Object based Information Extraction from High Resolution Satellite Imagery using eCognition

Neha Gupta[1], H.S Bhadauria[2]

[1] **M. Tech (CSE) Scholar, G.B. Pant Engineering College**
Pauri Gharwal, Uttarakhand-246194, India

[2] **Assistant Professor (CSE), G.B. Pant Engineering College**
Pauri Garhwal, Uttarakhand-246194, India

Abstract

High resolution images offer rich contextual information, including spatial, spectral and contextual information. In order to extract the information from these high resolution images, we need to utilize the spatial and contextual information of an object and its surroundings. If pixel based approaches are applied to extract information from such remotely sensed data, only spectral information is used. Thereby, in Pixel based approaches, information extraction is based exclusively on the gray level thresholding methods. To extract the certain features only from high resolution satellite imagery, this situation becomes worse. To overcome this situation an object-oriented approach is implemented. This paper demonstrated the concept of object-oriented information extraction from high resolution satellite imagery using eCognition software, allows the classification of remotely-sensed data based on different object features, such as spatial, spectral, and contextual information. Thus with the object based approach, information is extracted on the basis of meaningful image objects rather than individual gray values of pixels. The test area has different discrimination, assigned to different classes by this approach: Agriculture, built-ups, forest and water. The Multiresolution segmentation and the nearest neighbour (NN) classification approaches are used and overall accuracy is assessed. The overall accuracy reaches to 97.30% thus making it an efficient and practical approach for information extraction.

Keywords: *information; extraction; classification; high resolution, satellite image; eCognition*

1. Introduction

High resolution satellite images have many applications in various commercial and civil areas in recent years like meteorology, forestry, agriculture geology and landscape. The automated or semi-automated analysis of these images has been obstructed by the high complexity of such images. High resolution satellite images have rich contextual information. The information includes shape, texture and spatial characteristics. In order to deal such rich information content for information extraction, pixel-based approaches have faced substantial difficulties.

In order to estimate more accurate results object based feature extraction is a newly and widely used method recently used in many study areas. In the traditional pixel-based approaches for information extraction only the pixels spectral information is used to extract surface features [1]. Object based image analysis is implemented in order to extract relevant surface information, combining spectral and spatial information. Thereby, with the object based approach not only the spectral information in the image will be used as classification information, the texture and context information in the image will be combined into classification as well (Flanders et. al, 2003). The concept of object based information extraction is that to interpret an image, the relevant semantic information is represented by meaningful image objects and their mutual relationship rather than individual pixels.

To extract the certain features only from high resolution images, we need to utilize the spatial and contextual information of an object and its surroundings. In this situation the use of only spectral information, as in pixel based approaches for classification purpose becomes worse. To overcome this situation object-oriented approach is implemented. Object-oriented approach takes into account the form, textures and spectral information. The object oriented classification phase starts with the crucial initial step of grouping neighboring pixels into meaningful areas to extract homogeneous image objects, which can be handled in the later step of classification. According to the resolution and the scale parameter of the expected objects segmentation and topology generation must be set [1, 2].

Thus we can differentiate various levels of object categories as it allows multi resolution segmentation [2]. With the help of object based feature extraction, automatic recognition and segmentation of the common objects like buildings, roads, houses and vegetation from high resolution images have been carried out with a certain degree of success.

In this paper, object based information extraction is realized by classifying the image into four major classes: agriculture, built ups, forest and water. The classification procedure is carried out by the various tools provided by eCognition software. The classification procedure has been implemented using panchromatic image of the interested area. The object oriented information extraction consists of two main steps: Segmentation and the Classification. Segmentation is carried out by several tests to match with the successful segmentation step, after that classification is carried out by setting different parameters to the used software.

2. Methodology

With respect to the image analysis procedure this section introduces the test site and the data set as well as the methodological approach in order to extract abundant information of the earth surface from high resolution satellite imagery.

