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優勝作品專輯

作品編號 **050020**

參展科別 **動物學**

作品名稱 **Optimization of honey production by monitoring the behavior of bees based on studying their sounds**

得獎獎項 **三等獎**

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關鍵詞 **Secondary metabolites、surfactant、Aedes aegypti**

Abstract:

This is a first approach in the development of beekeeping and the preserving of bees, a crucial and important species in the balance of ecology on our planet.

This project consists in designing and building a small affordable device that will help beekeepers keep an eye on their hives and prevent theft whenever and wherever they are by providing them with instant and continuous data and information about their beehive status through a mobile application.

This IOT approach will rely on many physical variables especially the sound frequency of the bee buzz, which appears to be a way for the bees to communicate with each other in special circumstances.

That is why; we aimed to analyze the sound frequencies of the bee buzz to detect beehive behavioral changes.

Many other factors are also important for the keeping of a healthy beehive such us temperature, humidity, weight and fly activity.

And as for security measures we are going to add a GPS tracker to the system to keep track of the hives and alert the beekeeper if there is any kind of danger.

The development of this real time beehive monitoring system will not only help the beekeeper keep track of his hive and collect useful data but also increase the honey production and avoid many colony losses and thus preserve the bees and ensure their well-being.

Problematic:

Even though beekeepers are facing problems with preserving the colony and improving the production of honey Also theft can be serious problem for beekeepers there are no methods that are helping them understand the behavior of their bee colonies.

In Tunisia, beekeepers are mainly facing temperature and humidity problems as well as varroa and security problems.

So how can we monitor the health status of the bees, ensure high quality production of honey, and preserve their well-being?

Background research and data analysis:

Recent researchers have worked on the relation between the evolution of some physical variables in beehives and the status of the colony.
This research (1) has studied the relation between the level of frequency of the beehive and what they potentially mean:

Table 1: Honey bee signals and what they signify [7]

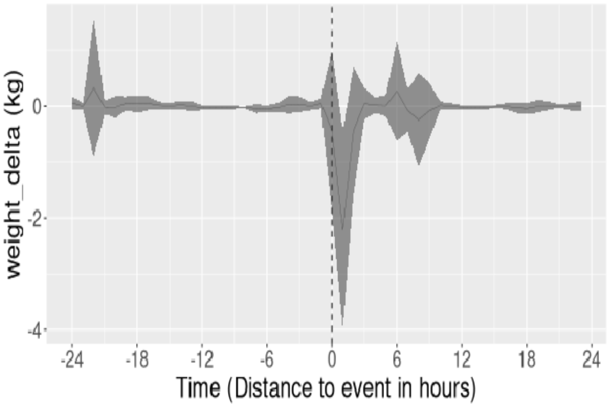
Signal	Frequency Range (Hz)	Signal Pattern	Sender	Significance
Recruit	200 – 350	Pulse Sequence	Forager	Indicates existence of a quality food source
Tooting	300 – 500	Pulse Sequence	Queen	Subset of piping. Prevents hatching of further queens
Quacking	300 – 350	Pulse Sequence	Queen	Subset of piping. Indicates viability of confined, mature queen
Worker Piping	300 – 550+	Single Pulse	Scout	Triggers colony hissing to prepare to swarm
Hissing	300 – 3600	Single Pulse	Colony	General warning/defense signal. Occurs during swarming, hive attacks, and other adverse events.

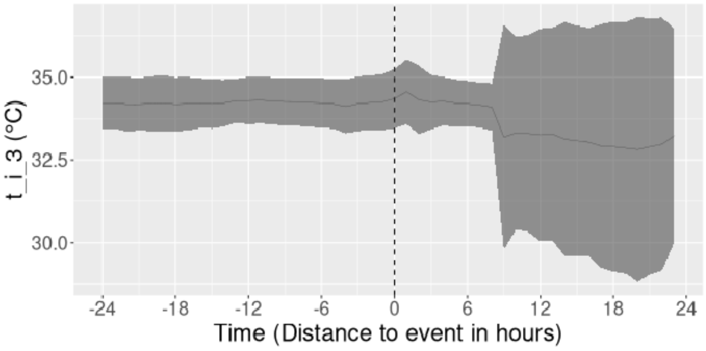
A sound of hissing coming from the whole colony with a single pulse and a frequency between 300 and 3600 Hz is a sign of a potential danger such as hive attacks and swarming. These two events may result in colony loss or a significant decrease in the production.

