Beehive Assessment Device

Dr. Phil Stack

PROBLEM STATEMENT

- Minimalize Disturbances to Colony
- Track and Record Critical Hive Metrics
- Develop a User-Friendly Visualization Platform

The key challenge beekeepers face is monitoring hive health with minimal disturbances to the colony. Traditional hive inspections can stress bees and disrupt the delicate hive environment. To address this, an internally mounted system to monitor temperature, humidity, weight, and internal imagery was developed.

REQUIREMENTS

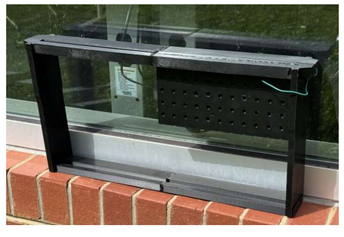
The table below outlines the primary system requirements that guided the development of this project.

#	Description
1	Solar Powered
2	AI Queen Bee Detection
3	AI Mite Detection
4	Sensor Monitoring of Temperature, Humidity, and Weight

CONCEPTS

- The initial concept for the custom frame prioritized securely housing the components and isolating them from the bees. As the idea developed, the design evolved into a more integrated system, ensuring seamless interaction between all elements and enhancing usability for the beekeeper.
- The original idea for transmitting data to the beekeeper involved wireless communication through an app. However, it became apparent that Bluetooth would be too slow, and the rural locations where beehives are typically placed often lack sufficient cell service for reliable wireless data transmission.

Prototype Assembly



FINAL DESIGN, APPROACH, PLAN

Mechanical

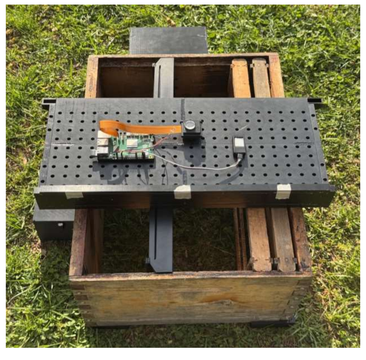
Custom 3D-Printed Deep Frame: Combines two deep frames, Incorporates a bee wax foundation, Provides space for sensors and electronics while maintaining the natural structure of the hive.
IR Camera Housing: Securely holds the infrared (IR) camera used for Mite Detection, Strategically designed to position the camera to capture close-up images of bees for AI detection accuracy.
Cable Box Housing: Organizes the cables running into and out of the deep frame. Houses the USB flash drive that enables the beekeeper to access the collected information.
Weight Sensor Housing: Designed to secure and protect the load cells, the housing will be placed at the corners of the beehive using a 90-degree extrusion to ensure accurate weight measurement.

Electrical

Processing & Data Management: Raspberry Pi 5 acts as the central processing unit, Python scripts control each sensor, automatically collecting data at 2:00 AM and 2:00 PM.
AI Processing: AI image processing that analyzes images to classify the queen and mites, which aids in monitoring hive health.

Final Assembly in Beehive

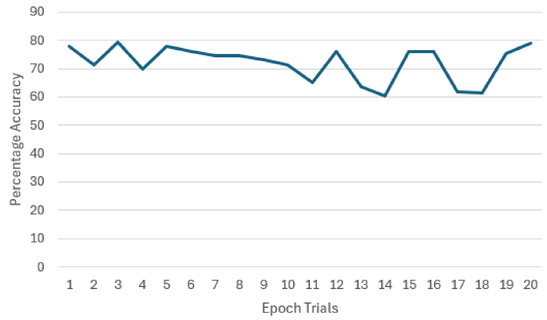
Electrical Assembly



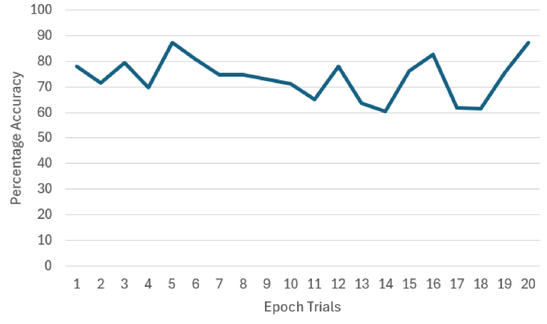
RESULTS

The team successfully developed a functional prototype of the beehive monitoring system. Utilizing a Raspberry Pi 5 in conjunction with various environmental and imaging sensors, data was collected and used to generate the figures shown below. AI models were trained to detect both the queen bee and mites on incoming bees. The trained models achieved an accuracy rate between 70–80% for both detection tasks, demonstrating promising performance for hive monitoring applications.

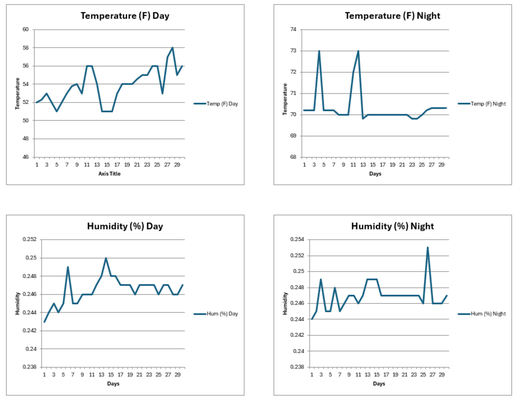
Mite Epoch Trials



Queen Bee Epoch Trials



Other Gathered Data



SUMMARY AND CONCLUSIONS

This project developed a compact AI-driven beehive monitoring system using a Raspberry Pi 5, weight and temperature/humidity sensors, and two cameras: one for queen bee tracking and one infrared camera for mite detection. Trained models achieved 70 to 80 percent detection accuracy. Housed in a 3D-printed double-deep frame, the system logs data locally and exports it via USB. Early testing shows the design is effective and scalable. Future goals include improving accuracy, adding wireless connectivity, and refining data visualization to advance smart hive management with embedded AI.

FUTURE WORK

One of the major limitations of the project was the lack of sufficient data available to effectively train the AI models for both queen bee and mite detection. The internet provided a starting point for data collection, many of the images differed from the conditions and perspectives the device will encounter once installed, which reduced the accuracy of the initial models However, once the device is installed, it will begin to collect a large dataset. The next phase of development will involve reviewing and labeling this new data, followed by retraining the AI models to improve accuracy and performance.

TEAM & ACKNOWLEDGEMENTS

Student Team Members

- John Cole, Engineering Technology
- Nicolas Fox, Electrical Engineering
- Tyler Wallace, Electrical Engineering

Faculty Team Members / Acknowledgements

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