IoT Based Incubator Monitoring and Controlling System for Jaundice Treatment

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Abstract—: Monitoring the well-being of infants is of paramount importance for ensuring their health and safety. This project introduces an affordable and efficient solution leveraging the Internet of Things (IoT) technology. The hardware module comprises an ESP32 microcontroller, serving as the central processing unit, along with a suite of sensors for comprehensive monitoring. These include a body temperature sensor for infant health assessment and ambient temperature, humidity, and gas sensors for environmental monitoring. The ESP32 microcon-troller integrates seamlessly with the inbuilt Wi-Fi module, facilitating real-time data communication and remote monitoring. The system collects data from the sensors and transmits it to a centralized platform for analysis and visualization. By comparing the acquired data with readings from established measuring tools, the system ensures accuracy and reliability. This project aims to address the challenges of affordability and accessibility in infant monitoring systems. By utilizing widely available components and IoT technology, it offers a cost-effective solution without compromising on performance. The integration of various sensors enables comprehensive monitoring, providing insights into both infant health parameters and environmental conditions. The pro-posed solution holds significant potential for widespread adoption in healthcare facilities and homes, empowering caregivers with real-time monitoring capabilities. Furthermore, its compatibility with existing measuring tools enhances its utility and reliability. Overall, this project represents a step forward in leveraging IoT technology to safeguard the well-being of infants, bridging the gap between affordability and effectiveness in infant monitoring solutions.

Index Terms—IoT (Internet of Things),Neonatal Care,Sensor Network,Remote Monitoring,Real-time Monitoring.

I. Introduction

Neonatal Intensive Care Unit (NICU) a An important lifeline for newborns who need breastfeeding medical care, especially birth premature. A premature baby is defined as a baby Born before 37 weeks of gestation and often charac-terized by low birth weight (less than 2,495 kg) or a major medical condition is required special care to address their unique health difficulty Unfortunately, the statistics bear this out With over 130 million children, this is an important issue Every year, 8 million people are born in the world and die subject to prior challenges in the first year of life. NICUs over the years the complex has grown exponentially a device to monitor the baby's vital signs; including body temperature, blood pressure, and pulse speed and breathing rate. However, progress has been made technology, especially the Internet of Things (IoT); change the face of my child care allowing medical professionals to monitor remotely This is an important parameter. A nascent research group emerged IoT based baby incubator control is a system that aims to improve the quality of care given to premature babies. These systems are diverse some focus mainly on aspects of control, others include control design function. primary usually controlled parameters in this system including the temperature and humidity of the given incubator direct impact on the comfort and well-being of chil-dren. However, the researcher conducted additional research is a parameter to provide more detail assessing the child's environment and physiological state. For example, references introduced a control system that includes humidity and pulse rate sensors expand the scope of observation outside the normal range. Meanwhile, he concentrated only in controlling the temperature of the incubator, show the diversity of research approaches in the field Based on these findings, researchers has designed an innovative system equipped A set of sensors to pick up different environments and physiological parameters. For example, developed a integrated microcontroller based system and weight, motion, temperature and humidity sensors, along with LoRa and NFC modules for This system contact has acquired local memory used database server for storage and capabilities receive information indicating a secure infras-tructure for data management. It's like that, a temperature con-trolled microcontroller based system LCD filled with humidity sensor and Wi-Fi module. Managing the Thingspeak Platform; This system efficiently stores sensor data The versatility of the IoT platform in healthcare application. There are some researchers out of control integrated system management ca-pabilities, allowing automatic response to sensor data. give For example, he created a system monitor environmental param-eters such as temperature, humidity, oxygen level and water level, actuators such as heaters and fans response to change. As such baby's temperature and heart rate sensor data, using infrared lights and buzzers as motivators and facilitate web-based remote monitoring GUI. Expand the scope even further, combined air temperature, humidity and skin temperature sensors, along with motor drive, suction and motor alarm. In this integrated system, LCD and RTC module for extended op-eration. In particular, systems based on microcontrollers have

been introduced environmental temperature, humidity, body temperature, heart rate and video images monitoring ability. By combining a Biometric fingerprint reader for configuration log tracking, this system has shown a multifaceted example approach to child supervision. communication Data storage in GSM module and web server, along with web and android active for monitoring shows the availability of the system and user friendly. Actors include fans, Heaters and nebulizers are made worse sensitivity to changes in the baby parameters. It is developed in a similar way The previous job is to connect the cooling fan additional drivers and functions This is determined by an iterative approach IoT-based continuous improvement and adaptation baby monitoring system to address growth health care needs.

