Smart Incubator Using IoT

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Abstract— **A worldwide Smart Incubator has been developed to create a womb-like environment for preterm babies, improving their chances of survival. The incubator allows remote access to the infant's medical data through mobile devices or computers, enabling continuous monitoring of health parameters for timely interventions. Utilizing Raspberry PI and various sensors, including temperature, humidity, and blood oxygen, the incubator maintains a temperature of 36.5-37.2°C to mimic the mother's womb. With automated and manual temperature control options, the technology ensures accurate data presentation for effective healthcare assessment and complication prevention**.

***Index Terms*—IOT, Incubator, Sensors, Low cost, Raspberry Pi.**

1. Introduction

Incubators are vital devices for monitoring and maintaining optimal conditions for newborn babies, particularly for premature or ill infants. Advanced technology in smart incubators now includes sensors and data transfer capabilities, allowing for real-time monitoring and storage of crucial medical data [1]. This data can be accessed remotely by medical professionals, enabling timely intervention and improved care for infants. Alarm signals can be triggered if any issues are detected, alerting healthcare providers for immediate action. These modern incubators enhance monitoring and ensure the well-being of newborn babies by facilitating quick response and minimizing risks.

The Internet of Things (IoT) is transforming monitoring systems for babies by enabling data exchange and automation. Utilizing components like wireless detectors, software, and cyber systems, IoT allows for continuous tracking of a baby's health and environment. Sensors such as temperature, wetness, and heart rate are interconnected with internet-capable objects to provide real-time alerts to parents. This technology not only enhances safety and well-being but also aids in environmental monitoring. A monitoring system combining Raspberry Pi and sensors like cameras and heart rate monitors ensures optimal care and security for babies.

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Our primary goal is to develop a system for premature babies that offers an optimal and supportive environment, ensuring their survival, while being cost-effective and low-maintenance. This innovative system will not only assist in monitoring vital parameters such as body temperature, humidity, and heartbeat but also serve as a solution for busy parents who may not always be able to be physically present with their child. Moreover, considering the widespread usage of Android phones, our system will enable the transmission of real-time data on temperature, humidity, and heart rate to one or multiple designated Android devices, spanning over a considerable range.

2. Existing System and Proposed Work

A. Existing System

Current baby incubators are essential pieces of equipment in hospitals, providing a controlled and safe environment for premature or ill newborns [2]. These devices mimic the warmth, humidity, and protection of a mother's womb, helping to regulate the baby's body temperature, protect them from infections, and allow medical professionals to provide necessary care without disrupting the baby. Equipped with features such as temperature and humidity control, access points for medical care, and monitoring capabilities, current baby incubators are crucial in improving outcomes for premature babies, ensuring their survival and healthy development. Regular monitoring and adjustments are necessary to meet the baby's changing needs, making these devices vital in neonatal care and providing vulnerable newborns with the best chance for a healthy start in life.

Fig.1. Existing system of incubator

B. Proposed System

A baby incubator is a medical device designed to provide a controlled environment for premature or ill infants in order to ensure their optimal growth and development. These devices regulate temperature, humidity, and oxygen levels to create an ideal setting for the baby's well-being.

A smart baby incubator is a more advanced version of the traditional incubator that utilizes Internet of Things (IoT) technology to monitor and control the environment inside the incubator [3]. This technology allows healthcare providers to remotely monitor the baby's vital signs, such as temperature, heart rate, and oxygen levels, in real-time. Additionally, smart baby incubators can be programmed to automatically adjust settings based on the infant's needs, making them more efficient and precise in providing the necessary care. IoT-enabled baby incubators also offer features such as alarms and alerts that notify healthcare providers of any deviations from normal parameters, ensuring immediate action can be taken. This technology not only facilitates better care for premature infants but also improves communication between medical staff and parents, providing peace of mind and reassurance during a stressful time. Overall, smart baby incubators using IoT technology represent a significant advancement in neonatal care, offering a more personalized and efficient approach to supporting the health and development of premature infants.

