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NEXT GEN GLUCOSE SENSORS

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Abstract:

With advancements in Sensor Technology, the Wireless Sensor networks (WAN) offer attractive solutions to many problems in process monitoring systems. The WSN has abundant applications in continuous or discrete monitoring systems irrespective of the field. The Bio-compatible wearable sensors allow vast amounts of data to be collected and mined for clinical trials, reducing the cost and inconvenience of regular visits to the physician. Implying this concept, our project is used to track diabetes using a wireless sensor network as an implant to continuously monitor the patient's blood glucose level. The sensor implanted in the body identifies the level of glucose in blood. The level thus measured needs to be monitored.
The most conveniently used method to monitor the implant would be to use a detector to telemeter the collected sugar concentration to an external receiver. In the case of our project, we aim to replace the detector by transmitting the monitored data as a message to the patient's cell phone itself. This is a simple and an efficient way to make the process less strain full for the patient and also relatively cheaper.

Thus the sensor can effectively monitor the glucose level and can also send a notification message to the patient, thereby reducing the need of tedious physical processes by the use of smart futuristic technology.

Keywords: Diabetic, Tissue Layer, Wireless sensor, Electromagnetic Frequency, TransImpedance Amplifier, Reactive Electrode

1.Introduction:

Advances in wireless sensor networking have opened up new opportunities in healthcare systems. The future will see the integration of the abundance of existing specialized medical technology with pervasive, wireless networks. They will co-exist with the installed infrastructure, augmenting data collection and real-time response. Unobtrusive, wearable sensors will allow vast amounts of data to be collected and mined for next-generation clinical trials. Data will be collected and reported automatically, reducing the cost and inconvenience of regular visits to the physician.

Therefore, many more study participants may be enrolled, benefiting biological, pharmaceutical, and medical-applications research.

The aim of our project is to monitor one of the most widespread diseases, the diabetes using a wireless sensor network as an implant to continuously monitor the patient's blood sugar level and update it as a message to the patient's cell phone.

We maintain the patient-id in the device and maintain it with a database and update the glucose level in a timely manner for observation.

2. SYSTEM ANALYSIS:

2.1 EXISTING SYSTEM

There are many (at least 20+) different types of blood monitoring devices available on the market today; not every meter suits all patients and it is a specific matter of choice for the patient, in consultation with a physician or other experienced professional, to find a meter that they personally find comfortable to use. The principle of the devices is virtually the same: a small blood sample is collected and measured. In one type of meter, the electrochemical, a small blood sample is produced by the patient using a lancet (a sterile pointed needle). The blood droplet is usually collected at the bottom of a test strip, while the other end is inserted in the glucose meter. This test strip contains various chemicals so that when the blood is applied, a small electrical charge is created between two contacts. This charge will vary depending on the glucose levels within the blood. In older glucose meters, the drop of blood is placed on top of a strip. A chemical reaction occurs and the strip changes color. The meter then measures the color of the strip optically.

2.1.1 LIMITATIONS OF EXISTING SYSTEM:

Unnecessary pain while testing for age hold persons. Since each and every time the needle should pinch for blood for testing the glucose level. No continuous monitoring of Glucose level. The patient doesn't have serious attention towards his health and doesn't maintain the proper medical Precautions.

2.2 PROPOSED SYSTEM:

In our proposed project we used to continuously monitor the blood glucose level using a glucose sensor in an embedded System. A Glucose **sensor** converts the measured glucose level in the blood. Which is then send to the ADC and the digitized output is send to the microcontroller and it is interpreted and calculated.Then it is transmitted to a patient Handset and a PC through Wireless Sensor Network Medium (WSN)

2.2.1 BENEFITS OF PROPOSED SYSTEM:

Continuous monitoring which gives proper update of patient's glucose level. Time efficient and strain less where no need of going clinical labs for glucose testing.Can be handheld since the measured data is updated to patient's handset itself.It creates self-awareness among the patients for their proper health maintenance.

3.Customary diabetic testing:

Control and outcomes of both types 1 and 2 diabetes may be improved by patients using home glucose meters to regularly measure their glucose levels. Glucose monitoring is both expensive (largely due to the cost of the consumable test strips) and requires significant commitment on the part of the patient. The effort and expense may be worthwhile for patients when they use the values to sensibly adjust food, exercise, and oral medications or insulin. These adjustments are generally made by the patients themselves following training by a clinician.

