Continuous Glucose Level Monitoring Device

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***Abstract*—Technology has been massively improved within the last few decades and helped to improve our lives . The sensor and algorithm became smarter to provide better suggestions to achieve our goals. As the fast food industry boomed , humans faced more diabetics and obesity related health issues. Patients with diabetic have to follow a strict lifestyle to remain healthy. Monitoring their blood glucose level is one of the most important tasks in their day to day activity. In this paper we will see how we can use the MQTT protocol to measure continuous blood glucose level and the approach that solves some of the major problems .**

I. Introduction

Diabetes affects an estimated 34.2 million individuals of all ages in the United States, both diagnosed and undiagnosed. reliable source.Diabetes, if not effectively controlled, can result in a buildup of sugars in the blood, raising the risk of catastrophic complications such as stroke and heart disease.Diabetes may express itself in a variety of ways, and how people manage it differs depending on the kind. Diabetes isn't usually caused by being overweight or leading a sedentary lifestyle. Some have been there since childhood.

The most common types of diabetes are type 1 diabetes, type 2 diabetes, and gestational diabetes, which we shall examine in further detail below. Less common types of diabetes include monogenic diabetes and cystic fibrosis-related diabetes.

Type 1 diabetes, often known as juvenile diabetes, arises when the body fails to manufacture insulin. Insulin is a hormone that breaks down sugar in the blood for utilization throughout the body. A person with type 1 diabetes may obtain a diagnosis as a youngster.Insulin must be administered on a regular basis to those with type 1 diabetes. Individuals may use injections or an insulin pump to do this. Type 1 diabetes has no known cure. Once diagnosed, a person must frequently test their blood sugar levels, give insulin, and make certain lifestyle modifications to help manage the illness.

Type 2 diabetes patients do not produce or utilize insulin properly. This is the most frequent type of diabetes, according to the National Institute of Diabetes and Digestive and Kidney Diseases and it has significant ties to obesity. A person suffering from type 2 diabetes may or may not require insulin. Medication, coupled with adjustments in exercise and nutrition, can often help control the disease[1].

II. Concept

In order to solve this problem we came up with a solution that helps with real time glucose monitoring devices. This continuous glucose monitoring device can be stuck to any part of the body and the device will send real time information to the patients. Blood glucose level usually fluctuates after taking food , after taking insulin and after a workout . Real time data is very helpful for a diabetic patient. After Getting the data the patient can push the prescribed amount of insulin to the blood. The data can be collected through smart phones and smart watches. Doctors and other health professionals also can keep track of their patients. In any emergency situation this device will provide an opportunity for the doctor to stay informed about a patient's current condition and intervene if required.

The monitoring device will have a tiny needle that will be inserted inside the skin. The needle consists of multiple layers , these layers work as a protection for the needle as the needle will remain inserted for a longer period of time .The needle contains an enzyme called glucose oxidase. This enzyme converts the glucose in the body into hydrogen peroxide. The hydrogen peroxide then reacts with the metals inside the sensor creating electrical charge which travels to a computer chip where it is then translated into blood glucose levels. Depending on the electrical charge different glucose data can be found. The device will have a button cell battery as it consumes very low power to transmit the data. The battery can be replaced after the battery is discharged. If the battery is low it will show an alert sign to replace the battery.

The Fig2 shows the device can be used in the following steps. In this scenario the dog is just an example , the same steps can be used for humans as well.

- Collect the necessary materials, including clippers, alcohol wipes, sensor, gloves, and medical adhesive
- Clean the surface with an alcohol wipe and allow it to dry.
- Apply the adhesive in a doughnut-shaped pattern and allow it to partially dry.
- The safety device is used to place the device safely to the skin but should not be touched.

