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The Technologies that Aid Soil Doctor

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Introduction

The success of crop production depends mainly on the health of the soil and the potential parameters used to measure the soil health are: soil pH and buffer pH, level of macro-nutrients (nitrogen, phosphorus and potassium), carbon (soil organic matter) content, clay (soil texture) content, soil moisture and temperature, cation exchange capacity, soil compaction, depth of any root restricting layers and soil structure and bulk density [1]. The sensor based technologies are involved to modify the traditional laboratory based soil assessment methods after 1990. Different types of sensors are manufactured to analyze various soil properties. Electrochemical sensors are developed for analyzing soil pH and the level of macro-nutrients. Electrical and electromagnetic sensors are designed for identifying soil texture, moisture content, depth variability and cation exchange capacity. The strength of soil organic matter and moisture are determined by the optical and radiometric sensors. The acoustic sensors characterize the soil texture, depth variability and bulk density. Finally the mechanical sensors are used to describe the soil compaction and compacted soil layers [2].

The placement of sensors and the distance between the sensor and soil decide the algorithm, data structure and the research objectives in soil quality analysis. Based on the distance and the type of data obtained by the sensors, the sensing platform is classified as satellite imagery, aerial imagery, laboratory spectrometer, and field spectrophotometer. In general, satellite and aerial images acquire a large coverage and an instantaneous view of study areas with rationally extensive spatial information but a small amount of spectral information (multispectral or panchromatic). The lack of spectral information tends to limit elucidation to qualitative determinations. Spatial comprehensiveness allows researchers to describe soil properties at field and potentially regional scales. Although the spatial resolution is very high in satellite and aerial imageries, the spectral and radiometric resolutions attained by the low-cost compact cameras are relatively low. Moreover, common digital cameras often provide poor radiometric and geometric calibrations. On the other hand, spectroscopic reflectance measurement of soil samples obtain detailed spectral information (hyperspectral), allowing quantitative analysis of soil properties. Soil samples for spectroscopic analysis are usually collected from grid-sampling and thus provide poor spatial resolution.

In recent years, lightweight multispectral and hyperspectral sensors of high quality are mounted on mini-UAV and UAV flights are performed to acquire images of the bare soil in the VIS-NIR and thermal infrared (TIR) regions. The high resolution thematic maps are produced from aerial images based on the meticulous projection of oriented images on the digital surface model (DSM). A digital surface model (DSM) is formed by determining a dense cloud of object points and adjusting the blocks through the identification of matching points among images [3] . In case of crops and ploughed soils where the images consist of regular texture, it is very difficult to search the matching point which is the initial step in photogrammetric workflow.

Automatic commercial software packages are evolving to process the photogrammetric blocks. But the images taken at low altitudes over vegetation and bare-soil are difficult to process by the automatic softwares, because of the target distance and its texture, and of the overlappings along and across strips. Efficiency can be improved by fine tuning the flight planning [4].

Soil analysis studies based on hyper spectral data, mostly use wavelengths in the visible (VIS) and near-infrared (NIR) regions of the electromagnetic spectrum. Most essential spectral signatures of soil components occur in the mid-infrared (MIR) and thermal-infrared regions. However, combinations of essential properties have overtones that can cause spectral signatures in the visible and near-infrared regions, making the VIS and NIR regions potentially useful in determining many soil components. UAV-based optical sensors quantify several important plant traits in a non-destructive way by remotely sensing the Plant soil feedback (PSF) effects in the field [5]. The temporal resolution can be increased through the repetition of sensing over the growing season. Hyperspectral imaging holds promise for use in studying PSF effects at field scale and relevant spatial-temporal resolutions

An algorithm has been developed by researchers from North Carolina State University and the University of Delaware to reconstruct hyperspectral images quickly and accurately using less data. The images are created using instruments that capture hyperspectral information concisely, and the combination of hardware and algorithm makes it possible to acquire hyperspectral images in less time and to store those images using less memory space.

Conclusion

Soil characterization is performed to apply site specific techniques in precision agriculture. High resolution data on bare-soil improve the efficiency of the soil analysis. Nowadays light and low cost optical and thermal cameras are available that can be mounted on lightweight UAV, thus providing an efficient way of collecting high resolution data. But the hyperspectral sensor techniques are not so wide spread due to their costs. Therefore, efforts have been done to reconstruct the hyperspectral images using less data with the help of hardware and algorithms. However, the production of soil or vegetation maps from UAV imagery still presents challenges.

In recent years, extensive and accurate studies were done to enhance and speed up the processing of images and the spatial co-registration, to generate thematic maps of different kinds for soil analysis and agricultural crop monitoring. Moreover, the development of structure based software (rather than motion) provides considerable improvements in accurate and automatic processing of images. The researchers can also integrate the multispectral images acquired by UAV with ground geophysical data to obtain an appropriate soil characterization.

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