NDVI Classification using Supervised Learning Method

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Abstract: With the blessings of Science and Technology, as the death rate is getting decreased, population is getting increased. With that, the utilization of Land is also getting increased for urbanization for which the quality of Land is degrading day by day and also the climates as well as vegetation are getting affected. To keep the Land quality at its best possible, the study on Land cover images, which are acquired from satellites based on time series, spatial and colour, are required to understand how the Land can be used further in future. Using NDVI (Normalized Difference Vegetation Index) and Machine learning algorithms (either supervised or unsupervised), now it is possible to classify areas and predict about Land utilization in future years. Our proposed study is to enhance the acquired images with better Vegetation Index which will segment and classify the data in more efficient way and by feeding these data to the Machine Learning algorithm model, higher accuracy will be achieved. Hence, a novel approach with proper model, Machine learning algorithm and greater accuracy is always acceptable.

Keywords: Urbanisation, Vegetation Index, Machine Learning, Land Cover Images, Land Utilization, Classification, Prediction, NDVI.

I. INTRODUCTION

With the creation of fire, Human beings started to take first step towards civilization. As the day went by, with the gradual development of human brain, people started to understand how to utilize the elements, e.g. water, minerals, food items etc. available in nature as per the requirement. Unlike that, humans started to understand the necessity of cultivation and Urbanization, which was a greater step towards Civilization. People still uses Land as per their requirement, e.g. construction and cultivation etc. But due to the increment of population day by day, the utilization of land is getting increased in a higher rate. As a result, the Land quality is getting degraded day by day which in turn is affecting the climate. So, to keep up the balance in weather with possible best quality of land, prediction with proper models and approach is required for further use in appropriate way.

Many methods with several techniques have been proposed for this particular purpose, over the years. Images which are used for this kind of study are satellite and aerial photos, but these images are too complicated as these include constructions, railways, grassland, roadways, forest area etc. So, vegetation indexes are used e.g. NDVI (Normalised Difference Vegetation Index) to segment and classify the images to identify the areas properly and on these NDVI images, Machine Learning Algorithms (both supervised and unsupervised), e.g. CA (Cellular Automata) Markov, Hybrid etc. are used to predict how the land will look like after some years. There are several software’s available in the market which provides fine detailed with high resolution image after pre-processing steps and manipulates ground truth data. But these methods become failure in order to get higher accuracy when classification and prediction are taken place. So, in this paper, we focus on the comparison of the vegetation indexes e.g. NDVI, RVI (Ratio Vegetation Index), DVI (Difference Vegetation Index), PVI (Perpendicular Vegetation Index), IPVI (Infrared Percentage Vegetation Index) etc. as they give different results after segmentation and classification.

Below is general block diagram Fig 1, which gives us brief description about the process that is usually taken place in-order to predict Land Use & Land Cover Change (LULC).

Fig 1: General Block Diagram Description

Data is acquired from various available sites. The commonly used is the USGS [10], which has collection of remote satellites images and it is collection of science directory about various natural hazard which also include impact of climate and land use change. It basically has data from US based sites. For Indian datasets, ISRO initiative web based tool, Bhuvan.

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For all these data availability, National Remote Sensing Agency (NRSA) plays important role. ISRO build this Bhuvan tool, with satellites Resourcesat-1, Cartosat- 1 and Cartosat-2 to get the best possible imagery of India. The Calibration and Segmentation of image gives importance to improve the image and get the part intended for action. Calibration includes different types of image enhancement techniques like noise removal, image optimization etc.

Different parameters need to be considered when land coverage is considered. Broadly it can be said as Evaluation and Ecological parameters. Evaluation Parameter like distance from road, hill area, river, cultivation area etc whereas Ecological includes temperature, rainfall, humidity etc.

All these parameters are calibrated to form a perfect dataset for further analysis. With these calibrated data, future prediction can be achieved through supervised or unsupervised learning.

The paper is sub-divided into following sections: Section II demonstrates the research work already done on this particular topic. Section III describes area of research accomplished through this project and its results are shown in Section IV. The paper conclusion and its future scope mention in Section V.

II. LITERATURE REVIEW

In this section the general description of different vegetation index apart from NDVI are analyzed and described in detail further.

[1] Rasha Alshehhi, Prashanth Reddy Marpu, Wei Lee Woon, Mauro Dalla Mura
Methodology: CNN classifier is used to learn and predict the roads and buildings from given image. For better enhancement of CNN out, Simple Linear Iterative Clustering Segmentation is used. CNN algorithm applied with ReLu Activation, Max Pooling, Convolution Layer, Fully connected Layers.

