

# Electronic Bee-Veterinarian: Safeguarding Honeybees Through Technology

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In Collaboration With: Boris Baer (UCR), Christos Faloutsos (CMU)

# Honeybees are Vital Pollinators

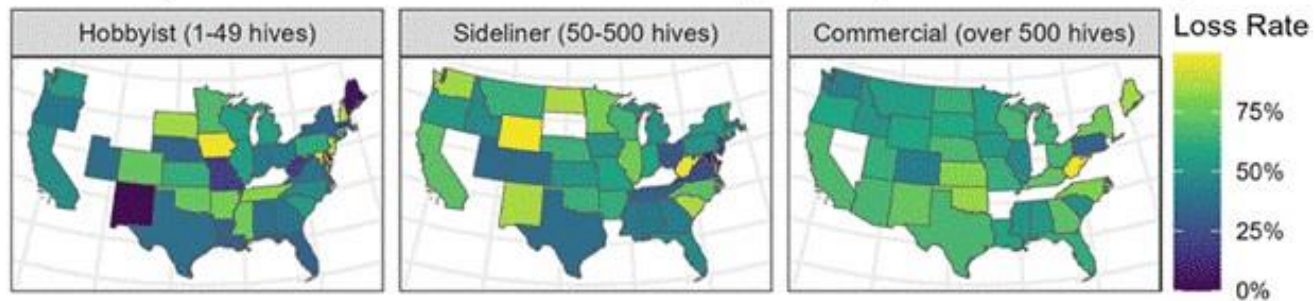
- Required for production of more than 80 crops of agricultural interest
- Economic value: up to \$550 billion globally and \$29 billion for the US
- Without honeybees, humanity will suffer



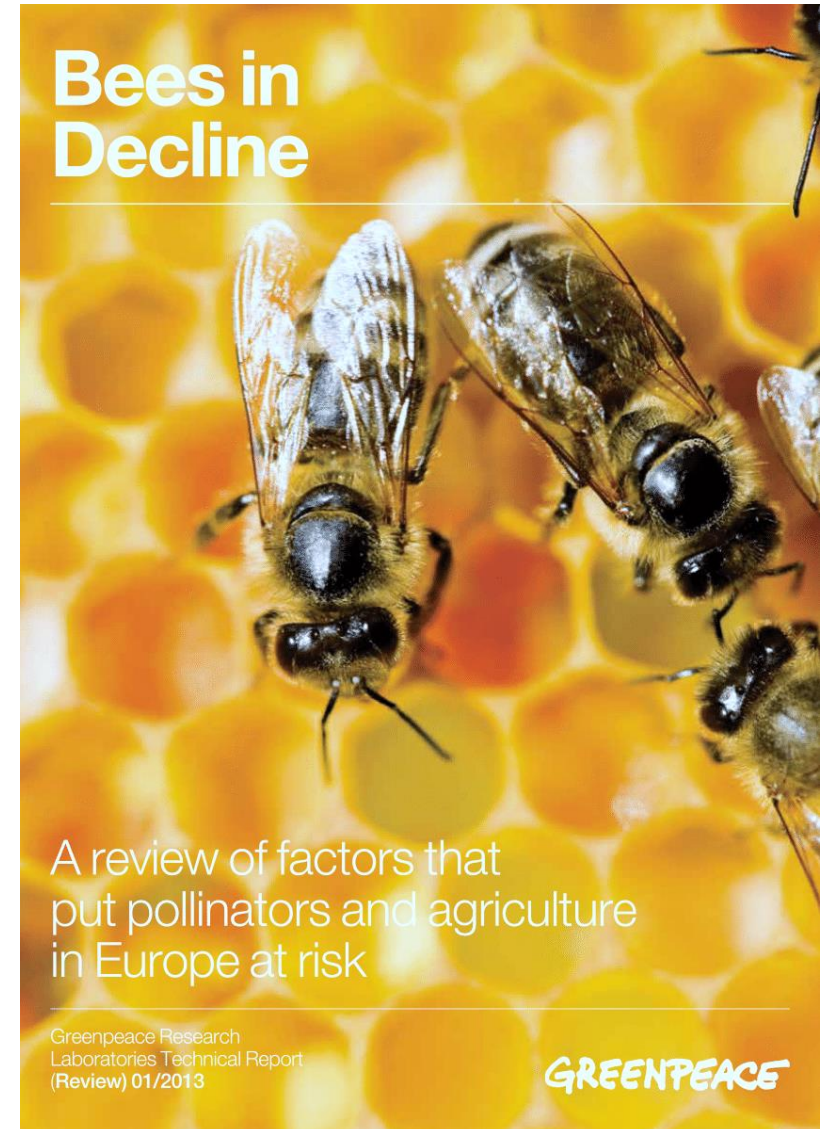
# Problem: Catastrophic Colony Loss

- 40-50% of colony loss every year (62% in 2024-2025)
- Reasons are multiple: environmental factors, parasites, pesticides, etc.

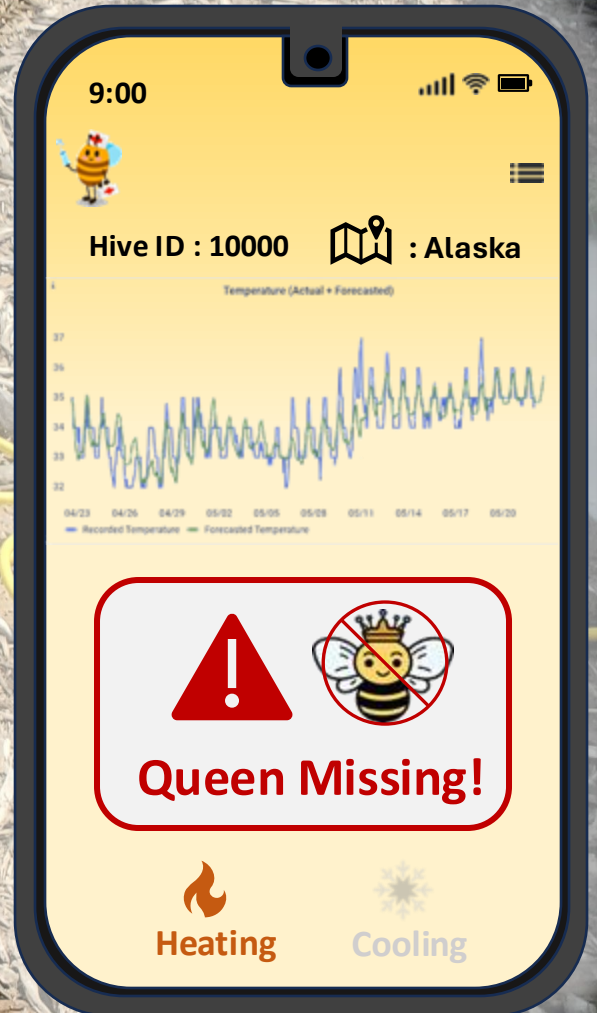
Colony Loss Rate June 2024-Feb 2025 by state (Summer location)



