IOT Based Health Care Wristband for Elderly People Using ESP32

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Abstract:-

With the increasing elderly population worldwide, there is a growing need for advanced healthcare solutions that offer real-time monitoring and timely medical assistance. This project focuses on the design and implementation of an IoT-based healthcare wristband for elderly people, utilizing the ESP32 microcontroller. The wristband is designed to monitor essential health parameters such as heart rate, body temperature, and physical activity. The system provides real-time data acquisition, analysis, and remote monitoring,enabling caregivers and medical professionals to track the health status of elderly patients from any location. In recent years, the integration of the Internet of Things (IoT) into healthcare systems has brought about transformative solutions for patient monitoring, especially for elderly individuals who often require continuous medical attention. This project presents the development of an IoT based health care wristband designed specifically for elderly people, utilizing the ESP32 microcontroller. The goal is to create a low-cost, compact, and efficient wearable device capable of real-time monitoring of vital health parameters while ensuring ease of use and reliability.The primary goal of this project is to enhance the quality of life for elderly individuals by providing continuous health monitoring and ensuring timely medical attention when needed.

Key Words:- IoT, ESP32, WiFi, SMS, GPS, MCU, API, HTTP

1.INTRODUCTION:-

1.1. Objective:-

To design and develop a low-cost, real-time health monitoring wristband using the ESP32 microcontroller, aimed at improving the quality of life and safety of elderly individuals by continuously monitoring vital health parameters and enabling remote health management through IoT connectivity.

Real time data transmission that can be done by the ESP 32 built-in WiFi/Bluetooth to a mobile phone or cloud server for remote monitoring by care givers. Fall detection can be done by integrating the accelorometer or the gyroscope sensor to alert automatically for caregivers.Data visualization by Storing historical health data in the cloud and provide visual reports through a user-friendly interface or dashboard.Low power consumption by optimizing the system for battery efficiency to ensure long-term usage without frequent charging,Emergency button for the elderly people at their emergency situations.

1.2. Description:-

The IoT-based healthcare wristband for elderly people using ESP32 is a smart wearable device designed to monitor vital health parameters in real time. It utilizes the ESP32 microcontroller, which offers built-in Wi-Fi and Bluetooth capabilities for seamless data transmission. The wristband continuously tracks vital signs such as heart rate, body temperature, and blood oxygen (SpO2) levels. This data is sent to a mobile app or cloud server, allowing caregivers and medical professionals to monitor the user's health remotely. In case of abnormal readings, the system can trigger alerts via app notifications, SMS, or email. An optional fall detection feature can also be included using motion sensors to enhance user safety.

The device is optimized for low power consumption to ensure longer battery life. Its compact and lightweight design makes it comfortable and convenient for daily use. Historical data is stored for trend analysis and visualization. This project aims to enhance elderly care by offering continuous health monitoring and timely interventions.

1.3. Focus Of The Project:- The focus of this project is to develop a smart wristband that ensures continuous health monitoring for elderly individuals. It uses the ESP32 microcontroller for real-time data collection and wireless communication.

The project also aims to provide emergency alerts in case of abnormal health readings or falls. Power efficiency and wearable comfort are key design priorities. Overall, it focuses on enhancing elderly safety and well-being through IoT technology.

2.COMPONENTS:-

2.1. ADXL335:-

An accelerometer is an electromechanical device that will measure acceleration force. It shows acceleration, only due to cause of gravity i.e. g force. It measures acceleration in g unit.

On the earth, 1g means acceleration of 9.8 m/s2 is present. On moon, it is 1/6th of earth and on mars it is 1/3rd of earth.Accelerometer can be used for tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

The ADXL335 gives complete 3-axis acceleration measurement.This module measures acceleration within range ±3 g in the x, y and z axis.The output signals of this module are analog voltages that are proportional to the acceleration. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry.

Basic structure of accelerometer consists fixed plates and moving plates (mass).Acceleration deflects the moving mass and unbalances the differential capacitor which results in a sensor output voltage amplitude which is proportional to the acceleration.Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

2.2. SIM800L :-

The SIM800L is a GSM module from Simcom that gives any microcontroller GSM functionality, meaning it can connect to the mobile network to receive calls and send and receive text messages, and also connect to the internet using GPRS, TCP, or IP. Another advantage is that the board makes use of existing mobile frequencies, which means it can be used anywhere in the world.

