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A SURVEY ON DIFFERENT FEATURES AND TECHNIQUES FOR FOREST HEIGHT ESTIMATION

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Abstract: - As large set of geographical information is available on the servers, so information analysis plays an important role in today era. Keeping this goal in mind paper focus on forest height estimation from different geographical data like TANDEMX, DTM, DEM, etc. Here detail survey of different vegetation, forest density, height techniques is study with their features. As various approaches are developed in this field by different researchers with their different requirements. So complete study of this forest height estimation is done in this work.

***Index Terms*: -** Image Processing, Forest Height, SAR Image, TANDEMX.

I. INTRODUCTION

Satellite remote sensing has a potential for increased use in monitoring forest logging [1–5]. Forest logging activities today cover large areas, which in many cases are hardly accessible for field inventories, and satellite remote sensing appears to be the only feasible approach to cover the monitoring needs. From a forest management perspective we may distinguish two needs for monitoring of logging. In tropical countries a monitoring is required within the REDD+ (Reducing Emissions from Deforestation and Degradation) framework for detection of illegal logging and for documentation of changes in forest biomass carbon stores. Deforestation and degradation has been going on at a high speed in tropical countries for decades and is a major source of carbon dioxide emissions [6]. In other countries such as Norway logging is part of a sustainable timber production, however; there are certain restrictions on clear-cutting. There are thresholds for the size of clear-cut areas, and forest owners are mandated to ensure regeneration after clear-cutting. Forest authorities need monitoring of clear-cut areas in order to check that forest owners comply with these regulations. Several methods for remote sensing of clear-cutting exist, based on a variety of space- and air-borne sensors and methods [7]. For example, in Sweden clear-cut detection has been carried out with SPOT optical imagery, where new clear-cuts are detected as having an increased brightness in the short-wave infrared (SWIR) band caused by reduced shadowing [7]. A novel method is developed in Sweden based on ALOS PALSAR, where new clear-cuts are seen as having a decrease in the L-band SAR backscatter intensity [8]. High InSAR coherence has been used to detect non-forested areas and new clear-cuts [9,10] and other severe disturbances such as storm damage [13]. In tropical regions, the PRODES project in Brazil is an effort that has been going on for several years based on annual, full-coverage Landsat imagery where clear-cuts are detected from a semi-automatic pixel-

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unmixing classification based on soil and shadow fractions [10]. Although methods like these may work well in many cases, they have certain limitations. Applications based on optical data are limited by clouds. Particularly in some tropical forest areas there is a persistent cloud cover [4]. Another type of detection problem is a result of an increasing share of forest logging being carried out as various types of partly logging, at the expense of complete clear-cutting. In tropical countries deforestation is partly replaced by forest degradation. In countries like Norway, there is an on-going trend to increase the amount of trees left after logging. This is a result of increasing attention to bio-diversity and landscape qualities in forest management (e.g., [5]). The majority of trees are still logged and the logging is still considered as clear-cutting. Partly logging is less detectable with remote sensing based on spectral properties, backscatter intensity, and InSAR coherence. The remaining trees after logging have similar spectral properties as the forest before logging. Short wavelength SAR, i.e., X- and C-band, has a minor penetration into a forest canopy, and backscatter intensity and coherence may show only minor changes after partly logging.

II. TanDEM-X

The TanDEM-X mission concept is based on an extension the TerraSAR-X mission by a second almost identical satellite, namely TanDEM-X. Flying the two satellites in a close formation with typical cross-track distances of 300-500 m provide a flexible **single-pass SAR interferometer configuration**, where the baseline can be selected according to the specific needs of the application.

