Carnegie Mellon University
School of Computer Science

Using Computer Science To Save the Bees

Researchers Use Sensors, Forecasting Models To Track Honeybee Health

Marylee Williams | Tuesday, March 4, 2025

Honeybees pollinate a third of what people eat and drink, from coffee to almonds, but colonies are on the decline because of extreme weather, pesticides and parasites.

Photo courtesy of University of California, Riverside.

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Researchers from Carnegie Mellon University's School of Computer Science (SCS) and the University of California, Riverside (UC Riverside) have created a system to help beekeepers monitor and analyze the health of their beehives and take corrective actions to prevent colony collapse — when a majority of the worker bees abandon the colony and its queen.

Beehives use thermoregulation to ensure the hive temperature stays between 33 and 36 degrees Celsius, about 91 to 97 degrees Fahrenheit. For example, bees might cluster to create insulation when it's cold or fan their wings when it's hot. But when beehives experience external stressors, such as pesticides or unexpected weather events, they lose the ability to regulate the hive temperature. That's when beekeepers

need to intervene to save the hive. Currently, beekeepers manage hive health using their judgment and experience to address problems, which can lead to oversights.

The Electronic Bee-Veterinarian [https://dl.acm.org/doi/10.1145/3719014] (EBV) uses low-cost heat sensors and predictive forecasting to assist beekeepers in managing hive temperature and overall honeybee health. Researchers used two sensors, one placed on the outside of the hive and one inside, to detect real-time temperatures in the bee colonies. This data was then fed into a model that calculates the hive health factor.

Christos Faloutsos [https://www.cs.cmu.edu/~christos/], the Fredkin University Professor of Computer Science in SCS's Computer Science Department [https://csd.cmu.edu/], said researchers looked to heat-transfer physics for the equation when developing the EBV's beehive health forecasting model.

"We derived equations based on the first principles of thermal diffusion, heat transfer and control theory," he said. "We put these equations together and then compressed all the historical data into one number, the hive health factor. If the health factor is close to one, the bees are healthy and thermoregulating. If it is much lower than one, it means the beehive isn't healthy and might need an intervention. Once we have this health factor computed every day, we can do standard forecasting and the beekeeper can take further action."

Understandability was a key aspect of this project, Faloutsos said. Researchers wanted everything to be condensed into one number, the hive health factor, so any beekeeper who adopted the technology could easily interpret the forecasting result.

Jeremy Lee [https://csd.cmu.edu/people/doctoral-student/jeremy-lee], an SCS doctoral student who worked on the project, said the team's multidisciplinary expertise contributed to EBV's success. Along with CMU, the team from UC Riverside included Shamima Hossain, a Ph.D. student in computer science; Boris Baer, a professor of entomology; Hyoseung Kim, an associate professor of electrical and computer engineering; and Vassilis Tsotras, a professor of computer science and engineering. The U.S. Department of Agriculture's National Institute of Food and Agriculture funded this research, among other awards, and the team presented its work at the 2024 SIAM International Conference on Data Mining.

"This is something I'm very interested in — using our expertise from computer science and working with other domain experts to make an impact in another area," Lee said.

Lee noted that this isn't the first time he's done research where his expertise in computer science created a real-world impact. Along with Faloutsos and other CMU and McGill University colleagues, Lee worked with criminology experts to detect human trafficking [https://cs.cmu.edu/news/2021/algorithm-uses-online-ads-identify-human-traffickers].

The project's next phase involves automating hive climate control. Faloutsos and the UC Riverside team have received USDA funding [https://portal.nifa.usda.gov/web/crisprojectpages/1033080-collaborative-research-cps-medium-ebeevet-an-electronic-bee-veterinarian-framework-to-secure-honey-bees.html] to research how the EBV's data can be used to automatically heat and cool hives without beekeeper intervention. Such technology could maximize honey production for beekeepers and help them prevent potential future challenges, such as stress from bee diseases.

For More Information

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