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Research Article

Iot based Toddler Monitoring System

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Abstract

Currently, the number of parents in Nigeria with adequate time to care for their toddler is drastically reducing due to the increased number of employed mothers and the enormous amount of chores women face on a daily basis. Most couples solve this issue by involving a third party, i.e. a nanny or a relative such as the grandparents, siblings, or nephew. However this approach is not optimal. In this work, an IOT toddler monitoring system is proposed as an efficient and cost-effective way to advance childcare in Nigeria. A new algorithm is proposed for the system, the latter aims at providing better care for the toddlers when the parents or caretakers are busy through constant monitoring and reporting. The design of this system utilizes an ESP32 microcontroller for the collection of data read from the various sensors interfaced with the microcontroller and the data is transmitted to a Blynk mobile application via Wi-Fi module. The proposed system uses sensors to monitor the infant's temperature, sound due to cry and the air quality of the infant's environment. The device was extensively tested to ensure its reliability and efficiency.

Keywords: IOT, Toddler, Child care, Embedded system, Monitoring, ESP32, Blynk

INTRODUCTION

Infant care is the supervision and care of a child aged three years and below, it can be a time-consuming, energy-draining activity, but it is required for the successful upbringing of the infant. In Nigeria, infant care is the first stage of childcare a married couple experiences once they have a child. When both parents have a full-time job, this poses a significant challenge for them, but more so, the mother, whose primary duty is to care for the new-born child. Leaving a new-born in improper care can result in several negative consequences, including but not limited to injuries, sickness and death. Most working parents tend to delegate the job of child care to their close relations or a nanny, but this sometimes proves to be a reckless way to handle child care as the story of evil nannies rain rampant and issues of negligence arise among relatives. The parent requires additional supervision to ensure that the child gets proper care. SIDs SUDDEN INFANT DEATH syndrome, or crib death, are said to occur in children aged 12 months or younger. It is known as crib death because most infants inflicted by it were in their cribs. Professionals are still researching the cause of this phenomenon, but it has been said that soft bedding and overheating might be a determining factor to this phenomenon. From a study carried out by researchers, It was discovered that infants laid in firm bedding posed less risk of suffering from crib death than those laid in softer bedding, and infants allowed to rest in warm temperature conditions suffered less from SIDs as well (Jabbar WA, 2019). The best way to combat these issues is by monitoring the infant constantly for abnormalities in health or behavioural patterns. With IOT Internet of Things connecting household appliances and systems to the Internet, it is now possible to build a system that facilitates monitoring from far away.

Statement of problem

Improper care of a toddler could leave them at risk of injuries, sickness and SIDs. Most parents end up too busy to take care of their wards. Having to work at least 8 hours a day for the sake of the household, most fathers would have no time to attend to their kids during the day; at night, the same could be said since they'd rather spend most of the time resting in preparation for the following day. Mothers

of the modern age can also be found working a 9 to 5 job, not allowing for the child to get all the motherly love and affection he needs to develop properly; even with mothers that serve as housewives, they have several house chores to take care of preventing them from being able to fully monitor their infants. A nanny could be used in this case, but not all parents can afford the services of a nanny, and there is still the risk of employing a carefree nanny. Proper monitoring is required to ensure that at any point in time, the child's health status is known, as well as the shift in the behaviour of the infant to know when to make diaper changes, carry out feeding, entertain the child and put him to sleep.