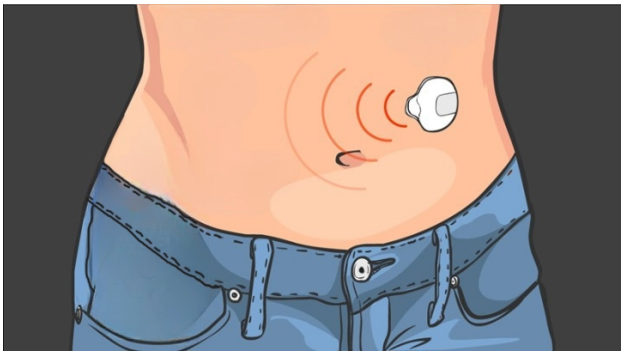

Fig. 1. Continuous Glucose Level Monitoring Device

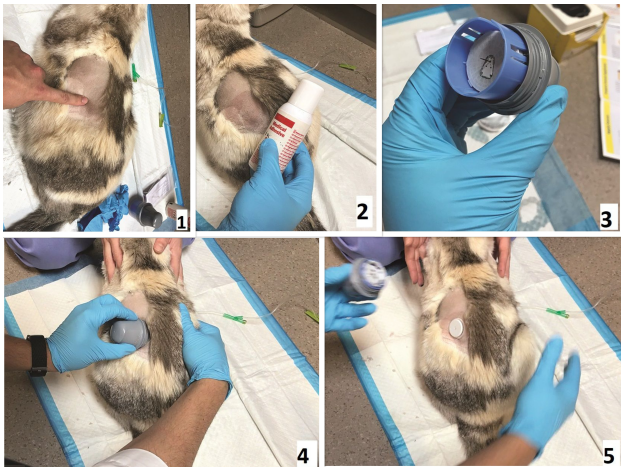

Fig. 2. Steps to use the device [2]

- Firm pressure may be applied to ensure good sensor contact and application device can be removed gently.

III. Designing of the Concept

A. Requirement

In the Requirement Fig 5 we can see the main requirements of the system . As shown in the figure continuous glucose level monitoring device is set high level requirement as the main goal is to collect glucose level data within a time interval. There are 5 sub level requirements for the continuous glucose level monitoring device.

- Real time system- The system being real time is one of the main requirements, as we require real time data from our sensors. As a more specific requirement we have derived requirement sensors which collect the data and the data is transmitted to the smart devices.
- Reliable - The system should be reliable and provide accurate data to users. As the system is a medical device it has to be very precise. Patients' health conditions might deteriorate for a false measurement so it has to be very accurate .
- Communication- The system should be able to establish stable communication to send data to the users smart devices . As a more specific requirement we will use MQTT protocol which is a very lightweight protocol and doesn't consume much battery .
- Safety- The system should be able to alert the patient when alarming glucose level is found. It will also be able to inform the medical team in extremely worse cases which is a more specific requirement

B. Models

1) Activity Diagram: In fig 3 the activity diagram shows the patient logins to the app and the server verifies the account. The server creates a topic where the device sends the current data and the doctor subscribes to the topic. Later we can see a diamond/condition with 3 options: good condition , bad condition and emergency. If the glucose level is good then the control flow ends. If the glucose level is bad then the server creates another topic where the doctor sends a prescription and the user subscribes to the prescription. If the glucose level is in an emergency condition the server directly sends a message to emergency for help and the control flow ends.

