Internet of Things for indoor environment monitoring of swiftlet farms

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Abstract
The swiftlet farming industry has reached billions of dollars in value, due to the high demand of edible swiftlet bird nest. Referred as "caviar of the east", edible bird nests (EBN) are produced by swiftlets from their saliva that are built at high and dark corners of natural limestone caves. Man-made swiftlet houses which closely resembles natural cave habitats have been constructed as breeding structures for swiftlets, to ease the process of harvesting the raw EBN. In order to produce high quality and pure EBN, ranchers monitor and control the swiftlet house environment. However, most of the environmental parameters monitoring and measurements are currently implemented manually using conventional systems in situ. Herein, we proposed an Internet of Things (IoT) system for swiftlet farming as a model for the swiftlet ranchers to ensure better monitoring of in-building environmental parameters for the swiftlets. To achieve this aim, we discuss indoor environmental factors for swiftlet house, such as air and surface temperatures, and relative humidity. Finally, a system has been developed to sense and monitor all the important parameters automatically in real-time and remotely, where the data can be monitored via the web. The system is capable of monitoring the associated environmental parameters to enable optimal environment for man-made swiftlet houses. The designed system is more effective than the traditional method in the terms of data collection time saving and real time monitoring.

Keywords: In-building environment monitoring, swiftlet farming environment, Internet of Things

1. Introduction

Swiftlet farming industry value has reached billions of dollars due to the high demand of edible swiftlet bird nest. The edible swiftlet bird nest (EBN) comes from the saliva of swiftlets namely the White-nest swiftlet (*Aerodramus fuciphagus*) and the Black-nest swiftlet (*Aerodramus maximus*), which are small natural limestone cave-dwelling insectivorous birds. The nutritional and medicinal properties of EBN, has been summarized by [1]. EBN are rich with nutritious minerals that rejuvenates the human body such as calcium, phosphorus, iron, sodium, potassium, iodine and eighteen types of amino acids.

As the number of caves EBN is dwindling due to over-harvesting and it is not enough to meet the current demand, therefore most of the supplies of EBN has been mainly sourced from man-made swiftlets houses. Herein, the swiftlet nesting house environment needs to be monitored and controlled to ensure optimal swiftlet cave-like habitat is achieved. The

Internet of Things (IoT) has shown that various agricultural farming environment can be achieved through automated monitoring and control of optimal environment to achieve higher yield via precision farming [2]. From our literature review, presently, there is a lack of literatures on IoT system deployed for swiftlet farming. This paper elaborates on the design of an IoT system for indoor swiftlet house monitoring and the monitoring performance of the IoT system in a real swiftlet house environment.

2. Materials and methods

The importance of right habitat and suitable environmental conditions for the swiftlets to produce EBN in swiftlet houses has been highlighted by [3]. Within the house itself, indoor environmental factors such as air and surface temperatures, relative humidity, air velocity and light intensity are critical for high quality EBN production. Herein, a natural cave-like environment should be provided in order for swiftlets to occupy and build their nest in the houses. Below is the summary of two main environmental factors, their optimal range and their impact towards EBN production [3-6].

Table 1: Temperature and humidity optimal ranges and its implications

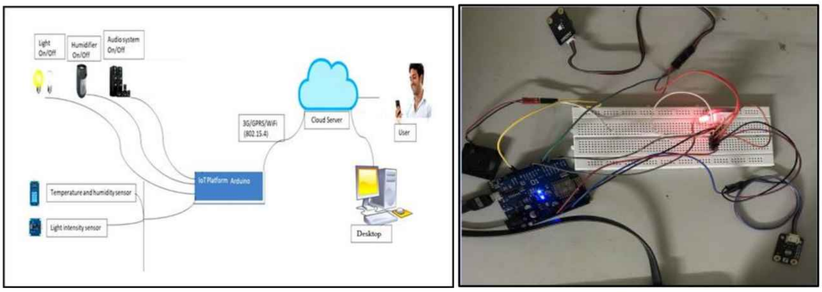
In-building environmental parameters	Optimal Range	Implications of environmental parameters towards swiftlet
Air and surface temperatures	25 °C - 35 °C	High temperature will damage the eggs, whereas low temperature harms young featherless swiftlets.
Relative humidity (usually humidifiers and water pools are used to maintain humidity levels)	80% - 90%	High relative humidity leads to fungal growth in the nests, swiftlets reluctant to nest on fungus covered surfaces. Good humidity ensures swiftlet nest do not crack. Low humidity affects adhering ability of the nest to the wall surfaces and nest falls easily.

