iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: IV Month of publication: April 2024

DOI: https://doi.org/10.22214/ijraset.2024.60869

Measuring Vital Signs such as Temperature, BPM, Humidity using different IOT Sensors and Designing a Mobile Application using Firebase

Raj Godara[1], Gurleen Kaur[2], Vardan Baliyan[3], Annu[4], Prof. Gaurav Soni[5]
Department of AIT-CSE, Chandigarh University, Mohali, Punajb, India

Abstract: This research describes the creation of an Internet of Things-based smart health surveillance system that allows for the real-time data tracking of a person's vital signs. An ESP8266 Node MCU microcontroller is integrated with temperature, humidity, and heart rate sensors in the system to gather information on the user's body temperature, ambient humidity, and heart rate. A specially created Android mobile application shows the gathered data, which is wirelessly sent to a Firebase cloud database. With the use of the mobile app, users can easily create individualized profiles, view vital sign data, and get warnings. Early health issue diagnosis and proactive illness management are aided by successful implementation, which shows that low-cost IoT devices, cloud computing, and mobile technologies may all be used for effective remote health monitoring.
Keywords: Heart Rate, Temperature, Sensors, Smart Health Monitoring, Internet of Things, Humidity.

I. INTRODUCTION

The Internet of Things' (IoT) quick developments have transformed several industries, including healthcare. Smart sensor, wireless communication, and cloud computing integration has opened the door to creative solutions that can greatly enhance patient care and illness management. The creation of remote health monitoring systems is one such remedy; these allow for the real-time surveillance of a person's vital signs, enabling patients and medical professionals to make educated decisions regarding their health. Demonstration of the design and construction of a "Smart Health Monitoring System" in this research project, which makes use of Internet of Things technology to continually monitor a person's humidity, heart rate, and temperature [1]. This research's driving force is the expanding need for easily available and effective remote healthcare solutions, especially when it comes to patient empowerment, preventative care, and the treatment of chronic illnesses. The primary processing unit of the system is an ESP8266 Node MCU microcontroller, which is connected with a DHT11 temperature and humidity sensor, a heart rate pulse sensor module, and other sensors. [2] The user's physiological factors, like the body temperature, heart rate (measured in beats per minute, or BPM), and environmental humidity levels, may be thoroughly monitored thanks to this sensor array. Wireless transmission of the sensor data is made to a Firebase cloud database, where it is securely stored and made accessible to a specially developed Android mobile application. The Java and Android Studio-created mobile application provides a user-friendly interface for viewing the recorded health data in real time. With the ability to immediately evaluate their temperature, heart rate, and humidity levels, users are empowered to actively control their own well-being. The application further has features for setting alert levels, generating user profiles, and examining past data trends in order to facilitate focused monitoring and timely actions. [3] The following are the main goals of this smart health monitoring system:

1) Real-time Vital Signs Monitoring: Using the chosen sensors, the system gathers and sends data in real-time on the user's temperature, heart rate (BPM), and humidity levels. [4]
2) Cloud-based Data Management and Storage: By integrating the Firebase Realtime Database, health data gathered from the sensors can be safely stored and synchronized, facilitating remote accessibility and analysis. [5]
3) User-friendly Mobile Application: By giving users access to the tracked health metrics in real-time through an easy-to-use interface, the Android mobile application encourages people to actively manage their health. [6]
4) Scalability and Adaptability: The system is scalable and adaptable, enabling the future integration of more sensors or features. This is made possible by the modular design of the system, which uses swappable hardware components and cloud-based data management. Using low-cost IoT devices, cloud-based data management, and mobile technologies to allow effective and accessible remote healthcare solutions is feasible, as demonstrated by the successful deployment and testing of this Smart Health Monitoring System.

This technology can help with early health issue diagnosis, proactive disease treatment, and support for preventative care activities by continually monitoring vital signs. [7][8]

The rest of the work is structured as follows: A thorough review of the system's literature is provided in Section 2, and a detailed explanation of the system architecture and the integration of its many hardware and software components is given in Section 3. In Section 4, the system's testing and implementation are covered, with an emphasis on the effectiveness and dependability of the created solution. The findings are presented in Section 5 and a results and discussion of the possible effects of the Smart Health Monitoring System on the healthcare industry. The study article is finally concluded in Section 6, which also suggests areas for further investigation.

II. LITERATURE SURVEY

1) The paper "Smart Health Monitoring System through IoT" presented at the International Conference on Communication and Signal Processing in April 2019 discusses the role of IoT in healthcare. The authors emphasize the potential of IoT in connecting individuals through wearable gadgets, enabling health monitoring and providing timely solutions for abnormal health conditions. The research focuses on capturing sensor data, analyzing it, and providing feedback to patients based on various health parameters. The paper reviews various applications and methods related to IoT in healthcare, discussing the use of wireless monitoring systems, Raspberry Pi-3 board, and Arduino board as gateways for capturing real-time data. The proposed work involves continuous monitoring of different health parameters through a smartwatch, with collected data sent to the cloud for further analysis. The paper also discusses the communication and interaction between smartwatches, smartphones, ThingSpeak cloud, and IFTTT, emphasizing the use of Bluetooth low energy for efficient wireless communication. The paper concludes that the proposed system provides flexibility and continuous monitoring of heart conditions, offering a preventive approach to healthcare. [1]

