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Spring Wheat Yield prediction based on UAV Imagery

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ABSTRACT

This report is a part of the vPheno (virtual phenotyping) project at NMBU that started in 2017. The aim of the project is to reduce the time it takes to develop more robust cultivars. So, using the data that has been collected as part of this project from 2017, I tried to develop machine learning models to predict the grain yield of spring wheat, using the data extracted from the images taken by Unmanned Aerial Vehicles (UAVs). The features extracted from the images were fed into the machine learning algorithm that predicted the yield. The results are discussed, and suggestion are included to improve the data collection methods and, consequently, the results for future studies.

1 INTRODUCTION

Wheat is the most important food source all around the world [Igrejas and Branlard 2020]. The global demand for wheat is projected to more than double by the year 2050 [Tilman et al. 2011]. This stresses the need for the increase in yield of food crops.

There are several methods for increasing the yield of wheat, e.g. cross breeding and selection. The most common and traditional is based on the yield of the crop.

The crop is cultivated, yield is calculated which is used to make decision if that crop is to be used for breeding or not. This is a very time-consuming process and involves a substantial cost as well. In this fast pace innovation age, there is a high demand to speed up the processes that can improve yield.

Remote sensing systems can be deployed to get the information in real time and then the data collected can be used to predict the yield. One such technique is to deploy Unmanned Aerial Vehicles (UAVs) to gather data from the field. That data is used to then predict different characteristics of the plants. Those traits include grain yield as well. My goal is to develop a model which can predict the yield of the crop with greater accuracy.

redefine goal

Since cultivated land is limited and it costs a lot to cultivate barren land, the better approach would be to focus on increasing the yield from the existing cultivable land. Moreover, cultivating more land would naturally cost more than cultivating less land and increasing productivity. So, the reason and motivation behind plant phenotyping is to increase the yield from the same fields. Regular phenotyping approaches are slow and costly. Using remote sensing for this purpose can be fast and cheap. That is the motivation behind the vPheno project at NMBU that aims at reducing the cost of the process to experiment with different varieties of wheat and enable them to do accurate selection of potential varieties of wheat. Machine learning algorithms will be used for this purpose.

This report contributes to the research project vPheno (virtual phenomics) at the Faculty of Bioscience at NMBU. The project, started in 2017, aims to help plant breeders reduce the time required to select better, high yield varieties of crops and speedup the process using image analysis techniques. Earlier results related to this work have been reported by Burud and Bleken [2017], Grindbakken [2018] and Lied [2019]. This report explores a different way of combining data, collected for different fields at different occasions. Moreover, including data for the year 2019 as input as well that has recently become available.

Include 2020 data as well, probably or just use robot.

The objective of this report is to generate a machine learning model that can predict the grain yield of wheat based on the image data collected from the field at different times during the season.

After this paragraph, provide a brief overview over the paper: what is in which section?

2 THEORY

2.1 Plant Phenotyping

Plant phenotyping is the study of how traits of the plants, termed as phenome, develop from their interaction with the environment and how their genome can be related to those traits [Minervini et al. 2014]. These traits include, among others, the plant yield, maturity time, plant height, etc. The importance of phenotyping has increased significantly with the increased demand for improving the yield. Plant phenotyping investigates how a plant's genome affects the observable traits of a plant (phenome). It is becoming increasingly important in our quest towards efficient and sustainable agriculture. While sequencing the genome is becoming increasingly efficient, acquiring phenotype information has remained of low throughput. Image based phenotyping are fast and nondestructive. They can predict the results and save time to make decision about the choice of the variety of wheat to be chosen for the next phase

2.2 Spectral Indices

Spectral indices are derived values from one or more reflection bands. The are several different spectral indices. The ones related to plants are called vegetation indices. We are focusing on the ones that can be derived from the spectral bands data we have for the project. The relevant vegetation indices and the formula to calculate them are as follows.

The MERIS terrestrial chlorophyll index – MTCI

$$MTCI = \frac{NIR - RedEdge}{RedEdge - Red}$$

Normalized difference vegetation index – NDVI

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Enhanced vegetation index - EVI

$$EVI = 2.5 \times \frac{NIR - RED}{NIR + (6 \times RED) - (7.5 \times BLUE) + 1}$$