What is swarming? (2)

“As your bees prepare for the main flow they are building their population and the queen is heading toward her maximum laying capacity of approximately 1,500 eggs per day. In Alberta, we see a huge population explosion unlike anywhere else in the world. Your hive can have 80,000 bees! That's a lot, and it can happen quickly in Alberta. Honey bees need sufficient room to grow, or they will decide as a colony to swarm. Essentially, when your hive runs out of room, the queen will lay another queen in preparation for leaving with half of the hive. When they swarm, half the hive will leave and the other half will stay with the new queen. It is survival, but it will leave you with no honey this season.”

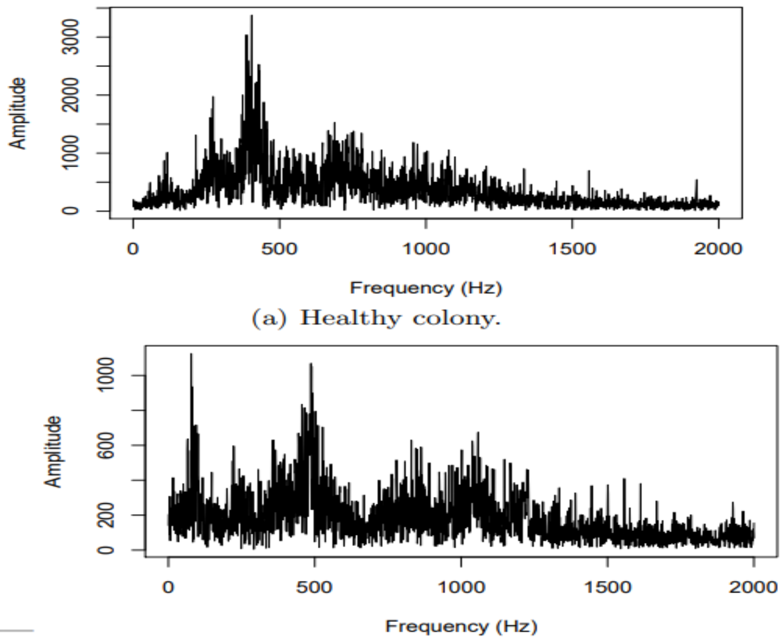
These diagrams extracted from this report (4) show the changes in weight and temperature before and during swarming event:





In another study (3), a relation between the presence of a queen in the colony and the sound frequencies of the honeybee buzz has been observed.

Frequency Analysis of Honey Bee Buzz for Automatic Recognition of Health Status...



(a) Healthy colony.

(b) Unhealthy colony.

Fig. 3. Comparison of the frequency spectrum of the healthy and unhealthy colonies.

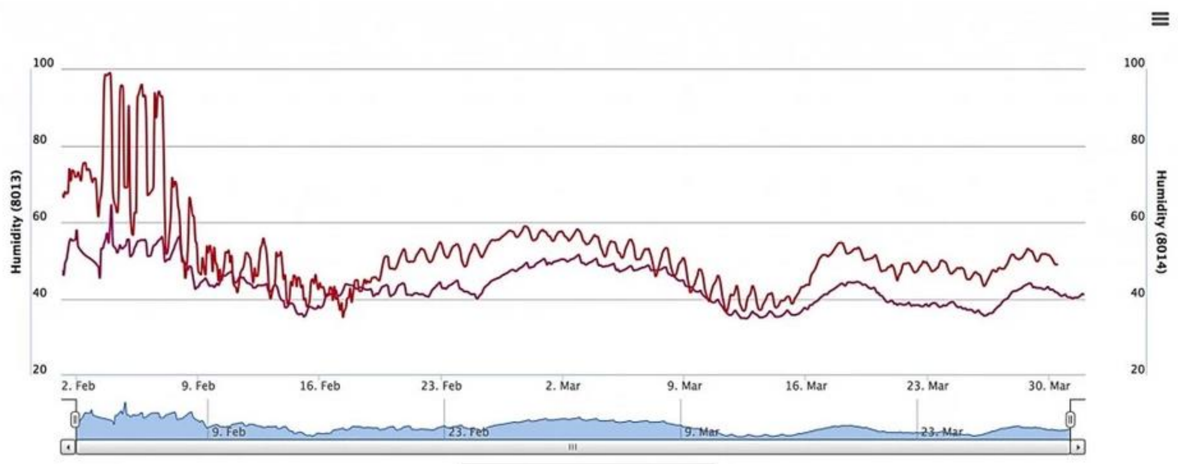
healthy colony; most of the sound activity is present around 400 Hz. On the other hand, in figure 3(b), the queenless colony present a different pattern; the emitted sound is distributed in more frequency bands.

