RESEARCH PAPER

Healnexus: Remote Health Monitroring System

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Abstract

The rise of Internet of Things (IoT) technology day by day, our thinking also is changing about healthcare monitoring. Traditional health monitoring system was bulky, expensive. New system we measure anywhere, anytime and low cost. Continuous tracking of vital health parameter like heart rate, ECG, temperature, and movement isn't just a convenience-it also becomes crucial for catching problems early and making remote care possible. This project gives a portable, affordable, and efficient IoT-based health monitoring system. Use of embedded hardware and biomedical sensors, HealNexus connects to the cloud and gives user-friendly health data. At first an Arduino UNO collects data from different IoT sensors than it pulls all data to gather, processes it, and packs it into structured form. The Arduino sends it to an ESP32 Wi-Fi module, which send it up to Firebase Realtime Database that showed in the frontend HealNexus Dashboard. we also view the health in HealNexus mobile app. To make patient easier the system dashboard add a multilingual AI chatbot gives dashboard queries, Health related questions and gives the data the information stays focused and reliable. It allows health supervision to move beyond hospital walls.

Keywords: MPU6050, DS18B20, AD8232 ECG, MPU6050, ArduinoUNO, ESP32, BPM

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Introduction

"HEAL" stands for health, wellness and recovery "NEXUS" stands for a network links with different systems. So, what work does HealNexus actually do? It connects different biomedical sensors—ECG, heart rate, body temperature, and motion [4]. It collects, processes and evaluates all these sensor data sends everything to the Firebase (a cloud platform), and it makes remote, continuous health monitoring possible through the dashboard [5]. Remote health monitoring system has become a game changer in biomedical engineering field and IoT based healthcare. Cardiovascular issues, stress, and lifestyle diseases are shown everywhere now a days, Vital signs need monitoring continuously, not only during hospital visits. People want ways to monitor their health at home, at work, and even they go anywhere [3]. Traditional checkups are not giving the real-time changes that matterwang2025chatbots. The necessary for affordable, portable, and smart monitoring systems keeps growing now a days. people want the systems that watch health signals non-stop and send the data to cloud to store for further review [1].HealNexus was built for learning platform and a working model to solve this problem. The system brings together of sensing microcontroller-based basic signal processing, wireless transmission of data, cloud integration, mobile access and AI interpretation [2]. At first its core is the Arduino Uno, choices for its simple and .
reliable. Each sensor has a different task that the AD8232 records ECG waveforms of activity of the heart, the KY-039 pulse sensor measures heart rate with the use of infrared light, the DS18B20 gives the body temperature readings and the MPU6050 gives body movement and activity tracking with the help of accelerometer and gyroscope [3].

But HealNexus not only use a bundle of sensors but also use ESP32 module acts as a network gateway and pulling processed sensor data from the Arduino through serial communication and push to the Firebase Realtime Database [4]. This setup works like modern IoT based healthcare systems that follows local devices collect the data, remote servers store the data and analyze it [5]. In this project, Firebase stores the health data along with the time also recorded and allows to real-time moni-toring, dashboard displays, mobile apps and AI-chatbot[6].

It is also to be user friendly, HealNexus includes a dedicated mobile app. This app gives users real-time sensor readings, graphical heart data, and alerts for abnormal health states. Patients, and doctor can access this data remotely, which makes the system useful for remote monitoring (at home) and telemedicine [7].

HealNexus also features a multilingual AI- chatbot, built specifically for dashboard data. Users can ask questions about their ECG, heart rate, temperature, and motion in different preferred languages [8]. The chatbot is only explaining the data of dashboard but not giving speculation, not giving medical diagnoses [8].

Above all, Modularity and scalability also need. HealNexus is designed as simple you can swap or add sensors without tearing the whole thing apart [8]. Its working process is similar to a professional medical IoT based system that capture the signals, digitize the signal, preprocess the signal, encode into JSON format, send them wirelessly, and store them securely inside cloud platform. The project gives students and researchers

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combination of electronics,programming, communication protocols, mobile computing, and AI—all are using in a one system. It can help in rural health monitoring for senior people health monitoring is very necessary but medical is not present there [8]. This is a prototype that not for clinical diagnosis but it gives lays the groundwork for understanding devices like fitness bands, or telemedicine platforms. HealNexus is not only just a technical related project but also gives practical step toward smart healthcare [8].

