Autonomous Fever Monitoring System For Child Using Arduino, ESP8266, WordPress, C# And Alexa

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Area of the Paper: Computer Science.
Type of the Paper: Experimental Research.
Type of Review: Peer Reviewed as per |C|O|P|E| guidance.
Indexed In: OpenAIRE.
DOI: https://doi.org/10.5281/zenodo.10710079
Google Scholar Citation: IJCSBE

How to Cite this Paper:
Chakraborty, S. & Aithal, P. S. (2024). Autonomous Fever Monitoring System For Child Using Arduino, ESP8266, WordPress, C# And Alexa. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)*, *8*(1), 135-144.
DOI: https://doi.org/10.5281/zenodo.10710079

International Journal of Case Studies in Business, IT and Education (IJCSBE)
A Refereed International Journal of Srinivas University, India.

Crossref DOI: https://doi.org/10.47992/IJCSBE.2581.6942.0339

Paper Submission: 27/01/2024
Paper Publication: 26/02/2024

International Journal of Case Studies in Business, IT, and Education (IJCSBE), ISSN: 2581-6942, Vol. 8, No. 1, February 2024

SRINIVAS PUBLICATION

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ABSTRACT

Purpose: *Nowadays, many electronic thermometers are available to measure baby fever. There are two types of thermometers. One type needs contact with the body, and the other is contactless. The contact-type thermometer must be touched to the body for a few minutes till the count is steady. Sometimes, our baby is unwilling to keep the thermometer on their body for a long time. Both contact and contactless thermometers are operated manually. The baby's body temperature cannot be captured When the mother or attender sleeps. However, the mother could not measure the temperature without sleeping all night. When the mother sleeps at night, and the baby's fever suddenly goes high, she needs to feed the baby fever medicine or water bath on the baby's forehead. It would be good if someone continuously measured the temperature and informed us of some abnormal temperature detection. Yes, now we have the solution. We can solve the problem using our IoT technology. We can automatically measure the baby's body temperature even when the mother sleeps. If the temperature is in an abnormal range, the system draws attention, producing an audio and visual alarm. The system reads the temperature in every predefined interval and saves it to the cloud. When we visit the clinic, the doctor generally wants a temperature history. Using this procedure, the temperature graph can be autogenerated. In this research work, we describe a process to measure the baby's body temperature autonomously and make a backup to the cloud.*

Design/Methodology: *we are making the project possible using IoT technology. We are using a contactless temperature sensor MLX90614. The temperature is processed by Arduino Mega and uploaded to the cloud through the Nodemcu using the MQTT protocol. We are saving the data to the WordPress database. Additionally, to extend the device's functionality, we integrated Alexa. When the mother needs to get the temperature, she must ask Alexa over the voice command. The Alexa will respond to the current body temperature as voice. It is required basically at night when all high-intensity lights are off.*

Findings/Result: *we created the prototype device and ran a proof of concept. The device runs for a couple of weeks. The device worked as expected. For the scope of improvement, we found a couple of points. For example, our device is bulkier due to the prototype; in practice, it is a handy device. The GUI is also more user-friendly. The complete process is automatic, and before the doctor's visit, we need to carry the temperature graph, which can be generated from our C# application.*

Originality/Value: *The medical device, especially for a baby, needs to be designed so that the baby gets a little bit involved. We surfed the net and found most of the automated fever measurement devices use contact type, which creates several complications for the baby when it is attached to the baby's body. So here, we added a couple of unique approaches to provide more value in our daily lives. We said a contactless temperature sensor so that there is no need for direct contact with the baby's body. The second one is that it is Alexa-enabled. The temperature can be a voice response if the room has no light, especially at night. The third one*

is the autogenerated temperature graph, which is very helpful when we go for a doctor's consultation. The above features provide novelty.

