EVOLUTION IN ELECTRICAL AND ELECTRONIC ENGINEERING
e-ISSN: 2756-8458

EEEE

Vol. 5 No. 1 (2024) 27-32
https://publisher.uthm.edu.my/periodicals/index.php/eeee

Development of IOT-based Infant Incubator System with Temperature Detection

Shaunmhaathy Kalidass[1], Wan Mahani Hafizah Wan Mahmud[1]*

[1] *Faculty of Electrical and Electronic Engineering,*
Universiti Tun Hussien Onn Malaysia, Batu Pahat, Johor,86400, MALAYSIA

*Corresponding Author: wanmahani@uthm.edu.my
DOI: https://doi.org/10.30880/eeee.2024.05.01.004

Article Info

Received: 14 January 2024
Accepted: 11 March 2024
Available online: 30 April 2024

Keywords

Incubator, IoT platform, SolidWorks

Abstract

This innovative work aims to improve existing infant incubators by creating a cutting-edge 3D model of an incubator housing using SolidWorks. Our main objective is to develop a completely automated solution that provides a reliable and controlled environment for premature newborns. Through the use of advanced technology such as DHT11 sensors, Arduino Durian Uno micro-controller, and IoT capabilities, our system ensures constant temperature regulation while minimizing the need for manual intervention. With a user-friendly software design and the inclusion of an IoT platform, this incubator offers effortless data retrieval through a Wi-Fi module and display on the Blynk mobile application, making it a truly state-of-the-art solution.The application not only accurately records and displays important temperature measurements, but also utilizes a responsive fan system, among other automated controls, to maintain an ideal incubator environment. The study's findings highlight the necessity to address spatial inequalities by showing noticeable temperature fluctuations within the incubator across various places. With an average period of about 15 minutes to achieve the crucial temperature of 37°C, the study again highlights the significance of careful temperature monitoring. The evaluation of the incubator's temperature regulation effectiveness is further aided by the examination of the fan's average turn-off time of two By integrating state-of-the-art sensor technologies and IoT connectivity, this innovative infant incubator system strives to elevate neonatal care and create a safer and more efficient healthcare environment for infants.

1. Introduction

The United Nations-established World Health Organization (WHO) is tasked with addressing both global communicable and non-communicable diseases. WHO reports that more than one in ten pregnancies worldwide result in premature births, estimated at approximately 15 million babies each year. The Oxford Dictionary defines preterm as the occurrence of birth after a pregnancy significantly shorter than the standard 40 weeks. Preterm births are classified by gestational age into three categories: intermediate to late preterm (32-37 weeks), very preterm (28-32 weeks), and extremely preterm (< 28 weeks). Typically, normal infants are born at 38-40 weeks with a weight ranging from 2500-4000 grams, whereas premature infants have a gestational age of 37 weeks or less and a body weight below 2500 grams [1][2][4].

Premature births play a significant role in the heightened infant mortality rate. Infants born prematurely necessitate specialized care, particularly in maintaining a stable temperature within the range of 35°C to 36°C, resembling conditions in the womb. The use of baby incubators becomes essential for closely monitoring and replicating the womb environment, effectively supporting premature infants, and lowering infant mortality rates. Premature birth poses diverse challenges, elevating the risk of death in comparison to term births due to the premature development of the infants' organ systems [3].

One of the primary reasons for proposing an infant incubator is to provide a controlled environment that mimics the conditions within the womb. Through this study, advancements in the design of infant incubators were pursued to overcome previous drawbacks. These limitations encompassed inadequate temperature regulation, restricted monitoring capabilities, and difficulties in replicating the womb environment accurately. The goal of enhancing infant incubator technology and functionality is to provide premature infants with more precise and dependable support. This progress aims to ultimately improve outcomes for premature births and reduce the number of infant mortalities.

2. Methodology

2.1 Hardware Design

The 3D CAD design of the device is presented in Fig. 1. All dimensions of the CAD design are in millimeters. The device was designed with a dimension of 1000 × 600 × 400 mm with a circular space with a diameter of 200 mm. Fig. 2 shows a photo of the prototype device. The incubator was designed using a rectangular box made of mounting board.

