CHARACTERIZING AGRICULTURAL SOILS USING MACHINE LEARNING WITH UAV AND GEOPHYSICAL TECHNIQUES

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Multispectral data acquired with unmanned aerial vehicles (UAV) are frequently used in agricultural applications to assess crop health or predict yields. When compared to most ground-coupled geophysical technics, UAV data are easy to collect, inexpensive, easy to process, and have high resolution. However, the penetration depth of UAV data is usually small, and multispectral data are not currently used to monitor soil properties. In this research, multispectral data were acquired using UAVs, while ground-coupled geophysical data were acquired to provide information on soil properties. The geophysical techniques used were ground penetrating radar (GPR), which provided information on soil volumetric water content (VWC), and electromagnetic induction, which provided electrical conductivity (EC) measurements. While multispectral data are not inherently sensitive to VWC or EC, vegetation vigor can be influenced by these properties. Thus, measurements of vegetation vigor from multispectral data have potential to correlate to soil properties. In this research, machine learning (random forest method) was used to predict VWC and EC based upon multispectral data. Results showed that multispectral data can be used to improve prediction of these parameters.

This research was performed at an agricultural research station in an 8.9 ha field with claypan soil. The field was divided into 56 plots that varied by crop type (corn, soybeans, or alfalfa) and by drainage (no tile drainage, moderate drainage, intensive drainage). Multispectral data were acquired over the entire field when the crops were mature, while geophysical data were acquired somewhat earlier. Geophysical data were acquired twice, once when the soil was fairly dry and once when the soil was saturated. Geophysical data were acquired in 18 traverses across the site, and the high-resolution multispectral data were averaged within the footprint of each geophysical technique. Machine learning was performed for both wet and dry conditions and assuming different levels of knowledge about the field; analysis was done assuming the crop type was unknown (all crops combined), assuming the crop type was known (each crop independently), assuming the drainage configuration is unknown, and assuming the drainage configuration was known. Results showed that multispectral data were most accurate in predicting VWC and EC when both crop type and drainage configuration was known, and knowledge of the drainage configuration had more impact on prediction than did crop type. Prediction was more accurate in dry soil than in wet, but this may be partially due to the lower overall variability observed in drier soils. An analysis of the predictive strength of different types of multispectral data (vegetative indices (VI) and raw multispectral data) showed that VI which were most important for prediction of VWC and EC were NDRE, VARI, and blue band data.