IoT-Based Patient Health Monitoring: Real-Time Heart Rate and Body Temperature Tracking with Doctor Alerts via IoT

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ABSTRACT
Health plays a important role in our everyday life. Internet of Things provides (IoT) provides Doctors and Care Takers with improved medical services via effective controller-based remote patient health monitoring system with doctor alerts.
The project has the capability of recording and transmitting emergency vital signs to the cloud/servers and then to the doctor's and caretakers to his Mobile. Whenever the values are crossing threshold, the system will raise a buzzer and sends alerts to doctors for immediate attention.

Keywords: IoT, Web Portal, Threshold

1. INTRODUCTION

At the heart of this advancement is a networked system designed to continuously track and evaluate a patient health, facilitating better diagnostic and treatment processes. Our project introduces an innovative web-based framework for patient management tailored for healthcare applications. The core aim is to establish a health monitoring system that utilizes readily accessible sensors to provide real data on patient health. The system is designed to enhance patient care by offering a comprehensive solution for monitoring health metrics outside traditional clinical environments. This process eliminates the requirement for frequent hospital visiting, providing a more flexible and patient-centered model of care. By enabling patients to be monitored at home, the system promotes greater independence and quality of life, while also potentially lowering personal healthcare expenses and preventing complications.
The proposed system ensures that patients and their families have continuous oversight from healthcare professionals, offering reassurance and timely intervention when necessary. This approach integrates advanced technology to deliver a more effective and responsive healthcare experience, making medical care more accessible and personalized.
The central aim is to develop an advanced Patient Monitoring System designed to assess and diagnose the health conditions of patients. In today's fast-paced and demanding world, providing adequate care and health support to bedridden patients during critical moments has become increasingly challenging. Hospitals face the issue of frequently monitoring the physical conditions of numerous patients as part of their diagnostic protocols. Such a system, when properly implemented, can deliver timely notifications to medical staff and physicians, allowing them to act swiftly in emergencies. Traditional monitoring systems often involve sensors that are physically connected to a PC located beside the patient's bed. These sensors gather data on the patient's condition, which is then processed and transmitted by a microcontroller. This approach necessitates frequent physical checks by doctors and nurses to evaluate the patient's status.

2.Existing Work

In the current landscape of healthcare technology, various systems are in place for monitoring patient health, particularly for tracking vital signs like temperature and Heart Rate. However, many existing systems rely on conventional methods that require manual intervention or direct observation, which can limit their effectiveness in providing continuous and real-time monitoring. Traditional patient monitoring systems are typically confined to hospital environments where patients are connected to medical devices that track their vital signs. These devices often require patients to remain within the confines of a healthcare facility, which not only restricts their mobility but also increases the cost of care. Furthermore, the data collected by these systems is usually stored locally within the healthcare facility, and the process

of sharing this information with doctors or other healthcare professionals is not always seamless, leading to potential delays in treatment.

One common type of existing system is the bedside monitoring system found in hospitals. While effective in providing real-time data to healthcare staff, these systems are limited by their stationary nature, requiring patients to be physically present in the hospital for monitoring. Due to this result, continuous monitoring outside of the hospital environment becomes challenging, which is particularly problematic patients.

Another limitation of traditional systems is the lack of integration with modern communication technologies. Most of these systems do not support real-time remote alerts, meaning that any abnormal readings must be manually reviewed by medical staff before any action is taken. This delay can be critical in emergency situations where immediate intervention is necessary. The absence of automatic alert mechanisms means that vital signs may be monitored only at specific intervals, leaving gaps during which a patient's condition could deteriorate without prompt medical attention.

Wearable devices represent a more recent advancement in patient monitoring, offering more mobility compared to traditional bedside systems. Devices, like smart watches, can monitor vital signs like temperature and Heart Rate. However, many of these consumer-grade devices lack the clinical accuracy required for medical purposes. Additionally, while some wearable devices can track data continuously, they often require the patient to manually share this data with healthcare providers, which again can lead to delays in intervention.

Moreover, existing wearable systems may not have robust mechanisms for sending real-time alerts directly to healthcare providers. In most cases, these devices rely on mobile apps to notify users of abnormal readings, placing the burden on patients or caregivers to act upon these notifications. The absence of an automatic alert system that directly informs doctors or medical professionals of critical changes in a patient's condition limits the effectiveness of these devices in emergency scenarios.

