RESEARCH PAPER

Smart Healthcare Framework For Secure Patient Identification And Real-Time Drug Delivery Monitoring Using Iot And Biometric Authentication

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Abstract

The safety of patients is largely determined by accurate identification of patients during the transfer of patients between facilities in hospitals. To ensure the safety patient during these transfers and to maintain the continuity of care, a bedside secure patient identification and monitoring system will be developed that combines the use of qr codes for patient identification with a biometric authentication process for authorized providers. Under the approach described in this research each patient will be issued a qr code wristband that will quickly allow providers to retrieve electronic health data for the patient through the use of a bedside touch-screen. Biometric data will be collected using an infrared heart rate sensor (max30100) to measure heart rate and blood oxygen saturation, and the temperature and humidity will be collected using a digital hygrometer (dht11). The data from the sensors will be collected by an esp32 microcontroller, and transmitted and stored on a cloud platform for real-time access and monitoring. By integrating cloud services you will have secure data management, remote access, system scalability and backup solutions. In order to improve the security of the systems, an authentication solution based on facial recognition has been used so that only employees who are authorized can access or modify the patient's information. The system architecture has been developed according to hl7 fhir interoperability standards to facilitate the exchange of data in a standard format between various healthcare systems. The proposed system will reduce errors with identification of patients, improve synchronization of data, and improve overall performance during transfers of patients in hospitals by utilizing a secure and intelligent framework for monitoring patients in a healthcare environment.

Keywords: Patient Identification, Qr Code Authentication, Facial Recognition, Esp32, Cloud-Based Healthcare Monitoring, Electronic Health Records (Ehr), Intra-Hospital Transfer, Biometric Access Control, Internet Of Things (Iot).

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I. INTRODUCTION

A foundation of contemporary healthcare systems is making sure patients are properly identified. This is especially important during transfers within a hospital (transferring a patient from one area of a hospital to another), which can include transfers between the emergency room, testing and imaging center, intensive care units, and operating rooms, as any misidentification would create opportunities for a variety of medical errors such as misadministration of drugs, delayed diagnoses, and complications from procedures. The most common methods of identifying patients (manually checking patient records versus attaching barcodes to wristbands) are inefficient and have a high risk for human error, which can affect both patient safety and efficiency of healthcare delivery. As IoT technology continues to advance, interest is also growing in the use of automated patient monitoring and identification systems in clinical practice. The Internet of Things (IoT) enables real-time collection and transmission of physiological data. This allows for continuous monitoring of patients and timely intervention by healthcare professionals. However, with rapid advances in technology and the convenience of using cloud-based healthcare systems, there have also been increasing concerns regarding the privacy of patient data and the risk of unauthorized access to this sensitive information. In response, this study provides a secure bedside patient data management system that uses QR codes for patient identification and biometric authentication of healthcare professionals. Each patient will have a wristband with a QR code that can be scanned when transferring between different hospitals so that their electronic health record can be quickly accessed by personnel at the receiving hospital. The system is based on the use of an ESP32 microcontroller to gather real-time, physiological data using built-in sensors (e.g., a MAX30100 pulse oximeter to track both heart rate and blood oxygen saturation) and DHT11 temperature and humidity sensor). Patient data that is collected about acquired patients will be transmitted securely to a cloud platform where it can be accessed remotely, stored centrally, and synchronized in real-time. In addition, the system uses facial recognition technology to authenticate any medical professional attempting to access or change a patient's record to ensure that only authorized personnel are permitted access to that patient's record. This solution will provide a systematic framework for exchanging standardized healthcare data between providers while implementing interoperability frameworks; thus, supporting clinical workflows and reducing the chances of patient identification errors during intra-hospital transfers. The goal of the IoT-based monitoring system is to improve patient safety, increase the security of data collected on patients, and provide for effective delivery of patient care using an intelligent and scalable framework for monitoring patients through the use of cloud computing and biometric authentication.