Regular blood testing, especially in type 1 diabetes, is helpful to keep adequate control of glucose levels and to reduce the chance of long term side effects of the disease. There are many (at least 20+) different types of blood monitoring devices available on the market today; not every meter suits all patients and it is a specific matter of choice for the patient, in consultation with a physician or other experienced professional, to find a meter that they personally find comfortable to use. The principle of the devices is virtually the same: a small blood sample is collected and measured. In one type of meter, the electrochemical, a small blood sample is produced by the patient using a lancet (a sterile pointed needle). The blood droplet is usually collected at the bottom of a test strip, while the other end is inserted in the glucose meter. This test strip contains various chemicals so that when the blood is applied, a small electrical charge is created between two contacts. This charge will vary depending on the glucose levels within the blood. In older glucose meters, the drop of blood is placed on top of a strip. A chemical reaction occurs and the strip changes color. The meter then measures the color of the strip optically.

Fig.1: Customary glucose level measurement using test strips

4. A Wireless implanted glucose monitoring sensor:

As a replacement to the conventional diabetic testing, new techniques for monitoring blood glucose levels, includes an implantable glucose sensor. The analog output current is proportional to the glucose concentration of the body fluid electrolyte and is therefore directly indicative of the blood glucose level.

On the whole, the glucose monitoring system is divided into two units:

- **The Sensor unit** which consists of the components that are responsible for measuring the blood glucose level and generating corresponding analog signals.

- **The Transmitting unit** which has the components for converting the received analog signals into digital data and transmitting them to a base station attached to the patient's cell phone.

4.1 Sensor unit:

- ### Structure of the sensor:

The glucose monitoring sensor has a sensing system withglucosedependent oxygen measuring sensor and base level oxygen measuring sensor. These sensors are arranged on an alumina disc. The sensor unit includes a titanium encased battery and microprocessor, a silicone-sheathed platinum electrode, and a glucose oxidase enzyme system enclosed in a semi permeable cellulose acetate membrane. This unit is placed inside a container. Biocompatible Titanium, being inert to human fluid, is used as material for the container. This sensor unit is implanted in the subcutaneous tissue layer of the body, with the sensor surface facing inwards.

- ### Working Principle of the sensor:

When a sensor is implanted in the body, the foreign body invasion doesn't go unnoticed. The environment around the sensor changes after initial implantation of the sensor. The body remodels the cells and moves the blood vessels around the device. The sensor relies on the chemical reaction in which glucose, oxygen, and water, when exposed to an enzyme that catalyzes (speeds up) the reaction, are recomposed into gluconic acid

$$C_6H_{12}O + H_2O + O_2 \Rightarrow C_6H_{12}O_7 + H_2O_2$$

(Glucose) (Gluconic acid)

The sensors focus on the amount of oxygen consumed for the chemical reaction. The hydrogen peroxide produced in the above reaction breaks down into oxygen atom and water.

$$H_2O_2 \Rightarrow {}^{1/2}O_2 + H_2O$$

Therefore the net reaction can be given as:

$$\text{Glucose} + {}^{1/2}O_2 \Rightarrow \text{gluconic acid}$$

Here, two glucose oxidase enzymes with platinum electrodes are employed to act as catalysts – one to speed up the reaction of glucose with oxygen and the other to speed up the breaking down of hydrogen peroxide into oxygen and water.The enzyme electrodes are covered with a semi permeable cellulose acetate membrane to prevent its reaction with unwanted molecules of the body fluid. Now, any oxygen that is left over is measured.

