Grenze International Journal of Engineering and Technology, June Issue

Review on IoT-based Wireless System for Continuous Heart Rate Monitoring with Cloud Storage

Rupali Prakash Gomase[1], Sandip Thakre[2] and Amol Dhenge[3]
[1-3]Department of Electronics (Communication) Engineering, Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur, India

***Abstract*— Cardiovascular diseases are one of the leading causes of mortality worldwide, which creates a requirement that demands constant observation of heart health indicators. The project introduces a wireless IoT system which enables users to monitor their heart rate in real-time while storing data in the cloud and receiving emergency alert notifications. The system uses the MAX30100 sensor, which employs photoplethysmography (PPG) technology to perform non-invasive measurements of heart rate and blood oxygen saturation (SpO_2) through fingertip contact. The ESP8266 microcontroller processes data, which local monitoring displays on an LCD, while the system uploads data to the Blynk cloud platform for remote smartphone access. The system activates a buzzer alarm and sends instant notifications to caregivers and healthcare providers when it detects abnormal readings that include dangerously high or low heart rates, which allows healthcare workers to respond without delay. The system functions as a compact portable device which healthcare professionals can use to administer home care and monitor elderly patients through telemedicine systems. The system combines real-time monitoring with data storage and emergency alerts to deliver an affordable dependable solution for managing cardiac health in a preventive manner.**

***Index Terms*— Cardiovascular diseases, Heart Rate Monitoring, IoT, Arduino controller etc.**

I. INTRODUCTION

The heart operates as the essential organ which maintains human life by serving as a blood pump which delivers oxygen and nutrients to every human body part. The heart maintains proper cardiac function which enables life to continue because it delivers nutrients and oxygen to body tissues while it removes carbon dioxide and waste products. The heart muscles contract and relax rhythmically to produce a heartbeat which functions under electrical impulses that the sinoatrial node generates. The heart generates beats which serve as vital signs of cardiac function and when the heart rhythm shows abnormal patterns this indicates that the person might experience serious health conditions which include arrhythmias and hypertension and cardiac arrest and myocardial infarction. The process of heart rate monitoring (HR) establishes a critical role for determining a person's medical condition while it helps to avert dangerous health emergencies [1].

Cardiovascular diseases now stand as the primary reason for people dying in modern society. Global health statistics show that heart-based medical conditions lead to millions of annual deaths which could have been prevented through early detection and prompt treatment. The standard approach to patient monitoring requires healthcare experts to operate electrocardiography (ECG) equipment and hospital devices which prevent patients from moving freely.

Grenze ID: 01.GIJET.12.2.511_22

The system creates difficulties for elderly patients and people who have a high chance of experiencing sudden cardiac arrest because they need to receive ongoing monitoring which should occur outside of hospital environments [1][2].

Healthcare has gained new opportunities because of the new Internet of Things (IoT) technologies that have emerged. IoT technology allows physical devices to connect with their built-in sensors and wireless communication systems which enable data transmission to cloud platforms for data storage and analysis and remote monitoring functions. The Internet of Medical Things (IoMT) enables healthcare providers to use continuous portable monitoring systems which deliver affordable medical services to patients at home. Patients can use wearable health monitoring devices to monitor their vital signs which include heart rate and oxygen saturation (SpO_2) and blood pressure throughout the entire day. Emergency situations receive instant alerts from these systems which help emergency responders to reach their targets faster while reducing the chance of serious consequences [3][4].

The project aims to build an IoT-Based Wireless System which will continuously monitor heart rate and store data in the cloud while sending emergency alerts. The system employs the MAX30100 pulse oximeter sensor which uses Photoplethysmography (PPG) as a non- invasive method to measure finger blood volume changes and determine heart rate and oxygen saturation levels. The ESP8266 microcontroller connects to the sensor which enables data processing and wireless transmission through Wi-Fi. The system shows processed data on an LCD display for immediate viewing while it uploads information to the Blynk cloud platform which enables healthcare staff and family members to monitor patient progress through a smart phone application.

The system's primary component functions through its emergency alert system. The system activates a local buzzer alarm and sends immediate alerts through the Blynk app

when the heart rate reaches critical levels for both high tachycardia and low bradycardia conditions. The system provides fast emergency response capabilities which particularly help elderly patients and individuals living in remote locations [5].

