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Survey on Object Based Image Classification and Analysis for Remote Sensing

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Abstract: *Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance. In this paper, we have shown object-based image analysis on ARD data obtained from Landsat satellite and applying NDVI, zonal statistics, classification, segmentation, change detection.*

Keywords: Classification, Remote-sensing, change-detection

I. Introduction

Environmental monitoring requirements, conservation goals, spatial planning enforcement, or ecosystem-oriented natural resources management, to name just a few drivers, lend considerable urgency to the development of operational solutions that can extract tangible information from remote sensing data. The 'work horses' of satellite data generation, such as the Landsat and SPOT satellites or the ASTER and MODIS instruments, have become important in global and regional studies of biodiversity, nature conservation, food security, deforestation impact, desertification monitoring, and other application fields.[1]

U.S. Landsat Analysis Ready Data (ARD) are pre-packaged and pre-processed bundles of Landsat data products that make the Landsat archive more accessible and easier to analyze and reduce the amount of time users spend on data processing for time-series analysis.[2]

1. NDVI: The NDVI is a dimensionless index that describes the difference between visible and near-infrared reflectance of vegetation cover and can be used to estimate the density of green on an area of land. The NDVI is computed as the difference between near-infrared (NIR) and red (RED) reflectance divided by their sum.

$$NDVIi = ((NIR-RED))/(NIR+RED)$$

NDVIi represents smoothed NDVI (sNDVI) observed at time step i and their ratio yields a measure of photosynthetic activity within values between − 1 and 1. Low NDVI values indicate moisture-stressed vegetation and higher values indicate a higher density of green vegetation. It is also used for drought monitoring and famine early warning.[3]

2. Zonal Statistics: Populating various vector formats (points and polygons) from raster images for looking at fallow, growing and cropping cycles in agricultural/rice paddies in Vietnam, using radar imagery. Radar data is measured in backscatter where high values are associated with high structure (vegetation) and low values are associated with low structure (non_vegetated/water/bare).

3. Classification: Based on the idea that different feature types on the earth's surface have a different spectral reflectance and remittance properties, their recognition is carried out through the classification process. In a broad sense, image classification is defined as the process of categorizing all pixels in an image or raw remotely sensed satellite data to obtain a given set of labels or land cover themes.[4]

4. Segmentation: Segmentation means the grouping of neighbouring pixels into regions (or segments) based on similarity criteria (digital number, texture). Image objects in remotely sensed imagery are often homogenous and can be delineated by segmentation. Thus, the number of elements as a basis for a following image classification is enormously reduced. The quality of classification is directly affected by segmentation quality. Hence quality assessment of segmentation is in the focus of this evaluation of different presently available segmentation Software [5]

5. Change Detection: Remote sensing change detection is a process for determining and evaluating differences in a variety of surface phenomena over time. Detecting, describing, and understanding changes in the physical and biological processes that regulate the earth system is of considerable interest for ecologists and resource managers today. Detecting land use change, range condition, desertification, changes in forest cover, regional evapotranspiration differences, soil moisture condition, and other physical and biological processes allows for the documentation of the spectral and temporal changes that are occurring within ecosystems. Change detection studies recognize that the biotic and abiotic components of the biosphere are linked and that human impacts on the earth now approach the global scale of biosphere processes (Hobbs, ed. 1990). Thus, change in any one of several components in the biosphere may potentially influence the other components.[6]

II. Related Work

In this section we will focus on the related work that has been done previously by several researchers who have developed various applications based on OBIA in remote sensing. In an article by M.V.K Sivkumar and Donald e Hinsman, Agricultural planning and use of agricultural technologies need applications of agricultural meteorology. Satellite remote sensing technology is increasingly gaining recognition as an important source of agrometeorological data as it can complement well the traditional methods agrometeorological data collection. Agrometeorologists all over the world are now able to take advantage of a wealth of observational data, product and services flowing from specially equipped and highly sophisticated environmental observation satellites. In addition, Geographic Information Systems (GIS) technology is becoming an essential tool for combining various map and satellite information sources in models that simulate the interactions of complex natural systems. The Commission for Agricultural Meteorology of WMO has been active in remote sensing and GIS applications in agrometeorology. The paper provides a brief overview of the satellite remote sensing and GIS Applications in agricultural meteorology along with a description of the WMO Satellite Activities Programme. The promotion of new specialised software should make the applications of the various devices easier, bearing in mind the possible combination of several types of inputs such as data coming from standard networks, radar and satellites, meteorological and climatological models, digital cartography, and crop models based on the scientific acquisition of the last twenty years [7].

