Image Processing Techniques for Vegetation Study - Retrospective

Shajimon K John
Research Scholar
Karpagam University
Coimbatore, INDIA

Dr. T K Mani
Principal
College of Engineering
Cherthala, Kerala, INDIA

ABSTRACT
Vegetation studies helps to develop a profile on extensive areas affected by vegetation changes. Image processing techniques does manipulation of digital images for various applications. The satellite image processing is increasingly used for vegetation mapping. Now a day's both multi spectral sensors and hyper spectral sensors are used for vegetation monitoring.

General Terms
Remote sensing, Vegetation study

Key Words
NDVI, LAI

1. INTRODUCTION
The earth observing system (EOS) was formed with an objective to study global changes on earth through continuous observation. Starting form TERRA, a multi - national, multi - disciplinary mission involving partnerships with the aerospace agencies of Canada and Japan, with MODIS (Moderate Resolution Imaging Spectro-radiometer) as sensor to the new generation sensors like AVHRR (Advanced very High Resolution Radiometer) fitted system have been in operation to full fill the objectives of EOS [1].

The present day techniques use both multi spectral and hyper spectral images remotely sensed and processed through image processing techniques. These are modelling using GIS (Geographic information systems) modelling approaches for economic and rapid means for mapping, assessing, monitoring of vegetation conditions [2, 3].

Due to economies of scale and synoptic view, the satellite remote sensing systems are the most prominent method for vegetation studies. The multi spectral air bone and satellite systems employed to gather data mainly in food production, geology of urban and rural locations, oil and mineral explorations. But the major problem is the two distinct objects may absorb and reflect radiation in the near spectrum, using multi spectral images they can not be differentiated [4]. This problem can be overcome to some extend with the help of hyper spectral sensors. The most multi spectral satellite systems measure varies three to six spectral bands within the visible to middle infra read region of the electro magnetic spectrum [4, 5]. Comparing with multi spectral imaging hyper spectral imaging provide a large number of wavelength bands with large data volume, data redundancy and band correlation.

The hyper spectral sensors are passive sensors that simultaneously record hundreds of narrow bands from the electromagnetic spectrum and group them to hyper spectral data cube [4, 6]. This also provides spectroscopic data in narrow spectral bands along the visible, near and short wave infra red regions [5]. The hyper spectral cameras measure the radiations reflected by each pixel at large number of visible and invisible wave lengths instead of the three primary colours [7]. At present these hyper spectral imaging is used for military intelligence, civil and commercial applications along with vegetation and soil studies [8, 9].

2. SPECTRAL SIGNATURE
Spectral signature gives an insight about spectral reflectance of various materials. This is a ratio of the reflected energy to incident energy as a function of wave length [9]. The graphical representation of spectral reflectance of an object as a function of wave length is known as spectral reflectance curve [8]. These curves are called as spectral signature and can help in discrimination of various types of vegetation species [10].

According to Zhang et al, filed based ecological studies have demonstrated that vegetation phenology tend to follow well defined temporal patterns like leaf growth rapid to steady level [10, 11]. Various vegetations follow different temporal growth patterns [12]. The short term and long term ecological process can be monitored using vegetation dynamics. These can be achieved by continuous observation of the satellite image. To characterize state and dynamics of vegetation can be done with the help of vegetation indices.

3. VEGETATION INDICIES
Vegetation Indices (VI) are optical measures of vegetation canopy 'greenness'. It gives a direct measure of photosynthetic potential resulting from the composite property of total leaf chlorophyll, leaf area, canopy cover, and structure. The best feature set can be developed by the reflectance in each spectral band. Normally use a linear combination or a normalized difference of bands for the study of vegetation indices. Vegetation is normally characterized by the 'red edge' [12]. This corresponds to the wave length interval at which chlorophyll cease to absorb. This absorption normally occurs from 670nm to 780nm wave length range of the electro magnetic spectrum [14]. The vegetation indices algorithms do simplifying multi reflective band data into a single value correlating to physical vegetation parameters like biomass productivity, leaf area index [4].