The system is built to be small enough to be moved easily during home and clinical medical procedures. The system enables medical professionals to monitor patients in real time while they also use cloud storage to keep patient health records for extended periods of time to support future medical examinations. The project uses IoT technology to create an effective and easy-to-use cardiac monitoring system which helps improve healthcare results while decreasing the chances of unexpected heart problems.

II. Problem Identification

- Heart-related ailments are the leading global cause of death because late diagnosis and insufficient monitoring equipment result in millions of annual fatalities.
- The traditional hospital equipment which includes ECG machines and Holter monitors proves to be both expensive and heavy while needing permanent clinical oversight to prevent patient movement.
- Patients who leave hospitals or reside in distant locations face a higher possibility of experiencing undetected heart problems because they lack access to ongoing monitoring equipment.
- Most sudden cardiac arrest cases become treatable through proper medical intervention which needs to occur within five minutes. The system fails to deliver real-time alerts which results in medical staff taking extended time to respond.
- High costs of advanced cardiac monitoring devices prevent low-income patients from accessing these devices which consequently limits their application in home healthcare settings.
- The market needs a heart rate monitoring system which combines affordability with portability and IoT functionality plus cloud storage and emergency alerting capabilities.

III. Literature Survey

A. Literature Review

Charlton P. H. et. al. 2023, The critical research pathways for wearable photoplethy- smography (PPG) have been compiled into this roadmap through multiple expert authors who contributed their knowledge. The study identifies four technological gaps which need to be addressed through interdisciplinary research between engineering and physiology and clinical trials to develop dependable clinical applications of wearable PPG technology. Organizations should develop better algorithms which can effectively remove motion artifacts while enabling users to wear their devices comfortably throughout the day and provide open access to benchmarking datasets which meet regulatory requirements for validation testing. The roadmap identifies two critical problems which need immediate attention: validation studies lack diverse population representation and cloud-stored physiological data faces risks to its privacy and security. The roadmap provides designers of low-cost IoT systems which use MAX30100 with ESP8266 guidance on how to build their systems through its recommendations about system robustness and validation processes and clinical endpoint selection because researchers should conduct complete testing of their systems in real-world situations while tracking all system failures that occur during testing.

Kyriacou P. A. et. al. 2023, The brief evaluation describes current research progress while documenting developments in wearable PPG technology and its associated algorithms. The study investigates sensor miniaturization together with adaptive sampling methods and machine-learning methods for arrhythmia detection and sensor fusion that combines PPG with accelerometer and ECG data. The authors demonstrate that resting heart rate measurement achieves high accuracy, yet its performance decreases during physical activity and at low blood flow, which makes algorithm correction together with multimodal fusion essential. The researchers assess validation methods, which reveal that numerous studies do not possess diverse study groups or authentic real-world testing conditions. The paper concludes by presenting essential research areas which require development through effective artifact reduction methods and unified assessment standards and clinical research that tests wearable devices against standard ECG technology across different demographic groups. The research findings demonstrate that IoT systems must establish their preprocessing and quality control procedures before transferring data to the cloud in order to prevent false alerts.

A. Elgendi, et al. 2022, The PPG technique underwent development through optical sensing advances and computational reading progress which enabled its application to heart-rate variability and blood-pressure estimation and peripheral vascular diagnostics. The authors explain PPG through its biophysical foundation and the two main sensor types (transmission and reflection) and the primary factors which cause inaccuracies (ambient light and motion artifacts and poor contact). The review presents two essential clinical translation obstacles which include the need for algorithms to work across different skin tones and the unpredictable outcomes from different device positions and the need for standard signal- quality measures. The study recommends that researchers should use PPG together with accelerometry and ECG as their primary recording method while making reproducibility tests. The review shows that embedded IoT devices need to implement two main features which include using low-cost sensors to handle signal-quality evaluation and establishing safe alert systems to prevent alarm exhaustion.

