Remote Sensing Methods for Forestry Applications – A Survey

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Abstract- *Remote sensing becomes the most important method to study the forestry details. Its technologies offer the potential to explore the effects of different environmental drivers, land-use changes and disturbances on forest quantity, function and dynamics at large spatial scales. For several types of applications of remote sensing in forestry in specific regions of the world such as tropical areas, users of forest information are demanding new establishment of sensors and platforms. This paper presents the review of the most recent advancements in diverse fields of remote sensing for forestry applications. Execution of the examined systems is assessed in diverse analysis situations.*

Keywords- Forestry, Applications, Remote Sensing, Sensors.

I. INTRODUCTION

To reliably and repeatedly screen woodlands, it is attractive to utilize remote sensing information. Various types of remote sensing information, including Aerial photography, Optical Multispectral Scanner, Radar, Lidar (Laser) and Videographic information have been utilized by woodland research and operational organizations to recognize, distinguish, arrange, assess and measure different vegetation types. Over the previous decades huge advancement has been made in showing the possibilities and constraints of the uses of remote sensing in forestry applications. Remote sensing can identify, distinguish, classify, assess and measure different timberland attributes both qualitatively and quantitatively. In a qualitative manner, remote sensing can group backwoods cover types to: coniferous and deciduous woods, mangrove woodland, marsh backwoods, timberland manors, and so on. The quantitative examination can quantify backwoods parameters (e.g., dbh, tallness, basal territory, number of trees per unite area, timber volume and woody biomass), floristic piece, life forms, and structure. Keeping in mind the end goal to see what sort of data we can be obtained from the present remote sensing sensors and stages and how exact is that, a stock of all remote detecting applications in ranger service is required. This paper exhibits a state of the art inventory of all remote sensing applications in ranger service.

II. REMOTE SENSING TECHNIQUES

The following illustrates the survey of remote sensing methods for forestry applications.

Barbara Koch [1] presented various remote sensing techniques for forest biomass mapping. Recent developments such as full wave laser scanning, polarimetric radar interferometry, and hyperspectral data are discussed in this paper. The biomass parameters have been derived using the space-borne full wave laser system [2][3]. But intensity, amplitude or waveform parameter for forests information extraction cannot be achieved using this technique. The information on the vertical structure of the vegetation cover can be obtained using LiDAR compared to optical sensors [4]. Recent techniques in the laser technology include flash LiDAR and the synthetic aperture LiDAR (SAL). The advantages of SAL Photon counting systems include improved operating distance and enhanced modelling approaches. Due to their relative weather independence SAR (synthetic aperture radar) data are of high interest for forest biomass mapping [5][6]. Backscatter, coherence and phase-based approaches are the three basic approaches based on SAR data for forest cover mapping and biomass estimations. The roughness of the objects in relation to the wavelength, the weather influence at different data take times, the exact co-registration and the saturation are the limiting factors when biomass mapping is based on backscatter values or on coherence. If indirect methods are used to estimate biomass, the most important single forest variable is the tree or canopy height. Such information can be obtained by SAR interferometric techniques such as repeat–pass or single pass interferometry (InSAR) and polarimetric interferometry (PolInSAR). Species and health status information improves biomass mapping. Hyperspectral data might be used for the assessment of this information. Hyperion and CHRIS/Proba are some of the hyperspectral satellite-based systems which deliver hyperspectral data in relatively high spatial resolution. The advantages of hyperspectral data are improved species identification, a better mapping of biochemical status of trees and the possibility of estimating biomass directly from the data.

In paper [7] forest structure is modelled with combined airborne hyperspectral and LiDAR data in a temperate forest site in Germany. Genetic Algorithm and spatial models were used for the modelling. The comparative analysis of the LiDAR height metrics and HyMap [8] metrics showed that the former provided the most effective information amongst the entire data source combinations, while the latter contributed only slightly to describe the variation beyond those explained by ALS data. The combined use of LiDAR and multispectral data for forest studies suffers from using different modelling schemes from Nearest Neighbour (NN) spatial models. An adaption of Most Similar Neighbour (MSN) presented in this paper. The Most Similar Neighbour (MSN) is a special case of NN method in which the distances between the target and reference units are weighted using the canonical correlations of the predictor variables. The hyperspectral data has found to be more potential for the separation of tree species compared to multispectral data.

The paper [9] evaluates the simulated data sets like bandwidth, NESZ and ambiguities for forest height inversion information at P-band. The simulated data sets are obtained from DLR Experimental Synthetic Aperture Radar airborne SAR data. This study is carried out as a part of BIOMASS mission. BioSAR 2007 and INDREX-II campaigns are used for the study. The parameters relating to the propagation path (ionosphere) and to temporal decorrelation have been selected along with the system related parameters. Comparative study between airborne data and the simulated data showed that P-band in space has a lower range resolution. Due to the selected small bandwidth, coherences of simulation data can less distinguish the land cover features. The inversion results of simulated data are higher than airborne SAR data.