In summary, while existing systems for patient health monitoring do provide some level of real-time data tracking, they are generally limited by their reliance on stationary equipment. These limitations highlight the need for more advanced solutions that can offer continuous, real-time monitoring with automatic alert systems capable of directly notifying healthcare providers in the event of an emergency. Such advancements would not only improve patient outcomes by enabling faster response times but also provide greater convenience and peace of mind for patients who require ongoing monitoring outside of traditional healthcare settings.

3.Proposed System

Proposed System for IoT Based Patient Health Monitoring: Real-Time Heart Rate and Body Temperature Tracking with Doctor Alerts. The integration of the IoT in healthcare offers a transformative approach to patient monitoring, particularly for tracking important signs temperature and heart rate in real time. This proposed system aims to address the limitations of existing health monitoring systems by offering a more accurate, cost-effective and reliable solution that can deliver timely alerts to doctors, thus improving patient outcomes.

1. System Architecture and Design

The proposed IoT-based patient health monitoring! system is designed to be both comprehensive and user-friendly, leveraging a combination of sensors, microcontrollers, and communication modules. The core components of the system include temperature sensors and ECG (Electrocardiogram) sensors, which are responsible for continuously monitoring the patient's body temperature and heart rate, respectively. These sensors are connected to a microcontroller that processes the data and identifies any deviations from the normal range, which might indicate a potential health issue.

The system operates on a simple but effective algorithm that prioritizes the detection and reporting of critical health parameters. Upon detecting abnormal readings—such as a significant rise in body temperature or an irregular heart rate—the system immediately triggers an alert that is sent to the patient's healthcare provider via the internet. This real-time alerting mechanism ensures that doctors are promptly informed of any potential health risks, allowing them to take preventive measures or initiate treatment as needed.

2. Data Processing and Alert Mechanism

The proposed system employs a robust data processing module that not only captures real-time data but also filters and analyzes it to ensure accuracy. The input data, consisting of temperature and ECG signals, is continuously monitored. The system is equipped to differentiate between minor, non-threatening anomalies and serious health threats, thus reducing the likelihood of false alarms.

Once the system identifies a critical situation, such as a life-threatening arrhythmia or a dangerously high fever, it initiates an alert protocol. The processed data, along with a brief analysis, is transmitted to the healthcare provider through a secure internet connection. The alert can be sent via multiple channels, including SMS, email, or through a dedicated healthcare application. This ensures that the doctor is notified regardless of their location, enabling swift medical intervention.

3. Cost-Effective and Scalable Solution

A significant advantage of the proposed system is its cost-effectiveness. Unlike traditional health monitoring systems, which can be expensive and require extensive infrastructure, this IoT-based system was designed to be affordable. The use of readily available components, such as low-cost sensors and microcontrollers, reduces the overall cost, making it accessible to a wide scope of patients, including those in resource-limited settings.

Furthermore, the system is scalable, allowing for easy integration with other health monitoring devices or systems. For instance, additional sensors can be added to monitor other vital signs, such as BP, without requiring major changes to the existing system.

4. User-Friendly Interface and Accessibility

The proposed system is designed with the end-user in mind, ensuring that it is easy to use for patients & healthcare providers. The user interface is intuitive, providing clear and concise info about the patient's body health. Patients can easily monitor their own health through a connected device, such as a smartphone or tablet, which displays real-time data and alerts.

For healthcare providers, the system offers a centralized platform where they can monitor multiple patients simultaneously, access detailed health records, and receive alerts in real time. This centralized approach not only improves efficiency but also enhances the quality of care provided, as doctors can quickly respond to potential health issues.

5. Global Connectivity and Rural Healthcare

One of the primary goals of proposed system is to extend quality healthcare to rural and remote areas where access to medical facilities may be limited. The system's reliance on IoT and global connectivity means that patients in these areas can benefit from continuous health monitoring without needing to travel very long distances to consult a doctor. This is particularly important for monitoring chronic conditions that require regular oversight, such as heart disease or diabetes.

