ACUTE RESPIRATORY DISTRESS AND FOOT ULCER DETECTION SYSTEM USING IOT FOR DIABETIC PATIENTS

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College: Sir M.V. Institute of Technology, Bengaluru
Branch: Department of Telecommunication Engineering
Guide: Mrs. M.S. Divya Rani
Students: Ms. Neha K.H.
Ms. Sahana N.
Ms. Sukanya

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Introduction:
A literature review was conducted to identify the different causes of renal failure and cardiac arrest in most of the diabetic patients. It was found that the risk of death due to cardiac arrest is Pulmonary Edema that has been increased among diabetic patients which is associated with cardiovascular disease. Pulmonary Edema is a fluid accumulation in the tissue and air spaces of the lungs. It leads to impaired gas exchange and may cause respiratory failure. It is due to either failure of the left ventricle of the heart to remove blood adequately from the pulmonary circulation (cardiogenic pulmonary edema) or an injury to the lung parenchyma or vasculature of the lung (noncardiogenic pulmonary edema). Pulmonary edema, especially acute, can lead to fatal respiratory distress or cardiac arrest in most of the diabetic patients. Congestive heart failure which is due to the heart's inability to pump the blood out of the pulmonary circulation at a sufficient rate resulting in elevation in wedge pressure and pulmonary edema.

Diabetic patients generally develop the complications of foot ulcers, breaking down of the skin tissue in the case poorly controlled diabetics. As the numbers of diabetic patient are increasing globally with the change in the lifestyle, these ulcers can often emerge surreptitiously, with patients not noticing until it’s too late. This sadly results in up to 34 percent of type II diabetics in India ending up losing toes, a foot, or a leg. The measures for the early detection of the diabetic related problems are gaining medical importance.

Few of the Prototype Models already developed include:
1) “HEALTH CARE FOOT WEAR FOR MONITORING THE DIABETIC PATIENTS”- It is designed to monitor the temperature, humidity and pressure of the diabetic feet. The monitored data from this system will help the concern physician to get the information and advise the patients for controlling their blood sugar level which is helpful to prevent the foot ulcers.
2) “IoT Based Monitoring of Foot Pressure Using FSR Sensor”- In this system, the insole shoe gives the pressure variation for the patient affected by foot abnormalities, fractures etc. This plantar pressure measurement identifies whether a person is having foot abnormalities or not that will prevent the patient disease.
3) “Simple and Cost Effective Foot Pressure Detection System for Diabetic Patients”- This system decides a suitable foot wear for diabetic patients and walking style for a given time based on the data read sensor and shown in the hand held device. It is envisioned that the said technique, developed and tested is effective biomechanical system to diagnose various disorders related to foot.
Although the system developed gives the necessary data to detect the foot ulceration, but fails to include the additional clinical test for recording the SPO2 and heart rate in case of emergency, experienced in most of the type II diabetic patients. Hence a new system model is developed to monitor the physiological parameters.

**Objectives**:

Healthcare and wellness management for the diabetic patient is one of the most promising information technology in the field of medical science. A health care monitoring system is necessary to constantly monitor diabetic patients’ physiological parameters. The smart medical system focuses on the measurement and evaluation of vital parameters e.g. SPO2, electrocardiogram (ECG), heart rate variability, foot ulcer detection etc.

The major objectives of the system includes:

1. To present a smart health monitoring system that has the capability to detect the specific abnormality of Respiratory function that indicates the situations known as Pulmonary Edema that results in Renal failure in most of the type II diabetic patients.
2. To develop a system that can analyse the signal periodically and detect the normal or abnormal conditions to detect Cardiac arrest.
3. Also to develop a smart system that can detect the Diabetic Foot Ulcer (DFU) that helps to reduce the bacterial load on the foot.

**Methodology**:

A new secure IOT Based Modern Healthcare monitoring system for diabetic patients is proposed, to give flexibility and fast operational speed to get expected outcomes. In this hardware, elements used are Arduino Mega, GSM, Wi-Fi, pulse oximeter or photoplethysmography sensor, pressure sensors etc. and more sensors also can be used to detect various biological functionality.

The proposed Smart system comprises of four main parts. The first part being detection of blood oxygen level to recognize the indication of pulmonary edema, second being detection of Electrocardiogram commonly referred to as ECG or EKG (heartbeat detection) to indicate the cardiac arrest, the third part is to detect the pressure from the pressure sensors to detect the foot ulcers under normal or abnormal conditions of patients and the last part is to provide the detected data for remote viewing. Remote viewing of the data enables a doctor or health specialist to monitor a patient’s health progress away from hospital premises in any emergency and non-emergency conditions.

