

Review Article

Land Cover Classification Schemes Using Remote Sensing Images: A Recent Survey

ABSTRACT

Air Economic development and growth in population have prompted rapid changes to earth's land cover over the last few decades, and there is every indication that the pace of these changes will accelerate the future. Therefore, systematic evaluations of Earth's land cover must be repeated at a frequency that allows monitoring of both long term trends as well as inter-annual variability, and at a level of spatial detail to allow study of land use patterns. Land cover analysis can be done most effectively through remote sensing images of various spatial, spectral and temporal resolutions to improve the selection of areas designed for agricultural, urban and/or industrial areas of a region. Astute efforts have been made in developing advanced classification algorithms and techniques for improving the accuracy of land cover classification. This paper reviews a wide range of advanced image classification approaches and techniques and improvising classification accuracy for remotely sensed images.

Methodology and Results: Recent image classification approaches for land cover pattern analysis have been brought together with their pros and cones by reviewing literatures, books, manuals and other related documents. As a result, suitable classification algorithms may be chosen from the many available literature, based on the type of image and application area.

Conclusion: Through this survey in various issues regarding, preprocessing, classification and accuracy assessment, new and unique land cover products may be generated which could not be produced by earlier techniques.

Keywords: Land use planning, land cover classification, remote sensing, image classification, Geographical Information Systems.

1. INTRODUCTION

Land is one of the most important natural resources on which human life and developmental activities are centered. Land cover refers to the physical material at the surface of the earth it can be a region covered by snow, forests, wetlands, dry land, grass land, open water, impervious surfaces and agriculture land. Land use refers to how people use the landscape whether for development, conservation, or mixed use.

Knowledge about land use and land cover is important for many planning and management activities and is considered an essential element for modeling and understanding the earth as a system. Information on land use and land cover also helps to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, predict and assess impacts from floods and storm surges, loss of fish and wildlife habitat.

The technological innovation in the field of Remote Sensing (RS) and Geographic Information System (GIS) have opened a new dimension to address a wide range of scientific problems of land use land cover classification as they provide timely, precise, and quality information inputs to decision making, while making sustainable use of natural resources and improving conservation practices. A satellite image provides qualitative information of a large geographic area that reduces the intricacy of field work. A suitable remotely sensed data for image classification is chosen by analyzing the strength and limitation of different type of sensor data available.

Land Use/ Land cover classification can be determined by analyzing satellite image. Remote sensors measure differences and variations of objects. The five main resolution characteristics of a satellite's sensor system can be summarised into:

- Spectral coverage/resolution i.e., band locations/width
- Spectral dimensionality: number of bands
- Radiometric resolution: quantization
- Spatial resolution/instantaneous field of view
- Temporal resolution

Once the raw remote sensing digital data has been acquired, it is then processed into usable information. The changes made to remote sensing data involve two major operations which are preprocessing and post-processing.

- Preprocessing of image data include radiometric correction and geometric correction.
- Digital image post-processing include image enhancement, image classification, and change detection.

Figure1 shows analysing satellite image for land cover feature identification which includes finding a suitable classification system, selection of training samples, image pre-processing, feature selection/ extraction, selection of suitable classification approaches, post-classification processing and accuracy assessment.

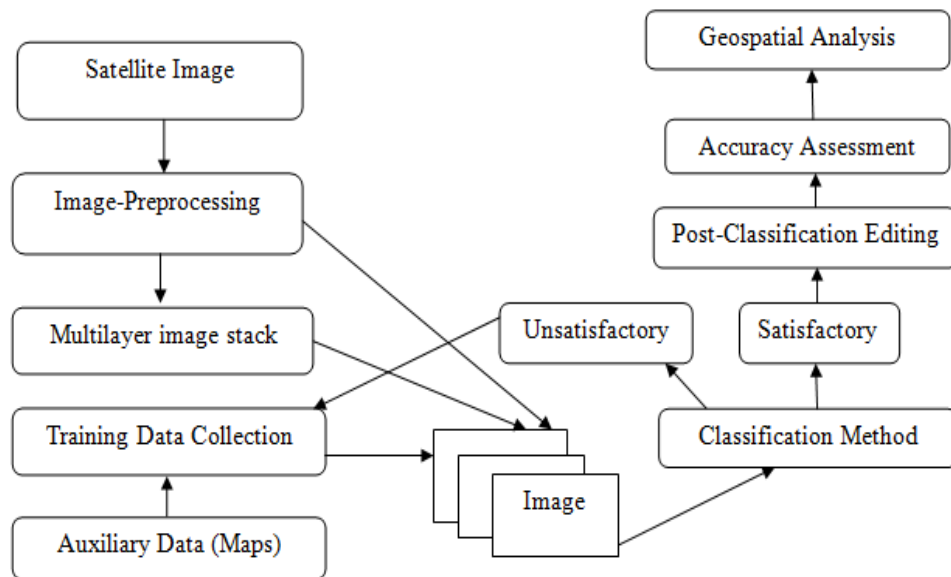


Figure 1: Satellite Image Analysis

These computerized process routines improve the image scene quality and aid in the data interpretation. Some of the major satellites which deliver images for precision agriculture are Indian Remote Sensing Satellite (IRS-1A, IRS-1C, IRS-1D), French SPOT, MODIS, ASTER, NOAA-AVHRR, LANDSAT TM/ETM, RADARSAT, ERS, RAPIDEYE, QUICKBIRD, IKONOS, ADEOS-II, CBERS-CCD and HJ-1 CCD etc.,