The SIM800L is a compact and cost-effective GSM/GPRS module designed for embedded applications where space and power efficiency are important. Manufactured by SIMCom, it supports quad-band frequencies (850/900/1800/1900 MHz), which allows it to operate globally on 2G networks. It can make and receive voice calls, send and receive SMS messages, and connect to the internet using GPRS for basic data transmission. These features make it suitable for IoT projects such as remote monitoring, smart metering, GPS tracking, and home automation.

The module communicates with microcontrollers (like Arduino, ESP32, or STM32) through a serial interface (UART), and typically operates at a voltage range of 3.4V to 4.4V, with a recommended input of 4V. It has a low power consumption in idle mode and bursts up to 2A during data transmission or network registration, so a stable power supply with sufficient current is essential. The module includes support for AT commands, which are used to configure settings, send messages, initiate calls, and establish data connections.

SIM800L also supports several communication protocols including TCP, UDP, HTTP, and FTP, which enables developers to push data to cloud servers or fetch remote data. It has interfaces for microphone and speaker, allowing for hands-free voice operations. Additionally, the small form factor and onboard antenna (or optional external antenna via an SMA or IPX connector) make it easy to embed in wearable and portable devices.

Due to its affordability and wide compatibility, SIM800L is widely used in IoT and mobile communication projects. However, developers must take care of power requirements and signal strength for reliable operation. Proper decoupling capacitors and antenna placement also significantly affect its performance in practical scenarios.

2.3. NEO-6MV2 :-

The NEO-6MV2 is a popular and widely used GPS module developed by u-blox, known for its high performance, low power consumption, and reliable GPS signal acquisition. It is commonly used in various projects such as vehicle tracking, navigation systems, drones, and IoT-based location-aware applications. The module provides accurate positioning data including latitude, longitude, altitude, speed, and timestamp, making it suitable for both personal and industrial GPS-based applications.

This module operates on a 3V to 5V power supply and communicates via serial UART (TX and RX pins), which makes it easy to interface with microcontrollers like Arduino, ESP32, and Raspberry Pi. It typically comes with a built-in ceramic antenna for better signal reception and an EEPROM for storing configuration settings. The onboard LED indicates satellite lock status—blinking when it is searching and solid when a fix is achieved.

The NEO-6MV2 supports up to 5 Hz update rate, meaning it can provide location data up to 5 times per second, which is adequate for most real-time tracking applications. It uses the NMEA protocol for communication, sending standard sentences such as GPGGA, GPRMC, and GPGSV that include positioning and satellite data. Additionally, the module features a backup battery (CR1220 in many modules) that allows it to retain configuration and GPS data for faster cold starts.

Overall, the NEO-6MV2 GPS module is a reliable and easy-to-use component that adds powerful GPS tracking capabilities to embedded systems and IoT devices, making it an ideal choice for real-time location tracking projects.

2.4. I2CLCD16X2_N:-

The I2C LCD 16x2_N is a commonly used 16x2 character LCD display integrated with an I2C (Inter-Integrated Circuit) interface module, making it highly efficient and user-friendly for microcontroller projects. A 16x2 LCD means it can display 16 characters per line on 2 lines, which is suitable for showing basic information such as sensor readings, status updates, and user prompts in embedded systems and IoT applications.

The key feature of this module is its I2C adapter (typically based on the PCF8574 I/O expander), which reduces the number of GPIO pins required to control the display. Normally, a standard 16x2 LCD requires at least 6 digital I/O pins, but with I2C communication, it can be operated using just two pins: SDA (data line) and SCL (clock line). This allows developers to save pins and simplify wiring, especially in projects using microcontrollers like ESP32, Arduino, or Raspberry Pi.

The I2C LCD 16x2_N usually comes with an adjustable potentiometer on the back to control the display contrast and a jumper to enable or disable the backlight. It communicates using a 7-bit I2C address, commonly 0x27 **or** 0x3F, which may vary depending on the manufacturer. Most platforms support this display using standard libraries

like LiquidCrystal_I2C in Arduino IDE, allowing quick setup and simple commands for writing to the screen.

