.

- Supervised classification are performed, comparing results of different spectral and spatial classifiers.
- The best classification images are combined with Certainty voting, Probabilistic fusion, Object Based Semantic Approach.
- A further Post Regularization step is introduced in the classified image.
- The spatial information from the neighborhood of each pixel is taken into account to improve the accuracies.

II. PREPROCESSING

Pre-processing methods use a small neighborhood of a pixel in an input image to get a new brightness value in the output image. Such pre-processing operations are also called filtration. Local pre-processing methods can be divided into the two groups according to the goal of the processing

- Smoothing
- Gradient operators

III. FEATURE EXTRACTION

Feature extraction can be viewed as finding a set of vectors that represent an observation while reducing the dimensionality. Feature extraction is performed on the preprocessed image using Discrete Wavelet Transform (DWT). DWT allows the analysis of images at various levels of resolution

The aim of preprocessing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. It aims to correct some degradation in the image.

There are two types of feature extraction

- Spectral Feature Extraction
- Spatial Feature Extraction

A. Spectral Feature Extraction

There are different types of spectral features which are extracted from the images and train those images.

1) Principal Component Analysis(PCA): Principal Component Analysis is used for spectral feature extraction from multi spectral images. PCA is a mathematical procedure that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables

B. Spatial Feature Extraction

There are different methods of spatial feature extraction techniques. They are

- Gray Level Co-occurrence Matrix(GLCM)
- Differential Morphological profiles(DMPs)
- Urban Complexity Index(UCI)

1) Gray Level Co-occurrence Matrix(GLCM): It is a standard technique for texture extraction and it is an effective method for enhancing the classification of high resolution images. The texture function of GLCM can be expressed as $\mathbf{f_{GLCM}\,(b,m,w,d)}$

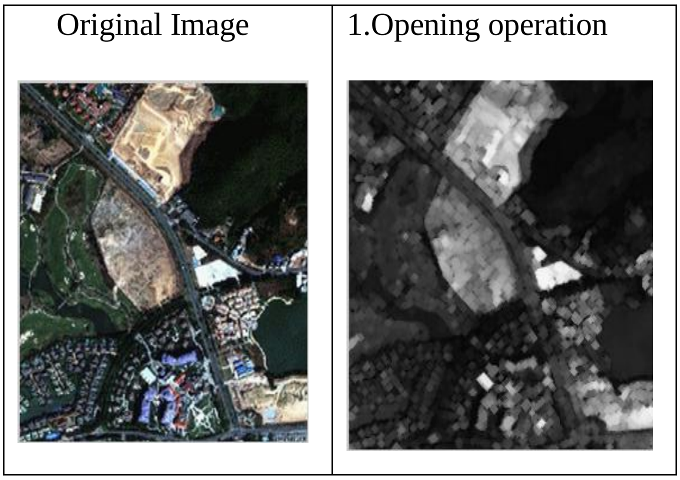
b- Base image
m- Texture measure
w- Window size

d- Direction

2) Differential Morphological Profiles(DMP): Differential Morphological Profiles (DMP) [2] has a set of different operations. The fundamental operators in mathematical morphology are erosion and dilation. When mathematical morphology is used in image processing, these operators are applied to an image with a set of known shape, called structuring element (SE). The application of the erosion operator to an image gives an output image, which shows where the SE fits the objects in the image. The erosion and dilation operators are dual but noninvertible.

The other two operations in the Morphological Profiles are openings and closings [1]. The opening and closing operators are used to remove the small bright (opening) or dark (closing) details. These two operations are the combinations of erosion and dilation. Structuring Elements have a variety of shapes and sizes. Thickening is controlled by a SE shape. In this paper the disk shaped structuring element is used. Structuring elements are typically represented by a matrix of 0's and 1's. Sometimes it is conveniently shows only 1's.

The following figure illustrates the opening and closing operations of the Morphological Profiles. Using these operations the bright and dark pixels are easily identified.