2) The "IoT-Based Health Monitoring System" is a study that explores the potential of the Internet of Things (IoT) in healthcare, mainly in remote health surveillance. The system uses wearable sensors and smartphones to continuously monitor a patient's vital parameters, such as heartbeat and temperature. The benefits of IoT-based health monitoring include disease prevention, remote diagnosis, and reduced healthcare costs. The system a uses wireless communication to transmit the data to a medical server, which can then be accessed by authorized personnel through IoT platforms. The system's experimental setup includes sensors for body temperature, pulse rate, and room humidity, the process of data transmission using IoT. The study also presents experimental results, including sensor calibration and diagnosis. The paper concludes by emphasizing the potential of IoT in remote health monitoring and disease diagnosis, allowing for continuous patient monitoring, reduced hospital stays, and remote diagnosis by medical practitioners. [2]

3) The document presents a "Smart Health Monitoring System" designed to provide continuous healthcare monitoring, especially in rural or remote areas. The system uses biomedical sensors connected to an Arduino UNO controller to gather patient data, which is then transmitted to a server and visualized on a smartphone through a dedicated Android application. The architecture includes the integration of medical sensors and a controller responsible for collecting patients' physical parameters. The data is saved in a CSV format on an SD card and uploaded to an online database. The hardware description includes the Arduino UNO and the calculation of temperature and heartbeat rate sensors. The development of an Android application named s-Health is highlighted, offering functionalities such as BMI calculation, medication reminders, nearby hospital information, and home remedies. The conclusion emphasizes the successful implementation of the system and proposes future enhancements, such as incorporating more sensors and refining the Android application's features to make it more dynamic. The document provides a comprehensive overview of the Smart Health Monitoring System and offers insights into potential future enhancements, including the expansion of sensor capabilities and the refinement of the Android application's features. [3]

4) The "IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review" is a comprehensive analysis of IoT-based healthcare-monitoring systems, focusing on remote patient monitoring and improving quality of life. In reviewing recent research on these systems, the report compares their efficacy, security, privacy, and data protection. It also covers issues with healthcare security and privacy, wearable and wireless sensor-based IoT monitoring systems, and recommendations for future IoT healthcare applications. The review emphasizes these systems' advantages such as real-time monitoring, preventive care, and remote healthcare, while addressing challenges such as range and bandwidth limitations, security and privacy concerns, and improved data protection. The paper also discusses the Internet of Wearable Things (IoWT) and its potential to revolutionize healthcare by integrating sensors into wearable devices for continuous monitoring of health and activity. The review emphasizes the importance of addressing security, privacy, and data protection concerns in the development of IoT healthcare applications. [4]

5) The research article "IoT-Based Health Monitoring System Development and Analysis" describes the development and deployment of an Internet of Things-based health monitoring system. The system measures a patient's body temperature, heartbeat, and oxygen saturation levels, sending the data to a mobile application via Bluetooth. This innovative electronic device aims to identify irregularities within the body, especially for patients in rural areas with limited access to healthcare facilities. The system aims to increase affordability and easy access to personal healthcare, particularly for patients with chronic diseases and during the COVID-19 pandemic. The study details hardware components, cost analysis, and real-life testing results, showcasing its potential for real-time health monitoring and remote patient care. It compares the developed system with existing IoT-based health monitoring systems, emphasizing its unique features and capabilities. Future improvements include integrating new algorithms for enhanced security, using Raspberry Pi as a microcontroller, adding additional sensors, and optimizing IoT management processes. The research presents a comprehensive approach to developing an IoT-based health monitoring system, demonstrating its potential for real-time health monitoring, remote patient care, and affordable healthcare solutions. [5]
6) The document presents an "IoT-based Health Monitoring System" that measures health-related parameters like body temperature, pulse, ECG, and blood pressure to predict diseases. The system aims to provide timely medical assistance and reduce the need for frequent health check-ups. It is user-friendly and can be implemented in homes, old-age homes, and work environments. The hardware part uses a PCB package and sensors, which are sent to a cloud server using machine learning algorithms to predict different diseases based on the measured parameters. The system uses microcontrollers and sensors like the ESP32 and MAX30100 to sense and calculate health parameters. Experimental results show a prototype of the system, calibrated using a microcontroller and displayed on an LCD. The future scope suggests increasing the number of sensors and predicting other diseases using different datasets. The conclusion emphasizes the importance of IoT in remote health monitoring and the system's potential to accurately predict heart disease. [6]
7) This document provides an in-depth analysis of an IoT-based Integrated Health Monitoring System, highlighting its potential benefits in real-time patient monitoring and healthcare quality improvement. It emphasizes the growing importance of healthy aging and the need for in-home health monitoring systems. The system uses Node MCU (ESP8266) for remote healthcare, a pulse/heart rate sensor, and Google Firebase for database storage. It uses two Android applications, Smart Care Patient and Smart Care Admin, for patient and healthcare provider interfaces. The system faces challenges such as expanding sensor capabilities, enhancing data storage, and improving security. Upcoming tasks include adding more sensors and growing the database, and introducing a web-based control system. The document serves as a comprehensive resource on the potential impact of IoT on healthcare, its architecture, implementation, and future directions for improvement. The proposed IoT-based Integrated Health Monitoring System has the potential to address critical healthcare challenges, particularly in remote patient monitoring and real-time healthcare decision-making. [7]

