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IoT Based Saline Level Monitoring System

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ABSTRACT

This paper presents the development and implementation of an Objects Salinity Monitoring System (IoT) Internet-based adapted to the hospital environment. The system aims to address the critical need for real-time monitoring of salt concentrations in medical infusion devices, ensuring timely refills and avoiding interruptions in patient care. Traditional methods of monitoring salt levels often rely on manual testing by hospital staff, which can be prone to human error and lead to delays in identifying low levels or empty containers. The proposed IoT solution provides an automated and reliable alternative, leveraging wireless connectivity and sensor technology to continuously monitor salt concentrations and provide instant notifications to medical staff when supplementation is needed. The system consists of three main components: salinity level sensors, a microcontroller, and a central monitoring interface. Salt level sensors are installed in saline tanks or infusion pumps, using non-contact methods such as ultrasound or capacitive sensors to accurately measure the remaining fluid volume. These sensors are connected to a microcontroller equipped with wireless communication capabilities, allowing data to be transmitted to a central monitoring interface. In summary, IoT-based salt monitoring systems provide a cost-effective, efficient, and reliable solution to improve patient care in hospital environments. By automating monitoring processes and providing timely notifications, the system helps improve operational efficiency, reduce the risk of medication errors, and improve the overall quality of care.

KEYWORDS: *Internet of Things (IoT), salinity monitoring, hospitals, infusion equipment, sensor technology, microcontrollers, wireless connectivity, real-time monitoring.*

1.INTRODUCTION

Historically, healthcare providers have relied on paper-based records to document patient health information. However, this method is prone to errors, difficult to update in real-time, and can lead to inefficiencies in data retrieval and sharing among healthcare professionals. Additionally, paper records are vulnerable to loss or damage, compromising the security and confidentiality of patient information. Electronic Health Records EHR systems have been widely adopted to digitize patient health records and facilitate data management within healthcare organizations. While

EHRs offer benefits such as improved accessibility and legibility of records, they may suffer from interoperability issues, making it challenging to exchange data between different systems and healthcare providers. Furthermore, EHRs can be complex to navigate, leading to usability issues for healthcare professionals and potential errors in documentation. RPM

(Rmote patient monitoring) involves using technology to monitor patients' health remotely, typically through wearable devices or home monitoring equipment. While RPM enables continuous monitoring of vital signs and other health parameters outside of clinical settings, it may be limited by the accuracy and reliability of the devices used. Additionally, RPM systems often require active patient engagement and may not be suitable for all patients, particularly those with limited technological proficiency or cognitive impairments.

2.LITERATURE REVIEW

IOT- monitoring systems have gained significant attention in various industries due to their ability to provide real-time data and automate monitoring processes. In the healthcare sector, IoT-based monitoring systems have been developed to monitor various parameters, including temperature, humidity, and inventory levels. The monitoring of saline levels is crucial in medical facilities to ensure that an adequate supply of saline is always available for patient care. Traditional methods of saline level monitoring are often manual and prone to errors. However, IoT-based saline level monitoring systems offer a more efficient and reliable solution. IoT-based saline level monitoring systems typically consist of sensors, actuators, communication modules, and a central monitoring platform. Sensors are used to measure the saline level in storage tanks, while actuators can be used to control the flow of saline. Communication modules transmit data from the sensors to the central monitoring platform, where it can be analyzed and acted upon. Sensors are used to measure the saline level in storage tanks. Various types of sensors can be used, including ultrasonic sensors, pressure sensors, and capacitive sensors: Actuators are used to control the flow of saline based on the monitored levels. For example, actuators can be used to open or close valves to maintain optimal saline levels.The central monitoring platform receives data from the sensors, analyzes it, and provides real-time information to healthcare providers. The platform may also include features such as data visualization, alerts, and remote monitoring capabilities.

3. MATERIALS METHODS

HARDWARE REQUIREMENTS:

The hardware requirements are

- Arduino uno
- Heart rate and pulse oximeter montor
- Accelerometer and Gyroscope
- ESP-32 Camera module
- ESP-8266 WIFI MODULE
- LCD
- Buzzer
- Panic button

SOFTWARE REQUIREMETS:

The software requirements are

- operating system: window
- Arduino ide
- Think speak app

❖ ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

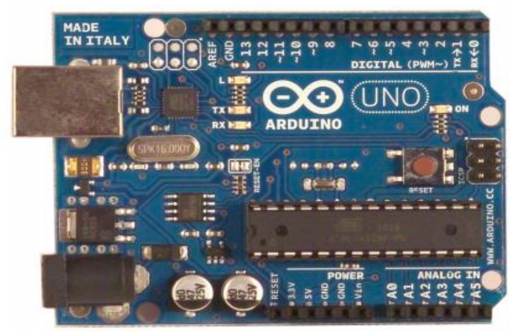


Fig: 1 Arduino uno

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Ground and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