2.1 Test Site and Data Set

Data to be used are high resolution orthophotos of 1995, 2000, 2003, and 2004 of the San Antonio area. The data used for analysis is the Land sat ETM+ image of San Antonio, ETMp27r40y01m7d21 (a subset of ETM + image with path27 row 40) from lab 3 of ES 5053 Remote sensing class.

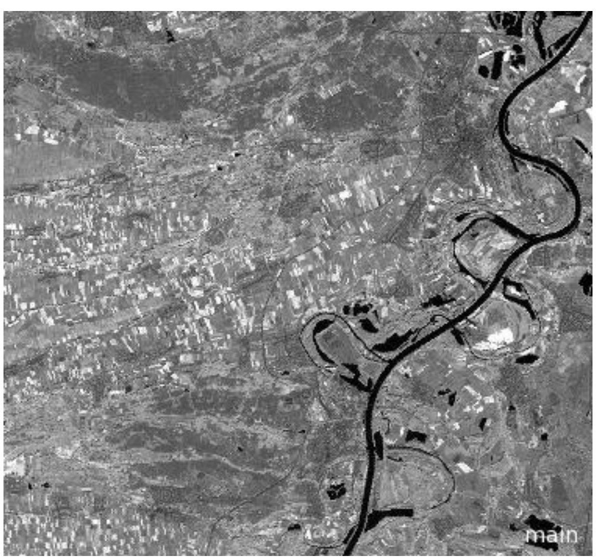

Fig.1.The Land sat ETM image to classify

2.2 Basic Concept

This paper focuses on the concept of the object oriented information extraction for the accurate classification of cultures for high resolution Satellite imagery.
Beginning with the initial preprocessing, object-oriented image analysis is performed using the software eCognition. This process has been carried out into three steps: Multiresolution Segmentation, Creation of General Classes, and Classification Rules (Rule Base).Thereby an initial image segmentation step groups the pixels that are similar in spectral context to get meaningful image objects on an arbitrary number of scale levels. Parameters are set for different object features such as shape, scale and spectral features. These image segments have to be calculated on different scale on arbitrary hierarchical levels on the basis of trial and error process for achieving proper segmentations of objects of interest.
The generated objects are classified by means of rule bases (classification rules) in the subsequent segmentation steps. This classification scheme defines two things: the classes to be identified and the features of the objects for their description and classification. Therefore, we have set up a classification repository which represents spectral, textual, geometrical, and hierarchical characteristics of the image objects. The defined classes and the organization of the work flow are shown in Fig. 3.

3. Object based Information Extraction by eCognition

3.1 Multiresolution Segmentation

Accurate segmentation is an important issue in the context of object-oriented classification. During the segmentation process meaningful image objects are created on the basis of several adjustable factors of homogeneity and heterogeneity in color and shape. Thereby the classes are organized within a class hierarchy. Multiresolution segmentation is a bottom up region-merging approach [2], starts with one pixel object and smaller image objects are merged into larger ones in the subsequent segmentation steps thus constructing a semantic hierarchy, in order to finding desired single objects of interest.
It is crucial to assign following parameters as accurate as possible because they have several different influences on classification accuracy:

Scale parameter: The value of the scale parameter influences the average object size. This parameter influences the maximal allowed heterogeneity of the objects. The larger the scale parameter the larger the objects become.

Color/Shape: The influence of color vs. shape homogeneity on the object generation can be adjusted with the help of these parameters. The higher the shape criterion the less spectral homogeneity influences the object generation.
Smoothness/Compactness: when the shape criterion is larger than 0 the user can determine whether the objects shall become more compact (fringed) or more smooth.
Spectral or color heterogeneity is the sum of the standard deviations of spectral values in each layer weighted with the weights for each layer is used:

$$h_s = \sum_{c=1}^{q} w_c \sigma_c \qquad (1)$$

Where *hs* is spectral heterogeneity;
q = bands number;
σc = standard deviation of *digital number* in *c spectral band*
wc = weight assigned to c spectral band.