III. METHODOLOGY

IoT technologies are being used in the development and deployment of the system, which involves a methodical approach that unifies several hardware and software components. [9][10] The following is an outline of the methodology and data flow diagram represented in Figure 1:

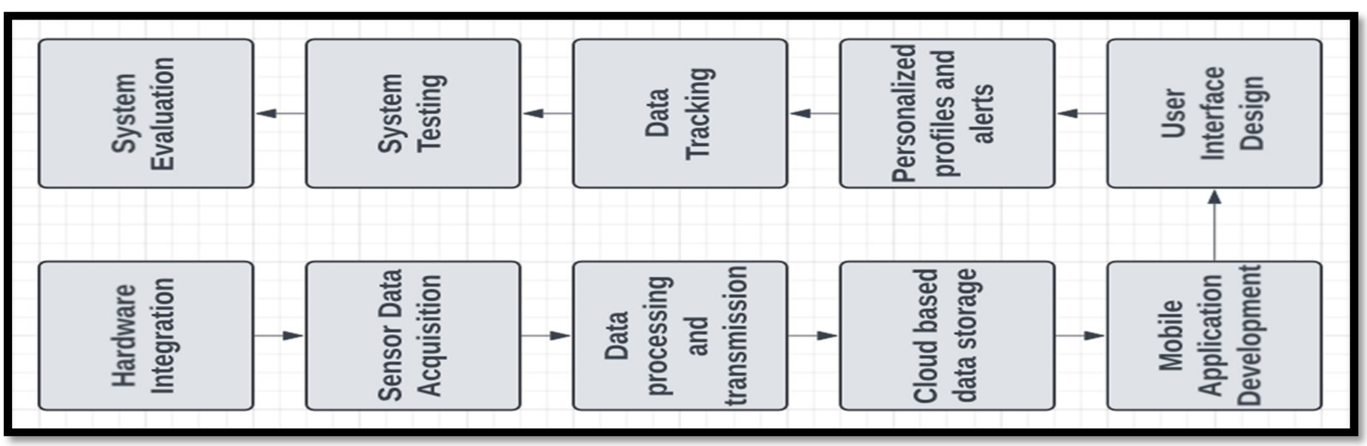

Figure 1: Dataflow diagram

A. Hardware Configuration

The CPU is an ESP8266 Node MCU microcontroller chosen for its simplicity of programming, low power consumption, and Wi-Fi capabilities. The precision and dependability of the DHT11 sensor for measuring humidity and temperature and the heart rate pulse sensor module in monitoring vital signs led to its selection. A breadboard and jumper wires are used to link the sensors to the ESP8266 Node MCU, allowing for easy data collection and transmission. [11][12]

B. Firmware Development

The firmware for the ESP8266 Node MCU microcontroller is developed using the Arduino Integrated Development Environment (IDE). In order to read and process sensor data, initialize and control the attached sensors, and create a wireless connection with the Firebase Realtime Database, firmware code is generated. To enable the sensors' functionality and the Firebase integration, pertinent libraries are loaded. [13][14]

C. Integration of Firebase

Because of its scalability, simplicity of interaction with mobile apps, and real-time data synchronization, the Firebase Realtime Database is selected as the cloud-based data storage option. To allow safe data transfer from the ESP8266 Node MCU to the database, the Firebase project is set up and the required parameters are established. [15][16]

D. Developing Mobile Applications

The mobile application is made using Android Studio, an approved Integrated Development Environment (IDE) for Android app development. Model-View-Controller (MVC) architectural pattern and Java programming language are used in the development of the mobile application. The mobile application incorporates the Firebase Android SDK, facilitating the smooth extraction and presentation of vital sign information from the Firebase Realtime Database. The smartphone app's user interface (UI) is intended to make monitoring vital signs simple and straightforward, with real-time temperature, heart rate (BPM), and humidity levels shown. [17][18]

E. User Experience and Data Visualization

The smartphone app presents the vital sign data in an understandable style by utilizing charts, graphs, and other visual features. User experience (UX) concepts are used to ensure the app's navigation flow is simple and easy to use, making it simple for users to access and interact with their health data. [19]

F. Alerts and User Profile Management

Users of the mobile app may establish individualized profiles and set alarm levels according to their own preferences or health problems. The software sends notifications to the user or their healthcare professional in the event that any of the monitored vital indicators diverge from the predetermined criteria. [20]

G. Monitoring Historical Data

With the use of the mobile app's capabilities for monitoring past data patterns, users may view and examine their vital sign data over time. With the help of this tool, users may see trends, keep tabs on their progress, make informed decisions regarding their well-being and health. [21]