<https://beeculture.com/survey-reveals-over-1-1-million-honey-bee-colonies-lost-raising-alarm-for-pollination-and-agriculture/>



# Research Goal: Safeguard Honeybees through Sensing, Learning, and Control



# Challenges in Traditional Beekeeping

1. No robust and reliable way to understand colony health
  - Manual, labor-intensive inspection every 2-3 weeks
  - Significant cost and time
2. Absence of systematic and eco-safe methods to support hive health
  - Especially under changing weather conditions
  - Icepacks and heating plates in summer/winter: on an ad-hoc basis
3. Inability to timely and accurately identify stressors in honeybees
  - Missed early distress signs
  - Sudden temperature shock to bee brood

# My Solutions: Electronic Bee-Veterinarian

1. No robust and reliable way to understand colony health

Thrust 1: Hive health quantification with real-time monitoring, forecasting & alerting method

2. Absence of systematic and eco-safe methods to support hive health

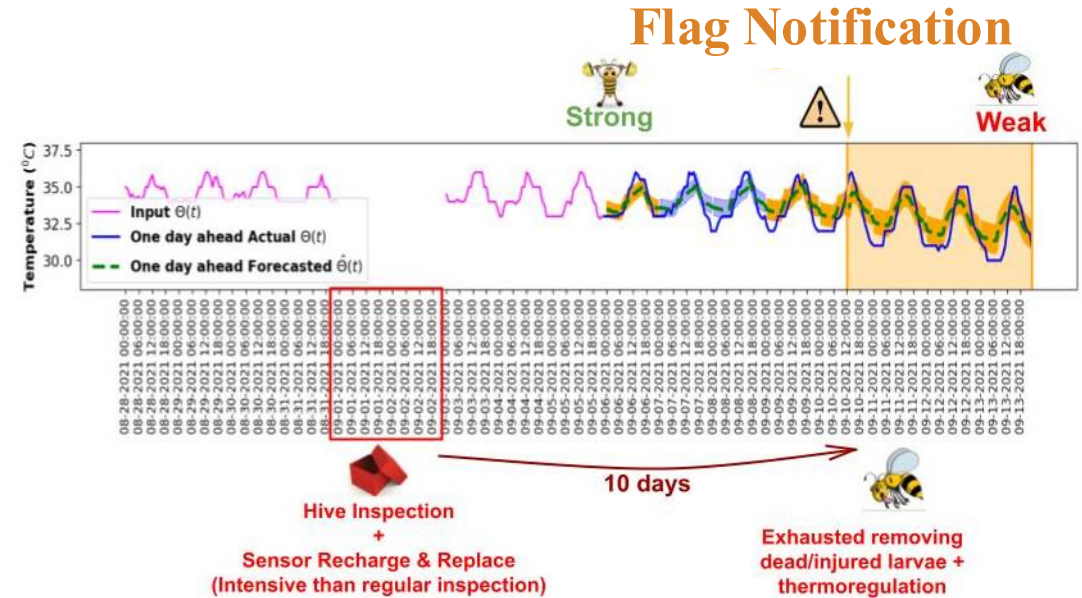
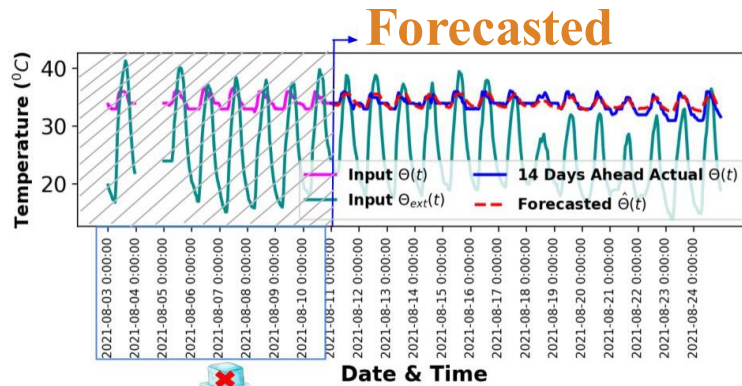
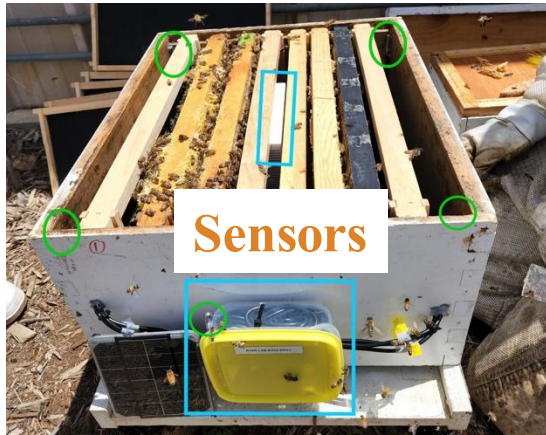
Thrust 2: Self-regulatory & economically sustainable in-hive climate management

3. Inability to timely and accurately identify stressors in honeybees

Thrust 3: Diagnostic tools for stressor identification and recommendation system for necessary actions