Review of related works

Multiple iterations have been made on the toddler monitoring system over the years; some of the advancements made in recent years are analyzed in this section (Chung CG, 2022). Worked on an IOT-based autonomous baby monitoring system using a mobile app for monitoring real-time parameters like temperature, humidity, consciousness, cleanliness and motion. The system operated using four phases namely; data collection, information sharing & processing, output display & notification and finally, user control. The components used in building this system were an Arduino Uno, a Wi-Fi module, Camera, Speaker, a sound sensor, temperature and humidity sensor LEDs, moisture sensor. The limitations with this system lay in the cost associated with the build-up as well as the bulkiness of the entire system. Furthermore, the system could also pose a risk to the child, considering that most of the components were exposed. W.A. Jabbar et al. (2019) designed and fabricated a baby monitoring system around a smart cradle utilizing NodeMCU as the brain of the system. The system comprises a cradle that swings when crying is detected. The cradle also has a mini fan fastened to it to provide cooling for the infant; both the mini fan and swinging can be activated through the sensors on the cradle or remotely from the MQTT server. The system also comes with an external Wi-Fi camera to monitor real-time vision. Parents can see and communicate with their babies using the tailor-made application of the Wi-Fi camera. The limitation of this system is its inability to measure the air quality of the toddler's surroundings, ensuring that the child is always breathing unpolluted air (Kumar V, 2022) worked on an IOT-based cradle-baby monitoring system that utilizes some aspect of machine learning. The smart cradle is fitted with a video monitoring system and triggers an automated cradle, swinging when the baby's cry is detected. If the baby's cry continues over a long period, the systems activate the buzzer and initialize a message to a mobile phone to notify the need for assistance. The cost is also fitted with a whirligig for the toddler's entertainment, significantly decreasing the likelihood of the baby crying the entire day. The system uses a Node microcontroller as the CPU and transmits all the data gotten from the sensing device to the MQTT server. However, this system does not measure parameters aside from sound and health-related parameters like oxygen saturation, heart rate and other non-invasive health procedures. Therefore, the application of the device is geared towards children less than six months old (Shreelatha, 2017) designed an advanced system for monitoring babies using Raspberry pi. This system is made of sensors which monitor parameters such as humidity, sound and temperature around the toddler including the infant's movements. It also keeps track of the infant's activities and sleeps cycles and then updates the parents remotely on the current state of their child. To do this, it utilizes a camera to let parents view their toddlers in real-time via a web page. The downside of this project is its lack of an air quality sensor that ensures the child rests in a non-hazardous environment. The entire project is also not cost-effective and is too expensive for production on a large scale (Pratap NL, 2021). Developed a smart cradle system to monitor the activities of the child various parameters such as heartbeat rate, gas molecules, temperature, dampness, motion and position of the infant were put into consideration in the design. The system utilizes an SODI board to interface the necessary sensors and actuators to determine the various parameters. All values obtained via the sensors were read using a mobile application. In the event of an abnormality, the system begins to trigger the smart cradle to regulate parameter like temperature; by turning ON or OFF a fan fixed to the cot. The rocking of the crib and playing of soft music would also be initiated as an attempt to stop the infant from crying. In addition, the system sends a notification to the parents or caretaker when the toddler's condition remains negative. Unfortunately, the system proves imperfect by not being a completely contactless system, which may place the toddler at risk of strangulation if the wires connecting some of the sensors get wrapped around the child In (Yusuf SD, 2019). A Raspberry Pi and wireless sensor network (WSN) was deployed to build and monitor the wellbeing of an infant. Many gadgets and sensors, including sound and motion sensors, cameras, temperature and humidity sensors, were integrated to observe the infants' nursery. Python 3.6 and Java 8.0 were utilized to program the system, while the Pub Nub 4.4 data streaming network was used for real-time data streaming and device signaling. From the analysis of the results, the system successfully publishes information to a third-party smartphone which can be tracked from the smartphone using the Internet. The limitations of this project are its ineffective system for regulating temperature and the overall cost of building the project. The system also fails to check for air quality (Dubey YK, 2019) proposed a contactless baby monitoring system that uses image processing to determine the activities of toddlers. The system detects the crying, position and motion of the child. If any irregularity is detected with the child, the system sends the parents an email containing text and images of the toddler. The video footage from the Pi Camera is processed using the Raspberry Pi B+ module. The MIC