In conclusion, the proposed IoT based patient health monitoring! system addresses the very critical limitations of existing systems by providing a more accurate, reliable, and cost-effective solution. Its ability to deliver real-time alerts to doctors, coupled with its user-friendly design and scalability, makes it a promising tool for improving patient outcomes, particularly in underserved areas. As the technology continues to develop, this system has great potential to become an integral part of modern healthcare.

4. Block Diagram of the Project

Block Diagram Explanation for IoT Based Patient Health Monitoring! System: Real Time Heart Rate and Body Temperature Tracking with Doctor Alert via IoT. The IoT Based patient health monitoring system, designed for real Time tracking of heart rate and body temperature, uses a combination of sensors and modules to efficiently monitor a patient's vital signs & alerts health care providers when necessary.

In today's fast-changing healthcare world, we really need better ways to monitor patients. Old-school methods often rely on healthcare providers checking in occasionally, can slow down the detection of serious health problems. But here comes the IoT to change things up! It lets us monitor! patients in real time and react fastly to any health issues that pop up. This project, called "IoT-Based Patient Health Monitoring: Real-Time Heart Rate & Body Temperature Tracking with Doctor Alerts via IoT," is all about creating a smart patient monitoring system. This system will keep an eye on important health signs like patient temperature & Heart Rate all the time. If something doesn't seem right, it will alert healthcare providers right away. This means quicker medical help and better recovery for patients.

The main idea here is real-time monitoring—it's super important for catching health issues early. We plan to use both a heart rate sensor and a temperature sensor to keep tabs on a patient's vital signs. The heart rate sensor, probably a pulse sensor, will measure how many times the heart beats per minute. Meanwhile, the temperature sensor, like an LM35 or DHT11, watches over body temperature—key to spotting infections or other problems. These sensors will connect to a Raspberry Pi, which is a cool little computer that acts as the brain of this system.

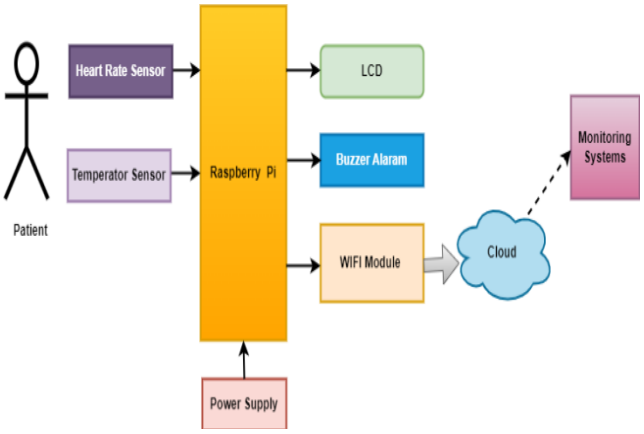

Fig 1. Block Diagram

The Raspberry Pi collects data from the sensors & figures out if those readings are normal. If something seems off, it will sound a buzzer right where the patient is—a loud alert! This helps the patient or nearby caregivers notice there's an issue fast. At the same time, this device will send information wirelessly to a central server using a Wi-Fi module like ESP8266. The server can be local or cloud-based; it keeps data safe and analyzes it for trends that might show worsening conditions.

One fantastic benefit of this system is how it sends real-time alerts to doctors no matter where they are! How cool is that? It connects through a mobile app called the Blink app. This app is easy to use and shows things like patient heart rate,. Patient body temperature in real time. So, doctors can keep an eye on patients continuously! If there's an abnormal reading, they get notified immediately so they can jump into action quickly. It's especially helpful for those with chronic conditions who really need careful watching, cutting down on those tiresome hospital visits and allowing for more personal care.

Another great thing about this system is how scalable it is! It can work in different places: hospitals, nursing homes, or even at home care settings. Each patient's information gets tracked separately so every healthcare provider can give special attention to each person they're looking after. This feature matters a lot when resources run low because one caregiver can look after many patients without being physically with each one.

By bringing IoT into patient monitoring, this project tackles big challenges in today's healthcare scene. With real-time data & alerts, health issues get spotted & addressed quickly—this helps lower complications and boosts overall patient care. Plus, having a mobile app makes checking on patients much easier and convenient for everyone involved—especially for older folks or those living far away from good healthcare options! This project not only steps up patient monitoring but also gives healthcare providers what they need to deliver quick and caring support.