Shafiq Ul Rehman et. al. 2024, The current study introduces a real-time Internet of Things system that monitors ECG and physiological data while using cloud-based analysis to evaluate sudden cardiac death risk and initiate emergency rescue notifications. The system uses wearable devices for monitoring and processes data at edge locations while employing cloud-based models for prediction and geo-notification to alert nearby emergency responders. The doctors found that using short-term ECG data together with heart-rate variability and contextual information about the patient's current activity and location achieved better results in detecting medical emergencies than using threshold rules only. The authors present results from prototype field experiments which used simulated events to show that ML-based classifiers applied at cloud and edge locations could provide timely alerts while decreasing false positive rates. The researchers require automated emergency notification systems to establish privacy and latency balance because they need regulatory frameworks to operate those systems. The study demonstrates how basic PPG and HR IoT devices can be transformed into advanced predictive emergency systems through complex technology development.

Abdul Hannan et. al 2023, The study presents a wearable system which combines PPG and accelerometer signals through machine-learning algorithms that use CNN and LSTM models to identify initial indicators of cardiac arrest. The authors trained the model on annotated datasets and validated on wearable-collected recordings, reporting improved sensitivity and lead time compared to simple threshold methods. The research demonstrates three main findings through its results which show that (a) data augmentation for motion artifacts increases model robustness, (b) subject-specific calibration further reduces false alarms, and

(c) a hybrid edge/cloud deployment system enables efficient latency and battery management through its on-device lightweight inference process which transfers suspicious epochs to the cloud for validation. The study highlights ethical concerns (false alarm consequences) and stresses clinician-in-the-loop validation for deployment. The results suggest MAX30100/ESP8266 systems should implement gradual machine learning adoption which begins with cloud-based analytics and uses local alerts at reduced capacity.

Jacob Hutton et. al. 2022, This systematic review investigates the effectiveness of wearable and ambient sensor technologies for detecting cardiac arrest events that happen outside of hospital settings. The review finds three sensor modalities which include PPG and accelerometry and impedance as promising options but shows that current scientific evidence remains insufficient because most studies have small participant groups and use simulated events which lack real-world testing. Algorithm performance studies showed that combined signal algorithms achieved better specific detection results through their ability to identify actual events. The paper needs researchers to conduct extensive future studies which should include standardized outcomes for measuring time-to-detection and false-alarm rate together with evaluating how clinical results affect patient survival and response time. The review warns developers that their advanced prototypes will not provide public health advantages until they undergo testing in real-world active medical environments and emergency system processes.

Suliman Abdulmalek et. al. 2022, This survey paper examines IoT healthcare deployments, focusing on architecture (sensors → edge → cloud), common communication stacks (MQTT/HTTP), and data-privacy strategies. The authors summarize multiple implementations that use MAX30100/MAX30101 sensors with ESP-series microcontrollers for HR/SpO_2 monitoring, noting strengths (cost, Wi-Fi connectivity) and weaknesses (security defaults, inconsistent sampling). The study found that users tend to adopt products more when these products deliver specific benefits through their alert systems and caregiver dashboard features and their energy consumption management systems. The paper demonstrates interoperability problems which exist between different IoT systems and it emphasizes the need for secure authentication methods and encrypted cloud transmission to protect patient data. For small research projects, adopting established IoT patterns (MQTT + TLS, token- based auth) is recommended before clinical data collection.

Macheso P. et. al. 2021, The study develops an affordable prototype which utilizes ESP8266/Nodemcu and pulse sensors to transmit heart rate and temperature data to ThingSpeak/Blynk. The system demonstrates accurate heart rate measurement during rest periods through its use of MQTT/HTTP as a basic telemetry system. The authors provide implementation information which includes details about sensor calibration and Wi-Fi reconnection procedures and mobile dashboard UI design and they identify three main challenges which occur during implementation: movement detection problems and noisy sensor data and expensive public IoT platform data storage solutions. The study presents its main practical contributions through sample code and hardware wiring diagrams and test logs which students can use to create prototypes with MAX30100 and ESP8266 and Blynk. The researchers suggest that users should implement local signal-quality assessments to stop faulty data transmission while saving bandwidth and battery power.

Reddy D. R. et. al. 2022, The conference paper presents a pulse-oximeter prototype which combines MAX30100 and an Internet of Things module to enable remote monitoring of SpO_2 levels and heart rate. The authors provide a description of system architecture together with the data acquisition firmware and the Thing Speak cloud integration. Performance testing against a clinical pulse oximeter validated heart rate measurements during rest periods but showed increased errors for SpO_2 results when testing under low perfusion and motion conditions which matches findings from existing research. The researchers present their latency and throughput findings while establishing local buzzer activation thresholds and cloud notification thresholds which will help decrease false alarm incidents. The study provides practical insights about sensor warm-up procedures and sampling frequencies and averaging window sizes which assist implementers in developing an academically validated prototype that includes performance baseline testing.