identifies sound due to cry, and then image processing is used to detect the mobility of new-borns in real-time and the bed's border condition. The Haar classifier trains the face identification algorithm on positive and negative non-face and face pictures respectively. Unfortunately, this system doesn't check for other parameters of the child aside from crying, position and motion; therefore, if an issue with the child's health arises, it wouldn't be detected immediately unless the parent is physically present (Savathri R, 2019) made a smart baby cradle that allows parents to monitor their infant and the cradle, sensors on the cradle measure and send parameters such as the temperature, motion and the crying sound of the infant, including the moisture content of the toddler's bed to a mobile application. The device allows parents to speak with their child and monitor the toddler via a camera mounted on the cradle. If crying is observed, the device prompts the cradle to swing gently to soothe the child. An Arduino UNO, temperature sensor, speaker, moisture sensor, sound sensor, a driver circuit, DC motor, Wi-Fi module and web camera were utilized in the production of this project. In a project by (Bhasha P, 2021), a system for observing the condition of babies based IoT technology was introduced. This system is made accessible, reasonably priced and operates effectively in real-time. A speaker, a sound sensor module, and a Node MCU microcontroller were incorporated in the system. At the cry of the child, the sound sensor module recognizes it and takes the appropriate action. In addition, the BLYNK application server is activated to deliver alert messages on the status of the children to the registered parent's mobile number. However, this project fails to measure quantities besides sound, limiting the scope of dangers the systems look out for when active (Nazar N, 2019) developed an intelligent cradle that would enable a mother or a father to keep tabs on their infant and perform specific home duties simultaneously. With the aid of a DC motor, the cradle will begin to swing when the infant screams. The temperature and wetness sensor measures the baby's temperature and moisture; if either rises beyond a certain threshold, a notification is sent to the parents. When a baby cries, the system's microphone detects it, and a song is played through the APR's installed speaker. A message is also sent to the parents via their smartphones using the Blynk server. The device also sets a reminder for the toddler's feeding time (Zakaria NA, 2018) developed a compact, lightweight gadget that can easily track a child's body temperature continually. It directly assists parents by warning them anytime their child's body temperature rises over average. This method uses a wearable sensor to keep track of the crucial parameter, which is body temperature. The information was then transmitted wirelessly to their parents. In addition, the system has been expanded to interface with mobile phones to enable remote monitoring. The system's architecture consists of a wearable sensor for tracking vital indicators and a buzzer managed by the same microcontroller, the ESPresso Lite V2.0, based on ESP8266, powered by a lithium-ion polymer battery. This project, although great, puts the toddler at risk of exposure to direct contact with electrical components, which could either be swallowed or slightly harm the child if exposed (Ibrahim DM, 2019) devised a plan to use a Raspberry Pi device to create a system that will make monitoring a toddler easier. The proposed system will include several features, including the ability to listen to the child's cries and display live video and audio, record audio and play it to the child, measure the room's temperature and humidity, support Arabic, and determine whether the baby is awake or asleep. However, the ability to detect the baby's cries is its most crucial feature. Unfortunately, this system fails in certain areas; rather than measuring the room's temperature, the child's temperature should have taken precedence. However, the system should have been equipped with more sensors to monitor other important parameters while remaining fully contactless (Hotur VP, 2021) developed an automated system that streams video online. An intelligent baby cradle allows parents and guardians to watch and reassure their children. In addition, the system has an MP3 player for calm music, a temperature sensor, and a moisture sensor is incorporated into the cradle's ESP32 wroom (micro-controller) platform. High-speed internet access makes using IOT platforms simple, and any confusion brought on by the baby will be relayed to the parents via SMS via GSM.

MATERIALS AND METHODS

This project features an ESP 32 microcontroller that serves as the system's central processing unit; this is where all the code for the device's behavior is sent, all the processing is done, and the relevant information is passed on from there. Various sensors are linked to the microcontroller to read the toddler's values of various physical quantities. When the device is powered, an infrared temperature sensor connected to the microcontroller reads the child's temperature from a distance; this information is processed by the microcontroller and sent to the mobile application (BLYNK app) via Wi-Fi. Suppose the temperature obtained via the sensor surpasses a particular threshold. In that case, a notification is sent via the app to alert the parent that the toddler probably has a fever and should receive immediate medical care. The system also has a gas sensor which reads ammonia gas and nitrogen gas; it makes a sound with the buzzer attached when either of the gases is detected, notifying the caretaker that the toddler might have soiled itself. In addition, a sound impact sensor is connected to detect the toddler's crying and a dust particle sensor is used to measure air quality. Data concerning the temperature, air quality and sound are sent to the mobile application of the parent or caretaker in real-time. Once a crying sound is detected, or the air quality indicates a negative change, the mobile application sends a notification to the parent **(Figure 1-2)**.