In summary, our "IoT-Based Patient Health Monitoring: Real-Time Heart Rate & Body Temperature Tracking with Doctor Alerts via IoT" project makes huge strides in merging tech with healthcare needs! By using IoT, we create a dependable way to keep track of patients continuously while making sure doctors can give timely help when necessary. We're moving towards making healthcare systems more connected & responsive so that patient safety & well-being shine through technological advancements.

Below is an in-depth explanation of the components used in this system and how they interact to achieve the desired functionality.

5.Flow chart

The flowchart for the IoT Based Patient Health Care Monitoring! System outlines the sequential steps involved in monitoring and responding to a patient's health data. Initially, the system begins by initializing all sensors and establishing a connection with the IoT module. The sensors then continuously measure the patient's patient temperature & Heart Rate.

This data is processed by the microcontroller, which compares the readings against predefined thresholds. If abnormal values are detected, an alert is triggered, the data is sent to the doctor through the IoT module. The system then loops back to continue monitoring in real-time.If the heart rate threshold changes due to age or any fluctuations, an alert is triggered via a buzzer, and a notification is sent to a nearby person's mobile device. The temperature sensor monitors the patient's body temperature.

If it detects that the temperature is above or below the set threshold, a buzzer alarm is activated. Simultaneously, the patient's actual health status is displayed on an LCD screen, and a notification is sent to the doctor or nurse through the Blink app

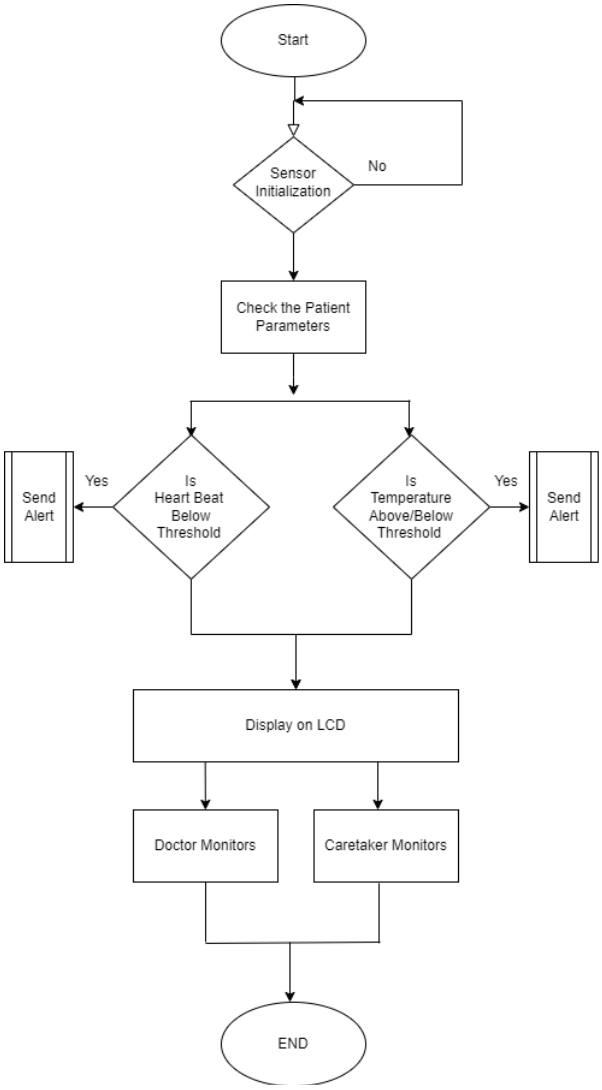

Fig 2. Flow chart

The schematic diagram of the system represents the interconnections and relationships between the different components that work together to achieve real-time monitoring of vital signs such as patient temperature & Heart Rate. This system is designed to ensure that health data is accurately collected, processed, and transmitted to healthcare providers, enabling timely medical intervention when necessary.