The block diagram of the proposed system is shown in figure 2 for implementing it with the help of Raspberry Pi controller. The central control unit of the incubator system is the Raspberry Pi, which serves as a crucial component in maintaining the incubator's environment. It is responsible for managing various sensors, including temperature, humidity, wetness, and heart rate sensors, which continuously monitor the conditions within the incubator. The data collected by these sensors is processed in real-time by the Raspberry Pi to make necessary adjustments to the settings of the incubator, such as regulating the heater and fan based on temperature and humidity readings. The system is further enhanced by additional sensors like the wet sensor for moisture detection, a camera for monitoring baby movements, and a heartbeat sensor. These sensors improve the system's capabilities and provide comprehensive oversight through an Android mobile application, allowing users to store data and monitor the baby's health. The Raspberry Pi can issue notifications and alerts to parents or medical personnel, while also collecting valuable data for detailed analysis, ensuring the optimal incubation environment and well-being of the baby.

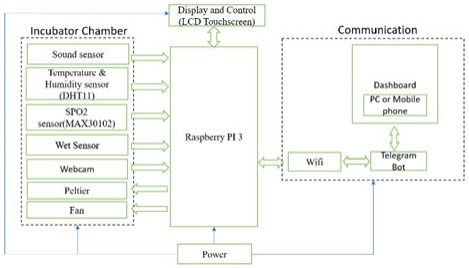

Fig.2. Block diagram of smart incubator

3. Software Requirements

For implement the proposed system the following software's are required:

- Raspberry Pi
- Telegram Bot
- Internet of Things

A. Raspberry Pi

The Raspberry Pi 3 Model B can serve as the central component in designing a smart incubator for various purposes, such as egg hatching or controlled environmental experiments. Leveraging temperature sensors, humidity sensors, and the GPIO pins on the Raspberry Pi, you can regulate the internal temperature and humidity levels, ensuring ideal conditions for incubation. The Raspberry Pi can also log crucial data, which can be stored locally or sent to the cloud for remote monitoring and analysis. Create a user-friendly interface, whether through a web application or a mobile app, for real-time monitoring and control, complete with alerts and notifications in case of deviations from the desired environmental parameters. Robust power management, including battery backup or UPS systems, is essential for continuous operation, and security measures should be implemented to safeguard the Raspberry Pi and the smart incubator from unauthorized access. This comprehensive setup enables precise environmental control, improving incubation success rates for a wide range of applications.

B. Telegram Bot

The integration of a Telegram bot within a smart baby incubator powered by IoT heralds a new era of infant care. This innovative technology enables seamless communication between caregivers and the incubator system, providing real-time updates and vital information. Parents can receive instant notifications about their baby's condition, including temperature, humidity levels, and heart rate, ensuring peace of mind even from a distance. Additionally, the Telegram bot allows for remote control of incubator settings, such as adjusting temperature or activating alarms in case of emergencies. This synergy of IoT and Telegram not only enhances the efficiency of neonatal care but also fosters a stronger bond between parents and their newborn, empowering them with constant oversight and control.

C. Internet Of Things

The Internet of Things (IoT) refers to the network of interconnected devices, appliances, and sensors that can communicate with each other and exchange data over the internet. This network enables everyday objects to collect, analyze, and share information in real-time, leading to increased efficiency, productivity, and convenience in various aspects of our lives. IoT devices can be found in homes, offices, industrial settings, and even in our cars. By harnessing the power of IoT technology, businesses can improve their operations, consumers can enhance their daily activities, and cities can become smarter and more sustainable. However, with this increased connectivity comes concerns about privacy,

security, and the potential for data breaches. It is crucial for individuals and organizations to implement strong security measures to protect their IoT devices and the sensitive information they collect.

4. Simulation Of Proposed System

A. Introduction

The simulation on Proteus demonstrates the capabilities of a smart incubator by showcasing its integration with various sensors like temperature, humidity, blood oxygen level, and wet sensors. These sensors enable continuous monitoring and analysis of vital parameters essential for maintaining an optimal environment for incubation. By incorporating these sensors into the smart incubator system, it ensures that the environment inside the incubator is constantly optimized for incubation purposes. This simulation highlights how the smart incubator effectively utilizes and interacts with multiple sensors to create the best possible conditions for successful incubation.