In paper [10] forest maps are derived from PALSAR and MODIS imagery. IKONOS images were used to evaluate these forest maps. Forests in the Brazilian Amazon has been identified and mapped using methodology that uses dual-polarization L-band SAR 500-m mosaic PALSAR imagery. The use of C-band and L-band SAR imagery have been evaluated in studies to map and monitor forests and stated that L-band SAR has greater sensitivity to vegetation structure than other bands (C-band) [11][12]. An algorithm that uses time-series MODIS imagery to map evergreen forest has been evaluated. The combination of PALSAR and MODIS resulted in improved estimation.

Paper [13] model full-scene forest canopy height from optical imagery, lidar transects and Geographic Object-Based Image Analysis (GEOBIA) by developing an airborne lidar sampling strategy. GEOBIA provides a possible option to the customary pixel-based approach to get definite geographic data [14]. Airborne lidar data helps in developing high-resolution digital canopy models that provide information on the vertical structure of forests. But airborne lidar data is expensive. To achieve the cost effective method, this study focuses on (i) determining appropriate lidar transect features (i.e., location, direction and extent) from an optical scene, (ii) developing a mechanism to model forest canopy height for the full-scene based on a minimum number of lidar transects, and (iii) defining an optimal mean object size (MOS) to accurately model the canopy composition and height distribution. It was found that (i) the transect areas got from the ideal lidar transect selection algorithm precisely catch the canopy height variability of the whole study range; (ii) proposed canopy height estimation models have comparative execution in two lidar transect bearings (i.e., north–south and west–east); (iii) a small lidar degree (17.6% of aggregate size) can accomplish comparative canopy height estimation accuracies as those demonstrated from the full lidar scene; and (iv) distinctive MOS can lead to distinctly diverse canopy height results.

Various uses of small footprint airborne lidar (light detection and ranging) have given exceptionally precise results to assessing woods stature. In any case, the related securing expense stays high, which constrains its utilization for one end to the other huge region mapping. In paper [15], a novel system has been built up by coordinating GEOBIA (GEOgraphic Object-Based Image Analysis), lidar transects and Quickbird imagery to gauge huge territory covering stature. GEOBIA has been through development due to high-spatial resolution imagery and the availability of powerful data processing software [14] [16]. Model results (from eight diverse lidar transect blends in two distinct headings, N-S and W-S) were contrasted and the comparing shelter range from the full lidar scene. In spite of the fact that our study zone was dominated by mixed forest stands, the calculation chosen transects all around demonstrated comparative canopy height variability as that utilizing all lidar information. To further sum up the precise canopy height data from lidar transects to the huge study territory, two machine learning methodologies – minimal-redundancy- maximal-relevance (mRMR) and support vector regression (SVR) were utilized. Results demonstrate that the highest correlation (R = 0.85) was accomplished utilizing a lidar transect front of 7.6% of the full scene (i.e., two transects in N-S heading), while the most minimal relationship (R = 0.75) was gotten from a lidar transect front of 3.8%.

Paper [17] concentrates on the use of Extreme Learning Machines (ELM) to the classification of remote sensing hyperspectral data. The particular point of the work is to get exact topical maps of soybean harvests, which have turned out to be hard to distinguish via mechanized methodology. The classification process is as follows: First, spectral information is changed into a hyper-spherical representation. Second, a strong picture gradient is registered over the hyper-spherical representation permitting a picture division that recognizes real harvest plots. Third, feature determination is accomplished by a greedy wrapper approach. Finally, a classifier is trained and tested on the chose picture pixel highlights. The classifiers utilized for highlight choice and last characterization are Single Layer Feedforward Networks (SLFN) prepared with either the ELM or the incremental OP-ELM. Original picture pixel elements are figured after a Functional Data Analysis (FDA) portrayal of the spectral data. SLFN-ELM uses fewer elements than the alluded calculations. Op-ELM is able to discover focused results utilizing the FDA highlights from a solitary spectral band.

Paper [18] gives an insight into the effect of coal exploitation on vegetation growth. Characteristic ecological environment has been affected by coal exploitation through huge scale underground misuse which debilitates the encompassing regions and is the reason for surface subsidence and breaks. These sorts of harm genuinely bring down the underground water table. Crumbling of the earth has surely an effect on and limits development of vegetation, which is an essential marker of a sound environmental framework. The study has been carried out in Bulianta coal mining zone. Vegetation development under coal abuse stretch has been checked dynamically by remote sensing innovation and it gives favourable circumstances, for example, extensive scale scope, high exactness and bottomless data. TM (Thematic Mapper) infrared and red bands were used to construct scatter plot. Results obtained after the detailed examination of the distributional qualities of vegetation pixels demonstrate that vegetation pixels are influenced by soil foundation pixels, while the conveyance of soil pixels exhibits a direct design. Linear regression helps in acquiring soil line mathematical statements. Another band, reflecting vegetation development, has been acquired taking into account the disposal of the soil background. An evaluating of vegetation pictures was removed by means of a density slice technique. The investigation demonstrates that before the abuse of the Bulianta coal mining zone, vegetation development had reduced; particularly middle development vegetation had been changed into low vegetation. It may have been created by the disintegration of the fragile environment in the western piece of the mining range. All the same, after the start of coal production, vegetation development has progressively enhanced, likely because of substantial scale ethereal seeding. Remote sensing translation results turned out to be reliable with the real circumstance on the ground.

