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Automatic Multisource Data Collection System for Preterm Infants in NICU

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Abstract
Preterm infants born before 37 weeks of pregnancy require continuous monitoring of vital parameters to ensure their well-being. The preterm babies are kept in the Neonatal Intensive Care Units for their constant monitoring. This system includes various sensors interfaced with an Arduino UNO board to provide nonstop monitoring for its major physiological parameters. The blood pressure is tracked by the pressure sensor, the body temperature is monitored by the thermistor, the breath by the sound sensor, and the movements of preterm infants are recorded by the accelerometer. They communicate with the Arduino from different sensor readings through a real-time LCD display such that the readings are monitored. The ESP32-CAM module provides video output for remote monitoring of premature infants, thereby increasing the amount of supervision from clinicians. There is also a USB-to-UART serial converter for feeding data into the AI machine-learning model on the system. The AI model performs analysis on the data collected by comparing with the previous data to observe the abnormality or distress condition for the preterm kids. Thus upon detection of critical situation, the system raises an email alert to the medical team to intervene as early as possible. This monitoring system increases the efficiency of the care given in the NICU by automating real-time data collection and analysis, as well as alerting cared clinicians. By fusing sensor technology with AI-embedded decision systems, it is a leading and dependable technology for enhanced neonatal healthcare outcomes while ameliorating the risks of premature complications.
Keywords: *Preterm Infants, Real Time Monitoring, USB to UART Converter, Machine Learning.*

1. Introduction
In today's world more than 15 million preterm babies born before the completion of 37-weeks gestation every year in the world. This is 10% of 150 million births in the world every year. These preterm babies need critical care to survive during the first 27 days of life and have a very high mortality rate. India has the highest rate of birth of preterm infants with 23% of total preterm births. Preterm infants born before 37 weeks of gestation face critical health challenges due to under developed organs. Doctors provide specialized medical care within NICUs for the infant's survival. Specialized nurses and other personnel at NICUs offer advanced monitoring, respiratory support, and nutrition, all to make sure these fragile newborns get the proper care needed to go beyond most complications and develop normally. The fragile health of preterm infants in the NICU requires constant monitoring and invasive methods for monitoring. Traditional monitoring methods often involve manual data collection; hence they require excessive time, entail greater scope for errors, and might delay response in critical situations. The automatic multisource data collection system by IoT can transform neonatal care by integrating multiple sensors to analyze important parameters like heart rate, blood pressure, temperature, and movement, in real time. This system can hence use IoT-enabled sensors to continuously collect and transmit data to a central monitoring unit, enabling the healthcare provider to quickly assess if abnormal readings arise to make timely and correct decisions. Manual alerts are generated in case of abnormal readings, which ensures the rapid involvement of authorities. Using machine learning enhances the automatic diagnosis of normal and abnormal health condition based on the heart rate, temperature, blood pressure and

movement of the infants. Multisource data collection allows a more extensive study with respect to the infant and thus helps greatly in diagnosis as well as treatment. Such a system may help in flattening the workload on the medical staff; improve correctness; and allow for undeterred kind thinking while considering interventions in very high-risk situations. The introduction of IoT within the confines of the NICU does not only improve the odds of survival for the fledgling infants that are treated, but the general care of a newborn is also improved through this, as real-time, data-driven insights help make better medical decisions.