Advantages:
• Boundaries which are irregular can be identified
• Disjoint road regions are identified
• Enhancing multiclass prediction using special features

Issues:
• Additional processing is needed to accurately identify the irregular shape
• Under segmentation due to low level feature mixing
• Error in results if shadows and occultation are on the image
• Can result in over segmentation due to superpixel combining

Metrics Used
• Mini-batch SGD
• Pixel-wise cross entropy

Extraction of roads and building measured based on:
• Correctness
• Completeness

Performance Evaluation:
• McNemar’s Statistical test

Dataset: Massachusetts Dataset

Parameters Used (Ground truth values)
Roads, Building Boundaries, background

Methodology: Random Forest Machine Learning Algorithm, which is ensemble based.
• It predicts the spectral band information of Landsat Images
• Input to the model are topographic and historical climatic variables

Advantages
Direct prediction of spectral information leading to highly valuable ecological related products to analyze LULC from multiple perspective
• Over-fitting of Data is reduced with combination of RF with Decision Tree (DT)

Issues
• Less number of ensemble leads to poor determination of modal performance

Metrics Used
The Landsat images are divided into Red, Green, Blue and Near Infra-red spectral bands
• Coefficient of determination (R2) determining RF model OOB score (out of box)
• True color photorealistic image with RGB
• NVDI to calculate error

Dataset: Landsat 7 reflectance Imagery

Parameters Used (Ground truth values)
Elevation, Aspect, Slope, Historical mean annual temperature & precipitation, Future mean annual temperature & perception

Methodology: Supervised Classification with Maximum Likelihood algorithm which is obtained using ERDAS software.
The output of ERDAS is LULC images which are fed to IDRISI Selva Software which is Land change modeler to model and predict the changes.

Advantages
Accuracy of results using software more than 80% in every stages

Metrics Used
ERDAS
• Geometric correction
• UTM projection (2D co-ordinate system which gives location of area on earth)

Dataset: Landsat Satellite images

Parameters Used (Ground truth values)
Built up Area, Open Land, Light Vegetation, Dense Vegetation, Water, Sand

Methodology: Images are initially geometrically corrected using Geometric Algorithm (GM) which uses PCA to identify Barren land and NDVI for Green cover layer
GM is followed by interpretation method to obtain tone, texture, pattern, size using standard photographic keys by Aerial photo-interpretation.
Advantages:
• Using of standard methods to acquire the data set leads to high resolution and accurate image

Issues:
Complex to implement, Incurring cost high due to use of aerial photo interpretation and stero microscope, Rapid changes in Land cover would violate the proposed system i.e. the system is valid only for fixed and constant land cover changes.

Metrics Used
Input Metrics - Geometric Algorithm
Output Metrics - Kappa coefficient for error calculation and accuracy

Dataset - Aerial Photos, MSS, TM, ETM+

Parameters Used (Ground truth values)
Mountain, Barren Land, Urban areas, Green Cover

River

Methodology:
Image obtained is processed using ENVI 5.1 and ArcGIS 10.2 software. These images are classified using maximum likelihood classifier. For prediction, we are using CA markov in EDRISI software. The map of reference is generated using Fuzzy segmentation combined with Weighted Linear combination

Advantages:
• Results are reliable with high consistence between actual, observed and predicted results

Issues:
• Due to hilly area, pixels of images were affected leading to inaccuracy.

Metrics Used
Single Land use dynamic- difference between the land area and unchanged land area are considered over land area with inverse difference in the year. This gives the rate of land used changes.

Dataset- Landsat Satellite - LANDSAT 5, LANDSAT 7 & LANDSAT 8

Parameters Used (Ground truth values)
Water, Construction area, Bare Land, Wood Land, Farm Land

[6] Chen Liping, Sun Yujun, Sajjad Saeed
Methodology:
MODIS data is coverted to synthetic data using STARFM. This data is then classified on basis of spatial and temporalar parameters using maximum likelihood estimator.

Advantages:
• results in high quality land cover maps over 5% improvement on neural networks. Synthetic data helps in recovering the high-resolution lost images with exact degree of accuracy.

Issues:
• Less accurate the actual observation

Metrics Used
Overall Accuracy and Kappa co-efficient

Dataset - Synthetic Satellite imaging

Parameters Used (Ground truth values)

Water, Grassland, Wetland, Deciduous forest, Evergreen forest

Methodology:
Images are obtained via satellite which are processed by SRTM DEM using the ArcHydro Tool in ArcGIS identifying watershaped areas. These Images are classified using Unsupervised Classification with spectral clustering. These classified images are fed to IDIRISI software where decision taking technique is applied along with CA Markov

Advantages:
• Suitable rating obtained by MCE. Future prediction of land using LULC parameters. 84.34 accuracy on socio-economic front line. 85.5 accurate result for LULC.