Type of Paper: *Experimental-based Research.*

Keywords: *Autonomous fever monitoring, IoT-based temperature monitoring, Making an Alexa-enabled device.*

1. INTRODUCTION :

Problem statement: We are happy in our workplace when our baby is happy at home. When they are healthy at home, we are happy to work outside. When our kids suffer from a fever, we are mentally disturbed. After returning from the office hard work, we sleep deeply at night and are unaware if our baby has a high fever. So we feel some automation system is required to track our baby's body temperature.

Indication of methodology: Here, we integrate a couple of technologies. At first, we detected the baby's body temperature using a contactless temperature sensor MLX90614. We are reading the temperature value from the temperature sensor through the I2C bus. The data is visible locally. Now, we must upload to the cloud to display from the remote. We are getting the help of IoT technology. The data is uploaded to the cloud server using the MQTT protocol and with the help of the ESP module. When the user asks to tell the fever over a voice in front of Alexa, the Alexa device sends the voice token to the AWS Alexa service. It processes the voice and converts it to a string. That string is sent to the lambda services. The lambda function requests the WordPress database to update the data within specific intervals. Getting the request, the WordPress response returns to the lambda services with the latest data. The lambda function responds to the Alexa services again, and Alexa responds to the user as voice.

Essential findings of others in this field: Several noticeable research studies have been carried out in this wing of the medical field. Here, we are describing a couple of research works. The research work (Joseph et al. (2018). [1]) describes a procedure to get the baby's body temperature via mobile. They calibrate their temperature value using a TG100 clinical thermometer to make the result as accurate as possible. We found one good research (Basmaji et al. (2022). [2]) on baby fever detection, which is based on artificial intelligence. They created an IoT node, which is affordable. The complete process became smart using AI, which is more reliable than other methods. The researchers in their work (Akbiyik et al. (2020). [3]) use thermal cameras to detect the baby's body temperature. Using thermal cameras, they also use baby monitoring to track. To transfer the reading data, they add an IoT network. The research work (Mothi et al. (2018). [4]) describes the infant body alerting system using the LM35 sensor, and to transfer the data wirelessly, they used a Bluetooth communication module. The researcher (Reddy et al. (2021). [5]) demonstrated An Automated Baby Monitoring System. They use Raspberry Pi B, a single-board computer, as hardware. To process the data, they use the CNN algorithm. The author (Chakraborty et al. [23-30]) has carried out several IoT-related works, which is the backbone of the current research work.

What study is done in this paper: here, we study several research works in the current scenario. We study how our designed system works in real-life applications. We also study whether our proposed system is feasible for daily use in our indoor environment. We study two types of sensor integration. One is contact type, and the other one is contactless sensor. We learned both performances and got the results as expected.

Principal conclusion: when our loving baby suffers from fever, we forget everything. And completely engaged in curing as soon as possible. We measure their body temperature occasionally and record it for the doctor's reference. For this, sometimes we awake the entire night. So the next day, our brain needs rest. In this scenario, we can get the help of our modern technology. Employing a couple of technologies, we can do the task completely automated. It gives us error-free data. Also, we can minimize the risk of critical situations due to fever by using high fever alarm data.

2. REVIEW OF LITERATURE/ CURRENT STATUS :

An enormous amount of research work has been carried out on automated fever monitoring systems. Here, we included some research projects where we found noticeable work already done. Table 1 lists a couple of research works and used technology.

