MIDTERM PROGRESS REPORT
IPRO-331 Non-Invasive Blood Glucose Monitoring System
Professor Opara

Team Members

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Jen Tullman	Amanda Ritter
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Revised Objectives

Our IPRO project revolves around the blood glucose monitoring that is associated with the treatment of diabetes. Most of the current techniques for monitoring blood glucose levels in diabetes patients require blood sampling through venepuncture, a procedure that is quite invasive and uncomfortable for patients, especially pediatric patients suffering from juvenile diabetes. Since monitoring of blood glucose is quite frequent throughout the day for patients, obtaining blood samples thus requires constant pricking and puncturing of the skin. To avoid this discomfort for patients, it is the goal of this IPRO project to develop a non-invasive technique, either in vivo or ex vivo, to measure blood glucose without the need of venepuncture so that patients can measure blood glucose in a more comfortable fashion. We have decided that an application of ultrasound and then extraction of the interstitial fluid for glucose testing will be our method.

Results to Date

Ultrasound

We adopted the ultrasound technique to determine the blood glucose level via non-invasive routes. Ultrasound can permeate the skin by disorganizing fat cells and thereby making the interstitial fluid available for glucose testing upon suction. Glucose in the interstitial fluid has been shown to correlate to blood glucose levels. The ultrasound group sought to determine the details needed to develop the ultrasound device. After meeting with Dr. Ralph Muehleisen, a professor in the Civil Engineering department at IIT, we came up with the following details:

1. The components of this device will be a transducer and an amplifier.
2. The frequency of the device will be approximately 20-55 kHz.
3. The power supply to run the device will be 20 W, and it can be provided in the form of batteries.

The proposed price range of the transducer and amplifier should be about $25-$100.

Vacuum Suction

The purpose of the vacuum suction would be to draw interstitial fluid (ISF) into a collection device that would be in contact with the biosensor for glucose measurements to be taken.

The intensity of the vacuum would depend on the volume of ISF required by the biosensor to take an accurate glucose reading.

Current experimental values in use:

- vacuum -10in. Hg
- pressure – 400 Torr
- ISF extraction rate - 12 $\mu lcm^{-2}h^{-1}$

Our model:

We will be using a gasket to form an airtight seal on the skin. There will be an internal piston within the glucose monitor that will be controlled by a button. Once activated it will cause the piston to move in a manner which would increase the volume in the sealed space and reduce the pressure, This will cause the ISF to be drawn out of the pores and fill the space within the sealed area. The ISF will be directed in a collection device (wick) for glucose measurement.

