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Research Paper

Blood Glucose Monitoring Using Non-Invasive Method Based On IOT

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Abstract – The current standard of diabetes management depends upon invasive blood pricking techniques. In recent times, continuous glucose monitoring devices have made some improvements in the life of diabetic patients. These proposed techniques have the potential to evolve into a wearable device for non-invasive diabetes management. The conventional Blood Glucose Monitoring (BGM) techniques currently used for the collection of blood samples through finger pricks make the process painful with the risk of infection. In recent years, researchers focus more on making BGM non-invasive under near infrared (NIR) rays. In Intensive Care Unit (ICU) the patients who are critically ill are admitted for the treatment and the Doctors need an all-time update patient's health related parameters like heart pulse and temperature. Manually doing this is a tedious task for the multiple patients. For this, IOT based system can bring about an automation that keep the Doctors updated all time over the internet. IOT Based ICU Patient Monitoring System is arduino based system which have collects patient's information with the help of few sensors and uses Wifi module to communicate the information to the internet where the heart beat pulse sensor and heart beat monitor module are electrically connected to the system and physically to be worn by the user. Thus, the doctor can get access to these vital parameters of the patient's health over the IOT Gecko web interface from anywhere in the world.

Keyword*:* ICU- Intensive Care Unit , BGM-Blood Glucose Monitoring, BGL-Blood Glucose Level, CGM-Continuous Glucose Monitoring, mg/dl-Milligrams per deciliter.

1. Introduction

Nowadays, medical electronics-sensors (E-sensors) are playing an important role in health care centers. Patient electronics-health (E-health) monitoring is one of the major advancements in the research field. Here we use the temperature sensor, heartbeat sensor to monitor the patient's body temperature, pulse and heart rate respectively. Hence the use of thermometer in home to check the body temperature before doctor's consultation, this proposed model (devices) can be used to check the patient's health condition in home as first aid information to the concerned patient otherwise now-a-days consulting doctors or going to the diagnosis centers, become to be very costly in terms of financial aspect. To minimize this situation, we describe the design of a Arduino microcontroller based on the advanced/high performance integrated health portable monitoring system. Like one of the parameter say Heart rate of the patient is measured by placing the index finger on IRD (Infra-Red Device) sensor and the pulse rate is also measured. The Heart Rate and the Body Temperature information is then sent to the web server through IOT. Now-a-days, a growing number of people in a developing countries like India forces to look for new solutions for the continuous monitoring of health check-up. It has become a necessity to visit the hospitals frequently for doctor's consultation, which has become financially related and also a time consuming process. To overcome this situation, we propose a design to monitor the patient's health conditions such as heart beat, temperature sent server to the web server via an IOT device. In recent development of internet of things (IOT) makes all the objects interconnected and recognized as the next technical revolution. Patient monitoring is one of the IOT application to monitor the patient health status. The Internet of things makes medical equipments more efficient by allowing the real time monitoring of health. Using IOT doctor can continuously monitor the patient's on his smart phone and also the patient history will be stored on the web server and doctor can be access the information whenever needed from anywhere.

Diabetes is a major medical concern that affects more than 9% of U.S. population. The condition can affect body organs and increase the risk of heart disease, stroke, blindness, kidney failure, neuropathy and congenital disabilities. Currently, though there is no cure for diabetes and patients can effectively manage their condition by monitoring the glucose concentration. A normal glucose concentration should be between 70 and 140 mg/dl (or 3.9-7.8 mmol/L) for

non-diabetics. The glucose concentration is considered high if it is above 140 mg/ dl after at least 8 hours without eating or drinking or above 180 mg/dl after 2 hours without eating. Clinical practice guidelines recommended that diabetic patients measure glucose concentration level at least three times a day (up to ten times for patients with Type 1 diabetes). The rise of global diabetes ,a growing number of subjects are suffering from the pain and infections caused by the invasive nature of mainstream commercial glucose meters. Non-invasive blood glucose monitoring technology has become an international research topic and a new method which could bring relief to a vast number of patients.