Table 1: the list of research work and used technology

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	Innovative body temperature monitoring system for children via mobile	Android mobile application, Rossmax TG100 thermometer	Joseph et al. (2018). [1]
2	A Low-Cost IoT Node for Fever Detection Using Artificial Intelligence	IoT, Artificial Intelligence	Basmaji et al. (2022). [2]
3	ThermoCam: Smart Baby Monitoring Assistant	IoT, RGB and a thermal camera	Akbiyik et al. (2020).[3]
4	Novel Continuous Infant Temperature Alerting System	LM35 temperature sensor, Bluetooth (HC05) Modul	Mothi et al. (2018). [4]
5	An Automated Baby Monitoring System	CNN, Raspberry Pi B	Reddy et al. (2021). [5]
6	New standards for fever screening with thermal imaging systems	thermal imaging systems	Ring et al. (2013). [6]
7	Recent advances in wearable medical diagnostic sensors and new therapeutic dosage forms for fever in children	wearable sensor, novel agent-based treatment	Liu et. Al. (2022). [7]
8	a healthcare monitoring system for an autism center in a 5g cellular network using a machine learning approach	Support Vector Machine (SVM), Internet of Things (IoT)	Mamun et al. (2019). [8]
9	SMART NANNY AN iot BASED BABY MONITORING SYSTEM	IoT	Nejkar et al. (2018)
10	Design of an automatic infant care system based on Arduino	Arduino	Qin et al. (2021). [10]

We included several research works based on various communication technologies in the table below. The research below was carried out for the basic communication module required for multiple IoT-based projects. The new researcher can integrate them into their research work.

Table 2: List of the author's research on IoT and the MQTT field.

S. No.	Focus/Subject	Technology/Algorithm/ Module/Components	Reference
1	A Practical Approach To GIT Using Bitbucket, GitHub, and SourceTree	Bitbucket and GitHub website. SourceTree windows application	Chakraborty et al. (2022). [11]
2	How to make IoT in C# using Sinric Pro	C# language. Sinric Pro IoT website	Chakraborty et al. (2022). [12]
3	Virtual IoT Device in C# WPF Using Sinric Pro	Sinric Pro IoT website, C# WPF framework	Chakraborty et al. (2022). [13]
4	MVVM Demonstration Using C# WPF	C# MVC framework	Chakraborty et al. (2023). [14]
5	Let Us Create An IoT Inside the AWS Cloud	AWS Cloud	Chakraborty et al. (2023). [15]
6	Let Us Create a Physical IoT Device Using AWS and ESP Module	AWS cloud, ESP Wifi Module	Chakraborty et al. (2023). [16]

7	Let Us Create Multiple IoT Device Controller Using AWS, ESP32 And C#	AWS cloud, ESP32 Wifi Module, C# language	Chakraborty et al. (2023). [17]
8	Let Us Create Our Desktop IoT Soft-Switchboard Using AWS, ESP32 and C#	AWS cloud, ESP32 Wifi Module, C# language	Chakraborty et al. (2023). [18]
9	Let Us Create an Alexa Skill for Our IoT Device Inside the AWS Cloud	AWS Cloud, Alexa developer console	Chakraborty et al. (2023). [19]
10	Let Us Create A Lambda Function for Our IoT Device In The AWS Cloud Using C#	AWS Lambda console, AWS cloud, C# language	Chakraborty et al. (2023). [20]
11	Modbus Data Provider for Automation Researcher Using C#	C# Language	Chakraborty et al. (2023). [21]
12	IoT-Based Industrial Debug Message Display Using AWS, ESP8266, And C#	AWS cloud, ESP8266 module, And C#.	Chakraborty et al. (2023). [22]
13	IoT-Based Switch Board for Kids Using ESP Module And AWS	AWS cloud, ESP8266 module And C# language	Chakraborty et al. (2023). [23]
14	Let Us Create an Alexa-Enabled IoT Device Using C#, AWS Lambda and ESP Module	AWS Lambda console, ESP module, And C# language	Chakraborty et al. (2023). [24]
15	Alexa Enabled IoT Device Simulation Using C# And AWS Lambda	AWS Lambda console and C# language	Chakraborty et al. (2023). [25]
16	CRUD Operation on WordPress Database Using C# SQL Client	WordPress website, C# SQL client module	Chakraborty et al. (2023). [26]
17	CRUD Operation On WordPress Database Using C# And REST API	WordPress website, C#, and REST API	Chakraborty et al. (2023). [27]
18	CRUD Operation on WordPress Posts From C# over REST API	WordPress website, C#, and REST API	Chakraborty et al. (2023). [28]
19	CRUD Operation On WordPress Custom Post Type (CPT) From C# Over REST API	WordPress website, C#, and REST API	Chakraborty et al. (2023). [29]
20	Let Us Build a WordPress Custom Post Type (CPT)	WordPress website and REST API	Chakraborty et al. (2023). [30]

