Ministry of Education and Science of Ukraine

ODESSA NATIONAL ACADEMY OF FOOD TECHNOLOGIES

International Competition of
Student Scientific Works

BLACK SEA SCIENCE 2020

PROCEEDINGS

ODESSA, ONAFT 2020

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3. INFORMATION TECHNOLOGIES, AUTOMATION AND ROBOTICS

MEASURMENTS FROM HIVE PREVENTS THE EXTINCTION OF BEES BASED ON IOT TECHNOLOGY

Authors: Sebastian Górecki, Arkadiusz Mączkowski, Konrad Koperek
Lodz University of Technology (Poland)

Abstract: *European plant cultivation depends on bees' participation in pollinating flowers. Colony Collapse Disaster and "Empty Hives Syndrome" is still growing. The aim of this article is proposing technological solutions for prevention of bee's colony reduction based on own research and temperature measurements from hive. A survey of beekeepers was conducted for better understanding beekeeper's problems. The electronic equipment developed for the study by student confirmed presumed objectives and the effectiveness of the proposed algorithms for detecting anomalies inside the hive. Presented result can help prevent the extinction of bees using IoT Technology.*

Keywords: *IoT, Bees, Algorithms, Swarming Detector, Machine Learning*

Introduction

Bees are treated as a deity, are considered exceptional, marvellous and wonderful creatures. In Poland, beekeeping is associated primarily with family tradition, continued for by next generations. Bees provide us with healthy and natural products, such as: honey, pollen and propolis. The main benefits of food produced by bees are antioxidants contained in it and antibacterial properties. Furthermore, EU parliament noted in resolution T6-0579/2008 that 79% of the world's food supply is dependent on honeybees while Great Brittany beekeepers say that this number exceeds over 80%.

Over the past 20 years, there has been a dramatic decline in the honeybee population (Apis Mellifera), in most countries of the world. The sudden decline in the population of bees - both breeding and wild - has far-reaching consequences. Pollination by bees ensures the reproduction of many plant species, especially crops that are the basis of nutrition for the world's population, which is why authors of article Intelligent Hives project focuses on reducing the risk of extinction of the bee population. One of the main factors causing the reduction of bee populations are like late detected disease, thefts, time-consuming maintenance or lack of technology development.

The aim of this article is to develop knowledge and show result of study that will be able to remotely monitor bee family and notify about anomalies based on temperature measurements to prevent bees from extinction. Solution of this problem will have an impact on an important part of the environment and will increase the awareness of people about data collection and analysis.

World agriculture problem

Bees are key pollinators for European agricultural crops, not only from economic perspective. It is estimated that over 35% of human food consumption depends on insect directly or indirectly [1]. The worldwide economic value of pollination amounted to €153 billion, which represented 9.5% of the value of the world agricultural reduction used for human food in 2005 [2]. Food would become a very scarce resource, in a situation when bees become extinct.

Solutions for beekeepers, which help bees

At this moment, beekeepers support their work with manual measurements, that is a worrying process for life of bees. Several companies provide single sensors that could be implemented in hives, however there is no a complex solution on the market yet.

There is a product on Polish market, called ControlBee, which provides only a location tracking and temperature monitoring, however with not precise results. This system does not possess the ability to monitor the hive in order to prevent the loss of bees. The ULmonitor is the next device on the Polish market, which is worth investigating. This system consists of periodical recording of humidity and temperature information by sensors placed in hives, transferring data to a phone. Unfortunately, like first product, the second product do not make analysis and is complicated for a beekeeper, who is not familiar with electronic system.

Survey among beekeepers

Beekeepers have been gathering knowledge for centuries. Traditions is passed on by generation to generation and own observations and practical experience. Beekeeper's knowledge is a good resource of bee protection, which is why survey was conducted among beekeepers to check beekeepers' awareness of hazards for bees, awareness of ways to protect bees and for the determination of important parameters for monitoring beehives. It was carried out on the 10th June 2018 and forty-four beekeepers took part in presented survey. Among the respondents were both experienced beekeepers who have been running their apiaries for many years, but also the less experienced ones. This cross-section of the beekeeping community also affected the number of hives owned by one beekeeper. The number ranged from 3 to over 90 hives per person.