Metrics Used
Multi Criteria evaluation based on weights which are created by AHP. (Analytical Hierarchy Process), Parameter aggregation using Weighted Linear Combination

Dataset - Landsat - MSS, TM, ETM+

Parameter Used (Ground truth values)

Socio-economic:
Population, Residential development, Industrial development Road network, Railway network, Area under winter crop physiogmomic - drainage network, slope

LULC:

III. PROPOSED METHODOLOGY
As discussed in Section I about the general idea of the process, we focussed our methodology to enhance the Vegetation Index as shown in Fig 2, so that further process could get benefitted. Vegetation Index is one of the major parameters on which the segmentation and classification as well as prediction depends. Vegetation indices are those which highlights the spectral bands of greens i.e. plants, trees etc by using some mathematical combination and they can be observed distinctly from image or map. It also distinct from soil to green and reduces any climatic effect, e.g. clouds, from the images as much as possible. The image acquired from satellites contains several bands which represents colours. By manipulating these bands, we get vegetation indices.

Fig.2 Proposed system methodology
NDVI Classification using Supervised Learning Method

As shown in Fig. 2, data for the purpose is acquired from a national website available which has an open data archive for Land change namely Bhuvan (bhuvan.nrsc.gov.in). The images obtained are the time series data taken by ResourceSat I. The images are received in four different bands namely Band 1: Green, Band 2: Red, Band 3: Near IR and Band 4: Short IR. We use open source software called as PRIMEWIN to extract the data. It is an image processing tool which was developed using VC++ for facilitating data ingest from satellites sensor and using its utilities for data ingest, visualization, enhancement, arithmetic approach, classification etc. Fig 3 depicts the look of the Open Source Software.

![Fig 3. PRIMEWIN – Open Source Tool](image)

From the UTILITIES tab, we import the data extracted from the satellite, which results in an image in which consists four BANDS (Fig 4). The BAND 1: Green, BAND II: Red, BAND III: Near Infra Red, BAND IV: Short Wave Infra Red.

This image obtained is pre-processed by false coloring technique and thereby enhancing the view of image using histogram equalizations. Followed by Pre-Processing are the morphological effects. We re-define the image applying various vegetation indices.

![Fig 4. Loading of data into different Range](image)

IV. RESULT AND DISCUSSION

A. VEGETATION INDICES

There are several vegetation indices like NDVI, RVI, DVI, PVI, IPVI etc. but every index highlights on the difference of Near Infrared (NIR) and Red band reflectance which separates the green from other elements present in the image. So, in this paper, we will observe the comparison of the vegetation indices which will help for better prediction.

DVI (Difference Vegetation Index): It is one of the simplest vegetation indices which separates green from soil. In case of reducing atmospheric effects, like any shadow or radiance, it does not make any change of those. Histogram equalization is needed.

DVI can be written as, \( DVI = \frac{NIR - Red}{NIR + Red} \) (1)

RVI (Ratio Based Vegetation Index): It is a simplest ratio-based index is called the Simple Ratio (SR). This value becomes high for vegetation but low for soil, ice, water, etc. It highlights the proper amount of vegetation and climatic as well as topographical effects get reduced.

It can be written as, \( SR = \frac{NIR}{Red} \) (2)

This simple ratio helps to reduce the climatic effect by the following:

\[
L_{NIR} = \frac{ENIR }{\pi} \text{NIR} 
\]

(3)

Hence,

\[
\frac{L_{NIR}}{L_{Red}} = \frac{ENIR }{\pi} \frac{NIR }{Red} 
\]

(4)

\[
\frac{L_{Red}}{L_{Red}} = \frac{\pi \frac{ENIR }{Red} }{\pi} 
\]

(5)

It removes irradiance and transmittance which cause the climatic and topographical effects. Also no further histogram analysis is required for this Ratio based Method.

NDVI (Normalized Difference Vegetation Index): It is mostly used index for prediction of Land Cover Images. It is a good index and its value varies from -1 to 1. It highlights amount of vegetation as well as separates them from soil. It somewhat minimizes topographic effects but cannot remove climatic effect like RVI.

