Modeling canopy architecture traits using UAS-acquired LiDAR features in diverse maize varieties

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Abstract

Plant growth and development is impacted by the ability to capture resources including sunlight, determined in part by the arrangement of plant parts throughout the canopy. This is a very complex trait to describe, but has a major impact on downstream traits such as biomass or grain yield per acre. Though some is known about genetic factors contributing to leaf angle, maturity, and leaf size and number, these discrete traits do not encompass the structural complexity of the canopy. In addition, modeling and prediction for plant developmental traits using genomics or phenomics are usually conducted separately. We have developed proof-of-concept models that incorporate spatio-temporal factors from drone-acquired LiDAR features in a maize diversity panel to predict plant growth and development over time to improve our understanding of the biology of canopy formation and development. Briefly, voxel models for probability of beam penetration into the foliage were generated from 3D LiDAR scans collected at seven dates throughout crop canopy development. From the same plots, key architectural features of the maize canopy were measured by hand: stand count; plant, tassel, and flag leaf height; anthesis and silking dates; ear leaf, total leaf, and largest leaf number; and largest leaf length and width. We develop a self-supervised autoencoding neural network architecture that separately encodes plant temporal growth patterns for individual genotypes and plant spatial distributions for each plot. Then, leveraging the resulting latent space encoding of the LiDAR scans, we train and demonstrate accurate prediction of hand-measured crop traits.

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NAPPN Annual Conference Abstract: Modeling canopy architecture traits using UAS-acquired LiDAR features in diverse maize varieties

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ABSTRACT

Plant growth and development is impacted by the ability to capture resources including sunlight, determined in part by the arrangement of plant parts throughout the canopy. This is a very complex trait to describe, but has a major impact on downstream traits such as biomass or grain yield per acre. Though some is known about genetic factors contributing to leaf angle, maturity, and leaf size and number, these discrete traits do not encompass the structural complexity of the canopy. In addition, modeling and prediction for plant developmental traits using genomics or phenomics are usually conducted separately. We have developed proof-of-concept models that incorporate spatio-temporal factors from drone-acquired LiDAR features in a maize diversity panel to predict plant growth and development over time to improve our understanding of the biology of canopy formation and development. Briefly, voxel models for probability of beam penetration into the foliage were generated from 3D LiDAR scans collected at seven dates throughout crop canopy development. From the same plots, key architectural features of the maize canopy were measured by hand: stand count; plant, tassel, and flag leaf height; anthesis and silking dates; ear leaf, total leaf, and largest leaf number; and largest leaf length and width. We develop a self-supervised autoencoding neural network architecture that separately encodes plant temporal growth patterns for individual genotypes and plant spatial distributions for each plot. Then, leveraging the resulting latent space encoding of the LiDAR scans, we train and demonstrate accurate prediction of hand-measured crop traits.