Narrowband-Internet-of-Things (NB-IoT) is an efficient technology for empowering Upcoming low-power-wireless-area networks (LPWANs). NB-IoT purposes to offer continuous connectivity to huge IoT system. It requires very low power and throughput, but it has far-off communication ability. NB-IoT is constructed on Long-Term-Evolution (LTE) with bandwidth 180 KHz-200KHz[9]. So, they can able to implement in LTE band. Though, forthcoming Heterogeneous-Networks (HetNet) are covering of numerous small- cells working under environment. Here, deployment of NB-IoT reduces inter-cell- interference from cell users. This raises serious concerns on the performance of NBIoT.In our work, we can measure health parameter using NB-IoT which can collect patient data from remote area. The outcomes express important impact on performance in environment NB-IoT.It operates in three modes. These are Standalone, Guard-band, In-band. Selection of mode depends on frequency band,mode of use, and network availability.

The project was successfully developed and implemented to achieve its following intended objectives:

1. Successfully developed and implemented a real-time health monitoring dashboard capable of collecting, processing, and visualizing health data with minimal latency.
2. Integrated a multilingual AI-powered chatbot to assist users with health-related inquiries andprovide analytical insights from dashboard data in multiple languages.
3. Demonstrated the implementation of NB-IoT (Narrowband Internet of Things) technology, enabling reliable data transmission and system deployment in rural and remote areas with limited internet connectivity.
4. Achieved seamless integration of hardware components, cloud services, and software applications to create a comprehensive and scalable healthcare monitoring solution.
5. Improved accessibility and user engagement through an intuitive dashboard interface and intelligent conversational support.
6. Established a cost-effective and energy-efficient framework suitable for continuous remote health monitoring and future healthcare applications.

The paper is organized in different sections. Section II elaborates the related work in the downlink. It includes CF-mMIMO design using different algorithms. Section III offers a network model and Lastly, Section V contributes numerical-results and simulation results.

1. Related Work

In paper [8], we got the idea that in globally Cardiovascular diseases are a major health problem. ECG is very important for monitoring the heart and helps to detect heart problems like irregular heartbeat and cardiac abnormalities. It is low-cost and portable ECG monitoring systems. IoT technology helps in remotely and real-time monitoring of patient's health data by doctor. Existing systems have Limitations like limited Bluetooth range, use of Raspberry Pi it is very expensive and unsuitable for low-resource area. The system uses ESP8266 as a microcontroller as a low cost. It is High accuracy, performance and Supports telemedicine.

In paper [5], we got the idea that use of IoT in the case of health monitoring. It is designed to monitor patient health remotely and also notify doctors when abnormal conditions are detected. Multiple sensors like ECG sensor for measures heart electrical activity, PPG sensor for measures heart rate using light, Temperature sensor for measures body temperature, Gyroscope/Accelerometer for detects body movement[10]. It focusses on detecting arrhythmia (heart rhythm disorder) and analysis of HRV (Heart Rate Variability). It also studied key HRV parameters like SDNN,SDANN,RMSSD,LF/HF ratioBoth ECG and PPG sensors also give reliable results.

In paper [10], we got the idea that use of IoT technology to monitor ECG. This system helps in diagnosing cardiopulmonary (heart and lung) problems. AD8232 ECG as a sensor and ESP32 microcontroller. It also monitoring in Real-time through internet and smartphone. It measures multiple health parameters like ECG signal, Heart rate (BPM), Body temperature, Pulse rate. It is such that as a low-cost and user-friendly system.

