Construction and Implementation of Raspberry Pi Based Baby Monitoring System

Article · February 2019

CITATIONS
0

READS
609

5 authors, including:

Samson Yusuf Dauda
Nasarawa State University Keffi Nieria
58 PUBLICATIONS **315** CITATIONS
SEE PROFILE

A. Z. Loko
Nasarawa State University
29 PUBLICATIONS **44** CITATIONS
SEE PROFILE

Construction and Implementation of Raspberry Pi Based Baby Monitoring System

Samson Dauda Yusuf[1], Lumbi Williams Lucas[2], Umar Ibrahim[3], Maleshesh, Markus Jones[4], Loko Abdulmumini Zubairu[5]

[1]*Senior Lecturer Department of Physics, Nasarawa State University, Keffi, Nigeria*
[2]*Assoc. Prof. Department of Physics, Nasarawa State University, Keffi, Nigeria*
[3]*Senior Lecturer Department of Physics, Nasarawa State University, Keffi, Nigeria*
[4]*Student Department of Physics, Nasarawa State University, Keffi, Nigeria*
[5]*Lecturer Department of Physics, Nasarawa State University, Keffi, Nigeria*

***Abstract* – Due to the difficulty faced by new born parents in doing their day to day tasks as well as care for their babies, a lot of parents have to hire a maid to assist them take care of their babies. However, a lot of maids have been confirmed to have some negative influence on these babies as they grow up and some could even expose these babies to so many unforeseen threats that could expose them to danger. In this study, construction and implementation of a baby monitoring system was carried out using a Raspberry Pi and wireless sensor network (WSN). Various devices and sensors such as sound sensor, motion sensor, camera, and temperature and humidity sensor were interconnected and used for monitoring the babies' room. The system was programmed using python 3.6 and Java 8.0 programming language, while Pubnub 4.4 data streaming network was used for real-time data streaming and device signalling. Results show that the system publishes data to an external smart phone and receive command from the smart phone successfully over the internet. From the temperature and humidity test on a sunny day with and without a fan as well as on a cloudy day shows that fan is not a suitable cooling system and the humidity of the room was always high. The system can be improved upon by using a more effective alarming system, introducing machine learning and port-forwarding.**

***Keywords* – Raspberry Pi, Baby Monitoring, Implementation**

I. INTRODUCTION

Nowadays it is becoming very difficult for most parents with new born babies to cater for their babies as well as do their day to day task due to relatively busy lifestyle as many women often involve in domestic tasks as well as income generating activities. So, women with new born babies cannot be with them all the time. Parents still have to cook, clean, do laundry, etc. but have to either choose to finish a task or go comfort the baby. Other times maybe that the parents are outside gardening or taking a shower, and unable to hear the babies cry. In this regard, Sagar*et al*. [1] explained that these babies could be exposed to so many unforeseen threats that could expose him/her to danger. Adding that, such dangerous situation could come from environment or stress due to long time neglect. In line with this, Fanchao *et al*. [2] added that, most parents have to hire a maid to assist them take care of their babies. However, a lot of maids have been confirmed to have some negative influence on these babies as they grow up and some could even expose these babies to so many unforeseen threats that could expose them to danger.

In an interview with the child psychologist, Fanchao *et al*. [2] noted that parents need to monitor their children; because children nowadays are having many threats. It could come from the neighbourhood and internet, sexual harassment, and lack of social skills. If there is a system or tool that can assist parents in monitoring child remotely, it's capable of providing security and comfort to the parents. While doing interview with parents Fanchao *et al*. [2] noticed that, most parents monitor their children by coming directly to the place where the child is to be able to do the monitoring. It becomes difficult for the parents themselves who have been busy with work since the workplace are often away from the child's location.

Innovations and developments in the field of computers have arouse rapidly over time and getting more sophisticated, from small to larger sizes. All over the world today, use of video surveillance is usually focusing mostly on monitoring public transport and public areas. According to Karthikraj*et al.*[3], 39% of the installation of the international monitoring system serves as a deterrent to violent crime and prevent burglary.

The number of infant deaths occurs due to improper care taken [2]. Mothers with newly born baby have to stay away from their babies due to various reasons. During such situation, health status of babies is hard to detect. Fanchao*et al*. [2] had pointed out that the sudden fall and increase in physiological parameters may cause sudden infants deaths syndrome (SIDS) and may lead to Apparently Life Threatening Events. Many women often involved in domestic tasks as well as income generating activities. So, woman with new born baby can't be with their babies at all times, and they may get caught in extreme case of distress. Sagar*et al*. [1] pointed out that house maids need to understand various reactions given by children like what child is trying to communicate, need to know the health status of children when

parents are away from them, necessary actions which should be taken when critical condition arrives on child.

