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Spatio-temporal analysis of remote sensing and field measurements for smart farming

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Abstract

For the optimization of crop yield and quality, there is an ongoing development in improving crop management advice, in order to cope with the spatial variability of the growth process, caused by local variations in, amongst others, soil composition, moisture and nutrition content. To achieve this improvement, reliable information is required on the actual status of the vegetation and the expected development and yield given different management scenarios. Remote sensing observations form a valuable information source for assessing the location of suboptimal growth, but hardly ever provide the cause of the arrearage. In order to determine this cause, the observations must be combined with other observations and models and analyzed integrally. This article presents the followed approach and initial results of a pilot project Smart Farming carried out in the Dutch North East Polder. Observations and data from several sources have been collected for a number of potato parcels in 2014. The collected data includes multi-temporal satellite and UAS observations, field based soil, vegetation and yield observations, soil type maps, height maps, historic parcel and crop information and meteorological data. A data driven approach was followed to determine the presence of relations between the various observations in order to couple location and probable cause of sub-optimal crop growth and determine temporal developments in series of observations. The available data was analyzed integrally using correlation, regression and histogram analysis techniques. All resulting spatial layers are visually presented in a GIS based web service environment, so that the advisor or farmer can view the raw and derived information interactively and form his/her conclusions.

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Keywords: Remote sensing; Smart Farming; Precicion agriculture; Biophysical properties; Spatio-temporal analysis; Correlation analysis; Regression analysis; Data fusion;

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1. Smart Farming

The agricultural sector in Flevoland (a province of the Netherlands) is both nationally and internationally famous for its cultivation of (seed)-potatoes. The province houses Emmeloord, also known as the "World Potato City". The sector estimates it is the second largest exporter in the world and generates the highest yield per acre worldwide. Nevertheless, it is estimated that the yields can be increased with an additional 10 to 20 percent and the quality of the products can also be increased if the cultivation process is controlled better. An essential element in further improvement is information. Information on when and where which cultivation measures like fertilization, irrigation and pest and disease control measures must be applied.

The goal of this project is the realization of "Task Map 2.0" and "AgroGIS". A task map is a standardized digital instruction which can be used by a dedicated machine to automatically and independently perform different tasks on particular areas of the parcel. Tasks like planting, fertilizing, irrigating, spraying pesticides, etc. The addition "2.0" refers to the fact that in contrast to the current task maps, which are based on one or only a few information sources, "Task Map 2.0" is the result of a comprehensive analysis of as many as possible relevant parcel data, of which a large amount is obtained from open data sources, and biophysical properties; historical yield data, soil properties, crop processing data of the current growth season and observed data for the current growth season like crop scans, laboratory analyses, satellite images, aerial photos and meteorological data. All this data is collected, stored and integrally analyzed in a special information system: "AgroGIS". The analysis consists of finding spatial and temporal relationships using all data layers to indicate sub-optimal crop growth. These relationships are partly established by automatic image optimization and interpretation algorithms and partly by visual inspection of the images by image analysis experts with a background in agriculture. Next specialized crop advisors interpret the information from "AgroGIS" and the found relationships to formulate an advice and construct "Task Map 2.0". The farmer him/herself ultimately decides whether (s)he fully or partially accepts the recommendations of "Task Map 2.0".

2. Project setup and data collection

The Smart Farming project is a collaboration between Dutch research institutes, Dutch industry and Dutch agricultural businesses. This collaboration led to the forming of the Smart Farming consortium: Aequator, BocaVista, Ecoflight, Infram, National Aerospace Laboratory, Profytodsd and Weevers Marknesse. This consortium was formed to investigate the possibility of using remote sensing solutions to gain better control of the cultivation process. Two farmers participated in the project. The parcels of these farmers which were investigated as part of this project are both located in the Dutch North East polder. During the growth season of 2014 one farmer cultivated seed-potatoes and the other farmer cultivated ware-potatoes.

The first steps of this project consisted of the collection of data. Different types of data were used to find relationships which indicate sub-optimal crop growth. The collected data can be divided into four groups:

- Soil: Electric conductivity of substrates, pH-values, organic matter content and lutum content.
- Vegetation: Remote sensing images; Images from Unmanned Aerial Systems (UAS) and satellites.
- Meteorological: Information about approximately 30 weather parameters.
- GIS: Parcel registration, elevation map, soil map and other thematic maps.

3. Data analysis

After the data is collected it is analyzed to find possible spatial and temporal relationships. When these relationships are found they can be visualized to gain more insight in the relationship.