Kwang Bok KimHyun Jae Baek, 2023, The article presents a technical overview of PPG sensor modalities and their signal-processing pipelines and their application cases which include HR and SpO_2 and blood-pressure estimation. The study explains how engineering trade-offs between sensor expenses and clinical accuracy standards create challenges for the development of medical devices which require common artifact-removal approaches using adaptive filtering and ICA and ML-based denoising methods. The authors demonstrate that wearable PPG devices need multi-sensor fusion and extensive annotated data to attain advanced applications which include arrhythmia classification and blood pressure estimation although heart-rate estimation at rest shows high accuracy. The paper recommends open data standards together with collaborative benchmarking because these methods can help improve clinical readiness which provides valuable guidance for researchers who work on IoT and cloud-based systems that need clinical validation.

B. Literature Summary

The need for Internet of Things heart monitoring systems has increased because cardiovascular disease rates have risen worldwide according to recent research. The majority of research projects use MAX30100 sensors and ECG electrodes and pulse oximeters together with microcontrollers Arduino and ESP8266 and ESP32 to obtain live physiological measurements. The system transmits data through Wi-Fi or Bluetooth to Blynk and ThingSpeak and custom IoT dashboards which enable remote monitoring. Mobile applications serve as the primary method to deliver alerts and notifications and visual displays of patient health information. Some works focus on energy efficiency while others prioritize data security and accuracy. The systems demonstrate strong performance through their ability to decrease cardiac emergency detection delays yet they still fall short in three key areas which include cost-effectiveness and portability and accuracy across different patient conditions.

C. Research Gap

- Accuracy Issues: The current systems experience reduced accuracy when they operate in noisy environments or when patients move their bodies.
- Limited Portability: The majority of existing solutions fail to achieve complete optimization for use in small, portable wearable devices.
- Integration Challenges: The existing research only develops low-cost systems which combine three vital parameters (HR, SpO_2, ECG) into one device.
- Data Security: The research project does not establish effective encryption methods which would protect medical data during transmission.
- Scalability Concerns: The research has been conducted on only small patient samples whose testing results show prototype performance.
- Battery Efficiency: The current devices on the market show high battery consumption which results in short operational periods.
- Emergency Response: The existing systems lack complete emergency healthcare service integration which would enable automatic alert sending.
- Affordability: The current IoT-based systems with advanced features remain expensive which prevents their use in facilities with limited resources.

IV. RESEARCH METHODOLOGY

A. Criteria for selecting this study:

- Worldwide heart disease rates continue to rise which creates a need for real-time monitoring systems that can effectively track heart-related medical conditions.
- The post-pandemic period requires healthcare systems to implement IoT-based solutions that enable remote monitoring of patients.
- The research study becomes feasible because low-cost sensors (MAX30100, ECG, SpO_2) and microcontrollers (ESP32, Arduino) have advanced at a fast pace.
- Hospital-based monitoring systems become unavailable for rural and low-resource areas because of their high costs and need for hospital facilities.
- The Internet of Things (IoT) system enables doctors and caregivers to receive real-time alerts through its cloud storage and data access services.
- The combination of predictive analysis with instant alerts enables doctors to stop patients from experiencing sudden cardiac death.
- Previous research studies have failed to establish compact portable monitoring systems which can track multiple parameters while maintaining secure data protection.
- The device development process focuses on creating an affordable and simple-to-use product which will serve many users.
- The program supports digital health projects which aim to achieve smart health care objectives.

B. Method of Analysis

- Worldwide heart disease rates continue to rise which creates a need for real-time monitoring systems that can effectively track heart-related medical conditions.
- The post-pandemic period requires healthcare systems to implement IoT-based solutions that enable remote monitoring of patients.
- The research study becomes feasible because low-cost sensors (MAX30100, ECG, SpO_2) and microcontrollers (ESP32, Arduino) have advanced at a fast pace.
- Hospital-based monitoring systems become unavailable for rural and low-resource areas because of their high costs and need for hospital facilities.
- The Internet of Things (IoT) system enables doctors and caregivers to receive real-time alerts through its cloud storage and data access services.
- The combination of predictive analysis with instant alerts enables doctors to stop patients from experiencing sudden cardiac death.