In paper [11], we got the idea that Uses different sensors like HW-827 Heart Rate Sensor for measures heart rate, DS18B20 Temperature Sensor for measures body temperature and ESP32 for data collection and transmission. After operation of the patient, it can monitor the health condition. Inside this data collected from different patient groups that can divides into three parts there are Healthy individuals, Pré-operative heart disease patients, post-operative heart disease patients and Each group had 20 participants. Physiological differences were observed between different groups that Healthy individuals have stable temperature and lower heart rate, pre-operative patients have highest heart rate and ECG values and post-operative patients have slightly higher temperature and heart rate than healthy individuals. This System supports real-time monitoring and telemedicine, also Improves personalized healthcare management.

In paper [12], we got the idea that Growth of wearable health monitoring using IoT. The system is also designed for heart disease patients and fitness athletes. This is providing high-quality, low-cost, and multipurpose health monitoring. Inside this Uses of Raspberry Pi and HealthyPi with biomedical sensors. The Sensors measure parameters like ECG, Heart rate, Body temperature, Blood oxygen. inside this Experiment was conducted on 15 test subjects and Data collected from people of different age, gender, and fitness levels.

The Data sent to IoT cloud platform [13]and dashboard and fuzzy logic use to detect physical activity

and health status. It can detect abnormal health conditions of body and physical activity states and Doctors can monitor patients remotely.

In spite of these substantial developments, we have some research gap. We focus on advancement in health monitoring in urban as well as rural areas. We try to develops a model which can reach rural area where network coverage is very poor or network unable to reach such as in dark forest, remote healthcare. Many studies emphasis on efficiency without estimating power budget, and limitation on real-time hardware.

2. Hardware Realizations

The HealNexus system uses of different hardware components that collect body signals, process the sensor data and send it to the cloud platform. The hardware architecture is designed such that accurate measurement, reliable communication, and real-time health monitoring. The major hardware components used in the system are Arduino uno and ESP-32 as a microcontroller, sensors like AD-8232 ECG module, KY-039 Pulse sensor, DS-18B20 temperature sensor, MPU6050 module to collect the data and Breadboard, Jumper wire used for Used for the connection. Inside the Table.1. Hardware Components and its uses[8].

The major hardware components used in the system are described as follows.

Figure 1: Arduino Uno

Fig.1. indicates the picture of Arduino Uno. It acts as the as the primary microcontroller. It is responsible for sensor data acquisition and initial processing. Microcontroller name is ATmega328P, operating at a clock frequency of 16 MHz and a supply voltage of 5V. The board has provided 14 digital input/output pins and 6 analog input pins these are used to interface with different biomedical sensors such as ECG, pulse, temperature, and motion sensors. It has 10-bit analog-to-digital converter (ADC) allows the Arduino Uno to convert analog signals from sensors into digital values. These processed signals are then transmitted to the ESP-32 module via serial communication.

Table 1: Description of Hardware Components

Hardware Components	use
Ardino uno	Collect,read,process data
ESP-32	Send data to cloud
AD-8232 ECG	Measure heart activity
KY-039	Measure heart rate
DS-18B20	Measure body temperature
MPU6050	Measure body movement
Jump wire	For connection

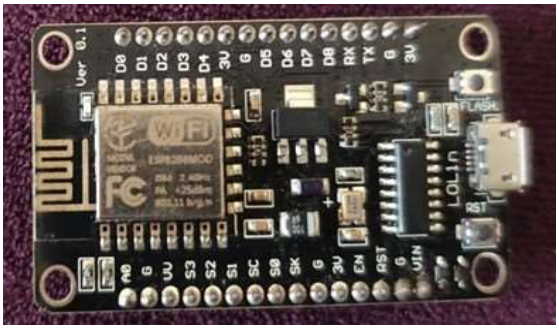


Figure 2: ESP32 Development Board

Fig.2. indicates the picture of ESP32 Development Board. The ESP32 development board act as a IoT communication gateway in the HealNexus system. It has a dual-core microprocessor that integrated Wi-Fi and Bluetooth connectivity. It receives sensor data from the Arduino Uno through UART communication and use of Wi-Fi uploads the data to the Firebase Realtime Database. It has capability of high data processing and suitable for cloud-based IoT applications. It is widely used in real-time data transmission, remote monitoring, and integration with dashboards and cloud platforms.
AD8232 ECG module is used to measure the electri- cal activity of the heart. AD8232 ECG module captures ECG signals using electrodes attached to the body that produce analog signal. The Arduino Uno reads that out- puts analog signal. This sensor provides accurate ECG waveforms, which are essential for monitoring cardiac activity and detecting abnormal condition. This sensor widely used in biomedical and wearable health monitor- ing systems.
Fig.3. indicates the picture of KY-039 Pulse sensor. It is used to measure heart rate. The used inside this is called photoplethysmography (PPG) technique. It con- tains of an infrared LED and a photodetector that mea- sures inside the body changes in blood volume caused