# Thrust 1

## Hive health quantification with real-time hive monitoring, forecasting & alerting method

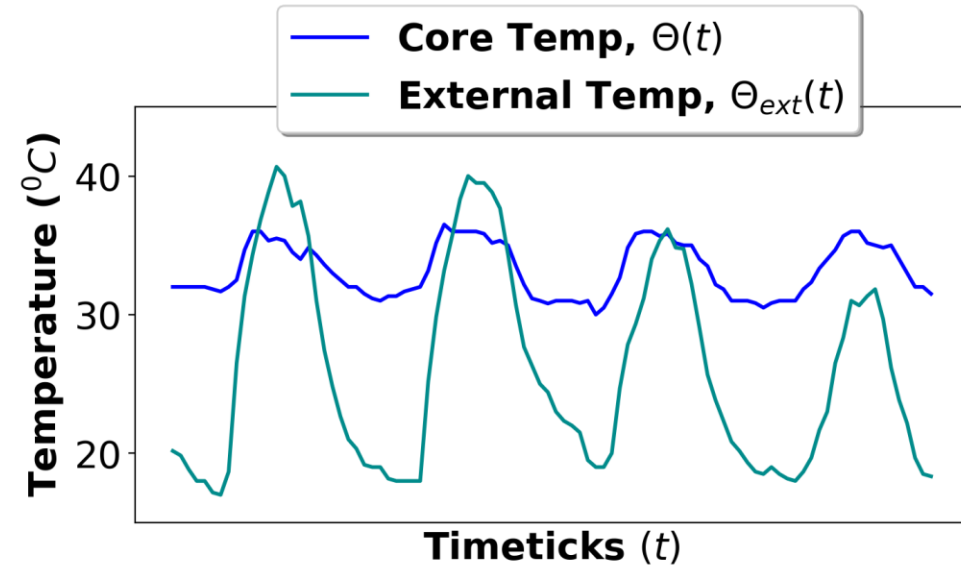


# Background

Hive temperature gives valuable information about hive health.



Core Area  
(Near brood nest area)  
Most Important!



$33^{\circ}\text{C} \leq \text{Core Temp, } \Theta(t) \leq 36^{\circ}\text{C} =$



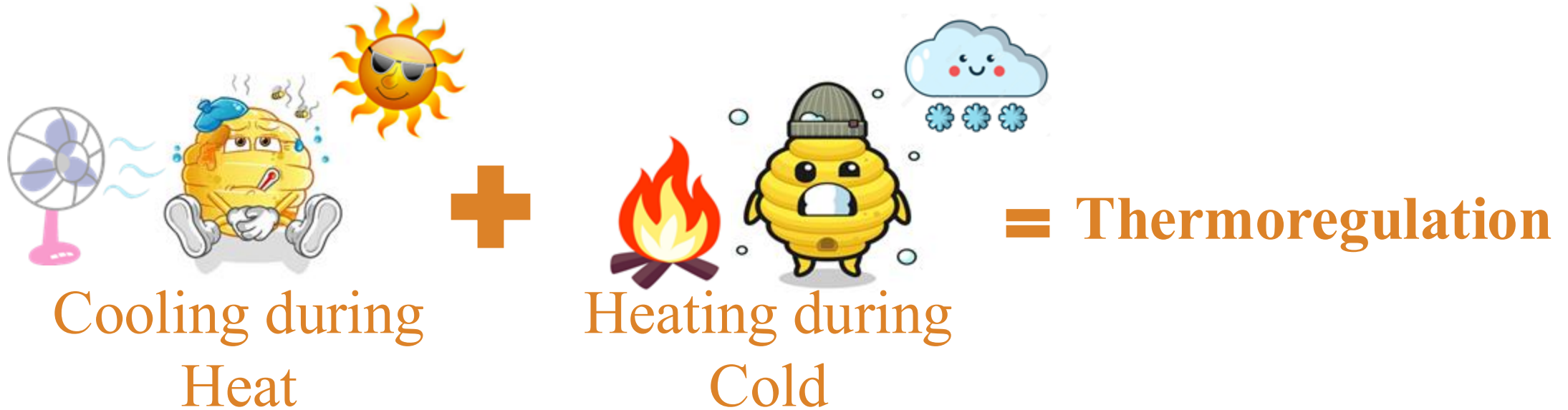
$\Theta(t) \leq 33^{\circ}\text{C}$  or  $\Theta(t) \geq 36^{\circ}\text{C} =$



*How do a healthy hive regulate core temperature so perfectly?*

# Background

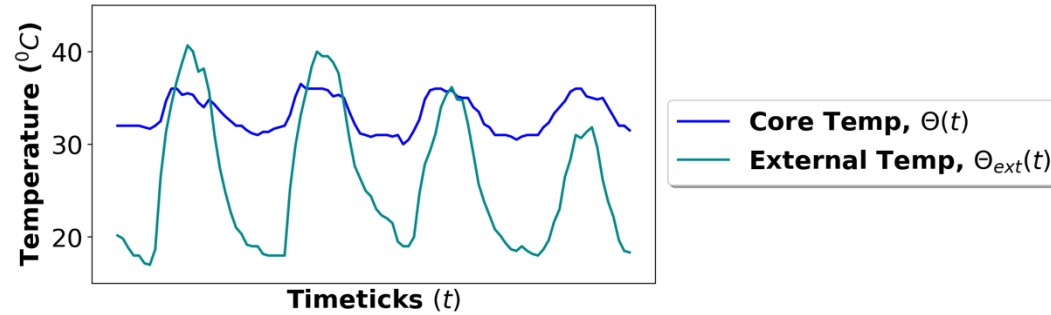
Think of hive core temperature as human body temperature....



