Time Series Modeling for Drought Stress Propagation in Plants using Hyperspectral Imagery

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The research introduces a novel algorithm called HyperStressPropagateNet that uses deep neural network based time series modeling to illustrate the qualitative and quantitative propagation of drought stress in a plant using hyperspectral imagery. The hyperspectral cameras typically capture a broad range of wavelengths at very narrow intervals of a few nanometers creating a hyperspectral cube. HyperStressPropagateNet uses spectral band difference-based segmentation method to create the binary mask of the plant which is then used to segment the plant in all bands of a hyperspectral cube to create the reflectance spectra at each plant pixel. The algorithm uses convolutional neural networks to classify the reflectance spectra generated at each pixel into either stressed or unstressed categories to determine the temporal propagation of stress. The limited water availability in the soil is confirmed by changes in the soil water content (SWC) measured using a hand-held device. The excellent correlation between the SWC and the corresponding temporal progression of percentage of stress pixels computed by HyperStressPropagateNet demonstrates the efficacy of the method. The algorithm is evaluated on a dataset of image sequences of cotton plants captured by the hyperspectral camera in the LemnaTec Scanalyzer 3D High Throughput Plant Phenotyping Platform in the University of Nebraska-Lincoln, USA. The excellent performance of the method is established based on evaluations using various metrics, e.g., confusion matrix, precision-recall curve, and F1-score. The method has the potential to be generalized to any plant species to study the effect of abiotic stresses on sustainable agriculture.