MAPPING REMOTE PLANTS THROUGH REMOTE SENSING TECHNOLOGY AND GIS

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Abstract: **Remote sensing implies to the collection of data about an object from a distance. With the use of LiDAR remote sensing technology, the three dimensional distribution of plant canopies and vegetation structural attributes can be accurately estimated. The measure of difference in reflectance from leaves of plants, due to the presence of chlorophyll pigments in different ratios, can be helpful to locate and characterize the plant remote location through remote sensing technology and Geographic Information System (GIS). The present study highlights the importance of remote sensing technology and GIS in detection of herbs located distantly.**

Key Words — Remote sensing, GIS, LiDAR, Spatial resolution

I. INTRODUCTION

A. Remote Sensing Technology

Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them. This process involves making observations using sensors mounted on platforms (aircraft and satellites), recording the observations on a suitable medium (images on photographic films and digital data on magnetic tapes). When electromagnetic radiation falls upon a surface, some of energy is absorbed, some transmitted through the surface, and the rest is reflected. Surfaces also naturally emit radiation, mostly in the form of heat. This reflected and emitted radiation is recorded either on the photographic film or digital sensor. Since the intensity and wavelengths of this radiation are a function of the surface, each surface is described as processing a characteristic ″Spectral Signature″[1]. If an instrument can identify and distinguish between different spectral signatures, then it will be possible to map the extent of surfaces (Figure 1).
The two main types of remote sensing: Passive (film photography, radiometers etc.) detect natural radiation that is emitted or reflected by the object or surrounding area being observed, while Active emits energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. RADAR
and LiDAR are active remote sensors where the time delay between emission and return is measured, establishing the locations, height, speed and direction of an object [2].

The mode of satellite can be geostationary, permitting continuous sensing of a portion of the earth or sun, synchronous with polar orbit covering the entire earth at the same equator crossing time. Sensors installed on satellites, used for making observations, consist of mechanisms usually sophisticated lenses with filter coatings to focus the area observed onto a plane in which detectors are placed. These detectors are sensitive to a particular region in which the sensor is designed to operate and produce outputs, which either represent observed area as in the case of the camera or produce electrical signals proportionate to radiation intensity.

B. Use of LiDAR sensor

Light detection and ranging is an optical remote sensing technology that can measure the distance or other properties of a target by illuminating the target with light, often using pulses from a laser. Wavelengths from a range about 10µm to UV range are used to suit the target. Typically light is reflected via back scattering. Different types of scattering are used for different LiDAR applications. Most common are Rayleigh scattering, Raman scattering, as well as fluorescence, and thus the LiDAR can be accordingly called as Rayleigh LiDAR, Raman LiDAR and Na / Fe / K Fluorescence LiDAR and so on [3]. Suitable combinations of wavelengths can allow for remote mapping of atmospheric contents by looking for wavelength dependent changes in the intensity of the returned signal.
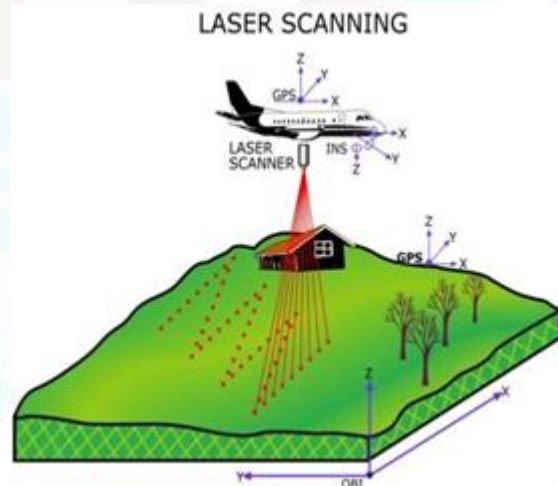
Figure 1. Schema of remote sensing technology
The quality of remote sensing data by LIDAR sensor consists of its spatial, spectral, radiometric and temporal resolutions.

Spatial resolution: It is a measure of the smallest angular or linear separation between two objects that can be resolved by the sensor. The greater the sensor's resolution, the greater the data volume and smaller the area covered. In fact, the area coverage and resolution are interdependent and these factors determine the scale of the imagery. The size of a pixel that is

recorded in a faster image may correspond to square areas ranging in size length from 1 to 1,000 m.

