Jurnal Teknologi

Full Paper

STINGLESS BEE COLONY HEALTH SENSING THROUGH INTEGRATED WIRELESS SYSTEM

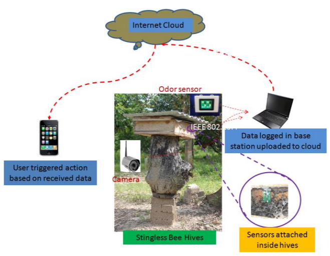
Harun, A.[a,e*], SK Zaaba[b,e], Kamarudin, L. M.[c,e], A. Zakaria[b,e], Rohani S. Mohamed Farook[c,e], Ndzi, D. L.[d], Shakaff, A. Y. M.[b,e]

[a]School of Microelectronic Engineering, Universiti Malaysia Perlis, Arau, Perlis, Malaysia
[b]School of Mechatronic Engineering, Universiti Malaysia Perlis, Arau, Perlis, Malaysia
[c]School of Computer and Communication Engineering, Universiti Malaysia Perlis, Perlis, Malaysia
[d]School of Engineering, University of Portsmouth, Portsmouth, UK
[e]Centre of Excellence for Advanced Sensor Technology (CEASTech), Universiti Malaysia Perlis, Malaysia

Article history
Received
1 June 2015
Received in revised form
13 August 2015
Accepted
29 September 2015

*Corresponding author
aziziharun@unimap.edu.my

Graphical abstract



Abstract

Stingless bees are usually common in tropical and subtropical region of the world especially in the tropical dry and humid forest. As stingless bee honey gaining reputation for its medicinal value, stingless bees keeping has been very popular in these regions of the world. In Malaysia, keeping stingless bee has only been very popular only in the last few years. The bee honey industry is a very lucrative industry and in 2013 alone Malaysia imported RM50 million ringgit worth of honey products. Although stingless bee keeping seem to be straight forward, there are a number of issues that could hinder the success. One of the main problems is colony loss which could be attributed to a number of reasons. However, the most important cause for this is stingless bees' habitat quality. In order to prevent colony loss and honey production impact, an integrated wireless sensing solution is being implemented at stingless bee test-farm to monitor the habitat environmental requirement for healthy and productive colonies. The system consists of sensor structures placed inside and outside of stingless bee hives for monitoring internal and external environmental parameters including hazardous gases. Sensors are connected to wireless sensor networks node places close to the hives and data collected are transmitted to base station wirelessly. A networked of hives with sensor attachment are constructed around the farm to provide sufficient data for comprehensive monitoring. Data from base station are then transmitted to farmer's mobile device for status update. This integrated system ensures changes to stingless bee hives and colonies development could be monitored real time and necessary steps and actions could be taken to prevent colony or yield loss. In this preliminary implementation comparison between environmental parameters from productive and non-productive hives are looked at especially temperature, humidity, and light intensity data.

Keywords: Stingless bee, habitat quality, wireless sensor networks, integrated wireless sensing

