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Land Cover Classification and Change-Detection Analysis Using Remote Sensing

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ABSTRACT

Remote Sensing is a concept to analyze objects on the basis of their radiation i.e. their response to the sun radiation (or any other radiation used by the active remote sensing). As the population is almost going to double every 50 years, it is very important that the administration have special plans to make the availability of basic resources to the masses. So, remote sensing is very helpful for urban planners in that case to study an area and come across different solutions. Here we have selected a specific region and discussed its land cover change detection on the basis of Landsat satellite imagery acquired from United States Geological Survey (USGS) earth explorer. This will also give some of the basic concepts of classification methods. Classified images give us the results, generated through comparison of satellite data acquired in 2002 and 2018. The results show devastating change in urban infrastructures, vegetation and water bodies. There has been a substantial increase in urbanization since 2002, following major events in the area e.g. the inflow of Afghan refugees during and post war. Due to 12.46km^2 increase in urban area of Peshawar and a decrease of vegetation of about 143.8km^2 we are facing major issues in urban sprawl in Peshawar. Moreover, the depletion of water bodies is recorded to be 11.85km^2 since 2002. The work also briefly describes two classifiers, maximum likelihood and minimum distance, which we used for our study.

Keywords: Remote Sensing, Classification, Comparison, Radiations, Maximum Likelihood, Minimum Distance, Machine Learning

Author`s Contribution	Address of Correspondence	Article info.
[1,2,4]*Manuscript writing, Data Collection Data analysis, interpretation, Conception, synthesis,* [3,5]*planning of research, and discussion*	*Nasru Minallah* *n.minallah@uetpeshwar.edu.pk*	*Received: April 16, 2018* *Accepted: Feb 26, 2019* *Published: June 30,2019*

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INTRODUCTION

Due to the expensive and out of reach solutions of Urban Planning and Management in developing countries, researchers and engineers are striving for different solutions. These types of problems can be solved with different approaches. Remote Sensing is one of the approaches. Remote Sensing has proven to be a substantial technology to monitor earth resources. It is used for providing assistance in the Urban Planning, detection of vegetation health, disaster detection and management and many other areas.

We perceive the surrounding world through our five senses. Some senses (touch and taste) require contact with the object. However, we obtain much information about our surrounding through the senses of sight and hearing which do not require close contact between the sensing organs and external object. This later form of perceiving our surroundings is the motivation behind using remote sensing technique. Remote sensing is the process of detecting and monitoring the physical characteristics of an area without any physical contact but the data is collected remotely via sensors [1].

The area of interest within this study is Peshawar, a district of Khyber Pakhtunkhwa (KP), Pakistan. Peshawar is historical city located close to the border of Afghanistan, having latitude and longitude of 34.025917, 71.560135.[2]

After the 2001 intervention of United States of America in Afghanistan, many people of the country migrated to the North Western part of Pakistan. Peshawar's phenomenal growth has been the result of large-scale migration of people from Afghanistan. This type of development causes major change in land use and land cover patterns [3]. As the scope of this study is focusing observation of large scale area, therefore a subset of the complete data will be utilized as sample data for training and testing of our proposed algorithms and to analyze the change behavior of the underlying pilot region.

Machine Learning Algorithms (MLA) are used in the experiment to classify the image on the basis of ground truth data. MLA is scientific process that does not depend on instructions, rather it decides on the basis of ground truth data [4].

The rest of the paper is organized as follows. The section: Experimental Setup briefly discusses the methodology of our work. The Data Description section explains the open access imagery acquired through satellites. It also briefly discusses history of the Landsat satellite. The section: Retrieved Data explains the data acquisition phase of our work. Followed by the Ground Truth Data section which explains our proposed procedure of ground truth data collection for the classification and analysis of the imagery. In the Classification section of the paper, two classifiers –i.e. Maximum likelihood and Minimum Distance classifiers are discussed. In the section: Results, we discuss the findings of our remote sensing experiments. Finally the paper is concluded with the section: Conclusion, by summarizing the results of our work.

EXPERIMENTAL SETUP

The imagery achieved is checked for AOI (Area of Interest). If AOI is present in the imagery then shape file is applied which has been provided by the GIS, else mosaicking, a process to stitch images, is used for missing AOI and then area is extracted. We found that the image quality was not good for classification. The image was first pan sharpened to reduce spatial resolution. In order to improve the quality of the remotely sensed multispectral imagery for classification and analysis, the multispectral imagery is pan sharpened. Contrast stretching and radio metric correction are also the processes for enhancing the quality of imagery, which we used after the area extraction in our classification process. Ground truth is provided for the classification using a GPS (Global Positioning System) device. Two classifiers -i.e. maximum likelihood and minimum distance are considered, which have low computational complexity and good classification performance. Figure 1 shows all the included processes in the entire classification [5].

