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IoT Smart Cradle for Baby Monitoring

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Abstract*:* In the modern era, more mothers are showing interest in work, and looking after their newborn babies has become a challenge for many families. Thus, many parents prefer to leave their babies with grandparents while they are off to work. But parents may become worried if they leave their baby for a long time. Newborns are delicate and need constant monitoring.

To solve this problem, a smart cradle with a baby monitoring system is proposed to monitor the baby in real time. The cradle automatically swings when it detects the baby crying. A lullaby toy and a small speaker are used to please the baby and to stop crying. An emergency alarm will be triggered if the baby won't stop crying after a certain period. An external camera is connected to Wi-Fi to monitor the baby at all times. The system consists of the Node-Microcontroller Unit as the primary controller. Sensors are used to monitor parameters like temperature, sound and moisture. The data collected by these sensors is sent to Blynk IoT server through Wi-Fi.

The baby monitoring system helps parents with time management and is a cost-efficient IoT system for real-time monitoring.

Keywords **- Smart Cradle, Node MCU, Baby Monitoring, Blynk IoT, Surveillance.**

I. INTRODUCTION

In recent years, there has been a significant rise in the number of Indian mothers looking to get employment, added to the increased job opportunities for women. The move towards double-income homes has driven parents into searching for alternative childcare arrangements only to find their newborns being taken care of by relatives or professional babysitters. However, even with these available options, the anxiety of working parents persists. Parents who work from the office are concerned about what may happen to their little ones, and they usually keep in touch with relatives or caregivers via texts or phone calls using their mobile phones. That shows how much they worry about them even when they are away.

Although many babies are born healthy and strong, some might be born prematurely or have vulnerabilities, making them more prone to environmental factors. According to WHO, most neonatal deaths (75%) occur within the first week of birth, where leading causes of mortality include premature births, birth trauma, congenital malformations as well as neonatal infections respectively. In contrast to other newborns who barely cry or need constant surveillance, these over-sensitive young ones often demonstrate heightened sensitivity, thus getting irritated by the slightest discomfort or sounds around them. This higher sensitivity demands extra attention since these neonates could be at risk if such carelessness occurred.

Hospitals usually monitor newborns using various equipment that can effectively watch over the baby. Nevertheless, this type of monitoring is somewhat demanding to implement in the home. Hospital staff may be more responsive than elderly caregivers and family members, who may be very old. Besides, caregivers may lose concentration or have limited capability to examine the baby's health status, thereby making them unable to determine when an emergency arises. As such, there is a need for a system that can record and inform the caretakers near the baby immediately about any abnormal behaviour or variations in the baby's condition.

The Internet of Things (IoT) has advanced considerably in recent years, bringing together software, wireless sensors, and actuators to create interconnected devices that can send and receive data instantly.

IoT technology can help create a network of sensors placed around the baby to watch for parameters like temperature and noise levels. This information is sent to an IoT server, which can enable remote monitoring. It helps the parents to keep track of their child's well-being from the outside of the home through mobile application alerts.

II. DESIGN AND DEVELOPMENT OF THE SYSTEM

The system is designed to continuously monitor various parameters, including temperature, baby wetness, and sound levels. It uses the Node MCU as the primary controller which has a built-in Wi-Fi module for communication. The system includes components such as a small fan, motor, and music player, that are activated in response to recorded data. An external camera is used to allow remote monitoring of the infant through the mobile application.

The system is designed using the following components.

- Baby Cradle
- NodeMCU ESP8266 Wi-Fi Board
- Temperature Sensor
- Sound Sensor Module
- Moisture Sensor Module
- 5V DC Fan
- 12V DC Motor
- DC Motor Controller Module
- DC Motor Speed Controller Module
- Music Player
- Buzzer Module
- ESP32 Camera Module
- 5V Relay Module
- 12V DC Power Source

The software used is as follows

- Arduino IDE Software
- Blynk IoT Platform

Node MCU

The NodeMCU ESP8266 is a low-cost microcontroller that has an integrated Wi-Fi chip. It has 11 GPIO pins. Some of these pins support PWM (Pulse-Width Modulation), making them flexible for interfacing with other devices. Additionally, it supports UART, SPI and I2C protocols, thus enhancing compatibility with various peripherals. The NodeMCU can be powered using either 3.3V or 5V. Also, it contains an analog pin used for connecting analog sensors to increase its sensing capabilities. It has a built-in LED connected to the GPIO2 pin. The NodeMCU also comes with a reset button (RST) that makes it easier to reset the device whenever required.