2. IMAGE CLASSIFICATION

Remote sensing image classification is a commonly adopted method to obtain land cover information from Satellite images and many classification algorithms have been widely applied. Digital image classification is the process of assigning pixels to meaningful classes. A pixel is assumed to be an individual unit which carries several spectral band values. The pixels of an image having comparable spectral values are assigned to one class. Classes are homogenous thus pixels of one class differ spectrally with the pixels of another class of the same image. These classes form regions on a map or an image, so that after classification digital image can be presented as a mosaic of consistent classes, each identified by a colour or symbol [1]. Image classification approaches can be done by either based on pixel information or based on use of training samples as shown in Figure2.

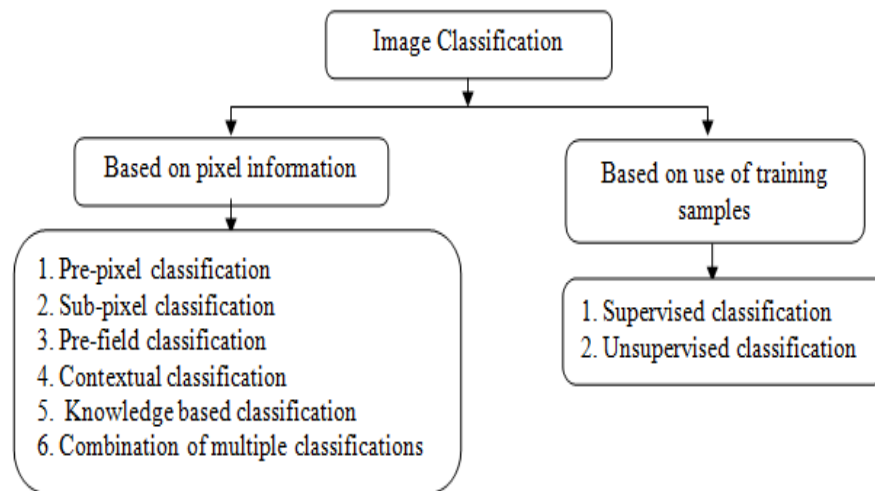


Figure 2: Image Classification Approaches

2.1 Supervised classification

Supervised classification methods require input from an analyst. The input from analyst is known as training set. Training sample is the most important factor in the supervised satellite image classification methods. Accuracy of the methods highly depends on the samples taken for training. Training samples are two types, one used for classification and another for supervising classification accuracy. Most commonly used supervised classification approaches are:

- Maximum likelihood
- Artificial neural network
- Decision tree
- Minimum Distance
- Parallel piped
- Mahalanobis distance
- K-nearest Neighbor
- Object base analysis

2.2 Unsupervised classification

Unsupervised Classification technique uses clustering mechanisms to group satellite image pixels into unlabelled classes/clusters. Later analyst assigns meaningful labels to the clusters and produces well classified satellite image. Unsupervised methods are usually very fast and computationally efficient. Most common unsupervised satellite image classifications are:

- ISODATA
- Support Vector Machine (SVM)
- K-Means

2.3 Per-pixel classification approach

Traditional Per-pixel classifiers typically develop a signature by combining the spectra of all training set pixels for a given feature. The resulting signature contains the contributions of all materials present in the training pixels, but ignores the impact of the mixed pixels. Per-pixel classification algorithms can be parametric or non-parametric [2]. Commonly used Parametric Classifiers are Maximum likelihood classifier. Commonly used non-parametric classifiers are neural networks, Decision tree and Support Vector Machine. To improve performance in a non-

parametric classification procedure, boosting, bagging or a hybrid of both techniques can be used [3]. Some of the per-pixel classifiers methods are described in Table 1.

Table 1: Per-pixel classifiers methods

Category	Advanced Classifiers	Authors
Per-pixel classifiers	Two unsupervised classifications, algorithms based on RBF Neural Network and K-means	Rollet.R, Benie.G.B, Li.W, Wang.S, and Boucher.J.M, 1998 [4]
	Minimum Distance-to-Means Classifier	Atkinson.P.M, and Lewis.P., 2000 [5]
	Spectral angle Classifier	Sohn. Y and Rebello.N.S, 2002 [6]
	Decision tree classifier	Lawrence.R, Bunn.A, Powell.S, and Zmabon.M, 2004 [7]
	Supervised classification was performed using the maximum likelihood algorithm and 25 classes.	David Barry Hester, Halil I. Cakir, Stacy A.C. Nelson and Siamak Khorram , 2008 [8]
	support vector machine	Marconcini.M, Camps Valls.G, and Bruzzone.L, 2009 [9]

2.4 Sub-pixel classification approach

Sub-pixel classification approaches have been developed to provide a more appropriate representation and accurate area estimation of land covers than per-pixel approaches, especially when coarse spatial resolution data are used. In sub-pixel classification each pixel is considered mixed, and the areal proportion of each class is estimated. Some of the Sub-pixel classifiers are described in Table 2 below.