NDVI can be written as, \( NDVI = \frac{(NIR - Red)}{(NIR + Red)} \) (6)

Crippen (1990) found out that the red radiance subtraction from NDVI difference part was irrelevant and formulated the Infrared Percentage Vegetation Index (IPVI) thus rewriting the NDVI formula as

\[
IPVI = \frac{(NIR)}{(NIR + Red)} 
\]

(7)

It’s proved from the different scientist that this functionality is equivalent to NDVI and RVI, but varies in only ranges in value 0.0-1.0. Although our analysis indicates the non-removal of atmospheric effects or cloud appearance. When Histogram is applied over the image, the cloud or atmospheric effects gets highly visible as shown below.
For better analysis and comparison of different vegetation index, we intended to take high resolution of all the vegetation Index and thus comparing it with the rest.

The highlighted area resembles the portion on which we are analyzing the high resolution effects. The Original Image of Fig.10 and its highlighted portion in High Resolution is shown in Fig.11.

Fig. 10: Raw Original Image

Fig. 11: High Resolution – Raw Image

Fig. 12 shows the cloud coverage has visibility and not completely removed. The shadowing effects of clouds also exists. Visibility of other details is not as clearer as RVI.

Fig. 12: High Resolution DVI

Fig. 13: High Resolution NDVI
Fig. 13 shows the shadowing effect mentioned in DVI has been completely removed. It also eliminates the atmospheric effect. The lack of feature visibility is only disadvantage of the NDVI.

![Fig 14. High Resolution IPVI](image)

Fig. 14 shows that an IPVI has good visibility of features, but it is worse enough when it comes to atmospheric and shadowing effects. The Clouds and shadows are highly visible along with other features.

![Fig 15: High Resolution RVI](image)

Fig. 15 shows that the RVI has the best representation in high resolution. It gives good visibility to land features and also eliminates the atmospheric and shadowing effects efficiently. Using these histogram equalized images, we are going to apply the supervised classification method of Maximum Likelihood. The various color indication are mentioned below Table 1, following the classification results.

**Table. 1 Classification Color Table**

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>Populated Area</td>
</tr>
<tr>
<td>GREEN</td>
<td>Vegetation Land</td>
</tr>
<tr>
<td>BROWN</td>
<td>Forest Area</td>
</tr>
<tr>
<td>YELLOW</td>
<td>Barren Land</td>
</tr>
<tr>
<td>BLUE</td>
<td>Water</td>
</tr>
</tbody>
</table>

Verification of the Classification is obtained by comparing the result with Google map of this location. The Process of identifying and locating the land is described below.

Initially, we define the area to be validated. Using the mouse we mark a point on the image, to gets its location Fig 19. By using those location highlighted in Fig 17, we copy paste the location in Google Earth Pro Tool and the search the area Fig 18.
As we have already marked the area of interest for different vegetation indexed classified images as shown above Fig 16 and comparing it with result of Google earth Pro tool, it is vegetation cover area, so should be colored in green as per Table 1. From Fig 16 (a) shows IPVI & (b) defines DVI were not able to recognize the vegetation cover, however Fig 16 (c) NDVI manages to determine few of the vegetation cover but Fig 16 (d) RVI gives the exact cover. Hence RVI proves to better Vegetation Index than the rest.

Google earth pro is an open source, geospatial software which displays a virtual globe with ability to analyze and capture geographical data as shown in Fig. 17-19. It is having a feature of displaying older data of a region i.e. if someone wants to know about a place from 20-30 years ago from now on, one can get the experience to see how the place used to look like. Here, in this work, using this feature, we have obtained the LULC image of the place, mentioned in the images above, for the year of 2010 and predicted the condition of the land using our proposed method for next 2-3 years.

V. CONCLUSION AND FUTURE WORK

We analyzed different Vegetation index like DVI, RVI, NDVI and IPVI in histogram stretching of original as well as high resolution histogram view. The difference method DVI lags to remove the atmospheric and shadowing effects and also lack in feature visibility. NDVI leads in minimizing of topographic effects, but complete removal is not achieved. The feature visibility lags in expressing, but histogram equalization of the same, results in better representation. IPVI is the best method for feature visibility but has a major disadvantage of atmospheric and shadowing impact even worst and clearer than DVI. RVI removes topographic effects and atmospheric effects with better feature feasibility view. Supervised Classification on the above Vegetation Indices also resulted in correct mapping of different features like water, vegetation land, barren land, rocky land etc with respect to RVI. The validation of correctness is done by comparing the results with Google Earth Pro tool. Hence, RVI method is most accurate compared with other different Vegetation Index which includes NDVI, DVI, and IPVI.

This work can be further extended for predicting the future land coverage of particular region, by intense training of data collected and classified using the neural nets.

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