Hardware Components

The system uses various sensors to monitor the baby's environment.

The DHT22 sensor measures the temperature surrounding the baby. It works on either 3.3V or 5V. It can read the room temperature for every 2 seconds. It outputs the digital data recorded. We have connected it to one of the NodeMCU digital pins. KY-038 Microphone Sound Detection Module measures the sound value operating on 5V. It can output both digital and analog signals. A potentiometer on the module can adjust the threshold of the digital signal. We have used it as a digital pin and connected it to one of the NodeMCU digital pins. A soil moisture sensor module measures the dampness of the baby. It operates on either 3.3V or 5V. It can also output both digital and analog signals. We have used the analog output and connected it to the analog pin (A0) of the NodeMCU. A DC fan cools down the temperature around a baby if it exceeds a certain threshold. The fan operates on 5V. A 12V DC motor with high torque swings the baby cradle whenever a baby cry is detected. A motor speed regulator is used to control the speed of the DC motor. The motor controller module controls the DC motor. An audio voice module with a speaker calms the infant by playing baby songs stored in an SD card.

A relay module controls the DC fan, motor and music player. The relay module operates on 5V. The ESP32 camera module monitors the baby and it operates on 5V. A USB-TTL converter is required to program the camera module as it only accepts serial communication. A 12V DC power adapter powers the motor and a DC-DC voltage converter converts 12V to 3.3V and 5V. The converter module output powers up the NodeMCU and other hardware. The ESP32 camera module may need more than 1A while it is streaming live, so a 7805 voltage regulator is utilized to convert 12V to 5V.

III. IMPLEMENTATION OF THE SYSTEM

SYSTEM ARCHITECTURE

The system comprises a NodeMCU as the primary controller. This controller is used to control all the hardware. The captured parameters are sent to the Blynk IoT server. Tracking these parameters is possible through a web browser or mobile app with a Blynk template-linked user account.

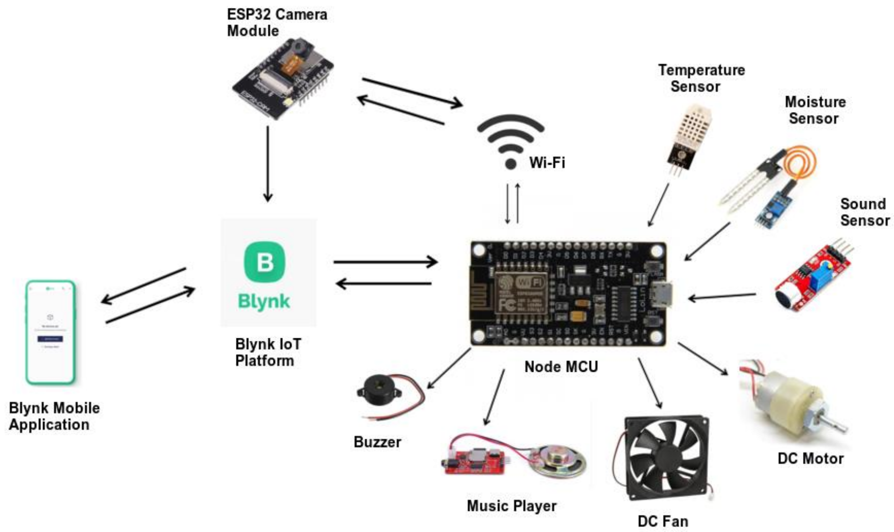


Figure 1. Components used for the baby monitoring system

Initially, the NodeMCU is connected to the Wi-fi network to connect with the Blynk IoT platform. After a successful connection, the system starts to monitor the parameters. The system mainly monitors three parameters. The readings take place every 10 seconds.

The first parameter monitored is temperature detection with readings taken at 10-second intervals. The fan turns on when the temperature surrounding the child exceeds the threshold level for three consecutive readings. The fun turns off when the temperature around the baby is below the threshold level for three continuous readings. This method helps in reducing the false temperature readings of the sensor that may arise and increases the chance of true temperature readings. An alert is sent to the parents via the Blynk server when the temperature exceeds the threshold, and the fan is automatically activated.

Next, baby dampness is detected. Here, a threshold is defined, and if the recorded value surpasses the threshold, an alert is sent through the Blynk server, indicating wetness, and the baby garment needs to be changed.