3. OBJECTIVES OF THE PAPER :

Description for Objectives:

(1) To study the autonomous baby body temperature measurement implementation procedure.
(2) To review the fever monitoring system.
(3) To analyze the performance of the fever monitoring system.
(4) To compare our system with the existing or already developed system.
(5) To evaluate the performance of autonomous fever monitoring
(6) To test the fever monitoring device.
(7) To prove the architectural feasibility of a medical autonomous monitoring device.
(8) To design a robust autonomous baby fever monitoring system that will be used daily.
(9) To develop a medical-grade device that is used in the domestic for fever monitoring purposes.
(10) To interpret the complete autonomous fever monitoring device.

4. METHODOLOGY :

Figure 1 depicts the project block diagram. The central coordinating part is the Arduino megaboard. The main part of the project is the MLX90614-based contactless temperature sensor. The central controller reads the temperature sensor within some predefined interval. We also have a contact

temperature sensor module for experiment or value comparison purposes. Both functions are the same. Reading the temperature value is displayed locally in the FND or LCD. If the temperature exceeds a preset value, it gives us an audio and visual alarm. Once the alarm starts, it will not stop until acknowledged by pressing the reset button. For remote display and to enable us to get data over Alexa, we need to upload data to the cloud server. We use the NodeMCU module to upload data to the cloud. It will connect to the WordPress database and upload over the MQTT protocol. If we ask Alexa for the current fever value, the request arrives at the Lambda console. Lambda fetches the WordPress website data and responds to the Alexa devices.

