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Regulating Blood Clot Time Parameter for Diabetes Manipulation

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ABSTRACT:
When it comes to modern health issues, diabetes is at the top of the list. It is the leading global cause of age-related vision loss, obesity, cardiovascular disease, stroke, limb loss, and kidney failure. Although now, the most popular approach to self-monitoring blood glucose (SMBG) is to measure blood glucose concentration using specialized instruments that analyze chemically blood samples obtained by puncturing the finger. There is a danger of infectious disease transmission, in addition to the discomfort, time consumption, and high expense associated with these treatments. This paper's primary goal is to provide arguments on the design and viability of an optical reflectance-based semi-invasive glucose measuring technology. Time needed for normal blood to clot is the guiding factor for the whole instrument's construction. Optical reflection mode, via the lens of a DVD writer, is used to quantify this clotting time for blood samples. The reported clotting time is adjusted according on the blood sugar level. This device is designed to detect blood glucose levels in samples in an easy-to-use and straightforward manner.

KEYWORDS: Diabetes, self-monitoring of blood glucose levels; optical reflectance technology; semi-invasive approach
.

INTRODUCTION:

betes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1]. Abnormally high levels of glucose can damage the small and large blood vessels,leading to: diabetic blindness, kidney disease, amputations of limbs, stroke, and heart disease [2]; also, excessive use ofglucose-lowering medication such as insulin can cause hypoglycemia or abnormally low blood sugar. According to the
Mexican National Health Information System there are more than 10 million people who are currently diagnosed with diabetes, of which 90% are type II diabetics, and it is the main cause of mortality in Mexico accounting for 13.6 percent of deaths in general [3]. Frequent monitoring of glucose concentration in diabetic patients is crucial for effective treatment because it can supply trend information that could help identify and prevent unwanted periods of hypo- and hyperglycemia [4]. Self monitoring of blood glucose is usually done in an invasive manner, which involves finger-stick testing which is painful to the patient and carries the risk of infection [5]. Recently, minimally invasive needle-based continuous glucose monitoring systems that can provide glucose measurements every 5 minutes or less have become available [4].

RESEARCH AND DEVELOPMENT OF NON-INVASIVE METHODS
Several techniques such as diffuse reflectance spectroscopy, electrical impedance spectroscopy, Raman spectroscopy, among others, have been used for noninvasive glucose monitoring [6]; even though these studies were
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(performed under different environments and clinical settings they can give a rough estimate of the sensitivity and reliability of current non-invasive glucose technology. These techniques present a Root

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Mean Square Error of reduction (RMSEP) that goes from 25 to 46 mg/dl [5,7,8,9,10,11,12,13,14]; which for a 126 mg/dl of Fasting Plasma Glucose level (FPG), which is considered a diagnostic criteria for diabetes [1], gives a relative concentration error higher than 5%. These studies rely on a single detection mechanism, but a combination of two or more detection mechanisms to reduce the error of prediction has not been investigated.Near infrared (NIR) spectroscopy has been used to monitor changes of glucose concentration in tissue owing to the fact that a change of refractive index takes place in the extra-cellular fluid due to the presence of additional glucose, which causes a small change in the overall scattering properties of the tissue that can be detected by NIR spectroscopy[15]. It has previously been reported that glucose variations affect the electrical properties of cellular membranes [14].This is due to specific reactions of blood and tissue cells to varying glucose concentrations, which changes the electrolyte balance across the membranes of blood and underlying tissue. These changes in the electrical properties of cellular membranes result in changes in the ac conductivity and tissue permittivity which can be measured using impedance spectroscopy [16].

OPTICAL ABSORPTION TECHNIQUES:

Optical absorption techniques for quantification of glucose are based on selective absorption of light by the molecule which is described by the Beer–Lambert law:

$$I=Io\ e^{-\varepsilon CL}$$

Here Io is the intensity of incident optical radiation, I is the transmitted intensity, e is the molar extinction coefficient in $(mol/L)^{-1}$ cm^{-1} and is dependent on wavelength, C is the molar concentration, and L is the pathlength in cm. Measurements are generally reported in absorbance, $A=\log(I0/I)$, such that the absorbance of several species is additive.