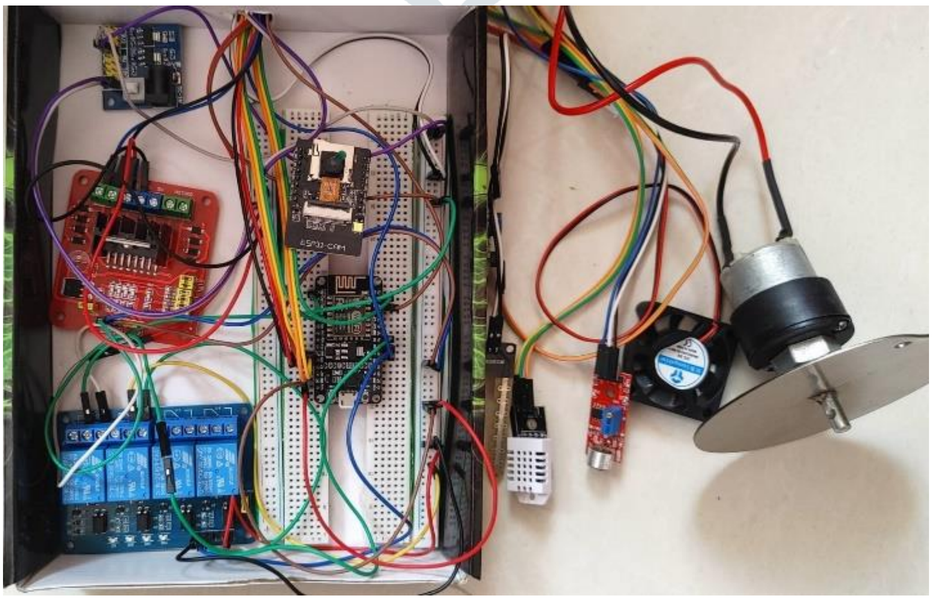


Figure 2. Hardware setup

Lastly, the sound is detected using a sound sensor module. The sound sensor records ten readings continuously with a delay of 500ms after the 10-second interval. The ten readings recorded in the 5-second interval are compared with the threshold. The general threshold for this is around 4-6. It can vary depending on the noise in the environment. This makes sure that the sound is captured over a period of time and reduces the chance of capturing sound during minor baby cries. When the detected count crosses the threshold, the DC motor swings the cradle while the music is played to calm the baby. A speed control module attached to the DC motor can regulate its speed.

If the baby won't stop crying after three continuous recordings, an emergency buzzer is activated, alerting parents via the Blynk App with an urgent notification prompting immediate attention.

To continuously monitor the baby, an ESP32 camera module is used. We can watch the infant remotely after the module connects to the Wi-Fi network. The camera interface in the browser enables us to change the resolution for better frame rates while offering features like taking snapshots and an LED with variable brightness for low-light observation. The relay module controls the fan, motor and music player. The NodeMCU digital pins send control signals to the relay module. The DC power source powers the DC motor and the DC converter module. The DC converter module powers the components based on their rated voltage.

All captured readings are updated to the Blynk Cloud for real-time access. Parents can configure notifications and alerts within the app according to their preferences.

ALGORITHM

Algorithm Design for IoT Smart Cradle

```
1. Define Wi-Fi Access Point Username/PW
2. Define Blynk IoT Server
3. Define ESP32 Camerea Moudle                 // For surveillance
4. Define NodeMCU pins for Relay board        // For switching actuators (swing motor, fan, musical toy, and buzzer)
5. Define NodeMCU pins for sensors            // For getting sensors data (Temperature, moisture, and sound)
6. Define T ← Temperature value               // From DHT_22
7. Define M ← Moisture value                  //From Moisture Sensor Module
8. Define S ← Sound value                     // From Sound Detection sensor
9. Define TEMTH ← Temperature Threshold value
10. Define MTH ← Moisture Threshold value
11. Define STH ← Sound Threshold value
12. Define Scount ← To keep track of continuous sound occurrences
13. Define Tar ← {T1,T2,T3}                   //Define a container to store the last three temperature readings.
14. Define Sar ← {S1,S2,....S9,S10}           //Define a container to store the successive sound readings over a period.
15. Initialize IoT-System                     // Switching ON the system at t = 0
16. NodeMCU records the data (sound, temperature, moisture)
17. Wi-Fi-based Webcam provides monitoring of baby
18.     for each round do
19.             Get T, M, and S
20.                 Update the temperature container      {T1,T2,T3} → {T2,T3,T}
21.                 Upload data to Blynk IoT Server over Wi-Fi
22.                 if all readings in temperature container >=TEMTH then
23.                         Switch ON FAN
24.                         Notify parents via Blynk App "Temp is High!"
25.                 else if all readings in temperature container <TEMTH then
26.                         Switch OFF FAN
27.                 if M >=MTH then
28.                         Notify parents via Blynk App "Baby wetness detected. Change diaper"
29.                 Define Srec ←         // count the number of positive readings
30.                 if Srec>=STH then
31.                         if Scount>3 then
32.                             Turn on buzzer
33.                             Notify parents via Blynk App "URGENT! baby crying for long time"
34.                         else if Scount<3 then
35.                             Increase Scount
36.                             Switch ON Cradle's Swing Motor
37.                             Switch ON Musical toy
38.                             Notify parents via Blynk App "Baby crying is detected!"
39.                 else
40.                         Decrease Scount to zero.
41.                         Switch OFF Cradle's Swing Motor
42.                         Switch OFF Musical toy
43.     end for
44. Monitor  actuators remotely via Blynk App.
45. Update camera vision over Wi-Fi
```