2.1 IoT system for swiftlet farm monitoring

Herein, we have developed an automated IoT system to monitor the indoor environment. It is able to replace the monitoring tasks done by farmers measuring humidity and temperature using handheld instruments in situ once in every three or four hours, every day. In addition, manual tasks to activate and deactivate the humidifier and audio sound systems (indoor and outdoor swiftlet sound to attract male and female swiftlets to nest) can be done remotely as scheduled and needed. The proposed system for monitoring (and controlling) the critical parameters in a swiftlet farm is shown in the Figure 1 (a) below.

2.1.1 IoT end user node

The IoT end user node is equipped with humidity, temperature and light intensity sensors that controlled by a microcontroller unit (MCU) as shown in Figure 1 (b). Herein, the AM2302 Digital Humidity Temperature DHT22 sensor with an analog to digital converter is connected to the WeMos-D1 MCU. The DHT22 sensor are made of two parts i.e. a capacitive humidity sensor and a thermistor. In addition, the WeMos-D1 MCU, which is an Arduino based MCU with an ESP8266-12 chip that enables WiFi connectivity within the same MCU board.

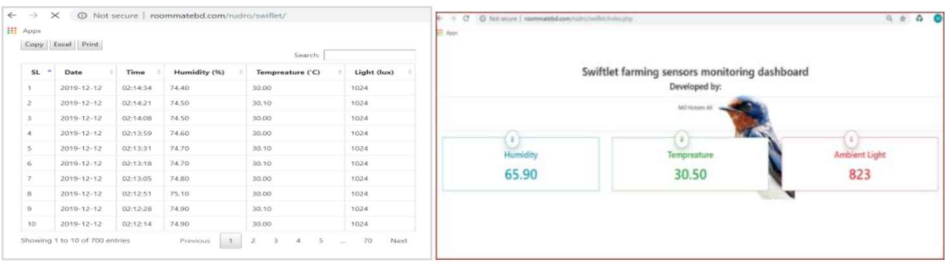


(a) (b)

Figure 1: IoT system for swiftlet farm monitoring (a) System components; (b) IoT nodes for measuring environmental parameters

2.1.2 Real-time data storage and visualization

The system is able to perform humidity and temperature measurements inside the swiftlet farm automatically where the data is stored in the cloud as in Figure 2 (a). The IoT node sends all the information via a MQTT protocol to the cloud using a WiFi connection that is linked to a 3G mobile network. The visualization of the data can be accessed real-time in a simple dashboard shown in Figure 2 (b).



SL	Date	Time	Humidity (%)	Tempreature (°C)	Light (lux)
1	2019-12-12	02:14:34	74.40	30.00	1024
2	2019-12-12	02:14:21	74.50	30.10	1024
3	2019-12-12	02:14:08	74.50	30.00	1024
4	2019-12-12	02:13:59	74.60	30.00	1024
5	2019-12-12	02:13:31	74.70	30.10	1024
6	2019-12-12	02:13:18	74.70	30.10	1024
7	2019-12-12	02:13:05	74.80	30.00	1024
8	2019-12-12	02:12:51	75.10	30.00	1024
9	2019-12-12	02:12:28	74.90	30.10	1024
10	2019-12-12	02:12:14	74.90	30.00	1024

(a) (b)