This module is highly energy-efficient, has a wide operating voltage range (typically 3.3V to 5V), and is ideal for applications where visual feedback or user interaction is needed. The I2C LCD 16x2_N is a reliable and compact solution that enhances user interface capabilities in embedded systems while maintaining a minimal hardware footprint.

2.5. MAX30102:-

The MAX30102 is a high-sensitivity pulse oximeter and heart-rate sensor module, widely used in health and fitness monitoring applications. It integrates a red LED, infrared LED, photodetector, optical elements, and low-noise electronics with ambient light rejection into a compact module. This allows it to measure oxygen saturation (SpO2) and heart rate by detecting changes in light absorption through the skin, typically from a fingertip or wrist.

The module communicates with microcontrollers through the I2C interface, which makes it easy to connect with platforms like ESP32, Arduino, or Raspberry Pi. It operates at 1.8V for logic and typically requires 3.3V or 5V for the sensor power supply, depending on the breakout board. The MAX30102 is designed to be energy efficient, supporting features like automatic power-down and programmable sample rates, which make it ideal for wearable and battery-powered devices.

The sensor is capable of high-resolution pulse waveform detection, enabling accurate tracking of heart rate variability and blood oxygen levels even during motion. Its integrated temperature sensor can help in compensating measurements and improving accuracy. The module is widely supported by open-source libraries, making it developer-friendly for integrating into projects such as health monitoring wristbands, fitness trackers, and IoT-based medical devices.The max30102 sensor consists of a Red LED and an IR LED and a photodetector respectively. The wavelength of the RED Led is 660 nm and the wavelength of the IR Led is 880nm.

The MAX30102 Sensor shines both the light through the skin and measures the reflection with the photodetector. This method of pulse detection through light is called Photoplethysmogram.The working of the sensor can be divided into two parts one is heart rate measurement and another is blood oxygen level measurement.The oxygen in the hemoglobin has a specific characteristic, that it can absorb IR light. When the concentration of hemoglobin is more, the redder the blood. Which simply means it can absorve more IR light. As the blood is pumped through the veins in the finger the amount of reflected light changes creating an oscillating waveform. And by measuring this wave we can get the heartbeat reading. Blood oxygen level measurement works on the principle that Red and IR light varies depending upon the oxygen level in your blood. Deoxygenated blood absorbs more RED light while blood with more sufficient oxygen absorbs more IR light. By measuring the ratio between two we can measure oxygen level.

Overall, the MAX30102 is a versatile and powerful solution for real-time physiological monitoring, offering compact size, low power consumption, and reliable performance suitable for both research and commercial use in wearable healthcare technology.

2.6.ESP32 Wrover Board:-

The ESP32-WROVER is a powerful and versatile development board built around the ESP32 SoC (System on Chip) developed by Espressif Systems. What sets the WROVER variant apart from the standard ESP32 boards is its inclusion of additional PSRAM (typically 4MB) and larger flash memory (usually 4MB or more), making it ideal for applications requiring more memory such as image processing, audio handling, and complex IoT tasks. It also features a built-in dual-core Tensilica LX6 processor, running at up to 240 MHz, offering high performance for multitasking and real-time processing.

The board comes with integrated Wi-Fi (802.11 b/g/n) and Bluetooth 4.2 (classic and BLE) capabilities, enabling robust wireless communication for smart home, wearable, and industrial IoT applications. It supports a wide range of digital interfaces including SPI, I2C, UART, ADC, DAC, PWM, and more, making it highly flexible for interfacing with sensors, displays, actuators, and other peripherals.

The ESP32-WROVER module is designed for low power consumption and features multiple sleep modes, making it suitable for battery-powered applications. It also includes a USB-to-Serial converter for easy programming and debugging, and some versions come with additional features like a microSD card slot, camera interface, or support for an LCD display, further expanding its use cases.

This development board is widely supported by open-source platforms like the Arduino IDE, PlatformIO, and ESP-IDF (Espressif IoT Development Framework). Its performance, memory capacity, and wireless capabilities make the ESP32-WROVER a go-to choice for advanced IoT projects, especially those requiring real-time data processing, multimedia features, or large amounts of sensor data handling.