Humidity and temperature have also been proved to be important factors which can tell us about the status of the beehive.

In fact, the brood needs temperatures to be between 34°-36℃. Studies suggest that a temperature outside this range can have negative effects on the health of emerging adult bees. In colder months, it becomes harder for the bees to keep the necessary hive temperature. As a result bees focus their energy on keeping the temperature and the queen will stop laying eggs leading to a decrease in the productivity of the hive.

Relative humidity is also as important as the temperature and can affect the activity of bees if it reaches high values. These graphs can explain the importance of the temperature-humidity factor:

Knowing when the relative humidity of the hive is so high that there is a risk of condensation generates a useful alert for bookoopers to increase hive ventilation. Graph 1 bolow clearly demonstrates this, whore during the first week of February relative humidity in one hive reached levels of 90% and even 100% (red line). This means condensation is accumulating inside the hive which could drip onto the cluster. While bees can deal with cold quite well, not so if they are wet! The hive next door (pink line), shows same pattern but without the excursion to saturation levels. Besides the high humidity ovent the levels are otherwise quite uniform and representative of what we normally observe in the healthy queen right colonies: 40- 60%



Humidity also plays an important role in the quality of the honey.

The best quality requires relative humidity values under 20%.

We had the chance to meet a Tunisian beekeeper who got us through the problems they encounter in our country. They were mainly facing temperature and humidity problems.

In fact, the internal beehive temperature is normally at 36℃ just like a human body.

During the winter, they could not keep this temperature because the material of the beehive (wood) was not as sufficient as necessary and during the hot summer days,

The high temperatures and long exposure to solar radiation caused damage to structure of the beehive.

Finally they affirmed that being able to monitor their hives was a good idea because every time they open a hive for inspection they were losing great amounts of the honey production.

Materials and methods:

Our way of approaching all these problems is a sort of data-collecting device.

However there are some several problems:

Electromagnetic fields seem to bother honey bees and cause them to leave the hive. Hence, putting electronic devices that are constantly working around the hive may not be as efficient as we thought.

Considering all these problems, our device will be a small box containing a GPS and a Node MCU and placed inside the hive without taking too much space. All the sensors will then be carefully placed inside the hive through little holes.

This device will be discontinuously powered to take short timed recording of the hive to avoid bothering the bees with the radiations.

The beekeeper will also be able to power the device as he wants using the mobile application.

All the data collected will be analyzed and sent to the beekeeper through the mobile app.

In the case of theft or a critical abnormality the keeper will instantly be notified.

Sensors and the data collected:

- Humidity and temperature sensors real time relative humidity and temperature values
- A camera to detect the varroa parasite
- Microphone (check the sound frequencies emitted by the colony)//noise sensor KY-037//
- GPS (check the position of the hive to avoid theft)

The humidity and temperature data will be gathered from a DHT11 sensor and plotted using thingspeak as well as the frequency data.

In addition, we are using the Nodecam module to record videos and detect the varroa which is a black parasite that will fall on the bottom of the hive when dead.

Finally, the device will be equipped with a U-Blox Neo-6M to ensure the safety of the hive.

Any data collected which matches with an anomaly in the hive will result in the instant warning of the owner through a mobile application.

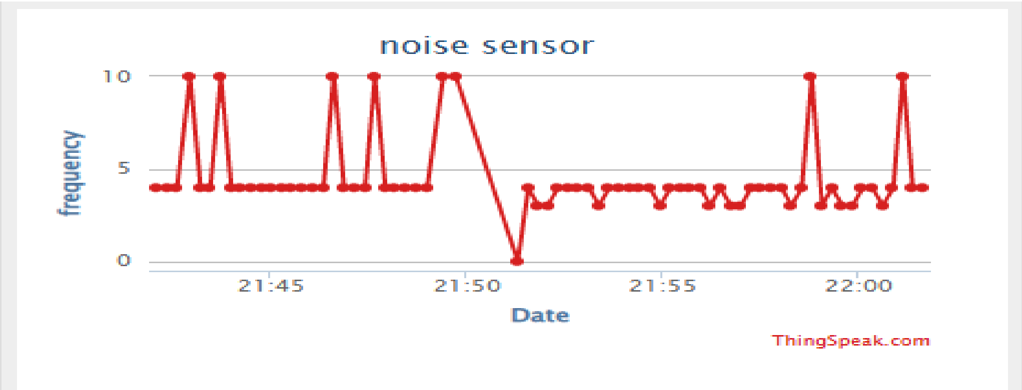
Coding:

Data study is concluded in three important parts using thingspeak:

*collect: with the three sensors and nodemcu, thingspeak collectes data and stores it in channels as graphs

```
#include <ESP8266WiFi.h>
#include <ThingSpeak.h>
const char *myWriteAPIKey = "8IZU9D3ZXAL7NPPE";
const char *ssid = "TOPNET5CFEBE92"; //AndroidAP
const char *pass = "IWGOYHR@9.4058FNDJ";//yomnaatast
unsigned long myChannelNumber = 1293434;// Enter your Thingspeak Channel Number
const char *server = "api.thingspeak.com";
int val=0;
WiFiClient client;
void setup()
{
WiFi.begin(ssid, pass);                                // Start WiFi connection
  ThingSpeak.begin(client);                            // Start ThingSpeak connection
  Serial.begin(115200);                                // Serial Baud Rate
                                      // Set the Motion Sensor pin as an Input
```

1



- This graph shows an unstable pulse and w frequency when the there is an abnormal condition in the hive at a period of time and then the decline and the pulse sequence which shows the stability of the bee.

*analysis:

Thingspeak provides access to MATLAB in order to analyze the data and compare it with the normal conditions in the hive in order to avoid any problems and to check the hive daily

*act:

Act on data as receiving an alert notification in case of any abnormal activities for example frequency between (300 HZ-3600 HZ)

Get data from Thingspeak with app mobile :

Esp32 will send data every period of time and that the application will send requested to the platform and then answer will be the last value of a specific field.

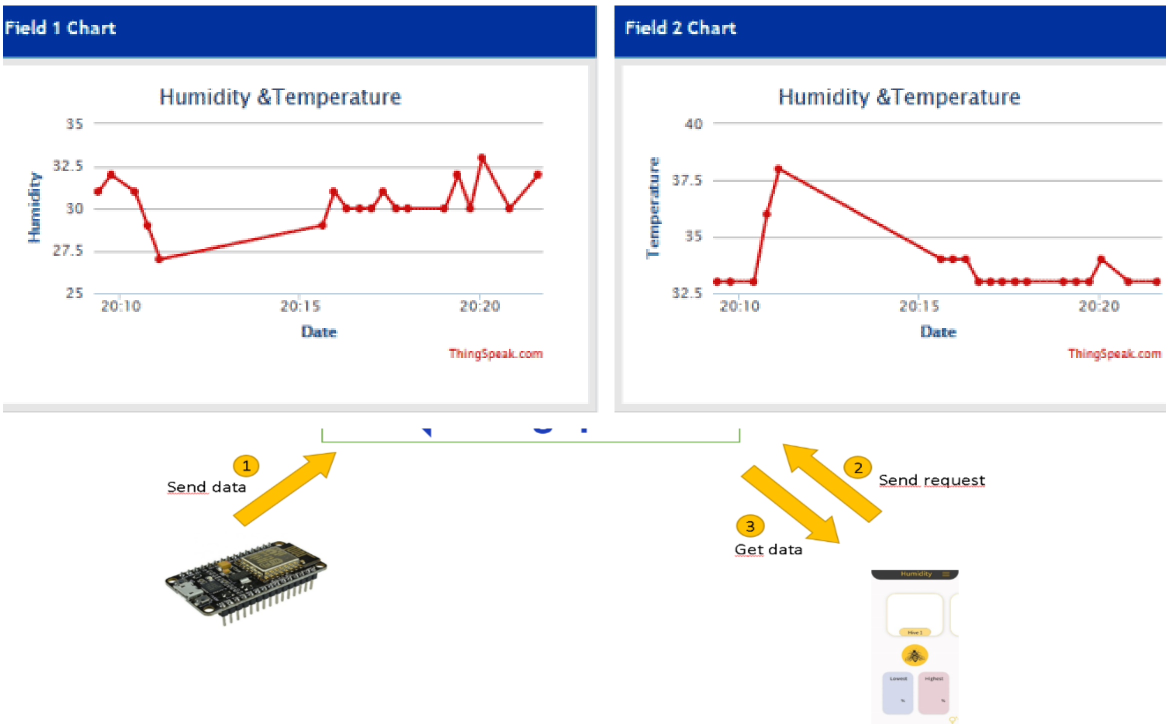
The code below will as well allow us to plot relative humidity and temperature data captured by the DHT11 sensor.