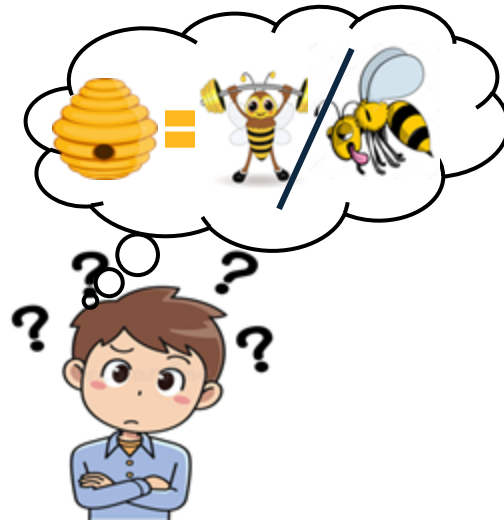
*Change in thermoregulation ability = 1st order response to stressors*

# Problem Statement

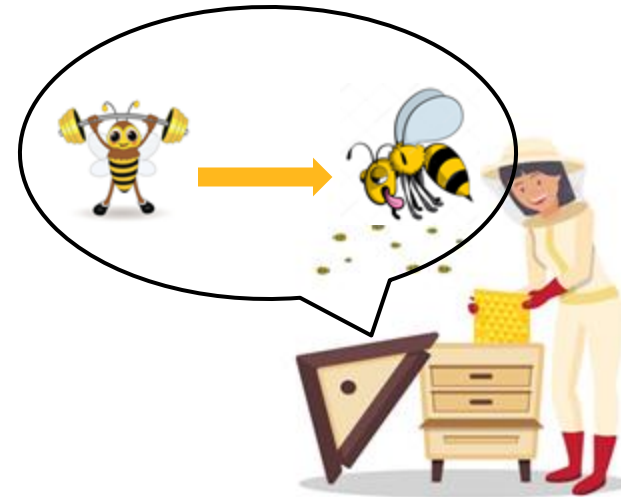
**GIVEN:**



**DO:**



**G1: Quantify  
Hive Health**



**G2: Detect &  
Explain Events**



**G3: Forecast &  
Alert**

# Contributions : EBV+ [1,2]

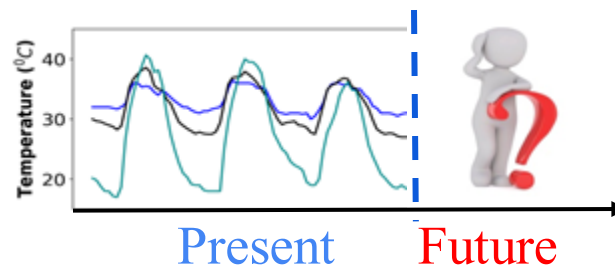
## C1: Principled

- Thermal diffusion
- Control theory

$$\nabla^2 \theta \propto \partial \theta / \partial t$$

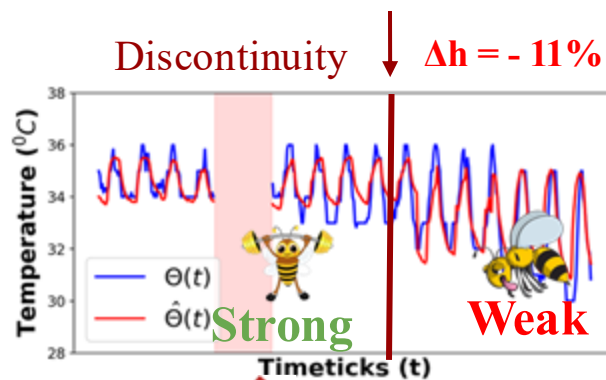
## C2: Effective

- Forecasting with high accuracy



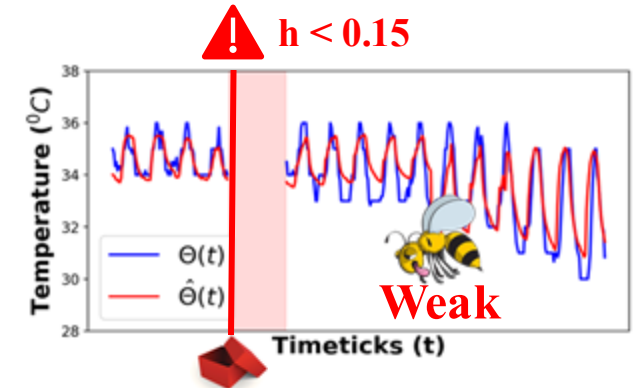
## C3: Explainable

- Hive health factor
- State discontinuity detection (offline)



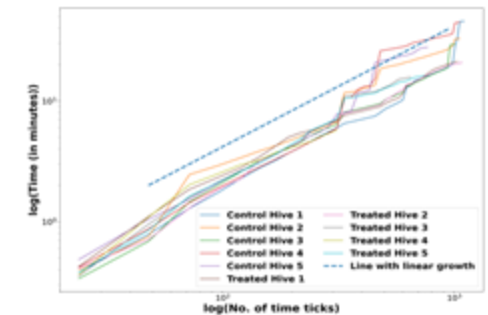
## C4: Proactive

- Real-time alert for beekeepers (online)



## C5: Scalable

- Linear with input size



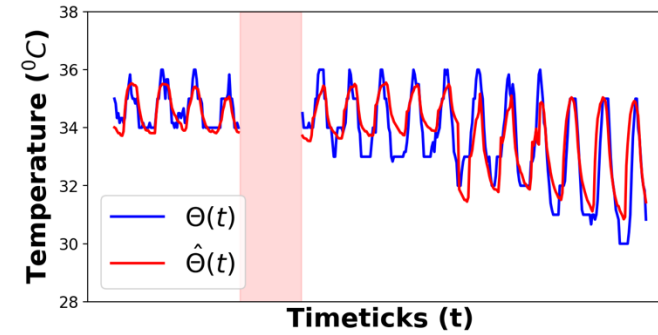
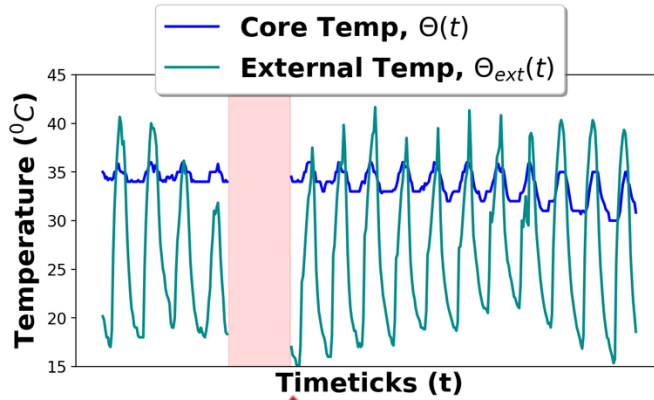
## C6: Informative