Abstrak

Kelulut adalah biasa di kawasan tropika dan sub-tropika di dunia, terutama di dalam hutan tropika basah dan kering. Oleh kerana madu kelulut mendapat reputasi untuk nilai perubatannya, menternak kelulut telah sangat popular di kawasan-kawasan ini. Di Malaysia, penternakan kelulut hanya menjadi popular hanya dalam beberapa tahun kebelakangan ini. Industri madu merupakan industri yang sangat menguntungkan dan pada tahun 2013, hanya Malaysia mengimport RM50 juta ringgit produk madu. Menternak kelulut kelihatan mudah, terdapat beberapa isu yang boleh menghalang kejayaan. Salah satu masalah utama adalah kehilangan koloni yang boleh dikaitkan dengan beberapa sebab. Walau bagaimanapun, sebab yang paling penting untuk ini adalah kualiti habitat kelulut. Untuk mengelakkan kehilangan koloni dan kesan pengeluaran madu, penyelesaian pengesanan tanpa wayar sedang dilaksanakan diladang kelulut untuk memantau habitat dan keperluan alam sekitar koloni yang sihat dan produktif. Sistem struktur terdiri daripada penderia diletakkan di dalam dan di luar sarang kelulut untuk memantau parameter alam sekitar dalaman dan luaran, termasuk gas berbahaya. Penderia disambungkan ke tempat-tempat tanpa wayar nod rangkaian penderia berhampiran dengan sarang dan data yang dikumpul akan dihantar kepada stesen pangkalan tanpa wayar. Rangkaian penderia beserta sarang dibina di sekitar ladang untuk menyediakan data yang mencukupi untuk pemantauan menyeluruh. Data daripada stesen pangkalan ke peranti mudah alih yang dikemaskini dan dihantar kepada petani. Sistem bersepadu untuk memastikan perubahan sarang kelulut dan pembangunan koloni boleh dipantau dalam masa sebenar dan langkah-langkah dan tindakan yang perlu boleh diambil untuk mengelakkan tanah jajahan atau prestasi yang merugikan. Dalam kajian awal ini, perbandingan didilakukan antara koloni produktif dan tidak produktif melihatkan kepada terutamanya suhu, kelembapan, dan keamatan cahaya.

Kata kunci: Kelulut, kualiti habitat, rangkaian penderia tanpa wayar , penderiaan tanpa wayar bersepadu

1.0 INTRODUCTION

Stingless bees live in all tropical and subtropical region of the world between 30 degrees north and south latitudes [1]. These bees are known for their reduced sting thus rendering it useless as protective weapon. Honey from these bees is known for its distinguished flavors and has been used as medicine to cure varieties of ailment since very long time ago. There has been some recorded usage of the honey for treatment of eye infection, open wound, laceration, diabetes mellitus and high blood pressure as well as other diseases as reported in some researches [2]-[5].

Stingless bee keeping industry in Malaysia started gaining popularity since the last several years. The number of bee farmers has increased drastically in the last 5 years and currently there are more than 1000 registered farmers nationwide. The bees honey industry is a very lucrative industry and in 2013 alone Malaysia imported RM50 million honey product and the number is in ascending trend [6]. Although there are more than 30 species of stingless bees in Malaysia, two most important species in managed bees are Trigona Itama and Trigona Thoracica [2][7]. Although stingless bee keeping seems to be straight forward, there are a number of issues that could hinder the success. The main problems are colony loss and unproductive hives which could be attributed to a number of reasons with the most important one being stingless bees' habitat quality.

One of the factors affecting the habitat quality is food constraint, which starve the colonies and thus causing them to migrate. Locating bee hives concentrating close around each other would increase competition among the colonies of multiple hives and triggers the aggressive behavior among some of them which in turn would cause the dispersion of some of the colonies [8]. Some researches show that temperature, humidity and the presence of fume or toxic smokes around the hives may significantly affect the honey production process and could cause the colony to leave the hive searching for another [8]. In essence, the location of hives and the environment where the hives are placed plays important roles in securing stingless bee colonies and ensuring good productive yield for each hives.

Some authors have implemented sensors in stingless bee hives to promote research in bee entomology [9] while some others install sensor to monitor the thermal effect in the colonies [1]. This research however is to design and develop an integrated sensor system using wireless sensor networks (WSN) to monitor stingless bee hives and their surroundings to understand favorable parameters for healthy colony which is indicated by high honey yield. Data extraction system will be connected to wireless network database using WSN equipped with GSM modem to limit intrusion to stingless bee colony which could potential cause colony migration. This paper is organized as follows: section I - introduction and the objective of the paper, section II – materials and method, section III – results and discussions, section IV – conclusion.