II. Literature Survey

Monitor children's health including tracking oxygen levels and breathing technique. Traditional control methods often lacks the ability to provide real-time updates This parameter requires a constant parent control By balancing work with several parents can have responsibilities outside the home Con-sistent personal care is difficult their baby. Hence the modern usage technology is needed to monitor the baby Get adequate and timely health status notifications all problems. Define normal limits allows for different ranges of parameters the normal state of the unfavorable situation. When a parameter exceeds the specified limit, parent immediately announced as necessary This approach movement ensures that the baby wins attention and care even in his absence the permanent presence of parents.

A serious condition characterized by sleep apnea stop breathing when sleeping, a significant risk, especially for peo-ple of all ages baby Insomnia can occur suddenly in children potentially fatal infant death syndrome (SIDS) situation There is an important problem to address need a control system that can detect and address sleep apnea and SIDS in real time. Developing smart cribs for babies control aims to reduce this risk through action pulse rate sensor as the primary heart rate monitor to assess respiration. Once symptoms are detected potential apnea, the system generates an alarm to tell you maintainers and enable electromechanical vibration stimulate the baby's breathing. A typical one breathing continues, stim-ulation ceases.

Additionally, the system includes a PIR sensor monitor the movement of the baby, humidity sensor to confirm urine, and temperature/humidity sensor monitor the environment.

The neonatal incubator is an important device that provides Thermal support is required for demanding newborns Special care Usually, the incubator manages the oxygenation level, the baby maintains relative humidity in the air breathes and continues to monitor our child's body temperature and heart rate. Vote on this project sensors and alarms are added to improve security size. The sound sensor detects when the baby is crying trigger an alarm to notify the nurse in an emergency emergency situation. In addition, the alarm can alert the nurse feed the baby as needed. Through the Internet thing (IoT), recorded data sent to a doctor or nurse that allows them to work proactively Actions to keep the environment safe ensuring the safety of the incubator and newborn. Applying this method will lead to more monitoring system and effective security for newborns In the incubator, it increases public anxiety.

Paper promotes development useful child control system Non-invasive sensors for all kinds of monitoring physiological function. This system is not evaluation of breath, movement, voice, posture, ambient temperature and humidity. On top of that These sensors process the data collected by the system can trigger adverse events such as apnea, seizures or adverse envi-ronmental conditions. In addition, there may be a significant respiratory condition It is determined by analyzing breath and blood data oxygen saturation (SpO2) using a machine study models such as neural networks. In addition, the proposed system allows tutors to work remotely Monitor patient status wirelessly communicate with a remote computer or cell phone for availability and charging timely intervention.

This paper introduces the implementation of a cloud-based system designed for real-time remote control Physiological control of singletons working ventricle. This baby is staged surgery to create channels for deoxygenated blood; but face the danger of gradual death from oxygen desaturation. The proposed system includes: 1) a A mobile application is con-nected to the Bluetooth sensor monitor heart rate and blood oxygen saturation degree, 2) a cloud-based server that stores the data sent from the smartphone, 3) the web interface that offers data collected for clinical analysis and 4) warning gen-erator that sends text messages in emergency situations. The paper presents the concept of systems operation, commercial implementation external sensors and popular cloud servers and performance test results

Paper offers remote weight monitoring system designed for premature baby incubators. The The system consists of load cell sensors, active filters, and Arduino Uno R3 integrated microcontroller With SIM900 GSM module. This allows in-stallation transfer heavy information to medical professionals. System Operation a animate the baby doll to simulate the movement of the child inside incubator. Test results show that regardless of the movement of the measured object. the measurement results were stable. In addition, the system has successfully transferred measured data mobile phone through SMS.