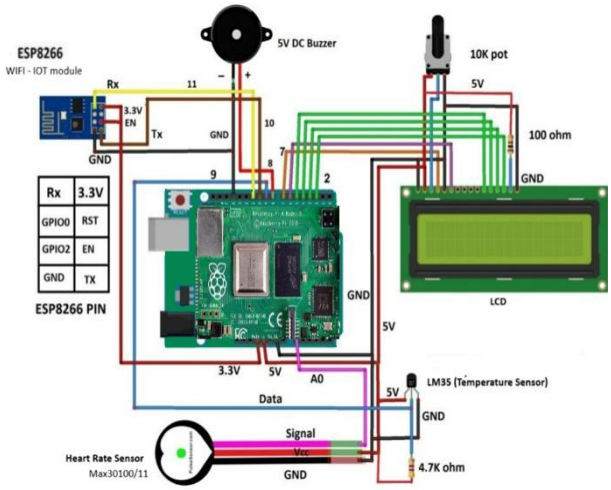

Fig 3. Schematic of the Project

6. RESULTS

Heartbeat Sensor outputs

The MAX30100/11 heart rate sensor provided precise measurements of the patient's heart rate by utilizing photoplethysmography (PPG) technology. During the project, the sensor effectively detected heartbeats and transmitted real Time data to the monitoring! system. Analysis of the data showed that the sensor maintained accuracy and reliability under various conditions. The system was able to detect abnormal heart rate patterns and generate alerts when thresholds were surpassed, demonstrating the sensor's effectiveness in monitoring cardiovascular health.

Fig 4. Heart beat sensor values displays on LCD

The same result is displayed on a mobile device connected to the WiFi module, which also sends an alert if the heartbeat reaches a maximum or minimum threshold companied by a buzzer sound.

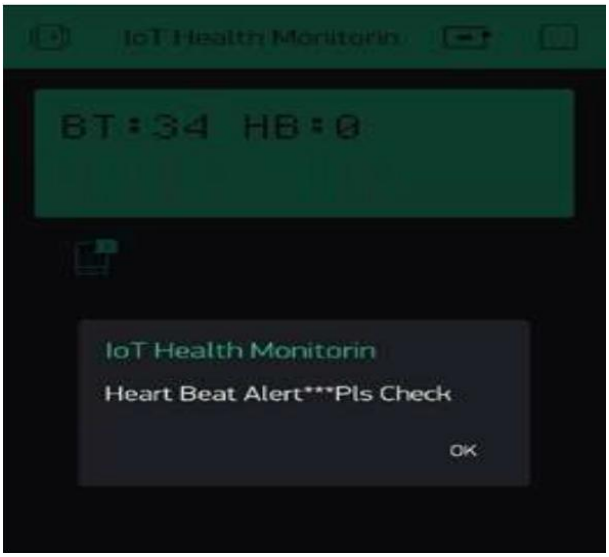

Fig 5. Giving Heart beat alert when it is minimum

Fig 6. Hear Beat alert on Blink app

Temperature Sensor

The temperature sensor accurately measured the patient's body temperature and provided consistent readings throughout the monitoring period. The sensor successfully identified deviations from normal temperature ranges, such as fever or hypothermia.

The system's capability to trigger alerts based on temperature fluctuations was validated, ensuring that any significant changes in body temperature were promptly communicated to healthcare providers.

Fig 7. Body temperature displaying on LCD

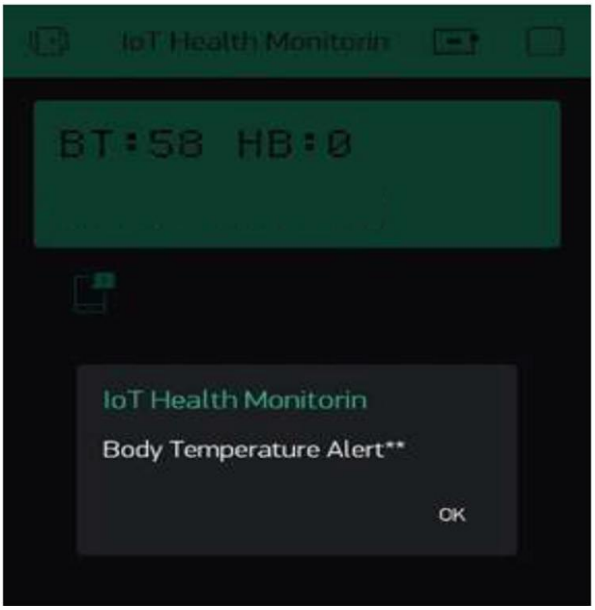

Fig 8. High temperature triggers an alert on the Blink app

Fig 9. Low body temperature triggers an alert on the Blink app

Buzzer
The buzzer was integral to the alert system, delivering audible notifications when heart rate or body temperature readings deviated from normal ranges. It effectively drew attention to critical conditions, ensuring that any anomalies were promptly addressed. The buzzer's performance was consistent, and it proved to be an effective component in the alert mechanism of the system.