B. Simulation Of Smart Incubator

In the simulation, the smart incubator is created using Proteus. A Raspberry Pi serves as the central control unit, with PYTHON programming enabling real-time control and monitoring of various parameters, including temperature and heartbeat. An Arduino board simulates temperature and heartbeat sensors, sending data to the Raspberry Pi. which responds by regulating the incubator's temperature and monitoring vital signs. Safety features like alarms for temperature fluctuations and heartbeat irregularities are integrated, and a user interface allows healthcare professionals to interact with the system. Data logging and remote monitoring capabilities enhance the system's functionality, while redundancy and backup systems ensure newborns' safety in case of failures, creating a comprehensive and safe incubation environment.

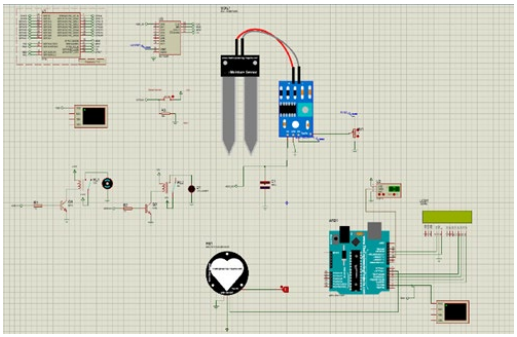

Fig.3. Simulation diagram of Proposed System

C. Simulation Results

In our research, we extensively tested various sensors such as wet and heartbeat sensors through simulations. The results of these simulations were incredibly successful, providing us with detailed and precise information on the performance and data generated by these sensors. The insights gained from this data will be instrumental in enhancing the development of advanced applications and technologies that depend on accurate sensor readings. This research will contribute to furthering our knowledge of these sensor types and their possible uses in incubators, ultimately leading to improved monitoring and care of patients in medical settings.

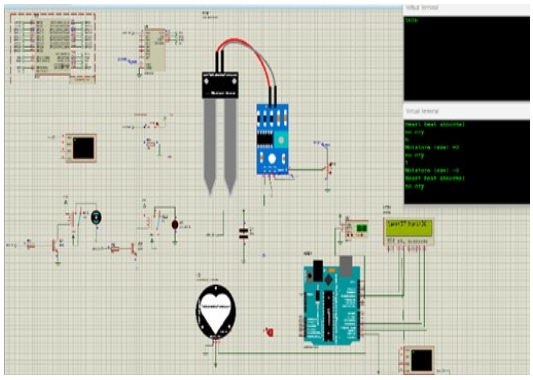

Fig.4. Simulation Results

D. Serial Monitor Output

Three simulated sensors are used to monitor moisture levels, heart rate, and body temperature. A reference value of 500 is set. A reading above 500 from the wet sensor indicates high moisture levels, while a reading below 500 suggests low moisture levels. The heart beat sensor differentiates between normal (0) and abnormal (1) heart rates, while the temperature sensor indicates normal ('a') or abnormal ('b') body temperatures. These sensors aid in early detection of abnormal conditions and facilitate appropriate actions to maintain optimal health and well-being.

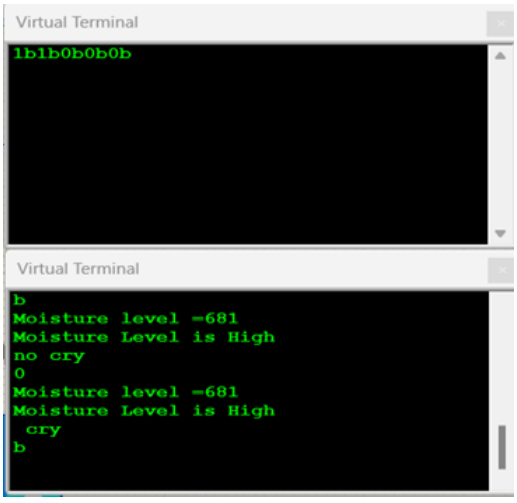

Fig.5. Serial monitor output

5. Hardware

The simulation results have been verified. The suitable components for the hardware implementation such as Raspberry pi controller have been developed and the results have been monitored using telegram and the system was thoroughly tested.