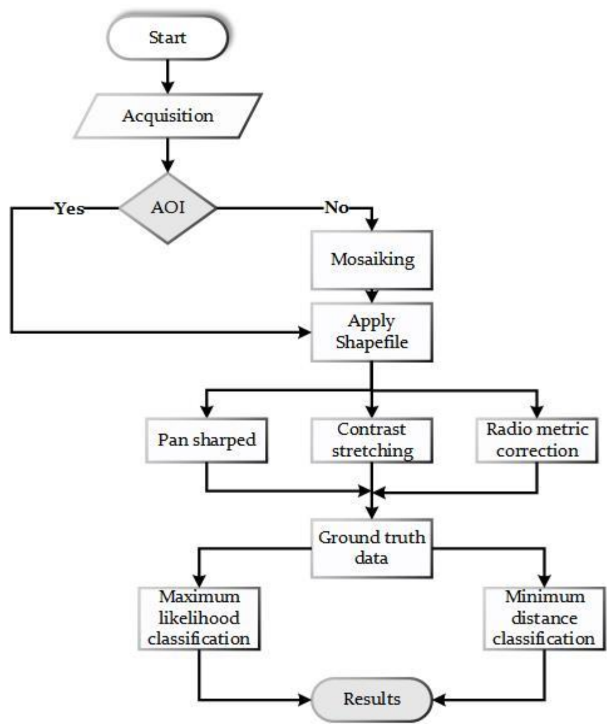

Figure 1. Flow chart of the proposed remote sensing mode

DATA DESCRIPTION

Remote sensing satellites are used to acquire imagery of the earth surface features for the study and analysis of earth surface feature through remote sensing techniques. This imagery is then preprocessed to adjust for experimental and other uses. Some of the satellites provide free imagery while others have some associated cost model. We use Landsat imagery data set in this paper.

The Landsat program is an initiative led by a joint venture of USGS and National Aeronautics and Space Administration (NASA) for earth observation. This initiative represents the world's largest running system of satellites for moderate resolution optical remote sensing for land, coastal areas and shallow waters.

Since 1972, land satellites have provided earth observation data to support work in agriculture, geology, forestry, education, mapping, emergency response and disaster relief [6].

Retrieved Data

The data set downloaded from USGS (United State Geological Survey) is for Peshawar region of KPK province in Pakistan. Essentially, there are two imageries of 2002 and 2018, respectively [7].

Figure 2. The image from 2002

Figure 3 The image from 2018

GROUND TRUTH DATA

Training data is collected by visiting the specific place with a GPS device. This helped us in accessing the exact location on the map. The GPS was of Handheld group (Handheld U.S. Kenaz R100). The Handheld Group is a worldwide supplier in markets such as forestry, transportation and field service. Different colors are chosen to specify respective area i.e. Urban Infrastructure (UI) is represented by Red, Barren Land is represented by Yellow, Vegetation is represented by Green and Water Body is represented by Blue color. For ground truth data selection, we have followed the rule to select samples of each category that are similar in both imageries – i.e. 2002 and 2018. The same samples of training and testing data are applied on both imageries to generate results and to compare.

Figure 4. The GPS Device

CLASSIFICATION

For classification of multispectral imagery, two classifiers are utilized which are described below;[9]

Maximum Likelihood

Maximum likelihood classification is so far the most popular classifier used in remote sensing. Maximum likelihood classification works on normal distribution and calculates the probability of each class that a given pixel belongs to specific class. Unless you select a probability threshold, all pixels are classified. Each pixel is assigned to the class that has highest probability. If the highest probability is smaller than a specified threshold, the pixel remains unclassified.

The maximum likelihood calculates the a-priori and a-posteriori information about the considered class. When the variance and the co-variance matrix are symmetric then the maximum likelihood calculates the Euclidian distance and based on these distance measures a class is assigned to pixel. When both the determinants are equal then the maximum likelihood is like mahalanobis distance [10].

Minimum Distance

Minimum distance is another simple supervised classifier which used Euclidian distance to calculate the interconnection amongst the known and unknown pixels. The minimum distance is same like the maximum likelihood but with less computational cost [11]. Like mahalanobis classifier the minimum distance also requires the threshold distance classifier [11].