❖ HEART RATE AND PULSE OXIMETE

Wearable devices hold the potential to transform health and medical monitoring. Heart rate, specifically, provides tremendous insight into heart function and health, during both activity and rest. Innovation and development of both optical semiconductors and lower-power integrated circuits makes the transition to wearables possible

Fig: 2 Hear rate and pulse oximeter

Until now, only large organizations, with deep development budgets, could deliver such advanced products.MAXREFDES117# delivers the promise of wearable devices to all developers. This unique design measures both heart rate and pulse oximetry. MAXREFDES117# features the MAX30102 with integrated red and IR LEDs for heart-rate and SpO_2 detection. This configuration ideally detects heart rate and pulse ox on a person's fingertip, earlobe, or other fleshy extremity. The small board size of 12.7mm x 12.7mm (0.5in x 0.5in) is ideal for wearable applications and may be stitched into fabric for immediate prototyping. Firmware is available for both Arduino and mbed platforms, enabling users to develop with virtually any platform. User needs to provide a 2V to 5.5V supply at the power input, perfect for virtually any battery or Arduino and mbed form-factor board.

❖ Accelerometer and Gyroscope

The **MPU6050 module** is a Micro Electro-Mechanical Systems (**MEMS**) which consists of a 3-axis Accelerometer and 3-axis Gyroscope inside it. This helps us to measure acceleration, velocity, orientation, displacement and many other motion related parameter of a system or object.

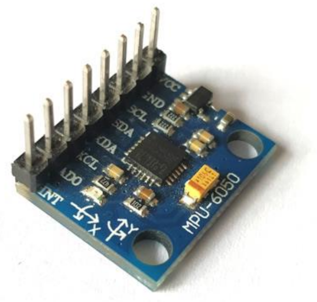


Fig:3 Accelerometer

FEATURES OF MPU6050:

- MEMS 3-aixs accelerometer and 3-axis gyroscope values combined
- Power Supply: 3-5V
- Communication: I2C protocol
- Built-in 16-bit ADC provides high accuracy
- Built-in DMP provides high computational power
- Can be used to interface with other IIC devices like magnetometer
- Configurable IIC Address
- In-built Temperature sensor

❖ ESP-32 CAMERA

The ESP32-CAM is a development board with an ESP32-S chip, an OV2640 camera, microSD card slot and several GPIOs to connect peripherals. In this guide, we'll take a look at the ESP32-CAM GPIOs and how to use them.

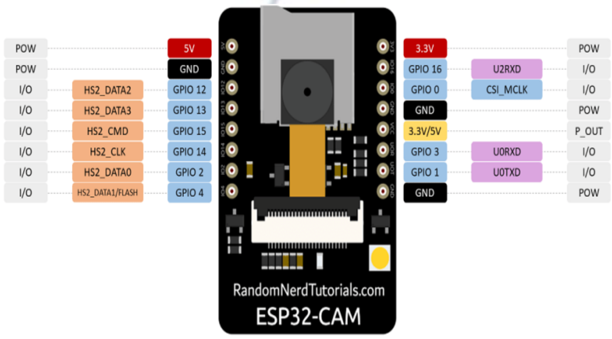


Fig:4 ESP-32 CAMERA

❖ ESP-32 Camera module

Node MCU is an open-source Lua based firmware and **development board** specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espress if Systems, and hardware which is based on the ESP-12 module.

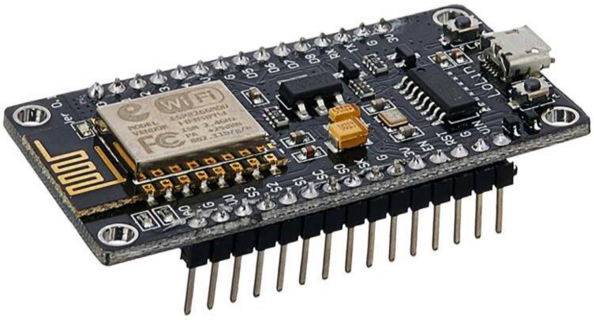


Fig:4 ESP-8266 WIFI MODULE

The **Node MCU ESP8266 development board** comes with the ESP-12E module containing ESP8266 chip having Ten silica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. Node MCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects.

