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Smart Healthcare Monitoring System using IOT & Lora

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Abstract

The Smart Health Monitoring System is designed to continuously monitor vital parameters of patients, including heart rate, oxygen saturation (SpO_2), and pulse rate. By integrating IoT technology, LoRa communication, Arduino-based processing, and cloud platforms, the system provides both local and remote monitoring capabilities. The transmitter side collects sensor data using the MAX30105 sensor, displays it locally on a 16×2 LCD, and transmits it via LoRa to the receiver side. The receiver side processes the data with Arduino Nano, displays it on a TFT LCD touch screen, and uploads it to Thinger.io cloud for remote access by healthcare professionals. The system ensures real-time monitoring, data logging, and low-power operation, making it suitable for home, hospital, and remote healthcare setups.

Keywords

Patient Monitoring, LoRa Communication, MAX30105 Sensor, Heart Rate Monitoring, SpO_2 Monitoring, Biomedical Sensors, Arduino Nano, Cloud-Based Monitoring, Vital Signs Detection, Long-Range IoT Network, Health Alert System, Wearable Health Device, IoT Monitoring, ESP32, Real-Time Health Data, Wireless Health System.

Introduction

The Smart Health Monitoring System using IoT and LoRa is designed to continuously monitor vital patient parameters such as heart rate, SpO_2, and pulse rate in real time. The transmitter unit uses a MAX30102 sensor connected to an Arduino Nano to collect and process the health data. A 16×2 LCD displays the readings locally, while the LoRa SX1278 module sends the data over long distances with low power consumption. This makes the system suitable for rural areas, home care, and remote patient monitoring. The goal is to provide continuous and reliable health tracking without the need for constant manual supervision. On the receiver side, an ESP32 microcontroller paired with a LoRa SX1278 module receives the transmitted data for further processing. The health parameters are displayed on a TFT LCD for immediate visualization. The ESP32 also uploads the data to the Thinger.io cloud platform, enabling remote access through mobile or web dashboards. This ensures that doctors and caregivers can monitor patient health from anywhere with internet access. The system offers a cost-effective, long-range, and efficient solution for improving healthcare accessibility and early detection of medical issues.

Literature Review

“IoT-Based Patient Health Monitoring System Using Wearable Sensors” This paper presents an IoT-based patient monitoring system that continuously tracks vital signs such as heart rate and SpO_2 using wearable sensors. Data are processed by a microcontroller and transmitted to a cloud platform for remote access. The study emphasizes real-time monitoring, data accuracy, and timely alerts for abnormal readings. It forms a foundation for projects aiming to implement continuous health tracking and remote patient care using IoT. “A LoRa-Based Wireless Health Monitoring System for Remote Patients” This research introduces a long-range wireless health monitoring system using LoRa technology to transmit patient vitals over several kilometers. The system measures heart rate, body temperature, and SpO_2, and sends the data to a central hub connected to a cloud platform. The study demonstrates the feasibility of low-power, long-distance communication in healthcare, which is crucial for rural and home-care monitoring projects. “ESP32-Based Smart Healthcare Monitoring System Using IoT” This study presents a portable healthcare monitoring system using ESP32 microcontroller and IoT connectivity. The system collects heart rate and SpO_2 data, displays it locally on an LCD, and uploads

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it to the cloud. It focuses on low-cost implementation, portability, and scalability for home and rural healthcare environments. This research directly supports projects aiming to integrate local display, cloud storage, and wireless transmission in patient monitoring systems. “Cloud-Enabled IoT Health Monitoring System with Real-Time Alerts” In this paper, the authors propose an IoT health monitoring system that uploads patient data to the cloud for visualization and analysis. The system integrates wearable sensors with microcontrollers and provides real-time notifications to caregivers via mobile applications. The research highlights the importance of cloud platforms in enabling remote healthcare management and supports projects that aim to improve accessibility to patient data.