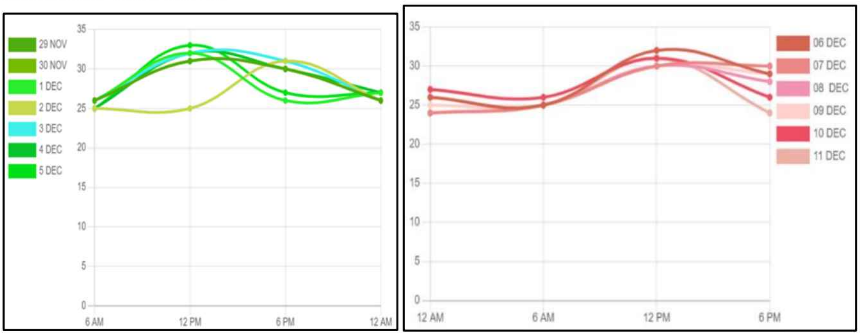
Figure 2: IoT cloud data storage (a) Snapshot of the cloud database; (b) Online real-time monitoring dashboard.

3. Results

In order to test the efficiency and effectiveness of the developed system, real time deployment have been conducted in a swiftlet farm located at Pusat Bandar Country Homes, Rawang, Selangor. Six days data monitoring of humidity, temperature and light intensity parameters has been performed and analysed to determine whether the system is giving similar findings in comparison to the manual in situ measurements.

3.1 Temperature readings

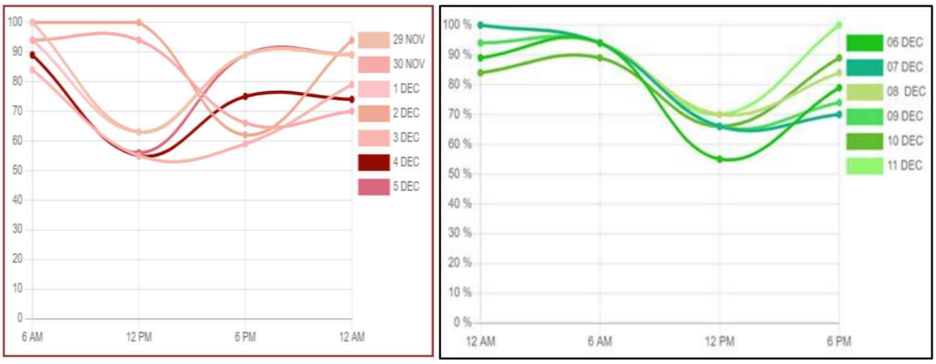
The swiftlet house minimum temperature and maximum temperature was 25 °C and 33 °C respectively as shown in Figure 3. The IoT system result shows that it is consistent with the in-situ measurements taken. As elaborated earlier the suitable temperature of swiftlet habitat is 25 °C-35 °C. If temperature readings are less than 24 °C, this can cause death to young swiftlets and if the temperature rises more than 35 °C, the birds will not nest in the man-made structures.



(a) (b)

Figure 3: Temperature readings (a) Manual readings (29 Nov, 2019 to 05 Dec, 2019); (b) IoT System readings (29 Nov, 2019 to 05 Dec, 2019)

3.2 Humidity readings



(a) (b)

Figure 4: Humidity readings (a) Manual readings (29 Nov, 2019 to 05 Dec, 2019); (b) IoT System readings (29 Nov, 2019 to 05 Dec, 2019)

The suitable humidity for swiftlet birds is 80-90 % according to our established literatures. The range of humidity measurements have been shown in Figure 4, where the humidity drops significantly at noon time and improves as dawn arrives. The humidifiers are timed to operate at noon time to counter the warming effect in the swiftlet house that significantly lowers the required humidity of the system. We can also conclude that if a humidity control mechanism based on the IoT system is deployed, the optimal humidity range which is between 80-90% can be achieved; by turning on and off the humidifier correspondingly, when the humidity drops and is too high (nearly 100%).

4. Conclusions

The IoT monitoring system for the swiftlet farm have been tested and the system has shown to produce consistent results with the in-situ measurements. It has shown the capability of sending measurements of temperature and humidity, within a regular interval in real-time. Internet of Things system for the swiftlet house has enabled autonomous measurements with a higher reliability, where the system operates automatically without the need to manually go to the site for measuring. The data can be viewed via the web in real time. Simulation of controlling the humidifier was also implemented but was not reported here.

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