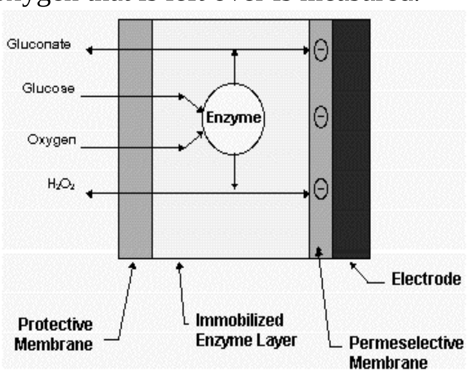


Fig.2: Overall structure of Glucose Biosensor

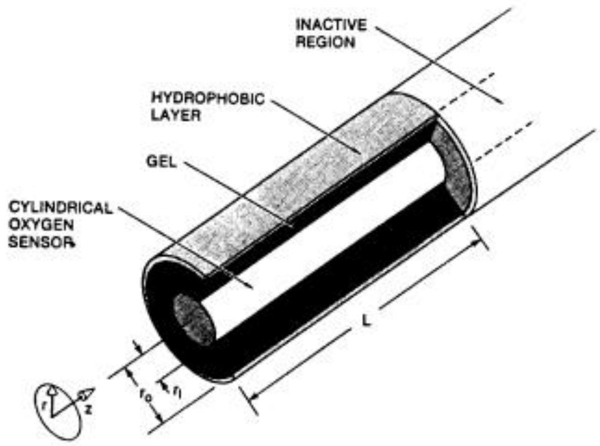


Fig.3: 2 Dimensional structure of the sensing unit

The above diagram shows a 2 dimensional image of the oxygen sensor unit. The core of the sensing unit is the oxygen sensor.

The sensor has a processor that would provide the ratio of left over oxygen to blood glucose. But there can be variation in the levels of oxygen produced due to various factors like body temperature, lack of sleep, inadequate food intake, remodeling of surrounding tissue, etc. To overcome that, the monitoring sensor has another sensor attached to it which keeps track of the base oxygen level in the implanted area. The change in the base levels of oxygen can be subtracted out of the change in levels of oxygen found in the glucose-dependent reaction, and only the change in oxygen levels that is unique to the glucose-dependent reaction is used to determine how much the levels of glucose have changed.

So, whenever there is a change in the oxygen levels, it will be reflected in the measurement of both the sensors. Thus the implant is successfully able to determine the amount of sugar level in blood without any physical strain to the patient.

4.2Transmitting Unit:

The most conveniently used method to monitor the implant would be to use a detector to telemeter the collected sugar concentration to an external receiver.

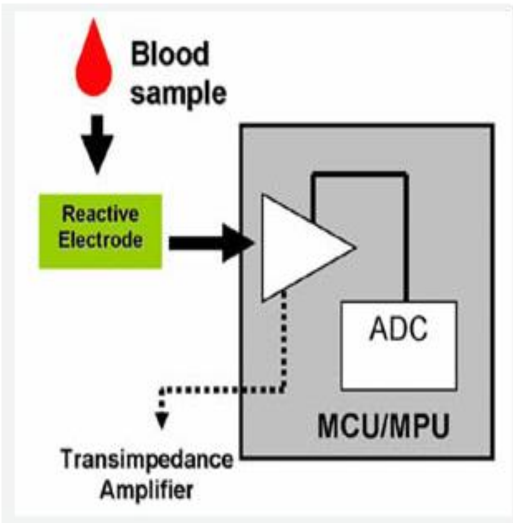
In the case of our project, we aim to replace the detector by the patient's cell phone itself. This is a simple and an efficient way to make the process less tedious and also relatively cheaper considering the money aspect.

- **Practical Implementation:**

This is made practical by attaching an integrated base station to the user's cell phone. For wireless communication inside the human body, the tissue medium acts as a channel through which the information is sent as electromagnetic (EM) radio frequency (RF). So, the information is transmitted as electromagnetic (EM) radio frequency (RF) waves.The MICS band (Medical implant communication service band) ranging between 400 MHz and 406 MHz, meant for communication in medical implants is allocated for data transfer between the glucose sensor and the base station.

The transmission unit of the glucose sensor has the following components:

- Flash memory of 8 kb to store abnormally high and low values to notify the user under such condition.
- EEPROM of 64 kB to store the measured value till transmission.
- **Real time clock.**
- A transimpedance amplifier that converts the current from electrodes into voltage and conditions the signal.
- 8 bit ADC(analog to digital convertor) that converts the analog signals from the amplifier into digital signal.
- Operational amplifier LM611 acting as a comparator whose reference voltages are preset depending on the abnormally low and high values.