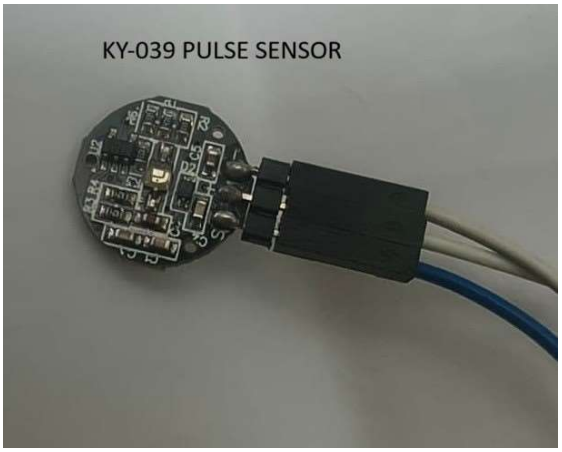


Figure 3: KY-039 Pulse sensor

by heartbeats. The sensor produced outputs as a ana- log signal that is processed by the Arduino Uno. Ar- duino Uno can calculate heart rate in beats per minute (BPM)[8].
Fig.4. indicates the picture of DS18B20 temperature sensor. This sensor we used to measure our body tem- perature in digital form accurately. It communicates with the Arduino Uno using a one-wire communication protocol that requires only a single data pin. This sen- sor has high accuracy and stable readings. A 4.7K ohm pull-up resistor also is used between the data pin and power supply to ensure proper communication.
Fig.5. indicates the picture of MPU6050 module. It is a 6-axis motion tracking sensor that combines a 3- axis accelerometer and a 3-axis gyroscope. It uses to measures body movement, orientation, and acceleration. I²C communication protocol is used to sensor communicates with the Arduino Uno. It is used to detect physical activity of body, posture, and motion patterns these are useful in health monitoring and activity track- ing applications[8]. Breadboard and Jumper Wires are used for circuit assembly and interconnection of compo-

Figure 4: DS18B20 temperature sensor

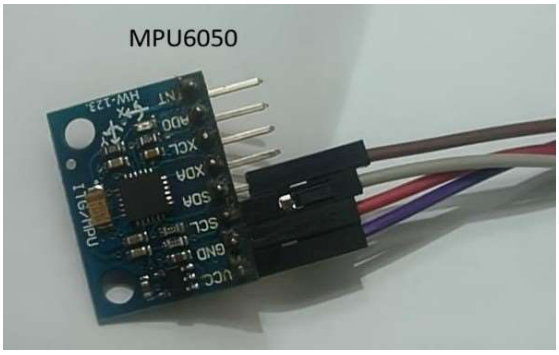


Figure 5: MPU6050 module

Figure 6: H. NBIoT HAT 7000E Module

nents. The breadboard allows prototyping without sol- dering. The jumper wires provide electrical connections between sensors, microcontrollers.

Fig.6. indicates the picture of the NB-IoT HAT 7000E module. It is used for wireless communication and data transmission over the Narrowband Internet of Things (NB-IoT) network. The module enables long- range, low-power connectivity, making it suitable for IoT applications deployed in remote and rural areas. It facilitates reliable transmission of sensor data from the microcontroller to cloud servers, even in locations with limited conventional internet infrastructure.

3. System Model

The HealNexus is focused on health monitoring in good or poor network area.It can reach remote areas.As well as it can able solve the query arise among user.It can reach low frequency region,We try to provide uni- form resources in every field of application.We try to give and update health parameter.

