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Automated Smart Healthcare Monitoring System

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Abstract

This research presents the design and implementation of a fully automated chair equipped with sensors to assess the health status of patients. The chair measures vital signs such as weight, blood pressure, heart rate, oxygen level, and temperature. The system is fully integrated with the ThingSpeak IoT cloud platform. The collected data in ThingSpeak is processed by a machine learning model in the cloud to detect sudden changes in vital signs and send alerts to notify doctors. The proposed method utilizes K-means clustering to identify abnormal or sudden variations in vital signs. Future developments aim to integrate the chair with a user-friendly application that includes patient details, a video call appointment option, medication and appointment reminders, and outpatient ID (OP ID) generation.

Keywords: Health Monitoring, Machine learning, ThingSpeak , IoT (Internet of Things) , Cloud Platform.

1. Introduction

Healthcare systems worldwide face significant challenges in managing patient checkups and maintaining accurate medical records. The traditional approach often leads to long waiting times, human errors in data entry, and inefficient use of medical resources. To

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address these issues, The research proposes a fully automated healthcare chair equipped with advanced sensors and integrated with the ThingSpeak IoT cloud platform. This system measures vital signs, processes the collected data using a machine learning model to detect sudden changes, and sends alerts to notify doctors. Additionally, the system aims to streamline the checkup process, reduce waiting times, and ensure precise and timely medical records maintenance.

The research aims to automate the

- Automate the general checkup process to save time and resources.
- Provide accurate and real-time monitoring of vital signs.
- Detect the abnormal variations in the signs and send notifications. Figure 1 shows the general components added to the smart chair.

Figure 1. Automated Smart Chair

2. System Overview

2.1 System Architecture

The system comprises an automated chair equipped with sensors. It integrates with the ThingSpeak IoT cloud platform that manages patient data, and alert generations. The system architecture is illustrated in Figure 2, showing the interaction between hardware components and the software application.

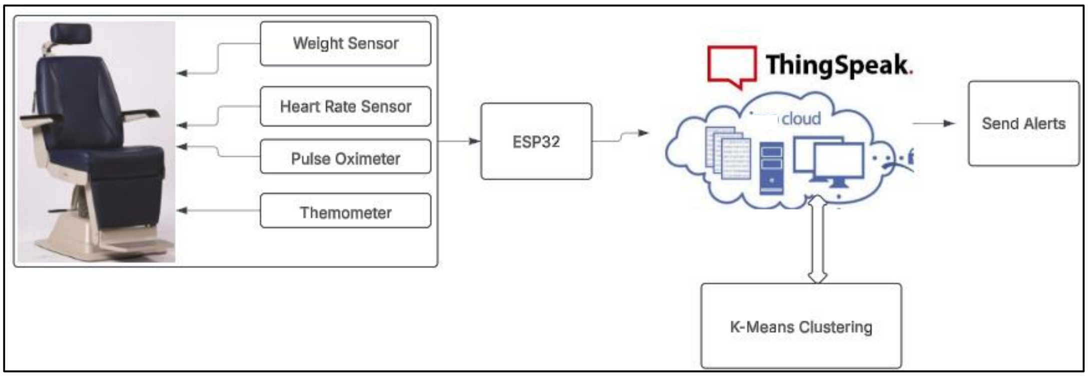

Figure 2. System Architecture

3. Hardware Components

3.1 Automated Chair

The design focuses on ensuring comfort with an adjustable seat and armrests. Integrated sensors monitor various health metrics, including weight, blood pressure, heart rate, oxygen level, and temperature. The system utilizes an ESP32 microcontroller, to collect and process the sensor data effectively

The Table 1 below shows the hardware requirements and the software requirements of the proposed.

Table 1. Components Used

Hardware	Device used	Software	Tools used
Weight Sensor	HX711	Cloud Platform	IoT cloud Platform
Heart Rate Sensor	MAX30100	Coding	MATLAB
Pulse Oximeter	MAX30102		

Thermometer	MLX90614		

The system incorporates a variety of sensors for health monitoring, including a weight sensor HX711 module for accurate weight measurement. An electronic blood pressure monitor is integrated into the armrest for convenient blood pressure tracking. For heart rate monitoring, an optical heart rate sensor, such as the MAX30100, is used, while a pulse oximeter sensor MAX30102 measures oxygen levels. Additionally, an infrared temperature sensor, such as the MLX90614, is employed for non-contact temperature measurement. The collected data are forwarded to ThingSpeak IoT cloud Platform which includes Kmeans clustering for detection of abnormal or sudden variations in the signs measured.

4. System Operation

The patient sits on the automated chair, where various sensors measure and record their vital signs. The collected data is then transmitted to the ThingSpeak IoT platform for analysis and storage, ensuring continuous monitoring and evaluation.

The primary coding developed for ThingSpeak and K-means clustering in the MATLAB enables the system to collect the data perform the analysis and send the alert notification through email to the patient caretaker and the doctor and suggests with the doctor appointment for the patient through SMS alerts using Twilio. Figure .3 depicts the general flow of the process.