2.0 MATERIALS AND METHODS

2.1 Equipments

The system consists of sensor structures placed inside stingless bee hives and outside for monitoring internal and external environmental parameters. The internal sensors include temperature, humidity, light intensity and micro camera for honey pots growth rate image capturing. External sensors include light intensity and VOC (Volatile Organic Compounds) sensor aside from temperature and humidity. VOC sensors module deployed at the experimental site is used for hazardous gases detection around the stingless bee hives. The module includes NH_3, CO_2, O_2, VOC, NO_2 and CO sensors which are used for hazardous gases detection. NO_2 and CO are mainly detected from motor vehicle exhaust which are detrimental for stingless bee colony health. Colony health is defined based on the productivity of stingless bee colony itself. Healthy colony is defined as having honey pots covering at least half of the hives size while unhealthy colony shows honey pots developed less than half of the hive size. In order to monitor honey production level, a wireless IP camera is deployed to capture still images of the hives and honey pots. The images are used to determine the rate of honey production for various hives locations and surroundings and the overall health of the colony itself. MEMSIC nodes capable of sensing temperature, humidity and barometric pressure were used in the monitoring. The nodes use Zigbee protocol and operate within 2.4 GHz to 2.5 GHz band with multiple channels within the band [10], [11].

2.2 System Setup

Sensors are connected to wireless sensor node placed close to the hive and data are transmitted to base station wirelessly. A networked of hives with sensor attachment are constructed around the farm to provide sufficient data for comprehensive monitoring. Data from base station are then serialized to GSM modem and transmitted to farmer's mobile device for status update.

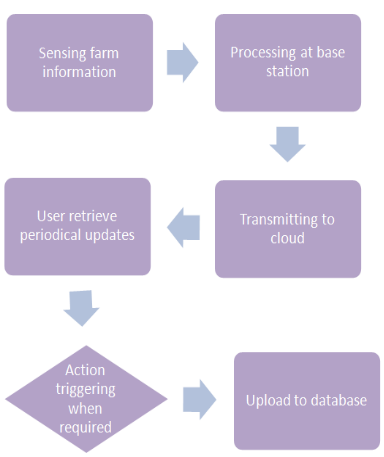


Figure 1 Flow chart showing the process designed for the system to collect and transmit data

Figure 1 shows the process for the system from sensing to processing the data and transmitting to internet. Then the data will be retrieved by farmer/user before uploading them to database for future usage. Farmer/user will have option to trigger any action if required once they receive the data.

This integrated system ensures changes to stingless bee hives and colonies development could be monitored real time and necessary steps and actions could be taken to prevent colony or yield loss. Figure 2 illustrates the whole process done at the hives in the farm and transmission to farmer/user smart phones. In this preliminary study however, only three sensors are utilized and data collection and processing is limited to simplest form compared to comprehensive processing as in Figure 2. The data collection was done for one full day taking into consideration lower temperature and high humidity in the morning and highest temperature of the day in the afternoon and lowest humidity reading at the time. In this preliminary data collection, three setups were devised and deployed for data collection. The first setup is deployment inside a healthy hive. Second setup is inside an unhealthy hive while the third setup is outside the hives under tree shade. All the setups consist of temperature, humidity and light intensity sensors connected to WSN node for automatic data collection. VOC sensors and camera are not deployed for this preliminary data collection. A base station for retrieving and storing data is placed close by but away from the hives to avoid interference with bee's activities.

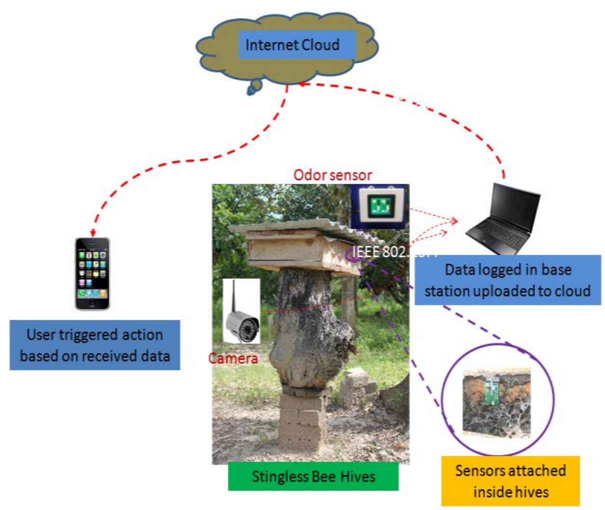


Figure 2 System implementation on stingless bees farm for colony health monitoring