2. People Health Monitoring

There are multiple types of present-day healthcare monitoring systems designed to improve the overall health of people with paralysis. These systems utilize advanced technologies such as wearables, the cloud and the Internet of Things, to allow for ongoing observation of patients with paralysis. The last decade has seen a substantial advancement in the capabilities of wearable technologies to capture physiological markers such as ECG, EEG, EFG, BP, temp, SpO2, among others. Figure 1 below depicts a typical overall layout of a monitoring system for people with paralysis. The diagram depicts how physiological readings from patients with paralysis will be transmitted to a central monitoring site (most often the cloud) via smart devices where they will be processed, evaluated, and made available to those parties or entities that are directly involved with the patients being monitored for paralysis.

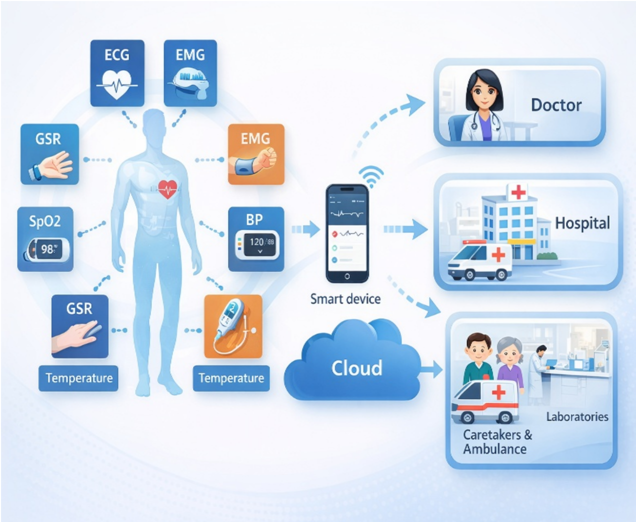


Fig. 1 General architecture of people healthcare monitoring system

3 Related work

Suliman Abdulmalek [1] associates provided an individualised IoT Framework for use in the healthcare sector. This new framework proposes that any data collected will first be sent to the cloud and then processed (re-ordered and de-categorised) before being sent to a client for subsequent use or decommissioning. The authors used results from a developed model to illustrate that the new architecture will provide many benefits.

Vijay Kumar's report (2) proposed a secure IoT healthcare platform for modern-day facilities. The report presented the healthcare ecosystem; discussed data's importance and challenges; and described security in healthcare generally, as being a major paradigm shift in IT-healthcare solutions (cloud/edge computing). The patient records; including all medical data as well as all physician and patient demographic data are stored on the health facility's storage, not on cloud-based storage; making medical records accessible and always available. Any attacks or unauthorized usage of medical records that are on a storage system similar to the cloud would create a risk to the health of patients. Security is always one of the primary and critical considerations for the healthcare industry. The use of mobile phones in developing countries has increased dramatically; health care executives in underdeveloped nations can utilize this technology to provide timely quality health care services.

By using Bluetooth and NFC-enabled mobile devices,

Mudassar Ali Khan et al. [3] suggested an innovative framework for improving healthcare through the implementation of tamper-resistant secure elements (SE) within the secure stores of smart cards to store sensitive information such as passwords and other confidential medical records.

A mobile phone-based system for detecting vehicle accidents was developed by Sangeethalakshmi K and his colleagues in 2006. In order to detect and inform authorities of a crash event faster than the traditional call to dispatch via road or phone, researchers have developed a vehicle-based automatic accident detection and notification system. This type of system will allow for accurate, timely location identification of accidents in order to dispatch the nearest available emergency vehicle to the scene of an accident. Their framework very effectively prevents the identification of false positives for accident events.

STREMS aims to enhance communication among Emergency Services (EMS) before an emergency occurs through the use of wearable sensors, smart phones and video streaming technology. The authors proposed a solution for the development of a real-time, cloud-based, information-sharing platform by using these technologies. To do this, they first starting with the creation of a physiological wearable sensing solution to provide multi-dimensional telemetry monitoring of a basic life support emergency vehicle without sophisticated medical technology or paramedics. Second, they began work developing a virtual communication platform for EMS via automated cloud-based video streaming.