- ➢ Previous research studies have failed to establish compact portable monitoring systems which can track multiple parameters while maintaining secure data protection.
- ➢ The device development process focuses on creating an affordable and simple-to-use product which will serve many users.
- ➢ The program supports digital health projects which aim to achieve smart health care objectives.

B. Comparison and Analysis

TABLE I

Sr. No.	Title	Sensor/Tech Used	IoT/Platform	Key Findings
1	The 2023 Wearable PPG Roadmap (npj Digital Medicine)	Wearable PPG sensors	Cloud + ML	Roadmap for future wearable PPG—motion artifact handling, validation standards
2	Wearable PPG:Current Status & Future Challenges (CinC)	PPG + accelero meter fusion	Algorithm - based	High accuracy at rest, poor under motion; need standardized reporting
3	PPG—New Applications for Old Tech (PMC)	PPG (reflection & transmission)	Algorithm - based	Extended use for HRV, BP estimation, vascular health
4	IoT-based Emergency Cardiac Death Risk Alert (Science Direct)	ECG + HRV sensors	Cloud + IoT	Real-time alerts; ML improved early-warning sensitivity
5	ML-based Smart Wearable for Cardiac Arrest Detection (J.Biomed.Informatics)	PPG + accelero meter	Edge + Cloud ML	CNN + LSTM improved sensitivity, early detection
6	Sensors for Out-of-Hospital Cardiac Arrest (BMJ Open)	PPG, impedance, accel.	Multiple sensors	Sparse real-world trials, small sample sizes
7	IoT Healthcare Monitoring for QoL (Sensors, MDPI)	MAX30 100, ESP boards	Blynk/Thing Speak	Data security & interoperability challenges
8	IoT Patient Monitoring (Res. Conf.)	Pulse sensor + ESP826	Thing Speak/Blynk	Motion sensitivity; limited long-term storage
9	Pulse Oximeter via IoT (ICICCS)	MAX30 100 sensor	ESP8266 + Blynk	SpO2 errors at low perfusion & motion
10	PPG in Wearables (Electronics, MDPI)	PPG in wearable	Cloud + ML	BP & arrhythmia detection not yet clinically reliable

- ➢ Wearable sensors (chest straps and wristbands) provide more precise measurements through their direct electrical and optical detection methods, while non-contact systems (FMCW radar and Wi-Fi CSI) offer easier deployment at the cost of decreased measurement accuracy.
- ➢ Optical sensors are the most common sensor type used in consumer products, although their measurement results are vulnerable to interference from skin tone and motion and ambient light conditions. The clinical environment requires electrical sensors (ECG-based) which demonstrate superior accuracy and reliability for patient assessment.
- ➢ Current technological systems provide health and fitness monitoring through their ability to track bodily functions and store information while allowing medical professionals to examine data from distant locations.

Limitations

- ➢ The system contains several limitations which affect its performance.
- ➢ The system experiences accuracy problems because of motion artifacts and sensor placement and environmental conditions.
- ➢ The system needs power to function, which creates two problems for users because it needs power yet users find devices uncomfortable during extended periods.

C. Evaluation of methodologies used in the reviewed studies

- ➢ Wearable Sensor-Based Methods:
  - The ECG and PPG sensors found in chest straps and wristbands deliver precise heart rate data.
  - The system delivers accurate results which medical professionals and athletes can use for their respective activities.
  - The system faces two challenges because users experience discomfort when they use the system for extended periods and their movements cause the system to lose its precision.
- ➢ Non-Contact Monitoring Methods:
  - The system uses Wi-Fi CSI and FMCW radar techniques to identify heartbeats by tracking movements in the chest area.

- The system allows users to monitor their health continuously because it requires no physical equipment to be worn for monitoring purposes.
- The system's accuracy suffers when users operate at extended distances which face obstacles and experience surrounding environmental sounds.

➢ Smart Device Integration:
- The IoT systems use their capabilities to collect data which they analyze and send to users through both smartphone devices and cloud storage systems.
- The system enables users to monitor their health condition in real time while medical professionals can track their patients' health status through data analysis techniques.
- The system needs continuous internet access and an operational battery system to function properly which creates security threats for user data.