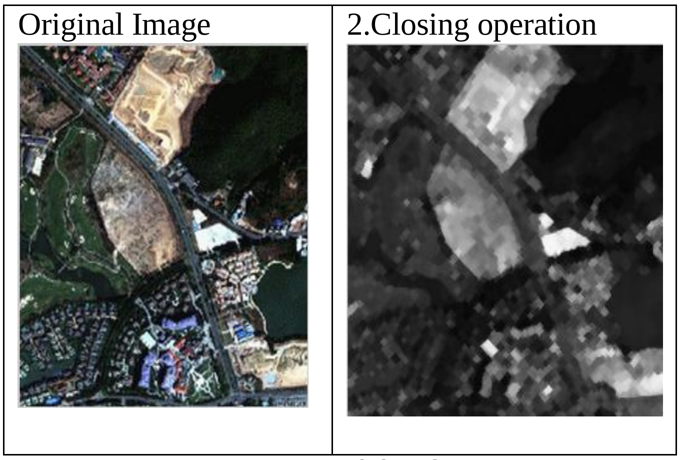


Fig 1: Morphological Operations

3) Urban Complexity Index(UCI): Most of the existing textural and structural features focus on the spatial domain alone, but few algorithms refer to feature extraction from joint spectral-spatial domains. Some of the natural features are water, forest, grass and soil. The basic idea of UCI is that natural features have more variability in the spatial domain than the spectral domain. UCI is based on 3-D wavelet transform. It processes the multi/hyperspectral image as a cube. It describes the variation information in the joint spectral-spatial feature space.

IV. CLASSIFICATION

The pixels of an image are sorted into classes and each class given a unique color defined by the spectral "signatures". There are two types of classification like supervised and unsupervised. Classification of remotely sensed data is used to assign corresponding levels with respect to groups with homogeneous characteristics. It is used to discriminate multiple objects from each other within the image. The level is called class. Classification will be executed on the base of spectral or spectrally defined features, such as density, texture. Classification divides the feature space into several classes based on a decision rule.

A. Supervised Classification

A supervised classification requires knowledge of the data as the analyst selects pixels that correspond to known features. In order to determine a decision rule for classification, it is necessary to know the spectral characteristic or features with respect to the population of each class The spectral features can be measures using ground based spectrometers. However due to atmospheric effects, direct use of spectral features measured on the ground is not always available. For this reason, sampling of training data from clearly identified training areas and corresponding to defined classes is usually made for estimating the population statistics.

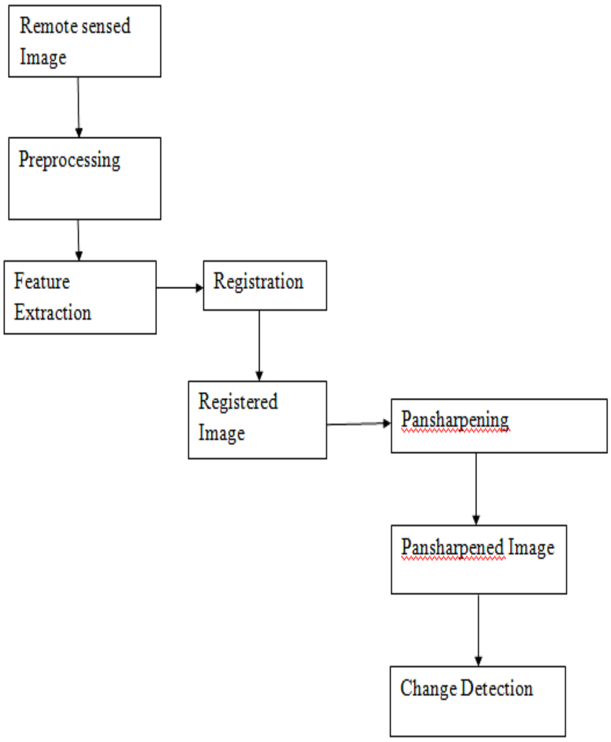


Fig 2: Remote sensed Image classification

B. *Unsupervised Classification*

Unsupervised classifications are more computers automated and cluster pixels which have similar spectral characteristics. The classification is based on spectral and spatial features.

V. SUPPORT VECTOR MACHINE (SVM)

SVM classifies binary data by determining the separating hyper plane which maximizes the margin between the two classes in the training data. Support vector machines (SVMs) [4], which are a classification paradigm developed over the last decade in machine learning theory, have been successfully applied within the remote sensing community to hyperspectral image analysis. Recent studies comparing SVMs with other classification schemes have concluded that they provide significant advantages in accuracy, simplicity, and robustness.

VI. PANSHARPENING

Pan-sharpening combines a low-resolution color multispectral with a high-resolution grayscale panchromatic image to create a high-resolution fused color image. In this sense, to “sharpen” means to increase the spatial resolution of a multispectral image. A multispectral image contains a higher degree of spectral resolution than a panchromatic image, while often a panchromatic image will have a higher spatial resolution than a multispectral image. A pan sharpened image represents a sensor fusion between the multispectral and panchromatic images which gives the best of both image types, high spectral resolution and high spatial resolution.

