Instrumented Beehive

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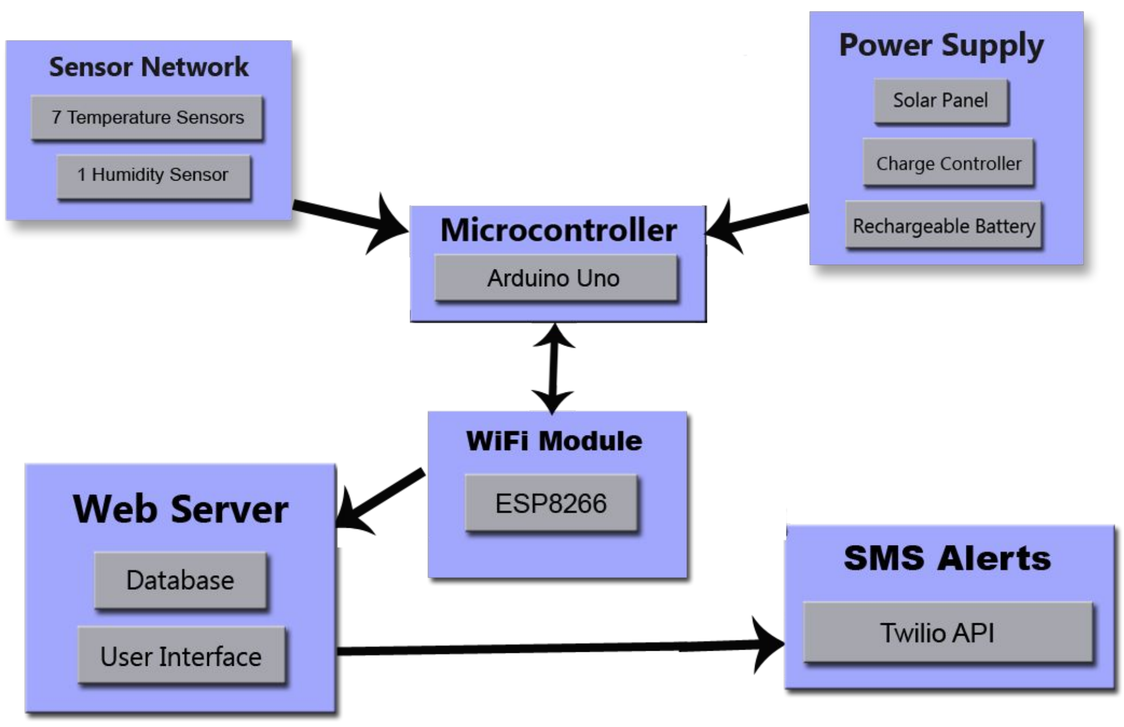
Abstract

Currently, beekeepers must go their hives and manually check on the health of their bees. Our system allows beekeepers to monitor the most important conditions, temperature and humidity, in their already existing beehives. We've created a dummy beehive frame equipped with sensors and a microcontroller which beekeepers will insert into their existing hives. The beekeepers will be able to analyze the conditions of their hives using our web interface as well as receive real-time alerts when abnormalities occur. Our system is powered by solar energy and also has a battery with enough capacity to power the system for weeks without sunlight.

System Overview

- 8 sensors taking readings every 15 minutes
- Arduino sends data to WiFi Module using AT Commands
- WiFi module creates TCP connection with server and sends data via HTTP POST request
- Server stores data in MySQL database using PHP
- Data graphs created using JQuery
- System is powered by Solar Energy

Block Diagram



Results

- Data from real beehive in graph form
- Beekeeper can analyze data to make sure hive is at optimal conditions
- Alerts triggered when spikes occurred

Specifications

Parameter	Value	Notes
Sensor Accuracy	+/- 1 °F	
Alert to phone	Temperature change +/- 5 °F Low Battery	Customizable
Data Collection	Every 15 mins	Customizable
Data Transfer	Every 15 mins	Customizable
Data Accessibility	Remote	
Renewable Energy Source	Solar	
Power Limitations	13 days	Worst case scenario
Operability	All weather conditions, all year	
Range	Within 300 feet of WiFi	