3.0 RESULTS AND DISCUSSION

Preliminary data were collected which comprised of temperature and humidity data set from internal and external stingless bee hives as well as comparison between healthy and unhealthy hives. Each data set are compared among the three setups and plotted as in Figure 3, Figure 4 and Figure 5.

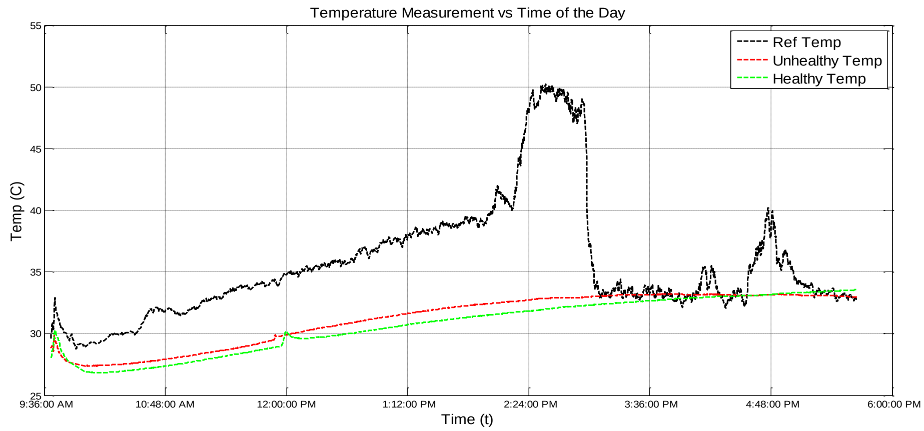


Figure 3 Temperature variation in the day for healthy, unhealthy hives and reference temperature around the farm

Figure 3 shows that as the temperature from reference sensor varies throughout the day, the temperature values from sensors inside healthy and unhealthy hives shows some stability and less variation is observed as temperature increase in the day. In the morning, lower temperature level was observed and the level climbed up gradually towards mid-day. Similar pattern was observed on all three sensors; however, it is also observed that sensors in both healthy and unhealthy hives shows lower temperature level as much as 5 degrees Celsius on average compared to temperature outside the hive. It is also noticeable that temperature in healthy hive showed lower level that in unhealthy hive most of the time during the day. As temperature level dropped as the day moves towards evening, the pattern still noticeable although the difference is statistically insignificant.

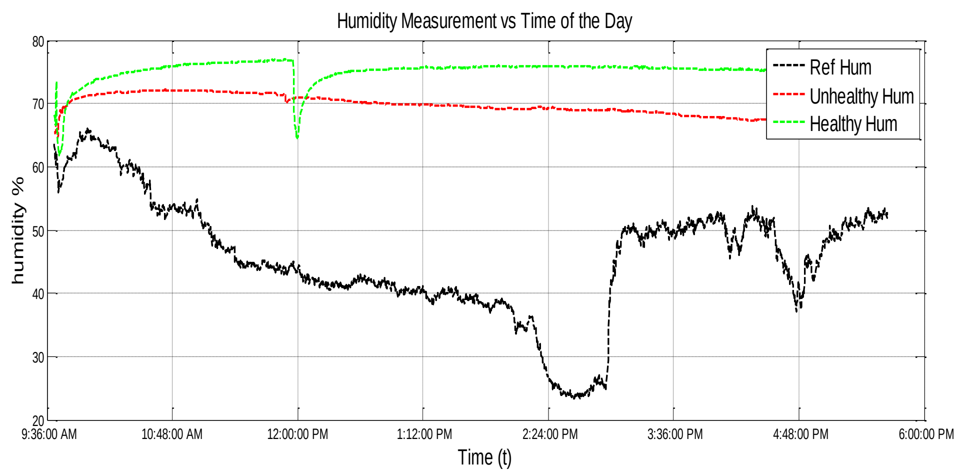


Figure 4 Humidity variation in the day for healthy, unhealthy hives and reference humidity around the farm