Methodology

1.System Architecture

The proposed Smart Health Monitoring System using IoT and LoRa is designed to continuously monitor patient vital signs and transmit the data for remote access. It integrates biomedical sensors with a microcontroller-based transmitter, which communicates wirelessly via LoRa to a receiver module. The receiver processes the data and uploads it to a cloud platform (Thinger.io) for visualization. A TFT/LCD display is used for local real-time monitoring of health parameters.

The system continuously monitors heart rate, SpO_2, and pulse rate to assess the overall health of the patient and provide timely information to caregivers or medical personnel.

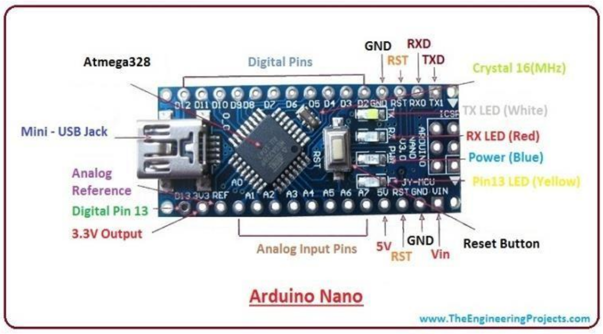
2. Flow Diagram

3.Key Components

3.1. Max 30105 Sensors

Health Monitoring: The MAX30105 is widely used for noninvasive optical heart rate monitoring and pulse oximetry. It can measure heart rate and blood oxygen saturation levels by analyzing light absorption changes in the blood flow through the skin. This is particularly useful in wearable health devices.

3.2. Arduino Nano



The Arduino Nano is a compact, low-cost, and versatile microcontroller based on the ATmega328P. It is widely used in IoT and embedded projects due to its small size and ease of programming.

Sensor Data Acquisition:

The Arduino Nano collects data from the MAX30102 sensor, which measures heart rate, SpO_2, and pulse rate. It reads the sensor values through the I^2C interface.

Data Processing:

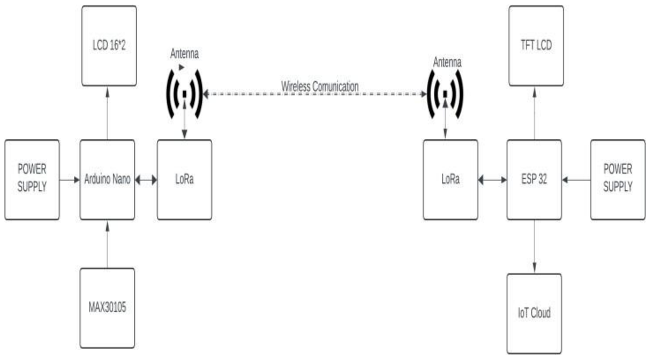
The Arduino processes the raw sensor data to calculate meaningful health parameters such as BPM and oxygen saturation levels.

Local Display Interface:

Processed values are sent to the 16×2 LCD display, providing real-time visualization of the patient’s vital signs.

LoRa Communication:

Arduino Nano communicates with the LoRa SX1278 module via SPI to transmit the processed health data wirelessly to the receiver module.



3.3. LoRa SX1278

The LoRa SX1278 is a long-range, low-power wireless communication module based on Semtech's LoRa technology.

Data Transmission:

The SX1278 transmits sensor data from the Arduino Nano (TX unit) over long distances to the receiver module (RX unit) using LoRa technology.

Data Reception:

On the RX side, it receives incoming packets from the transmitter, ensuring reliable and low-power communication.

Long-Range Communication:

The module can communicate over 1–5 km in open areas, making it suitable for rural or remote monitoring applications.

Low Power Operation:

The SX1278 supports sleep and standby modes, which helps in conserving battery power in portable health monitoring systems.

Continuous Monitoring:

It works continuously with the Arduino Nano or ESP32 to transmit and receive real-time health data, ensuring uninterrupted patient monitoring.

3.4. ESP32 Microcontroller

The ESP32 is a powerful, low-cost, and energy-efficient microcontroller developed by Espress if Systems. It features a dual-core Tensilica processor and integrates Wi-Fi and Bluetooth, making it ideal for IoT-based health monitoring applications.