Spectral resolution: It refers to the dimension and number of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive. Narrow bandwidths in certain regions of the electromagnetic spectrum allow the discrimination of various features more easily.

Temporal resolution: It refers to how often a given sensor obtains imagery of a particular area. Ideally, the sensor obtains data repetitively to capture unique discriminating characteristics of the phenomena of interest.

Radiometric sensitivity: It is the capability to differentiate spectral reflectance from various targets. This depends on the number of quantization levels within the spectral band. The number of bits of digital data in the spectral band will decide the sensitivity of the sensor.

3. How LiDAR sensor can help in locating herbs at distinct location?

Plants are green because they have a substance called chlorophyll in them:

Chlorophyll a: The most abundant pigment in plants, and absorbs light with wavelengths of 430 nm (blue) and 662 nm (red). It reflects green light strongly so it appears green to us.

Chlorophyll b: This molecule has a structure similar to that of chlorophyll a. It absorbs light of 453 nm and 642 nm maximally. It helps increase the range of light a plant can use for energy.

Carotenoids: This is a class of accessory pigments that occur in all photosynthetic organisms, & absorb light maximally between 460 nm and 550 nm and appear red, orange, or yellow to us.
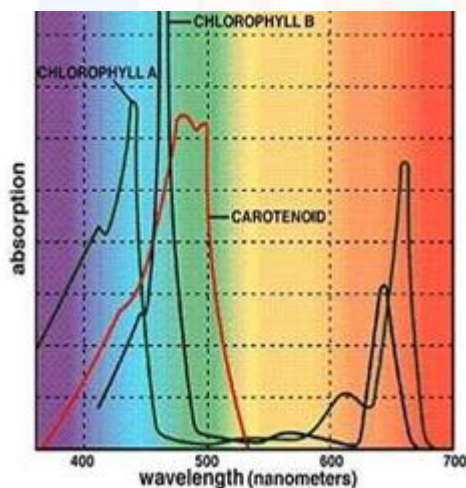
Key differences among lidar sensors are related to the laser's wavelength, power, pulse duration and repetition rate, beam size and divergence angle, the specifics of the scanning mechanism (if any), and the information recorded for each reflected pulse. Lasers for terrestrial applications generally have wavelengths in range of 900–1064 nm, where vegetation reflectance is high. In the visible wavelengths, vegetation absorbance is high and only a small amount of energy would

be returned to the sensor (Figure 2). One drawback of working in this range of wavelengths is absorption by clouds, which impedes the use of these devices during overcast conditions. Bathymetric lidar systems (used to measure elevations under shallow water bodies) make use of wavelengths near 532 nm for better penetration of water

The power of the laser and size of the receiver aperture determine the maximum flying height, which limits the width of the swath that can be collected in one pass [4]. The intensity or power of the return signal depends on several factors : the total power of the transmitted pulse, the fraction of the laser pulse that is intercepted by a surface, the reflectance of the intercepted surface at the laser's wavelength, and the fraction of reflected illumination that travels in the direction of the sensor. The laser pulse returned after intercepting a morphologically complex surface, such as a vegetation canopy, will be a complex combination of energy returned from surfaces at numerous distances, the distant surfaces represented later in the reflected signal. The type of information collected from this return signal distinguishes two broad categories of sensors. Discrete-return lidar devices measure either one (single-return systems) or a small number (multiple-return systems) of heights by identifying, in the return signal, major peaks that represent discrete objects in the path of the laser illumination. The distance corresponding to the time elapsed before the leading edge of the peak(s), and sometimes the power of each peak, are typical values recorded system [4]. Waveform recording devices record the time-varying intensity of the returned energy from each laser pulse, providing a record of the height distribution of the surfaces illuminated by the laser pulse [5][6][7]. By analogy to chromatography, the discrete-return systems identify, while receiving the return signal, the retention times and heights of major peaks; the waveform-recording systems capture the entire signal trace for later processing (Figure 3.)
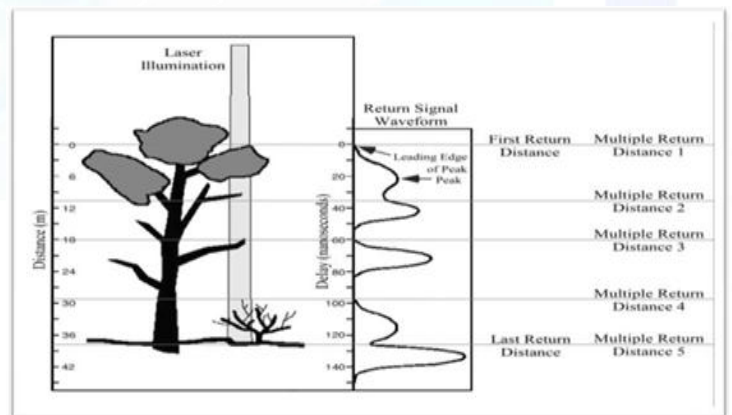