Another paper by Aishwarya Gupta*, Ayush Shroff*, Aman Saxena* on Monitoring Mangrove Forest Cover Changes Using Remote Sensing and GIS Data with Machine Learning Techniques studied that change in green cover of mangrove in parts of Sundarbans region using machine learning techniques with the help of remote sensing and GIS. It compares the result of various algorithms to detect change in forest cover such as rule-based techniques and learning based techniques. Monitoring of mangrove forest decline has become an urgent need for our country. As lack of mangroves will result into depletion of the plant population which will result into increasing the carbon dioxide level in the environment which will lead to ozone depletion, pollution etc. and the ecosystem will collapse. In this paper image classification technique has shown drastic changes than earlier used decision learning and support vector machine algorithms. [8]

Major study by Andreas Bernhard Brink*, Hugh Douglas Eva monitored 25 years of land cover change dynamics in Africa their study examines the changes in sub-Saharan's natural land cover resources for a 25-year period. We assess these changes in four broad land cover classes – forests, natural non-forest vegetation, agriculture, and barren – by using high spatial resolution Earth observing satellites. Two sets of sample images, one 'historical' targeted in 1975 and a second 'recent' targeted at the year 2000, have been selected through a stratified random sampling technique over the study area, targeting a sampling rate of 1% in each of the strata. The results, presented at eco-region level and aggregated at sub-Saharan level, show a 57% increase in agriculture area at the expense of natural vegetation which has itself decreased by 21% over the period, with nearly 5 million hectares forest and non-forest natural vegetation lost per year. The impacts of these changes on the environment on one site and on the socio-economy on the other site are discussed and possible pressures on human wellbeing are highlighted. [9]

III. Literature Review

Sr. No	Title	Author	Methodology Advantages	Result/Conclusion Limitations	Year of publication
1	"An Introduction to Remote Sensing"	Dr. Robert Sanders on	This paper deals with the introduction of remote sensing, digitizing of images, image classification,	Remote sensing technology has developed from balloon photography to aerial photography to multi-spectral satellite imaging.	2017

			Current application of remote sensing.		
2	"Principles of Remote sensing"	Shefali Aggarwal	This paper deals with the topics like what is remote sensing, what are its principles, Stages in remote sensing, Historic overview and how remote sensing works.	Radiation interaction characteristics of earth and atmosphere in different regions of electromagnetic spectrum are very useful for identifying and characterizing earth and atmospheric features.	2018
3	Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey	Selçuk Reis	This paper aims investigating land use/land cover changes occurred in Rize between 1976 and 2000 using remote sensing and GIS. The LULC changes were analyzed according to both slope and altitude.	There were also some problems that had stemmed from using different sensor technologies (spatial resolution and spectral resolution) in comparing Landsat MSS and ETM data, and in determination of land cover. These problems were tried to be eliminated by independently applying supervised classification change detection technique to both images.	2008
4	Monitoring Mangrove Forest Cover Changes Using Remote Sensing and GIS Data with Machine Learning Techniques	Aishwarya Gupta Ayush Shroff Aman Saxena	This paper uses following methodologies Data Acquisition Data Pre-Processing Image Mosaicking Image Stacking Image Classification	As soon as the techniques have been applied the changes shown in both rule based and random forest were far better than the earlier used algorithm and techniques.	2020
5	Mapping Land Cover Using Remote Sensing Data and GIS Techniques: A Case Study of Prahova Subcarpathians	Marina-Ramona Rujoiu-Mare Bogdan-Andrei Mihai	The paper proposes an alternative methodology for obtaining a highly accurate land cover model for a complex landscape, by integrating satellite images with ancillary data derived from currently available land cover models.	This method provide an example of semi-automatic generation of land cover data for an area where land cover classes have, in the same time, high variances and spectral similarities. The land cover dataset resulted could be used in other GIS analysis for the entire region or for some local scale approaches.	2016
6	Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach	Andreas Bernhard Brink Hugh Douglas Eva	The study examines the changes in sub-Saharan's natural land cover resources for a 25 year period. We assess these changes in four broad land cover classes – forests, natural non-forest vegetation, agriculture and	Over the last 25 years unprecedented land cover and land use changes have occurred in sub-Saharan Africa. The main drivers of these changes were both human and natural. A high rate of population increase, economic development and globalization on one side and of	2009