➢ Data Processing & Algorithms:
- The system uses digital filters together with peak detection algorithms to improve the quality of the received signals.
- The complex algorithms demand substantial computational power which makes them unsuitable for real-time processing.

E. Highlighting trends, advancements, and challenges Trends

The development of heart rate monitoring technology now uses non-contact wearable devices that work with IoT and smart devices instead of traditional contact-based devices. The practice of monitoring health and fitness together with sleep patterns has become more common. People now use heart rate variability (HRV) as a tool to measure their stress levels and cardiovascular health. The field of health technology now uses artificial intelligence and machine learning to create predictive models and personalized health recommendations and detect system anomalies. The demand for multi-parameter monitoring systems that track heart rate and SpO_2 and respiration and temperature has grown because these systems provide thorough health evaluations.

Advancements

Non-contact monitoring technology has achieved its main breakthrough through the creation of FMCW radar and Wi-Fi CSI remote sensing systems. Wearable optical and ECG sensors now provide higher accuracy with improved comfort. The system enables users to store data in real time while they analyze information through their smartphones and cloud platforms and use telemedicine services. The algorithms used for signal preprocessing and peak detection and HRV computation have developed into more powerful systems which now deliver better accuracy. The development of sensor miniaturization together with low-power designs enables extended monitoring capabilities. AI-driven analytics and predictive modeling provide personalized health insights while detecting anomalies at an early stage.

Challenges

Heart rate monitoring technology has improved yet it still encounters existing issues. Sensor accuracy testing shows that motion artifacts and skin color differences and environmental conditions all impact sensor performance. Non-contact methods experience restricted operational range and decreased ability to detect obstacles. The use of wearable devices leads to problems with user comfort and their power supply systems and the ability to use them over extended periods. The Internet of Things systems that use IoT technology face problems with data protection and system security and network connectivity issues. Low-power devices experience performance issues because their operational needs exceed their available computational capacity. The system needs both device standardization and clinical-grade system validation to achieve dependable performance. The industry faces difficulties because it needs to find a solution which provides accurate results while being easy to use and affordable to consumers.

V. Discussion

A. Synthesis of findings from literature

The emergency aid system is designed to provide realtime monitoring and rapid response for patients at risk of cardiac events. The system architecture includes Bluetooth equipped wearable ECG detectors which transmit patient data to edge computing services and community physician software interfaces. The extended module needs future implementation but current integration remains incomplete. The wearable ECG device continuously captures cardiac signals which it transmits through Bluetooth to the edge or fog computing terminal that operates as a data management broker. The cloud server and physicians subscribe to patient health data topics which they need for their work.

Cloud computing manages the processing and predictive analysis of patient ECG data as demonstrated in Fig. 2. The front end can use an additional filtering component to decrease noise levels which will improve signal quality. The system creates more precise predictions which lead to timely emergency alert notifications. The system design requires ongoing monitoring while using minimal power to maintain dependable connections between patients and edge servers and healthcare providers.

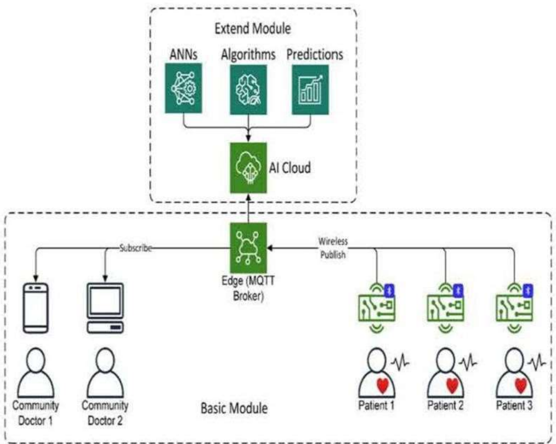

Figure 1. The whole architecture of the emergency aid system [4]

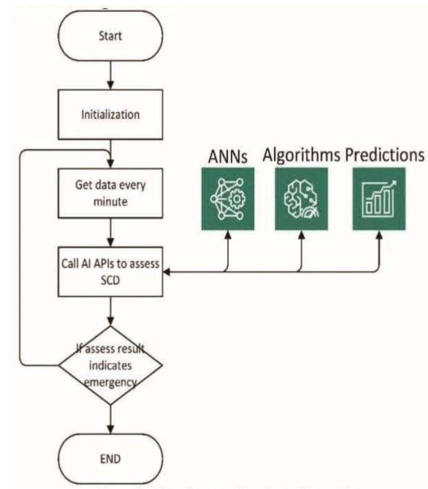

Figure 2: Cloud computing logic flow [4]