The SAR (Synthetic Aperture Radar) instruments of TerraSAR-X and TanDEM-X are fully compatible, both offer transmit and receive capabilities along with polarimetry. These features provide a maximum of flexibility in supporting operational services (acquisition of highly accurate cross-track and along-track interferograms without the inherent accuracy limitations imposed by repeat-pass interferometry) and in data product quality. The following basic interferometric SAR (InSAR) observational modes are available (Figures 2 and -3):

1) Bistatic mode where the SAR instruments of both spacecraft look into a common footprint thus providing different views of the observed target area (Note: bistatic InSAR is characterized by the simultaneous measurement of the same scene and overlapping Doppler spectra with 2 receivers, avoiding temporal decorrelation; PRF synchronization and relative phase referencing between the satellites are mandatory). **-** One satellite serves as a transmitter and both satellites record the scattered signal simultaneously. In this tandem configuration, both spacecraft fly in a close orbit formation. The baseline of this configuration can be selected according to the specific needs of the application. This enables the acquisition of highly accurate **single-pass cross-track and/or along-track interferograms** without the inherent accuracy limitations imposed by repeat-pass interferometry due to temporal decorrelation and atmospheric disturbances.

2) Pursuit monostatic mode where both satellites are operated independently avoiding the need for synchronization; hence, both SAR instruments look acquire data from the same swath with a short time difference of a few seconds corresponding to an along-track distance of 30-50 km. Different to conventional **repeat-pass** (i.e., two-pass or multi-pass) InSAR observations, the temporal decorrelation is still small for most terrain types with the exception of ocean surfaces and vegetation in the case of moderate to high wind speeds.

3) Alternating bistatic mode is similar to bistatic mode, but the transmitter is switched from pulse to pulse between the two satellites.

The baseline for operational DEM generation is the **bistatic mode** which minimizes temporal decorrelation and uses efficiently the transmit power. This mode uses either TSX or TDX as a transmitter to illuminate a common radar footprint on the Earth's surface. The scattered signal is then recorded by both satellites simultaneously. This simultaneous data acquisition makes dual use of the available transmit power and is mandatory to avoid possible errors from temporal decorrelation and atmospheric disturbances.

The alternating bistatic mode can be used for phase synchronization, system calibration, and to acquire interferograms with two different phase to height sensitivities; the simultaneously acquired monostatic interferogram has a higher susceptibility to ambiguities especially at high incident angles.
A mission concept has been developed which enables the acquisition/generation of a global DEM within three years. This concept includes multiple data takes with different baselines, different incidence angles, and data takes from ascending and descending orbits to deal with difficult terrain like mountains, valleys, tall vegetation, etc.

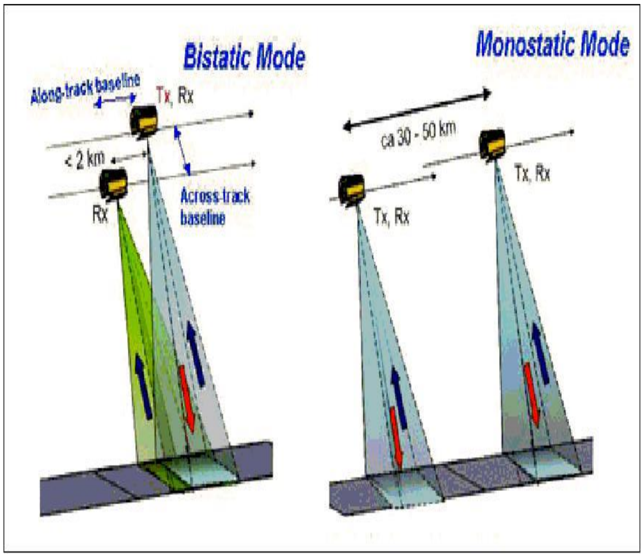

Figure 1: Concept of TanDEM-X InSAR observations in bistatic (left) and monostatic (right) modes

(Image credit: DLR)

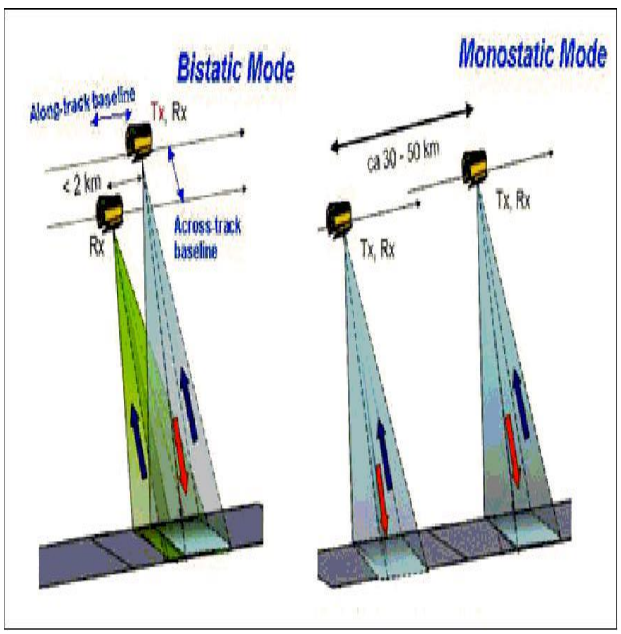

Figure 2: Schematic view of the alternating bistatic mode (image credit: DLR)