Figure 4 shows the variation in humidity level from sensors inside healthy and unhealthy hives as well as humidity from outside the hive. From Figure 4, it is observed that as humidity from outside the hives varies in the day, humidity level inside healthy and unhealthy hives stay almost completely stagnant except for few variations. As humidity level decreases in the day, the humidity levels inside hives stays the same except at around noon when the level inside the healthy hive drop shortly from 78% to around 65% before climbing up to around 75% level in about 15 minutes when the level stays approximately the same until end of the day. The humidity level for sensor inside unhealthy hive shows some reduction from 72% to about 70% after mid-day and continue to show reduction until the level went down to about 68% at the end of the day. All in all, the humidity level for sensor in unhealthy hive shows a reduction of 4% in total from the beginning of the day until end of the day. On the other hand, aside from sudden short drop during afternoon, there is not observable drop in humidity level for sensor in healthy hive. On average, there is almost 20% difference between humidity recorded by sensor outside the hive and those inside.

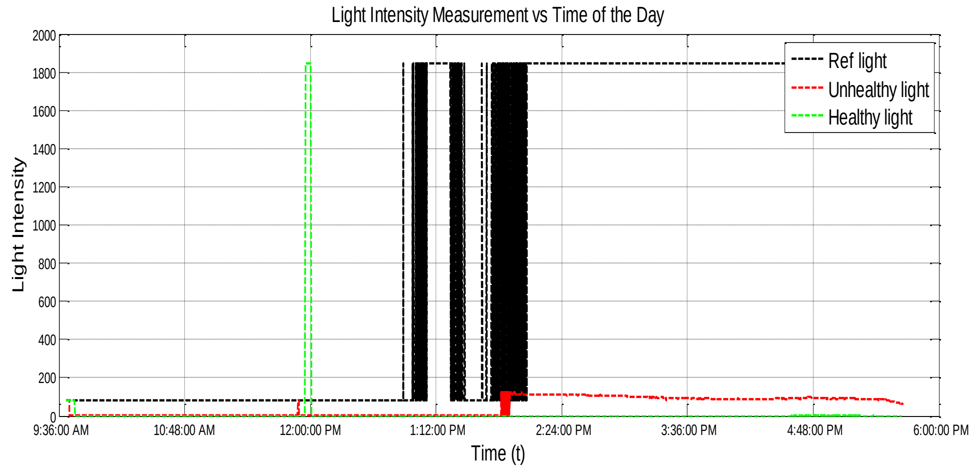


Figure 5 Light intensity variation in the day for healthy, unhealthy hives and reference light intensity around the farm

Figure 5 shows the light intensity for the day for all sensors inside healthy and unhealthy hives as well as outside the hives. It is observed that the light intensity level were very low for sensors inside the hives while the one outside the hive recorded very high light intensity level on average. From Figure 5, light intensity level recorded by sensor inside healthy hives shows very minimum level of light except for a sudden spike during noon time. The light intensity level inside unhealthy hive however shows some increment after 2 PM although the level is still below 200. The light penetrates into the hive as sun tilted towards the west through small holes at the wall of the hive. This light penetration may be a reason for the reduction humidity level in the unhealthy hive after midday. All in all, the inside of healthy is very dark while there is some light inside unhealthy hive after 2 PM onwards.

