

NON INVASIVE TECHNIQUE TO MEASURE GLUCOSE AND HAEMOGLOBIN LEVEL IN BLOOD USING NIR-OCCLUSION SPECTROSCOPY

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ABSTRACT:

Diabetes has evolved as one of the principal health care epidemics of the modern era. Diabetes can also result in reduced blood haemoglobin level causing anemia. Therefore maintaining healthy blood glucose and Hb levels are essential for the prevention of conditions like diabetes, obesity and other long-term and short-term micro & macrovascular complications such as diabetic ketoacidosis and severe hypoglycemia. For the effective management of Type I and Type II Diabetes, frequent blood sugar monitoring is required. As the available invasive blood glucose monitoring techniques reduce the patient compliance causing pain, discomfort and inconvenience to patients due to frequent finger prickings, the technologies for non invasive glucose monitoring gained importance in the recent decades. The purpose of our project is to develop a non-invasive method for measuring blood glucose and Hb levels based on NIR- Occlusion spectroscopy. The development of this technique would considerably improve the quality of life for diabetic patients, facilitate their compliance for glucose and Hb monitoring and also reduce the complications and mortality associated with this disease.

Keywords: Diabetes, anemia, NIR, occlusion, glucose, haemoglobin.

INTRODUCTION:

Diabetes is the biggest health challenge of the 21st century. It is the major cause of blindness, obesity, ageing population, heart disease, stroke, amputations and renal failure in the world. Diabetes affects the body's ability to produce or utilize insulin, a hormone that is needed to properly process blood glucose. As a result, diabetics must regulate their own blood sugar levels through diet and insulin injections. The key point in the regulation of blood sugar is the accurate measurement of the blood sugar level.

There are mainly three types of diabetes namely, type I, type II and gestational diabetes.

In type I diabetes, β cell in pancreas are destroyed so the pancreas cannot produce sufficient insulin. It is also called as insulin dependent. In type II diabetes reflects the inability of the body to use the

secreted insulin since the problem with receptors cause the cells do not absorb glucose. While gestational diabetes occurs during pregnancy. After delivery it may lead to Type II diabetes.

Anemia may occur along with diabetes because the hormone that regulates red blood cell production, erythropoietin (EPO), is produced by the kidneys. Kidney damage at several levels is a complication of diabetes, and one problem often leads to the other. Changes in the kidneys that occur with diabetes range from diabetic nephropathy all the way to chronic kidney disease. Early detection and treatment is essential to prevent or delay disease progression.

There have been continuously increasing research efforts in the field of glucose and haemoglobin monitoring during the last few decades. The frequent monitoring of blood glucose is critical for diabetic management, as the maintenance of physiological

glucose level, *i.e.*, 72–144 mg/dL, is the only way that a diabetic can lead a healthy lifestyle by avoiding life-threatening diabetic complications, such as diabetic retinopathy, kidney damage, heart diseases, stroke, neuropathy and birth defects.

Currently, blood glucose and haemoglobin can only be monitored through the use of invasive techniques. The risk of infection and measurement inaccuracy are present with all of the invasive techniques. In addition, discomfort also caused by the invasive method. A truly noninvasive glucose and haemoglobin-sensing device could avoid complications of diabetes and anemia. Non-invasive monitoring of blood glucose offers many advantages, which avoid pain and discomfort from frequent finger-pricking.

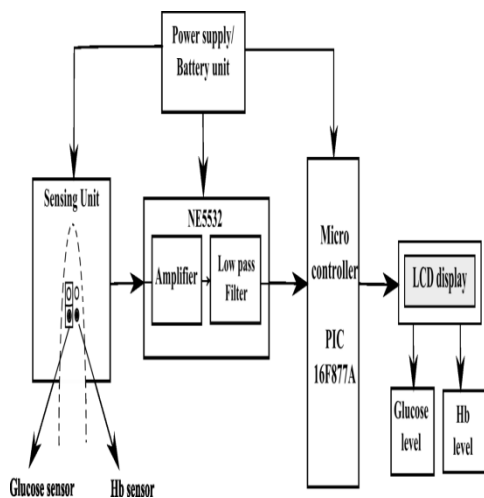
AVAILABLE TECHNOLOGIES:

Nowadays non invasive technologies were used to measure blood glucose and haemoglobin level. Noninvasive techniques like near-infrared and Raman spectroscopy, polarimetry, light scattering, photoacoustic spectroscopy, polarization technique, mid infrared spectroscopy etc are available to measure the glucose level in blood. But there is no device to measure blood glucose and haemoglobin combined.