2. Literature Survey

[1] Neonates Recording Platform (NRP), a hardware-software tool to be deployed at the bedside in a real NICU environment. The NRP enables data from various sources to be collected, labeled, processed and stored. In NRP, the collected data is organized hierarchically in a portable format and is automatically cleaned and validated thereby ensuring its usability for healthcare professionals and data scientists. Additionally, NRP enables medical staff to configure trials and add customized text or tagging events. [2] Neo is capable of acquiring vital data in real time by integrating with diverse devices connected to newborns in neonatal intensive care units (NICUs). Neo is built on an affordable Internet of Things platform that aggregates and sends the real-time data to a cloud-based big data platform called integrated NICU. Neo automates immediate vital sign status and past trends as graphs or charts that the doctor and nurses can view from anywhere through the Internet. Physiological signal and clinical parameters from Neo is used to score different diseases like sepsis, respiratory distress syndrome, necrotizing enterocolitis, and retinopathy of prematurity. [3] The system employs IoT technology to wirelessly collect the data from the sensors and relay the information to doctors or nurses. The doctors can use a mobile application or a web-based dashboard to monitor the status of all the babies in the NICU. [4] The monitoring system is controlled through the use of a Raspberry Pi attached to a visual camera and a thermal IR camera with temperature sensor MLX90640, which was able to measure the body temperature remotely [5-8]. The software of this smart infant incubator was used to improve monitoring system, which involves image processing techniques. The results of measured ambient temperature were found to be accurate and reliable.

3. Existing System

The primary purpose of the system is to monitor the various health conditions of the infant, while it simultaneously provides caregivers with real-time data via an LCD display. The sensors will be used to monitor four essential physiological parameters: In the case of the pulse oximeter, SpO2 and pulse rate of the infant are measred. This information is sent to the microcontroller for processing. This thermistor is that type of sensor used to measure the body temperature of the infant. Pressure sensor is used for the measurement of blood pressure of the infant. Motion sensor for detection of movements or activity levels of the patient. Detecting patient movement and activity levels is very useful from lying still to moving or desperation. Each of the above sensors continuously sends real-time data to the 8051 Microcontroller, which processes the data and obtains information as to whether the condition of the infant is stable, shown in Figure 1.

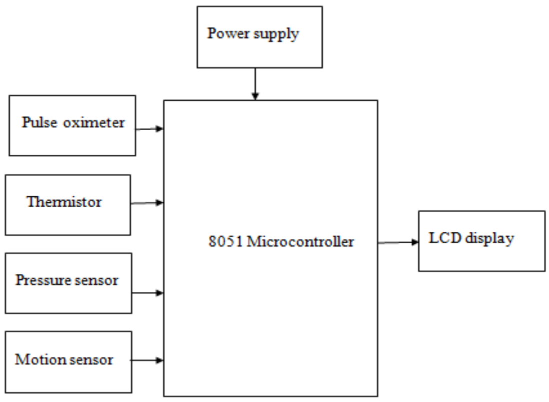

Figure 1 Existing Block Diagram of The System

The LCD display is responsible for showing the following real-time health parameters like Heart rate (bpm), Oxygen saturation (SpO2%), Body temperature (°C or °F), Pressure readings and Movement status. With these, doctors, nurses, or caregivers can check the conditions of a infants at a glance. Thus, the 8051-based infant monitoring

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system can ultimately bring the dependable continuous monitoring of a infant's vital signs with the joined effort of a pulse oximeter, thermistor, pressure sensor, and motion sensor to provide real-time health updates. The 8051 Microcontroller system will process the dada and show it in the LCD screen so that caregivers will be given intimation to important health metrics at once. Hence, the system is helpful for hospitals such care monitoring and remote healthcare applications [9-13].

