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Babysock to Monitor Newborns to Detect Risk for Neonatal Compromise

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Abstract- This paper proposes a non-invasive neonatal monitoring device for continuous assessment during the first 30–60 minutes postpartum. The wearable, sock-based system integrates an Arduino microcontroller with temperature and MAX30102 sensors to measure oxygen saturation, heart rate, and skin pH. It enables real-time, wireless monitoring for early detection of conditions such as hypoxia and acidosis, improving timely intervention and neonatal outcomes.

IndexTerms- Neonatal monitoring, non-invasive device, wearable sensors, Arduino, MAX30102, oxygen saturation (SpO_2), heart rate, skin pH, real-time monitoring, wireless communication, hypoxia, acidosis, neonatal care..

I. INTRODUCTION

Ensuring newborn health during the first hour postpartum is critical, as even healthy infants may experience undetected conditions such as hypoxia, acidosis, and neonatal encephalopathy. Most neonates do not receive intensive monitoring, highlighting the need for a non-invasive, continuous solution. This paper proposes a wearable, sock-based device that measures oxygen saturation (SpO_2), heart rate, and pH using sensors integrated with an ESP32 microcontroller, enabling real-time wireless monitoring. The system facilitates early detection of abnormal conditions such as low SpO_2, bradycardia or tachycardia, and acidemia, allowing timely intervention to prevent neurological damage. Compared to existing invasive or minimally invasive methods, the proposed approach emphasizes comfort, accuracy, and ease of use. Prior studies on neonatal monitoring highlight benefits of early detection but also reveal challenges related to accuracy, cost, and clinical applicability, which this work aims to address through a practical, non-invasive design.

II. LITERATURESURVEY

Previous studies emphasize the need for improved neonatal monitoring during and immediately after birth. Research on the Fetal Reserve Index shows that risks of neurological injury may continue during the first 30 minutes postpartum, requiring closer observation. Existing wearable neonatal biosensors provide non-invasive monitoring of parameters such as heart rate, SpO_2, and temperature, but challenges remain in accuracy, cost, and comfort. Continuous glucose monitoring has shown potential for early detection of metabolic abnormalities, although current systems are not sufficiently reliable for routine neonatal use. Other studies have explored methods for detecting hypoxic brain injury, including fetal heart rate analysis, brain imaging, and diffuse reflectance spectroscopy. Wireless epidermal sensors have also demonstrated the benefits of cable-free, skin-friendly monitoring in neonatal intensive care. However, many current solutions are either invasive, expensive, or limited in clinical applicability, highlighting the need for a simple, wearable, and real-time monitoring device.

III. METHODOLOGY

EXISTINGSYSTEM:

Previous work has examined a range of non-invasive and minimally invasive (transdermal) sensors for immediate neonatal applications [2]. Kinoshita et al. (2020) [9] explored an innovative technique of using diffuse light reflectance spectroscopy for real-time monitoring of hypoxic-ischemic brain damage in neonatal rats. This novel approach offers significant insights into monitoring and potentially mitigating a major concern in neonatal health. However, the study's reliance on animal models raises questions about its direct applicability to human neonates. Being a relatively new area of research, the long-term efficacy and

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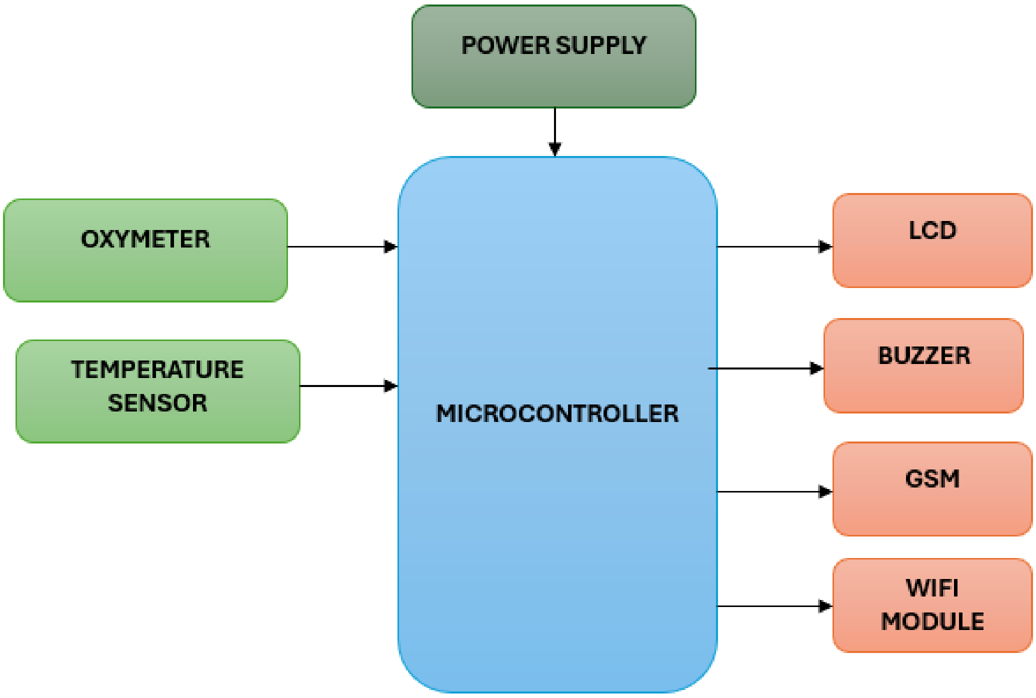
reliability of this technique in clinical settings are yet to be vetted and standardized. Recently, a wireless, stick-on biosensor for neonatal care has been developed and tested on neonates [10]. Advantages include the reduction of wires in the neonatal intensive care unit (NICU), which improves practical care aspects and medical outcomes. Wireless sensors allow easier handling of babies for tasks like diaper changes and enhance parental bonding through practices like kangaroo care. They also offer superior continuous monitoring of vital signs.