In visible wave lengths healthy green leaf reflects very little solar energy while dead vegetation and soil reflects greater amount of solar energy. But near infra red region healthy green vegetation reflects greater amount of solar energy while dead leaf and soil reflects very little solar energy. The most popular vegetation indices are narrow band reflection ratios, normalized difference vegetation index (NDVI), edge green first derivative normalized difference (EGFN), etc. [15]. The commonly used distance based vegetation indices are soil adjusted vegetation index (SAVI), perpendicular vegetation index (PVI)

Normalized Difference Vegetation Index (NDVI)

The NDVI gives an estimate of green vegetation as a ratio of the difference between reflectance values in visible red (R) and the near infra red (INR) wave lengths to the overall reflectance in those wave lengths [15].

$$NDVI = \frac{NIR - R}{NIR + R}$$

Normally NDVI ranges from -1 to +1, with values corresponding to photo synthetic vegetation cover. The negative values indicate presence of cloud, snow or water and positive values indicate green vegetation.

Green Vegetation Index (GVI) uses green region instead of red region in the electro magnetic spectrum researchers like Lecain et al was able to develop a linear relationship between GVI and the green up in the progress of the season [4].

$$GVI = \frac{NIR - G}{NIR + G}$$

Leaf Area Index (LAI)

The one sided green leaf area per unit ground area is basically denoted by LAI [14]. This is mainly used as a major parameter for determination of crop growth.

$$LAI = \frac{LeafArea}{SampleArea}$$

It gives an abstraction of a canopy structural property as a dimensionless variable that ignores canopy detail such as leaf angle distribution, canopy height or shape.

Enhanced Vegetation Index (EVI) defined as

$$EVI = \frac{2.5(NIR - R)}{(1 + NIR + (6R - 7.5B))}$$

The coefficient "1" accounts for canopy background scattering and the blue and red coefficients, 6 and 7.5, minimize residual aerosol variations. The EVI is more functional on NIR reflectance than on Red absorption, and therefore it does not ”saturate" as rapidly as NDVI in dense vegetation, and it has been shown to be highly correlated with photosynthesis and plant transpiration in a number of studies.

Distance Based Vegetation Index

The distance based indices tries to compensate the effects of disturbing factors like soil background, atmospheric conditions like rain, fog, etc [14]. The pixels in the image were a combination of vegetation and soil information. Many researchers proved that these distance based indices tries to minimize the soil brightness and other parameters that disturbs the index calculation.

Soil Based Vegetation Index (SAVI) is one of the prominent techniques that provides compensation factor to soil brightness.

$$SAVI = \frac{NIR - R}{NIR + R + L}(1 + L)$$

where L is a constant that follows LAI. Huetc [4] defined the optimal adjustment factor for L as 0.25 for high vegetation density, 0.5 for intermediate vegetation density and 1 for low vegetation density. This is a compromise between NDVI and PVI.

Perpendicular Vegetation Index (PVI) corrects for soil reflectance. PVI is developed with a linear rather than a scattered relationship with the fraction of intercepted photo synthetically active function than NDVI.

$$PVI = \sqrt{(G_{ir,s} - P_{ir})^2 + (G_{r,s} - P_r)^2}$$

where Prs and Pirs are reflectance of soil background in R and NIR bands, Pr and Pir are reflectance of vegetation in R and NIR bands. Or simple words PIV is determined by calculating the distance between intersection of green band for red and near IR band and the vegetation pixel image coordinate [4].

Hyper spectral study:

Now a day the hyper spectral data are used for variety of vegetation studies like water content, plant pigment content, canopy architecture and density [4]. Later stages even identification of vegetation species and vegetation stress and diseased vegetation also identified using hyper spectral imagery [4]. Hyper spectral imaging can be termed as the next generation satellite imaging. Much is expected from hyper spectral studies like unique identification of most surface types like rocks, soils and vegetations.