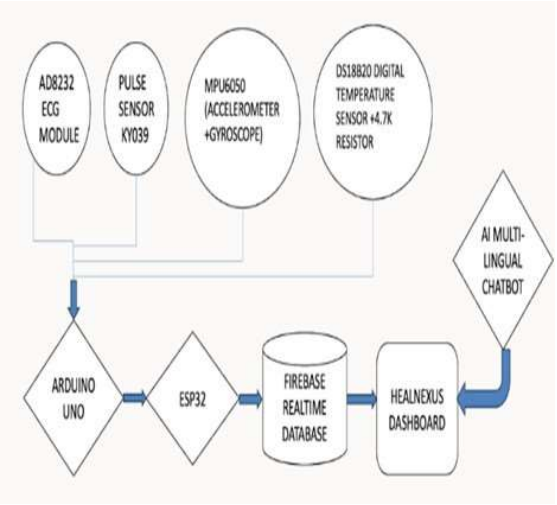


Figure 8: System Methodology

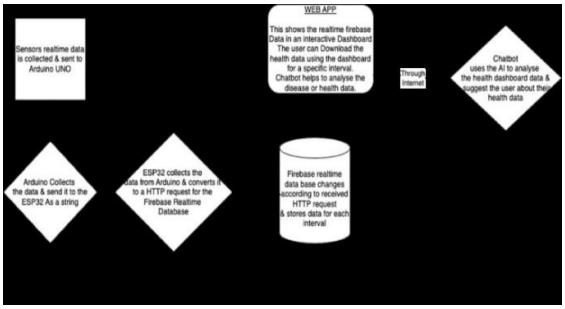


Figure 7: System Architecture

Fig.6. indicates the picture of system Architec- ture. The Arduino UNO collect the all the sensor data (AD8232 ECG, pulse sensor KY-039, DS18B20 temperature sensor, and MPU6050 motion sensor) that send to the ESP-32 with the delay of one second and also print serial monitor in Arduino IDE with the baud rate of 9600.ESP 32 collects the data from the Arduino UNO as a string (ECG, LO+, LO-, BPM, Temp, AccX, AccY, AccZ, GyroX, GyroY, GyroZ, Steps) e.g. 320, 1,0, 40, 40,1, 0,1,1,2,3,3. Then the ESP throws the data into a Realtime database of firebase that showed in the frontend Heal Nexus Dashboard. The Multilingual AI chatbot only deals with the dashboard data avoiding giving any sensitive advice and focused towards analyzing the dashboard data.

Fig.7. indicates the picture of system Methodology. At first all the sensor (AD8232 ECG, pulse sensor KY-039, DS18B20 temperature sensor, and MPU6050 motion sensor data) collected by the Arduino uno. Arduino uno sends the sensor data to ESP-32 as a string. Through wi-fi ESP-32 sends the data to firebase Realtime database. firebase Realtime database connect to the HealNexus dashboard to show real time data. HealNexus dashboard also add the multilingual chatbot to solve the dashboard related queries.

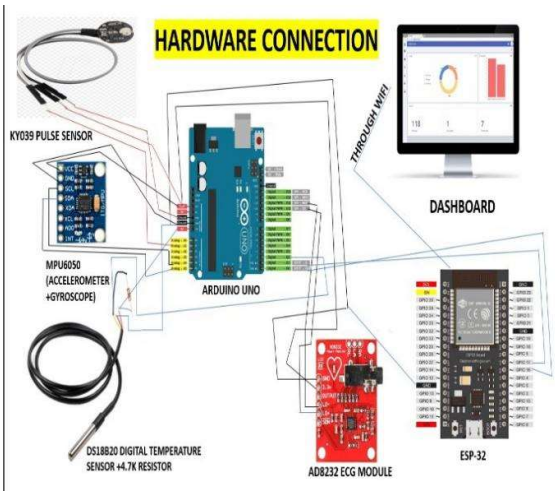


Figure 9: Hardware Connection

Figure 10: Hardware Connection in real time

Fig.8 and Fig.9 indicates the picture of Hardware Connection. AD8232 OUT data connect with Arduino UNO with A0 pin. AD8232 LO+, LO- connect with D11 and D10 pin of Arduino UNO. KY-039 Pulse Sen- sor data connect with Arduino UNO A1 pin. MPU6050 SDA and SCA connect with Arduino UNO by A5 and A4 pin. All ground should be connected with GND. All Power should be connected with 5V or 3.3V depending on sensor. ESP-32 GPIO17 and

GPIO16 pin Connec- tion with Arduino UNO by Tx and Rx pin.

