Abstract- Diabetes has emerged as a major healthcare problem in India. Today the technologies available in the market are invasive methods. Since invasive methods cause pain, time consuming, expensive and there is a potential risk of infectious diseases like Hepatitis & HIV spreading and continuous monitoring is therefore not possible. Hence there is an immense need to develop non-invasive glucose monitoring (NGM) devices that will reliable, instantaneous, cost effective and alleviate the pain and suffering of diabetics associated with the frequent pricking of skin for taking the blood sample for glucose testing.

NGM device is one such which can be used for continuous monitoring of glucose levels in human body.

Keywords- Blood Glucose Measurement, Non-invasive, Glucose Concentration, NIR spectroscopy, Diabetes

I. INTRODUCTION

Diabetes is one among the supreme health challenges of the current century. Glucose concentration changes in the blood in any direction i.e. increase or decrease in blood glucose concentration proves fatal for the patient. The acceptable range of glucose concentration is from 70 mg/dL (milligram of glucose in 100 millilitres of blood) to 110 mg/dL or 3.9 to 6.0 mM/L. But soon after eating glucose concentration of a person may rise to a level up to 140 mg/dL. [5]

In the blood glucose monitoring industry, it is well accepted that there are three “C” terms that drive people’s willingness to test: Cost, Comfort and Convenience. Non-invasive blood glucose monitoring should be limited to a technique which produces no pain or discomfort to perform the test, involves no blood or other body fluid obtained by piercing the skin (more on this later), and does not require or cause any tissue damage, injury, or deterioration.

II. METHODOLOGY

There are different methodologies developed for non-invasively blood glucose measurement.

A. Mid-Infrared Spectroscopy

Mid-infrared (MIR) spectroscopy employs the same principles as infrared spectroscopy; in other words, it is the absorption measurement of MIR frequency by a sample positioned in the path of an MIR beam. It is based on light in the 2500 to 25,000 nm region of the spectrum. Absorption differences when MIR light meets human tissues can be represented by certain modelling techniques in spectral quantitative analysis. A partial least squares algorithm is now normally used for multivariate calibration for these constituents.

MIR exhibits decreased scattering phenomena, yet increased absorption, because of the higher wavelengths compared with near infrared (NIR) spectroscopy.23 Light can penetrate skin to a depth of a few micrometers. As a result, only reflected light can be considered, because there is no light transmitted through a body segment. Moreover, another possible advantage of MIR spectroscopy is that the response
peaks of glucose and other compounds are sharper with MIR than with NIR, where they are often broad and weak. [9]

B. Fluorescence Technology

This technique uses fluorescence reagents to track the presence of glucose molecules in blood. Many approaches exist, such as measuring changes in fluorescence resonance energy transfer between a fluorescent donor and an acceptor, or measuring glucose-induced changes in intrinsic fluorescence of enzymes. One study reported that glucose levels in tears reflect concentrations similar to those in blood, and thus, fluorescence of tears can be used as non-invasive glucose monitoring.

This technology is very sensitive; it can detect single molecules. It causes little or no damage to the body. In addition, it can give results in terms of fluorescence intensity and decay times, both of which are independent of light scattering and fluorophore concentration, which can reduce loss through diffusion or degradation.

C. Raman Spectroscopy

Raman spectroscopy is based on the use of a laser light to induce oscillation and rotation in human fluids containing glucose. Because the emission of scattered light is influenced by molecular vibration, it is possible to estimate glucose concentration in human fluids.

This effect depends on the concentration of the glucose molecules. This technique can measure very weak signals, even in human fluids. The wavelength range of Raman spectrum is considered to be 200 cm$^{-1}$ to 2,000 cm$^{-1}$. Raman spectrum of glucose can be differentiated from those of other compounds in this band.

Raman spectroscopy usually provides sharper and less overlapped spectra compared to NIR spectroscopy. The intensity of spectral features is proportional to the concentration of the particular species, and the spectra are less sensitive to temperature changes. Moreover, it is comparatively less sensitive to water, and the interference from luminescence and fluorescence phenomena is only modest. [4]

D. Near infrared spectroscopy (NIR)

Near infrared (NIR) spectroscopy is located in the wavelength region of 730–2500 nm. The principle is similar to that of MIR spectroscopy. NIR spectra are made up of broad bands corresponding to overlapping peaks: the overtones (ie, first, second, third, and combination overtones), formed by molecular vibrations. It allows blood glucose measurement in tissues by variations of light intensity, based on transmittance and reflectance.