B. Methodology for future research directions Proposed System

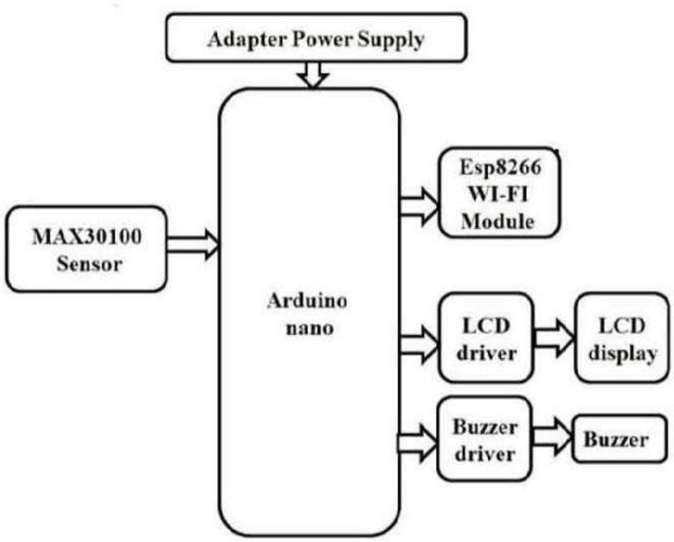

Figure 3: Cloud computing logic flow [4]

Working

- Sensor Data Acquisition: The MAX30100 pulse oximeter sensor continuously measures heart rate and blood oxygen saturation (SpO_2) from the patient.

  The sensor establishes communication with the ESP8266 microcontroller through I2C protocol by utilizing SCL (GPIO5/D1) and SDA (GPIO4/D2) pins.

- Microcontroller Processing: The ESP8266 functions as the main controller which executes embedded C programs that are stored in its built-in memory.
  The device captures live data from the sensor and presents it on an LCD screen for nearby observers to see.
- IoT Data Transmission: The ESP8266 uploads heart rate and SpO_2 information to the Blynk cloud platform through its Wi-Fi module.
  Users can use their smartphones to monitor patient data remotely through the Blynk app interface.
- Emergency Detection & Alert: The system activates a local buzzer when it detects abnormal readings which include extremely high or low heart rate and low SpO_2 levels.
  The Blynk app transmits real-time alerts to caregivers and healthcare providers who need to take immediate action.
- Power Management: The system receives power through USB and battery sources which operate at minimal power usage to support ongoing monitoring.

Methods Used

- The MAX30100 pulse oximeter sensor was used to monitor patient heart rate and SpO_2 levels through its Sensor Integration feature.
- The ESP8266 microcontroller received embedded C programming which I used to create a system that processes sensor data in real time.
- The I2C protocol SCL and SDA pins established sensor-microcontroller communication to enable precise data transfer between these two devices.
- I used the ESP8266 Wi-Fi module to transmit real-time data to the Blynk cloud platform which enabled remote monitoring.
- The system used an LCD screen to show heart rate and SpO_2 values which enabled users to receive instant feedback.
- The system sent buzzer alerts and Blynk notifications to caregivers when abnormal readings occurred through its Emergency Alert System.
- The system uses both battery and USB power sources to enable continuous monitoring which designers built for low-power operation.

VI. CONCLUSION

The research shows how IoT technology has improved heart rate monitoring systems and cardiac arrest detection systems through its use of wearable sensors and microcontrollers and real-time data communication systems. The MAX30100 pulse oximeter and ESP8266 microcontroller system enables healthcare professionals to monitor patients continuously because it tracks heart rate and SpO_2 levels, which helps them identify cardiac irregularities early. The Blynk app integration enables patients to access their medical information remotely, which helps medical staff respond promptly to emergencies while increasing patient security. The design of wearable devices includes lightweight and compact components, which enable users to move freely while using the device, and the device uses minimal energy, which permits extended operation without battery changes. The system provides real- time alerts through both buzzer sounds and app notifications, which notify caregivers and healthcare providers about emergency situations. The technology shows advancement yet still faces three major difficulties because it needs to resolve issues with motion artifacts and environmental interference and data security problems. The combination of wearable sensors and cloud monitoring systems and AI predictive analytics creates a medical solution that continuously monitors cardiac health in elderly patients and people who have heart problems.