Table 2: Arduino UNO Connections

Sensor	Arduino UNO Pin
AD8232 OUT data	A0
AD8232 LO-	D11
AD8232 LO+	D10
KY-039 Pulse Sensor data	A1
DS18B20 Data	D2(with 4.7k ohm pull-up)
MPU6050 SDA	A5
MPU6050 SCL	A0
All Sensor Grounds	GND
Power	5V or 3.3V depending on sensor

Table 3: Arduino UNO → ESP-32 Connection

UNO Pin	ESP32 Pin
UNO TX	GPIO17
UNO RX	GPIO16

4. Results and Discussion

Here, we analyze the performance HealNexus system using different health parameter under two techiques, namely ESP-232 and NB-IoT allocation.

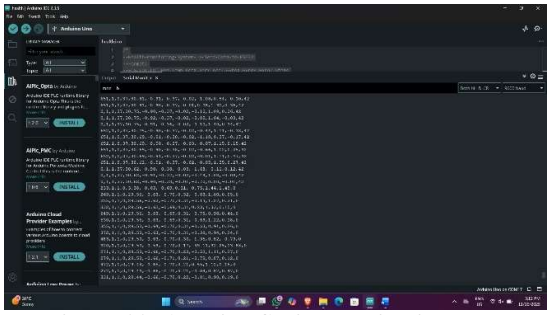


Figure 11: Arduino Serial Monitoring Data

Fig.10 indicates the picture of Arduino serial m[]onitoring data. At first the Arduino Serial Monitor output; you can see the Arduino UNO grabbed real-time data from all the connected sensors without a delay. The numbers kept entering, that shows the sensors were send data right and actually working. Each line in the output is a set of commas to separated values—represent these numbers readings from different sensors like ECG signal amplitude value, pulse sensor changes pulse rate, body temperature, and the three-axis of acceleration and gyroscope data from the MPU6050 sensor. Flow of data in the Serial Monitor means the Arduino kept up solid communication with the sensors at the time. The Arduino reads the sensor data and handled analog-to-digital convert smoothly. You can also see from the sensor values changing that means the system responds in real time body signal. capturing together all the data from all the sensors gives the one serial output.

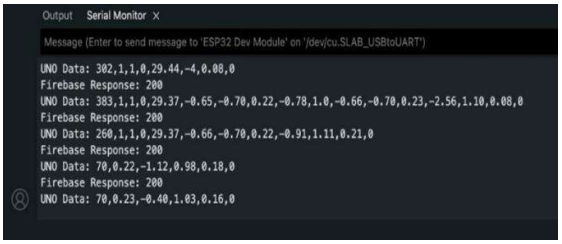


Figure 12: Enter Caption

Fig.11 indicates the picture of Arduino to ESP-32 sending data in serial monitoring. ESP32 Serial Mon-

itor output, you can see the ESP32 take the sensor data straight from the Arduino UNO by connecting with Tx and Rx of each other than passing it along as a network gateway for cloud(firebase) upload using Wi-Fi. The monitor flashes incoming packets marked "UNO Data," which proves that reliable serial communication between the UNO and the ESP32. Once the ESP32 takes a data packet, it processes the information and fires off an HTTP PUT request to upload it to the cloud (Firebase Realtime Database). The Serial Monitor keeps reporting "Firebase Response: 200," which means that upload worked; a 200 code just means Firebase got the data and stored it without any issue. So, the ESP32 takes the role as a wireless gateway that takes sensor data from the Arduino, converts it into JSON and sends it off to Firebase over Wi-Fi.