When most parents think of SIDS they do not realize that they are referring to two medically defined terms. One is Sudden Unexpected Infant Death (SUID) and the other is Sudden Infant Death Syndrome (SIDS). According to Jaouad*et al*. [4], about 4,000 infants under one-year-old die each year from both SUID and SIDS of which about one half of the deaths come from SIDS. Most frequently the causes of deaths include SIDS, cause unknown, accidental suffocation and strangulation in bed. In 2010, 2063 deaths were from SIDS, nine hundred and eighteen (918) as cause unknown, and six hundred and twenty-nine (629) as accidental suffocation and strangulation in bed [4].

Sudden Infant Death Syndrome (SIDS) is the sudden death of an infant less than one year of age that cannot be explained after a thorough investigation and autopsy, while sudden unexpected infant death (SUID) is the death of an infant younger than one year of age that occurs suddenly and unexpectedly [4]. As about half of the deaths can't be explained, The American Academy of Paediatrics policy is now to provide a safe sleep environment with recommendations to include supine positioning, use of a firm sleep surface, breastfeeding, room-sharing without bed sharing, routine immunizations, consideration of using a pacifier, and avoidance of soft bedding, overheating, and exposure to tobacco smoke, alcohol and illicit drugs. Recently, with the development of technology, home healthcare and remote monitoring of physiological data have gained importance. Faruk*et al*. [5] explained that it is a popular implementation to track home healthcare of patients, particularly babies.

In the case of Nigeria, parents love their children and may want to be with them all hours of the day, but sometimes that's just not possible, because even as babies appreciate being carried around in sling, they sometimes need to rest in their cribs while the parent carries on about their daily routine. Fanchao*et al*. [2] explained that baby monitors allow this much needed flexibility when it comes to space.

In view of the above, this study is aimed at constructing and implementing a baby monitoring system using Raspberry Pi and wireless sensor network (WSN). Various devices and sensors such as sound sensor, motion sensor, camera, and temperature and humidity sensor will be interconnected and used for monitoring the babies' room. The system will also be programmed using python 3.6 and Java 8.0 programming language, while Pubnub 4.4 data streaming network will be used for real-time data streaming and device signaling. The system runs on 5volts battery pack and requires an active internet connection to function effectively but could also function without an internet connection. This study will be of great importance to parents, especially mothers who are too busy but still interested in the welfare, security and daily routine of their babies. Having a monitor in the baby's room will allow a parent to know what's going on in real time circumstances. Fanchao*et al*. [2] emphasized that wherever the parent is, be it into the rest room, the kitchen, or out into the garage you can check up on your baby by simply listening to make sure they are alright thereby giving the parents peace of mind.

This paper is organized as follows: the next section presents the theoretical background, followed by the research method. Then, we present the construction and implementation of the prototype, followed by the output test results. Finally, the discussion of the findings and both theoretical and practical implications are described. The paper concludes by presenting the research limitations and proposing avenues for future research.

II. REVIEW OF PREVIEW STUDIES

A. Baby Monitoring Systems and Models

A Baby Monitoring system is a system or tool that can assist parents in monitoring child remotely, it's capable of providing security and comfort to the parents [2]. Several studies on Baby monitoring system have been conducted [7, 8,9 10, 11]. Daing*et al.*[6] used an Arduino Uno based on ATMega328 to process data from sensors (SN-PULSE pulse rate sensor and SN-model HMD humidity sensor) in an Incubator equipped with an LCD display to show the humidity inside the Incubator. The sensor values were processed by the Arduino and sent to the PC for continuous monitoring. Fanchao*et al.*[2] proposed a project to design and implement a Smart Baby Cradle with a microcontroller, a webcam, mobile toy, stepper motor, a mic and speaker. The proposed study was able to help young parents to take care of their babies with a mobile device application. Karthikraj*et al*. [3] designed and implemented a prototype of Child monitoring system and motion detection using Raspberry Pi. The system was used to deter crime and prevent burglary as well as help parents to monitor children easily through internet. Motion developed by Folkert Van Heusden and Kenneth Laursen outputs data in form of .jpg image and video .mpg formats when motion is detected by the Passive Infrared (PIR) sensor.

Patil and Mhetre [10] explained that advancements in wireless sensor network have introduced some technologies. The early developed smart jacket for neonatal monitoring which uses biosensor built for monitoring, heart frequency, body movements, heart rate, and body temperature. The smart jacket technology was limited for clinical usages. It was embedded with Bluetooth for communication over short range. Health tracker and Health gear are some wearable wireless technologies which monitor baby's vital signs and notify to parents. Wireless-Crib monitor that uses Breath-Optics technology focuses on respiratory system of body and accordingly sends alerts. According to Patil and Mhetre [10] these technologies haven't implemented any support system. Digitally enhanced cordless Telecommunication Technology

which sends live images and also voices of baby to parent's display unit. Very little information about vital signs is delivered to parents.