Acknowledgement

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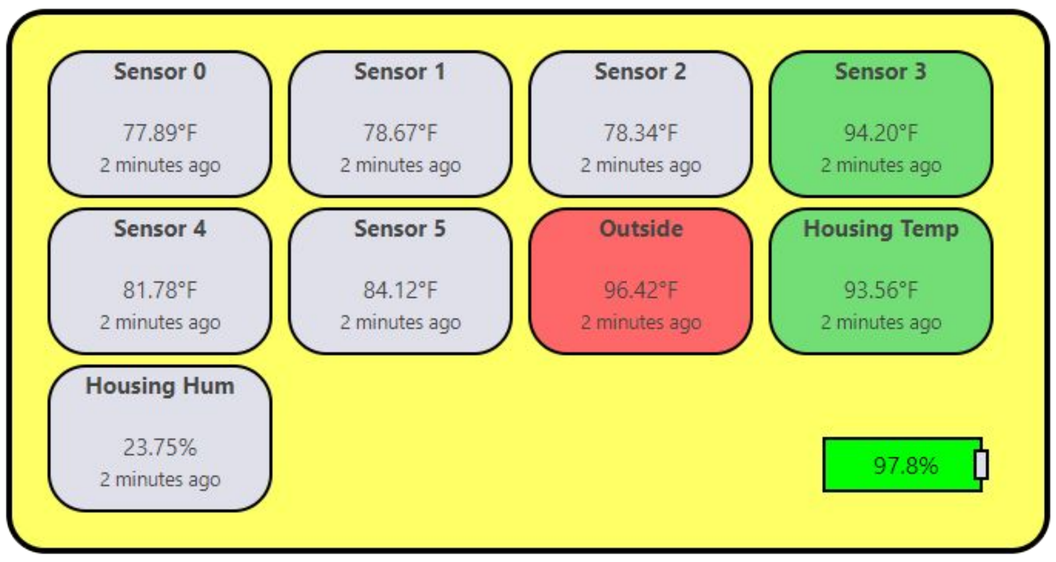
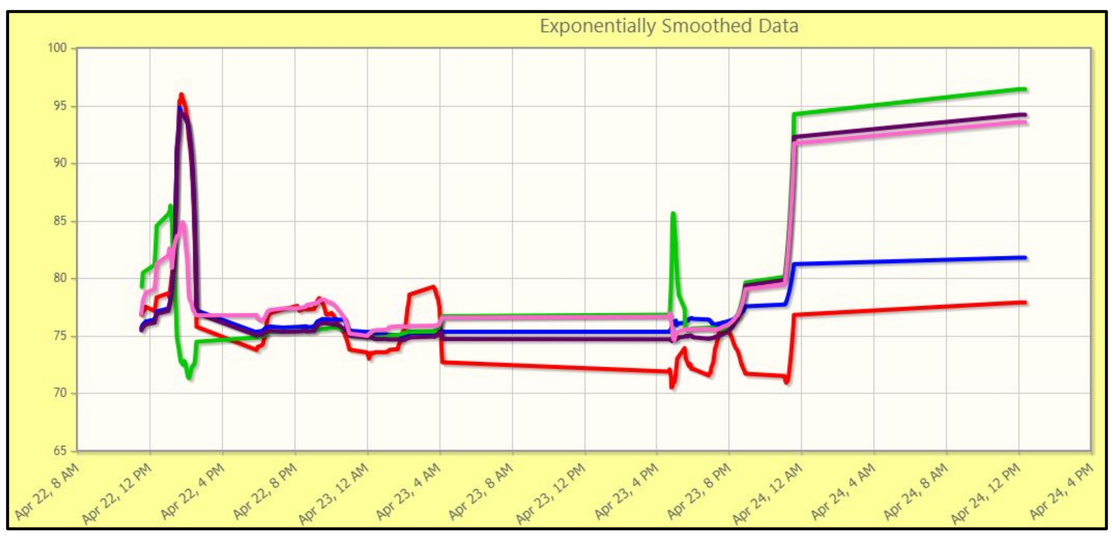
Server



Home Page Features:

- Most recent readings for each sensor with how long ago it has been updated
- Current battery percentage
- Choose sensors and time period to great graphs for
- Change settings for alerts and the delay



Data Analysis Features:

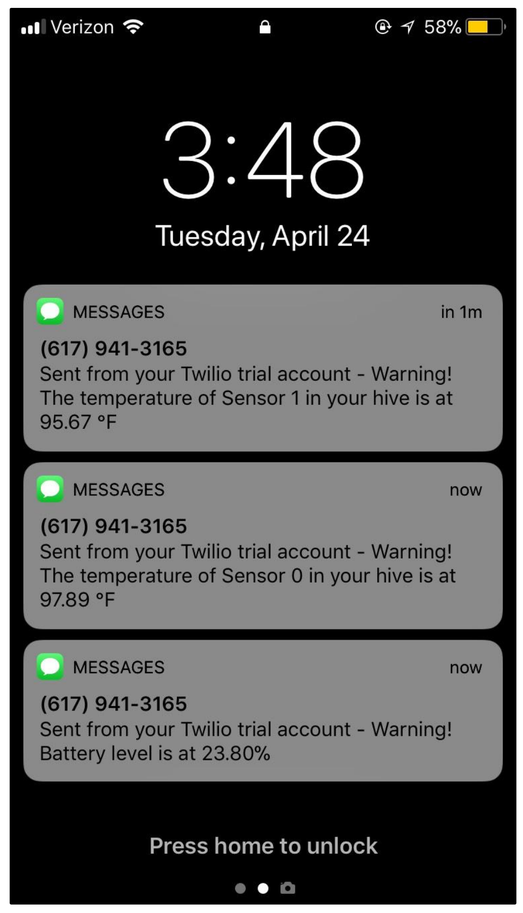
- Graphs with raw data
- Graphs with exponentially smoothed data for better visibility
- Both can further analyzed by zooming in on specific points
- All data points provided in table form
- Sensor metrics provided (average, maximum, minimum, standard deviation etc.)

Cost

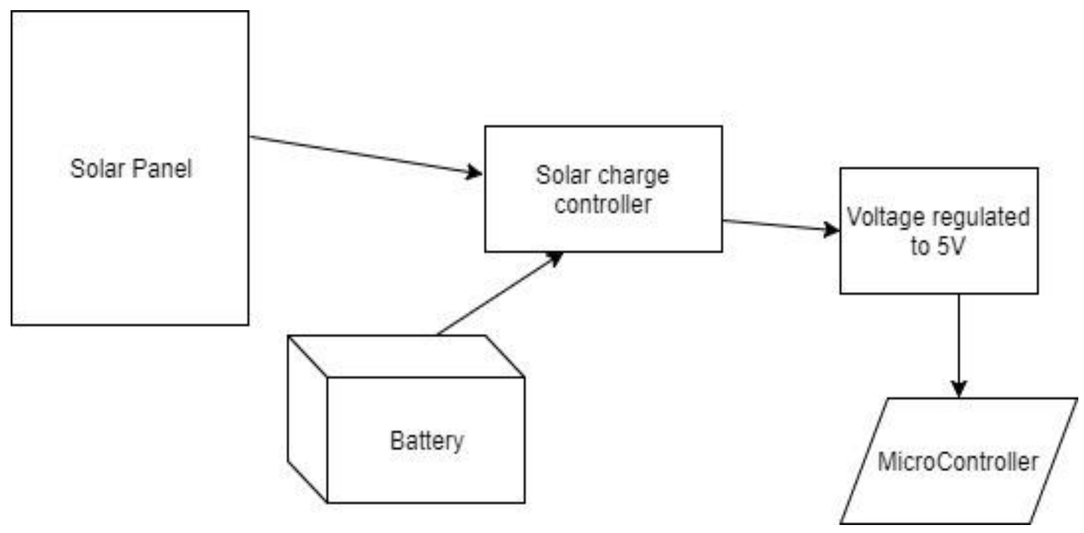
Parts	Development	Production (1000)
Sensor Network	$48.57	$27.17
Arduino/WiFi Module	$36.90	$31.21
Solar Panel	$105.00	$105.00
Battery	$118.39	$89.75
Rest of Power System	$109.65	$98.11
Housing	$51.94	$44.23
Total	$470.45	$395.47

Alerts

- SMS alerts are sent using Twilio API
- Alerts include:
  - Moving average (temp and humidity)
  - Trending in direction (temp and humidity)
  - Battery level
- All can be customized and turned on/off



Power Supply



- 13 V rechargeable Lead Acid Battery at 100%
- 50W Solar Panel charges Battery
- Solar Charge controller controls regulation of charging and output voltage
- Minimum battery threshold: 8V
- System can last for 13 days without solar power
- Alert gets sent out when battery is at 25%
- Beekeeper can customize the alert trigger

Experiment

- Entire system set up at Warm Colors Apiary
- Data recorded from inside a beehive with bees
- Data uploaded to server's database
- SMS alert sent when there is a spike in data