For reducing the deviation from a compact or smooth shape, it is useful in most cases to mix the criterion for spectral heterogeneity with a criterion for spatial heterogeneity.

$$h_{g\_s} = \frac{1}{\sqrt{n}} \qquad (2)$$

Where *hg_s* = fractal factor of spatial heterogeneity;
l = border length;
n = number of pixels of the image

The second is a compactness f*actor* (*hg_c*) that depends from dimensional ratio of polygon axis:

$$h_{g\_c} = \frac{1}{b} \qquad (3)$$

Where *hg_c* = compactness factor;
l = border length;
b = the shortest possible border length given by the bounding box of an image object parallel to the raster.

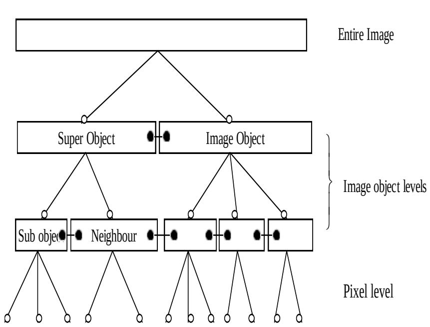

Fig.2. Image segmentation optimization

Thus we developed a classification based optimization procedure in order to obtain a more accurate and consistent segmentation. The basic idea behind this approach is to iteratively optimize the shape of image objects in accordance with the rule base for the identification of significant individual structures. Therefore all objects are linked to neighboring objects on the same level, super objects on higher levels, and to sub objects on lower (finer scale) levels.

3.2 Image Classification using Proposed Method

Segmentation phase is followed by the accurate classification of images by setting up of classification rules called rule bases. eCognition software offers two different classifiers: a nearest neighbour (NN) classifier and fuzzy membership functions. Both classifiers act as class descriptors [12].

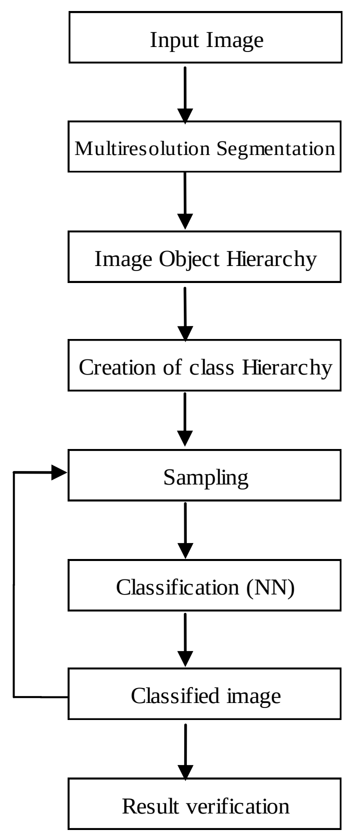

Fig. 3 Flow Chart for the Proposed Method

In the proposed method nearest neighbour (NN) classifier is used for classification which assigns classes to image objects based on minimum distance measurements. NN classifier is appropriate for describing variation in fine resolution images. Thereby each feature offered by eCognition can be used to determine the feature space for the nearest neighbour classifier. Multiresolution segmentation is the base of object oriented classification. The image is segmented to produce meaningful polygonal image objects by setting certain parameters of homogeneity and heterogeneity in color and shape.

4. Classification Accuracy Assessment and Results

Parameters are set on the basis of rule bases. In the proposed method all image layer weights are equal to 1. The composition of homogeneity criterion for shape and compactness are set to 0.1 and 0.5 respectively. The scale parameter is 40. The result of segmentation achieves good effects [Fig. 4]. After image segmentation the polygonal image objects of interest are generated [Fig. 5]. The layer object hierarchy is based on 4 classes: Agriculture, built-ups, forest and water. Assign each class a different color and samples to determine which class an object belongs to.
The scale parameter is an abstract value to determine the maximum possible change of heterogeneity caused by fusing several objects. There are two geometric features: compactness and smoothness that can be used as evidence. Smoothness describes the similarity between the image object borders and a perfect square. Compactness describes the closeness of pixels clustered in an object by comparing it to the circle. After defining the parameters, eCognition produces a new image with new grouping of pixels. After defining the four classes the standard nearest neighbour (NN) classifier is used for object based classification.