4.0 CONCLUSION

This paper presented an integrated wireless sensing system designed to acquire environmental parameters around stingless bees' farm and inside the hives. The selected parameters include temperature, humidity, light intensity, VOC (Volatile Organic Compounds), and also images from inside the hives. The parameters will be evaluated and analyzed to understand the specific environmental influence on stingless bees' healthy colonies which would lead to improvement in honey production. This paper however, looked into only temperature, humidity and light intensity parameters only.

Based on preliminary data collection on limited environmental parameters i.e. temperature, humidity and light intensity, it is observed that healthy hives have very high humidity level while lower temperature level. The amount of sunlight managed to penetrate into the hives is also very minimum. In comparison, unhealthy hives have lower humidity level while a little bit higher temperature level. The amount of sunlight managed to get into the hives is also more significant. While the current data do not support any conclusion as yet, the ultimate goal is to map the whole farm area to determine locations preferable for hives placement and locations to avoid in the placement exercise. Additional data from current parameters as well as from other surrounding parameters would help in the mapping process in the future.

Acknowledgement

The authors would like to express gratitude to Bayu Kelulut Smart Digital Farm CEO, Mr. Abdul Hisham Mohd Yusof for providing support and assistance in ensuring the success of the project.

References

[1] Torres, W. Hoffmann and I. Lamprecht. 2007. Thermal Investigations Of A Nest Of The Stingless Bee Tetragonisca Angustula Illiger In Colombia. *Elsevier Thermochimica Acta*. 458: 118-23.
[2] Trigona Bee Farm. *Trigona Bee Farm*. 05-Feb-2015.
[3] G. Santos and Y. Antonini. 2008. The Traditional Knowledge On Stingless Bees (Apidae: Meliponina) Used By The Enawene-Nawe Tribe In Western Brazil. *Journal of Ethnobiology and Ethnomedicine*. 4(1): 19.
[4] M. K. Choudhari, S. A. Punekar, R. V. Ranade and K. M. Paknikar. 2012. Antimicrobial Activity Of Stingless Bee (Trigona sp.) Propolis Used In The Folk Medicine of Western Maharashtra, India. *Journal of Ethnopharmacology*. 141(1): 363–367.
[5] M. K. Choudhari, R. Haghniaz, J. M. Rajwade and K. M. Paknikar. 2013. Anticancer Activity of Indian Stingless Bee

Propolis: An In Vitro Study. *Evidence-Based Complementary and Alternative Medicine*. 2013: 1-10.

[6] R. Mail. 2014. Stingless Bee Honey – The Mother Medicine. *Borneo Post Online*, 31-Aug-2014.

[7] J. C. Biesmeijer and E. J. Slaa. 2004. Information Flow And Organization Of Stingless Bee Foraging. *Apidologie.* 35(2): 143-157.

[8] T. Nagamitsu and T. Inoue. 2002. Foraging Activity And Pollen Diets Of Subterranean Stingless Bee Colonies In Response To General Flowering In Sarawak, Malaysia. *Apidologie.* 33(3): 303-314.

[9] M. Q. Leite, L. H. Najm, and P. L. P. Corrêa. 2010. System Architecture For Data Acquisition, Extraction And Analysis For Experiments With Weblabs. *ICDIM.* 56-62.

[10] A. Harun, M. F. Ramli, L. M. Kamarudin, D. L. Ndzi, A. Y. M. Shakaff, A. Zakaria and M. N. Jaafar. 2012. Comparative Performance Analysis of Wireless RSSI in Wireless Sensor Networks Motes in Tropical Mixed-crop Precision Farm. *Intelligent Systems, Modelling and Simulation (ISMS), 2012 Third International Conference*. 606-610.

[11] A. Harun, D. L. Ndzi, M. F. Ramli, A. Y. M. Shakaff, M. N. Ahmad, L. M. Kamarudin, A. Zakaria and Y. Yang. 2012. Signal Propagation in Aquaculture Environment for Wireless Sensor Network Applications. *Progress In Electromagnetics Research.* 131: 477-494.