Martin BOHUŠÍK[1], Vladimír BULEJ[2], Miroslav CÍSAR[3], Michal BARTOŠ[4]

Opiekun naukowy: Ivan KURIC[5]

SYSTEM MONITORINGU DLA PSZCZÓŁ

Streszczenie: Artykuł dotyczy stanowiska monitorowania pasieki z zastosowaniem technologii IoT (Internetu Rzeczy). Celem artykułu jest przedstawienie kompletnego projektu instalacji do monitorowania pasieki.

Słowa kluczowe: monitoring, ul, Arduino, Raspberry Pi, IoT

CREATION OF A MONITORING SYSTEM FOR BEES

Summary: The article focuses on beekeeping monitoring stations implementing IoT technology. The goal of this article was to create a complete design of the beehive environment monitoring system that implements IoT technologies

Keywords: Monitoring, Beehive, Arduino, Raspberry Pi, IoT

1. Introduction

Nowadays all of us know, that bees are very important for the human life on Earth. For this reason, it is necessary to use the newest technology and help bees to live here. However, we will not present any revolutionary technical innovation in this article (like a Harvard engineers in 2013, which created the RoboBee), but we will focus on development of a bee monitoring system, which can be used by some beekeepers in their bee farms. Every automatic monitoring system for bee hives brings several significant benefits in the same time. It can significantly facilitate bee life in beehives

[1] Ing., University in Žilina, Faculty of Mechanical Engineering, Department of Automation and Production Systems, e-mail: martin.bohusik@fstroj.uniza.sk
[2] Assoc.-prof., Ing., PhD., University in Žilina, Faculty of Mechanical Engineering, Department of Automation and Production Systems, e-mail: vladimir.bulej@fstroj.uniza.sk
[3] Ing., PhD., University in Žilina, Faculty of Mechanical Engineering, Department of Automation and Production Systems, e-mail: miroslav.cisar@fstroj.uniza.sk
[4] Ing., University of Zilina, Faculty of Mechanical Engineering, Department of Automation and Production Systems: michal.bartos@fstroj.uniza.sk
[5] prof. Dr. Ing., University of Bielsko-Biala, Faculty of Mechanical Engineering and Computer Science, Department of Industrial Engineering: kuric.ivan@gmail.com

– the beekeepers don´t need to active checking bees by opening a roof on the beehives when they use the monitoring system. As a result, bees will be calmer and beekeepers have more free time. Beekeepers can anytime check current measured interior/exterior values of beehives in their mobile phones, laptops or some different „smart" devices (devices which can be a connect to the internet - Internet of Things [1]). Nowadays some companies have created beehive monitoring systems, but most of them are expensive for a regular beekeeper. All of those monitoring systems are different – each of them is able to provide only some functions for beekeepers (it can alert a person to an unauthorized visit to the bee farm, etc.).

2. Comparison of available monitoring systems

In the table below (tab. 1) the most commonly used monitoring systems in Slovakia are displayed. We can see our own monitoring system in the last column which is named "Our Project". Our monitoring system is cheaper than other monitoring systems and contains all of the most used functions such as other monitoring systems. This is the reason, why a lot of beekeepers make their own monitoring system (like Our Project).

Table 1. Comparison of the most used monitoring systems in Slovakia

System / parameter	**Chytré včely**	**OSBeeHives**	**Bee Hive Monitoring**	**Our Project**
Exterior temperature	✔ YES	✔ YES	✔ YES	✔ YES
Interior temperature	✔ YES	✔ YES	✔ YES	✔ YES
Atmospheric pressure	✔ YES	✔ YES	✔ YES	✔ YES
Exterior humidity	✔ YES	✔ YES	✔ YES	✔ YES
Interior humidity	✗ NO	✔ YES	✔ YES	✔ YES
Weight of hives	✔ YES	✗ NO	✔ YES	✔ YES
Solar system	✔ YES	✔ YES	✔ YES	✔ YES
Alert notifications to SMS	✗ NO	✔ YES	✔ YES	✔ YES
Identify a queen bee	✗ NO	✔ YES	✔ YES	✔ YES
Price	250€	240€	577€	**150€**

3. Sensors and devices of our monitoring system

To make a functional monitoring system for the five beehives is needed: 1x Raspberry Pi 3 type B+ (fig. 1 left); 1x Arduino Uno (fig. 1 right); 5x sensor DHT22 (as many units as we need to according to number of beehives, to monitor temperature and humidity), 5x set of scales for weight measuring (Load cell) with transducer HX711 – this set consists of four weight sensors with transducer included. Every piece of

these weight sensors must be under each corner of the beehive. Also, it is necessary to buy some bundle of connecting wires, which will be used for connection of some Arduino boards (or RPi) with other el. devices/sensors, which contain correct pins. We recommend to buy connecting wires with connectors „female-male" and „male-male". Total price for this monitoring system, which will monitor temperature, huminidy and weight of five beehives is less than 90€. All the aforesaid devices, except Raspberry Pi, is possible to buy cheaper from Chinese online stores – Aliexpress, Alibaba, Ebay.

