Maize Yield Prediction Based on Multi-Modality Remote Sensing and Deep Neural Network Models in Nitrogen Management Practice Trials

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Predictive models based on recurrent neural network architectures, in conjunction with input feature selection strategies (Recursive Feature Elimination (RFE) and the Shapley Additive Explanation (SHAP) deep learning implementation) were investigated for the 2021 and 2022 experimental trials. While feature importance varied through the growing season, thereby reducing the overall number of features that could be eliminated, the total number of hyperspectral and LiDAR based features was reduced.

Temporal attention networks were also implemented to investigate both potential improvements in yield prediction and the relationship of attention weights to physiological processes. As in previous years, sensor data inputs were acquired during vegetative and reproductive stage flights, timed to coincide with phenology (e.g. heights and flowering development), biomass, and tissue N concentrations collected from ground sampling methods. NNI was determined for each biomass sample. The multiple N rates provided a range of outcomes at maturity for whole-plant biomass yield, grain yields, and final N efficiencies.

The architecture for the original stacked LSTM is shown below, with inputs of remotely sensing data, GDD, precipitation, radiation, and management practices. The LSTM architecture augmented with the temporal attention mechanism is illustrated in the following:
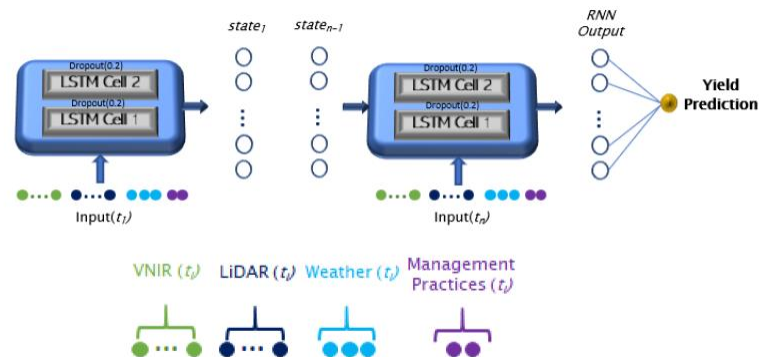
Yield predictions obtained for 2021 and 2022 using the two network models are:
a) Prediction Results from Stacked LSTM in Field 72 in 2021.
b) Prediction Results from Attention Network in Field 72 in 2021.
c) Prediction Results from Stacked LSTM in Field 54 in 2022.
d) Prediction Results from Attention Network in Field 54 in 2022.
e) Prediction Results from Stacked LSTM in Windfall in 2022.
f) Prediction Results from Attention Network in Windfall in 2022.