REFERENCES

[1] P. H. Charlton, P. A. Kyriacou, et al., ―The 2023 wearable photoplethysmography roadmap,‖ npj Digital Medicine, 2023. [Online]. Available: PMC
[2] P. H. Charlton and P. A. Kyriacou, ―Wearable Photoplethysmography: Current Status and Future Challenges,‖ Computing in Cardiology (CinC) Proceedings, 2023.
[3] A. Elgendi, et al., ―Photoplethysmography—new applications for an old technology,‖ Journal, 2022. [Online]. Available: PMC
[4] S. U. Rehman, I. Sadek, B. Huang, S. Manickam, and L. N. Mahmoud, ―IoT-based emergency cardiac death risk rescue alert system,‖ Procedia Computer Science, ScienceDirect / Elsevier, 2024.
[5] A. Hannan, S. M. Cheema, and I. M. Pires, ―Machine learning-based smart wearable system for cardiac arrest detection,‖ Journal of Biomedical Informatics, Elsevier, 2023.

[6] J. Hutton, S. Lingawi, J. H. Puyat, C. Kuo, B. Shadgan, J. Christenson, and B. Grunau, ―Sensor technologies to detect out-of-hospital cardiac arrest,‖ BMJ Open, 2022. [Online]. Available: PMC
[7] S. Abdulmalek, A. Nasir, W. A. Jabbar, M. A. M. Almuhaya, A. K. Bairagi, M. A.-M. Khan, and S.-H. Kee, ―IoT-Based Healthcare-Monitoring System towards Improving Quality of Life,‖ Sensors, MDPI, 2022. [Online]. Available: PMC
[8] P. Macheso and A. Meela, ―IoT Based Patient Health Monitoring using ESP8266 and Arduino,‖ International Journal / Conference, 2021. [Online]. Available: ResearchGate
[9] D. R. Reddy, N. Saketh, and D. Vijay Sai, ―Design and Development of Pulse Oximeter Using Internet of Things,‖ ICICCS Conference, 2022. [Online]. Available: ResearchGate
[10] K. B. Kim and H. J. Baek, ―Photoplethysmography in Wearable Devices,‖ Electronics, MDPI, 2023
[11] Pravin Tajane, ―Compact Size of Multiband Planar Monopole Antenna for Portable Device Applications,‖ Progress In Electromagnetics Research C, vol. 156, pp. 207–216, 2025.
[12] Pravin Tajane, ―Transforming healthcare: Harnessing the power of IoT in the healthcare system,‖ AIP Conference Proceedings, vol. 3214, no. 1, 2024.
[13] Pravin Tajane, ―Size reduction in multiband planar antenna for wireless applications using current distribution technique,‖ Lecture Notes in Bioengineering, pp. 151–160, 2021.
[14] Pratiksha Girsaware, Kushal Masarkar, Suraj Mahajan, ―Review On Real Time Monitoring System for Medical Treatment using smart Syringe pump,‖ www.isteonline.in, vol. 48, special issue no. 2, pp. 323–326, March 2025.
[15] Pragati Patil, Ritesh Banpurkar, Suraj Mahajan, Technological Innovations & Applications in Industry 4.0, eBook, ISBN 9781003567653, Taylor & Francis, 27 January 2025.
[16] Pravin Tajane, ―Design and implementation of multiband planar antenna with DGS for wireless applications,‖ Lecture Notes in Electrical Engineering, vol. 546, pp. 503–512, 2020.
[17] Pravin Tajane, ―Design of Multiband Planar Antenna by using Mirror Image of F Shaped with Inverted U Shaped and Modified Ground Plane,‖ in IEEE International Conference on Electrical Computer and Communication Technologies (ICECCT), 2019.
[18] Pravin Tajane and P. L. Zade, ―Design of multiband antenna with U shaped strip and L shaped strips for WLAN/BLUETOOTH/WIMAX/HYPERLAN,‖ in International Conference on Trends in Electronics and Informatics (ICEI), Tirunevely, India, 11 May 2017.