- In line with domain experts

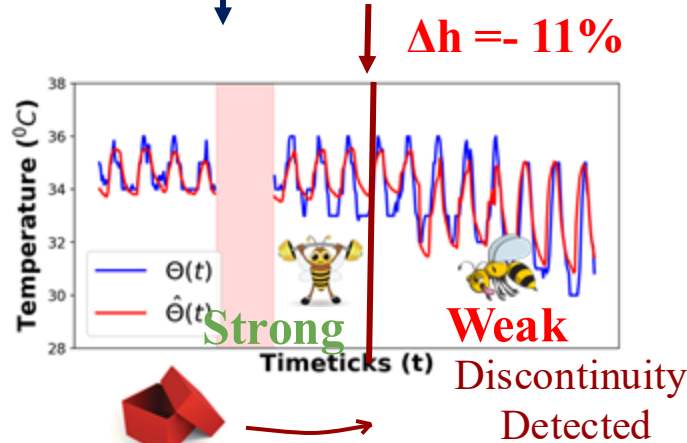


1. MS Hossain et al., “Principled Mining, Forecasting and Monitoring of Honeybee Time Series with EBV+,” In ACM TKDD; Just Accepted February 2025.  
 2. MS Hossain et al., “EBV: Electronic Bee-Veterinarian for Principled Mining and Forecasting of Honeybee Time Series,” In SIAM SDM 2024.  
 UCR ORCA Forum 2025 MS. Hossain

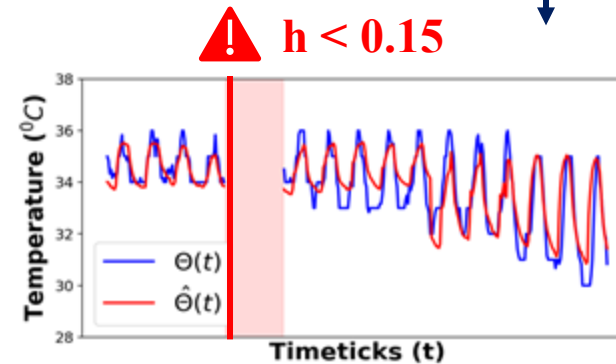
# Overview of Proposed Method : EBV+



## 1. $EBV_{model+}$ : Reconstruction G1: Quantify Hive Health



## 2. $EBV_{fit\&cut+}$ : Segmentation G2: Event Detect. (Offline)



## 3. $EBV_{fcast\&warn+}$ : Proactive Alert G3: Forecast & Alert (Online)

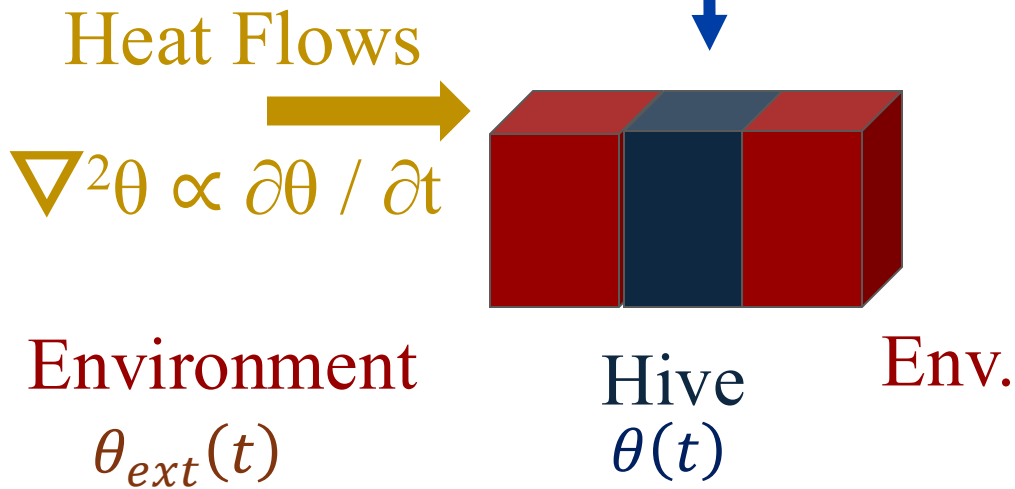
# EBV<sub>model+</sub> for Reconstruction & Forecasting

$$\frac{\partial \theta(t)}{\partial t} = 2(\theta_{ext}(t) - \theta(t)) - h \frac{r_c r_h (1 - e^{-\theta(t)})}{r_h + r_c e^{-\theta(t)}}$$

# EBV<sub>model+</sub> for Reconstruction & Forecasting

$$\frac{\partial \theta(t)}{\partial t} = \underbrace{2(\theta_{ext}(t) - \theta(t))}_{\text{Without Bees}} - h \frac{r_c r_h (1 - e^{-\theta(t)})}{r_h + r_c e^{-\theta(t)}}$$