For this project, the following components were used to

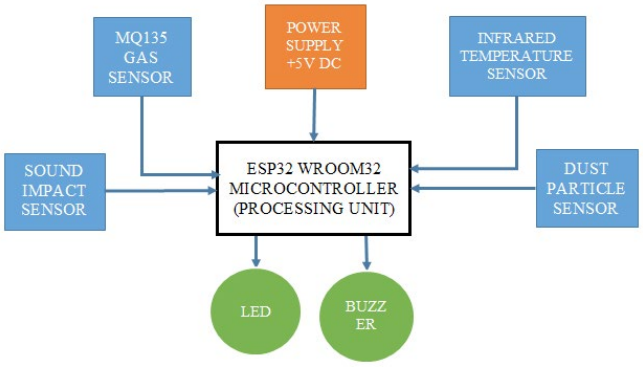

Figure 1. Block diagram of the toddler monitoring system.

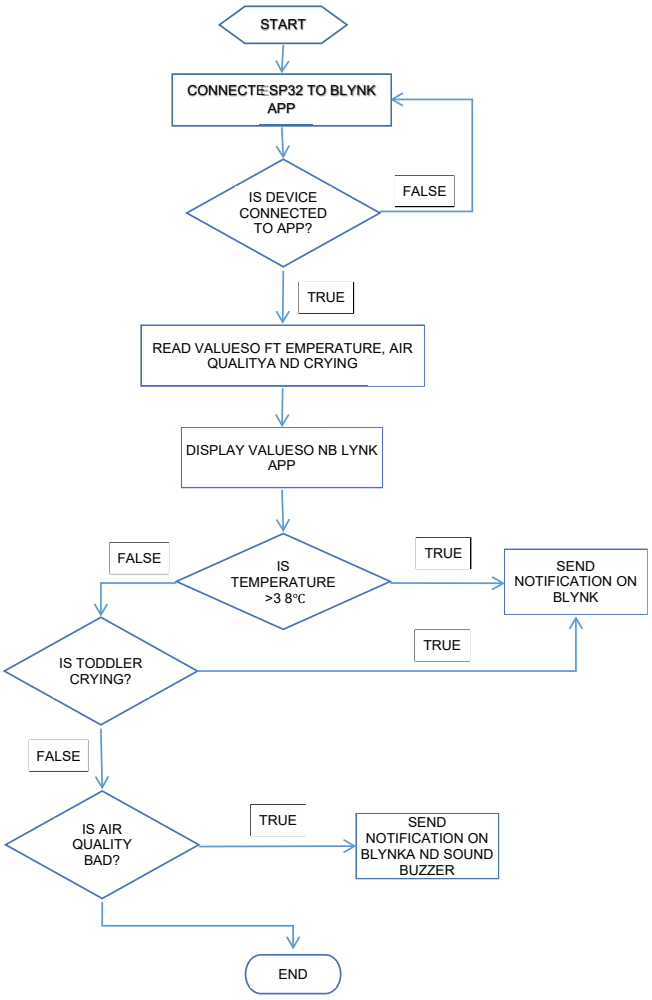

Figure 2. Flowchart of toddler monitoring system algorithm.

build the system.

- ESP 32 micro-controller
- Dust sensor (GP2Y1010AU0F)
- Infrared temperature sensor
- Sound impact sensor
- MQ135 gas sensor for (NH3 and Nitrogen)
- Buzzer
- Two LEDs
- PCB solder-able board
- Two 3.7v battery

Flowchart and algorithm

Algorithm

I. Initialize the ESP 32 microcontroller.

II. Temperature values are read from the (MLX90614) infrared temperature sensor.

III. Air quality is measured using the Dust sensors (GP2Y1010AU0F) and MQ135 gas sensor.

IV. Crying is detected using a sound impact sensor.

V. Values for temperature, air quality and sound are sent to the Blynk server and are made available on the blink app.

VI. When each quantity falls or rises above a set threshold, a notification is sent from the app.

RESULTS AND DISCUSSIONS

The mobile application used for the project is the Blynk app, connectivity of the application to the system hardware and the Internet was tested extensively to ensure that the code written to establish the connection between the app and hardware worked perfectly. And there was minimal lag when receiving data from the Blynk servers **(Figure 3-4)**.