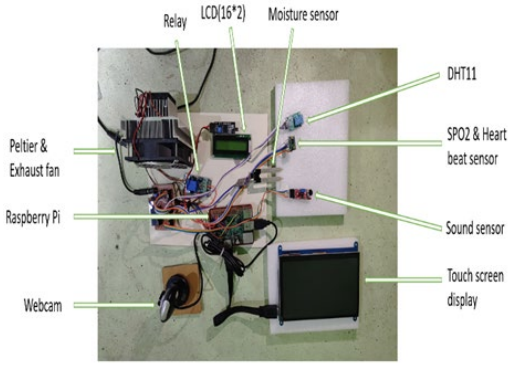

Fig.6. Hardware basic circuit

The basic circuit of the hardware is designed, construction is done and connections are given from the Raspberry pi microcontroller to the entire components and their working are tested and verified.

The mechanical structure consists of a cardboard box where circuit is placed. A glass structure is made in order to place the baby. The glass structure has holes on every side to change the position of the baby.

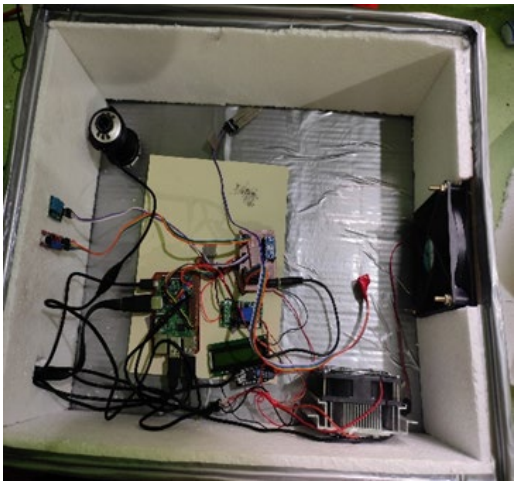

Fig.7.Overall test setup

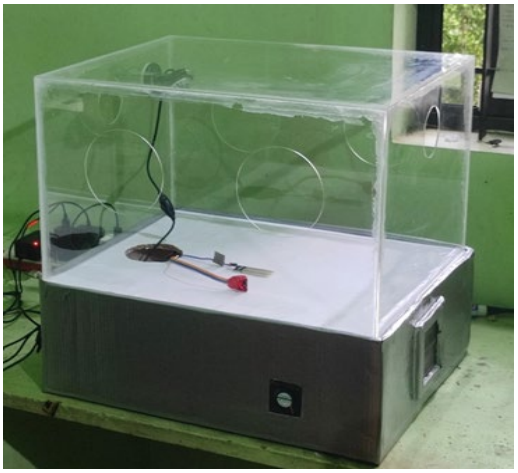

Fig.8. Mechanical structure

The smart incubator system shown in the picture is composed of different sensors. The different sensors used are temperature and moisture sensor, heart beat and SPO2 sensor, sound sensor and humidity sensor. All the sensors are connected to Raspberry pi which is the main controller. A webcam is used to cover the baby's movement. A peltier module and exhaust fan is there to maintain the temperature inside the incubator. LCD display is used to monitor the different readings from the detector. The LCD display is placed on the side of the incubator.

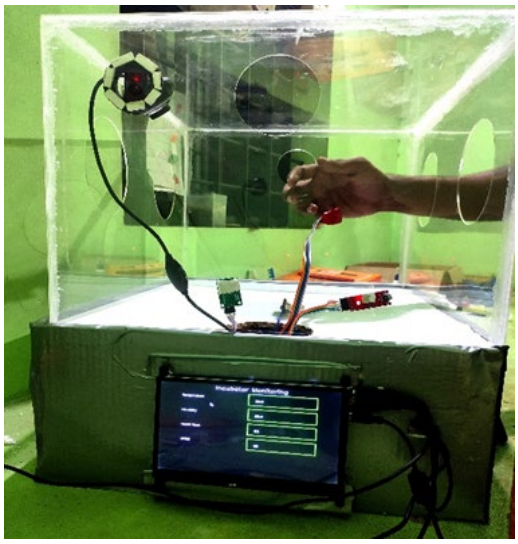

Fig.9. Image depicting the positioning of the LCD Touchscreen

Fig.10. Figure depicting the positioning of the exhaust

6. Results And Discussion

The results obtained from various sensors are displayed in the figure and monitored through a Telegram bot. Any abnormalities in the readings trigger notifications through the bot to alert users of potential issues. This system ensures that prompt action can be taken in response to deviations from expected sensor data.