- An integrated antenna to transmit signals at radio frequencies. The MICS band, having a frequency range of 401 MHz to 406 MHz, is allocated for data transfer between the base station and the sensor.

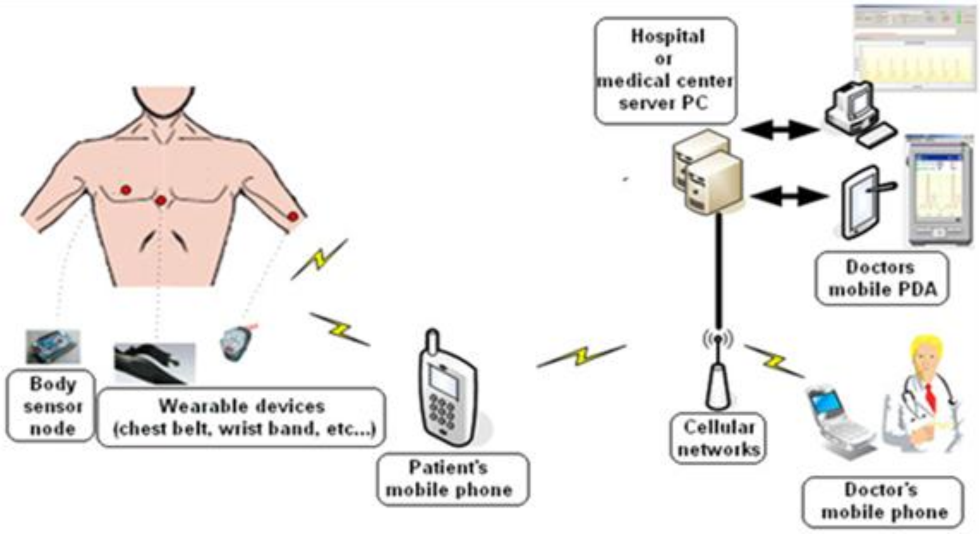
The Transceiver is chosen keeping in mind the following factors: size requirement, impedance matching between the sending and receiving end, low power consumption. The transmission and reception involves radio frequency range. An appropriate software application is installed in the user's smart phone which allows the received data to be sent as a notification to the cell phone.

4.3 Database Design:

This phase explains about Database design used in diabetes risk application. The application uses only one database table. It is the table of hospital.

No	Name	Type	Key	Information
1	Id_	Integer	primary	ID for Patient
2	Name	Varchar		Name of Patient
3	telephone	varchar		Telephone number of patient

The entire representation of the system can be expressed by the following diagram:



5. Conclusion and Future Enhancement

Thus, our approach monitors the blood glucose level continuously and send message over period by using a real time clock. This approach also notifies when the glucose level is abnormally low or high. This technology provides affordable solutions for continuous glucose monitoring. The sensor implant keeps the diabetic updated with the blood glucose level and reduces the burden of frequent visit to the physician. The database that we develop for our project will make the physician to have a detailed report on patient's Glucose level changes that makes him still more helpful for treatment. In the sense to make this project a still more better the future implementation is made in direct mobiles where the sensors are directly fit in it and gets updated automatically which makes a big market for even the mobile and also the glucose device. With advancement in MEMS technology the size of the prototype can be reduced to nearly 50 percent and we can introduce rabbit processor which can save patient information such as photo etc. and we can add CAN protocol to control the event from some other location. With advancement in Tele communication we can add GPS and a-GPS to monitor and locate the patient and suggest some positive therapy. We can add GSM kit to send the information to the physician or the patient handset. A sensor alarm and more efficient algorithm can be added to check component working parameters An advanced report based management can be done and cloud storage is maintained

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Dr.S.PadmaPriya received her BE (Electronics and Communication) from Madras University in the year 1991. And M.Tech (Information Technology) from Punjab University and M.E.(Embedded Systems) from Anna University, and Ph.D. (Computer Science) from Berhampur University . She has been the member for evaluation committee for projectsand served has Resource coordinator for Bharathidasan University and IGNOU. She has published papers in many national level conferences on embedded systems. She is now presently Heading over the Information Technology Department in Prathyusha Institute of Technology and Management.

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