4. Proposed System

Various biomedical sensors are included in the system to measure the vital parameters of preterm infants. The blood pressure sensor monitors the blood pressure levels of the infant so that these levels remain within safe bounds. Any fluctuations in blood pressure may symbolize stress or medical conditions underneath that need to be reached on with urgency. The thermistor is a temperature sensor: Preterm babies suffer highly from temperature variations since their bodies have not been sufficiently developed to take care of heat and so they keep monitoring the body temperature of the infant. Any deviation from normalcy is detected and the caregiver is alerted immediately. The sound sensor incorporated with the respiratory mask to detect the breathing rate based on the sound produced by the infant during breathing. The accelerometer is a motion sensor that is important for tracking movement among preterm infants. An accelerometer detects involuntary movements and extreme inactivity. Little movement may double as an indication for possible neurological issues or weakness, and sudden jerks may imply seizures. These sensors are all used to monitor the patient in real-time, thus feeding their data into the Arduino UNO for interpretation. The camera allows the ESP32 CAM module Monitor for infant's video footage. The module transmits real-time video to a display or towards a remote-only monitoring. The video output makes it possible for someone like a caregiver or doctor to visually view the patient's condition when necessary. The USB to UART converter developed in this work transfers data from the Arduino to a machine learning-based AI model, which takes that sensor data in and analyses it for anomalous patterns. It then triggers an alert if there is a detection of critical health issues. Once the AI model detects an abnormal condition, an alert is sent out via email to the concerned medical professionals or caregivers. This will ensure a timely intervention in case of any emergencies, thus improving patient safety. The LCD display connected to the Arduino, shall show sensor readings in real-time, allowing on-site caregivers to exactly and instantly check the infant's vitals without accessing any remote system. This patient monitoring system efficiently integrates multiple health monitoring sensors, video surveillance, and AI-based analysis to ensure comprehensive patient care. The Arduino UNO acts as the central controller, collecting data from various sensors, transmitting it for further processing, and displaying real-time information. The use of an ESP32 CAM module adds an additional layer of monitoring, while the AI model enables smart decision-making by sending email alerts during emergencies. This system can greatly help in hospitals, home care, and remote patient monitoring areas, shown in Figure 2 [14-16].

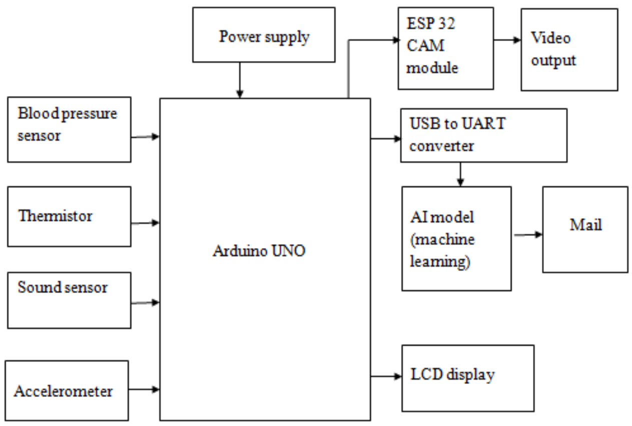

Figure 2 Proposed Block Diagram of The System

5. Result and Discussion

The proposed system for monitoring preterm infants in the NICU integrates multiple sensors, an Arduino UNO microcontroller, and machine learning-capable technologies to further enhance the health monitoring process. In view of providing early detection of any sudden and further worsening anomaly of an infant's health in the neonatal intensive care unit, this system does capture, process, and transmit blood pressure,

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temperature, respiratory levels, and movement. The blood pressure sensor performs real-time monitoring of the blood pressure of such a difficult-to-repair infant that simple machines used in the past wouldn't be able to keep track of. The thermistor, which accurately monitors both hypothermia and high fever, is also a key device. A sound sensor is utilized for detecting the sounds during the respiration. The accelerometer is incorporated to check for any kind of movements. It is essential to provide consistent mapping of the excessive movements of the provided infants that could signal their discomfort since they need regular monitoring, shown in Figure 3.