Node MCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

FEATURES OF ESP-8266:

- Microcontroller: Ten silica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna

❖ LIQUID CRYSTAL DISPLAY

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

Fig:5 Liquid crystal display

Nowadays, we always use the devices which are made up of LCDs such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries to replace the utilization of CRTs. Cathode Ray Tubes use huge power when compared with LCDs, and CRTs heavier as well as bigger. These devices are thinner as well power consumption is extremely less. The LCD 16×2 working principle is, it blocks the light rather than dissipate. This article discusses an overview of LCD 16X2,

Features of LCD16x2

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight

❖ BUZZER

A **buzzer** is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications.

Fig:6 Active passive buzzer

There are two types are buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beep.... sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown here is most widely used because it can be customized with help of other circuits to fit easily in our application.

This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval.

FEATURES OF BUZZER:

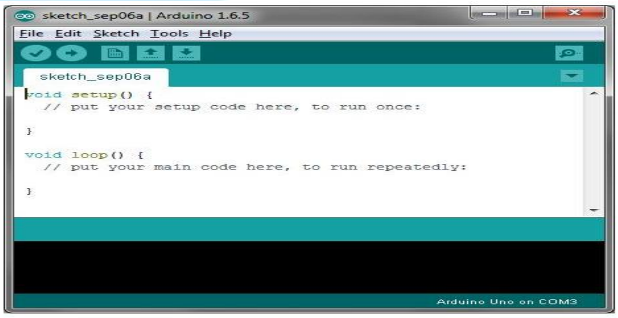
- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

❖ PANIC BUTTON

A panic switch is an electronic device that can be pressed for immediate assistance in case of an emergency situation, be it intrusion, fire, panic, or medical. The main purpose behind installing a panic alarm system is to get quick assistance whenever someone is in need of help.

❖ ARDUINO IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.



Arduino IDE Default Window

Fig:7 Arduino ide

Programs written using Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and are saved with the file extension . ino The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting the Arduino Software (IDE), including complete error and also displays errors. The console displays text output by messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

❖ THINK SPEAK APP

Thing speak is Iot platform for user to gather real-time data;for instance, climate information ,location data and other device data .In different channeles in Thing speak ,you can summarize information and visualize data online in charts and analyze useful information Thing Speak can integrate IoT:bit (micri:bit) and other software /hardware platforms.Through IoT:bit, you can upload sensors data to Thing speak (e.g. temperature, spo2 ,panic button,heart beat ,fall detection,weight and other device information).

EXISTING METHODS:

Traditional Paper-Based Records: Historically, healthcare providers have relied on paper-based records to document patient health information. However, this method is prone to errors, difficult to update in real-time, and can lead to inefficiencies in data retrieval and sharing among healthcare professionals. Additionally, paper records are vulnerable to loss or damage, compromising the security and confidentiality of patient information.

Electronic Health Records (EHR): EHR systems have been widely adopted to digitize patient health records and facilitate data management within healthcare organizations. While EHRs offer benefits such as improved accessibility and legibility of records, they may suffer from interoperability issues, making it challenging to exchange data between different systems and healthcare providers. Furthermore, EHRs can be complex to navigate, leading to usability issues for healthcare professionals and potential errors in documentation.

Remote Patient Monitoring (RPM): RPM involves using technology to monitor patients' health remotely, typically through wearable devices or home monitoring equipment. While RPM enables continuous monitoring of vital signs and other health parameters outside of clinical settings, it may be limited by the accuracy and reliability of the devices used. Additionally, RPM systems often require active patient engagement and may not be suitable for all patients, particularly those with limited technological proficiency or cognitive impairments.

Telemedicine Platforms: Telemedicine platforms allow for remote consultations between patients and healthcare providers via video conferencing or messaging applications. While telemedicine offers increased accessibility to healthcare services, it may not adequately address the need for continuous monitoring of patient health between appointments. Furthermore, telemedicine consultations may lack the physical examination component, limiting the ability to assess certain health conditions accurately.

Health and Wellness Apps: There is a proliferation of health and wellness apps available for smartphones and other devices, offering features such as activity tracking, medication reminders, and symptom monitoring. While these apps can empower patients to take control of their health and adhere to treatment plans, they may lack clinical validation and regulatory oversight. Additionally, the fragmented nature of the app market can make it challenging for healthcare providers to recommend or integrate specific apps into patient care plans.

PROPOSED SYSTEM:

The proposed system aims to create a comprehensive patient health monitoring and alert system using Arduino Uno, MAX30102 Pulse Oximeter Sensor, MPU6050 Accelerometer, 16x2 LCD Display, Buzzer, NodeMCU, and integration with ThingSpeak cloud platform along with an Android mobile application. This system will offer real-time monitoring of vital signs, fall detection, panic button activation, and instant alerts to caregivers or healthcare professionals.