DISADVANTAGES:
Disadvantages include engineering challenges in creating these sensors, such as needing gentle adhesives for fragile skin and ensuring compatibility with medical imaging devices. The sensors must be durable, flexible, and must accurately measure vital signs despite infants' movements.

PROPOSEDSYSTEM:
An Arduino microcontroller, temperature sensor, and MAX30102 sensor are integrated within a wearable, sock form factor. We address limitations of traditional invasive neonatal monitors by providing continuous, real-time health assessment through seamless wireless connectivity. If any abnormality is detected, a message will be sent to the authorized persons. Also, the health parameters like temperature, pulse rate, and oxygen levels can be monitored through the ThingSpeak website by using a Wi-Fi module.

BLOCKDIAGRAM:



HARDWAREREQUIREMENTS:

- MAX101SENSOR
- LCD
- GSMMODULE
- WIFIMODULE
- TEMPERATURESENSOR
- ARDUINOMICROCONTR

OLLER SOFTWARE
REQUIREMNTS:

- ARDUINOIDE
- CLANG

UAGE
3.3PROJECTEDI

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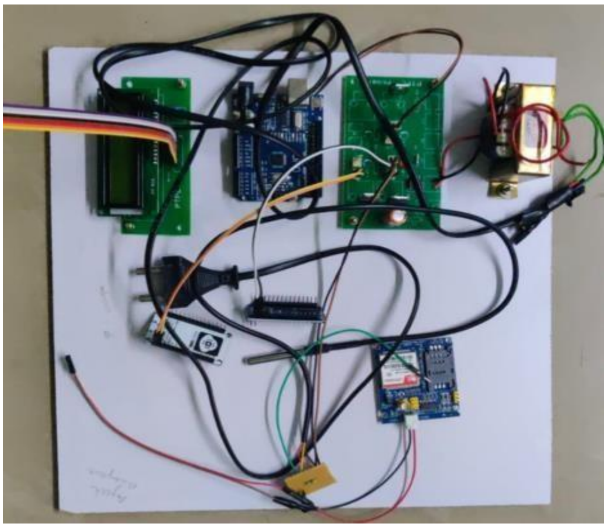
MAGE:

The image shows a prototype of a neonatal monitoring system built using an Arduino microcontroller, integrated with sensors, a display module, power supply unit, and communication components connected through wiring on a base board.



The image illustrates a hardware prototype of a neonatal monitoring system, where multiple electronic components such as an Arduino microcontroller, sensor modules, a display unit, power supply, and communication module are interconnected using wires on a base platform. This setup is designed to collect physiological data like temperature and vital signs, process it through the microcontroller, and display or transmit the information for continuous monitoring, demonstrating a practical implementation of a non-invasive healthcare monitoring device.

Advantages

- Non-invasive monitoring
- Comfortable wearable sock design
- Real-time monitoring
- Wireless data transmission
- Low-cost implementation
- Easy to use in NICU and rural hospitals