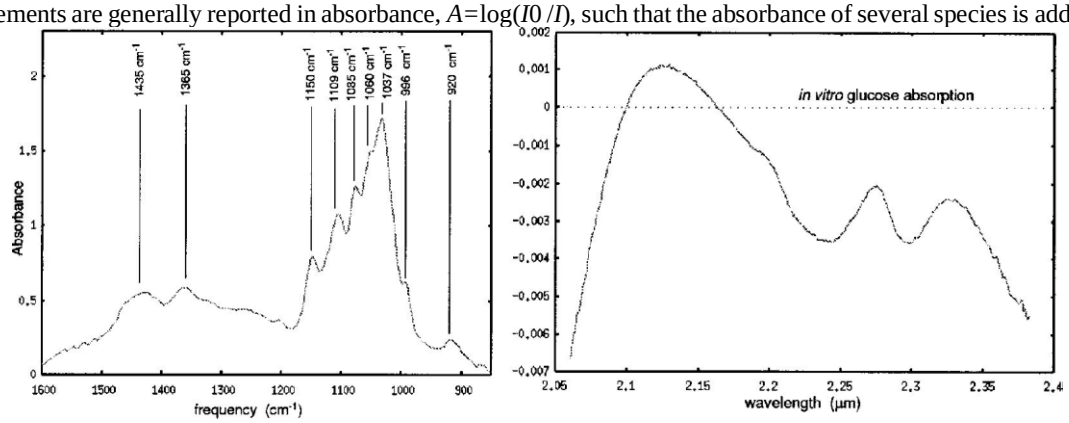

Fig.1 Optical absorption spectra for glucose. (a) Mid infrared region extending from 1600 to 900 cm−1 or 6.25 to 11 mm and showing absorption peak assignments. (b) Near-infrared region extending from 2.0 to 2.5 mm or 5000 to 4000 cm−1. Note that the magnitude of the three absorbance peaks in the NIR region is much smaller.

Optical absorption spectroscopy for glucose quantification has generally been restricted to either the mid infrared MIR or the near-infrared NIR spectral region. Fig.1 shows examples of both MIR and NIR optical absorption spectra for aqueous glucose after water subtraction. The MIR region of the spectrum ranges from 2.5 to 50 um (4000–200 cm^{-1}), and it is in this region that absorption bands due to fundamental stretching and bending modes of the molecule may be seen. For this reason, spectroscopy in the MIR or ‘‘finger-print’’ region is extremely useful for spectral identification of compounds. However, the magnitude of background absorption bands due to solution constituents likewater severely limits the path length which can be used in MIR transmission spectroscopy to a few hundred microns or less. The near-infrared region which lies between 2.0 and 2.5 mm has become increasingly popular for aqueous glucosemeasurements. This region contains a relative minimum in the water absorption spectrum and readily identifiable glucose peak information. Glucose sensing using near infrared spectroscopy is by no means a simple problem. Glucose absorption peaks whose magnitude is relatively small compared to a large aqueous background spectrum often yield low signal-to-noise measurements. NIR spectral measurements are further plagued by a lack of repeatability. Near

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infrared spectra are sensitive to a host of factors including temperature, *p*H, and scattering. Additionally, *in vivo* measurements may be susceptible to differences in skin pigmentation, hydration, blood flow, probe placement, and probe pressure. Finally, it should be noted that the NIR spectrum of glucose is very similar to that of other sugars including, in particular, fructose which is often used by diabetics as an alternative to glucose. Despite these difficulties, near infrared methods have demonstrated significant promise in becoming a viable technique for non invasive glucose sensing. For this reason we used near infrared reflectance technique for measuring blood glucose semi-invasively.