In the hospital, the nurse monitors the health in the nursery newborn babies, but it is unlikely that they will then, leaving the baby vulnerable less Traditional wireless surveillance systems dangerous due to radiation exposure. To solve this problem, We offer an automatic Li-Fi wireless base A system to monitor older children. This is the system using wearable sensors for continuous monitoring critical infant health param-eters. that Abnormalities are reported immediately. to ensure timely intervention even in absence mentor Li-Fi technology offers a safer alternative to standard wireless methods to reduce radiation is a risk for the baby. By combining advanced control opportunities and security-conscious technology, we The system aims to improve the care and safety of children hospital environment.

Sudden Infant Death Syndrome (SIDS) a is the main cause

of infant death. To solve this problem, we propose to develop an analytical model using Baby's heartbeat, tremors, and prone body A position to reduce the incidence of SIDS. This is it suitable system for nursery home or hospital; SpO2, vibrate and heart rate combined with the global network for mobile networks Communication Application (GSM). Heart attack baby's heart rate monitor sensor, SpO2 Sensors detect abnormal sleep conditions that may occur cause breathing problems and SIDS. Additionally, the vibration sensor senses abnormal vibrations indicative of panic conditions during sleep. Using data from these sensors, an analytical model is constructed to detect potential SIDS causes. Linear regression analyses between heart rate and SpO2, as well as heart rate and vibration, inform the model. Based on predictive values, alarm signals are transmitted to concerned parties such as parents, medical advisors, or ambulatory services. A prototype implementing this analytical model will incorporate a heart rate sensor, SpO2 sensor, vibration sensor, ARM processor, and GSM for wireless communication.

Oral-feeding disorders are common among preterm infants, impacting growth and neurodevelopment. Coordination of sucking, swallowing, and breathing is crucial to avoid compli-cations such as choking, aspiration, or apnea. However, current evaluation methods for preterm infants are subjective and lack real-time monitoring of feeding coordination. To address this, we propose a wireless oral-feeding monitoring system. It quantitatively measures sucking pressure, swallowing activity using a microphone, and diaphragmatic breathing movement via surface electromyogram. Additionally, we introduce a detection algorithm to evaluate suckingswallowingbreathing events. Clinical validation confirms the accuracy and utility of the system, highlighting its potential in assessing oral feeding parameters in both term and preterm infants.

In this paper, we present the development of a compact infant monitoring system that incorporates non-contact physical and environmental sensors. Our proposed system utilizes ultra-wideband radar to detect infant breath, while simultaneously monitoring surrounding parameters with environmental sensors to detect abnormalities. Additionally, to prevent mechanical accidents, the system includes tri-axial vibration sensing for both the infant and cot. Realtime visual monitoring is provided to users, and numerical sensing data is recorded and transmitted to a server database. This allows parents and family members to access and monitor the data directly using a mobile phone or computer through a network connection. Qualitative evaluation of the system application demonstrates its promise as a portable and compact infant monitoring tool.

III. Methodology

A. Histogram Equalization

3. System Design A. IoT based child monitoring system An IoT-based child monitoring system has been developed ensure comprehensive control beforehand Babies in Neonatal Intensive Care Units (NICUs) by combining hardware and software components. The core of the system is the ESP32 The microcontroller platform was chosen for its availability, Low power consumption and built-in Wi-Fi opportunity. It serves as the center of the microcontroller The processing unit for the system is seamless communication between hardware and software modules is different. Sensor integration plays an important role role in system design with sensors for monitoring vital signs such as body temperature, environment temperature, humidity and gas levels carefully selected and combined. This sensor provides real-time information about the child's physiological parameters environmental conditions that enable health professionals to monitor the child's well-being racket.

On the software side, custom algorithms are developed to collect, transmit, and analyse the sensor data. These algorithms ensure the accuracy and reliability of the measurements while also enabling secure transmission of data over Wi-Fi to a centralized server or cloud platform. Once the data is received, it is processed and analyzed to detect any abnormalities or deviations from normal ranges. In the event of such anomalies, the system triggers alerts or notifications, allowing for timely intervention by healthcare professionals.

B. Working of Infant Monitoring System

A user-friendly interface is designed to provide healthcare professionals with easy access to real-time data, configuration options for monitoring parameters, and historical records for each infant under care. This interface enhances usability and facilitates informed decision-making, ultimately improving the quality of care provided in NICU settings.