Blink App
The Blink app enabled remote monitoring and management of patient health data. Integration with the IoT system allowed the app to receive and display real-time data from the heart rate and temperature sensors. The app's user-friendly interface facilitated easy access to health metrics and alerts, enabling healthcare providers to monitor patient conditions from any location. The analysis confirmed that the app effectively supported remote oversight and enhanced the system's overall functionality.

Overall System Performance
IoT Based Patient Health Care Monitoring System successfully integrated the MAX30100/11 heart rate sensor, temperature sensor, LCD display, buzzer, and Blink app to provide comprehensive real-time health tracking. The system demonstrated its ability to accurately monitor and display vital signs, issue alerts for abnormal readings, and support remote monitoring through the app. The analysis verified that the system met its objectives, offering a robust and effective solution for patient health management.

7.CONCLUSION
In conclusion, the IoT-based Patient Health Monitoring! System has successfully met its primary objectives by integrating various modules such as the heartbeat detection module, temperature sensor, and WiFi connectivity to achieve real-time monitoring of vital signs. The individual components, all readily available and cost-effective, have performed as intended, demonstrating the feasibility of the system in a practical healthcare setting.
The advancements in integrated circuits, Micro Electro Mechanical Systems (MEMs), and microcontrollers have significantly contributed to the development of this system. These technologies, now more affordable and efficient, had paved the way for the creation of sophisticatd embedded systems that are increasingly being adopted in the healthcare industry. This project highlights the potential of embedded systems in enhancing healthcare delivery, particularly through the adoption of IoT.
As internet penetration continues to rise globally, especially in developing countries, the adoption of IoT-based health monitoring! systems is expected to accelerate. The integration of these systems with smartphone technology further amplifies their potential, making real-time health monitoring accessible to a broader population.
From an engineering perspective, this project has provided a valuable opportunity to apply theoretical knowledge in a practical context. The design and fabrication of the circuit modules involved electric circuit analysis, while the wireless communication between microcontrollers relied on principles of electromagnetic fields. Additionally, software programming played a important role in integrating the various components into a cohesive system.

8. Future Scope
Looking ahead, the development of a biomedical telemetry system promises substantial advancements in patient monitoring technology. This innovative approach leverages mobile communication between microcontrollers to provide real-time health data.
The envisioned system integrates a suite of advanced components, including temperature sensors, heart rate monitors, blood pressure gauges, Analog-to-Digital (A/D) converters, signal conditioning circuits, microcontrollers, data cables, mobile phones, and LCD displays. Here's a detailed look at its future capabilities:

1. **Temperature Sensing**
   Future iterations of the temperature sensor will offer enhanced accuracy and sensitivity, allowing for more precise monitoring of body temperature. This data will be seamlessly converted from analog to digital signals by advanced A/D converters, ensuring high fidelity in patient temperature readings.
2. **Microcontroller Enhancements**
   The microcontroller will play a pivotal role in managing and processing data from various sensors. Future advancements may include improved processing power and the ability to handle more complex algorithms for better health analysis and predictive diagnostics.

3. **Mobile Data Transmission**
   With the evolution of mobile technology, data transmission via GSM networks will be complemented by newer communication protocols, such as 5G and beyond. This will enhance data transfer speeds and reliability, providing healthcare professionals with immediate access to patient information.
4. **PC and Remote Monitoring Integration**
   The system will expand its capabilities to include cloud-based data storage and remote access, allowing healthcare providers to monitor patient data from any location. This integration will facilitate more comprehensive analysis and long-term health tracking.
5. **Heart Rate and Blood Pressure Monitoring**
   Future sensors for heart rate and blood pressure will incorporate advanced features such as non-invasive monitoring and continuous tracking. These improvements will provide more detailed and accurate health metrics.
6. **Signal Conditioning and Data Accuracy**
   Innovations in signal conditioning circuits will lead to more robust noise filtering and signal enhancement, ensuring that the data collected is of the highest quality and reliability.
7. **LCD and Advanced Displays**
   The LCD display will evolve to offer more interactive and user-friendly interfaces. Future designs might include touchscreens and real-time graphical representations of health data, making it easier for medical staff to interpret patient conditions quickly.
8. **Integration with Emerging Technologies**
   The system will integrate with emerging technologies such as artificial intelligence (AI) and machine learning to offer predictive analytics and automated alerts. These technologies will help anticipate potential health issues before they become critical.