4. WORKING

The saline level in the IV bag is monitored using an load cell sensor connected to the Arduino Uno.The Arduino constantly measures the weight between the sensor and the saline level. If the level goes below a certain threshold, it triggers an alert.The heart rate and pulse oximeter measure the patient's vital signs and send the data to the Arduino Uno. Arduino processes the data and sends it to the ESP8266 WiFi module .The ESP32 camera captures visual data of the patien t.The camera sends the data to the Arduino Uno, which then transmits it to the ESP8266 WiFi module. The accelerometer and gyroscope sensor detect any movement of the patient.If any movement is detected, the Arduino triggers an alert.

The Arduino Uno collects all the data from the sensors and transmits it wirelessly using the ESP8266 WiFi module.

The ESP8266 WiFi module sends the data to a remote server or cloud platform for storage and further analysis .In case of any emergency, such as low saline levels, abnormal vital signs, or movement of the IV stand, the system triggers an alert .The alert is displayed on the LCD screen, and a buzzer is activated to draw immediate attention .The data collected from the sensors can be accessed remotely through a web interface or a mobile application .The user can monitor the patient's vital signs, saline levels, and visual feed in real-time .The entire system can be powered using a reliable power source or a rechargeable battery for portability.

BLOCK DIAGRAM:

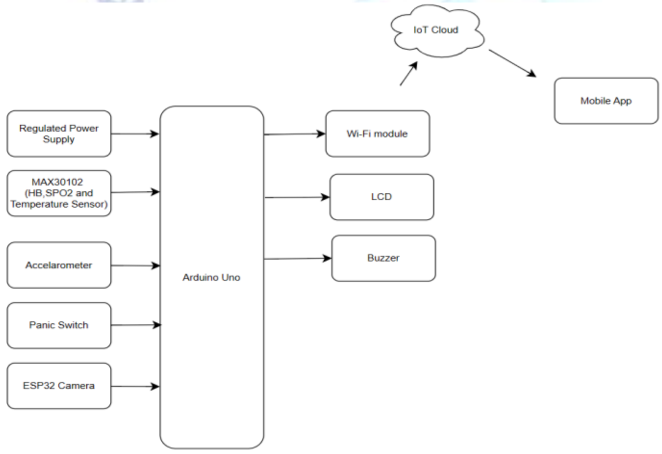


Fig:9 Block diagram of the iot based saline level monitoring system

5. RESLTS AND DISCUSSION

The final results of the project are described here ,However the main focus is on the saline level monitoring results that how these results are used to the health status of the patient.

Fig: Results in Lcd display

The above figure shows the heart rate .SpO2 ,temperature ,Fall detection ,weight of saline and panic button .The project main objective was to design the system to monitor the patient health monitor .The presented system can also use pratically .The system will show the status in both LCD and THINK SPEAK APP.

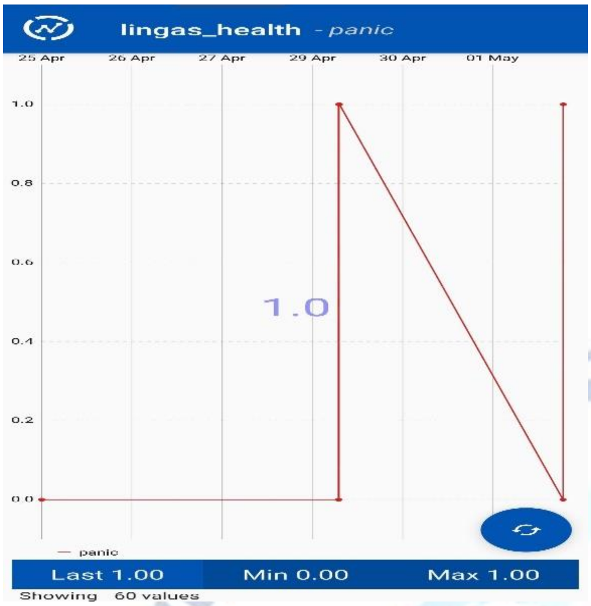
- To ensure that there were no electrical hazards ,all the wires were tapped together for a zero human contact.
- The components were enclosed in the box to placed in up side of the patient, to ensure the safety of the patient.