Without Bees



**Physics:**

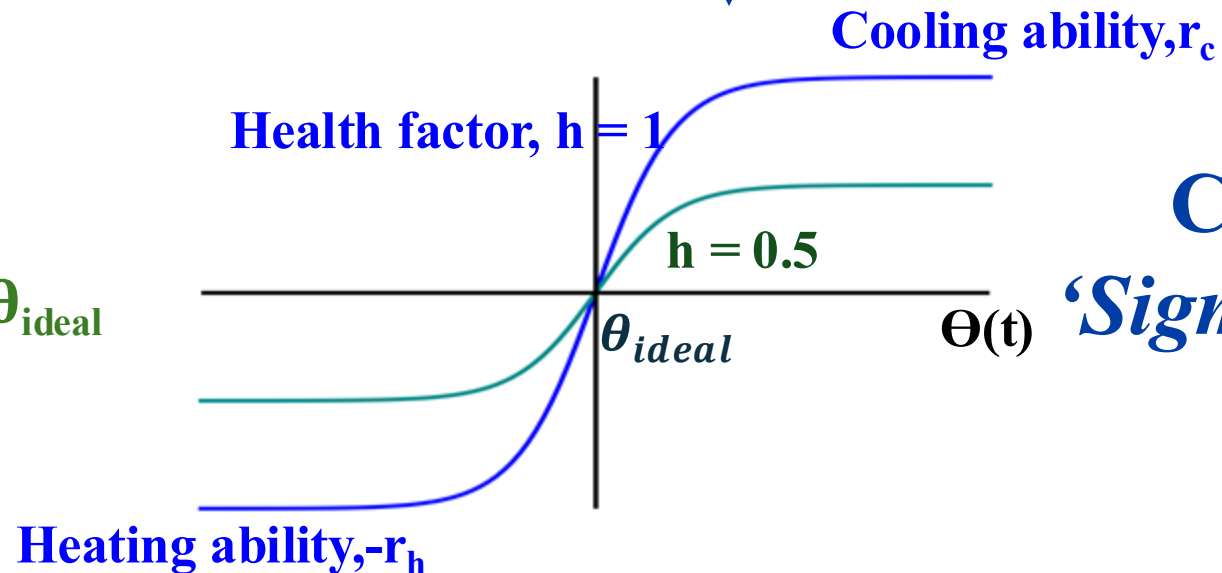
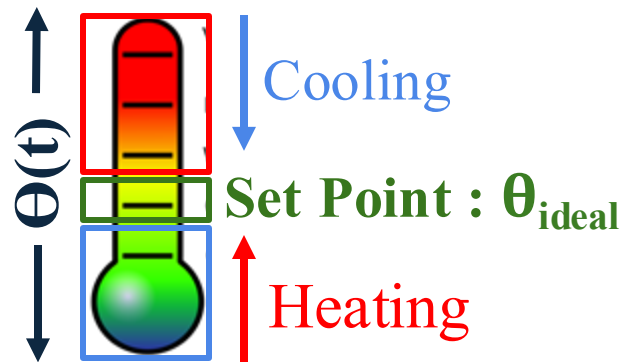
**Thermal Diffusion**

*Env. Temp.  $\propto$  Hive Temp.*

# EBV<sub>model+</sub> for Reconstruction & Forecasting

$$\frac{\partial \theta(t)}{\partial t} = 2(\theta_{ext}(t) - \theta(t)) - h \underbrace{\frac{r_c r_h (1 - e^{-\theta(t)})}{r_h + r_c e^{-\theta(t)}}}_{\text{With Bees Only}}$$

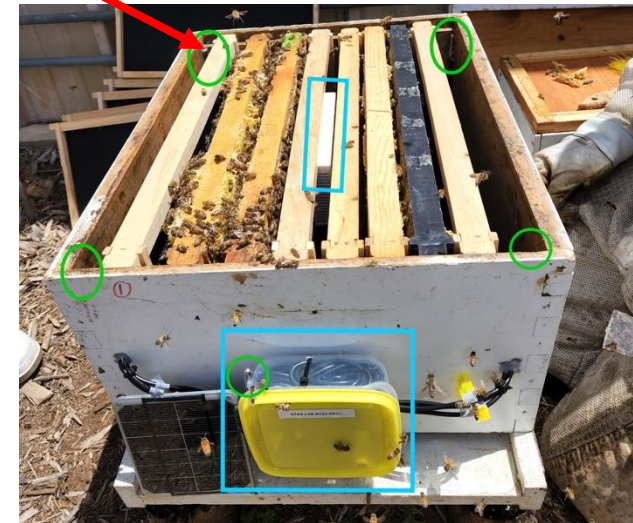
With Bees Only



Control Theory:  
*'Sigmoid' P-Controller*

# Field Deployment (UCR Ag-Ops)

Sensors



**Phase 1:** August 2021 - September 2021 (10 hives)

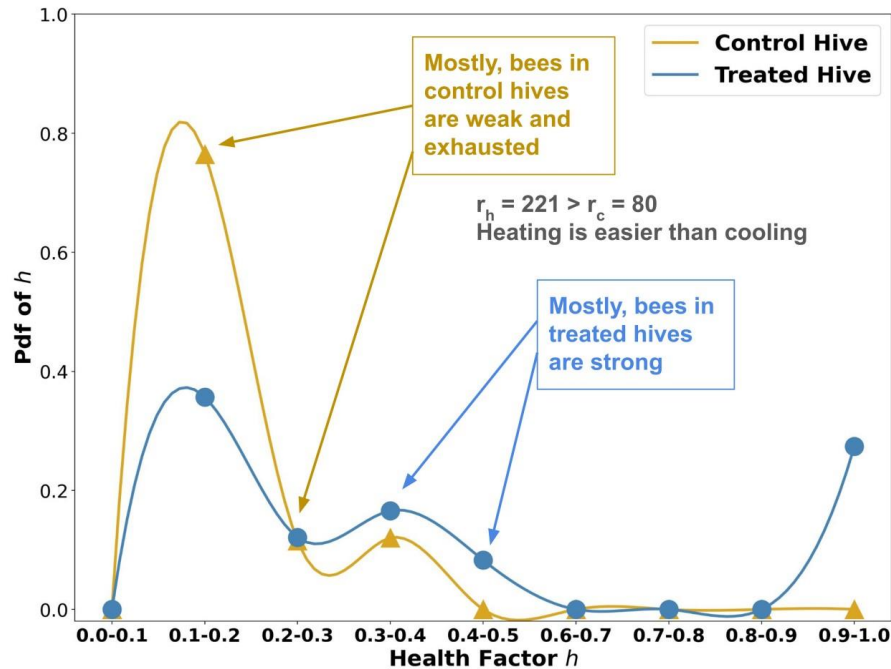
**Phase 2:** March 2024 - Ongoing (6 hives)

# Case Study from Field Deployment (Phase 2)



# Broader Impact of EBV+

## Quantitative assessment of traditional beekeeping treatments



*Ice treatment helps during extreme hot weather*

## Ongoing Collaboration with Entomologists

1. Compare –
  - a) Various hive setups
  - b) Different genotypes of bees
2. Select healthy hives for stressor testing in lab environment
3. Effect of *Varroa* mite infestation on hives

# Recognition from Industry Practitioners & Professional Beekeepers

UNIVERSITY OF CALIFORNIA, RIVERSIDE

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AWARDS » SEPTEMBER 13TH, 2022 » CIBER SQUAD HONORED FOR BEE HEALTH SOLUTIONS

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## CIBER Squad honored for bee health solutions

AUTHOR:  
**IMRAN GHORI**

September 13, 2022

**A** team of UC Riverside doctoral students researching honey bee health won an honorable mention in the Wilbur-Elis Innovation Awards.