The high sensitivity of the photoconductive detectors is the main advantage of NIR spectroscopy. Water is reasonably transparent to the signal bandwidth used by NIR, which makes it possible to use for blood glucose monitoring. In addition, the measuring signal has high energy compared with MIR spectroscopy. Perhaps even more important, this method is less expensive than MIR. Materials are relatively low in cost, and there is a wide range of commercial products available.

III. METHODOLOGY OF IMPLEMENTATION

Poor penetration is the main limitation of MIR. Other limitations, as with NIR, include problems with confounding factors, such as water content in blood.

Photonic sensing can suffer from strong scattering phenomena, especially in fluorescence technology. Moreover, there are limitations, such as short lifetimes and biocompatibility, which need to be dealt with, possibly through the use of colorimetric assays.
The main limitations of Raman spectroscopy are instability of the laser wavelength and intensity and long spectral acquisition times. In addition, as the power of the light source must be kept low to prevent injury, the signal-to-noise ratio is significantly reduced. Moreover, as with NIR spectroscopy, interference from other compounds remains a problem.

Hence we preferred NIR spectroscopy for glucose measurement which has high accuracy & Measuring signal has high energy.

Figure 1. Diagram of proposed system

IV. RESULT AND OBSERVATION

4.1 Observation of 1st Person

As given in Table 1 for 1st person, Gray threshold value at 09:05 am i.e. before tea considered as a reference value. Then we took observations after tea, before & after lunch, before evening tea. Gray threshold value 0.33333 considered as a reference value & calculated difference for further observations.

<table>
<thead>
<tr>
<th>Time</th>
<th>Gray threshold</th>
<th>Reference Value</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:05am</td>
<td>0.33333</td>
<td>0.33333</td>
<td>0.00000</td>
</tr>
<tr>
<td>09:40am</td>
<td>0.39216</td>
<td>0.33333</td>
<td>0.05883</td>
</tr>
<tr>
<td>12:40pm</td>
<td>0.40392</td>
<td>0.33333</td>
<td>0.07059</td>
</tr>
<tr>
<td>03:30pm</td>
<td>0.38824</td>
<td>0.33333</td>
<td>0.05491</td>
</tr>
<tr>
<td>04:30pm</td>
<td>0.38431</td>
<td>0.33333</td>
<td>0.05098</td>
</tr>
</tbody>
</table>

4.2 Observation of 2nd Person

As given in Table 2 for 2nd person, Gray threshold value at 09:05 am i.e. before tea considered as a reference value. Then we took observations after tea, before & after lunch, before evening tea. Gray threshold value 0.54510 considered as a reference value & calculated difference for further observations.
Table 2. Observation of 2nd Person

<table>
<thead>
<tr>
<th>Time</th>
<th>Gray threshold</th>
<th>Reference Value</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:05am</td>
<td>0.54510</td>
<td>0.54510</td>
<td>0.00000</td>
</tr>
<tr>
<td>09:40am</td>
<td>0.54902</td>
<td>0.54510</td>
<td>0.00392</td>
</tr>
<tr>
<td>12:40pm</td>
<td>0.55294</td>
<td>0.54510</td>
<td>0.00784</td>
</tr>
<tr>
<td>03:30pm</td>
<td>0.55208</td>
<td>0.54510</td>
<td>0.00698</td>
</tr>
<tr>
<td>04:30pm</td>
<td>0.55118</td>
<td>0.54510</td>
<td>0.00608</td>
</tr>
</tbody>
</table>

4.3 Comments

- The response of equipment should be same with respect to time schedule of entire day.
- Normally due to fasting of overnight sugar content of blood very low in the morning.
- So before having any food intake we have measured the light intensity & considered this value as a reference value.
- Then we observed values of gray threshold by taking different types of food through entire day.

V. CONCLUSION

In this paper, we have shown the implemented strategy of non-invasive glucose measurement using NIR spectroscopy and measured glucose level in the blood. The light intensity dependent. From observations we conclude that glucose concentration changes with respect to our food.

REFERENCES


[9] Chi-Fuk So1Kup-Sze Choi1Thomas KS Wong2Joanne WY Chung2,3, “Recent advances in non-invasive glucose monitoring”Medical Devices: Evidence and Research, 27 June 2016