INSTRUMENTATION SCHEME FOR NON-INVASIVE GLUCOMETER:

The technology is based on the property of glucose to affect the scatter of light. Glucose changes the refractive index and hence the scattering properties of the organ (finger), leading to change in scattering coefficient, as a result concentration of glucose can be measured.In the proposed glucose sensing system, transmission mode is used in the design of probe. As in case of transmission mode the light traverses the thumb/finger, and typically encounter many more glucose molecules along their paths than in the reflection mode as a result increased sensitivity can be achieved corresponding to glucose concentration. However in this scheme fine calibration depending upon the skin thickness and pigmentation is considered. The generalized Instrumentation scheme for noninvasive blood glucose sensing system is given in Fig.2.

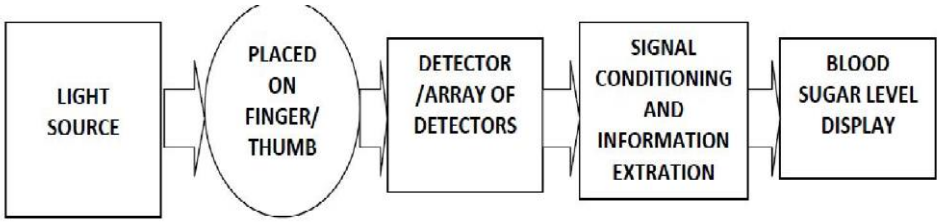

Fig.2 Generalized Instrumentation Scheme for Non-Invasive Blood Glucose Sensing System

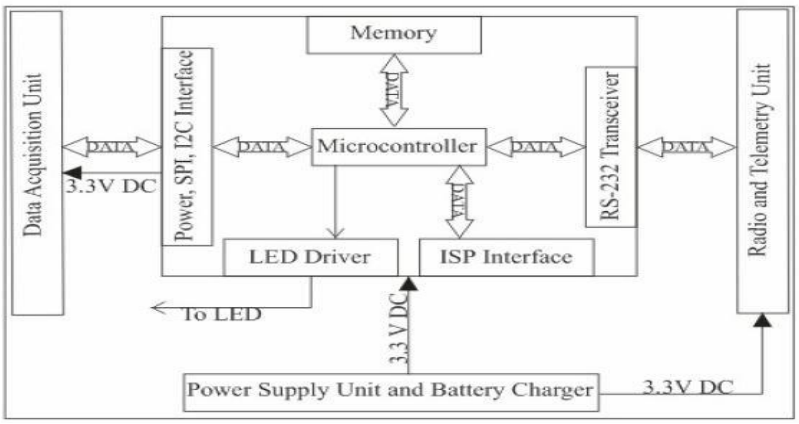

Fig.3 Instrumentation scheme of the non-invasive blood glucometer.

This new technology allows for a non-invasive glucose-level blood testing. According to the company the new method is simple and accurate and may help people suffering from diabetes to live their lives in a slightly more comfortable manner without constantly worrying about being pricked with a needle. This proposed system introduces a non invasive type glucose measurement using non invasive type glucose sensor. The sensor is placed in human finger this sensor has two IR sensors the IR sensors pass infrared waves into the finger at different wavelength. According to the glucose level the IR waves get absorbed by the blood. The amplifier will amplify the reflected IR waves according to the obtained analog values the microcontroller will convert them into digital the digital values will be displayed in the PC. To interface PC with our microcontroller we need a level converter i.e., RS232 to TTL logic converter in PC we can view the values using VB.NET application.

Software Workflow in short:

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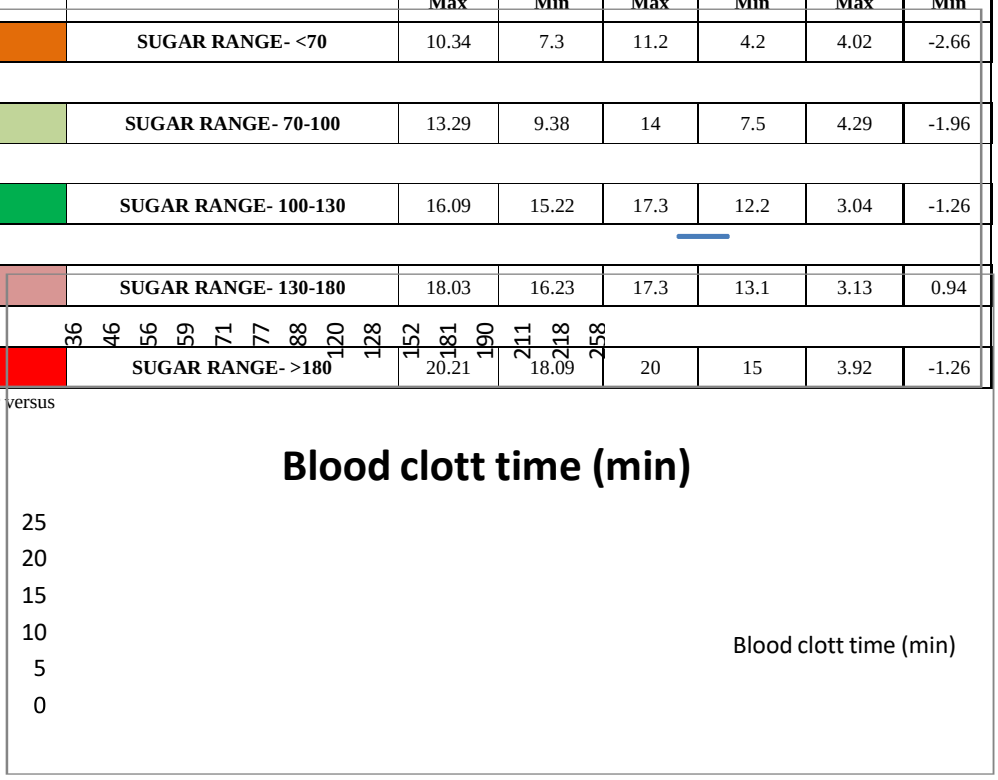
1. Power up the system.
2. First detect the presence of finger via sensor & signal conditioning unit.
3. Then trigger out the IR output signal via transistorized driver circuits.
4. Wait for data input signal for logic change.
5. Record time for change.
6. Calibrate the time as required.
7. Compare the time record for various sugar ranges.
8. Send the message via GSM for abnormal ranges to concerned authorities.
9. Send data to PC if required for data logging purposes.

RESULTS:

The present work is based on the principle of relation between blood clotting time and blood sugar level. The blood sugar level is detected by monitoring the clotting time of blood. As the blood sugar level increases in blood the clotting time required will also be more. Hence the instrument is calibrated depending on the blood clotting parameter, the results as obtained from the present work are represented in the following table:

Colour	Range	Read Time		Observed Time		Deviation	
		Max	Min	Max	Min	Max	Min
	SUGAR RANGE- <70	10.34	7.3	11.2	4.2	4.02	-2.66
	SUGAR RANGE- 70-100	13.29	9.38	14	7.5	4.29	-1.96
	SUGAR RANGE- 100-130	16.09	15.22	17.3	12.2	3.04	-1.26
	SUGAR RANGE- 130-180	18.03	16.23	17.3	13.1	3.13	0.94
	SUGAR RANGE- >180	20.21	18.09	20	15	3.92	-1.26

ig. 4 Blood Sugar versus



od Sugar versus Observed Blood clotting time

I. Conclusion and Future Work

The need for new glucose sensors in diabetes is now greater than ever. Although development of an acceptable, continuous & automatic glucose sensor has proven to be a substantial challenge, progress over the past several decades has defined sensor performance requirement & has focused development efforts on a limited group promising candidates. The advent of new glucose sensing technologies could facilitate fundamentally new approaches to the therapy of diabetes. Present paper demonstrates only fragments of a significant progress in its role study. Despite fulfilled significant scientific research work in this area there are a lot of blanks, problems to solve both in fundamental

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and practical issues of non invasive glucometer. Recent answers on puzzling questions mostly are limited via technical and methodological imperfections. Figuratively we are still at the beginning of the way, thorny and hard, and only productive cooperation of scientists may bring success.

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