Figure 3. Illustration of the conceptual differences between waveform recording and discrete-return lidar devices. At the left is the intersection of the laser illumination area, with a portion of a simplified tree crown. In the center of the figure is a hypothetical return signal (the lidar waveform) that would be

collected by a waveform-recording sensor over the same area. To the right of the waveform, the heights recorded by three varieties of discrete-return lidar sensors are indicated. First-return lidar devices record only the position of the first object in the path of the laser illumination, whereas last-return lidar devices record the height of the last object in the path of illumination and are especially useful for topographic mapping. Multiple-return lidar, a recent advance, records the height of a small number (generally five or fewer) of objects in the path of illumination.

Both discrete-return and waveform sampling sensors are typically used in combination with instruments for locating the source of the return signal in three dimensions. These include Global Positioning System (GPS) receivers to obtain the position of the platform, Inertial Navigation Systems (INS) to measure the attitude (roll, pitch, and yaw) of the lidar sensor, and angle encoders for the orientation of the scanning mirror(s). Combining this information with accurate time referencing of each source of data yields the absolute position of the reflecting surface, or surfaces, for each laser pulse. There are advantages to both discrete-return and waveform recording lidar sensors. For example, discrete-return systems feature high spatial resolution, made possible by the small diameter of their footprint and the high repetition rates of these systems (as high as 33,000 points per second), which together can yield dense distributions of sampled points. Thus, discrete-return systems are preferred for detailed mapping of ground [8] and canopy surface topography.

An additional advantage made possible by this high spatial resolution is the ability to measure the reflectance from leaves of different herb species, and aggregate the data over areas and scales specified during data analysis, so that specific locations on the ground and the specific specie can be distinguished from other species due to presence of chlorophyll in different ratio among plants, such as a particular forest inventory plot or even a single tree crown, can be characterized. Finally, discrete-return systems are readily and widely available, with ongoing and rapid development, especially for surveying and photogrammetric applications [8]. The primary users of these systems are surveyors serving public and private clients, and natural resource managers seeking a cheaper source of high-resolution topographic maps and digital terrain models (DTMs). A potential drawback is that proprietary data-processing algorithms and established sensor configurations designed for commercial use may not coincide with scientific objectives.

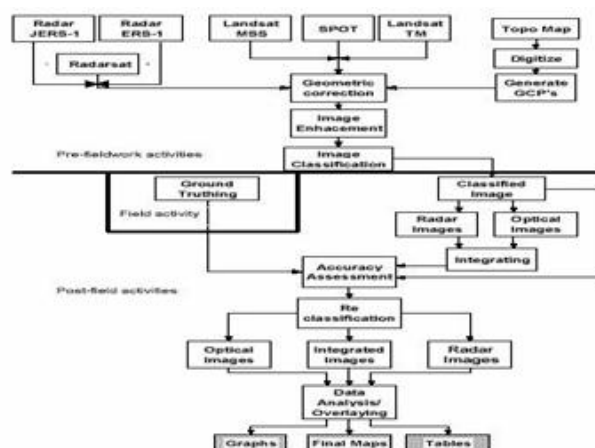4. Analysis of Data generated through GIS Software

Figure 4. Flow chart for studying the ecosystem changes using satellite data and GIS [9]
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A Geographical Information System (GIS) is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modeling, representation and display of geo referenced data to solve complex problems regarding planning and management of resources. Functions of GIS include data entry, data display, data management, information retrieval and analysis. The applications of GIS include mapping locations, quantities and densities, finding distances and mapping and monitoring change. Esri's **ArcGIS** is software for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database. This software can be helpful to analyze the data in image format and help in characterizing the specific herb species from other species at remote locations.

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