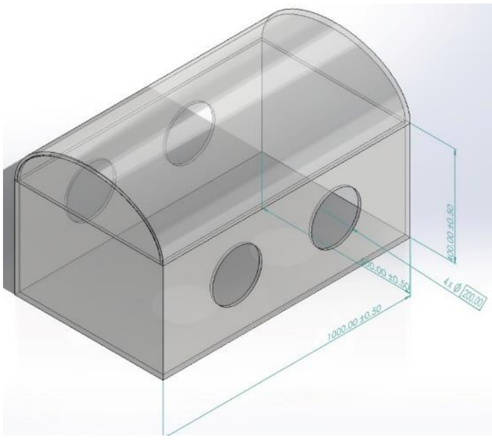

Fig.1 *3D CAD design of the incubator*

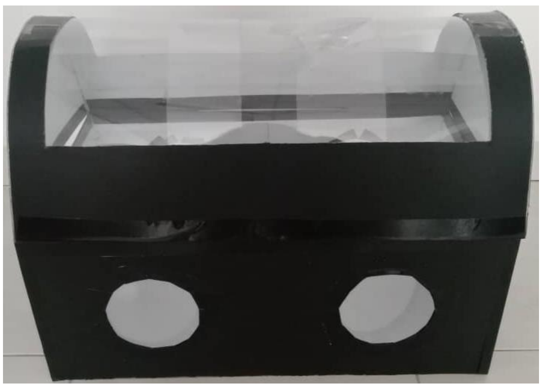

Fig. 2 *A photo of the prototype*

2.2 IoT Based Incubator System

As shown in Fig. 3, the system comprises input devices (sensors) and output devices, all of which are connected to a Durian Uno V3. The monitoring is accomplished as the sensor measures and transmits the associated parameter to Durian Uno V3, which is then processed. All the collected data will be sent to Blynk application. Through the Blynk application, the entire device may be monitored.

Evolution in Electrical and Electronic Engineering Vol. 5 No. 1 (2024) p. 27-32

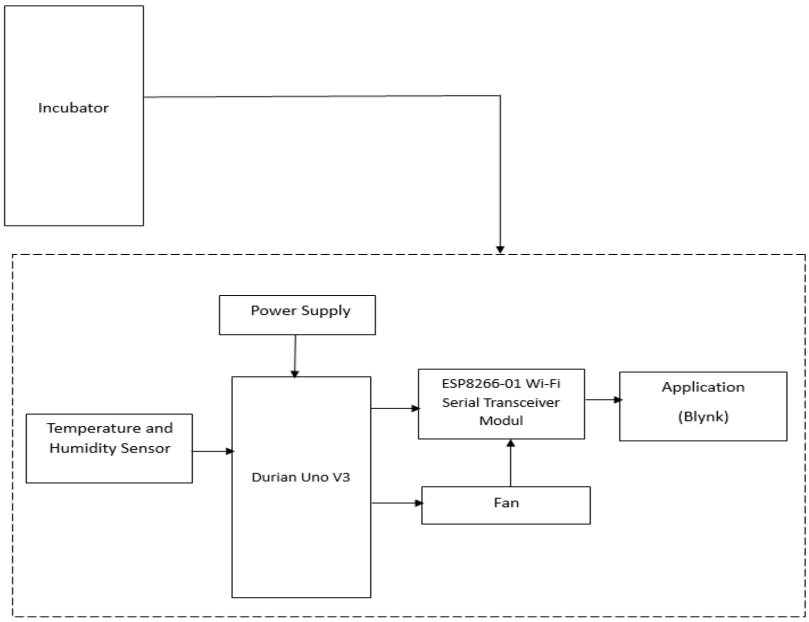

Fig. 3 *Block Diagram of Development of IoT-based Infant Incubator System*

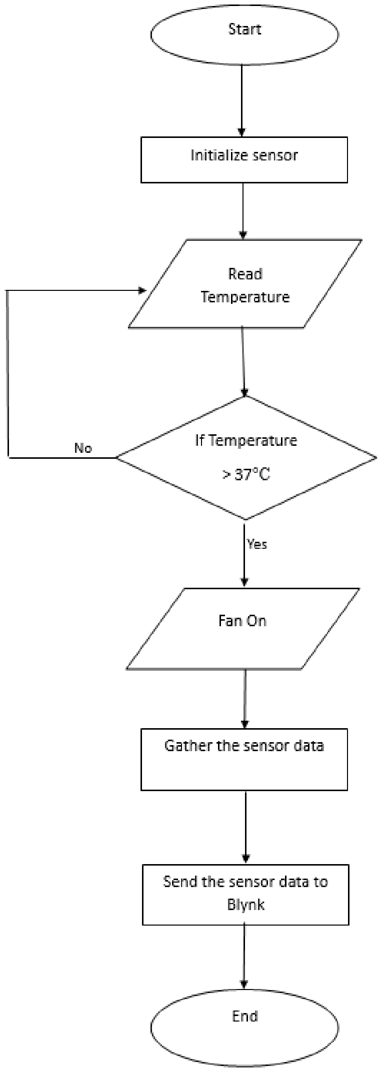

Fig. 4 *Flowchart of the system*

Fig. 4 shows, which starts with the sensor's initialization. The temperature sensor then gathers information from the system, and the fan is automatically turned on if the temperature drops above 37°C. The sensor then keeps collecting data and sends it to the Blynk application. Therefore, the user can only open the application and able to know the temperature and humidity condition in incubator.

Fig. 5 shows the setup of the system when all the processes have been done. The program code has been built into the Arduino Durian Uno V3. The power supply for this system is required from the laptop. The sensor will operate with a 3V DC source, and it is connected at Arduino Durian Uno V3 port. When the Arduino Durian Uno V3 is connected to the available Wi-Fi the Esp8266 Wi-Fi Module will request authentication to connect with Blynk. The ESP8266 Wi-Fi Module connected to the available Wi-Fi. The display can only be shown at the serial monitor by using Arduino IDE. Then, the sensor will start reading the parameter. If the Wi-Fi is connected to ESP8266 Wi-Fi Module, the value for the temperature will be shown at the Blynk Application. The parameter value is displayed by using Blynk App. The result will be taken after the Wi-Fi and DHT 11 temperature sensor is done reading the parameter.