Tresna*et al.* [12] used the ubiquitous GSM based system which comprised of wearable hardware device which senses the physiological parameters of baby and send it to centralized server. The centralized server is for data analysis, storage and intelligent support system. The sensed data is sent to sever where it is checked for abnormal conditions. Accordingly, SMS is sent to parent. In case of critical situation expert system sends alert. The watch designed to monitor health by measuring body temperature and heart rate. It uses infrared sensors which put on forehand and phototransistor to measure heartbeats. Kuldeep*et al.*[13] designed a sensory vest for babies which are one wired technology where the vest includes integrated sensors for heart rate, humidity, temperature, and respiration. The vest needs to connect to data acquisition unit. A Bluetooth-enabled in home patient monitoring system implements Bluetooth based architecture which communicates with healthcare centre via internet for early detection of Alzheimer's disease. In line with this, Sagar*et al*. [1] designed and developed a wearable health monitoring system for babies. The system consisted of sensors (temperature and heart rate sensor), ArduinoLilypad, Bluetooth module, and battery. Data from the sensors were processed by the Arduino and sent to a cloud server where it can be accessed by other clients. Also in this work, a list of benchmark was created to compare biological systems which the sensor system was going to handle. For body temperature benchmark; this was divided it into armpit (normal temperature 35.5 – 37.0^0C and fever temperature > 38.5^0C) and skin temperature (normal temperature 29.0 – 34.0^0C and fever temperature > 35.2^0C). For heart rate benchmark; it was divided into new born (100 – 160 BPM), 0 – 5 months (90 – 150 BPM), 6 – 12 months (80 – 140 BPM), 1 – 3 years (80 – 130 BPM).

III.MATERIALS AND METHOD

The method and steps that will be used to achieve this project is outlined below with block diagram. The Raspberry Pi 3 board was chosen as the main controller for this study owing to its unique and peculiar features and it is also highly flexible and a cheap solution for home automation. The GPIO pins were programmed using Python programming languages, python programming languages provides robust and easy application programming interface (API) to manipulate the Raspberry Pi pins. Fritzing software was used to create the circuit diagram, while Java programming language was used to develop the Android mobile application because of its simple and straight forward syntax for developing mobile application. The block diagram of the system is presented in Figure I and the labeled diagram of the Raspberry Pi which is the main controller for this study is showed in Figure II.

This system is powered by a 3.7volts 9.8Ah Rechargeable Lithium battery. The charging and discharging time can be calculated using the equations 1 and 2:

$$C_T = \frac{B_C}{C_C} \quad (1)$$

$$D_T = \frac{B_C}{L} \quad (2)$$

Where C_T = Charging time in hours (hr)

D_T = Discharge time in hours (hr)

L = Load (Raspberry Pi module) (A)

B_c = Battery Capacity in Ah

C_c = Charging Current (A)

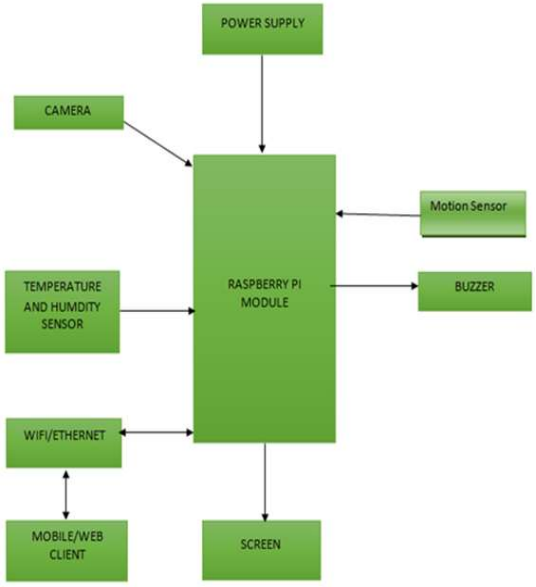

Fig. I Block diagram of the proposed System

From the general block diagram of the proposed Raspberry Pi based Home Automation System in Fig. I, at first the main controller which is the Raspberry Pi will try to initialize an active internet connection to Pubnub server and if unsuccessful, it automatically enters into auto mode. In this mode, it scans and monitors the baby on its own. On detecting noise or sound above the set threshold (60decibel) a number of times, it plays a melody tone assuming that the baby is crying. On detecting an intruder, it also plays a tone also as one of its security features for safety.