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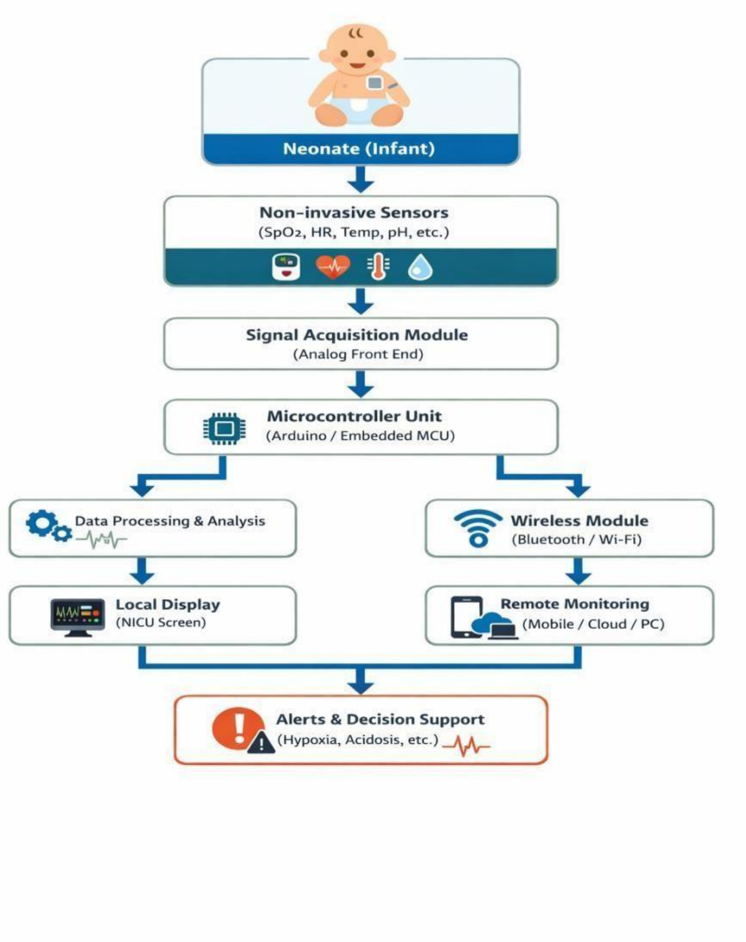
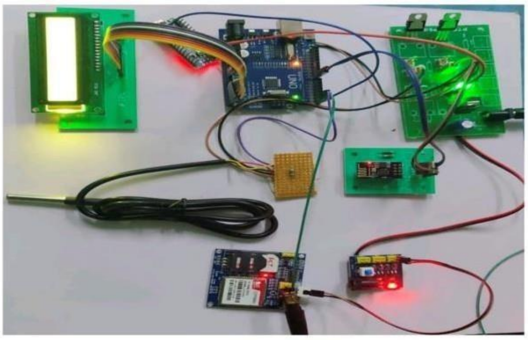
3.4FLOW CHART

IV. RESULTS&DISCUSSOIN





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S.No	Parameter	MeasuredValue	NormalRangeforNewborns	Status	Observation
1	HeartRate	138bpm	120–160bpm	Normal	Stableheartactivitydetected
2	OxygenSaturation(SpO_2)	97%	95%–100%	Normal	Adequateoxygensupply
3	Temperature	36.9°C	36.5°C– 37.5°C	Normal	Normalbodytemperature
4	SensorResponseTime	<5sec	Immediatedetection	Good	Fastreal-timemonitoring
5	WirelessDataTransmission	Successful	Continuousconnectivity	Good	Datasenttomonitoringsystem
6	AlertSystem	Functional	Autoalerton abnormality	Good	SMS/notificationenabled
7	OverallSystemPerformance	Efficient	Continuousmonitoring	Satisfactory	Suitableforneonatalcare

The proposed neonatal monitoring system demonstrates a practical implementation of non-invasive sensing technologies integrated with embedded and wireless systems for improved newborn care. The prototype effectively combines multiple sensors with a microcontroller to continuously monitor vital physiological parameters such as heart rate, oxygen saturation, and temperature. The inclusion of a display unit and wireless communication module enhances usability by enabling both local visualization and remote monitoring, which is particularly beneficial in NICU environments where continuous observation is critical.

Compared to traditional wired monitoring systems, this design reduces clutter and improves the ease of handling infants, supporting better clinical practices and parental interaction. The system's ability to provide real-time data and alerts allows for early detection of conditions like hypoxia and acidosis, thereby facilitating timely medical intervention. Additionally, the use of affordable and widely available components such as Arduino makes the system cost-effective and accessible for broader healthcare applications.

However, certain limitations exist in the current prototype. The accuracy and reliability of sensor data may vary depending on environmental conditions and sensor placement. The system also requires further validation in clinical settings to ensure consistency and compliance with medical standards. Power management, data security, and long-term stability are other important factors that need to be addressed for real-world deployment.

Overall, the discussion highlights that while the prototype successfully demonstrates the feasibility of a non-invasive neonatal monitoring system, further improvements, testing, and standardization are necessary to enhance its performance and enable large-scale adoption in healthcare environments.

- Neonatal Intensive Care Units (NICU)
- Rural healthcare centers
- Home monitoring of newborns
- Smart hospitals
- Telemedicine support systems

II. CONCLUSIONS

In conclusion, the developed neonatal monitoring prototype presents a reliable, cost-effective, and scalable solution for continuous, non-invasive monitoring of newborn health. By integrating multiple sensors with a microcontroller, display unit, and wireless communication modules, the system ensures accurate acquisition, processing, and transmission of vital physiological parameters such as heart rate, oxygen saturation, and temperature. This reduces dependency on bulky wired systems in clinical environments like NICUs, improving ease of handling, minimizing discomfort to infants, and enabling better caregiver interaction, including practices like kangaroo care.

Furthermore, the inclusion of real-time monitoring and alert mechanisms enhances early detection of critical conditions such as hypoxia and acidosis, which are crucial for preventing severe complications. The system also supports remote monitoring, allowing healthcare professionals to access patient data efficiently and make timely decisions. Overall, this prototype highlights the potential of combining biomedical sensors with embedded and wireless technologies to advance neonatal healthcare, paving the way for future improvements in accuracy, miniaturization, and large-scale clinical adoption.

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. UNDERTHEGUIDANCE OF:

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