H. Assessment and Testing

The Smart Health Monitoring System is put through a rigorous testing and assessment process to guarantee the overall performance, accuracy, and dependability of the system. This include evaluating the mobile application's functioning, cloud-based data storage, wireless data transfer, and hardware integration. In order to improves the system as per the needs and preferences of future users, user acceptability testing is carried out to obtain their input. [22]

I. System Preservation and Deployment

The Smart Health Monitoring System is ready for real-world implementation following its successful testing and assessment. To keep the system up to date with the newest security patches, bug fixes, and feature upgrades, planned ongoing maintenance and updates are made. [23]

The suggested approach creates a complete real-time health monitoring system by using the advantages of mobile, cloud, and IoT technologies. The Smart Health Monitoring System employs a methodical approach to enable people to actively manage their health and assist medical professionals in delivering prompt, well-informed treatment. [24][25]

The system architecture of the Smart Health Monitoring System is depicted in Figure 2:

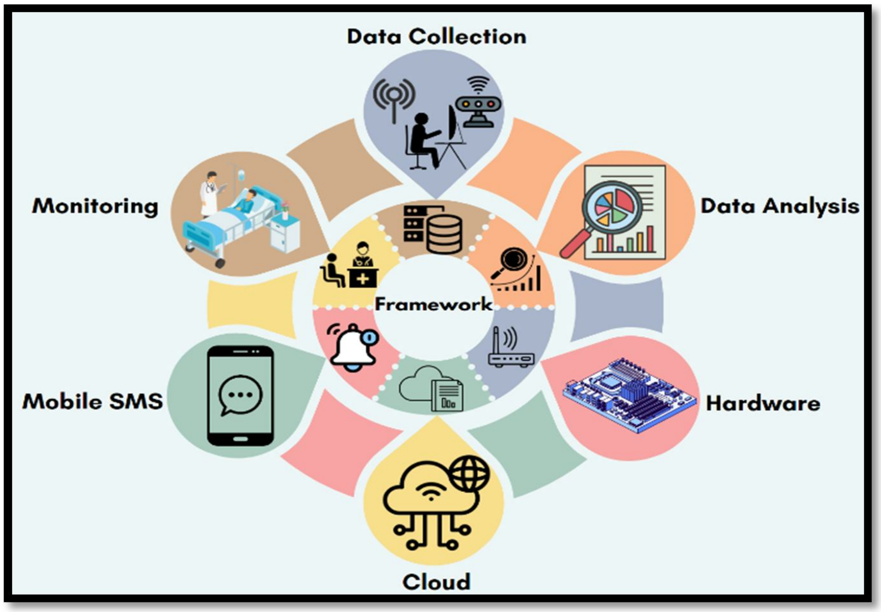

Figure 2: System architecture

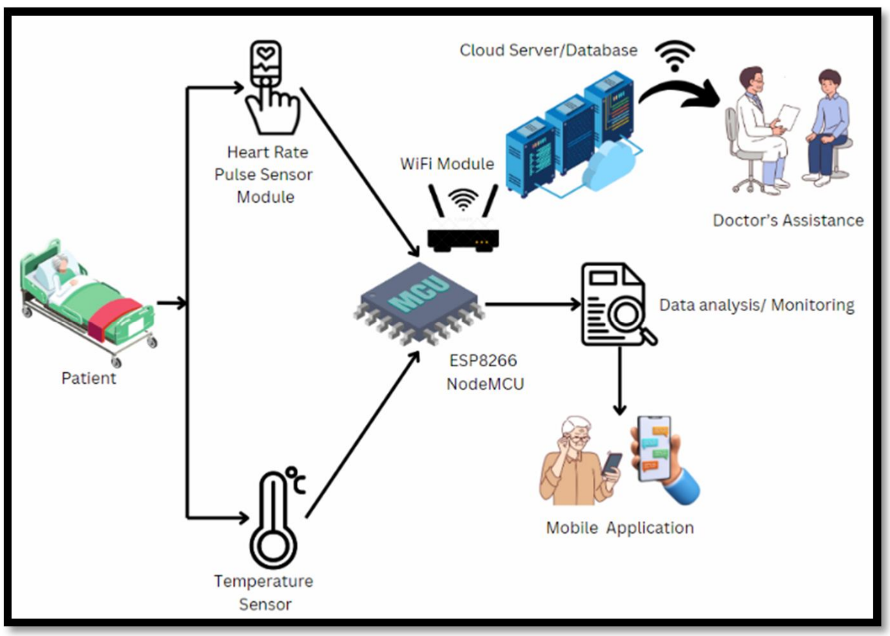

Figure 3: System overview

Figure 3 shows the overview of the designed system.

IV. IMPLEMENTATION AND SYSTEM TESTING

Several hardware and software components have to be seamlessly integrated in order to construct the Smart Health Monitoring System. Using a breadboard and jumper wires, the ESP8266 Node MCU microcontroller was configured as the central processing unit and linked to a DHT11 temperature and humidity sensor additionally a heart rate pulse sensor module.