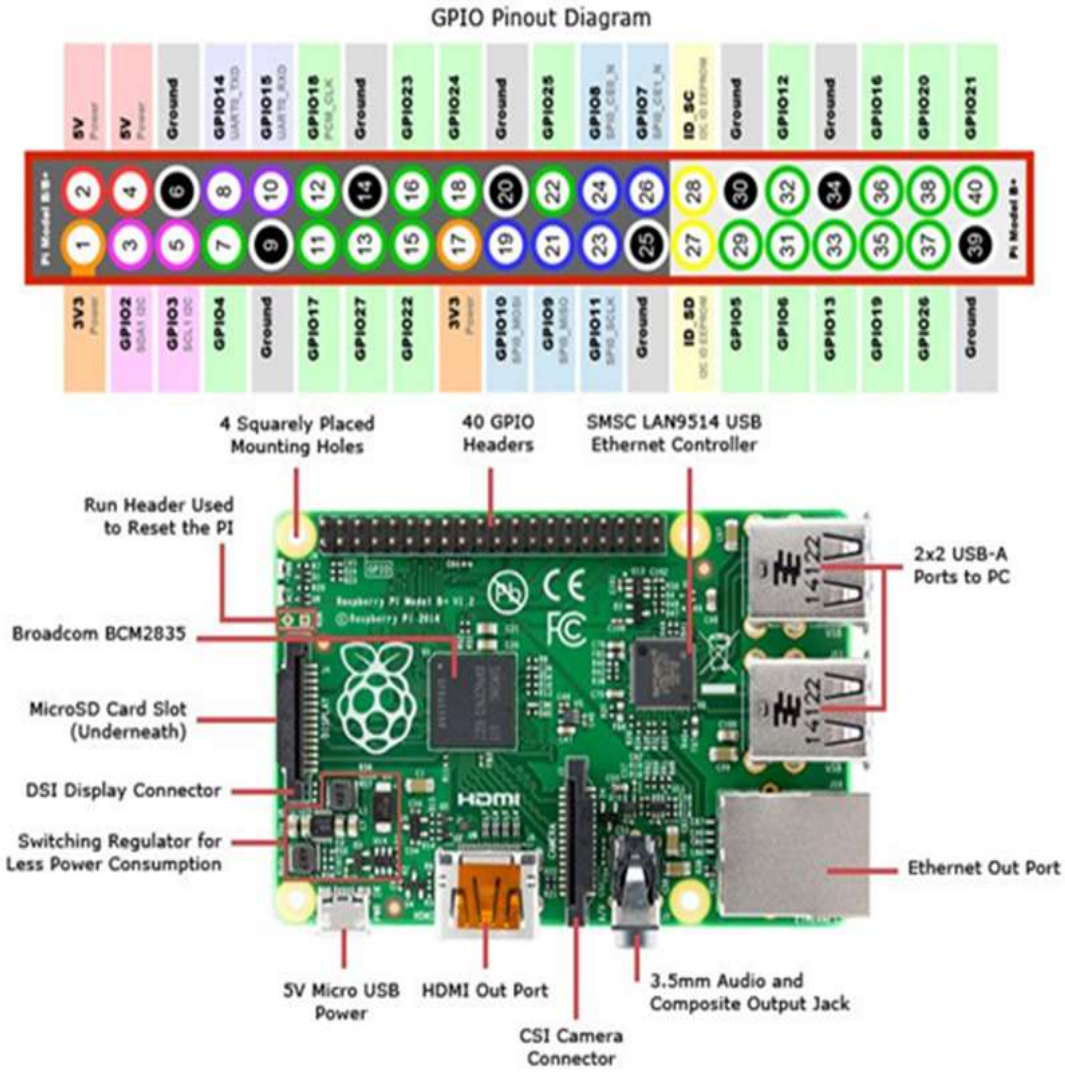

Fig. II Raspberry Pi 3 model B module and pin out configuration [14].

If an active internet connection is established, the main controller reverts to the normal mode. In this mode, it is capable of receiving commands from external clients remotely and publishing/sending out its sensors' data to its external clients remotely. On receiving any command, the controller processes it and acts on it and then sends back feedback if the command execution was successful. The camera feed from the system is always streamed out to its external clients within its Local Area Network (LAN). The flow chat of the system can be shown in Figure III.

A. Program Algorithm

The general algorithm can be explained in the following steps:

Step 1: Start

Step 2: Declare variables to hold sensors' data temperature, humidity, sound

Step 3: Declare Boolean variables to hold the states of the motion sensor, sound sensor and system mode

Step 4: add an events and interrupt to listen for change in state of motion sensor and sound sensor

Step 5: if internet connection is active publish sensors' data

listen for events from sensors

else

listen for events from sensors

if sensors' variables state changes

return to step 5.