Table 2: Sub-pixel classifiers methods

Category	Advanced Classifiers	Authors
Sub-pixel classifiers	Rule-based machine-version approach	Foschi and Smith, 1997 [10]
	Image Sub-pixel classifier	Huguenin. R.L, Karaska. M.A, Blaricom,.D.V and Jensen. J.R, 1997 [11]
	Neural Networks	Mannan.B and Ray A.K , 2003 [12]
	Regression modeling	Yang.X and Liu.Z , 2005 [13]
	Fuzzy-spectral mixture analysis	Tang.J, Wang.L and Myint S.W, 2007 [14]

2.5 Per-field classification approach

The Per-field classifier is designed to deal with the problem of environmental heterogeneity. The Per-field classifier averages out the noise by using land parcels (called 'fields') as individual units. The per-field classifications are often affected by such factors as the spectral and spatial properties of remotely sensed data, the size and shape of the fields, the definition of field boundaries and the land cover classes chosen [15]. Some of the pre-field classifiers are described in Table 3.

Table 3: Per-field classifiers methods

Category	Advanced Classifiers	Authors
Per-field classifiers	Per-field classification based on per-pixel or sub-pixel classified image	Aplin and Atkinson,2001 [16]
	Per-field or per-parcel classification	S. Wu, J. Silvan-Cardenas and L.Wang, 2007 [17]
	Object-based classification	Volker Walter, 2003 [18]
		Mengistie Kindu , Thomas Schneider, Demel Teketay and Thomas Knoke [19]
		Thunig. H, Wolf,.N , Naumann.S, Siegmund.A,Jurgens.C, Uysal.C and Maktav.D [20]

2.6 Contextual classifier approach

Contextual classifier is an approach of classification based on contextual information in images. "Contextual" means this approach is focusing on the relationship of the nearby pixels, which is also called neighborhood. The goal of this approach is to classify the images by using the contextual information. Contextual classifiers were developed to overcome with the problem of intra-class spectral variations. Some of the contextual classifiers are described in Table 4.

Table 4: Contextual classifiers methods

Category	Advanced Classifiers	Authors
Contextual classifiers	Fuzzy contextual classifier	Binaghi.E, Madella.P, Montesano. M.G and Rampini. A, 1997 [21]
	Point-to-point contextual correction	Cortijo and De La Blanca 1998 [22]
	Contextual classifier based on region-growth algorithm	Lira and Maletti 2002 [23]
	Frequency-based contextual classifier	Xu.B, Gong.P, Seto.E and Spear.R, 2003 [24]
	Extraction and Classification of Homogeneous Objects	Lu.D and Weng.Q, 2004 [25]

2.7 Knowledge-based classification approach

Knowledge based classifier is more suited to handle complex data. Different kinds of ancillary data, such as digital elevation model, housing, soil map and temperature are easily available;

they may be integrated into a classification procedure in different ways [26]. Some of the Knowledge based classifier is described in Table 5.

Table 5: Knowledge based classifier methods

Category	Advanced Classifiers	Authors
Knowledge based classifier	Knowledge-based classification	Dobson.M.C, Pierce. L.E, Ulaby. F.T, 1996 [27]
		Schmidt.K.S, SkidmorE. A.K, Kloosterman.E.H, Van Oosten.H, Kumar.L and Janssen.J.A.M, 2004 [28]
		Hashimoto. S, Tadono.T, Onosato.M, Hori.M, 2012 [29]
	Rule-based syntactical approach	Onsi 2003 [30]

2.8 Combination of multiple classification approach

Research have explored different techniques such as a production rule, a sum rule, stacked regression methods majority voting and thresholds to combine multiple classification results to provides improved classification accuracy compared to the use of a single classifier. Some of the Combination of multiple classifiers is described in Table 6.

Table 6: Combination of multiple classifiers methods

Category	Advanced Classifiers	Authors
Combination of multiple classifiers	neural network, decision tree classifier, and evidential reasoning	Huang and Lees, 2004 [31]
	maximum likelihood classifier (ML), support vector machine (SVM), artificial neural networks (ANN), spectral angle mapper (SAM), minimum distance classifier (MD) and decision tree classifier (DTC)	Lijun Dai and Chuang Liu,2010 [32]
	multiple support vector machine (SVM) with the core of the radial based function (RBF), SVM with the core of linear function, Neural network (BP), decision tree of rough set, random forest, and K nearest neighbor	Jiahui Xu, Weimin Ju and Zhongwen Hu, 2012 [33]

3. SUMMARY



Selection of a suitable classifier requires consideration of many factors, such as classification accuracy, algorithm performance, and computational resources. Unsatisfactory results have been reached with spectral classifiers, with higher spatial resolutions images have higher within-class spectral variability. Hence Spatio-contextual classifiers have potential to information extracted

from the spatial domain. A number of studies have reported significantly higher classification accuracy with image segmentation and object-based image classification.

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