REFERENCES

[1] Saranya. E, Maheswaran. T, "IoT Based Disease Prediction and Diagnosis System for Healthcare", International Journal of Engineering Development and Research (IJEDR) | Volume 7, Issue 2 | ISSN: 2321-9939, pp.232-237, 2019.

[2] M.M. Dhanvijay and S.C. Patil, "Internet of Things: a survey of enabling technologies in healthcare and its applications,,Computer Networks, vol. 153, pp. 113–131, 2019.

[3] Islam, S.R., Kwak, D., Kabir, M.H., Hossain, M. and Kwak, K.S., "The internet of things for health care: a comprehensive survey," IEEE Access, vol.3, pp.678-708, 2015.

[4] Mohammad Dawood Babakerkhell, Nitin Pandey, "Analysis of Different IOT Based Healthcare Monitoring Systems", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-6S2, April 2019.

[5] S.M.R. Islam, D. Kwak, M.H. Kabir, M. Hossain, andK.-S. Kwak, "Internet of Things for health care: a comprehensive survey," IEEE Access, vol. 3, pp. 678–708,2015.

[6] Dr.T. Poongodi, Dr. Balamurugan Balusamy, Dr.P. Sanjeevikumar, Dr. Jens Bo Holm-Nielsen, "Internet of Things and E-Healthcare system-A Short review on challenges", IEEE India info.vol.14 No. 2, pp. 143-147, 2019

[7] Smiju Sudevan, Mani Joseph, "Internet of Things: Incorporation into Healthcare Monitoring", IEEE, 2019.

[8] Goutam Motika, Abinash Prusty," Wireless FetalHeartbeat Monitoring System Using ZigBee & IEEE 802.15.4 Standard", 2011 Second International Conference on Emerging Applications of Information Technology, 978-0-7695-4329-1/11 $26.00 © 2011 IEEE DOI 10.1109/EAIT.2011.89

[9] M.M.E. Mahmoud et al., "Enabling technologies on a cloud of things for smart healthcare," IEEE Access, vol. 6, no. c, pp. 31950-31967, 2018.

[10] R Sangeetha, Dr.R. Jegadeesan, M P Ramya and G Vennila, "Health Monitoring System Using Internet of Things", International Journal of Engineering Research and Advanced Technology (IJERAT), E-ISSN: 2454-6135, Volume.4, Issue 3 March-2018.

[11] S. Kraijak and P. Tuwanut, "A Survey on IoT Architectures, Protocols, Applications, Security, Privacy, Real-World,"11th Int. Conf. Wireless. Commun. Netw. Mob. Comput. (WiCOM 2015), pp. 1-6, 2015.

[12] J. Qi, P. Yang, G. Min, O. Amft, F. Dong, and L. Xu, "Advanced internet, of things for personalized healthcare systems: A survey," Pervasive Mob. Computer. vol. 41, pp. 132-149, 2017.

[13] S.B. Baker, W. Xiang, and I. Atkinson, "Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities," IEEE Access, vol. 5, no. c, pp. 26521-26544, 2017.

[14] Yuehong, Y.I.N., Zeng, Y., Chen, X.,& Fan, Y., "The internet of things in healthcare: An overview", Journal of Industrial Information Integration,1, 3-13, (2016).
[15] Ejaz, W., Anpalagan, A., Imran, M.A., Jo, M., Naeem, M., Qaisar, S.B. and Wang, W., "Internet of Things (IoT) in 5G wireless communications", IEEE Access, vol.4, pp.10310-10314, 2016.
[16] Ejaz, W., Anpalagan, A., Imran, M.A., Jo, M., Naeem, M., Qaisar, S.B. and Wang, W., "Internet of Things (IoT) in 5G wireless communications", IEEE Access, vol.4, pp.10310-10314, 2016.