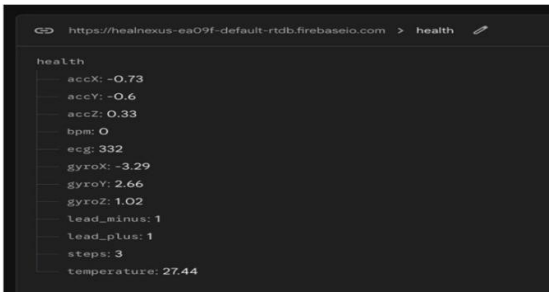


Figure 13: Firebase Realtime Data Base

Fig.12. indicates the picture of Firebase Realtime database. The figure illustrates that successful configuration and operation of the Firebase Realtime Database for the HealNexus system. The database structure shows that the sensor data transmitted from the ESP32 was received correctly, stored, and organized. It is storing parameters include acceleration values along the X, Y, and Z axes (accX, accY, accZ), gyroscope readings (gyroX, gyroY, gyroZ), ECG signal value (ecg), body temperature, and step count. The presence of these parameters data inside the database. It verifies that multi-sensor data from the Arduino was successfully processed by the ESP32 and correctly formatted before being sending to Firebase. The numerical values displayed in the database dynamically changed over time during operation of the system, indicating real-time data updating rather than static storage the data.

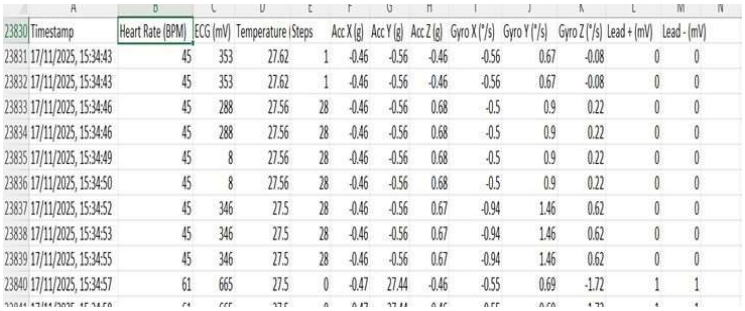
Figure 14: Dashboard Of Healnexus

Fig.13. indicates the picture of Dashboard of HealNexus .The figure shows the HealNexus Health Monitoring in action inside the Dashboard. It pulls in real-time data. The dashboard take everything straight from the Firebase Realtime Database. you see a true end-to-end system—from the sensors themselves, all the way

up to the cloud display. Inside this Live Vital Signs section like heart rate (BPM), ECG (in mV), body temperature (°C), and step count, all updatingDASHBOARD OF HEALNEXUS as new data comes in. The dashboard shows live acceleration along the X, Y, and Z axes (accX, accY, accZ), plus angular velocity from the gyroscope (gyroX, gyroY, gyroZ), each with their own units. The numbers keep shifting, so you know it is monitoring continuously. The Heart Rate and ECG Monitor graph tracks both ECG signals and heart rate trends in real time . You can watch the lines move; see the spot changes in cardiovascular activity in the graph. The live graph proves the system can capable to capture, transmit, and plot high-frequency biomedical data without missing a beat. For body temperature, the graph maps changes across each particular time. This proves the DS18B20 sensor's reliability, and it fits smoothly into the cloud analytics pipeline. The Daily Steps count the step count goal of the particular day. It shows your progress as a percentage. It is clear that the system tracking health and also a practical tool for fitness.