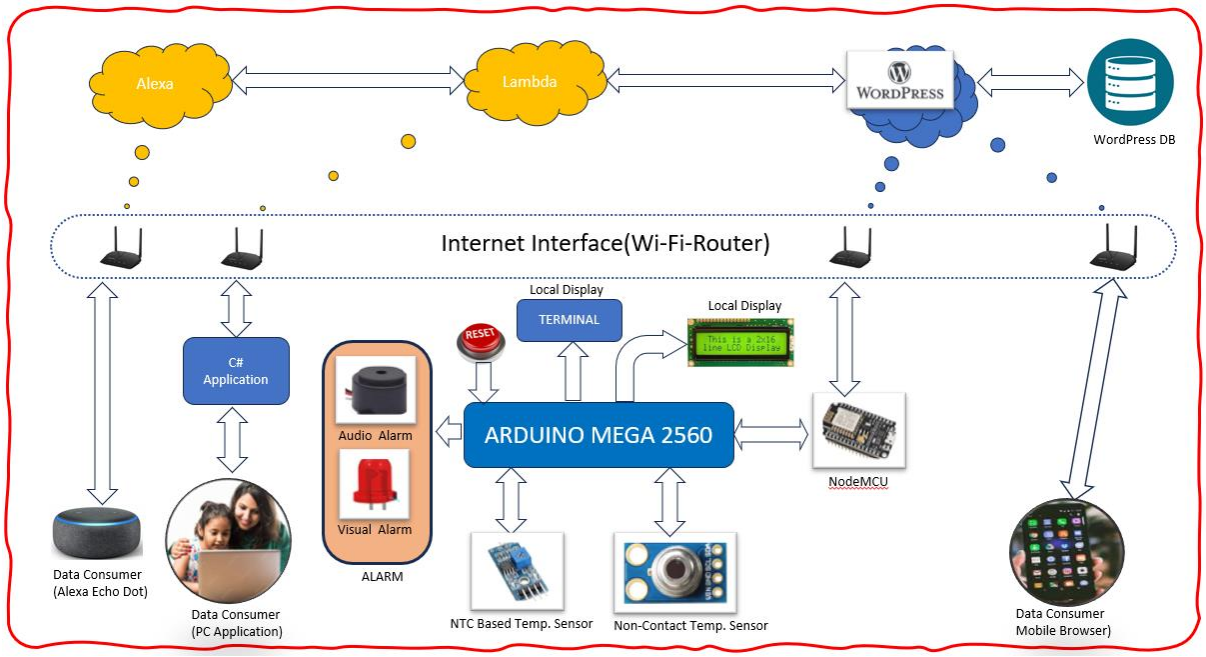

Fig. 1: The project block diagram

5. EXPERIMENTS :

If we want to execute the experiment, we need to follow the following steps:

(1) Purchase the hardware components from the local or online store.
(2) Connect MLX90614 module with Arduino mega I2C bus.
(3) Optionally connect LCD or FND for local display.
(4) Create a WordPress or other cloud server database to store the fever data. The reference paper [26-30] can provide helpful information.
(5) install the MLX90614 module library depicted in Figure 2. Write Arduino code to read the temperature from the MLX90614 sensor. It sends to the one serial port of the NodeMCU serial port.

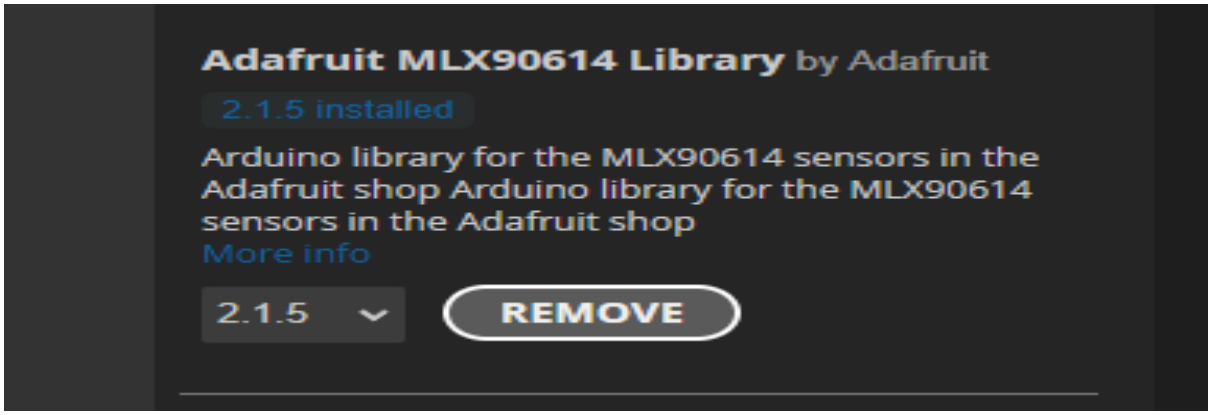

Fig. 2: the library to read data from contactless temperature sensors.

(6) Write firmware of NodeMCU. The paper [15-20] can be a good reference for the new researcher. Now, we write the firmware in such a way that:
   (a) In the firmware, we must add wifi credentials, router ID, and password.
   (b) When the NodeMCU starts, it connects with a Wi-Fi router.
   (c) Once the connection is successful, try to connect with the cloud server.
   (d) In the NodeMCU, there are two serial ports. One is dedicated to debugging. Another one will connect with Arduino Mega.
   (e) Now, the nodeMCU waits for data from Arduino mega. When it receives the data from the host controller, it is instantly sent to the WordPress database. And read the response from the server and response back to the Arduino.
   (f) Here, NodeMCU acts like bridge devices. We can do the complete process with only NodeMCU. However, this modular approach has several advantages. It will isolate from lots of protocol overhead. Using this architecture, we can have lots of possibilities. The nodeMCU will not be an obstacle to sensor reading delay. And vice versa, Arduino Mega will not disturb sending the data to the server, and there is no need to wait for the server's response. Both can run with their optimum performance.

