Computers and Electronics in Agriculture 159 (2019) 69–74

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Analysis of a multiclass classification problem by Lasso Logistic Regression and Singular Value Decomposition to identify sound patterns in queenless bee colonies

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ARTICLE INFO

Keywords:
Queenless state
Beehive monitoring
Bee sound
Sound analysis

ABSTRACT

This study presents an analysis of a multiclass classification problem to identify queenless states by monitoring bee sound in two possible cases; a strong and healthy colony that lost its queen and a reduced population queenless colony. The sound patterns were compared with patterns of healthy queenright colonies. Five colonies of Carniola honey bee were monitored by using a system based on a Raspberry Pi 2 and omnidirectional microphones placed inside the hives. Feature extraction was carried out by Mel Frequency Cepstral Coefficients (MFCCs) method. A multiclass model with three outcome variables was constructed. For feature selection and regularization, a Lasso logistic Regression model was used along with one vs all strategy. To provide visual evidence and examine the results, data was analyzed by scatter plots of Singular Value Decomposition (SVD). The results show that is possible to detect the queenless state in both cases. Queenless or healthy colonies can generate slightly different patterns and the data clusters of the same condition tend to be close. The proposed methodology can be applied for the analysis of more conditions in bee colonies.

1. Introduction

The queen bee is the most important bee in a colony, she plays a vital role inside the hive, she is the only one who lays eggs; around 2000 eggs per day. The queen bee maintains the order of the colony primarily by the utilization of pheromones which transmit information within colony members. It is common to find queenless colonies, the queen bee could accidentally die due to illness or bad beekeeping practices. When a colony loses its queen, all bees tend to change their behavior from a state of organized activity to one disorganized (Butler, 1954). Loss of the queen bee during the period when there are no males can result in the death of the colony. Apart from the traditional techniques (beehive inspection) there are no alternative methods for queenless state identification.

Researchers have been analyzing different parameters by using sensors to determinate the colony state. The most studied parameters are temperature, humidity, vibrations, weight and sound (Zacepins et al., 2015; Meikle and Holst, 2015; Stalidzans and Berzonis, 2013; Bencsik et al., 2011). The application of technology and data analysis results in the development of Precision Beekeeping (PB). The PB has been defined as an apiary management strategy based on the monitoring of individual bee colonies to minimize resource consumption and maximize the productivity of bees (Henry et al., 2019; Zacepins et al., 2015, 2012; Kviesis et al., 2015). To determine the colony state, i.e., changes in bee sound while preparing to swarm were studied in Ferrari et al. (2008) and Eskov and Toboev (2011); the results claim that sound can be used to predict this event, monitoring the changes in the sound frequency prior to swarming process. Varroa is probably the most dangerous mite of honey bees (Moritz and Southwick, 1992). Infestation can change the sound produced by a healthy colony, in Qandour et al. (2014), a comparison of a healthy colony with an infested one was analyzed, the results show that there are differences in sound produced by infested colonies. In Bromenshenk et al. (2015) a review of studies about bee as biosensor to detect the presence of toxic chemicals and bee pest is presented, preliminary results show that colonies tend to be noisier when exposed to organic insecticides. The queenless state detection by sound analysis was previously studied in Howard et al. (2013), the results show that the signal spectrum emitted by queenrigth colonies is different from queenless colonies, however, the classification method used was not successful. Another example is

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https://doi.org/10.1016/j.compag.2019.02.024
Received 11 September 2018; Received in revised form 16 January 2019; Accepted 20 February 2019