Figure 3. Algorithm Design for IoT Smart Cradle

FLOWCHART

The below flowchart shows the step-by-step process of how the algorithm works.

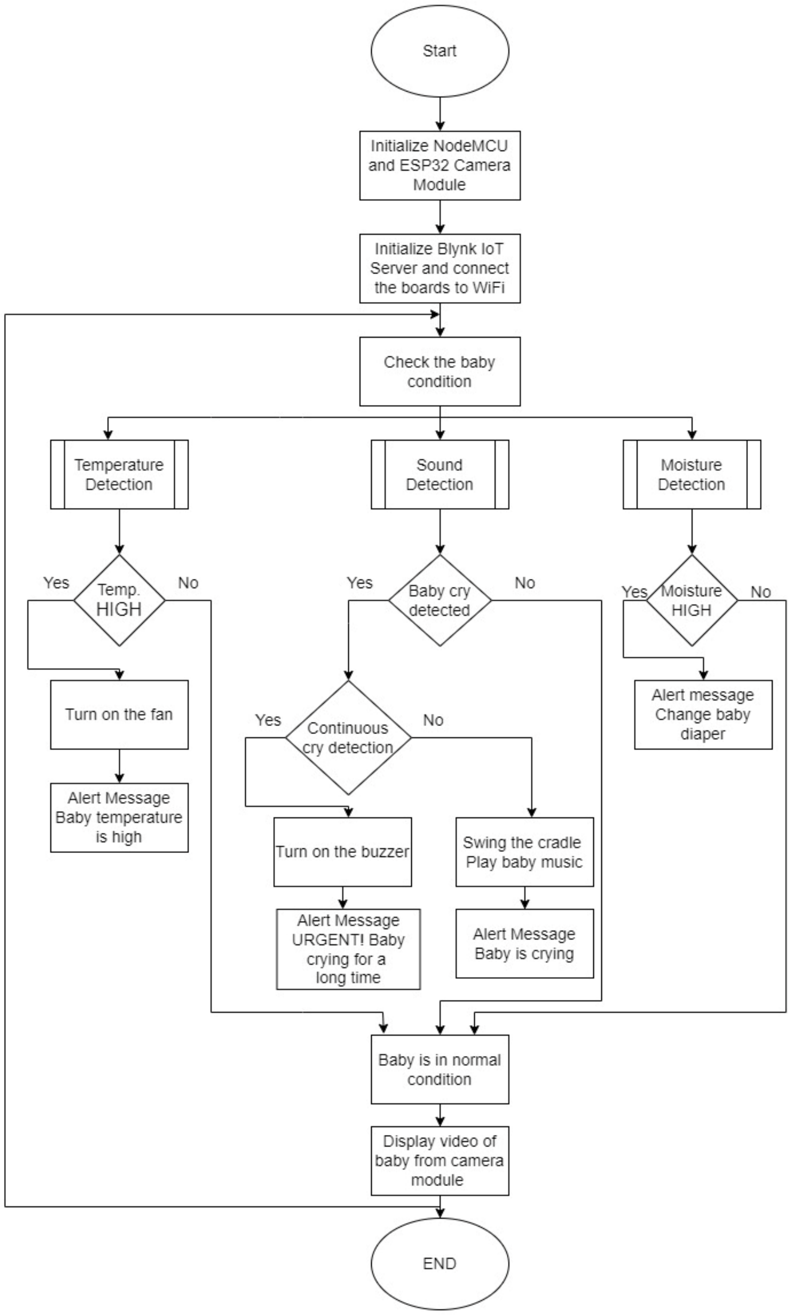


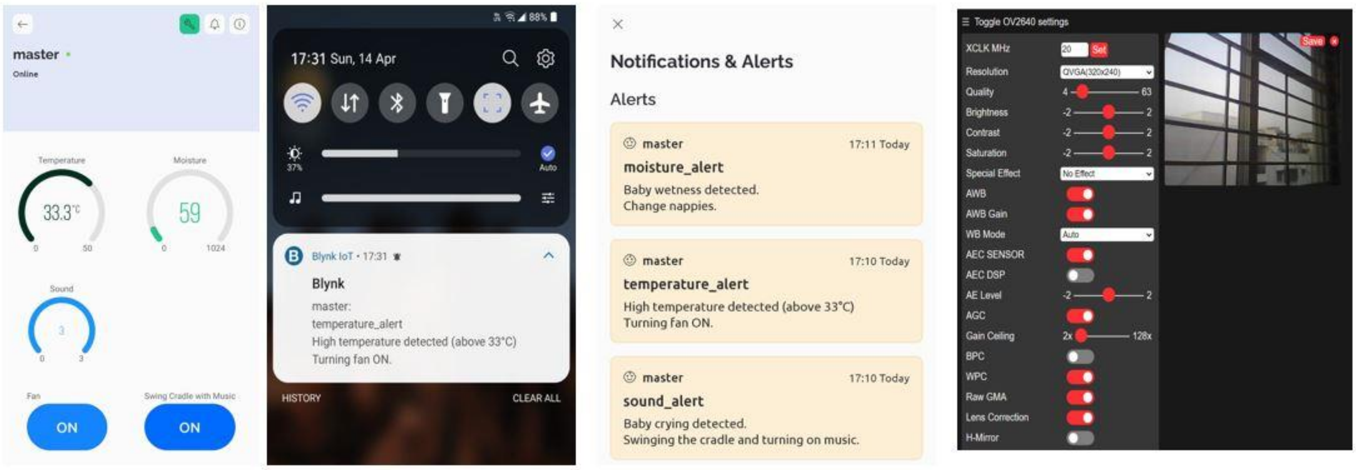
Figure 4. Flowchart depicting the working of Smart Cradle

IV. RESULTS AND VERIFICATION

We have used the Blynk application to monitor the data in real time. All the connected hardware is interfaced with the NodeMCU, and the data recorded are transmitted to the Blynk platform. From Fig 5a, we can see the readings of the sensors through the Blynk mobile application.

A smartphone was used to play the sound of a crying baby to test the completed prototype while it was in the cradle. The system assumed that the infant was crying because of the detected sound, so when the phone rang for a few seconds, the cradle began to swing. A hot air blower was used to check for the temperature. When the temperature crossed the threshold of 33°C, the fan turned on. When moisture was applied to check the dampness of the baby, an alert was sent to the smartphone indicating that the baby's dampness was high.

The parents receive alerts regarding the baby's condition, as shown in Fig. 5b. With the Blynk smartphone app and web dashboard, the user may easily swing the cradle with music and turn the small fan on and off remotely.



(a) (b) (c) (d)

Figure 5. (a) Blynk Mobile Dashboard (b) High Temperature alert (c) Recorded alerts history (d) ESP32 camera livestream

Notifications are set in the mobile app to alert the parents if the recorded values exceed the threshold. From Fig 5c, we can see the history of the temperature, moisture and sound alerts generated from the recorded data.

The ESP32 camera can be accessed to monitor the baby at all times. From Fig 5d, the live stream of the baby can be viewed after connecting the camera module to Wi-Fi.

V. CONCLUSION

A smart cradle that monitors a baby's vital indicators, including temperature, moisture, and crying state, has been developed and implemented using IoT. The NodeMCU and Blynk are interfaced with all the required sensors in the built system.

The Blynk program provides the parent with the appropriate alarms or notifications about the baby's temperature, the wetness of the baby's bed, and the baby's crying. With the ESP32 camera module inserted in the cradle, it is possible to monitor the child's posture and condition for every few moments.

The project displays the necessary foundation for infant monitoring, including screening important indicators such as health monitoring and real-time baby surveillance.

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