Arduino Uno was used for RPi, due to available many analog and digital I/O pins (RPi have only 40 digital pins), which we can use for certain sensors [2]. Control system for this monitoring system will be Raspberry Pi 3 and Arduino Uno.

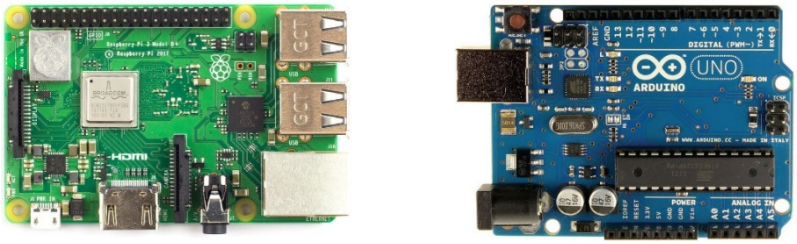
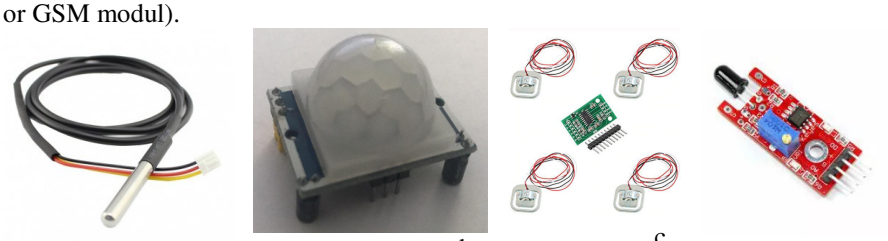


Figure 1. Raspberry Pi and Arduino UNO

Temperature and humidity sensors used are DHT22 type. This sensor is different than his predecessor (DHT11) for its parameters – temperature range is -40 - 125 °C (with tolerance ± 0,5 °C) and humidity range is 0 – 100% (with tolerance ±2 – 5%). There was designed a set of 4 weight sensors for each beehive (one under each behive conrner), while each measuring unit can be loaded with maximum weight 50 kg. When there are used four units under one beehive, monitoring system is able to measure the total weight up to 200kg.

As you can see, every sensor of designed monitoring system is not very expensive. For this reason, you can install a lot of sensors for your project/monitoring system. In practice this means, that we can buy, for example, GPS modul (its price on internet shop is 4€) and add it to our monitoring system as well. Monitoring system will display current location of beehives, generated from coordinates of a GPS module. Today there is a wide range of sensors for monitoring system available on the market (fig. 2) [3,4], e.g. PIR sensor for detection of human motion (if PIR sensor is active, monitoring system can send message to our device in real time via internet connection / or GSM modul).



a, b, c, d,

Figure 2. Available sensors: DHT22; PIR sensor; Load Cell and HX711; IR sensor

Another very useful sensor for monitoring system is IR sensor. This sensor is cheap and really important for monitoring beehives because it can detect fire at the beehive farm and monitoring system sends notification/message to the beekeeper, so he can call firefighter units. This sensor with its low price (0,50€) can save many bee families.

4. Five basic steps of the monitoring system development process

This chapter briefly summarizes information on how to create your own beehive monitoring system.