Figure 15: Multilingual Chatbot

Fig.14 indicates the picture of Multilingual chatbot for Health Assistant running inside the HealNexus dashboard. It has we are using 6 different languages (English, Hindi, Odia, Telugu, Tamil, Bangali) user can question related to dashboard health related data using any of these languages. Users interact with a clean, straightforward chat interface. The system responds quickly, taking real time data from the cloud and answer it user's need. It can answer only dashboard related question, Health related questions and gives the data the information stays focused on this topic.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
23830	Timestamp	Heart Rate (BPM)	ECG (mV)	Temperature (Steps		Acc X (g)	Acc Y (g)	Acc Z (g)	Gyro X (°/s)	Gyro Y (°/s)	Gyro Z (°/s)	Lead + (mV)	Lead - (mV)	
23831	17/11/2025, 15:34:43	45	353	27.62	1	-0.46	-0.56	-0.46	-0.56	0.67	-0.08	0	0	
23832	17/11/2025, 15:34:43	45	353	27.62	1	-0.46	-0.56	-0.46	-0.56	0.67	-0.08	0	0	
23833	17/11/2025, 15:34:46	45	288	27.56	28	-0.46	-0.56	0.68	-0.5	0.9	0.22	0	0	
23834	17/11/2025, 15:34:46	45	288	27.56	28	-0.46	-0.56	0.68	-0.5	0.9	0.22	0	0	
23835	17/11/2025, 15:34:49	45	8	27.56	28	-0.46	-0.56	0.68	-0.5	0.9	0.22	0	0	
23836	17/11/2025, 15:34:50	45	8	27.56	28	-0.46	-0.56	0.68	-0.5	0.9	0.22	0	0	
23837	17/11/2025, 15:34:52	45	346	27.5	28	-0.46	-0.56	0.67	-0.94	1.46	0.62	0	0	
23838	17/11/2025, 15:34:53	45	346	27.5	28	-0.46	-0.56	0.67	-0.94	1.46	0.62	0	0	
23839	17/11/2025, 15:34:55	45	346	27.5	28	-0.46	-0.56	0.67	-0.94	1.46	0.62	0	0	
23840	17/11/2025, 15:34:57	61	665	27.5	0	-0.47	27.44	-0.46	-0.55	0.69	-1.72	1	1	

Figure 16: Excel Sheet Report

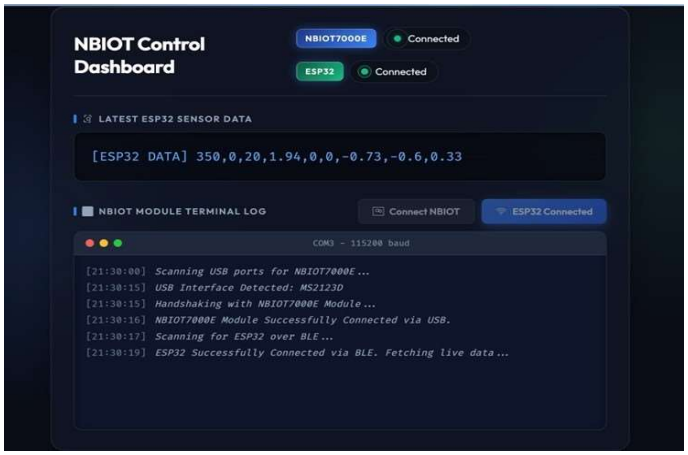


Figure 17: NBIoT Dashboard

This dashboard includes all the output data that communicates with ESP 32 from hardware sensors to the local medium device and send the data to the specified mobile no using the hardware capacity of NB IOT module through a specified small frequency for a specific time with regular small intervals with changing real time sensor data.

5. Conclusions

Previously, focus was based on the advancement of precoding approaches in CF-mMIMO. Even if, it doesn't have unique inference for such type. To accomplish requirement of users in near future-wireless network system, we try to transfer from cellular-network to CF-network, commonly DAS design. Scalable CF-mMIMO can connect more distributed MIMO systems. Due to mMIMO, it has ability to increases diversity-gain of system. So over-all, these methods are considered to fulfil basic requirements such as SE, data rates, throughput, power allocation and scalability. Our work projected on MMSE, RZF, hybrid approach for signal-precoding to transfer to CPU. Results obtained based on simulations shows a comprehensive study on different parameter based on power allocation. It focused on power budget of APs.With restrictive power, it improves SE with respect to UEs with less complexity. Our work has added novelty that hybrid processing greatly performs in terms of SE and sum-rate. It also can implement in wider field. MMSE and RZF processing method also helps to find better data rates. Our work explores radiation-aware using optimized method and precoding.

In future we will try to implement CF-mMIMO technique using optimization technique to energy efficient using max-min control of power.

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