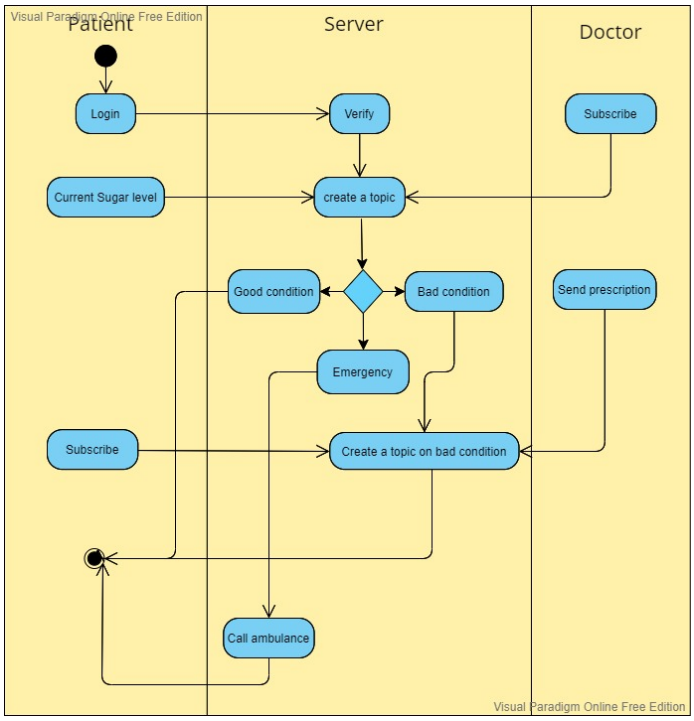

Fig. 3. Activity Diagram

2) State machine diagram: In fig 4 the state machine diagram the system starts with idle and is triggered to check status state. Again we have 3 conditions: good, bad and emergency. If it's good , the state will transition to idle state. If the patient has a good glucose level , the states remain in a loop. If it's bad , it will be transmitted to the doctor and the doctor will prescribe for the current condition and the state terminates. If it's too bad , it will be transmitted to the calling ambulance and the state terminates.

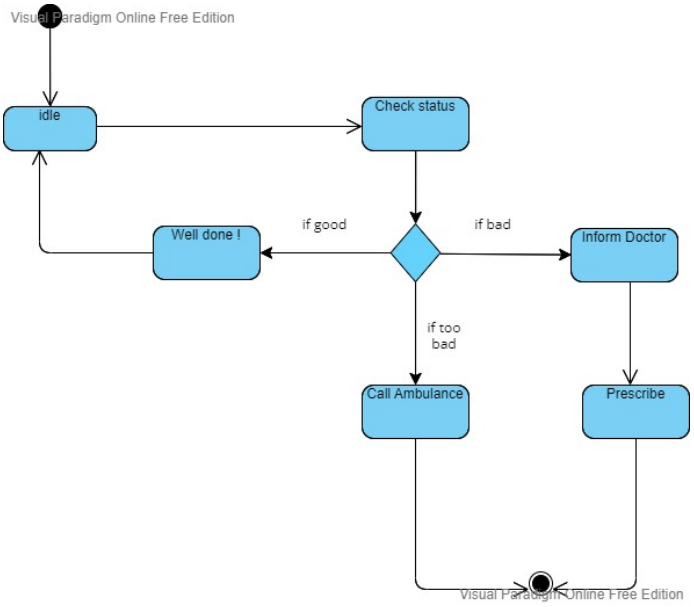

Fig. 4. State machine diagram

C. Hardware

The sensors send data to the user. The pink circle shows the contact point of the needle or we can also say sensor. The small blue square shows the antenna and the large blue square covered with foil shows the NFC sensor which helps to pair with the phone. The core are the two chips. The larger one is an RF430 which is responsible for Radio-frequency identification (RFID). The smaller one is an EM9304 Bluetooth chip. A cell battery will be connected for the power supply.

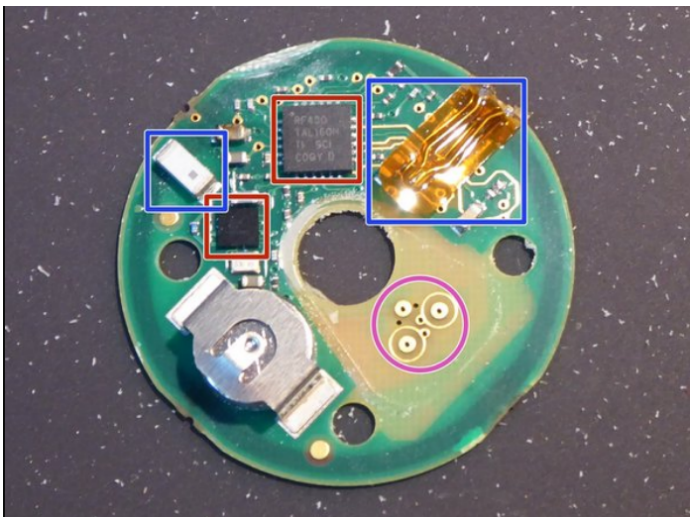

Fig. 5. Hardware [3]

D. User interface

The user interface should be simple so it is easier for the user to use .The diagram shows a sample with a graph showing glucose level. Pressing the + button allows communication with the medical team. If the level is too low it shows the result in red and green for optimal glucose level.