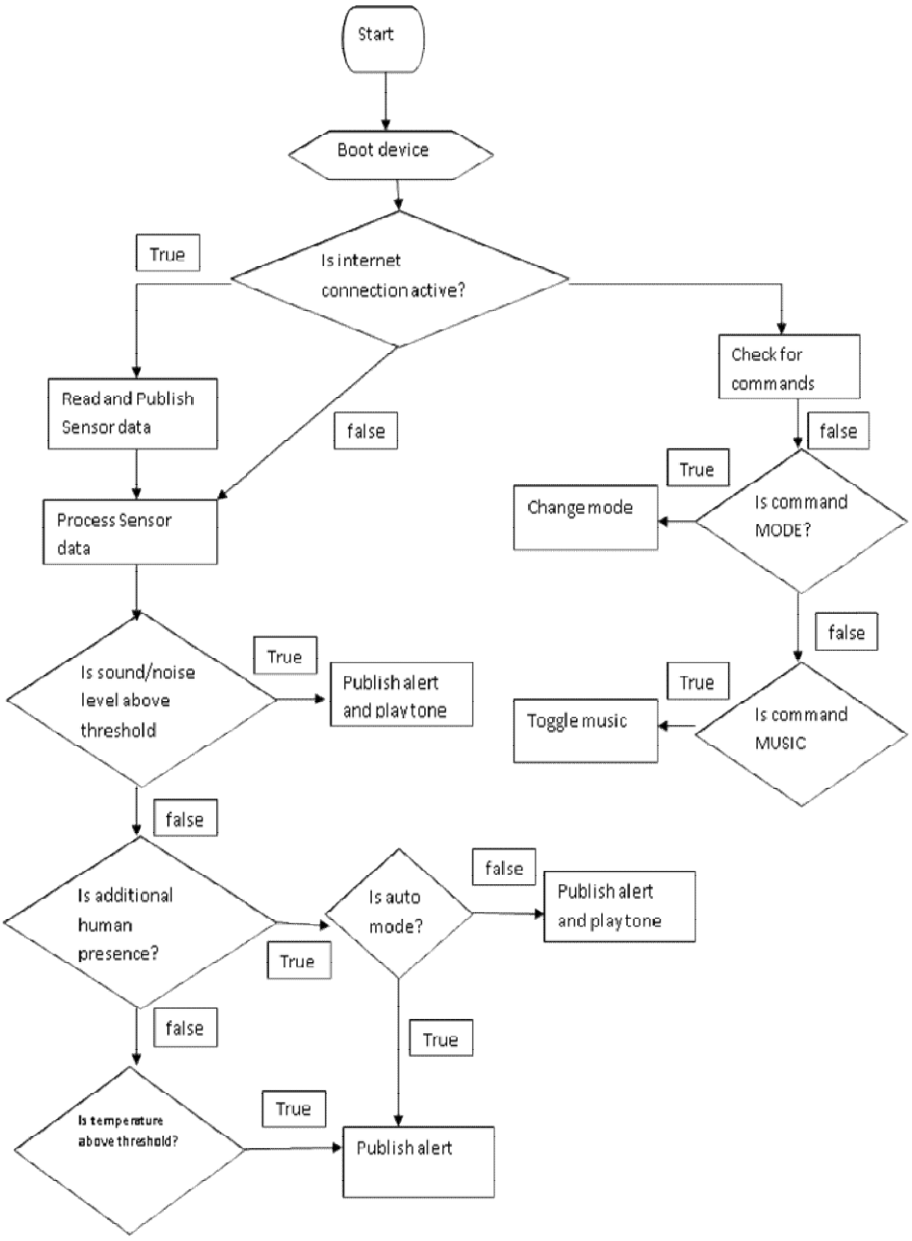

Fig. III Flow Chart of the System

From the circuit diagram of the system shown in Fig. IV, the raspberry pi is the main controller and other peripherals are attached to it. The OLED SSD1306 screen is attached to the Raspberry Pi through the I2C bus (SDA and SCL) and is powered from the Raspberry Pi 3.3volts pin. The ADS1115 analog to digital converter is also attached to the Raspberry Pi through the I2C bus and powered from the Raspberry Pi 3.3volts. The ADS1115 offers four channels for connecting analog devices/sensors and the sound sensor OUT pin is attached to the ADS1115 A0 pin. The Sound sensor is powered from the Raspberry Pi 5volts pin and its OUT which emits analog signal (voltage) is attached to the A0 channel of the ADS1115. DHT222 temperature and humidity sensor is also attached to the Raspberry Pi 5volts pin and its OUT pin is attached to the Raspberry Pi BCM pin 4. The values of temperature and humidity are programmatically extracted from the output of the DHT22 sensor. A 5volts piezo buzzer is attached and controlled programmatically from the Raspberry Pi module pin 5 through the I2C bus. PIR sensor is powered from the raspberry pi 5v pin.