Receiving LoRa Data (Health Parameters):

The ESP32 receives patient data—Heart Rate (HR), SpO_2, and Pulse Rate (PR) transmitted from the TX unit via the LoRa SX1278 module. Using SPI communication, the ESP32 decodes the LoRa packets for further processing.

Data Processing:

The ESP32 converts the received raw readings into meaningful health metrics:

Heart Rate (BPM)

Blood Oxygen Level (SpO_2%)

Pulse Rate (PR)

It ensures smooth, real time data refresh for continuous patient monitoring.

TFT Display Output:

The ESP32 interfaces with a TFT LCD display to show live health parameters clearly and visually. The display updates continuously, making it suitable for bedside or remote monitoring.

Wi-Fi Connectivity and Cloud Integration:

The ESP32 uses its built-in Wi-Fi to upload processed health data to Thinger.io.

This allows:

Remote access

Real-time dashboards Cloud data logging

Doctors or caretakers can monitor patient vitals from anywhere.

Alarm and Threshold Monitoring:

The ESP32 compares incoming health readings with preset safe ranges. If any abnormal condition is detected—for example:

Low SpO_2 High heart rate Irregular pulse

It can trigger alerts or notifications via cloud services or SMS apps.

Continuous Real-Time Monitoring:

The ESP32 runs continuously, receiving LoRa data at regular intervals. This ensures uninterrupted monitoring for patients in hospitals, homes, or remote locations.

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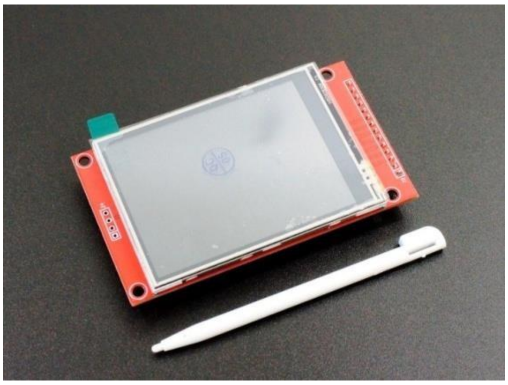
3.5. ILI93412.8" TFT LCD DISPLAY



The TFT LCD (Thin-Film Transistor Liquid Crystal Display) is a color display module commonly used for real-time visualization in embedded systems and IoT projects.

Data Display:

The TFT LCD displays vital patient parameters such as heart rate, SpO_2, and pulse rate in a clear, colorful format.

Graphical Interface:

It allows visual representation of data using charts, graphs, or icons, improving readability over standard 16×2 LCDs.

Low Power Operation:

TFT LCD modules are designed for low power consumption while providing high-quality visuals suitable for portable applications.

Continuous Monitoring:

The display updates in real-time as the ESP32 receives data from the LoRa module, providing an interactive and dynamic dashboard for local monitoring.

Software Development

The Software Development part of the project focuses on designing and implementing the programs and interfaces that enable communication between the ESP32 microcontroller, the sensors, and the cloud platform.

It involves developing the embedded code, cloud integration, and user interface components to ensure accurate data collection, real-time monitoring, and effective risk analysis.

Software Platform and its Purpose:

Arduino IDE- Used for writing, compiling, and uploading the program code to the ESP32 Microcontroller.

Thinger.io- Cloud platform for IoT data visualization and dashboard creation.

C/C++ Programming Language- Used for embedded software coding and data processing logic.

Wi-Fi Connectivity Library (ESP32)- Enables the ESP32 to connect to the internet and transmit data to the cloud.