PROPOSED TECHNOLOGY:

Here we use NIR spectroscopy along with occlusion principle to measure the glucose and haemoglobin level in blood non invasively and effectively. When NIR is used along with occlusion, effective blood glucose and haemoglobin measurement is obtained.

BASIC BLOCK DIAGRAM:



The figure shows the block diagram of the device. It consists of two NIR reflective sensors correspondingly in the range of 1000nm and 870nm. When the finger is placed on the sensor unit, the IR rays emitted by the sensor (LED) passes through the finger and the reflected waves from the tissue are received by the sensor (photodetector). Photodetector convert the light signal into the electrical signal which is given to the low pass filter. Low pass filter filters the noise from the signal and it is then amplified. This amplified signal is given into the microcontroller unit. The microcontroller PIC16F877A contains an inbuilt Analog to Digital Converter and it converts the analog signal into digital values. These digital values are displayed in the seven segment LCD display. For each parts to operate, 5V power supply is provided.

WORKING PRINCIPLE:

The NIR Reflective sensor consists of two light sources such as 1000nm to detect the blood glucose level and 870nm to detect the haemoglobin level. When the light rays pass through the finger glucose and haemoglobin molecules in blood absorb the light source. Occlusion spectroscopy is used to get accurate results. NIR spectroscopy enables investigation of tissue depths in the range of 1 to 100 millimeters with a general decrease in penetration depth as the wavelength value is increased.

In contrast to other configurations, we use transmitted light in addition to reflected light for glucose and haemoglobin measurement. In the transmission mode the light traverses the whole organ (finger), and the photons typically encounter many more glucose and haemoglobin molecules along their paths than in the reflection mode. This enhances the sensitivity to glucose and haemoglobin and clinically relates to an average over a whole organ rather than a highly localized measurement. In addition, the influence of local factors such as skin morphology and pigmentation is reduced considerably.

APPLICATIONS:

It can be used for,

- Diagnosing anemia, hyperglycemia, hypoglycemia etc.
- Management of diabetes mellitus through continuous glucose monitoring.
- Effective and accurate glucose and Hb monitoring non invasively.

PROJECT IMPLEMENTATION SUMMARY:

The initial problem was the use of invasive and minimally invasive methods for blood glucose concentration measurements. To address this problem, this project observed uses near-infrared as a possible means to measure blood glucose and Hb levels. Such implementation would be non-invasive. To implement the near-infrared spectroscopy, light emitting diodes that emit light at 1000nm and 870nm were chosen and used. To detect the reflected light, a photodiode with an electromagnetic sensitivity to electromagnetic light between wavelengths of 1000nm to 870nm was used.

A reflective optical sensor serves this purpose well and it reduce the losses that occur while constructing LED- Photodiode pair manually. The peak wavelength of glucose and Hb reflective sensors are 1000nm and 870nm approximately. To test the device, measurements are taken from various individuals with low and high blood glucose as well as haemoglobin levels. The voltage reading from the photodiode is amplified and filtered using a non inverting amplifier and is converted into values by the microcontroller and the output is viewed in the display.

Using near-infrared light of wavelength 1000nm, minimum photodiode output voltages were the same for all individuals (1.5V). Maximum photodiode output voltages ranges from 3 to 3.8V for the individuals.

RECOMMENDATIONS:

Due to the lack of time and available resources, some ideas of improvement were not implemented. Presented here are suggestions and recommendations for the further development of future implementations or extensions this project.

The development of a stable base to hold and align the emitted infrared light with the active area of the photodiode may yield more accurate and precise results. Additionally, a method of stabilizing the finger movement and trying out the device measurements in different individuals with varying finger size, skin thickness, finger positioning, lighting conditions, amount of occlusion applied to finger etc is advantageous. Also, the use of stronger light sources may yield greater voltage differences for various in individuals. Light sources of 2050nm will need to have higher power

output (greater than 28mW). Laser or Ultrasound implementation

may also yield results. For better data analysis, computerized signal processing could be used along with the use of near infrared light at many more different wavelengths.

FINAL CONCLUSION:

In conclusion, this project has suggested a means for non-invasive blood glucose and haemoglobin levels testing. With implementation of NIR- occlusion spectroscopy at a wavelength of 1000nm and 870nm, there is a relation between glucose or Hb level in blood and light reflectance. Although not as accurate as present day invasive or minimally invasive techniques for measuring blood glucose- Hb concentrations, but the use of near-infrared light provides a means of non-invasive measurement with less pain and discomfort to the diabetic patients and improve the quality of their life through effective diabetes management.

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