3D LiDAR POINT CLOUD PROCESSING USING STATISTICAL AND MACHINE LEARNING METHODS FOR PRECISION AGRICULTURE

A thesis submitted

in partial fulfilment for the degree of

Doctor of Philosophy

by

REJI J

Department of Earth and Space Sciences

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

Thiruvananthapuram – 695547

February 2023

ABSTRACT

Within the context of precision agriculture, site-specific crop management has been emerging as the globally relevant, environmentally sustainable and economically beneficial agronomic paradigm. In pursuing this, field-sensitive optimal agronomic practices related to crop monitoring, management, and intervention procedures are undertaken by acquiring spatially contextual information on inter and intra-field variability of crops' condition and growth. Field-level data on the crop type, growth status and potential trajectories of crops' traits form core information capsules in the decision-making process for arriving at responsive implementation strategies. Optical remote sensing data, both multispectral and hyperspectral, have been widely used for crop classification and biophysical characterization at various scales and spatial extents. However, the limited levels of diversity in the spectral characteristics and lack of structural features in optical remote sensing data constrain discrimination and biophysical characterization of crops with reasonably good accuracy and spatial scale.

LiDAR remote sensing is an evolving approach that offers distinct structural features of objects. Understanding the potential of LiDAR data (generally called point cloud) for discrimination and biophysical characterization of crops is vital for assessing its relevance in precision agriculture. Terrestrial laser scanner (TLS) offers the possibility of acquiring LiDAR point cloud at the plant scale in an agricultural field. With an overarching aim of estimating biophysical parameters (plant height, crown area, biomass), discriminating crops at plant level and predictive modelling of crop growth, the objectives of this research are (1) multi-temporal estimation of biophysical parameters of crops at different levels of nitrogen using TLS point cloud, (2) to develop a deep learning (DL) based methodology for multi-crop point cloud classification of crops, (3) examining the potential of fusing TLS point