[26] The firmware for the Node MCU, which managed sensor data collecting, processing, and wireless transmission to the Firebase Realtime Database, was developed using the Arduino IDE. The Firebase project was set up to provide for safe data storage and transfer of vital sign information. [27] Using Android Studio and the programming language, Java, the Android mobile application was created in accordance with the Model-View-Controller (MVC) design pattern. The app's integration of the Firebase Android SDK made it possible for the vital sign data to be easily retrieved and displayed from the Firebase database. [28] The smartphone app's user interface was created to offer a simple and easy way to track temperature, pulse rate (BPM), and humidity levels in real time. The program also had tools for collecting historical data, managing user profiles, and adjusting alert levels. To ensure the Smart Health Tracking System's dependability, accuracy, and functionality, extensive testing and assessment were carried out. This involved evaluating the mobile application's functionality, cloud-based data storage, wireless data transfer, and hardware integration. [29] To get input from future users, user acceptability testing was carried out. The system was then improved to their needs and preferences. The Smart Health Tracking System underwent successful testing and assessment before being ready for implementation in real-world settings. It also included plans for regular maintenance and upgrades to keep the system current with the newest security patches, bug repairs, and feature additions.[30]

V. EXPERIMENTAL RESULTS

Vital health metrics were measured by the built system uses a DHT11 temperature and humidity sensor, a heart rate pulse sensor module, and an ESP8266 Node MCU microcontroller. [31] To receive and display the collected data, the mobile application—which was created with Java and Android Studio—integrated with the Firebase database with ease.[32] The program included a user-friendly interface with readings for the humidity level, heart rate (BPM), and measured temperature. Throughout testing, the system successfully collected and instantly sent the health data to the mobile application. These findings support the efficiency of the created Internet of Things (IoT)-based health observing system in gathering and displaying vital health indicators via a mobile application, permitting remote monitoring and possible medical uses. [33]
Figure 4 represents the hardware setup of the designed system.

