Development of a Predictive Model of Honey Bee Foraging Activity Under Different Climate Conditions

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Pollination services provided by managed honey bees are essential to a variety of agricultural crops. In February and March, more than 80% of the nation's beehives are rented by almond growers for pollination. The "bee hour", which is defined as an hour with temperature above 55°F, wind speed below 15 mph and no rainfall, has emerged as a tool for almond growers to predict pollination. This allows them to plan treatment to extend the bloom period if forecasted bee hours are low and time pesticide sprays to reduce the risk of honey bee exposure to pesticides, one of the leading causes of colony loss. However, as a binary classification, the "bee hour" calculation does not offer high precision. In this research, a machine learning model is developed to predict foraging activity under different climate conditions. In total, 57,333 honey bee foraging trips were recorded and analyzed through radio frequency identification tracking of 1,508 foragers in summer, fall and early spring, and 9 climate factors were recorded using a weather station. To take advantage of the temporal nature of the dataset, two recurrent neural network architectures, Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU), were selected to analyze the data. GRU performed best, achieving R-squared scores of 0.84-0.91 across seasons after optimization. Compared to the "bee hour" method, the model provided accurate and precise predictions of foraging activity. Furthermore, the model identified several days of significant foraging activity under weather conditions previously considered non-permissive that all followed days of low or no foraging activity, a novel finding which suggests that honey bees may adjust foraging behavior in response to a previous lack of foraging.

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