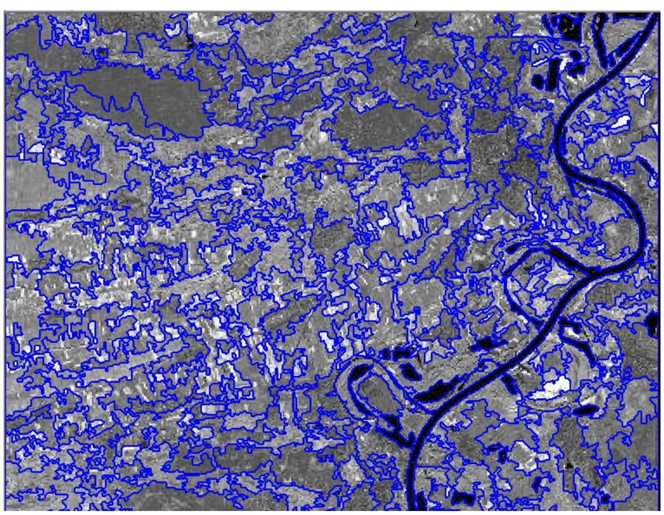

Fig.4. Segmented image (Scale parameter is set to 40)

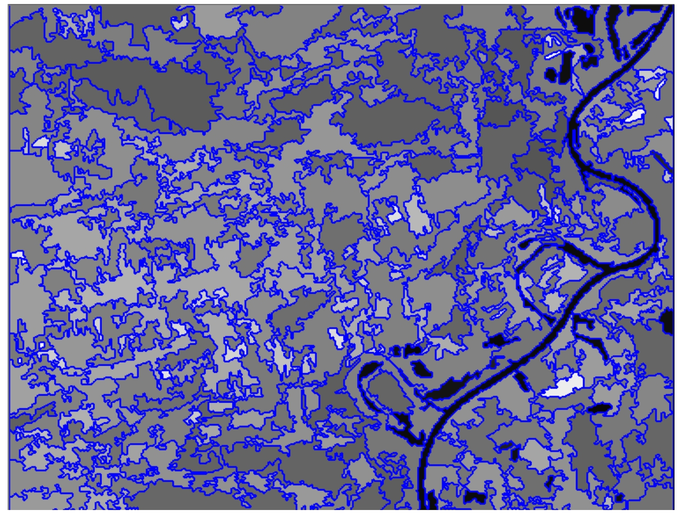

Fig.5. Polygonal Image Objects

Finally classify the image object based on the principle of nearest neighbour. After sample objects have been selected for each class, for each image object, classifier finds the closest sample object in the feature space. After finding the closest sample object for a particular class the object is assigned to the class to which it belongs to on the basis of the formula[12] given below. Results of the classification procedure are shown in Fig. 7.

$$d = \sqrt{\sum_f \left[\frac{v_f^{(s)} - v_f^{(o)}}{\sigma_f} \right]^2} \quad (4)$$

d: distance between sample object *s* and image object *o*;
$v_f^{(s)}$: feature value of sample object for feature *f*;
$v_f^{(o)}$: feature value of image object for feature *f*;
σ_f : Standard deviation of the feature values for feature f.