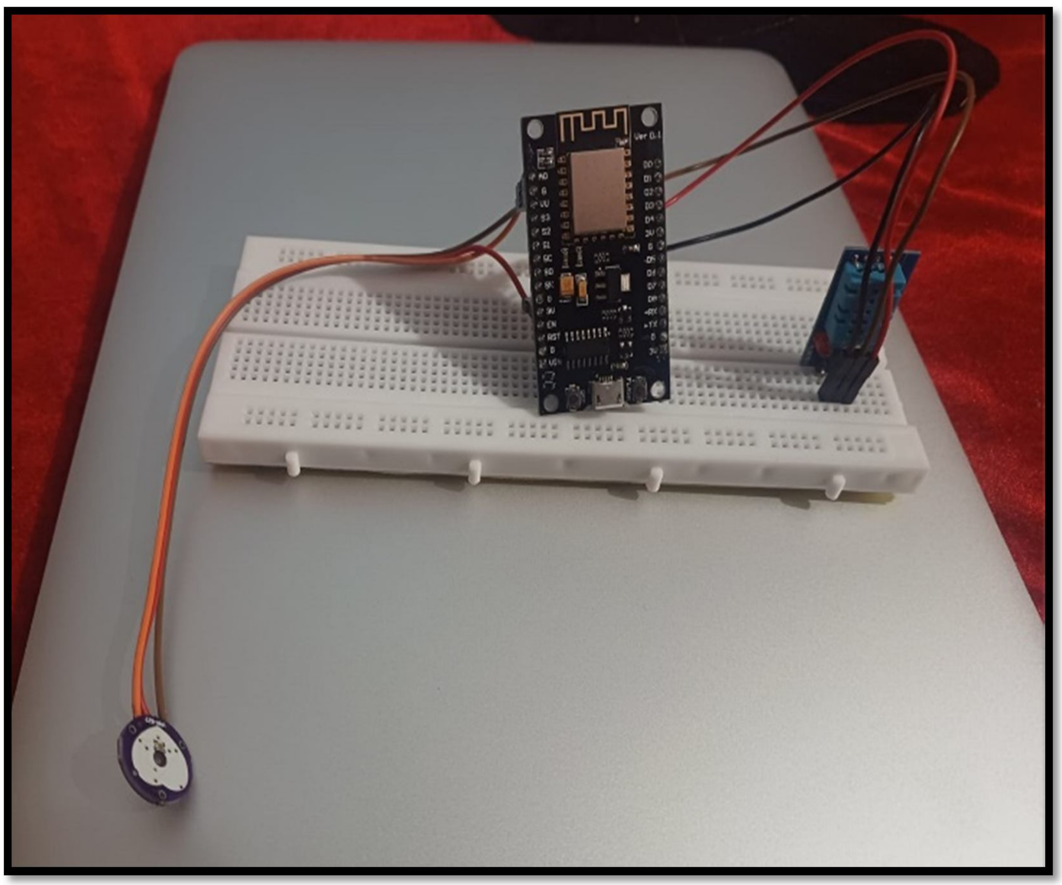

Figure 4: Hardware Setup

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

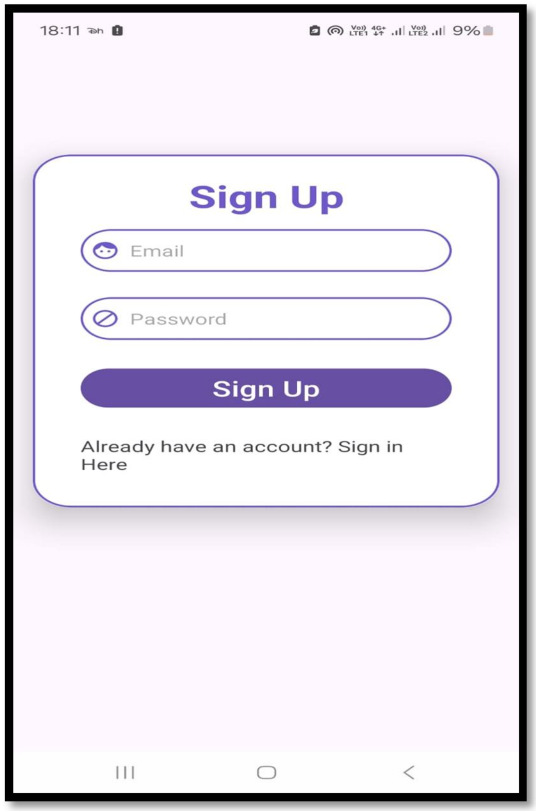

Figure 5: Login Page

Figure 5 is a glimpse of the mobile application login page for the authorized users.

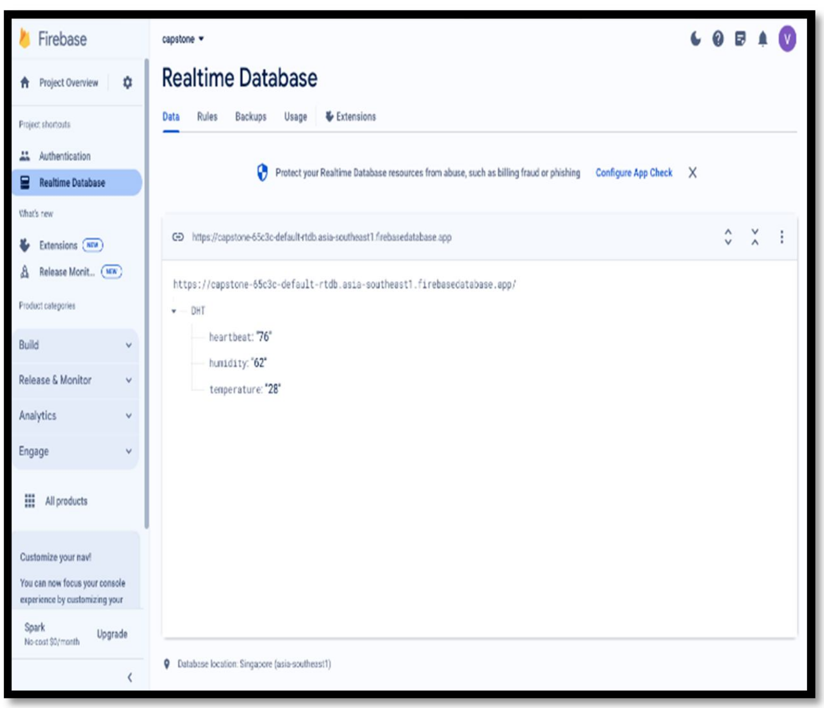

Figure 6: Realtime Database Page

Figure 6 represents the real time database page on Firebase.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue IV Apr 2024- Available at www.ijraset.com

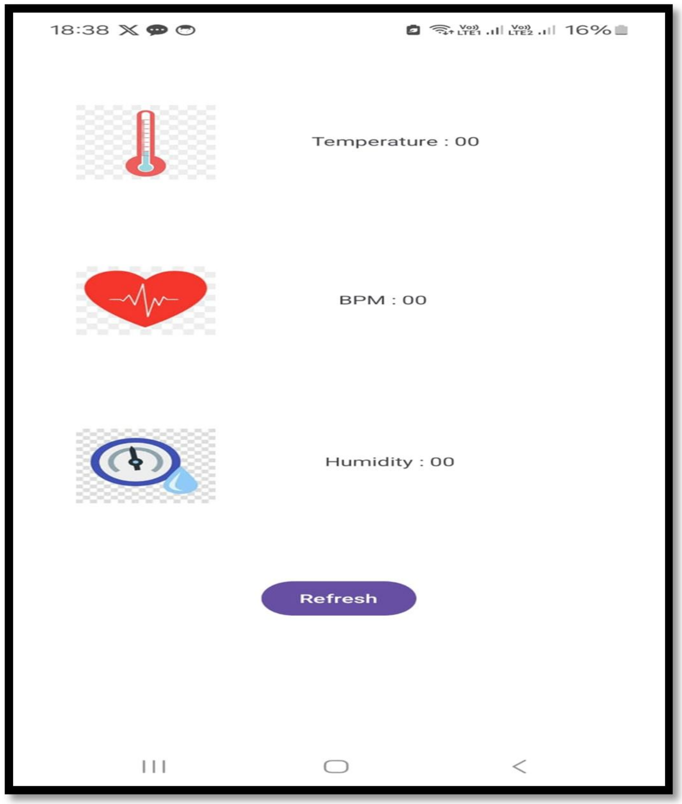

Figure 7: Application Interface

Figure 7 represents the mobile application interface before readings.