Alruwailil et al. (2019) has proposed an exoskeleton arm. It uses a battery-powered motor to increase productivity and quality of human work. The Exoskeleton Arm also allows individuals with spinal injuries to rebuild muscle strength and improve motor function by providing support to their arms (increasing arm strength by 40 lbs). Additionally, this technology can be utilized by individuals who handle heavy loads on a regular basis, such as construction workers and delivery personnel.

As previously mentioned, the authors of Ref.[7] proposed a framework that can help improve both the diagnosis as well as treatment of diabetes through their novel method of converting the physical attributes associated with diabetes into an intelligent system that uses multiple data mining techniques (for example clustering and classification) to determine what type of diabetes an individual has. In their research, they gathered and included data from a total of 650 diabetic individuals to classify and analyse the severity of diabetes as being mild, moderate, or severe. The healthcare industry produces big data in several forms (floating images and video and text, prescriptions, etc).

To improve people's and patients' delivery of services from within the cloud by enhancing current methods for storage and retrieval processes in Big Data Analytics in healthcare with the help of tools, and methodologies developed by Chaudhary, A et al.[8].

According to Peddoju et al. [9], the emergence of new technologies like big data and cloud computing can help solve many of the problems that exist in the health care sector. By providing immediate, effective responses to health-related needs, fewer patients will die as the demand for health information increases. Machine learning techniques were also used to analyze a diabetes dataset in order to provide insight into the level of diabetes among individuals. In addition, authors presented a model for enabling cellular-based systems to facilitate the merging of data collected over wireless networks with existing systems, such as the cloud and other telecommunications networks, through the use of various types of infrastructure. As a result, this paper discusses innovative approaches to collecting, processing and transforming data from the healthcare system so that it can be utilized for analysis and decision-making. In addition, it describes various options for deploying healthcare solutions.

The authors H. Upadhyay [10] created an architectural framework for combining IoT and wearables for delivering prompt health care services to patients by developing a model for the transmission of health data via IoT to a cloud-based environment from a medical device while collecting patient health information from a wearable. In addition to this, they have also created a model for using predictive analytics to track a patient's health status and make sure they have access to prompt information on their health and well-being. In addition, the authors provided a number of other alternative solutions to address patient-specific health issues and provide solutions to health-related security concerns; however, there is no literature available to date that describes an IoT-based analysis of a patient's total health statistics and provides timely notifications to patients regarding their health status by predicting real-time patient health statistics via deep learning and advanced analytic methods. The literature review is summarized in Table 1.

4. Existing system

This project is primarily implemented to assist the monitoring of an individual's wellbeing from a distance using GSM technology. The development of this health monitoring system allows a physician or family member to monitor an individual's pulse or heart rate, and body temperature from a remote location, using a Microcontroller within the AVR Family, with interfaces to an LCD, a Heartbeat Sensor, and a Temperature Sensor. This health monitoring system will operate on a 12 Volt transformer using a GSM modem to transmit this information to an individual's mobile phone by way of SMS. The introduction of this health monitoring system also allows for a physician to SMS a patient with a status update at a predetermined amount of time. In addition, this Health Monitoring System provides a physician with timely updates concerning an individual's health and accurately provides a measurement of that individual's health parameters. This health monitoring system provides a physician with accurate updates regarding a patient, along with precise measurements for the patient's health parameters.