2. Materials And Methods For Monitoring Blood Glucose Concentration

HARDWARE SPECIFICATION:
This section gives the details and specifications of the hardware on which the system is expected to work. The specifications of system needed for the proposed solution to work smoothly.

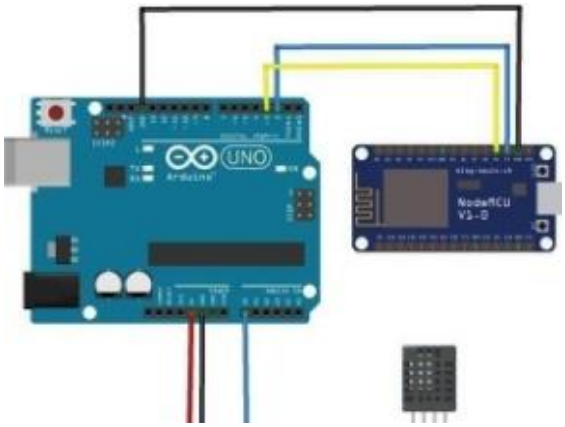
LCD-016M002B:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred by seven segments and other multi segment LEDs. The reasons are: LCDs are economical; easily programmable; have no limitation of displaying special & even (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in a 5x7 pixel matrix. This LCD has two registers namely Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc., The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

FEATURES:

5x8 dots with cursor
Built-in controller(KS 0066 or Equivalent)
+5V power supply(Also available for +3V)
1/16 duty cycle.
B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K
(LED)N.V. optional for +3V power supply.

NODE MCU and ARDUINO:



Node MCU V3 is mainly used in WiFi Applications which most of the other embedded modules fail to process unless incorporated with some external WiFi protocol. Following are some major applications used for NodeMCU V3. Install the Arduino IDE open the Arduino IDE from the desktop icon Click on File tab and than open preferences. In arduino IDE go to tools>Boards>select NODEMCU 1.0 (ESP-12E Module) again go to tools and select port. Change the WiFi name and password from the following code. Now click on Upload button to upload the following code. Connect the led's positive leg on the D9 pin of board and negative to the ground of the code. Power up the board and open the serial monitor from Arduino IDE after connecting to the WiFi it will show you the IP address type on the web browser (Edge, Chrome, Firefox etc.,)

ARDINO UNO:

Arduino UNO is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board that can be integrated into a variety of electronic projects. This board can be interfaced with other Arduino boards, Arduino shields, Raspberry Pi boards can control relays, LEDs, servos and motors as an output.

ZIGBEE:

Zigbee is a wireless network module that is being controlled globally. It is a low power network and comprise of sensors, control systems and instrumentations. Its benefits are really beneficial for domestic purposes and they can be seen in medical monitoring, industrial automation, low power network and comprise of sensors, control systems, instrumentation and HVAC Control.

UART:

UART stands for universal asynchronous receiver/ transmitter and defines a protocol, or set of rules, for exchanging serial data between two devices. UART is very simple and only uses two wires between transmitter and receiver to transmit and receive in both directions. Both ends also have a ground connection.

SOFTWARE SPECIFICATION:

This section gives a brief insights into the software required for this project which are given below,

- MP LAP
- PROTEUS

MP LAP:

To compile the code, open the "Run" menu and select "Build Main Project". The "Output" pane should show the build output from MPLAB X. One of the last lines of the output should say "Loading code from" and have the full path to the HEX file produced during compilation.

PROTEUS:

Proteus is a complete development platform from product concept to design completion. Its advantages are intelligent principle layout, hybrid circuit simulation and accurate analysis, single-chip software debugging, single-chip and peripheral circuit co-simulation, PCB automatic layout and wiring.

3. **Result and Discussion**

- MAX30100 SENSOR
- OPTICAL GLUCOMETER
- NODEMCU

MAX30100 SENSOR

INTRODUCTION

The MAX30100 is an integrated sensor for both heart-rate and blood oxygen saturation measurement. It combines two LEDs, a photo detector, optimized optics, and low-noise analog signal processing to deduct pulse oximeter and heart-rate signals. Here it additionally measures the figure temperature also.