2.7. Buzzer:-

A buzzer is a simple electronic component used to generate sound, often for alarms, notifications, or audio feedback in electronic systems. It comes in two main types: active and passive. An active buzzer has a built-in oscillator and produces sound when powered with a DC voltage, while a passive buzzer requires an external signal or pulse (like PWM) to produce tones. Buzzers are commonly used in embedded projects to alert users about events like system errors, successful operations, or threshold breaches (e.g., high temperature or low battery).

Buzzers typically operate on 3.3V to 5V, making them compatible with microcontrollers such as the ESP32, Arduino, or Raspberry Pi. They are easy to use, usually having two pins — one for power and one for ground. Passive buzzers are preferred when a range of tones or melodies is needed, while active buzzers are better for simple beeps or alerts. Due to their compact size, low cost, and ease of integration, buzzers are widely used in applications like digital watches, timers, health monitoring devices, and home automation systems.

3. METHODOLOGY:-

The proposed project focuses on developing an IoT-based wristband tailored for elderly individuals, using the ESP32 microcontroller as the core component. The methodology begins with the design and selection of hardware components suitable for health monitoring. The ESP32, chosen for its built-in Wi-Fi and Bluetooth capabilities, acts as the central processing unit. Sensors such as a heart rate monitor (e.g., MAX30102 or MAX30102), temperature sensor (e.g., LM35 or DS18B20), and fall detection sensor (e.g., ADXL335 accelerometer) are integrated into the wristband to continuously collect vital physiological and motion data from the user.

Following hardware integration, the next step involves developing embedded software to read sensor data, process it, and transmit it wirelessly. The firmware is written using the Arduino IDE or PlatformIO, utilizing ESP32 libraries to handle sensor inputs, establish network connections, and send data to a cloud server or mobile application via MQTT or HTTP protocols. Special emphasis is placed on optimizing the power consumption of the device to ensure long battery life, which is crucial for wearable applications.

Once the data reaches the cloud platform (such as Firebase, Thingspeak, or Blynk), it is stored and visualized for real-time monitoring. Alerts and notifications are configured to be sent to caregivers or family members via SMS, email, or push notifications when abnormal conditions are detected, such as irregular heartbeat or a fall. The system also includes GPS tracking (optional, using a GPS module) to assist in locating the elderly person in case of emergency.

Finally, the wristband is tested with simulated and real-time inputs to validate its performance, accuracy, and reliability. User feedback is collected to refine the design, interface, and features for better usability. This methodology ensures a comprehensive approach, combining hardware and software development with user-centered design to enhance the safety and wellbeing of elderly individuals through IoT technology.

4. WORKING PROCESS:- The working process of the IoT-based healthcare wristband can be broken down into five main stages: data collection, data processing, data transmission, data storage and analysis, and alert generation.

1) Data Collection:
The wristband continuously collects real-time health data from the attached sensors.Heart Rate and SpO2 Sensor: Measures the pulse and oxygen saturation using photoplethysmography (PPG) technology.Temperature Sensor: Monitors the wearer's skin temperature.Accelerometer: Captures movement data and identifies sudden falls based on acceleration patterns.Data is collected at predefined intervals (e.g., every 5 seconds).

2) Data Processing:The ESP32 microcontroller receives raw data from the sensors.It filters and processes the data to remove noise and inaccuracies.Algorithms are used to analyze the data for abnormal values, such as:Heart rate exceeding or falling below safe limits.Abnormally high or low body temperature.Sudden acceleration patterns indicating a fall.Data is formatted and prepared for wireless transmission.

3) Data Transmission: The processed data is transmitted from the ESP32 to a remote cloud platform.

Communication is established using:

- i Wi-Fi Protocol: For direct internet connectivity and faster data transfer.
- ii MQTT or HTTP Protocols: Ensure reliable and secure communication between the device and cloud.
- iii Time-stamped data packets are sent to the cloud for further analysis and storage.
- iv Stage 4: Data Storage and Analysis
- v Data is stored on a cloud platform (e.g., Google Firebase, AWS IoT).
- vi Cloud-based algorithms monitor trends and detect anomalies in real time.
- vii Data visualization tools present health metrics on a user-friendly dashboard.
- viii Historical records are maintained for long-term tracking and analysis.