The TanDEM-X mission concept allocates also sufficient acquisition time and satellite resources to secondary mission objectives which cover the following application spectrum:
• Moving target indication with a distributed four aperture displaced phase center system
• The measurement of ocean currents and the detection of ice drift by along-track interferometry
• High resolution SAR imaging based on a baseline-induced shift of the Doppler and range spectra (super-resolution)
• The derivation of vegetation parameters with polarimetric SAR interferometry
• Large baseline bistatic SAR imaging for improved scene classification, as well as localized very high-resolution DEM generation based on spotlight interferometry.
• Demonstration of high resolution wide-swath SAR imaging with four-phase-center digital beamforming.
In short, the TanDEM-X mission concept encompasses enabling technologies in a number of ways, including the first demonstration of a bistatic interferometric satellite formation in space, as well as the first close formation flight in operational mode. Several new SAR techniques will also be demonstrated for the first time, such as digital beamforming (DBF) with two satellites, single-pass polarimetric SAR interferometry, as well as single-pass along-track interferometry with varying baseline.

III. Different Techniques

In Praks et al. (2012), the scattering phase center (SPC) location for airborne X- and L-band data in boreal forests was investigated. For X-band, the SPC was typically about 75% of the canopy height (measured with ALS), which is in line with Perko et al. (2011) who suggested 70%-75%. An RVoG model was applied and they found that at X-band, the ground contribution could most likely be assumed negligible for canopies possessing tree heights exceeding 10 m. Compared to ALS height measurements the RMSE was close to 1.5 m in homogeneous regions.

Hurtado (2012) evaluated this approach with TanDEM-X InSAR data and found the R2 to be 0.62 for the interferometric forest height estimation of ALS height. The performance of biomass estimation from Pol-InSAR data was tested in Neumann et al. (2012). Airborne P- and L-band data were used with an RVoG model approach at the Swedish test site Krycklan and the most successful estimations were found with L-band data. It was found that the intensity at HH-VV was more sensitive to biomass than any other polarization at L-band. In contradiction to some earlier reported studies, it was also found that the incidence angle and topography dependence had a large impact on the results. This might be due to the fact that P- and L-band data were utilized, where the ground contribution and therefore its topography becomes more pronounced.

In Solberg et al. (2013), TanDEM-X InSAR data were used to evaluate the interferometric height sensitivity to spruce tree volume and biomass. They found the stem volume and AGB to be proportional to the interferometric height, with 19-20% RMSE at stand-level. A crucial finding in this study was the possibly linear relation between the interferometric height and stem volume, as this stands in contradiction to earlier studies claiming curvilinear relationships (Askne et al. 1997; Mette et al. 2004; Woodhouse 2006). A possible explanation given was that stand volume and AGB might be linearly related to the canopy height while it could be curvilinearly related to the mean tree height and top height (H100; recall Section 1.1.1).

Askne et al. (2013) compared IWCM, RVoG and a penetration-depth (PD) model for AGB estimations from TanDEM-X data. 50 They found the RMSE to be between 17% and 33% at stand-level with IWCM, 17% and 40% with RVoG and 18% and 33% with PD. Their results validated the finding by Solberg et al. (2013), however this should be evaluated in a wider range of environmental conditions. Space borne SAR systems rarely offer fully Pol-InSAR data but rather “compact” Pol-InSAR with, for example, only two polarizations.

Arnaubec et al. (2014) evaluated the precision of vegetation height estimations when an RVoG model was applied to P-band data at different or many polarizations. It was found that a loss in vegetation height precision could be calculated, independent of estimation method, when derived from an adaptation of the Cramer-Rao bound. It is possible that a similar theoretical derivation could be done for X-band data.