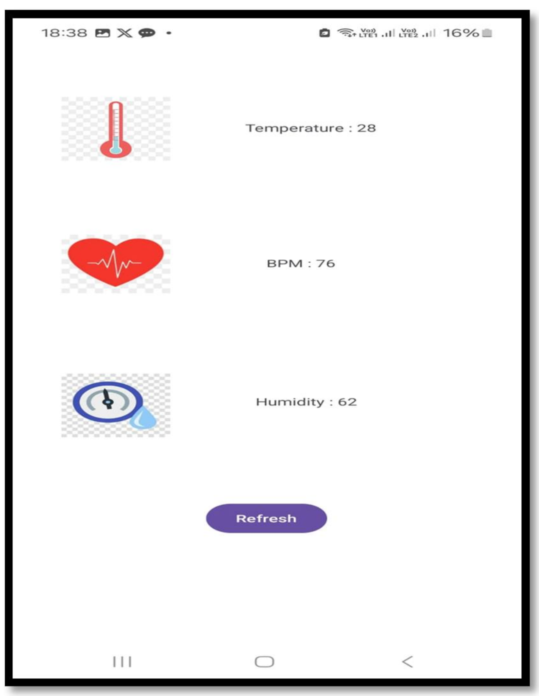

Figure 8: Readings

Figure 8 shows the readings of the vital signs of a person on the mobile application.

VI. CONCLUSION

The designed system, which was developed with the help of Internet of Things technologies, has effectively shown that it is possible to use mobile applications, cloud computing, and inexpensive hardware components to achieve effective remote health monitoring. The system effectively monitors body temperature, heart rate (BPM), and ambient humidity levels by merging the ESP8266 Node MCU, temperature sensor, humidity sensor, and heart rate sensor. [34] Real-time monitoring, customizable profile management, and timely notifications are made possible by the user-friendly Android mobile app and the wireless data transmission to the Firebase Realtime Database. The system has demonstrated its accuracy, dependability, and usefulness via rigorous testing and user input, supporting proactive disease management, early health issue diagnosis, and preventative care efforts. This initiative sets the stage for future developments in Internet of Things (IoT)-based healthcare solutions, giving people the ability to take charge of their health and assisting medical professionals in providing high-quality treatment. [35]