RESULTS AND DISCUSSION

Both the images have been classified on the basis of Ground Truth Data (GTD). Each image gave a unique classification for the same GTD and image of the same area of interest (AOI). Different colors have been chosen for different interests. Red color indicates urban, green color indicates vegetation, yellow color indicates barren land and blue color indicates water bodies respectively. This is because of the changes in between the considered duration which supports the idea that after every 50 years,[12] the population become almost double. Figure 5 gives full explanation of urban and vegetation of 2002 in that specific area. Figure 6 give us detailed information of urban and vegetation of AOI of the year 2018 [13]. We compared both the classified images and generated results on the basis of change in the classification data. As the main focus of the paper is on urban, vegetation and water detection [14], we will just consider those specific change. In the 2018 image, urban is relatively very congested in shape. This observation is quite revealing, namely the population increased only in the middle of the image which is actually the city area of Peshawar. This can also lead to a hypothesis that, population from rural areas rush toward urban for the availability of resources. Green color indicates vegetation. In Figure 5 the green color is very dense and has covered a lot of area. On the other hand, in Figure 6, the green color has been almost half of the Figure 5. This indicates an alarming change [15].

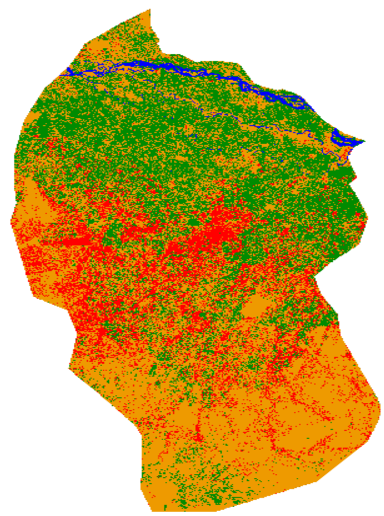

Figure 5. Classified image of 2002

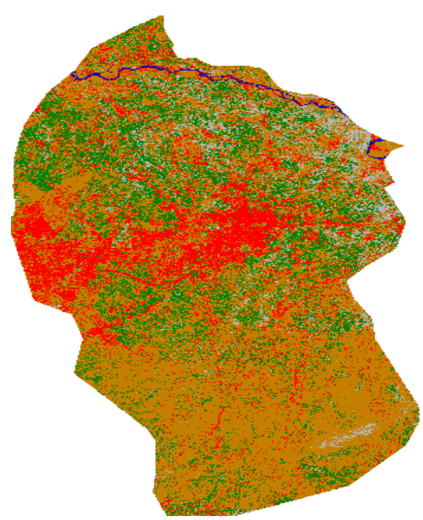

Figure 6. Classified image of 2018

Error! Reference source not found. represents number of pixels classified into different classes respectively. Also the table is capable of showing the difference between the classified images discussed earlier. The data from the years 2002 and 2018 have clear visionary differences. But here table will represent mathematical differences. The table is also capable of showing area covered by each class respectively in square kilometers. **Error! Reference source not found.** describes the results among the two well-known classifiers. These are maximum likelihood and minimum distance. The table also shows the percentage accuracy which eventually gives us the best classifier.

Table 1. Change Analysis in Numerical Form

Classes	2002		2018		Change
	Pixels	Area(km^2)	Pixels	Area (km^2)	
Urban	923051	207.68	978416	220.14	12.46 km^2
Vegetation	1688800	379.98	1049724	236.18	143.8 km^2
Barren Land	2947269	663.13	3190630	717.89	54.76 km^2
Water Bodies	76097	17.12	23429	5.27	11.85 km^2

Table 2. Classification Table

Classifier Name	2002 Image Accuracy	2018 Image Accuracy	Kappa Coefficient of 2002	Kappa coefficient of 2018
Maximum Likelihood	89.3743%	88.0418%	0.8088	0.8326
Minimum Distance	65.0132%	64.5621%	0.7231	0.7145

CONCLUSION

The recorded statistics from observations of two Landsat scenes of Peshawar clearly indicate an increased rate of urban sprawl over the years, while a decrease in vegetation is recorded to an alarming level. Urban area cover increased to 12.46km^2 since 2002 while vegetation area has been decreased to 143.8 km^2. As substantial decrease in water bodies has been recorded as well, which is 11.85km^2 decrease. With the increase in urban sprawl, pollution escalates, giving rise to number of health and social problems. Developing countries do not have appropriate resources for the management of this urban increase. With the use of open data, we can map different aspects of our environment including pollution.

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