(7) Now, build an application in C# to read the data from the cloud server. The paper [26-28] can be our reference document.

(8) Create a GUI to interact with the user. Integrate the graph control and feed the data to display to generate the temperature graph. Provide the facility to export as PDF.

(9) It can be more desired now to send the created PDF to the mobile number.

6. RESULTS & DISCUSSIONS :

Everyday technology is integrated into our busy life schedule to make life meaningful and hassle-free. In this scenario, automated fever monitoring is one of the essential devices that makes our lives easier. We tested with various scenarios. The result is promising. The system was once developed in the lab, and the product available in the market is slightly different. The market product executes more journeys than the lab product. There are several aspects to introduce in the market, such as ease of use, consistency, portability, and cost perspective. We must focus on these aspects once the proof of concept is over. These journeys are not so challenging, but we need to validate them. Once all these are over, we need to be certified by the concerned authority. Once it is done, it can be used for our needs. Then, receiving feedback from time to time from the market needs to improve the quality to accept more users.

7. ANALYSIS / Comparison OF RESULTS :

There are various types of temperature sensors available to measure the body temperature. The contactless temperature sensor MLX90614 will be perfect for the baby. The response time is also less than that of silicon-integrated sensors like LM35. The NTC or PTC-based temperature sensor also has more response time, which makes it difficult to measure the baby's body temperature. We must calibrate the reading with a good thermometer for the sensor we used before practical implementation. The inside of the ice is zero degrees, and the boiling water is a hundred degrees centigrade. Put the sensor into the ice and boiling water to calibrate and verify the result or outcome from the sensor output.

8. SUGGESTIONS :

There are a couple of suggestions that lead us to further reading-

1) For more information on contactless temperature sensor integration using Arduino: https://lastminuteengineers.com/mlx90614-ir-temperature-sensor-arduino-tutorial/
2) For analog-related information: https://www.arduino.cc/reference/en/language/functions/analog-io/analogread/

9. CONCLUSION :

To simplify our lives, we employ another important gazed In our daily lives, which can be categorized as medical equipment. To simplify fever monitoring, we describe one device that can measure the temperature of the baby's body. First, we describe the relevancy of the topic. Then, we discussed several research studies already done in this sub-wing of the medical field. With this scenario, we discussed a couple of research works like Joseph et al. (2018) [1], where the current temperature is displayed on the

mobile. Akbiyik et al. (2020) [3] used a thermal camera to detect babies' existence and temperature. In this scenario, the author's work Chakraborty et al. [23-30] demonstrates through research work, which is the backbone of the current research work. Then, we describe the objective of the research work. After that, we added the project's methodology with a block diagram. The block diagram shows the central part is a non-contact temperature sensor MLX 90614 under MLX. It reads data by microcontroller and sends it to the cloud using the internet. In the experiment section, we provided the practical procedure to recreate the experiment at the research lab. After that, we discuss the result and, next, the analysis. We added a couple of suggestions for the researcher for an in-depth study on this area. Then, we conclude the project topic. We acknowledge the contributor for whom this research was possible. All things have pros. And cons. This device has no outsides of the cons. We added some limitations, which are transparency and needful thought before implementation. Finally, we include the research work from where we got lots of information to execute the project. We provide some limitations. We provide the code in GitHub if the researcher wants to continue the research.

10. LIMITATIONS :

The items below are the limitations of the project.

(1) This project is for proof of concept. For production-worthy code, we need more robust code.
(2) The final product should be portable for easy handling.
(3) Rigid testing is needed before productization in the market.
(4) In the contactless mode, the distance mode should be proper; otherwise, it can produce an error result.

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