**Implementation**:

The components used in this proposed model include Arduino Mega, a power supply unit, Pulseoximeter sensor, pressure sensors, pulse sensors, and a LCD display. The Arduino Mega is used as a central processing unit for monitoring the ECG, SPO2 and foot ulcer of the patients. The working of this project is explained with the help of a block diagram shown in the

![Fig.1. System architecture](image-url)
There are two main sections: Transmitter section and the Receiver Section. The transmitter section comprises a smart shoe like system which consists of pressure sensors known as Force Sensing Resistor sensors placed on the 5 areas of rubber insole to detect the pressure at various areas of each foot. Continuously the data is sent to the Arduino Mega board. The Pulse oximeter is fitted around the ankle wrist that detects the blood oxygen saturation level of a diabetic patient. The transmitted data is encoded into serial data over the air through RF module i.e. GSM and Wi-Fi module and subsequently the measured values of the patients are displayed on the LCD display and in case of emergency an SMS alert is sent to patients or caretakers mobile. With the help of an antenna placed at the transmitter end, the data is transmitted to the receiver section. The receiver section is RPM (Remote Patient Monitoring) system which is a technology used for monitoring patients outside of conventional clinical settings, for example, in the home settings or hospitals which may lead to increase in the care of patient and decrease in the healthcare delivery cost. The remote healthcare system offers Healthcare specialist, Doctors: to Access the digital data of ECG, SPO2 and foot pressure sensors output to a centralized view of all the diabetic patients allowing clinicians to tailor workflows, protocols and interventions, creating customized care plans according to a patient’s condition and status and hence alerts and reminders that trigger patient in case of medical emergencies. Measured Data coming from sensors to Arduino Mega is processed to convert it to digital format that’s make easy to process data in system digital format so that it gives advantage on operational speed, and digital processing is much more efficient than analogue signal. For connectivity we are using Wi-Fi application to connect devices and software system. Database used is Things Board, this database is used because system stores data in table format and records format which is flexible to use. When abnormal data is indicated, alert message will be sent to doctor’s mobile and hence avoid risk and handle critical situation.

Results and Conclusions:

The proposed technique consists of a Keypad that is used to choose between the calculation of foot pressure values or Heart rate/SpO2 one at a time. Force Sensing Resistor (FSR) is used to measure the foot pressures at 10 different points. The MAX30100 is used to measure heart rate and SpO2. We use Arduino MEGA to obtain data from the above sensors. The data is processed in the Arduino and then sent to the patient’s/care-taker’s phone as an SMS using the GSM 800C Module. The processed data is also sent to Thingsboard platform through ESP8266-01 (WiFi) Module. Thingsboard is an open-source IoT platform for the device management, collection, processing and visualisation of data.
In our project the threshold values are obtained for a person weighing between 50-60kgs. If the sensor values do not exceed the defined threshold values the following result is obtained.

0th position: 1498  
1th position: 439  
2th position: 670  
3th position: 471  
4th position: 2191  
5th position: 386  
6th position: 394  
7th position: 397  
8th position: 398  
9th position: 4981

Your Heart Rate: 72 bpm
Your heart is doing GREAT!
Your SPO2: 92%
Your lungs are doing GREAT!

Fig. 5. Results viewed on Serial Monitor

Fig. 6. SMS received on phone

Fig. 7. Thingsboard Platform
Scope for future work:

The project is mainly used in chronic Health monitoring for all the types of diabetic patients. This project improves the initiative aimed to assist community health centers at both rural and urban areas of the city in redesigning their systems to increase diabetic patient self management through goal setting and patient activation. In-House smart diabetic health systems are provided, which can be built from the customized systems in a matter of minutes as per the user's requirements. The proposed system is very useful for recorded vital data analysis and reporting. This system has an intelligent component that allows user to generate reports on the fly. For Example- users can generate reports that list all patients with diabetics. These reports can also be created and saved.

In the future, the proposed system will be added with an Android app that will receive the signal from the transmitter module and alert a healthcare provider if there are abnormalities in the level of SPO2, heart rate and the foot pressure distribution. It would also test device on fracture patients and compare the results with a normal foot pressure distribution.

By incorporating a mathematical modelling and/or artificial intelligence technique along with a thorough clinical testing this system would be capable of detecting diabetic foot ulcer aggravations by foot pressure intensities, monitor both Parkinson patients and recovery of neuropaths remotely with the IOT technology based on gait abnormalities.

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By incorporating a mathematical modelling and/or artificial intelligence technique along with a thorough clinical testing this system would be capable of detecting critical level of SPO2, Heart rate and diabetic foot ulcer aggravations by foot pressure intensities, monitor the patients and recovery of neuropaths remotely with the IOT technology based on gait abnormalities.