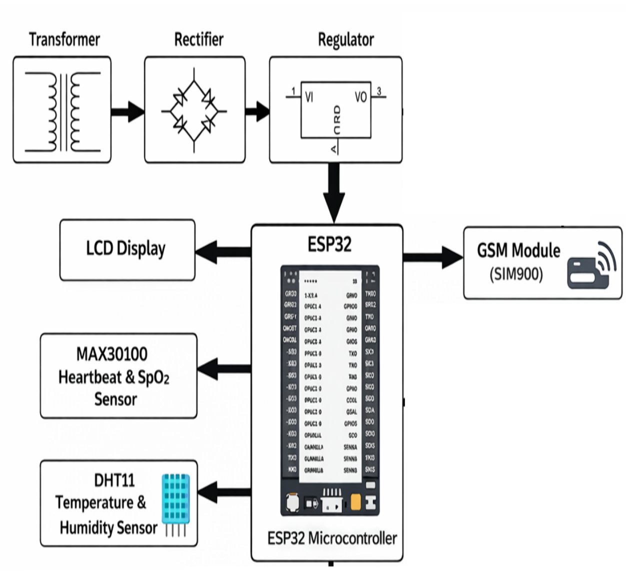


Fig 2: Existing Block diagram

5. Proposed system

The goal of this proposal is to offer patients a more secure identification and monitoring solution at each bedside during intra-hospital transfers. It features an integration of IoT -based physiological data gathering via sensors, patient identification through QR codes, the storing of data in the Cloud, and a method to authenticate patients biometrically. The objective here is to minimize error in identifying patients during their intra-hospital movement, ensuring access to secure electronic health records (EHR) while continuously monitoring vital signs throughout a transfer. As part of a new architecture being proposed within a patient's transfer process, each patient will have one unique wristband coded in a QR code format that will link their identification data to their EHR. When transferring a patient from one place to another, the QR code on the wristband is scanned with a bedside device that allows immediate retrieval of information on that patient, thereby limiting manual entry of data and limiting the chances of making medical errors with regards to patient identification. The proposed system will utilize the ESP32 microcontroller as the primary source from which physiological parameters will be acquired via sensors connected to the microcontroller. The MAX30100 sensor will be used to continuously acquire heart rates and blood oxygen saturation levels (SpO_2) from each patient. The DHT11 sensor will be used to acquire temperature and humidity where each patient is during their transfer from one area to another. These parameters are key indicators of the status of a patient; therefore monitoring these indicators will help ensure the stability and safety of patients during their entire transfer process.

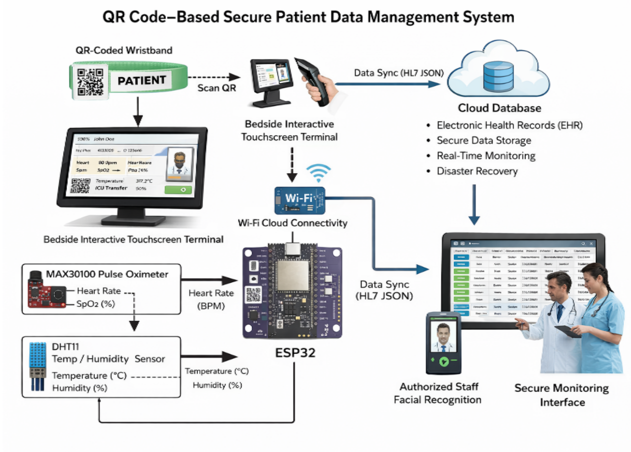


Fig 3: Block diagram

The wireless transmission of the sensor information to the cloud-based server, provides for secure storage and real-time monitoring of the data being monitored. With cloud-based solutions, healthcare professionals have remote access to patient records and are provided with secure access through high availability, data backup, and disaster recovery. To provide secure access to the patient records, we also incorporate facial recognition as an authentication method for healthcare personnel to access patient data. This ensures only authorized personnel can access and edit sensitive patient records. Additionally, the system architecture incorporates an interoperability component to allow hospitals' information systems to exchange information in a standardized manner. This combination of IoT-enabled monitoring, secure authentication, and cloud-based data storage, will help improve operational efficiency, enhance patient safety, and provide a reliable basis for intelligent monitoring of healthcare patients during intra-hospital transfers.

6. SYSTEM DESIGN

The planned development of a Secure Bedside Patient Data Management System provides clinicians with a means of ensuring safe and accurate identification of patients in addition to continually monitoring health status and providing secure access to Electronic Health Records (EHR) when patients move between locations inside of a given hospital setting. The proposed system combines IoT-based sensing devices with QR code technology, biometric authentication devices, wireless communication, cloud data storage, and web-based monitoring through the integration of the above technologies into a single healthcare monitoring infrastructure.

