Using machine learning for audio-based identification of beehive states

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Bee colonies within the Università Politecnica delle Marche Campus. Credit: Cecchi et al.

Researchers at Università Politecnica delle Marche, Queen Mary University of London and the Alan Turing Institute have recently collaborated on a research project aimed at identifying beehive states using machine learning. Their study, pre-published on arXiv, investigated the use of both support vector machines (SVMs) and convolutional neural networks (CNNs) for beehive state recognition, using audio data.

The data used in this study was collected as part of the NU-Hive project, a research endeavor that led to the development of a system to monitor the condition of beehives by exploiting the sounds they emit. The researchers trained machine learning algorithms to analyze this audio data and identify the states of different beehives.

"Our research is motivated by the decline in honeybee colonies over recent years in Europe and the rest of the world," Stefania Cecchi, a researcher who carried out the study, told TechXplore. "This decline has generated an increasing interest in the safeguard of honey bees, due to their great importance for sustaining human life. In this context, the main objective of our research is the study and development of an innovative system to monitor the condition of beehives, using the sound produced by bees and machine learning algorithms."

Bees are the most important pollinators of food crops on the planet; hence, their survival is of utmost importance. In recent years, bee colonies have been declining, an issue that could have serious consequences for the sustenance of humans, as well as that of other animals in the food chain.

Installation of the acquisition system. Credit: Cecchi et al.

One of the key indicators that a beehive requires urgent human intervention is the absence of the queen bee. Searching for the queen manually is a challenging and time-consuming task for beekeepers, which in many cases disrupts the normal life cycle of the hive, causing significant stress to the bees inhabiting it.

The sounds produced by beehives offer important clues about their state, including the absence of the queen bee. Cecchi and her colleagues decided to explore the possibility of using machine learning to analyze beehive sounds, as this could help to

identify beehives at risk without unnecessary stress for bees, while also reducing human efforts associated with manual interventions.

"We are at the early stage of development and at this time we are able to identify the presence or absence of the queen bee, which is an important issue for beehive survival," Cecchi explained. "Our system is based on machine learning methods that automatically recognize different beehive states using audio as input. The system is trained on a database created by our acquisition systems and the model is then applied to identify the presence or absence of the queen bee."

Cecchi and her colleagues carried out several experiments in real-world settings that highlighted the potential of exploiting Mel spectra and Mel-frequency cepstral coefficients (MFCCs), and Hilbert Huang Transform (HHT) as features to determine the presence of a queen bee in a hive. MFCCs and HHTs are sound representations or specific ways to decompose audio signals.

Software interface for real time monitoring. Credit: Cecchi et al.

The researchers tested the performance of both SVMs and CNNs in analyzing these particular sound features to determine the absence or presence of the queen bee. SVMs were found to generalize better on unseen hives than CNNs, yet the latter achieved good results in hive-dependent scenarios. Overall, the study gathered very promising results, particularly when combining HHT and MFCC features.

"The system is capable of recognizing the absence of the queen bee in a beehive," Cecchi said. "Searching for the queen is an arduous recurrent task for beekeepers that disrupts the normal life cycle of the hive. Our system can significantly reduce the number of searches and interventions needed. Furthermore, our approach allows for prompt beekeeper interventions at the earliest possible time, thus avoiding the bee's dispersion and hive decline due to the absence of the queen bee."

The findings gathered by Cecchi and her colleagues highlight the vast potential of machine learning to analyze audio data of beehives and effectively detect whether they are endangered. In future, their method could aid the safeguarding of bees and consequently that of all species feeding on pollinated crops. The researchers are now looking to apply the same method to other risk-associated beehive states.

"We want to extend this approach to the automatic identification of other important beehive states such as swarming prediction, detection of anomalous situations, and the presence of varroa mites," Cecchi said. "This will allow us to build a complete system for classifying beehive states, providing beekeepers with a continuous and autonomous analysis of their beehives."

More information: Audio-based identification of beehive states. arXiv:1811.06330 [cs.SD]. arxiv.org/abs/1811.06330

www.researchgate.net/project/N … -bee-hive-monitoring

A preliminary study of sounds emitted by honey bees in a beehive. www.aes.org/e-lib/browse.cfm?elib=19498

To bee or not to bee: investigating machine learning approaches for beehive sound recognition. dcase.community/documents/work … shop_Nolasco_131.pdf