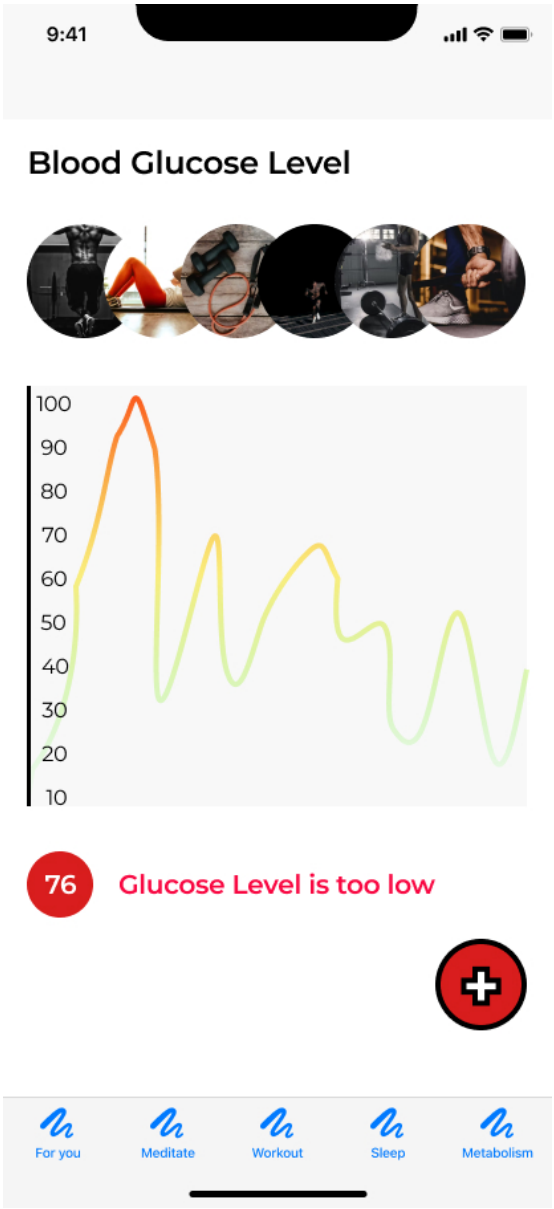

Fig. 6. Sample of user interface

IV. Discussion

By using the system the user will check the glucose level and intake the prescribed insulin. We thought about connecting doctors and patients together so that the patient always remains safe. Diabetics is a deadly disease we should give our latest technology to mankind. The device will also have some pros and cons . The main cons can be said sticking the device to the sensor to the body for a long time might be uncomfortable and might lead to itching , rashes. The device has more advantages compared to standard glucometers. Standard measures current blood glucose by a finger stick sample placed on a test strip and inserted into the device [].

Continuous measurement can provide real time data which can be very effective

1) Improvement during the project: Initially finding concrete topics was very tough, medical devices with alarm was tough to find. Discussing with other members helped to find a concrete direction. I came up with a blood glucose monitoring device as I saw diabetic patients struggle a lot with the disease. I even saw people having eye problems due to extreme diabetic conditions. In every weekly discussion I learnt a lot of new smart approaches for doctors and patients. I took help from other colleagues to refine my diagrams .

V. Conclusion

The latest technology has the potential to save lives, improve health, and help develop long-term healthcare solutions. This system was created using a variety of engineering techniques. This device can be helpful for people with diabetes and also. Connects patients and doctors. This system can therefore be invasive, simple, fast and reliable to monitor our blood glucose level.

References

[1] "Diabetes: Symptoms, Treatment, Prevention, and Early Diagnosis." Www.medicalnewstoday.com, 30 Nov. 2021, www.medicalnewstoday.com/articles/323627?c=1479834201822type-2-diabetes.

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[3] "FreeStyle Libre 2 Sensor Teardown." IFixit, 22 Oct. 2020, de.ifixit.com/Teardown/FreeStyle+Libre+2+Sensor+Teardown/137719. Accessed 14 June 2022.