Sponsored by Wilbur-Willis, an agricultural company, the competition invited student teams from U.S. colleges and universities to propose better approaches for providing food for a growing global population.

UCR's team, dubbed the CIBER Squad, was one of four groups to win a \$5,000 honorable mention prize. Its focus was on reversing the decline in bee populations.

The team consisted of Chris Allen, Jess Webb, Genesis Chong, and Sakshi Watts, all doctoral students in entomology. A fifth member, Shamima Hossain, is a doctoral student in computer science. The students are affiliated with the Center for Integrative Bee Research, or CIBER, a multidisciplinary research group.

The team developed a three-pronged approach for saving bees: breeding hardier bees that are better able to handle heat, diseases, and parasites; working with local bee keepers on health management tools; and increased bee health monitoring including the use of electronic sensors in hives.



The CIBER Squad from top left, Chris Allen, and Jess Webb; and bottom left, Genesis Chong, Shamima Hossain, and Sakshi Watts.



**Wilbur-Elis Innovation Award (2022)**  
**Honorable Mention**

**UCR Bee Health Conference (2022)**  
Attended by SoCal Beekeeping Clubs (500+ members)  
**Locate me: 4<sup>th</sup> from bottom right**

# Media Coverage

UNIVERSITY OF CALIFORNIA, RIVERSIDE Search

**UC RIVERSIDE** News

HOME LATEST ARTICLES CALENDAR EXPERTS IN THE NEWS INFO FOR MEDIA INSIDE UCR UCR MAGAZINE

NEWS » FEBRUARY 21ST, 2025 » BEEHIVE SENSORS OFFER HOPE IN SAVING HONEYBEE COLONIES

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## Beehive sensors offer hope in saving honeybee colonies

Innovation allows for remote monitoring of beehive health



AUTHOR:  
**DAVID DANELSKI**

February 21, 2025

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**A** UC Riverside computer science team has developed a sensor-based technology that could revolutionize commercial beekeeping by reducing colony losses and lowering labor costs.

Called the Electronic Bee-Veterinarian, or EBV, the technology uses low-cost heat sensors and forecasting models to predict when hive temperatures may reach dangerous levels. The system provides remote beekeepers with early warnings, allowing them to take preventive action before their colonies collapse during extreme hot or cold weather or when the bees cannot regulate their hive temperature because of disease, pesticide exposure, food shortages, or other stressors.

“We convert the temperature to a factor that we are calling the health factor, which gives an estimate of how strong the bees are on a scale from zero to one,” said [Shamima Hossain](#), a Ph.D. student in computer science at UCR and lead author of [a paper explaining the technology](#).

This simplified metric — with a score of ‘one’ meaning the bees are at full strength — allows beekeepers unfamiliar with the underlying model to assess hive health quickly.



Shamima Hossain and Boris Baer

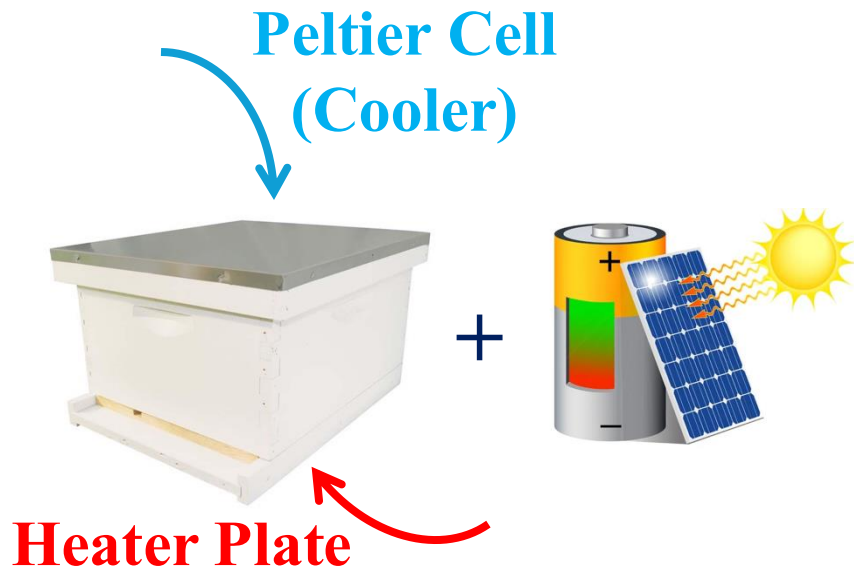


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# Thrust 2 (In Progress)

## Self-regulatory & economically sustainable in-hive climate management



Design an Automated Controller with Energy Harvesting Device



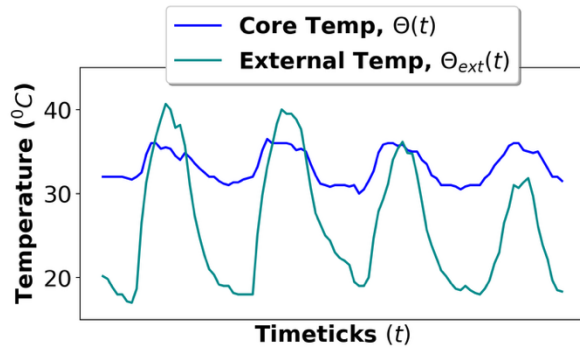
Estimate Controller Parameter & Schedule of Operation



