

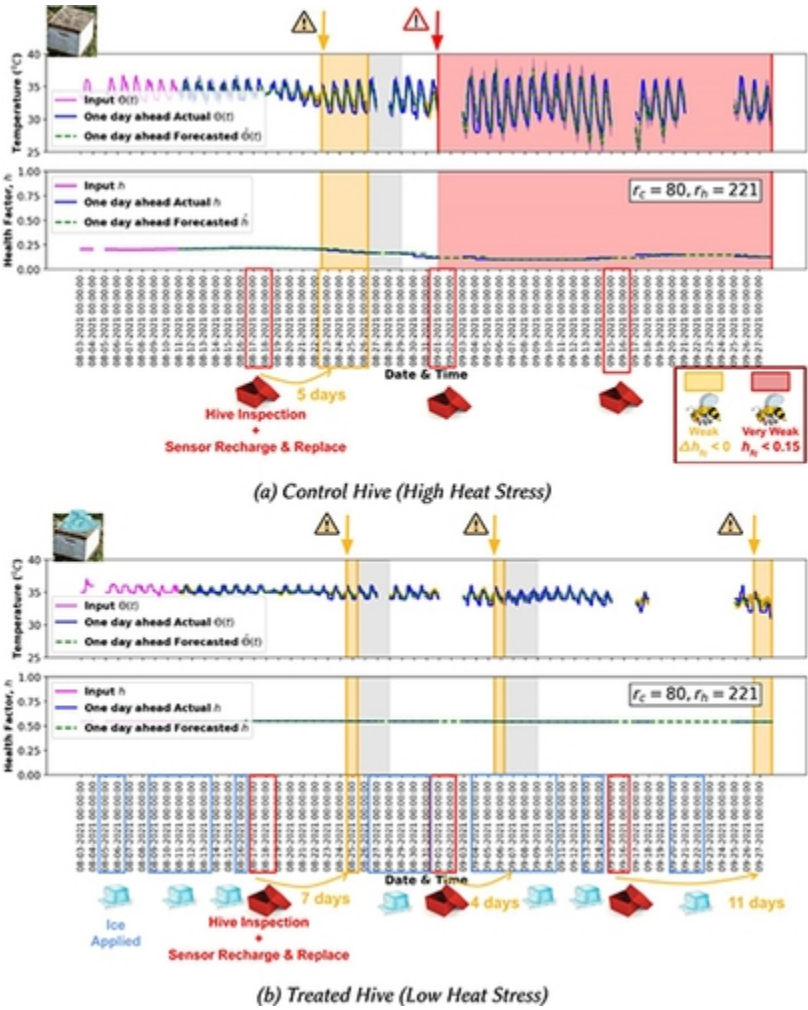
FULL DESCRIPTION

Background

In 2024, more than 60% of managed honeybee colonies were lost, posing a significant threat to global food production. Honeybees are essential pollinators for over 80 key agricultural crops. However, beekeepers currently lack effective tools to detect early indicators of hive health decline, often intervening only after irreversible damage has occurred. There is an urgent and growing demand for a reliable, cost-effective, and predictive system that can provide early warnings and support proactive high management.

Technology

The **Electronic Bee Veterinarian (EBV)** is a predictive health monitoring system that **quantifies** beehive health in real time. It analyzes hive temperature data by modeling the colony's thermoregulation capability using the thermal diffusion equation and a bio-inspired sigmoid (P) feedback controller. EBV not only **detects anomalies** in bee behavior and **forecasts** the hive's core temperature days in advance, but also it generates an **interpretable "hive health" score** - a direct, quantifiable measure of the colony's ability to maintain its core temperatures. This enables beekeepers to identify early signs of stress and **take timely action** to prevent colony collapse.



EBV forecasts (dashed green line) the next day's core temperature (solid blue line) well and raises flags (orange vertical lines) followed by unexpected events (red boxes: intensive high inspection, sensor recharge and replace). It also raises alarms (red vertical lines) if h falls below a threshold: very weak bees. (a) Control hive (high heat stress). (b) Treated hive (low heat stress).

ADVANTAGES

- ▶ Accurately forecasts hive temperature and provides early alerts of potential threats to colonies.
- ▶ Generates interpretable and explainable hive health score, designed for easy understanding by beekeepers.
- ▶ Enables preventative measures by beekeepers, significantly reducing the risk of colony collapse.
- ▶ Computationally efficient, thus cost-effective for real-time monitoring of small and large-scale colonies.
- ▶ Grounded in established scientific principles, and provides a reliable and trustworthy analysis.

SUGGESTED USES

- ▶ Commercial beekeeping
- ▶ Precision agriculture
- ▶ Smart hive technology
- ▶ Environmental research for studying the impact of climate and other stressors on bees

STATE OF DEVELOPMENT

Proof-of-concept has been successfully demonstrated and validated using multiple real-world datasets from active beehives.

RELATED MATERIALS

- ▶ Please visit the [Center for Integrative Bee Research \(CIBER\)](#) to learn more about their research at UCR
- ▶ Please visit [UC Riverside Artificial Intelligence Research and Education Institute \(RAISE\)](#) to learn more about AI at UCR

RELATED MATERIALS

- ▶ [Principled Mining, Forecasting, and Monitoring of Honeybee Time Series with EBV+](#)

PATENT STATUS

Patent Pending

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