WORKING PRINCIPLE OF MAX30100

This can be a Pulse Oximeter and pulse Sensor module based upon Maxim's MAX30100 integrated IC which is an compact low cost integrated solution for measuring pulse Sensor module based upon Maxim's MAX30100 integrated IC which is an compact low cost integrated solution for measuring pulse additionally as Pulse oximeter. MAX30100 sensor has two leds and a Photo-detector the two leds are accustomed emit two different wavelength of sunshine. One led may well be a red led while the alternative one is an infrared led. The photo- detector is then accustomed sense the absorbance of the blood flowing through the finger tip. This signal is then processed employing an occasional noise analog signal processing unit and then an enclosed micro-controller then converts it into digital output and provides out data in i2c protocol. MAX 30100 Sensor Module has an inbuilt transformer so it's going to be powered via 5 Volt and

may well be interfaced to any 5 volt micro-controllers, Arduino furthermore as Raspberry Pi.

FEATURES:

- Operating Voltage-1.8V to 3.3V
- Input Current-20mA
- Complete Pulse Oximeter and Heart-Rate Sensor Solution Simplifies Design.
- Integrated LEDs, Photo Sensor and High-Performance Analog Front-End Tiny 5.6mm x 1.2mm 14-Pin Optically Enhanced System-in-Package.
- Ultra-Low-Power Operation Increases Battery Life for Wearable Devices Programmable Sample Rate and LED Current for Power Savings.
- Ultra-Low Shutdown Current (0.7µA,typ).
- Advanced Functionality Improves Measurement Performance.
- High SNR Provides Robust Motion Artifact Resilience .
- Integrated Ambient Light Cancellation..
- High Sample Rate Capability.
- Fast Data Output Capability.

APPLICATIONS:

- Fitness Assistant Devices
- Medical Monitoring Devices
- Wearable Device

CONCLUSION:

Thus temperature, pulse rate and spO2 level are successfully measured using MAX30100 Sensor.

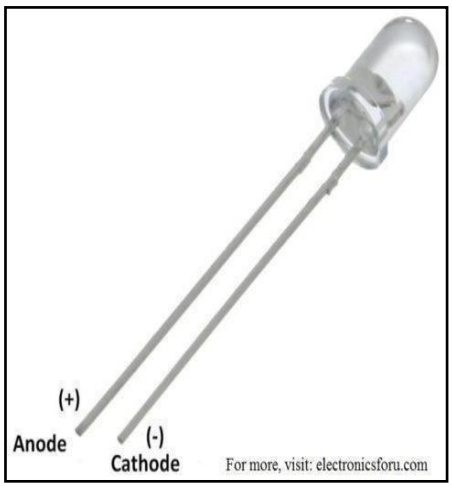
OPTICAL GLUCOMETER.

INTRODUCTION

Blood glucose monitors are used to measure the amount of glucose in the blood, especially in patients with symptoms or a history of abnormally high or low blood glucose levels. Most commonly, they enable diabetic patients to administer appropriate doses. This unit consists of a NIR photodiode and photodetector. It is used to measure the blood glucose level of patient using IR principle.

NIR LED:

NIR LEDs are usually made of gallium arsenide or aluminium gallium arsenide. In complement with IR receivers, these are commonly used as sensors. The appearance of IR LED is same as a common LED. The specific 950nm wavelength is invisible to the human eyes.



WORKING:

It consists of two parts, the emitter circuit and the receiver circuit. The emitter is an NIR LED and the detector is an NIR photodiode. The NIR photodiode is sensitive to the NIR light emitted by an NIR LED. The photodiode resistance and output voltage change in proportion to the NIR light received. This is the underlying working principle of the NIR sensor.