RESULTS IN THE THINK SPEAK APP:

WEIGHT OF THE SALINE

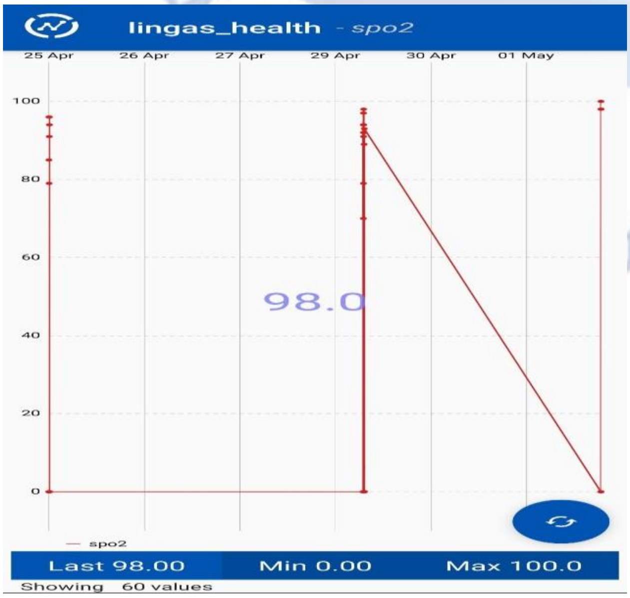
FALL DETECTION OF THE PATIENT:

PANIC BUTTON:

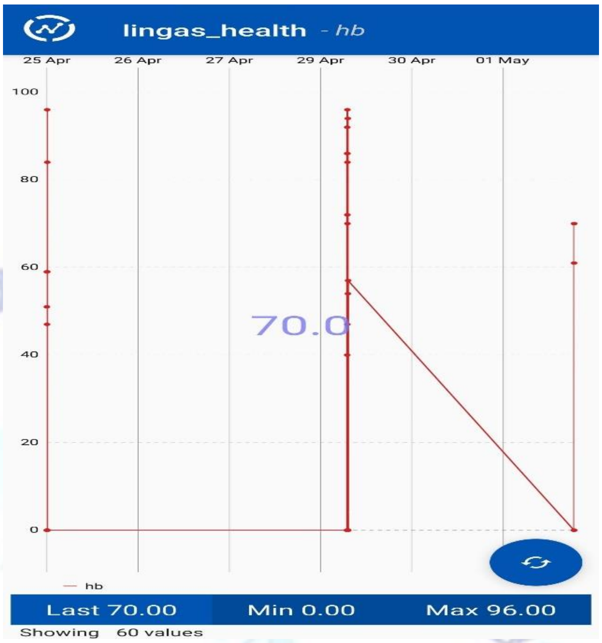


TEMPERATURE:

SpO2:



HEART BEAT:



6. CONCLUSION

In conclusion, the proposed Comprehensive Patient Health Monitoring System represents a significant advancement in healthcare technology, offering a holistic solution for real-time monitoring and management of critical health parameters. By leveraging Arduino Uno, MAX30102 Pulse Oximeter Sensor, MPU6050 Accelerometer, NodeMCU, 16x2 LCD Display, Buzzer, and integration with ThingSpeak cloud platform and an Android mobile application, this system addresses key challenges in patient care and safety.

Through the integration of advanced sensors, seamless connectivity, and intelligent data analysis, the system enables continuous monitoring of vital signs such as heart rate, blood oxygen levels, and movement patterns. Additionally, features such as fall detection and panic button activation provide immediate alerts in case of emergencies, empowering caregivers and healthcare professionals to intervene promptly. And esp32 camera provides the real time photo scene of the situation.

Overall, the Comprehensive Patient Health Monitoring System offers numerous benefits, including enhanced patient safety, improved clinical outcomes, remote access to patient data, and peace of mind for caregivers and patients alike. By leveraging the power of technology to provide proactive, personalized, and continuous healthcare monitoring, this system has the potential to revolutionize patient care and contribute to the advancement of healthcare delivery.

APPLICATIONS:

Healthcare Facilities: Hospitals, clinics, and healthcare centers can use this system to monitor saline levels in IV bags, ensuring timely replacements and uninterrupted patient treatment.

Home Healthcare: Patients receiving treatment at home can benefit from this system, as it allows caregivers to remotely monitor saline levels and receive alerts in case of low levels or emergencies.

Emergency Medical Services (EMS):Ambulances and emergency medical services can use this system to monitor saline levels and vital signs of patients during transportation, ensuring their safety and well-being.

Clinical Trials:The system can be used in clinical trials to monitor patients' response to treatment and ensure the accurate delivery of medication through IV bags.

Telemedicine: Healthcare providers can use the system for remote patient monitoring, allowing them to assess patients' condition and make necessary adjustments to their treatment plan in real-time.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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