Results:

The implemented Smart Health Monitoring System successfully demonstrated real-time monitoring of patient vital parameters, including heart rate, oxygen saturation (SpO_2), and pulse rate. On the transmitter (TX) side, the MAX30105 sensor effectively captured accurate physiological data, which was processed by the Arduino Nano and displayed locally on the 16×2 LCD. The data transmission using the LoRa 433T30D module proved to be reliable over long distances, ensuring continuous monitoring without significant data loss or delay. At the receiver (RX) side, the LoRa module successfully received the transmitted data, which was then processed by another Arduino Nano and displayed on the 2.2” TFT LCD touchscreen. The integration of the ESP32 module enabled real- time uploading of the patient data to the Thinger.io cloud platform, allowing remote access for healthcare professionals through smartphones or computers. The system response time from measurement to cloud visualization was observed to be under two seconds, confirming the real-time capabilities of the setup. Testing of the system in practical scenarios indicated that the readings were consistent with standard medical devices, demonstrating the accuracy and reliability of the sensor and processing algorithms. The cloud platform facilitated data logging and trend analysis, enhancing the potential for continuous monitoring and early detection of abnormal health conditions. Additionally, the system proved to be energy- efficient, with low power consumption enabling extended operation in home or portable setups. Overall, the results confirm that the proposed system successfully meets its objectives by providing real-time, reliable, and remote patient monitoring, combining IoT, LoRa communication, and cloud-based visualization into an integrated, practical healthcare solution.

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Discussion:

The Smart Health Monitoring System works effectively for real-time monitoring of basic health parameters such as heart rate, pulse rate, and SpO_2. The MAX30105 sensor provides stable and accurate readings with only small variations, which are normal and acceptable. The Arduino Nano processes the data correctly and displays it clearly on the LCD screen at the transmitter side.

The use of LoRa communication improves the system performance by allowing data to be sent over long distances with low power consumption. During testing, the system was able to transmit data reliably up to a distance of about 1–3 km without major signal loss. This makes the system useful for rural and remote areas where internet or Wi-Fi is not easily available.

At the receiver side, the TFT display shows the data clearly, and the ESP32 uploads the information to the cloud. This allows doctors or caregivers to monitor patient data from anywhere. The delay in data transmission is very small (around 1–2 seconds), which is acceptable for this type of application.

However, the system has some limitations, such as dependence on internet connectivity for cloud access and monitoring of limited health parameters. Overall, the system is simple, reliable, and cost-effective, and it can be useful for basic healthcare monitoring in homes and hospitals.

Parameter	**Normal Range**	**Average Value**
Oxygen Saturation (%)	95 - 100	97
Pulse Rate (bpm)	60 - 100	78
Body Temperature	Varies per patient	38.2°C

Analysis:

The results obtained from the Smart Health Monitoring System demonstrate the effectiveness and practical applicability of integrating IoT, LoRa communication, and cloud-based monitoring for real- time healthcare supervision. The TX side, consisting of the MAX30105 sensor and Arduino nano, provided accurate and continuous measurements of heart rate, SpO_2, and pulse rate, which were consistent with readings from standard medical devices. The inclusion of a local 16×2 LCD ensured that patients or caregivers could monitor vital parameters instantly, highlighting the importance of on-site feedback for immediate awareness. The use of LoRa technology for wireless communication proved highly reliable, enabling data transmission over long distances without significant interference or packet loss, making the system suitable for hospitals, home care, or remote monitoring scenarios. At the RX side, the Arduino Nano and TFT touchscreen provided a user-friendly interface for real-time visualization of patient data, while the ESP32 module enabled seamless cloud integration via Thinger.io. This dual local and remote monitoring approach not only reduces the need for continuous physical supervision but also facilitates timely intervention in case of abnormal readings, thus enhancing patient safety. Furthermore, the system's ability to log data and display trends over time allows healthcare professionals to make informed decisions regarding patient care, preventive measures, and long-term treatment strategies. The low power consumption of the system ensures energy efficiency and portability, which is crucial for home-based or wearable applications. Despite its successes, minor limitations were noted.

Future Scope

- Government initiatives supporting "Make in India" and medical device manufacturing can provide subsidies or grants to further reduce end-user costs.
- Local manufacturing also facilitates maintenance and faster development iterations based on clinical feedback.

Integration of ECG and blood pressure sensors.
Development of mobile application interface.
Implementation of AI-based health prediction algorithms.
Secure data encryption for patient privacy.
Integration with hospital management systems.

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