Maximize Net Profit

# Thrust 3 (In Progress)

## Diagnostic tools for stressor identification and recommendation system for necessary actions



Date	Colony #	Notes
04/09/2024	S-M-06	No swarm cell
04/09/2024	S-M-07	1. Requeening was in process (cell removed) 2. Young queen; might have emerged 1-2 days ago
04/09/2024	S-M-11	Swarm cell removed
04/09/2024	S-M-12	No swarm cell
04/09/2024	S-M-14	Swarm cell removed; Solar panel replaced
04/09/2024	S-M-27	Swarm cell removed

### Beekeepers' Notes

Collect Data by  
Inducing Stressors



No Queen



Mite Infestation



No Broods



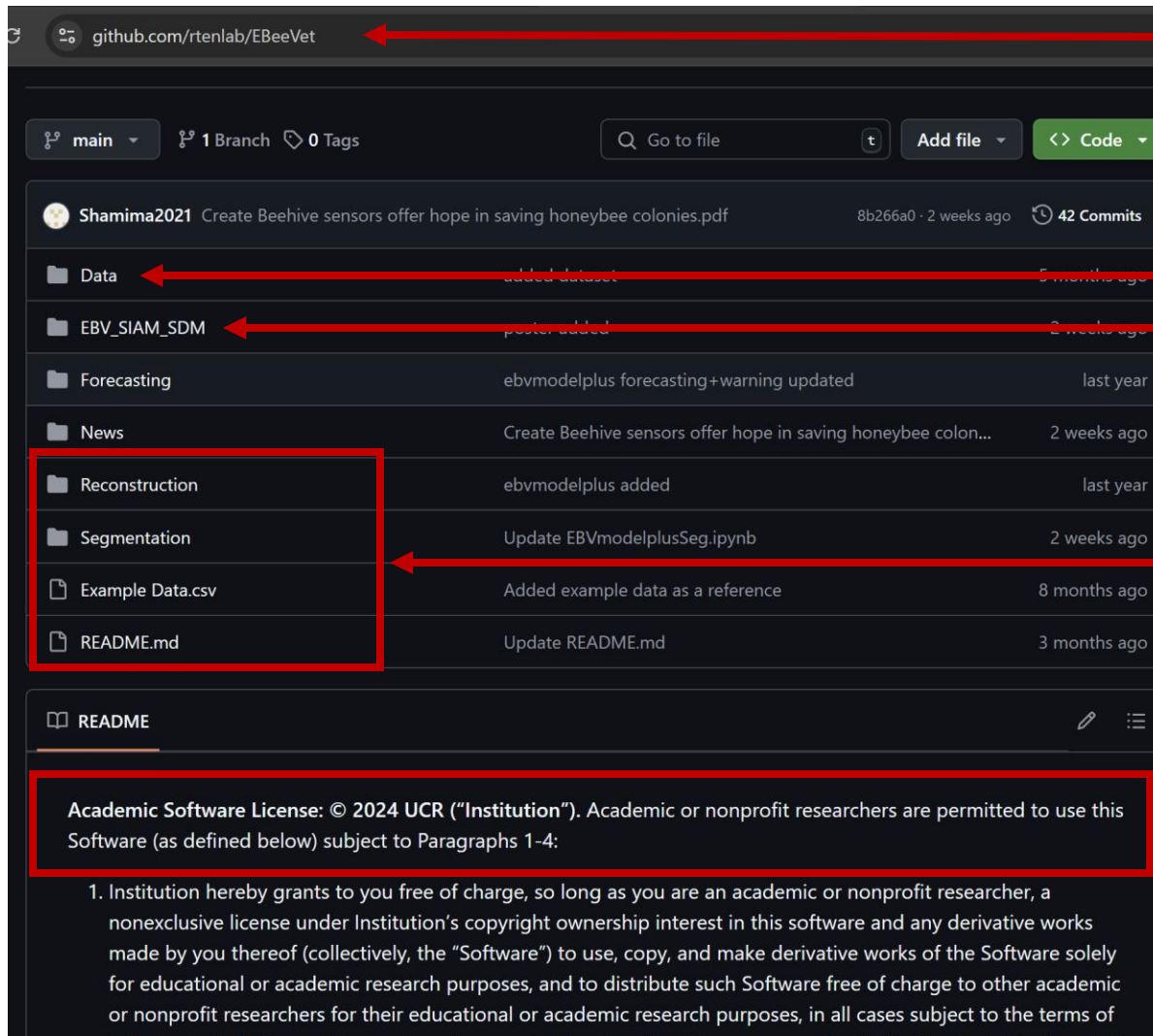
Pesticide Hit



Classify Stressors  
(Multi-class)

Integrate with Proactive  
Alert Method

# Open-Sourced on Github



The screenshot shows the GitHub repository page for 'rtenlab/EBeeVet'. The repository is owned by 'Shamima2021' and has 42 commits. The commit history is as follows:

Commit Message	Author	Time
added dataset	Shamima2021	5 months ago
poster added	Shamima2021	2 weeks ago
ebvmodelplus forecasting+warning updated	Shamima2021	last year
Create Beehive sensors offer hope in saving honeybee colon...	Shamima2021	2 weeks ago
ebvmodelplus added	Shamima2021	last year
Update EBVmodelplusSeg.ipynb	Shamima2021	2 weeks ago
Added example data as a reference	Shamima2021	8 months ago
Update README.md	Shamima2021	3 months ago

The repository contains the following files and folders:

- Data
- EBV\_SIAM\_SDM
- Forecasting
- News
- Reconstruction
- Segmentation
- Example Data.csv
- README.md

The README file contains the following text:

Academic Software License: © 2024 UCR ("Institution"). Academic or nonprofit researchers are permitted to use this Software (as defined below) subject to Paragraphs 1-4:

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1. [github.com/rtenlab/EBeeVet](https://github.com/rtenlab/EBeeVet)

2. Data

3. Published Papers

4. Codes &

README /w

instructions to use

5. Academic

Software License

# Conclusion

*THANK YOU!!*

Contact:  
mhoss037@ucr.edu

- ✓ Hive health quantification with real-time monitoring, forecasting & alerting method
- ✓ Self-regulatory & economically sustainable in-hive climate management
- ✓ Diagnostic tools for stressor identification & recommendation system for necessary actions