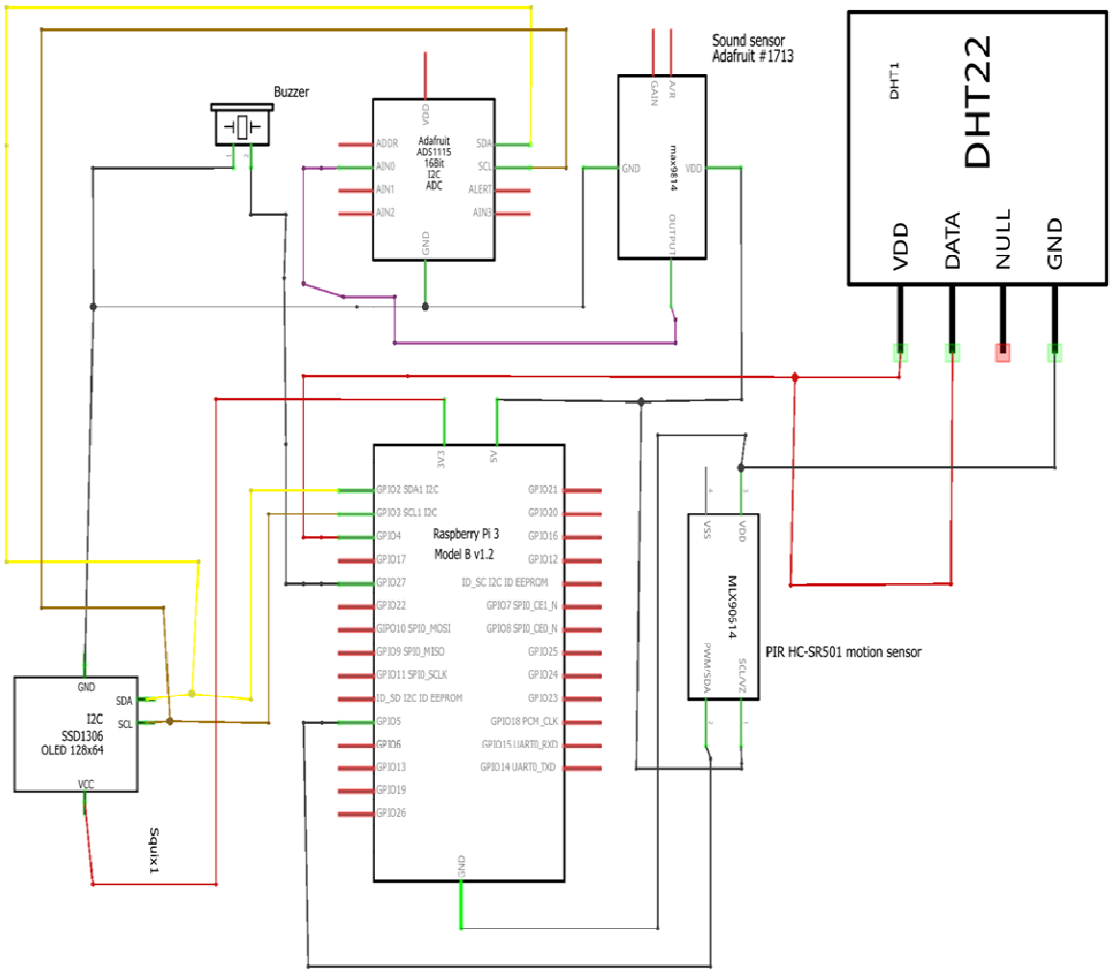

Fig. IV Circuit diagram of the system using Fritzing Software Version 0.91

IV. RESULTS AND DISCUSSION

A prototype of the system was developed and the entire system was enclosed in a box as shown in Figure V. The charging time in hours (CT) and discharging time in hours (DT) of the battery was calculated using equations 1 and 2, as follows:

$$C_T = \frac{(9.8)Ah}{3A} \approx 3.3$$

The Charging time will be approximately 3hrs 18mins excluding power losses.

$$D_T = \frac{(9.8)Ah}{2.1A} \approx 4.7$$

The discharge time under a load of 2.1A is approximately 4hrs 42mins.

However, the system was tested and the observed experience was recorded with the system in a room at Mararaba, Karu LGA, Nasarawa State, Nigeria in the month of July, 2018. Nasarawa State has an annual temperature of 28.4^0C. Data from the temperature and humidity (DHT22) sensor was collected, tabulated and charts generated from it.

Data from the room on a sunny day in the afternoon without a fan switched on was tabulated as shown in Table I. The data was collected at an interval of one hour for six hours as indicated in Figure VI. Similarly, data from the room on a sunny day in the afternoon with a fan switched on was also tabulated as shown in Table II. The data was also collected at an interval of one hour for six hours as indicated in Figure VII. Finally, data from the room on a cloudy day was also tabulated as shown in Table III, the data was also collected at an interval of one hour for six hours and this is also indicated in Figure VIII.