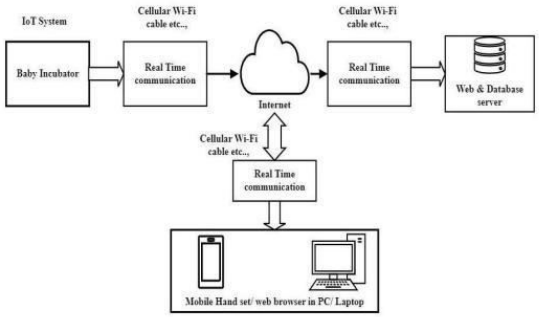

Fig. 1. working of infant monitoring system

The block diagram provided illustrates an Internet of Things (IoT) system designed for a baby incubator. Let's break down the different modules:

Baby Incubator: This serves as the central component of the system, housing the infant. It likely incorporates sensors to monitor vital signs such as temperature, heart rate, and respiration. Additionally, it may include controls for regulating temperature and humidity within the incubator.

Real-Time Communication: This module encompasses the method through which the incubator transmits data. It could utilize cellular, Wi-Fi, or cable connections, enabling the incubator to send data to the web server.

Web Database Server: This server is responsible for storing the data transmitted from the incubator. It may also facilitate access for healthcare professionals to view the data remotely. Access could be via a web browser on a PC or laptop, or through a mobile app on a smartphone or tablet.

Mobile Handset Web Browser: These tools represent the means by which healthcare professionals can remotely monitor the baby's health. A web browser on a PC or laptop offers a po-tentially more detailed view of the data, while a mobile handset provides quick updates on the baby's status. In conclusion, this IoT system enables remote monitoring of a baby in an incubator, enhancing the quality of care by allowing healthcare professionals to track vital signs and intervene promptly if necessary.

C. DHT11 Sensor:

The DHT11 sensor is dedicated to measuring temperature and humidity levels. It interfaces with the ESP32 micro-controller to transmit the gathered data, providing essential environmental insights.

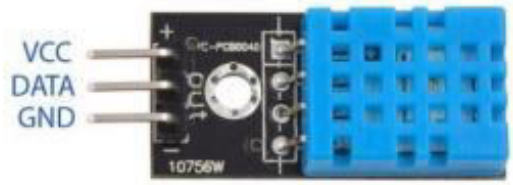

Fig. 2. DHT-11 Sensor

D. ESP32 Microcontroller:

As the system's central processing unit, the ESP32 micro-controller receives inputs from both the DHT11 sensor and the heart rate sensor. It undertakes data processing tasks and subsequently transmits the processed information to both the LCD display and the built-in Wi-Fi module.

Fig. 3. ESP32 Microcontroller

LCD with I2C Module: The LCD display, coupled with the I2C communication protocol, showcases vital data such as heart rate, temperature, and humidity readings, received from the ESP32 microcontroller.

ESP32 Wi-Fi Module (built-in): Integrated within the ESP32 microcontroller, this module wirelessly transmits data gathered from the DHT11 sensor and heart rate sensor to a mobile phone.

Mobile Phone: Receiving data wirelessly from the ESP32 Wi-Fi module, the mobile phone likely employs an app to display this information in a userfriendly format. Overall, the system continuously monitors temperature, humidity, and heart

Fig. 4. ESP32 Wi-Fi Module

rate, with the ESP32 microcontroller processing and wirelessly transmitting this data to a mobile phone app for convenient viewing.