- The first step is to create conceptual design / block schema of your monitoring system – as many types of the monitoring system are available, which differ according to measured values.
- The second step is to buy suitable sensors/devices and then connect them correctly according to a wiring diagram. Correctly connected devices are important for seamless operation of the monitoring system.
- In the next step, the user must turn on the microcomputer Raspberry Pi and install the operational system (*Raspbian*). After successful installation of the operation system, open a terminal and perform installation of the programs *"Arduino IDE"* and *"Node-RED"*. If programs in RPi don´t have an actual version, it is possible to upgrade it in the terminal.
- In the fourth step, we make sensor testing. Raspberry Pi must obtain correct values from all connected sensors. If we are sure about correctly connected sensors with board devices, then we can test it. The simplest way will be to connect RPi with Arduino UNO via USB cable, run application Arduino IDE, insert program including sensor library (programs and libraries are published on the support internet pages or from a tutorials) and click the button "compilate project" (verification). If compilation was successfully ended, select from options of correct boards (on the top bar), connection port and processor. We can upload program for connected sensors to the device now. Right now, it is time to look for values from sensors in the serial monitor, where we can see actual values from sensors.
- The final step is "creating window of monitoring system". We must have some knowledge here about the software "Node-RED" - what is broker, topic, subscriber/publisher etc. Anyway, turn on the Node-RED from terminal, where it shows IP address which can be opened in any internet browser (Google Chrome, Opera etc.). We must add to the Node-RED module "dashboard" for correct creating of a graphs and tables. Create "flow" according to the connected data pins. Once the flow has been correctly created we can see actual graphs and tables on the IP address of the Node-RED. If user want to get some notifications about high or low values on his device, one has to set min. and max. values, for example min. 30% and max. 75%. When will be the actual value lower or higher than set value, user will get notification from the monitoring system to his device through e-mail (fig. 3).

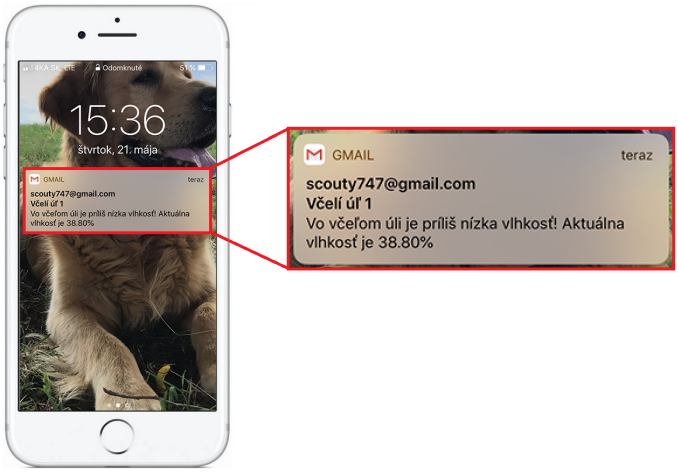


Figure 3. Received email from monitoring system [5]

5. Graphic displayed monitoring system

The main goal of the monitoring system design is to process information from the exterior/interior sensors and subsequently display them in graphs and tables on the web server, which is created by RPi. In figure 4 card "Včelnica Štiavnik" is showed where are displayed all actual values from five beehives. For each beehive is created column, where are located values (actual temperature, humidity and weight), which belongs to the specific beehive. In the first row are values of the interior temperature. Here can be three colors - green color (temperature is good), orange color (temperature is higher than it should be) and red color (temperature is high). In the second row are interior humidity and the third row showing weight from the load cell.

Figure 4. Graphic displayed monitoring system

If monitoring system sends notification through e-mail account to the user devices, this is how email should look like:

1. first row – sender email address
2. second row – specific beehive
3. third row – predefined text with variable values (variable values are actual values of the monitoring system)

E-mail can be sent through SMTP. Temperature is also displayed in the table graph for easy check of max./min. values during a certain period. The function is working also for sending notifications of the humidity monitoring. In the last column is a date and recommended values, which should be achieved in beehives.

6. Conclusion

In this paper we had a close look about creating your own monitoring system. This monitoring system can be configured by user according to his requirements. Monitoring system can save many bee families so it´s quite important to present this system for beekeepers. Every beekeeper can create his own monitoring system according to the instructions. For its low price, everyone can use this device.

ACKNOWLEDGEMENT

This article was made under the support of project APVV-17-0310. Project title: Implementation of the 4th Industrial Revolution Principles in the Production of Tyre Components.

REFERENCES

1. BURGESS, M.: What is the Internet of Things?: *https://www.wired.co.uk/article/internet-of-things-what-is-explained-iot*, 2018
2. BADAMI V.: A tour of the Arduino UNO board. Available on: *https://www.hackerearth.com/blog/developers/a-tour-of-the-arduino-uno-board/*, 2016.
3. DIACONESCU M.: Connecting to the Real World via Sensors. Available on: *https://web-engineering.info/node/61*, 2016
4. NEDELKOVSKI D.: How I2C Communication Works and How To Use It with Arduino. Available on: *https://howtomechatronics.com/tutorials/arduino/how-i2c-communication-works-and-how-to-use-it-with-arduino/*, 2019
5. BOHUŠÍK M.: Monitoring of the bee hive with using IoT technology (in Slovak). Diploma Thesis. University of Zilina, 2019, p. 71