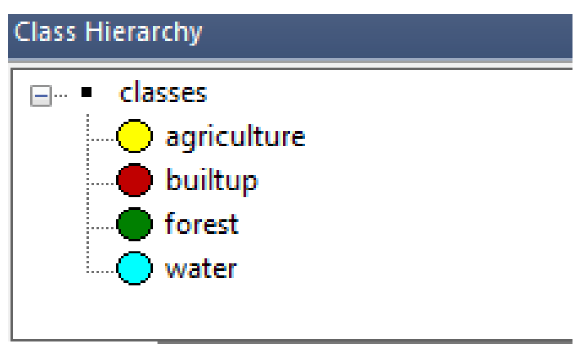

Fig. 6 Created Class Hierarchy

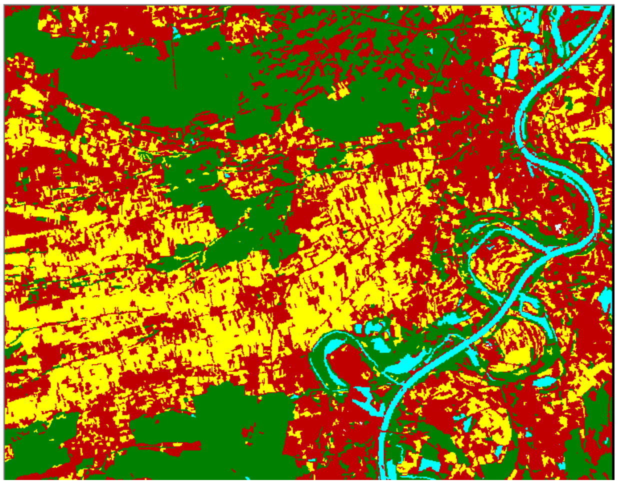

Fig.7. Final Results of object-oriented Information extraction by eCognition

Membership function of each class is provided by eCognition software. The overall accuracy reaches 97.30 % (Table 1)

TABLE 1 CLASSIFICATION RESULT ASSESSMENT

Class	Object	Mean	Stddev	Min	Max
Agriculture	259	0.9677	0.095997	0.3385	1
Built-ups	206	0.97	0.0631	0.4193	1
Forest	181	0.9587	0.044998	0.8121	1
Water	43	0.9956	0.00894	0.9726	1
Overall Accuracy : 0.973					

5. Conclusion and Outlook

From the experiment, it can be seen that the classification accuracy has been improved greatly by the newly arisen object-oriented approach. Besides, the whole procedure proves efficient and feasible because of the following reasons: Firstly, Use of object's multi-feature including spectrum, shape, texture, shadow, context, spatial location. Secondly, the object oriented approach of information extraction guarantee the classification accuracy by making full use of high resolution images information. Thirdly, with manually adjustment of different parameters, multi-scale makes image object resolution adaptive for specific requirements, data and tasks.

High resolution satellite images are widely used in various commercial and civil areas in recent years like meteorology, forestry, agriculture geology and landscape. In conclusion, it is proven that the object-oriented information extraction approach will be the trend for the high resolution remotely sensed data. The object based approach provided by eCognition software is a big step forward in interpretations of remote sensing images [12] and is an efficient and practical approach for information extraction.

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Neha Gupta pursuing M. Tech (CSE) from Govind Ballabh Pant Engineering College, Pauri Gharwal, Uttarakhand, India-246194. She received her B. Tech degree in Computer Science and Engineering from Uttarakhand Technical University, in 2012 with 82%. Qualified Gate with 94 percentile. Presently working in the field of Satellite Image Processing.

H.S Bhadauria received his B. Tech in Computer Science and Engineering, M. Tech in Electronics Engineering from Aligarh Muslim University, Aligarh and Ph. d from Indian Institute of Technology, Roorkee, India, in 1999, 2004 and 2013, respectively. He has published some 40 research papers in International and National Journals and Conferences. His areas of Interest are Digital Image processing, Digital Signal Processing and AdHoc Network. Presently working as Asst. Professor in Govind Ballabh Pant Engineering College, Pauri Gharwal, Uttarakhand, India-246194