Vegetation fraction

Vegetation fraction is a quantitative index in forest management. It is defined as the percentage of vegetation occupying the ground area in vertical projection [5]. Gutaman’s mosaic pixel model is one of the most acclaimed models used in vegetation fraction studies. In this model each pixel is assumed as a mosaic pixel and the NDVI is calculated for full vegetation, dense vegetation and non dense vegetation

For uniform full vegetation

$$NDVI = NDVI_{\infty} - (NDVI_{\infty} - NDVI_0)e^{(-kLg)}$$

For dense vegetation

$$NDVI = f_g NDVI_{\infty} + (1 - f_g)NDVI_0$$

For non dense vegetation

$$NDVI = f_g NDVI_g + (1 - f_g)NDVI_0$$

Having a variable density

$$NDVI = \sum f_{gi} NDVI_{gi} + (1 - \sum f_{gi})NDVI_0$$

where Lg is the leaf area index, k is the extinction coefficient. NDVI∞ and NDVI0 are reflective signals from green vegetation to bare soil.

Hence the vegetation fraction f_g can be expressed as

$$fg = \frac{NDVI - NDVI_0}{NDVI_\infty - NDVI_0}$$

Weighted NDVI

This method is also a distance based index that provides minimization variables for soil background effect [6].

$$WDVI = g \times r$$

with the slope of the soil line is termed as ‘g’ and is calculated from two atmospherically corrected images of the same area under two different conditions like one taken during growth stage of the vegetation other during fallow stage of the season for that vegetation itself. The inverse of the WDVI can be calculated as

$$IWDVI = R - g \times NIR$$

where R and NIR are derived during the crop season and g is from the fallow season. The value of IWDVI is normally directly proportional to the amount of soil component seen by the sensor.

4. CONCLUSION

In general this review illustrates the various multi spectral image processing techniques for vegetation study with brief insight into hyper spectral techniques also.

5. REFERENCE

[1]. Oliveria Thomasz, Oliveira Luciano, Carvakho Luis, Martinhago Adriana, Freitas Savio, “ Comparison of MODIS NDVI time series filtering by wavelets and Fourier analysis to generate vegetation signatures”, INPE 2009.

[2]. Huihui Zhang, Yubin Lan, Ronald Lacey, W C Hoffmann, Yanbo Huang, “ Analysis of vegetation indices derived from aerial multi spectral and ground hyper spectral data”, IJABE, vol 2, No3, 2009.

[3]. Sudhanshu Sekhar Panda, Daniel P Ames, Suranjan Panigrahi, “Application of vegetation indices for agricultural crop yield prediction using neutral network”, Remote Sensing 2010

[4]. Shwetank, Jain Kamal, Bhatia K F, “Review of rice crop identification and classification using Hyper spectral image processing system”, IJSC vol. 1, No1, Jan 2010.

[5]. Smith R B, “Introduction to hyper spectral imaging”, www.microimages.com.

[6]. Susan M Schweizer, Jose M F Moura, “Efficient detection in hyper spectral imagery”, IEEE Transactions on Image processing, 10, no4, April 2001.

[7]. Anshu Miglani, S S Roy, et al, “Evaluation of EO 1 hyperion data for agricultural applications”, j. Indian Soc. Remote Sensing Sept 2008.

[8]. Boardman J W, Kruse F A, Green R O, “Mapping target signatures via partial un mixing of AVIRIS data in summaries, JPL publication 1995.

[9]. Chen J M , et al, “Combat airbone spectrographic imager used for mapping biophysical parameters of boreal forests”, J Geophy Res. 1999.

[10]. Zhang X, et al, “Monitoring vegetation phenology using MODIS”, Remote sensing of Environment, 2000.

[11]. Zhang et al, “An advanced tool for real time crop monitoring in China”, IEEE international Geoscience and Remote sensing symposium, France 2003.

[12]. Bruce L M, et al, “Denosing and wavelet based feature extraction of MODIS multi temporal vegetation signatures”, GI science and remote sensing 2006.

[13]. Zhu Liang, WU Bing – Fang, Zhou Yue Min, meng Ji Hua, Zhang Ming, “A study on fast estimation of vegetation fraction in three Georges immigration area using SPOT5 imagery”, International archives of photogrammetry, remote sensing and spatial information sciences, 2008.

[14]. Kempeneers P, Ded Backer, Debruyn W, Scheunders P, “Wavelet based feature extraction for hyper spectral vegetation monitoring”, IJRS 2005.

[15]. G A Carter, “Ratios of leaf reflectance in narrow wave bands as indicators of plant stress” I J RS 1994