			barren – by using high spatial resolution Earth observing satellites. Two sets of sample images, one 'historical' targeted at 1975.	natural hazards such as floods, landslides, drought and climate change on the other side have continuously and are still eroding Africa's natural ecosystems and resources	
7	Using Remote Sensing to Detect and Monitor Land-Cover and Land-Use change	Kass Green, Dick Kempka, Lisa Lacke.	This paper reviews the EOCAP project to date by presenting the findings and methods of several completed pilot projects	The following preliminary technical conclusions have been developed: Assessing land-cover change in forested areas is fairly straightforward and easily implementable with image subtraction. The immediate adoption of these techniques by several Pacific Meridian clients supports its commercial value. Assessment of land-cover change in non-forested areas is more difficult because of both the rapid occurrence of change and the less definable relationships between spectral change and land-cover change	2019
8	An investigation of pixel based and object based image classification in remote sensing	Mohammed Chachan Younis Edward Keedwell Dragan Savic	This research evaluates pixel-based and object based image classification techniques for extracting three land use categories (buildings, roads, and vegetation areas) from six satellite images. The performance of eight supervised machine learning classifiers with 5-fold cross validation are also compared	The comparison of the pixel and object-based approaches has shown that the object-based approach, when combined with 10,000 objects using SLIC segmentation, was superior to the pixel-based approach, has a much higher degree of accuracy.	2018
9	Rule-based classification framework for remote sensing data	Hela Elmannai Amina Salhi Monia Hamdi	The presented work aims to benefit from the nonlinear source separation process to enhance land cover identification. The source separation technique aims to provide underlying images and to compensate the mixing process	. The proposed approach provides reliable results compared to the SVM and enhances classes' separation. The proposed approach could be enhanced by including contextual information. Nevertheless, the major weakness of our method is the formal concept of the source space.	2019
10	The Remote Sensing and GIS Software Library (RSGISLib)	Peter Bunting Daniel Clewley	The goal of study of this paper is to know about the remote sensing land GIS software kibrary.	The library has been used in a number of publications and continues to be actively developed supporting ongoing research across	2013

		Richard M. Lucas Sam Gillingham		a wide range of topics including vegetation science	
11	Random forest classifier for remote sensing classification	M. PAL	.The objective of this study is to present results obtained with the random forest classifier and to compare its performance with the support vector machines (SVMs) in terms of classification accuracy, training time and user defined parameters	The results reported in this study suggest that the random forest classifier can achieve a classification accuracy which is comparable to that achieved by SVMs.	2013
12	Very High Resolution Object-Based Land Use–Land Cover Urban Classification Using Extreme Gradient Boosting”	Stefanos Georganos Tais Grippa Sabine Vanhuysse Moritz Lennert Michal Shimoni	— In this paper, the recently developed extreme gradient boosting (Xgboost) classifier is implemented in a very high resolution (VHR) object-based urban land use–land cover application. In detail, researcher investigated the sensitivity of Xgboost to various sample sizes, as well as to feature selection (FS) by applying a standard technique, correlation-based FS.	The results demonstrate that optimized Xgboost with a Bayesian model consistently outperforms RF and SVM in different VHR data sets and classification schemes but at the cost of increased computational time. The improvement of Xgboost offers expands as the amount of training data increase	2017

IV. Conclusion

Geo-spatial data and machine learning together create vast suite of opportunities for analysis of different kinds of terrains without physically collecting data. Assessing land-cover change in forested areas is straightforward and easily implementable with image subtraction. Among (Gaussian Maximum Likelihood, Support Vector Machines, Random Forests, Extra Tress, Gradient Boosted Trees, Neural Network, K Nearest Neighbour) K Nearest Neighbour provided results with the highest accuracy.

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