Stool detection test

To ascertain the possibility of the gas sensor being used to detect stool, values of the gas sensor were read from the office and a necessary house. The resulting values from the office were found to be slightly random but were within the range of 400 to 520 while that for the necessary house fluctuated between 500 and 650 **(Table 1)**.

DISCUSSION

During the testing of this device, it was noticed that;

- The sound impact sensor requires continuous production of loud noise to cause a change in reading.

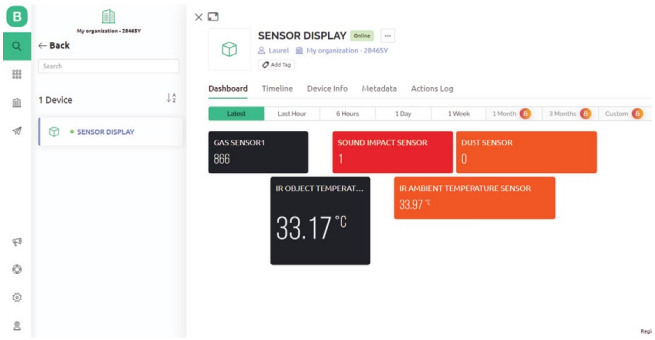

Figure3. Image of blynk web test.

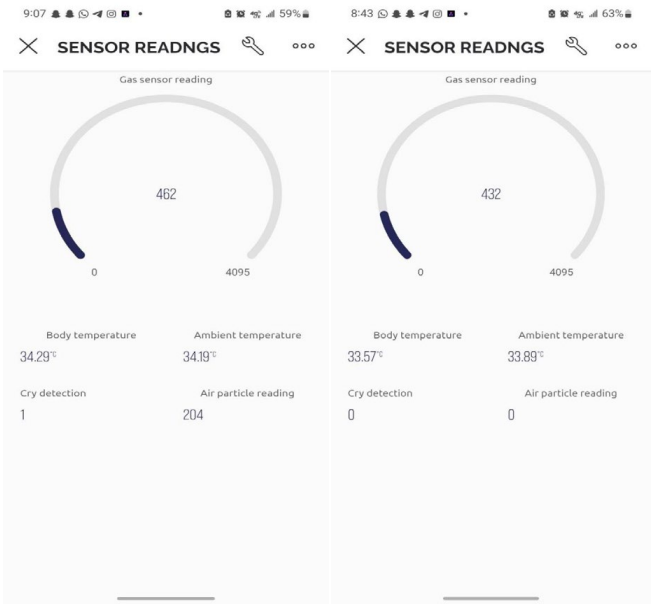

Figure 4. Images of blynk app test.

Table 1. Stool detection test .

S/no	Gas sensor reading for clear air	Gas sensor reading in the presence of stool
1	432	525
2	462	560
3	442	624
4	503	598
5	496	614

- The dust particle sensor used to measure air quality proved difficult to interface with the rest of the build.
- There was minimal data transmission lag between the ESP32 microcontroller and the Blynk servers.
- The quantity of Gas in the air slightly changes with a drastic increase in the amount of air particles.
- It can be concluded that it's possible to detect stool using this system.

CONCLUSION

A fully functional IoT toddler monitoring system prototype was proposed, designed, constructed and tested. An ESP32 microcontroller was used as the system's processing unit, and various vital infant parameters were read. The parameters include; temperature, sound from the child's cried and air quality of the child's environment. The system presents a number of perks with its relatively cost-effective build. It can be made readily available for parents at a low price; it is also a fully contactless system; thus, the possibility of the device posing a health risk to the child is minimized. Furthermore, every parameter measured is sent to a mobile application (BLYNK app), and the readings are available in real-time. With this project, the future of child care can be improved greatly, but even with this project, the physical presence of a parent cannot be circumvented in the upbringing of a child.

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