REFERENCES

[1] Mohan, Madhan & Pichandi, Sathya. (2019). Smart Health Monitoring System through IOT.
[2] Valsalan, Prajoona & Tariq, Ahmed & Hussain, Ali. (2020). IOT BASED HEALTH MONITORING SYSTEM. 2020. 10.31838/jcr.07.04.137.
[3] Khan, Tarannum & Chattopadhyay, Manju. (2017). Smart health monitoring system. 1-6. 10.1109/ICOMICON.2017.8279142.
[4] Abdulmalek, Suliman & bin, Abdul Nasir & Al-Areeqi, Waheb & Almuhaya, Mukarram & Bairagi, Anupam & Khan, Md. Al-Masrur & Kee, Seong-Hoon. (2022). IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review. 10.3390/healthcare10101993.
[5] Khan, Mohammad & Alanazi, Turki & Albraikan, Amani & Almalki, Faris. (2022). IoT-Based Health Monitoring System Development and Analysis. Security and Communication Networks. 2022. 1-11. 10.1155/2022/9639195.
[6] Gajare, Mansi & Dani, Manas & Deshmukh, Payal & Chaudhari, Pritesh. (2021). IOT based Health Monitoring System.
[7] Sultana, Salma & Rahman, Sadia & Rahman, Md & Chakraborty, Narayan & Hasan, Tanveer. (2021). An IoT Based Integrated Health Monitoring System. 549-554. 10.1109/ICCCA52192.2021.9666412.
[8] D. A. M. Budida and R. S. Mangrulkar, "Design and implementation of smart HealthCare system using IoT," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, India, 2017, pp. 1-7, doi: 10.1109/ICIIECS.2017.8275903.
[9] Rahaman, A., Islam, M.M., Islam, M.R., Sadi, M.S., Nooruddin, S. (2019). Developing IoT based smart health monitoring systems: A review. Revue d'Intelligence Artificielle, Vol. 33, No. 6, pp. 435-440. https://doi.org/10.18280/ria.330605
[10] S. M. R. Islam, D. Kwak, M. H. Kabir, M. Hossain and K. -S. Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," in IEEE Access, vol. 3, pp. 678-708, 2015, doi: 10.1109/ACCESS.2015.2437951.
[11] Islam, M.M., Rahaman, A. & Islam, M.R. Development of Smart Healthcare Monitoring System in IoT Environment. SN COMPUT. SCI. **1**, 185 (2020). https://doi.org/10.1007/s42979-020-00195-y
[12] Azzawi, Mustafa & Hassan, Rosilah & Abu Bakar, Khairul Azmi. (2016). A Review on Internet of Things (IoT) in Healthcare. International Journal of Applied Engineering Research. 11. 10216-10221.
[13] Ennafiri, Mohamed & Mazri, Tomader. (2020). INTERNET OF THINGS FOR SMART HEALTHCARE: A REVIEW ON A POTENTIAL IOT BASED SYSTEM AND TECHNOLOGIES TO CONTROL COVID-19 PANDEMIC. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLIV-4/W3-2020. 219-225. 10.5194/isprs-archives-XLIV-4-W3-2020-219-2020.
[14] M. Hummady, Muna & Fadhil, Heba. (2023). Smart Healthcare Medical Bracelet using the Internet of Things. 10.1109/ICCA56443.2022.10039622.
[15] Taştan, Mehmet. (2018). IoT Based Wearable Smart Health Monitoring System. Celal Bayar Üniversitesi Fen Bilimleri Dergisi. 14. 343-350. 10.18466/cbayarfbe.451076.
[16] Mohammed, B. G., & Hasan, D. S. (2023). Smart Healthcare Monitoring System Using IoT. International Journal of Interactive Mobile Technologies (iJIM), 17(01), pp. 141–152.
[17] Rahman, Muhammad Zia, et al. "An intelligent health monitoring and diagnosis system based on the internet of things and fuzzy logic for cardiac arrhythmia COVID-19 patients." Computers in Biology and Medicine 154 (2023): 106583.
[18] Hosseinzadeh, Mehdi, et al. "An elderly health monitoring system based on biological and behavioral indicators in internet of things." Journal of Ambient Intelligence and Humanized Computing (2023): 1-11.
[19] Shrivastava, Anurag, Midhun Chakkaravarthy, and Mohd Asif Shah. "Health Monitoring based Cognitive IoT using Fast Machine Learning Technique." International Journal of Intelligent Systems and Applications in Engineering 11.6s (2023): 720-729.
[20] Nasser, Nidal, et al. "A smart healthcare framework for detection and monitoring of COVID-19 using IoT and cloud computing." Neural Computing and Applications (2023): 1-15.
[21] Munnangi, Ashok Kumar, et al. "Survival study on deep learning techniques for IoT enabled smart healthcare system." Health and Technology 13.2 (2023): 215-228.
[22] Akhbarifar, Samira, et al. "A secure remote health monitoring model for early disease diagnosis in cloud-based IoT environment." Personal and Ubiquitous Computing 27.3 (2023): 697-713.
[23] Boopathi, Sampath. "Internet of things-integrated remote patient monitoring system: Healthcare application." Dynamics of Swarm Intelligence Health analysis for the next generation. IGI Global, 2023. 137-161.
[24] Boopathi, Sampath. "Internet of things-integrated remote patient monitoring system: Healthcare application." Dynamics of Swarm Intelligence Health analysis for the next generation. IGI Global, 2023. 137-161.
[25] Alsudani, Mustafa Qahtan, et al. "RETRACTED ARTICLE: Smart logistics with IoT-based enterprise management system using global manufacturing." Journal of Combinatorial Optimization 45.2 (2023): 57.

[26] Sharif, Zubair, et al. "Priority-based task scheduling and resource allocation in edge computing for health monitoring system." Journal of King Saud University-Computer and Information Sciences 35.2 (2023): 544-559.
[27] Jacob Rodrigues, Mariana, Octavian Postolache, and Francisco Cercas. "Physiological and behavior monitoring systems for smart healthcare environments: A review." Sensors 20.8 (2020): 2186.
[28] Selvaraj, Sureshkumar, and Suresh Sundaravaradhan. "Challenges and opportunities in IoT healthcare systems: a systematic review." SN Applied Sciences 2.1 (2020): 139.
[29] Greco, Luca, et al. "Trends in IoT based solutions for health care: Moving AI to the edge." Pattern recognition letters 135 (2020): 346-353.
[30] Jacob Rodrigues, Mariana, Octavian Postolache, and Francisco Cercas. "Physiological and behavior monitoring systems for smart healthcare environments: A review." Sensors 20.8 (2020): 2186.
[31] Ghazal, Taher M., et al. "IoT for smart cities: Machine learning approaches in smart healthcare—A review." Future Internet 13.8 (2021): 218.
[32] Selvaraj, Sureshkumar, and Suresh Sundaravaradhan. "Challenges and opportunities in IoT healthcare systems: a systematic review." SN Applied Sciences 2.1 (2020): 139.
[33] Greco, Luca, et al. "Trends in IoT based solutions for health care: Moving AI to the edge." Pattern recognition letters 135 (2020): 346-353.
[34] Ullo, Silvia Liberata, and Ganesh Ram Sinha. "Advances in smart environment monitoring systems using IoT and sensors." Sensors 20.11 (2020): 3113.
[35] Dahan, Fadl, et al. "A smart IoMT based architecture for E-healthcare patient monitoring system using artificial intelligence algorithms." Frontiers in Physiology 14 (2023): 1125952.