The results of this survey indicate not only that beekeepers are aware of the dangers that could happen to them, but also most of them have lost their bee families at least once. Over 90% of beekeepers have heard about Empty Hives Syndrome and as much as 72.7% of the respondents recorded a loss of family in their apiary.

According to the beekeepers' answers, the loss of a colony is not only very costly, but it is also connected with a long time of reconstruction of a bee colony. Less than 91% of the respondents answered that this type of loss is expensive and the rest of them answered that it may be so. None of the respondents answered this question in the negative. When asked about the time of reconstruction of the lost family, two answers received a total of less than 80% of votes. It was "3 to 6 months" and "6 to 12 months". It follows that in such a situation a beekeeper must reckon with a smaller profit from his activity for several to even several months.

Thanks to the survey presented above and the conversations conducted with beekeepers we were able to deduce what an average beekeeper need. Our device and its functionality are created based on consultations with customers. This can be proved by the functions available in various BeeHUB variants. The basic version focuses on humidity and temperature measurements, while we are currently developing and testing further products that would allow, among other things, sound analysis that helps to detect swarm and the addition of a scale that would not only meet the greatest need of beekeepers, but would also be cheaper than other scales for hives available on the market.

Internet of Things

The Samsung Techonomic research presented that over 80% of Europeans has no idea about Internet of Things really is. This may seem strange as statistically in each home on our continent there are 19 electronic devices on average. Internet of Things is a collection of technological solutions that are designed to home automate, an office or a whole city! It's not only for fun, most of all means for solutions that translate into effective time, security and space management.

Idea of Intelligent Hive, which can monitor bee's family is a perfect example of a system utilizing the features of IoT. Simple implementation of the low power consumption device for monitoring hives, turns an average hive into an Intelligent Hive. User can place the device into the hive, distributes the sensors and turns it on, which is sending valuable data gathered by these sensors with low latency. Data is processed in the cloud and advanced data analytical solutions with embedded artificial intelligence mechanism, combined with machine learning, is conducting analysis of variety of IoT data.

To create system based on IoT, it is necessary to expand, choose or create main components:

- Hardware - electronic components, which are the source of data;
- Middleware - accountable for storage and data analysis;
- Presentation – presentation and visualization of data.

Fig 1. Concept of IoT system structure.
Source: Sebastian Górecki

Based on a conceptual structure, prototype of system was created. This model was designed as a prototype of an actual device for prevent bees' diseases with a simple Internet interface for a beekeeper, with possibility of data download with idea for prediction anomalies.

The Wi-Fi network is widely available and quite cheap for beekeepers to create and maintain easily accessible environment for test device to cloud. For this reason, prototype electronic equipment was based on this network in the conceptual version of the project. Using Wi-Fi, data from the device was sent to the cloud - in this case to open source database. It would be worth to utilize the LoRaWAN network in the future or the 5G network for data transfer, due to the relatively large range of the sending device. Expanding listed networks allow cheap data transfer at long distances, with small delays and a stable link.

Fig 2. Data downloaded from prototype device, presenting variation in temperature from 10/09/2018 to 16/09/2018.
Source: Sebastian Górecki

Temperature inside hive

The data taken from the test equipment from the study for all 2018 beekeeping season, where example of short period is presented in Fig. 2. confirmed that each bee family creates own environment in a hive. In swarming period exposes a specific temperature in the beehive. Despite changing external conditions, bees can maintain their optimal temperature in the nest the best for the brooding. in a range of 33-36 °C. In winter season, bees maintain a temperature around 25 °C in the centre of the withers.

Observing the temperature in the nest, it can be determined at what stage the bee family is. For example, in the cold weather, the temperature under the coating will increase, when food intake increases. During late autumn or winter the temperature in the beehive may be equal to the outside temperature, which may be caused by underfeeding. However, swarm extinction is usually the result of a disease, not a lack of supplies. When you see a cooled beehive, you can eliminate it in advance, so that the disease does not spread to other bees.

Presented identification algorithm of Fig. 3. algorithm which was made by scientists from Latvia was tested on historical temperature data of honeybee colonies gathered from prototype devices and successfully identified all swarming events. An algorithm should be included in the software, to detect swearing period. In the period of warm-up for final take-off of bees, the temperature above upper hive body rises by 1.3-3.5° C from normal brood rearing temperature 34- 36 °C to 37 °C. In observed swarming events, it was found out that a bee colony needs around 14 min to warm up before final take-off [3].