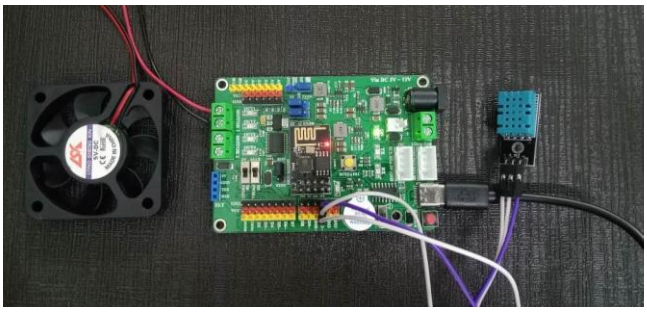

Fig. 5 *Connection of the circuit with Arduino Durian Uno V3*

3. Results and Discussion

The system was tested on an incubator that designed prototype using mounting board. Data samples were collected using the DHT11 will send the input to the micro controller which is Durian UNO which will read the signal and shows the reading. The table below shows the analysis that has been carried out several times to ensure that the system operates smoothly and according to specifications and achieves the objectives set out without any problems. The average was collected and presented in Table 1 to Table 3. Examples of the output were provided in Fig. 6.

Fig. 6 *Output from Blynk application*

Table 1 *Analysis of temperature with different position in incubator*

No of tries	Top	Side (1)	Side (2)
1	39.5°C	37.5°C	39°C
2	38.5°C	37.4°C	37.4°C
3	39°C	37.8 °C	38°C
Average	**39°C**	**37.5°C**	**38.1°C**

Table 2 *Analysis of average time taken to reach 37°C temperature*

No of tries	Initial temperature	Time taken to reach 37°C Temperature (min)
1	32.8°C	16
2	33.8°C	10
3	30.8°C	23
4	33.7°C	10
5	31.3°C	18
Average	**32.5 °C**	**15**

Table 3 *Analysis of average time taken for fan to turn off*

No of tries	Time taken for fan turn off (minute)
1	3
2	2
3	2
4	3
5	2
Average	**2**

Table 1 reveals significant temperature differences within the incubator at various points. Particularly, the average temperature at the top of the incubator is 39°C, while the temperatures on one side are 37.5°C and the other side is 38.1°C. These regional variations highlight how crucial it is to handle temperature distribution in order to maintain stable conditions inside the incubator. An average starting temperature of 32.5°C and about 15 minutes to achieve the target temperature are shown by Table 2's analysis of the time needed to reach the critical temperature of 37°C. The importance of precisely controlling the incubator's temperature is shown by this data. A further factor in evaluating the incubator's dependability and effectiveness is the average time it takes for the fan to turn off shown in Table 3, which stands at two minutes after many tries. This indicates that the incubator can adjust to varying management strategies and maintain a consistent temperature.

4. Conclusion

In conclusion the successful progress in developing software design and a prototype for the incubator resulting in positive outcomes. The mobile application, Blynk, has been fully realized, allowing for the retrieval of data from the ESP8266 Wi-Fi Module and its display within the Blynk App. Results indicate precise temperature and humidity readings that can be accessed remotely with a reliable internet connection. The proposed IoT-based infant incubator system has undergone development and testing, serving as a foundation for future research and enhancements. Recommendations for future work include integrating a warning buzzer for low temperatures, adding more sensors like blood pressure and heart rate monitors, and exploring connectivity with GSM modules for areas without Wi-Fi access. These proposed refinements aim to further improve the system's functionality and adapt it to evolving trends.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author attests to having sole responsibility for the following: planning and designing the study, data collection, analysis and interpretation of the outcomes, and paper writing.

References

[1] S. Sendra, P. Romero-Diaz, J. Navarro-Ortiz, and J. Lloret, "Smart Infant Incubator Based on LoRa Networks," Proc. IEEE/ACS Int. Conf. Comput. Syst. Appl. AICCSA, vol. 2018-Novem, 2019, doi: 10.1109/AICCSA.2018.8612863.

[2] H. Mittal, L. Mathew, and A. Gupta, "Design and Development of an Infant Incubator for Controlling Multiple Parameters," Int. J. Emerg. Trends Electr. Electron., vol. 11, no. 5, pp. 2320–9569, 2015.

[3] M. Shaib, M. Rashid, L. Hamawy, M. Arnout, I. E. Majzoub, and A. J. Zaylaa, "Advanced portable preterm baby incubator," in 2017 Fourth International Conference on Advances in Biomedical Engineering (ICABME), 2017, pp. 1– 4.

[4] World Health Organization. Preterm birth: Fact sheet N0363. May 2012.