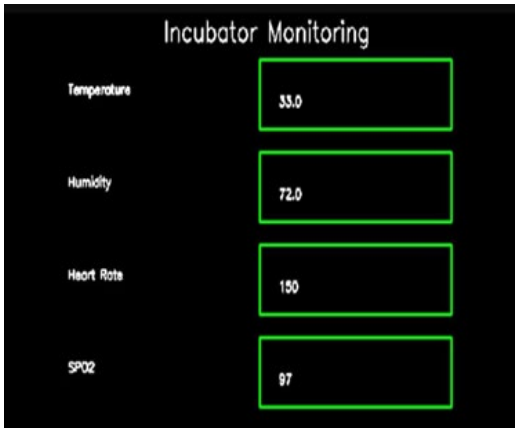

Fig.11. User Interface

The User Interface of the Smart Incubator is created using open cv, which is a library of programming functions. The results of the different sensors are shown in the user interface.

Fig.12. Alert messages

In the representation of the output, it is visually evident that the temperature reading falls below the desired threshold, indicating a low temperature condition. Concurrently, the depiction also illustrates an elevated heartbeat rate, signifying a potential concern regarding the infant's health status. These critical observations are succinctly encapsulated within an alert message transmitted through the Telegram platform, ensuring timely notification and proactive intervention in the incubator system's monitoring process.

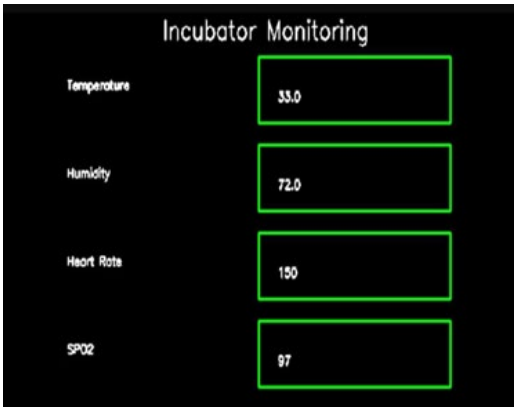

Fig.13. User Interface

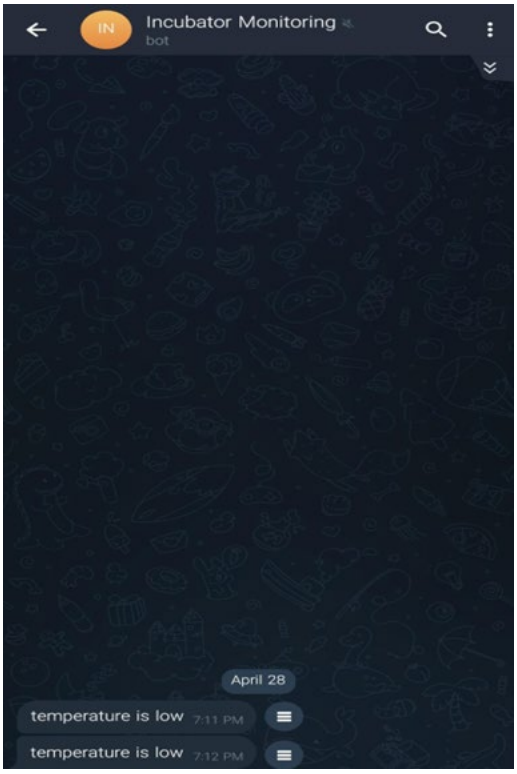

Fig.14. Alert messages

In figure 14, it is shown that the temperature is low. This information is conveyed in the Telegram as an alert message. Since the heartbeat is normal, no alert message is sent.

7. Conclusion

The smart incubator is an innovative device that continuously monitors newborn babies and sends their medical data directly to cloud storage for analysis. This data can be accessed from mobile phones and computers, allowing caregivers to take necessary actions based on the information. By monitoring health parameters like heart rate, temperature, and humidity, this system can quickly detect any changes in the baby's health. Temperature monitoring is crucial for identifying internal diseases, while humidity measurements help with hydration and respiratory issues. Continuous monitoring of the baby's

heartbeat is essential for detecting cardiovascular disorders. Future plans include implementing ECG monitoring, controlling oxygen supply, and adding solar cells for power efficiency. In hospitals, this system could monitor all pathological parameters in infants, revolutionizing neonatal care.

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