thingspeak_DHT | Arduino 1.8.13

Fichier Édition Croquis Outils Aide

thingspeak_DHT

```
const char *ssid = "iPhone";
const char *pass = "123456789";
unsigned long myChannelNumber = 2019167;// Enter your Thingspeak Channel Number
const char *server = "api.thingspeak.com";

WiFiClient client;
void setup()
{
WiFi.begin(ssid, pass);                                   // Start WiFi connection
  ThingSpeak.begin(client);                                 // Start ThingSpeak connection
  Serial.begin(9600);                                     // Serial Baud Rate
                              // Set the Motion Sensor pin as an Input

  Serial.println();
  Serial.print("Connecting to ");
  Serial.print(ssid);
  while (WiFi.status() != WL_CONNECTED)
  {
    delay(5000);
    Serial.print(".");
  }
  Serial.println();
  Serial.println("WiFi connected");
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());
  dht.begin();
  }

void loop() {
  // Wait a few seconds between measurements.
  delay(100);
 if(WiFi.status() != WL_CONNECTED){
    Serial.print("Attempting to connect to SSID: ");
    Serial.println(ssid);
    while(WiFi.status() != WL_CONNECTED){
      WiFi.begin(ssid, pass);  // Connect to WPA/WPA2 network. Change this line if using open or WEP network
      Serial.print(".");

    }
    Serial.println("\nConnected.");
  }
  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  int val_hum = dht.readHumidity();
  int val_tem = dht.readTemperature();
  Serial.println(val_hum);
  Serial.println(val_tem);

  ThingSpeak.setField(1,val_tem);
  ThingSpeak.setField(2,val_hum);
  int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);

}
```



ESP32-CAM using ESP8266

The camera will help the beekeeper know if there is **parasite** Varroa

Install ESP32 CAM board

Configure board to ESP32 Wrover Module

Set Baud Rate

Get the Example Code

Upload the code & get Error

Fix the Error & Re-upload Disconnect 100--GND wire

Open Serial Monitor

Press RESET on ESP32 CAM board

Get URL in serial monitor

Open the URL in browser

Conclusion:

We aim to further our research and develop this idea by working on a completely smart beehive, which would be able to control many physical variables such as temperature and humidity. In addition, we think that working on diseases that might attack bees by finding solutions of detecting them and trying to find ways not only to avoid these abnormalities but also to cure them.

Acknowledgments:

Finally we would like to express our special thanks to the ATAST family and all of our coaches for their help and support throughout this project.

This project is a way of linking between theoretical and practical learning, so we would like to thank everyone who helped us by boosting our confidence and believing in what we are doing.

RESOUCES:

(1):https://libres.uncg.edu/ir/asu/f/Wilson_Preston_August%202019_Honors%20Thesis.pdf

(2): https://hiveworld.ca/blogs/education/swarm-season

(3):https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjEjbPhopj8AhUuhP0HHf1VBPYQFnoECAoQAQ&url=https%3A%2F%2Frcs.cic.ipn.mx%2F2017_142%2FFrequency%2520Analysis%2520of%2520Honey%2520Bee%2520Buzz%2520for%2520Automatic%2520Recognition%2520of%2520Health%2520Status.pdf&usg=AOvVaw3Il9fyu0263DLxobR7qKfg

(4): https://doi.org/10.1109/SusTech53338.2022.9794223

(5):
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【評語】050020

1. This research is to design an intelligent beehive to monitor the information of the beehive and bee colony in real time to increase the production of honey. The present study is to analyze the sound frequencies of the bee buzz to detect beehive behavioral changes by developing a device.
2. The concept is worth to study. The relevant physical conditions affecting the hives were all factors monitored in this study design.
3. The results are preliminary to tell the feasibility of the device. This work needs to provide more solid data under different conditions to achieve the experimental aim.
4. The report mentions the design concept and environmental factor monitoring data，but the part about how to optimize it is less clear.