Advancements in Multi-temporal Remote Sensing Data Analysis Techniques for Precision Agriculture

Abstract: Demand in agriculture production will increase more than 50% by 2050 according to the Food and Agriculture Organization (FAO), which will create an imbalance between food demand and supply. In this regard, an essential aspect of FAO's manifesto, defined by its strategic aims, is focused on contributing towards more productive and sustainable agriculture. Precision agriculture has the potential to deal with this demand, which includes a set of tools that incorporate information acquisition, analysis, management, and deployment to help in making site-specific decisions, with the objective of maximizing production while reducing environmental noise generated by overuse of fertilizers and chemicals. Recent developments in Remote Sensing (RS) sensors and geospatial technologies are the leading sources of agriculture-related information - in the form of vegetation indexes. This goes on wards in maintaining the near real-time constraints whilst supplementing cost-effective methods of monitoring agriculture resources. There has been a rising demand for multi-temporal remotely sensed imagery to exploit vegetation dynamics. Among crops, grape production has been considered one of the most profitable asset in the agriculture sector and developing in many countries, as well organized competitive and high-value industry. Proper knowledge of the spatial variability in vineyards is considered as a key factor for vine growers to estimate the outcomes in terms of yield and quality. Monitoring vegetation status during the crop phenological cycle through means of remotely sensed data is beneficial for the winegrowers. This thesis aims at the multi-temporal analysis of remote sensing data and introducing new methodologies to address critical applications in the precision agriculture domain.

The first part is focused on the viticulture related application in which the three main problems are discussed which are 1) Vigor variability assessment of vineyards is performed by using Unmanned ground vehicle (UAV) and satellite-based multi-spectral imagery with a comparison. Advanced vegetation indices are extracted from UAV imagery to understand the influence of inter-row and vine canopies contribution in the moderate resolution satellite imagery. 2) RGB imagery acquired from UAV is used to generate a Path plan for the Unmanned Ground Vehicle (UGV) to move autonomously in a vineyard. 3) Vegetation index derived from freely available moderate spatial resolution satellite imagery

refined by using UAV imagery for the vineyard environment. Results of proposed advanced remote sensing methods proved their potential in improving the agricultural practices and decision making for site-specific vineyards, and these can be integrated with the existing practices to improve the production and quality.

The second part of the dissertation is to exploit the use of freely available sentinel-2 satellite imagery to improve the previous remote sensing methods used to address applications in precision agriculture. Two tasks are discussed in this part. 1) A new Recurrent-Convolution Neural Network (R-CNN) based approach is presented to classify different land covers and crop types by learning temporal features from sentinel-2 time series data. The results show considerable improvement as compared with the other mainstream methods. 2) A multi-temporal data analysis is performed to find a relationship between several vegetation indices derived from sentinel-2 image time series and biophysical parameters such as Above Ground Biomass and height of Maize crop.