TABLE I
TEMPERATURE AND HUMIDITY READINGS ON A SUNNY DAY WITHOUT A FAN

Temperature (^{O}C)	Humidity (%)	Time (hrs)
28.4	77.7	1pm – 2pm
28.5	77.7	2pm – 3pm
28.6	77.3	3pm – 4pm
28.7	76.9	4pm – 5pm
28.8	76.5	5pm – 6pm
28.9	75.9	6pm – 7pm

TABLE II
TEMPERATURE AND HUMIDITY READINGS ON A SUNNY DAY WITH A FAN

Temperature (^{O}C)	Humidity (%)	Time (hrs)
28.3	73.2	1pm – 2pm
28.1	72.7	2pm – 3pm
28.0	72.5	3pm – 4pm
28.0	72.5	4pm – 5pm
27.8	72.4	5pm – 6pm
27.5	72.3	6pm – 7pm

TABLE III
TEMPERATURE AND HUMIDITY READINGS ON A CLOUDY DAY

Temperature (^{O}C)	Humidity (%)	Time (hrs)
26.9	80.2	1pm – 2pm
28.6	67.6	2pm – 3pm
28.8	68.1	3pm – 4pm
28.7	68.0	4pm – 5pm
29.1	68.8	5pm – 6pm
27.5	72.3	6pm – 7pm

Table I shows tabulated values of temperature and humidity from 1pm – 7pm in a room without a fan. The temperature values increased as the humidity decreased. Table II shows the tabulated temperature and humidity values respectively from 1pm – 7pm in a room with a fan. The temperature values decreased very slowly while the humidity values didn't show much difference. Table III contains tabulated values of temperature and humidity on a cloudy day from 1pm – 7pm. The humidity values are lower compared to Table I and II. The temperature a decrease at the initial state, increases as time goes on and decreases again.

Fig. VPrototype of baby monitoring system

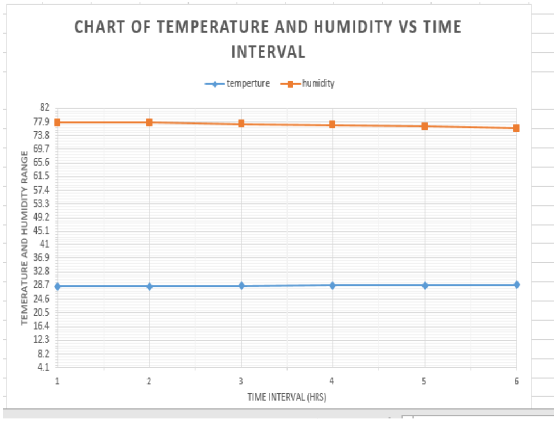

Fig. VITemperature and humidity against time on sunny day without fan

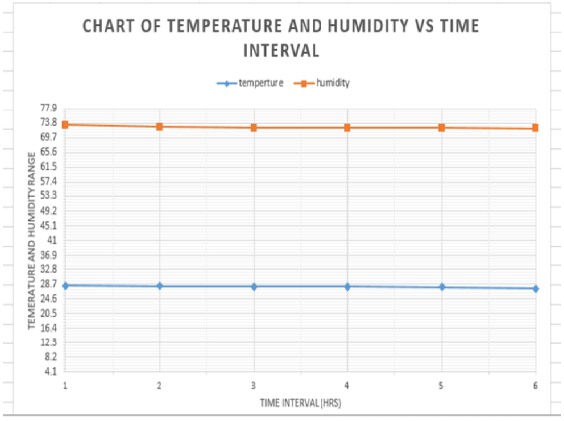

Fig. VIITemperature and humidity against time on sunny day with fan

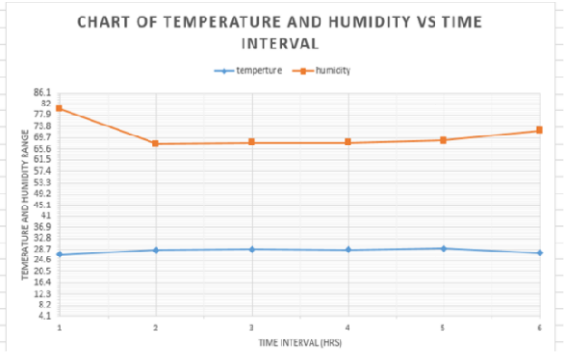

Fig. VIIITemperature and humidity against time on cloudy day

V. THEORETICAL IMPLICATIONS

From the charts in Fig. VI, VII and VIII, the temperature hovered around the mean annual temperature of Nasarawa state which is 28.4^{o}C. It is quite obvious from Figure VI and VII that standing fan is not an effective device for cooling especially in areas with high temperature like Nasarawa state.

According to Urgent Care [15], the optimum humidity level for human comfortable especially for children is between 40% - 60% and temperature of 23^{0}C, also Wikipedia [16] and Green Garage [17], noted that the temperature and humidity range for human comfort are 20^{0}C – 22^{0}C and 30% – 60% respectively but from Figure VI, VII and VIII, the result from this study shows a humidity range of 67.6% - 80.2% and temperature of 26.9^{0}C -28.9^{0}C which does not agree with the result from Urgent Care and Green Garage. It is quite obvious that the room will be uncomfortable and portray a health risk to a baby which might lead to Sudden Unexpected Infant Death.