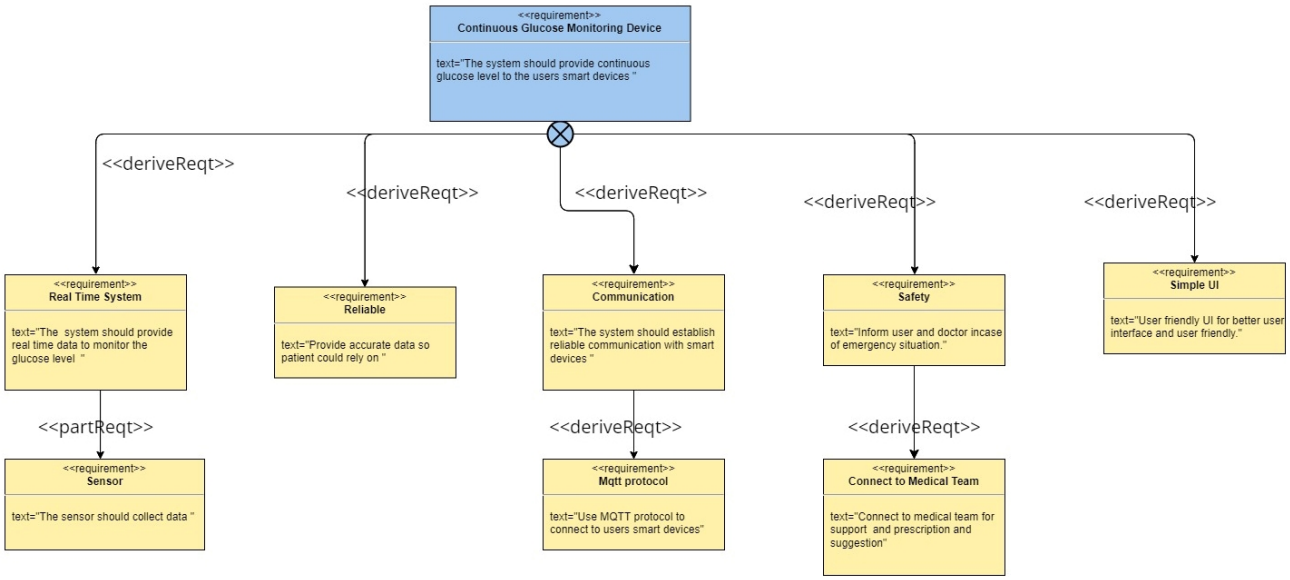

Fig. 7. Requirement diagram

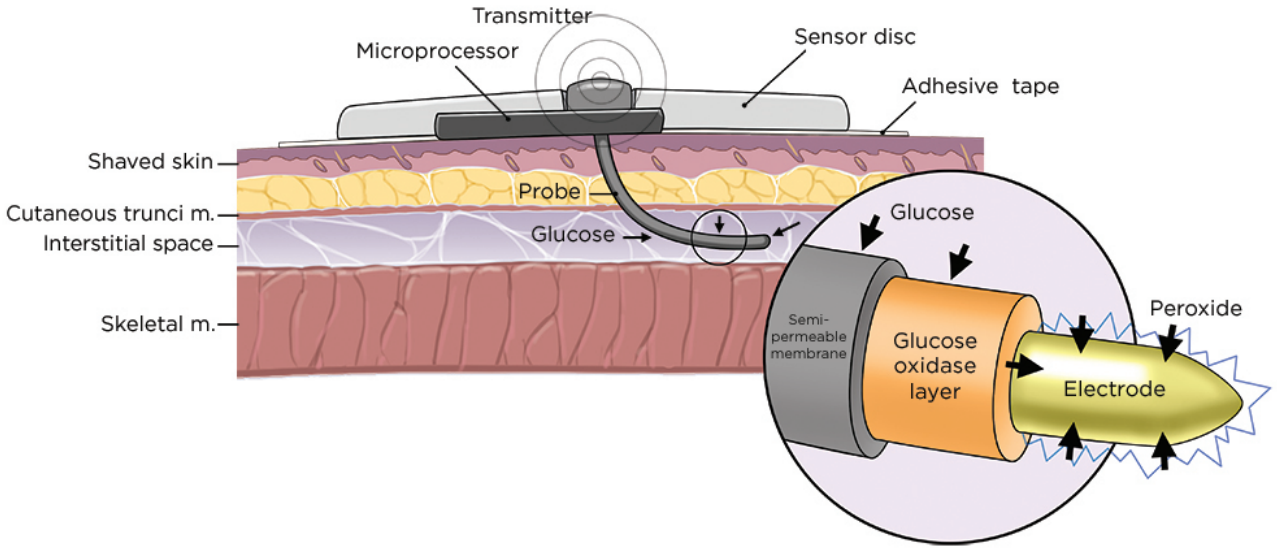

Fig. 8. mechanism of the device[2]