VII. CHANGE DETECTION

Change Detection is a process of identifying change between two dates that is uncharacterized of normal variation. Change detection is the process that helps in determining the changes associated with land use and land cover properties with reference to geo-registered multitemporal remote sensing data.

Change detection is useful in many applications such as land use changes, habitat fragmentation, and rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques.

This method searches a neighborhood of a given center pixel in the before and after scenes to determine the resulting per-feature differences for that pixel. The size of the search radius around the center pixel is determined by the estimated co registration error.

VIII. RESULTS

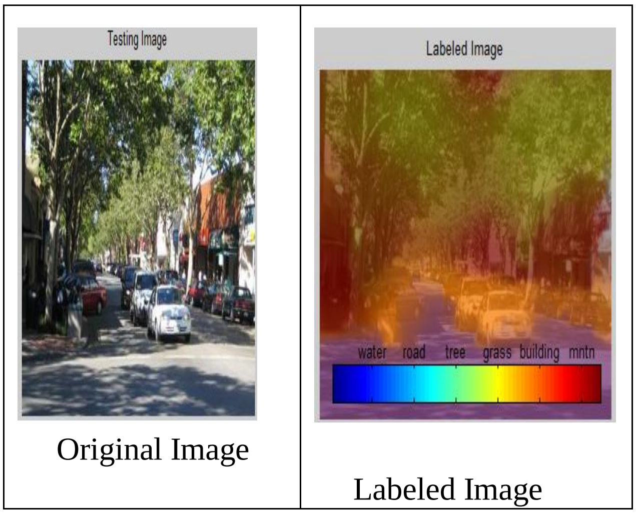


Fig 3: Classified image

The above figure gave the result of the classified image. The classification is purely based on supervised approach. The original image is mapped with the trained image and classifies the remote sensed image based on training. If the images are well trained then it provides accurate classification.

Fig 4: Original Image

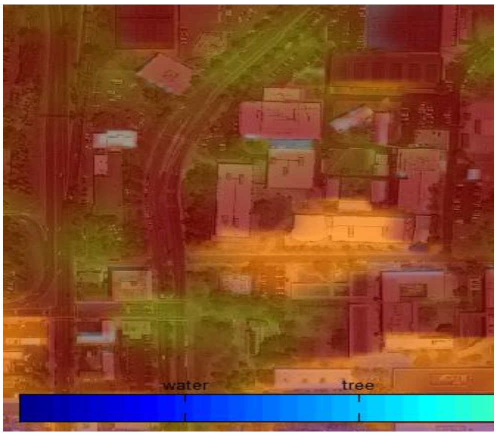


Fig 5: Classified Image

Fig 6: Before Tsunami

Fig 7: After Tsunami

IX. PERFORMANCE ANALYSIS

The performance analysis is used to prove the efficiency and accuracy of the proposed system. In the existing system they have used either spectral features or spatial features. But both the spectral and spatial features are used in the proposed system. It improves the efficiency of the existing system. Change can be detected with the help of correlation.

A graph has to be labeled with the degree of correlation between two curves. Small amount of change exhibit less correlation.

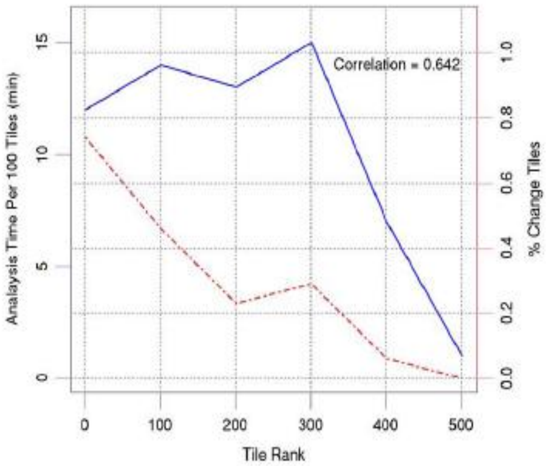


Fig 8: Performance of Change detection between two images

X CONCLUSION

The proposed algorithms are effective for change detection. The proposed methods improve the overall performance. It has the potential to enhance the discrimination between spectrally similar classes by forming a hyper dimensional feature space. It provides the most accurate results for both quantitative evaluation and visual inspection. It provides good accuracy.

XI FUTURE ENHANCEMENTS

This paper is applicable to detect changes for different natural disasters.

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