From the data, temperature and humidity has a tremendous effect on human body and health especially that of a Child. Zhiwei[18] noted that young children are more influenced by heat in terms of respiratory function. An effective cooling system preferable an Air conditioning unit or a humidifier which is friendly to the environment should be installed in the room to regulate the temperature and humidity levels within its normal range.

VI. CONCLUSION

This research could be described as a success; having gained additional knowledge and experience in electronics, internet of things (IOT) and digital communication in both technical and academic fields. Raspberry Pi 3 model B module was used as the control unit in this work. The embedded program was written using Python language which is more effective and simple in developing embedded technology compared to other programming languages while the Mobile application was developed using Java programming language. The construction of Raspberry Pi Baby monitoring system provides a very good solution to aid parents and guardians in taking care and monitoring their kids amid tight work schedule, daily activities and providing a layer of security. Its wireless sensor network and external clients can be deployed to fully monitor babies and can provide data to determine the health condition of the baby.

VII. LIMITATIONS AND RECOMMENDATIONS

Some limitations of the study are worth mentioning. First is that the camera feed from the system could only be captured from devices within its local area network and second, the system can only send/publish sound level to its external client. Therefore it is incapable of receiving audio signal from its external client. However, for future studies, a port-forwarding system may be incorporated in order to access the camera feed from outside the local area network. In addition, a more effective alarm system and an introduction of machine learning may also be a great advantage for the improvement of this device.

REFERENCES

[1]. Sagar D, Niranjan K, Akshay K, Shaikh SG. Wearable health monitoring system for babies. International Journal of Computer Engineering and Technology 2016;2(15):15-23.
[2]. Fanchao M, Yu L, Xiaoye L, Kiru S. Smart baby Cradle. Simon Fraser University School of Engineer Burnaby (Technical Report); 2016, 1 – 2.
[3]. Karthikraj V, Eswar A, Lenin S, Preetha N, Selvaraj, M. A prototype of Child monitoring system and motion detection using Raspberry Pi. International Journal of Advanced Research methodology in Engineering and Technology 2017;3(1):163-167.
[4]. Jaouad A, Moyo T, Wang H, Zuber D. Knight's wireless baby monitor. University of Central Florida, Florida (Technical report); 2014, 4 – 6.
[5]. Faruk A, Emre K, Yunus K. A real-time Infant health monitoring system for hard of hearing parents by using Android-based mobile devices. Istanbul University – Journal of Electrical and Electronics 2017;17(1):3107-3112.
[6]. Daing NFMI, Muhammad MAJ, Radzi A. Arduino Based Infant monitoringsystem. International Research and Innovation Summit 2017;1(1):15-23.
[7]. Tupe K, Jandrao V, Chappe S, Turukmane AV, Bhusalwad, P. Child health care monitoring system using sensor technology. International Research Journal of Engineering and Technology 2017;4(3):258-261.
[8]. Saranya A, Venkatesh C, Selva KS. Design and Implementation of automatic child monitoring (ACM) system using wireless network. International Journal of Computer Science and Mobile Computing 2016;5(4):356-363.
[9]. Jeevan D, Kasiselvanathan M. A novel design of real time Children tracking system using Raspberry Pi. International Journal of Power Control Signal and Computation 2015;8(2):152-156.
[10]. Patil SP, Mhetre MSR. Intelligent baby Monitoring System. ITSI Transaction on Electrical and Electronics Engineering 2014;2(1):11-16.
[11]. Rohit NB, Shete VV, Somani SB. Child tracking system on Mobile terminal. International Journal of advanced Research in Computer and Communication Engineering 2015;4(6):213-217.
[12]. Tresna AS, Yoga P. Design and implementation temperature and heartbeat sensors in measuring vital signs through watch. IEE 4th International Conference on system Engineering and Technology 2014;3(1):640-644.
[13]. Kuldeep M, Ravi RC, Dheresh S. A Premeditated CDM Algorithm in Cloud Computing Environment for Fpm. International Journal of Computer Engineering and Technology 2013;4(4):213-223.

[14]. Bhagya SKC, Rana JC. Irrigation system using Raspberry Pi and GSM. International Journal and Magazine of Engineering, Technology, Management and Research 2016;3(1):55 – 62.
[15]. Urgent Care. Effects of Humidity on the Human Body, https://share.upmc.com/2014/06/effects-humidity-body; 2014, [accessed 11 July 2018].
[16]. Wikipedia. Thermal Comfort. https://en.wikipedia.org/wiki/Thermal_comfort; 2012, [accessed 31 July 2018].
[17]. Green Garage. Human Comfort Zone.www.greengaragedetroit.com/index.php/Human_comfort_zone; 2013, [accessed 31 July 2018].
[18]. Zhiwei X. The Impact of Heat Waves on Children's health. International Journal of Biometerology 2013;239-247.