Kugler et al. (2014) check the performance of "compact" Pol-InSAR with TanDEM-X data was thoroughly, where forest height was the primary estimated parameter. They evaluated single- and dual-polarization cases against ALS forest heights by applying a two-layer RVoG model, at the test sites Krycklan (in northern Sweden), Traunstein (in southern Germany) and Mawas (a tropical test site in Indonesia). The lowest RMSE was found at the Swedish test site, with 1.58 m and with r 2 =0.91 for the single-polarization inversion. The dual-polarization inversion was noisier but still had an RMSE=2.02 m and r 2 =0.86. They noticed a topographic influence on the inversion performance at the Krycklan test site. It was concluded that the correlation between the SPC and tree top was strong but varied with seasonal and environmental changes. They only noticed weak effects of the incidence angle on the penetration, but in general the penetration was surprisingly high for being from X-band. It was not made clear if the deep penetration was due to actual penetration through the vegetation volume or due to gaps in the vegetation layer.

IV. Methods Based on Remote Sensing Techniques

Remote sensing techniques, both passive and active, have been widely and actively used for extracting forest parameters and detecting changes. The aim is to obtain forest variables at the lowest possible cost, yet providing accurate estimates over a large area.

Aerial photography and digital images since the late 1920s, aerial photographs and more recently digital/digitized aerial images have been used in forestry as a tool to support the monitoring and management of forest resources and as an integral part of most forest inventory procedures. The approach has been used in a variety of ways to determine the dimensions, form, volume, growth and species of trees. Of the information desired on trees and stands, tree height the extraction of information from aerial photographs traditionally utilized a visual interpretation method based on color, shape, texture and context information. However, automatic methods were also proposed along with the development of digital camera and digital photogrammetric techniques. A review of aerial photograph used for vegetation attribution determination was published by Fensham and Fairfax (2002).

Satellite optical remote sensing methods

Since the launch of the first earth observation satellite, the usefulness of various types of optical satellite image data for forest applications has been widely studied. Coarse spatial resolution AVHRR/NOAA images have been used most commonly for mapping forest and detecting land cover changes on the regional or global scale

Radar Active synthetic aperture radar (SAR) is the sensor type which images volumes of vegetation rather than reflectance from the surface of the canopy. The transmitted microwave radiation penetrates the vegetation canopy to a depth depending on the wavelength and polarization. The imaging processing makes SAR suitable for mapping parameters related to forest biomass, such as stem volume. Furthermore, SAR works in almost all weather conditions (Bovolo and Bruzzone, 2005). Forest attributes are usually determined with statistical regression techniques or physical modeling to relate the backscatter, coherence or interferemetric of SAR/INSAR with forest attributes such as tree height or volume.

Airborne laser scanning over the past few years, ALS has become a very important technique in various forest applications, such as generation of high quality digital terrain model (DTM) in forested area. From individual trees, the height, crown diameter and tree species are then derived using ALS and possibly with aerial image data. A comparison of optical airborne and space borne instruments and laser scanning can be found in Hyyppä and Hyyppä (1999), prompting confidence about the future of ALS in forests.

Automatic terrestrial measurements Side by side with airborne and space borne remote sensing methods, rapid technological development has made terrestrial laser measurements a complementary way of performing accurate forest measurements. Terrestrial laser scanners are capable of recording sample plots with extremely high accuracy

(Watt et al., 2003; Hopkinson et al., 2004; Thies and Spiecker, 2004; Thies et al., 2004), but are not yet practicable because of the high cost of data processing and the large volume of data. However, this is a potential way of establishing changes in stems in future. At the moment, automatic terrestrial measurements can be seen as complementary techniques for operative stand wise forest inventory; they provide an accurate reference for developments in airborne remote sensing but do not replace the need for airborne data over large areas.

V. CONCLUSIONS

In this paper a deep study of different forest height estimation techniques is explain with their requirement area. In those techniques different features of image is utilize for different analysis. Paper has given brief explanation of the different type of image for analysis. Paper has given TANDEMX images methods for developing and analysis. So a robust and fast algorithm is the requirement of the field which provide effective forest height estimation.

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