SET-UP

This setup consists mainly of a NIR source with a specific wavelength in the range of 750-1500nm, a tissue sample subjected to NIR radiation, and a photodiode to measure the attenuated light waves that are either transmitted or reflected from the tissue sample to the detector. The above diagram illustrates the set-up in a detailed manner.

CONCLUSION:

Thus using this NIR photodiode and receiver, the glucose level of a patient can be obtained.

NODE MCU:

INTRODUCTION:

Node MCU is an open source platform supported ESP8266 which could connect objects and let data transfer using the Wi-Fi protocol additionally, by providing variety of the foremost important features of microcontrollers like GPIO, PWM, ADC etc., it can solve many of the project's needs alone.

USE OF NODEMCU:

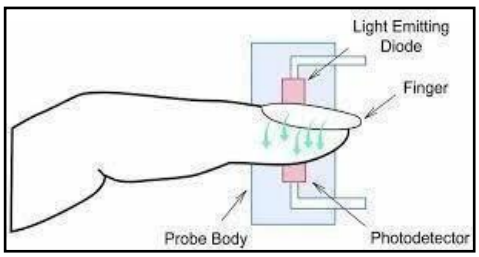
Node MCU is used during this project to process the knowledge obtained from the max sensor, and optical glucometer. It also sends the knowledge to MQTT dash mobile app through cloud.

DATA INPUT TO THE MICROCONTROLLER:

The information input to the Node MCU is that the digital interrupt from various sensors. This information is continuously sent to the microcontroller from the all sensors via serial communication. This stranded or single wires are used for serial communication between the sensor and microcontroller. This Node MCU calculates the numerous health parameters of patient and displays it on LCD and stores it in the cloud.

CONCLUSION:

Thus the information obtained from input side are processed and sent to Cloud through Node MCU. According to whether the blood glucose test has caused injury to human skin, it can be simply divided into invasive and non-invasive blood glucose monitoring.



Invasive Blood Glucose Monitoring

Hospitals employ invasive electrochemical biosensors to measure blood glucose concentration. These biosensors leverage automatic lancet devices to prick the finger for extracting blood samples. By leveraging Faraday rotators, electro-optic modular, or liquid crystal, existing methods can modulate the polarization state of the light beam to infer the glucose concentration from sample blood. Although recent work has made efforts to reduced blood sample requirement to less than 1 μL, these methods are still painful since patients with diabetes have to frequently measure (>3 times) blood glucose every day. At present, invasive blood glucose detection technology is mainstream, convenient and practical, so both hospitals and household glucometers adopt the method of blood sampling first and then analysing it in vitro for blood glucose measurement.

Non-Invasive Blood Glucose Monitoring

Non-invasive blood glucose monitoring, as its name implies, refers to the deduction of human blood glucose without causing damage to human tissues. There are lots of methods for non- invasive blood glucose detection, which can be generally divided into optical methods, microwave methods and electrochemical methods. Optical methods include Near-Infrared Reflectance Spectroscopy (NIRS), polarized optical rotation, Raman spectroscopy, fluorescence, optical coherence tomography (OCT) and so on. In addition to glucose in human blood, there are also considerable amounts of glucose in other biofluids (such as saliva, tears, sweat and ISF).

Utilizing the coherent correlation between biofluids and blood glucose value, the electrochemical method usually measures the glucose content in body fluids first and obtains the blood glucose value indirectly after the calibration of the algorithm or data model. The range of glucose in ISF is the closest to the range of blood glucose in both healthy and diabetic, which provides a theoretical basis for the development of an ISF glucose sensor. However, a large number of research works have shown that there is a time-lag phenomenon between the ISF glucose and blood glucose, that is, ISF reflects the change of blood glucose level with a certain delay, which ranges from about 4-10 min.

Transdermal biofluid extraction generally adopts reverse iontophoresis (RI) technology, which can achieve the purpose of rapid extraction of ISF. Minimally invasive approaches leverage subcutaneous sensors to measure glucose concentration in body fluids other than blood, e.g., sweat, saliva, and interstitial fluid. These methods, known as continuous glucose monitoring (CGM), can monitor glucose continuously and automatically.