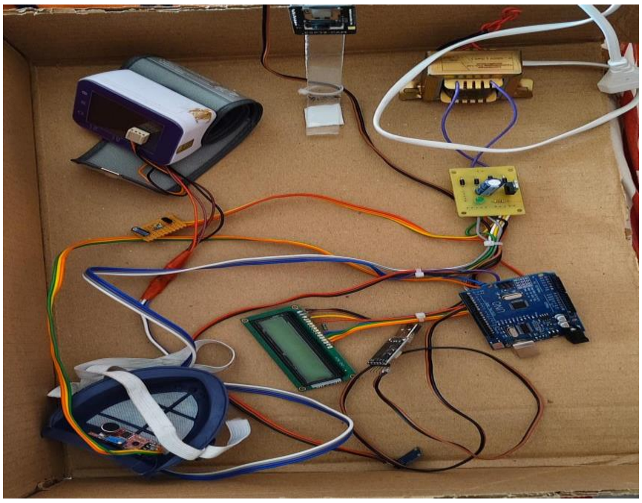

Figure 3 Hardware Implementation of The System

The core of the system is provided by the Arduino UNO, which offers the basic layer of processing, collecting real-time vital statistics from the various sensors of the system and controlling communication with the other interfaced modules. It captures live video footage of the infant using a camera module embedded on board the ESP32-CAM for visual monitoring purposes. The LCD provides real-time data visualization, enabling healthcare providers to glance at the infant's vital signs and determine any permeability. Sensor data is sent to the AI-based machine learning model through the USB-to-UART converter for intelligent analysis and identification of anomalies. If a critical condition occurs, the system will issue alerts automatically by way of an email message. The video output from the ESP32-CAM module augments monitoring, enabling caregivers to visually assess the condition of the infant remotely. Therefore, all things being equal, the system performs well, providing a valid and reliable real-time health monitoring solution for preterm babies in the NICUs. In brief, with IoT and AI technologies integrated, there are proper interventions before the complication rises painfully. The neonatal monitoring system for preterm infants in NICUs based on IoT includes multiple sensors, microcontrollers, and machine learning methods and, therefore, represents a larger paradigm of neonatal care. This will build enhanced traditional methods of monitoring, which will include real-time data acquisition, smart computations, and remote access, thus ensuring advanced neonatal care and an early warning system against potential health risks, shown in Figure 4.

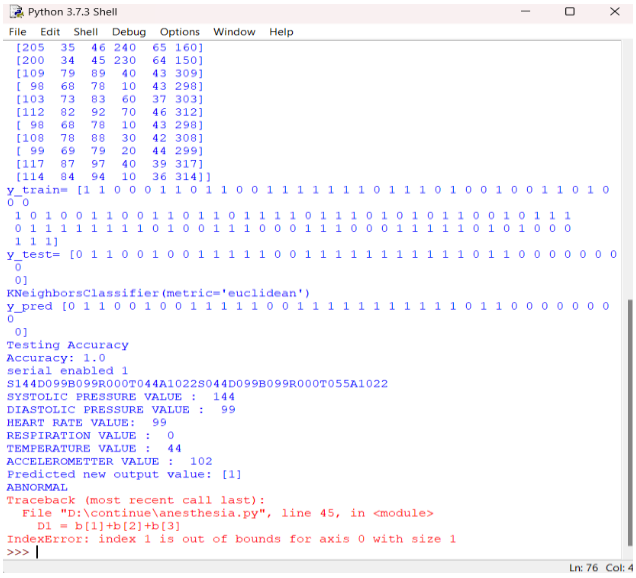

Figure 4 Result of The System

Some major stakeholders from the system include:

- **Live monitoring:** It helps one in continuous tracking of a neonate's vital signs, which ensures immediate detection of anomalies.
- **Automated alerts**: The AI-driven anomaly detection helps in reducing the response time for an immediate solution.
- **Remote monitoring options:** The ESP32-CAM module and email alerts allow

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caregivers to check the infant remotely and help them care for the infant.

- **Improved healthcare outcomes:** Earlier assistance from this system will prevent other complications that may arise with preterm infants. Summing up, it has vast benefits for NICUs to improve the care of such neonates. Further advancement could integrate cloud storage, expand machine learning capabilities, and improve wireless communications for greater reliability and accuracy.

6. Future Scope

- Advanced sensor integration: Adding ECG sensors for accurate heart activity monitoring.
- Improving the internet connectivity: Connection through 5G internet.
- Improving the accuracy of the system.
- Improved alert mechanism.

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