Gas Sensor: Gas sensors are devices that help us understand the amount of gas in the environment and the natural state of its movement. Gas sensors reveal the amount of gas in the environment and the nature of the gas composition with electrical signals and can provide its change. The ability of a Gas sensor to detect gases depends on the chemiresister to conduct current. The most commonly used chemiresister is Tin Dioxide (SnO2) which is an ntype semiconductor that has free electrons (also called as donor). Normally the atmosphere will contain more oxygen than combustible gases. The oxygen particles attract the free electrons present in SnO2 which pushes them to the surface of the SnO2. Flowchart for Infant

Fig. 5. Gas Sensor

Monitoring System

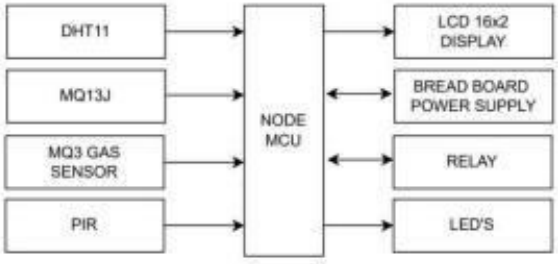

Fig. 6. Data processing sequence for an IoT-based infant incubator monitoring system

IV. Results and Discussion

The implementation of the IoT-based infant monitoring system using the ESP32 microcontroller yielded promising results, demonstrating its efficacy in monitoring infant well-being and environmental conditions. The system successfully collected data from the various sensors, including the body temperature sensor for infant health assessment and ambient temperature, humidity, and gas sensors for environmental mon-itoring. The collected data was transmitted in real-time to a centralized platform via the integrated Wi-Fi module, enabling remote monitoring and analysis. Through comparative analy-sis with data from established measuring tools, the system demonstrated accuracy and reliability in its measurements. The correlation between the data acquired from the IoT-based system and that from traditional measuring tools validated its effectiveness in infant monitoring.

One of the key advantages of the IoT-based monitoring system is its affordability and accessibility. By leveraging widely available components and IoT technology, the system offers a cost-effective solution without compromising on per-formance. This makes it suitable for deployment in healthcare facilities as well as in home settings, providing caregivers with valuable insights into infant well-being. Furthermore, the comprehensive monitoring capabilities of the system enable caregivers to monitor both infant health parameters and envi-ronmental conditions simultaneously. This holistic approach to monitoring enhances the safety and comfort of infants, reducing the risk of adverse health events.

However, it is important to acknowledge certain limitations and areas for improvement. While the system demonstrated accuracy in its measurements, further calibration and val-idation may be required to ensure consistent performance across different environments and scenarios. Additionally, the integration of additional sensors or features, such as motion detection or sound monitoring, could enhance the system's capabilities and utility.

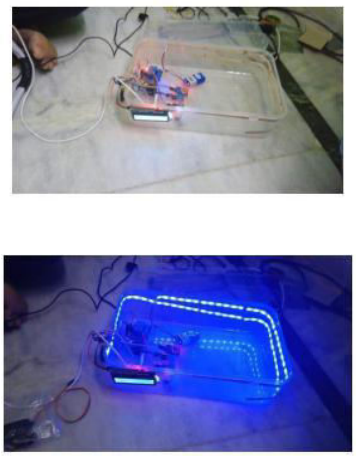

Fig. 7. Implementation of infant incubation Monitoring system

V. Conclusion and Future scope

In conclusion, the introduction of an affordable and efficient IoT-based solution for monitoring the wellbeing of infants marks a significant advancement in infant care technology. By leveraging the capabilities of the ESP32 microcontroller and a suite of sensors, the system ensures comprehensive monitoring of both infant health parameters and environmental conditions. The seamless integration of the inbuilt Wi-Fi module enables real-time data communication and remote monitoring, enhancing accessibility for caregivers. Moreover, the system's ability to collect, analyse, and visualize data fa-cilitates informed decision-making and timely interventions to ensure the health and safety of infants. With its cost-effective design and compatibility with established measuring tools, the proposed solution has the potential for widespread adoption in healthcare facilities and homes, empowering caregivers with the tools they need to provide optimal care. Overall, this project represents a significant step forward in bridging the gap between affordability and effectiveness in infant monitoring solutions, ultimately contributing to improved outcomes for infants worldwide.

Future work in this area could focus on further enhancing the capabilities and usability of the IoTbased infant monitoring system. One avenue for improvement is the integration of machine learning algorithms to enable predictive analytics, allowing the system to anticipate and proactively respond to potential health issues before they escalate. Additionally, research could be conducted to explore the feasibility of incorporating additional sensors for monitoring other vital parameters, such as oxygen saturation or respiratory rate, to provide a more comprehensive picture of infant health.

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