Paper [19] focuses on vegetation spectral measurements for detecting crop water status in mature olive groves. The crop water status was detected in terms of leaf water potentials (LWP). The study was conducted in an olive grove of Sicily during summer season 2011 and LWP was acquired for the full spectral measurements (350-2500 nm). Two different approaches were examined to detect crop water status in terms of LWP. Specifically, using existing families of Vegetation Indices (VIs) and applying Partial Least Squares Regression (PLSR) were optimised and tested. The results demonstrated that an attractive estimation of LWP at tree covering and leaf levels can be gotten utilizing vegetation lists taking into account the near infrared-shortwave infrared (NIR-SWIR) domain requiring, however, a particular optimisation of the corresponding “centrebands”. At tree overhang level, a great forecast of LWP was acquired by utilizing improved records working in the visible domain, similar to the Normalized Difference Greenness Vegetation Index (NDGI), the Green Index (GI) and the Moisture Spectral Index (MSI). On the other hand, files consolidating SWIR and NIR wavelengths were utilized to obtain a palatable estimation of LWP at leaf level. The best forecast was particularly found by advancing the MSI and the Normalized Difference Water Index (NDWI). Even utilizing the PLSR system, an amazing forecast of LWP at both tree covering and leaf levels was gotten. On the other hand, this strategy requires the accessibility of full spectra with high determination, which must be acquired with handheld spectro radiometers or hyper-spectral remote sensors.

The study of paper [20] is based on the fact that learning of the appropriation of vegetation on the landscape can be utilized to research ecosystem working. The sizes and movements of creature populaces can be connected to assets provided by diverse plant species. This study was carried out in Yellowstone National Park (Yellowstone) and shows the utilization of imaging spectroscopy to the investigation of vegetation utilizing spectral feature analysis of information from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). A radiative exchange model and field reflectance estimations of a ground calibration site were utilized for calibrating the AVIRIS information, gained on August 7, 1996. The pixels of the calibrated AVIRIS information over regions of known timberland and nonforest vegetation types in Yellowstone were averaged for creating a spectral library of canopy reflectance signatures. The absorption features of vegetation in the spectral library are compared with the spectra from the AVIRIS information to determine the dispersions of this vegetation. The continuum removal and least squares fitting algorithms in the US Geological Survey's Tetracorder expert system were utilized for this purpose. A crucial component of this methodology was spectral feature examination of the 0.68 µm chlorophyll and the 0.98 and 1.20 µm water ingestion elements present in the spectra of vegetation.

III. FORESTRY APPLICATIONS

Remote sensing is used in a wide array of applications. Forestry applications of remote sensing include the following:

1. Reconnaissance mapping: Objectives to be met by national forest/environment agencies include forest cover updating, depletion monitoring, and measuring biophysical properties of forest stands,forest cover type discrimination and agroforestry mapping.
2. Commercial forestry: Of importance to commercial forestry companies and to resource management agencies are inventory and mapping applications: collecting harvest information, updating of inventory information for timber supply, broad forest type, vegetation density, and biomass measurements, clear cut mapping / regeneration assessment, burn delineation infrastructure mapping / operations support forest inventory, biomass estimation and species inventory.
3. Environmental monitoring: Conservation authorities are concerned with monitoring the quantity, health and diversity of the Earth's forests. deforestation (rainforest, mangrove colonies), species inventory, watershed protection (riparian strips),coastal protection (mangrove forests),forest health and vigor.

IV. CONCLUSION

A key development in remote sensing has been the increased availability of high-spatial- and high-spectral-resolution remotely sensed data from a wide range of sensors and platforms including photographic and digital cameras, video capture, and airborne and spaceborne multispectral sensors. Hyperspectral imagery promises to provide enhanced discrimination of forest cover and physiological attributes. Radar applications are being developed that penetrate the forest canopy to reveal characteristics of the forest floor. New technologies such as LIDAR can provide estimates of forest biomass, height, and the vertical distribution of forest structure with unprecedented accuracy.

In this paper, we presented a quick overview of the main advantages and disadvantages of each technique and their potential for application in forest management. We may conclude that the future is bright in this area and we will see more and more applications being develop soon in response to the needs of our forest practitioners.

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