5) Alert Generation and Notification System:

Threshold Monitoring: Predefined limits for each health parameter are set.Alert Triggers: If any sensor detects a value outside normal limits, the ESP32 triggers an alert.

Notification System:Emergency alerts are sent via SMS, email, or mobile app notifications.

Alerts are forwarded to caregivers, healthcare professionals, or emergency services.

Fall Detection Alerts: If a fall is detected, immediate notifications are sent.

6)Safety and Security Considerations:

- i. Data Encryption: All transmitted data is encrypted to prevent unauthorized access.
- ii. Access Control: Only authorized users can view and manage patient information.
- iii. Error Handling: Mechanisms are in place to manage sensor malfunctions and connectivity issues.

4.A WORKFLOW:-

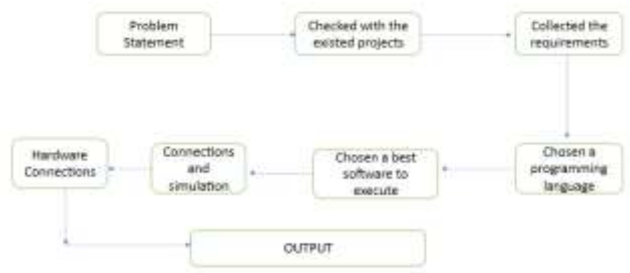

Figure-1

System Workflow Summary

- i. Data Capture: Sensors collect real-time health data.
- ii. Processing: ESP32 filters and analyzes the data.
- iii. Transmission: Data is sent securely to the cloud.
- iv. Storage: Data is logged and analyzed for long-term tracking.

Alert Generation: Critical events trigger emergency notifications.

5. CONNECTIONS:-

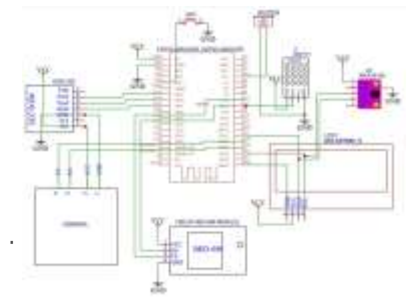

Figure-2

6. FUTURE SCOPE:-

The IoT-based wristband for elderly care has significant potential for enhancement and real-world application. In the future, this project can be expanded to include more advanced health monitoring features, such as blood oxygen level (SpO_2), blood pressure, and ECG monitoring, offering a more comprehensive view of the user's health status. Integration with AI and machine learning can enable predictive analytics, allowing the system to detect potential health issues before they become critical, based on patterns and trends in the data.

Another important direction for development is integration with electronic health records (EHRs), allowing seamless sharing of health data with doctors and healthcare providers. This would improve diagnosis and remote consultation, especially for elderly individuals living in remote or rural areas. Additionally, adding voice assistant features could help users interact with the device more naturally, for example, to request help or get updates about their health metrics.In terms of connectivity, future versions can utilize LoRa or NB-IoT for low-power, long-range communication, especially useful in areas with poor Wi-Fi coverage. Battery efficiency and solar-powered charging options could also be explored to extend usage time and make the device more sustainable and user-friendly.Lastly, this wristband can evolve into part of a larger smart healthcare ecosystem, connecting with smart home devices, emergency services, and even robotic assistants for elderly care. As IoT infrastructure becomes more widespread and affordable, the scalability and impact of such wearable health monitoring devices will continue to grow, making them an essential tool for the aging global population.

7.CONCLUSION AND RESULTS:-

In conclusion, the IoT-based wristband using ESP32 presents an innovative and practical solution to address the growing healthcare needs of the elderly population. By integrating vital health monitoring sensors with real-time data transmission capabilities, the device ensures continuous observation of the user's condition while offering timely alerts during emergencies. The use of the ESP32 microcontroller enhances the system's efficiency through its powerful processing and wireless communication features, making the wristband compact, affordable, and energy-efficient.

This project successfully demonstrates how IoT technology can be applied to improve the safety, independence, and overall well-being of elderly individuals. It also lays the foundation for future developments in remote health monitoring and smart healthcare solutions. With further improvements and real-world deployment, such a wearable system can play a crucial role in reducing response times during health crises and enhancing the quality of life for senior citizens.

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