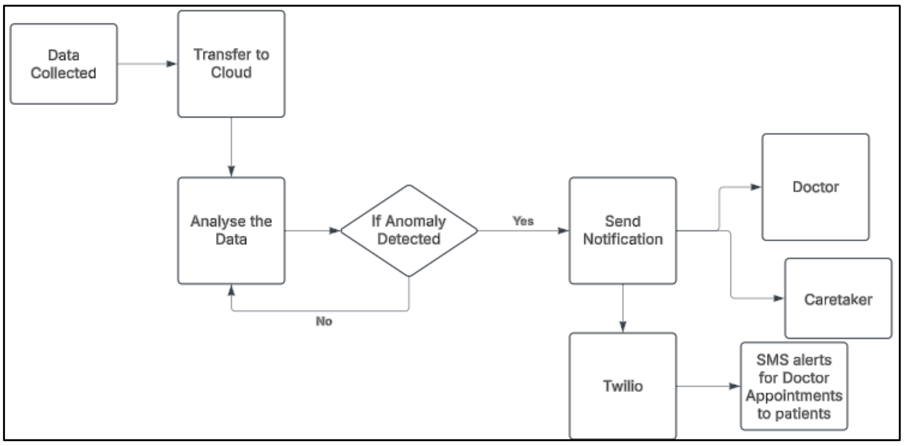

Figure 3. General Workflow

The Table.2 below shows the samples of patients' data collected on different time of the day

Table 2. Sample of Patient Data Collected.

Patient	Time Period (Min)	Weight(kg)	Heart Rate (bpm)	Oxygen level (%)	Body temperature (Celsius)
1	14:50	81	109	80	35.0
2	14:55	63	98	85	36.1
3	14:57	84	75	96	36.8
4	15:00	76	72	98	37.0
5	17:03	55	82	95	36.5
6	17:08	98	72	93	36.4
7	17:13	49	65	90	36.9
8	17:18	56	70	92	37.01
9	20:00	65	72	96	36.54
10	20:05	78	71	95	36.0
11	20:10	66	86	94	36.8
12	20:15	87	85	92	36.9

Twelve patients' health information is shown in the Table.1 including their weight, heart rate (bpm), oxygen saturation (%), and body temperature (Celsius) at different points in time. According to the heart rate data, there is variation among the patients; some, like Patient 1 (109 bpm), have increased heart rates, which may be a sign of tachycardia, while others, like Patient 4 (72 bpm), have heart rates that fall within the normal range. Generally speaking, oxygen levels are within normal ranges; most patients have levels above 90%, while Patient 1's (80%) levels are below the usual range, raising possible concerns. A few measurements indicate a slight fever, especially in Patient 8 (37.01°C) and others like Patient 4 (37.0°C). Body temperatures range from 35.0°C to 37.01°C. While many patients' vital signs seem stable overall, there are a few cases when values like temperature, heart rate, and oxygen level differ from the usual range, suggesting potentially problematic situations that need closer observation or more testing.

The vital signs including the signs represented in Table 1 was processed using K-means algorithm. Initially, the data collected were normalized to ensure all the features were on a comparable scale. The number of clusters was determined based on the previous analysis. The centroids were randomly initialized, and the Euclidean distance between the each patient's details and the centroids were determined to assign the patients to the closest cluster. The process was repeated until no significant change was observed in the centroids. Finally, the anomalies were determined by calculating the distance of each patient from their assigned centroid. According to the samples of patient data illustrated in Table 1 the Patients with a significantly large distance from their centroid were flagged as anomalies. Based on these criteria, Patient 1 (with a high heart rate of 109 bpm and low oxygen level of 80%) and Patient 3 (with a relatively higher weight and more extreme vital signs) were identified as potential anomalies due to their deviation from the normal patterns observed in the other patients.

5. Results

The proposed automated chair is still under the development stage the software modules for the data collection and analysis have been developed using the MATLAB, and the system is successfully visualizing real-time sensor data in ThingSpeak. The prototype, however, is still under development and not yet fully implemented. The Figure.4 below shows the results visualized through ThingSpeak.

Figure 4. Results Visualized through ThingSpeak.

The Figure .5 depicts the SMS alert forwarded to patient 1 diagnosed with abnormal signs

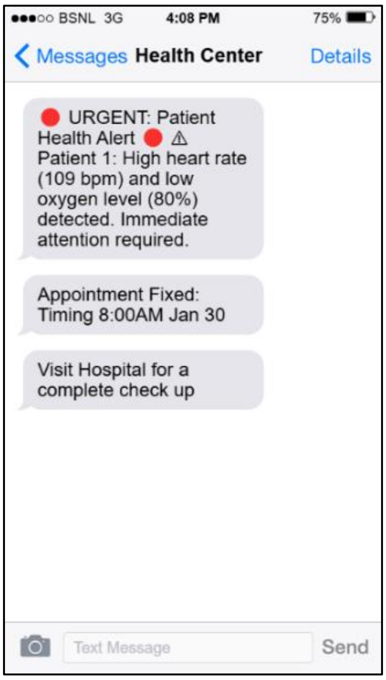

Figure 5. SMS Alerts

6. Conclusion

This research presents a comprehensive solution for automating the general checkup process, improving patient management, and ensuring accurate medical records. The proposed system has the potential to revolutionize healthcare delivery by reducing waiting times, minimizing errors, and improving patient outcomes. Future enhancements could include integrating more advanced diagnostic tools and expanding the system's capabilities to handle complex medical conditions. Additionally, future developments aim to integrate the chair with a user-friendly application that includes patient details, a video call appointment option, medication and appointment reminders, and outpatient ID (OP ID) generation, further enhancing patient care and accessibility.

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