The system architecture consists of five major modules:

- Patient Identification Module
- Physiological Data Acquisition Module
- Processing and Communication Module
- Cloud Storage and Data Management Module
- Authorized Access and Monitoring Module

Each module is interconnected to enable real-time acquisition, processing, storage, and secure retrieval of patient information during hospital transfer operations.

Patient Identification Module

In the proposed system, each patient is provided with a QR-coded wristband that contains a unique patient identification number. This QR code acts as a digital reference to the patient's Electronic Health Record stored in the cloud database. When a patient is transferred between departments, the QR code is scanned using a bedside touch screen interface or mobile scanning device. Upon scanning, the patient's unique ID is transmitted to the ESP32-based processing unit, which requests the corresponding medical data from the cloud server. This automated identification process eliminates manual record verification and significantly reduces the risk of patient misidentification.

Physiological Data Acquisition Module

The physiological monitoring unit is responsible for collecting real-time health parameters of the patient during transfer. The following sensors are used:

MAX30100 Pulse Oximeter Sensor

This sensor measures:

- Heart Rate (beats per minute)
- Blood Oxygen Saturation (SpO_2)

DHT11 Sensor

This sensor monitors:

- Body temperature
- Ambient humidity conditions
- These sensors are interfaced with the

ESP32 microcontroller to continuously monitor the patient's vital parameters and detect any abnormal changes during movement within the hospital.

Processing and Communication Module

The ESP32 microcontroller serves as the central processing unit of the system. It performs the following operations:

- Collects sensor data from MAX30100 and DHT11
- Reads patient identification data from QR scan
- Converts the acquired data into digital format
- Performs threshold analysis for abnormal conditions
- Establishes Wi-Fi communication with the cloud server
- Transmits patient health data using HTTP protocol

If any abnormal physiological condition is detected, an alert signal is generated through a buzzer to notify the attending medical staff immediately.

Cloud Storage and Data Management Module

The collected patient information is transmitted wirelessly to a cloud-based platform where it is securely stored and managed using a structured database. The cloud server performs the following functions:

- Storage of Electronic Health Records (EHR)
- Real-time synchronization of physiological parameters
- Data encryption for secure transmission
- Remote accessibility by authorized personnel
- Backup and disaster recovery support
- Standardized data exchange support (HL7 FHIR format)

A PHP-based web server is used to handle incoming data from the ESP32 module and store it in a MySQL database for further analysis and retrieval.

Authorized Access and Monitoring Module

To enhance system security and prevent unauthorized access, facial recognition technology is incorporated into the monitoring interface. Only registered healthcare professionals whose biometric facial data is stored in the system database are allowed to:

- Access patient records
- Modify transfer details
- Monitor real-time physiological data

After successful authentication, medical staff can view patient status and vital signs through a secure web-based monitoring dashboard.

MONITORING AND ALERT SYSTEM

A centralized monitoring interface is provided for nurses and doctors to observe real-time patient data during transfer. If any parameter exceeds predefined threshold limits, the system generates:

- Audible alert through buzzer
- Updated health status on the cloud dashboard

This ensures immediate medical attention and improves patient safety during intra-hospital transport. The integration of QR-based identification, IoT-based physiological monitoring, cloud storage, and biometric authentication ensures secure and efficient patient data management. The proposed system minimizes identification errors, enhances real-time monitoring, improves data accessibility, and supports intelligent healthcare operations during intra-hospital transfers.

