Predicting inner temperature, humidity and weight of a beehive by using VAR models

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Abstract

Beekeeping is the activity dedicated to maintaining bee colonies and providing them with the necessary care to obtain the by-products derived from the hives. Bees play an important role both in agriculture, providing products such as honey, and in the environment as pollinating agents. Precision agriculture is a management strategy that gathers, processes and analyzes spatio-temporal data to support management decisions. It can be used to predict the health status of beehives and, therefore, to anticipate different events, like hive collapse, swarming or the presence of diseases affecting the bees.

The objective of this work is to predict the inner temperature, humidity and weight of the hive using sensor data and meteorological information.

Data were obtained from the hive of Grund-und Mitteschule Vohburg through the we4bee project. The studied dataset collects information five times a day about internal temperature and humidity, weight, and external weather conditions. In addition, some information provided by the beekeeper is included in the model (feeding, honey harvest or swarming events). Missing data were addressed using the multiple imputation by chained equations methodology. Then, VAR models were applied to predict the internal state of the hive (temperature, humidity, and weight) employing the exogenous meteorological variables and inner sensor data.

Predictions of hive conditions were made between one and nine days ahead. To validate this model, a 100-fold cross-validation was performed, providing as best result a mean absolute error (mean ± standard deviation) of 0.149 ± 0.143 kg for weight, 1.013 ± 0.712 ºC for temperature and 2.611 ± 2.092 % for humidity.

The proposed approach provides information on the hive status and can help the beekeeper to anticipate certain events. Despite the difficulty of these data, the proposed methodology allows establishing a starting point for the study and prediction of the state of the hives.

Keywords: precisión beekeeping, sensor data, forecast, VAR model