CGM sensors leverage tiny electrode (invasive needles), which are functionalized with an enzyme flim using an electro polymerisation method, to measure glucose concentration in ISF. The overall measurement error is approximately 10% [60]. However, CGM sensors have needles, and they require periodic replacement of sensors. Some CGM sensors (Medtronic Guardian and Dexcom G5) require calibration (e.g., finger stick blood samples) for optimal sensor accuracy. Our work differs in that our system has no needles, and it requires neither of periodic sensors replacement nor calibration.

Fieldname	Attribute	Type	Size	Description
Id	Primary key	Int	10	It uniquely store id in the table
Temperature	Null	Int	12	It store Temperature of the Patient Monitoring
Heart beat	Null	Int	12	It store Heart beat of the Patient Monitoring

System Implementation is the stage of the project when the theoretical design is tuned into working system. If the implementation system stage is not carefully controlled and planned, it can cause chaos. Thus it can be considered to be the most critical stage in achieving a successful new system and in giving the users a confidence that the system will work and be effective. The implementation stage in a project involves, Careful Planning investigation of the current system, checking constraints and the implementation. Training the staffs in the newly developed system. A software application in general is implemented after navigating the complete life cycle method of a project. Various life cycle processes such as requirement analysis, design phase, verification, testing and finally followed by the implementation phase results in successful project management.

The software application which is a Windows based application has been successfully implemented after passing

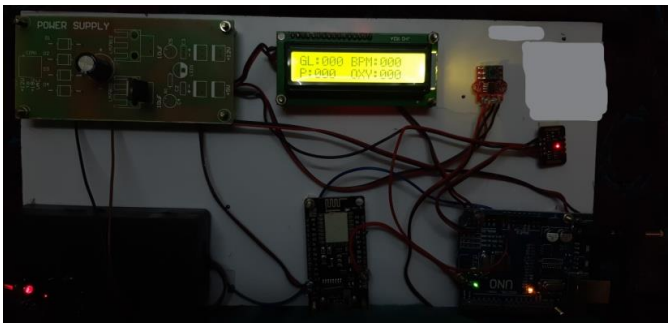
various life cycle processes mentioned above. As the software is to be implemented in a high standard industrial sector, various factors such as application environment, user management, security, reliability and finally performance are taken as key factors throughout the design phase. These factors are analyzed step by step and the positive as well as negative outcomes are noted down before the final implementation. Security and authentication are maintained in both user level as well as the management level. The data is stored in MySQL, which is highly reliable and simpler to use, the user level security is managed with the help of password options and sessions, which finally ensures that all the transactions are made securely. The application's validations are made, taken into account of the entry levels available in various modules. Possible restrictions like number formatting, data formatting and confirmations for both save and update options ensures the correct data to be fed into the database. Thus all the aspects are charted out and the complete project study is practically implemented successfully for the end users.

4. Conclusion

In this paper, we analyzed the solutions currently available for the implementation of the application of this technique is necessary that it would provide a piece of appropriate technical information about the patient's health condition. The application of this technique is necessary because it would provide an appropriate technical information about the patient's health condition. This technique is more feasible, easy to handle, provides mobility, decrease the opportunity for inaccurate data analysis it can be implemented among communities to develop the overall welfare of people using the technology available.

Having the technology proposed provides more flexibility such as it is more cost efficient, decreased obstacles to network communication, supporting patients in self monitoring, and availing guidance and standards in maintaining the privacy of data and the alert system would lead to an successful implementation of this project. A non-invasive system is developed using NIR LED sensor which helps for regular blood glucose monitoring in an economical way.

Experiments are performed using our prototype and commercially glucometer, PPG signals are obtained based on a prototype system and linear regression method used to model the relationship between PPG signal and BGC. The results show that the NIR system is an encouraging method for non-invasive estimation of BGC. In the near future, we will plan an experimental procedure for more subjects. In addition, we will use different wavelength and multiple regression analyses for further improvement of the proposed system.



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