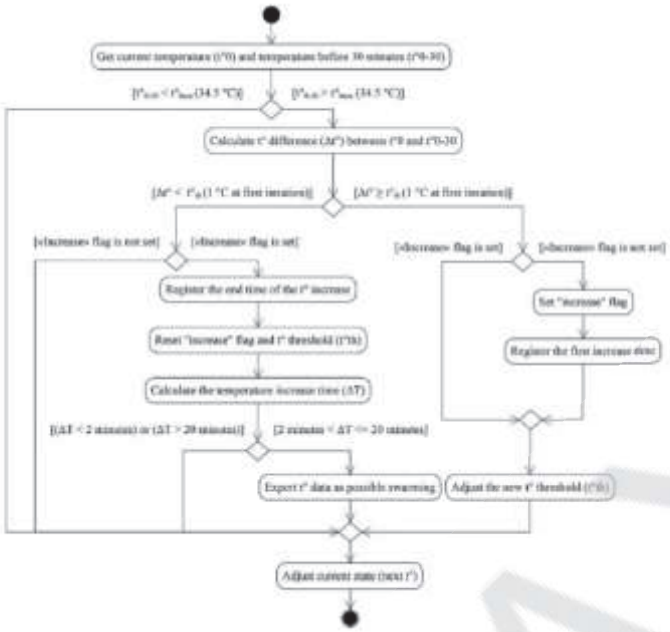

Fig 3. Activity diagram of one iteration of swarm identification algorithm.
Source: Remote detection of the swarming of honeybee colonies by single-point temperature monitoring

Machine learning implementation

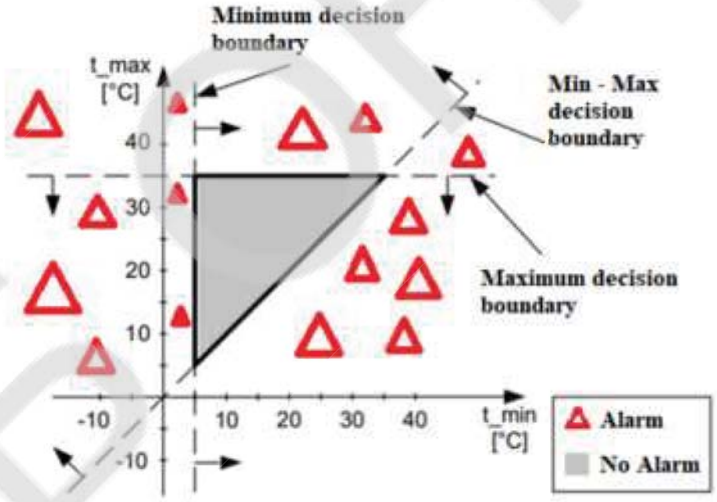

Fig 4. Activity diagram of one iteration of swarm identification algorithm.
Source: Sebastian Górecki

Usage of machine learning should concentrate on the idea [4] contained on Fig. 4. which shows classification set of training data with minimum and maximum temperature boundaries and minimum-maximum boundary. Temperature readings, which are placed outside boundary triangle are extreme for beehive colony and cause sending an alarm message to the beekeeper, when diseases or swarm period occur.

This temperature classification will be tested for anomaly detection in the next season 2020. However, tasted on the collected data from the past years, it is accurate and effective.

Summary

Colony Collapse Disaster and so-called "Empty Hives Syndrome", particularly in North America and most of Europe is still growing. Intelligent Hive is a solution,

enabling analysis of the alarm state, by monitoring such parameters as temperature inside the hive. The idea of basing the bees' state of health anomalies detection system on IoT technology promises to be very fast, accurate and efficient. Data collected using a dedicated circuitry, software and machine learning algorithms, with a combination of gathered knowledge for one season, based on existing scientific research and analysis affirmed that the temperature analysis have been conducted properly. Investigated activity diagram of one iteration of swarm identification algorithm and the proposed temperature classification that can be used in machine learning algorism to detect bad health bees' condition. System with the solutions quoted will be developed and tested further. Presented ideas and result can help prevent the extinction of bees using IoT Technology.

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