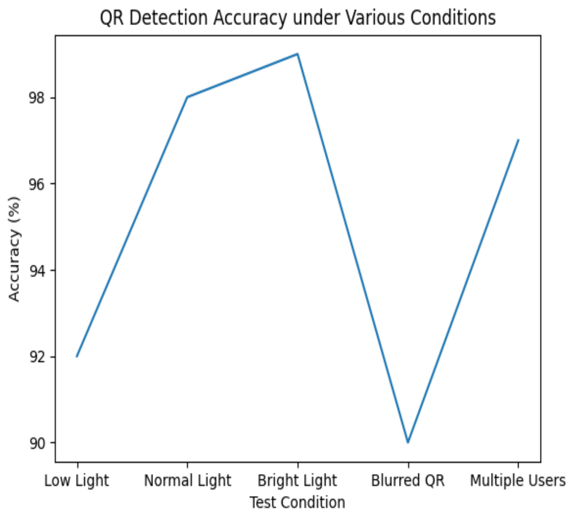
7. RESULTS AND DISCUSSION

The developed QR Code–Based Attendance Monitoring System using was successfully implemented and tested under various environmental and operational conditions. The system performance was evaluated based on QR detection accuracy, processing time, and response rate for real-time attendance logging.

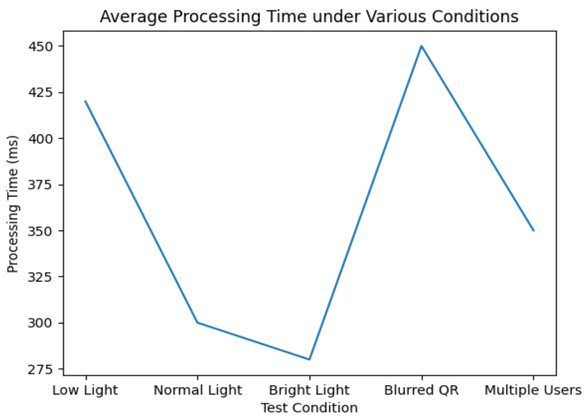
Experimental Results

Test Condition	Detection Accuracy (%)	Avg Processing Time (ms)	System Response
Low Light	92%	420 ms	Good
Normal Light	98%	300 ms	Excellent
Bright Light	99%	280 ms	Excellent
Blurred QR Code	90%	450 ms	Moderate
Multiple Users	97%	350 ms	Very Good

Various Conditions, Performance Charts



Average Processing Time under Various Conditions



DISCUSSION

- The system demonstrated high detection accuracy (above 95%) under normal and bright lighting conditions, indicating robust performance of the camera and decoding algorithm.
- In low-light environments, accuracy dropped slightly due to reduced image clarity affecting QR decoding.
- Detection of blurred QR codes resulted in the lowest accuracy (90%) and highest processing time (450 ms), showing sensitivity to motion blur or poor print quality.
- During multiple user scanning scenarios, the system maintained a high accuracy of 97%, proving its capability for real-time group attendance monitoring—useful for classrooms and labs.
- The average processing time remained below 500 ms in all cases, ensuring near-instantaneous attendance updates to the database.

Overall, the system provides a reliable, low-cost, and efficient solution for automated attendance tracking, making it suitable for deployment in educational institutions and workplace environments.

8. CONCLUSION

The proposed IoT-enabled Patient Identification and Real-Time Health Monitoring System has been demonstrated to be a safe and effective way of increasing patient safety in a hospital setting. The utilization of combined QR code-based patient authentication with facial recognition technology and physiological parameter monitoring through the use of ESP32 microcontrollers, MAX30100 heart rate and blood oxygen sensors, and DHT11 temperature sensors ensure accurate identification and constant monitoring of patients' health conditions throughout the hospital transfer process. Utilizing cloud-based electronic health record (EHR) systems provides an easy access point for authorized medical personnel to view patient records while at the same time reducing the risk of manual errors due to lack of access to the patient record. In addition, patients' vital parameters (heart rate, temperature and blood oxygen levels) can be continuously recorded allowing for early identification of any abnormality in a patient's condition; therefore minimizing unnecessary delays in providing medical assistance. Experimental results indicate that the proposed system performs very well with high identification accuracy rates and low processing times making it ideal for implementation within smart health care infrastructures. In addition, utilizing HL7 FHIR interoperability standards will enhance the ability for other hospital-based computers to integrate with the system.

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