Abstract

The remote sensing phenomenon is based on the principle of getting information about the object without any physical contact. Remote sensing techniques for Earth observation have become a reality with the development of space-borne sensors. Microwave in remote sensing is widely promoted due to their ability to penetrate cloud, even the top layer of the soil surface, as well as provide day and night coverage of Earth features. The use of the microwave region of the electromagnetic spectrum in remote sensing has different capabilities that enhance remote sensing technologies utilized in other spectral regions. For instance, microwave interaction mechanism with different Earth surface features is usually governed by their structural (i.e., size, shape, orientation, and density) and physical (i.e., leaf area index, water content, biomass, soil moisture, and dielectric constant) properties.

In microwave remote sensing, the amount of energy scattered off the target is the key to understanding the target properties and is represented by the target scattering coefficient. In the last few decades, significant advancements have been made in developing theoretical microwave scattering models for interpreting experimental data and field measurements to validate the model. Our key research interests in bistatic radars for active remote sensing include the electromagnetic modeling, simulation, and data retrieval of vegetated fields and rough soil surfaces.

This thesis presents an optimization technique for an indigenously designed bistatic scatterometer system to interpret target scattering response and information retrieval of land bio-geophysical parameters. The theoretical microwave scattering model embedded with the geometric configuration of the bistatic scatterometer system, frequency, polarization, and physical properties of the target is developed and used to simulate the bistatic scattering coefficient of the target. The developed model is also utilized to interpret the experimental results and understand the interaction mechanism for microwave electromagnetic signals

with the complex targets, such as vegetated rough soil surfaces. The radiative transfer theory has been extensively used in the interpretation of the experimental data obtained from the vegetated rough soil surface at the ground altitude. The decomposition of the single and multiple scattering components utilizing the radiative transfer theory allows the interpretation of the dominant scattering component with respect to temporal change in the physical and structural properties of the target. For vegetative terrain, volume and multiple scattering play a crucial role at high frequencies of electromagnetic wave scattering. In addition, at low frequencies, the rough soil surface scattering plays an important role. The theoretical model emphasizes wave scattering from the rough surface when volume scattering is not considered. The parametric function and empirical relations are used to connect the scattering model with target parameters which facilitate efficient and accurate interpretation of the target information retrieval by inverting the model. The retrieval of the desired vegetation and land surface information helps to better understand the environmental dynamics at a local and global scale. Specifically, the possibility of bistatic radar for vegetation biophysical and soil moisture retrieval is explored using electromagnetic scattering models that give bistatic scattering simulations. The sophisticated electromagnetic scattering models are excellent for describing the complex scattering phenomenon based on physics, their structural properties, and mathematics, but it involves so many parameters that do not exist for each observed pixel for retrieval. Therefore, the inversion of these electromagnetic scattering models is computationally complex and tedious for desired target information retrieval. In the scientific field of remote sensing, machine learning approaches have also been employed to overcome the complexity of the electromagnetic scattering model. In our study, the potential of machine learning technique (i.e., support vector machine) is also evaluated for vegetation biophysical parameter retrievals.

The experimental findings presented in the thesis may be used as a reference to find the optimum parameters, such as incidence angle, polarization, and frequency, for future advancements in the bistatic radar system to monitor vegetation/land scattering response more authentically ever before. The bistatic scattering simulation finding and retrieval of vegetation biophysical and land surface parameters utilizing the microwave scattering model have shown excellent potential for monitoring vegetation health and surface characteristics.

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