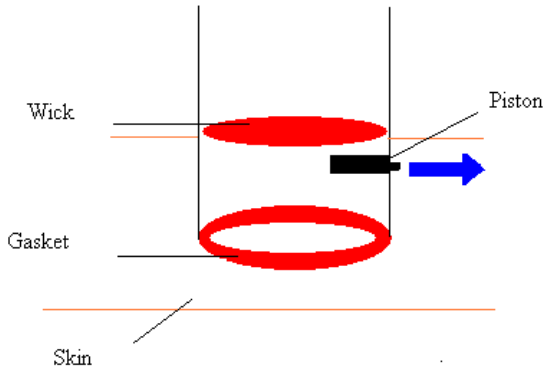

Figure 1.Activation of Piston

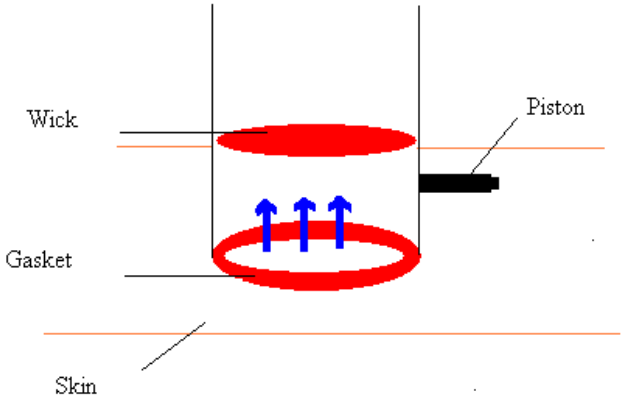

Figure 2. Upward movement of ISF

Reaction

After utilizing ultrasound to extract the interstitial fluid from the skin, it becomes necessary to design a biosensor to detect glucose levels in the interstitial fluid. A method that we are proposing is the use of an oxygen pressure electrode (pO_2 electrode). The pO_2 electrode is actually a complete electrochemical cell consisting of a small platinum cathode (area about 300 squared microns) and Ag/AgCl anode in phosphate buffer with added KCl. The platinum cathode covered by a thin film of electrolyte is separated from the test solution (interstitial fluid) by a gas permeable membrane. This electrode utilizes glucose's reaction with glucose oxidase to produce hydrogen peroxide. Hydrogen peroxide is then converted to oxygen. In the presence of oxygen, a current is observed

which is due to a diffusion of oxygen from the test solution through the membrane to the cathode, where it is reduced. The current is directly proportional to the pO_2 in the test solution. With this approach, the rate of fall in pO_2 under standardized conditions is a measure of glucose concentration in the glucose oxidase reaction. Thus, the current from the electrode reaction can be read to ultimately determine the concentration of glucose in the sample interstitial fluid. From the sensor, data from the electrode can be transmitted to a computer unit for further analysis of the glucose concentration in interstitial fluid to correlate it to blood glucose concentration.

Website

We are making our IPRO team web page so others can easily understand and see what we have done so far in our project. In the web page, we will have several links so we can introduce our team project, working processes and information related to noninvasive glucose monitoring. In the 'Members' section, our group members will be introduced and their role in our project explained. The second section, 'Research', will deal with the background of diabetes and theories on how to measure the glucose level from the interstitial fluids. The third section, 'Boards', will have our project plan, information such as articles and out progresses will be shown. The forth section, 'News', other methods to measure the glucose level non-invasively will be linked for comparison with ours. The fifth section, 'Album', pictures and all of the stages of our project, figures of our research will be included. The last section, 'Link', similar web pages and references will be uploaded. Our progress so far is that we have received the username and passwords for our IIT website. The Website group is working together to come up with a color scheme and format in which the site will be most successfully viewed.

Updated Individual Assignments

WEBITE

Ronak Lakhia	Amanda Ritter
Maeran Uhm	Kristina Chapman

AESTHETICS

Sheetal Bhat	Michelle Chen
Adeseye Adekeye	Jayashree Nakkana

DESIGN

Jen Tullman	Bhargava Gannavarapu
Priti Patwari	Norby Wang

Team Leader – Kristina Chapman

Professor Opara has been extremely useful in the design process especially with the measuring the products of the glucose-oxidase reaction.

Revised Calendar

Week #	Tuesday	Thursday
1	1st day of IPRO	Background Lecture
2	Background Lecture	Brainstorming
3	Method Presentation	Method Presentation
4	Method Chosen	Broke into 3 groups
5	Work in Groups	Work in Groups
6	Work in Groups	Work in Groups
7	Work in Groups	Work in Groups
8	Work in Groups	Midterm project report
9	S P R I N G	B R E A K !!!!!!!!
10	Work in Groups	Presentation by Dr. Corcoran
11	Work in Groups	Work in Groups
12	Work in Groups	Work in Groups
13	Prep for Presentation	Prep for Presentation
14	Prep for Presentation	Prep for Presentation
15	Prep for Presentation	Final prep for IPRO day
16	Finish Final Report	Finish Final Report

Barriers/Obstacles

The major obstacle that we have is that we are the first semester in this IPRO and that we have had to conceptualize how to solve the non-invasive blood glucose monitoring problem and that, unfortunately, we probably won't be able to see the finished project. Another barrier is that we need financial support to make our dream a reality.