GLUMO

Noninvasive Blood Glucose Monitoring

The Problem

- Diabetes
    - is the seventh leading cause of death in the U.S. and
    - a key factor causing serious health complications such as heart disease and kidney failure.
- The current practice of using single droplet blood glucose metering is:
    - Painful
    - Messy
    - Unsanitary
      and
    - Not continuous!

The Solution

Shining infrared light through the skin and measuring the amount of infrared absorbance in glucose molecules present in the blood.

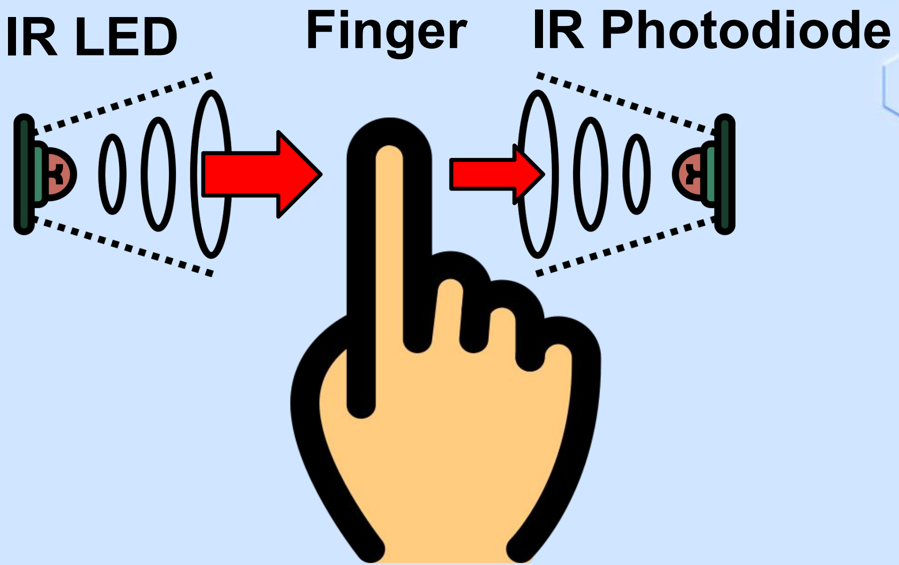
Challenge: Infrared can also be absorbed in water, tissue, and other elements present in the blood.

Solution: Use of high quality sensors and emitters coupled with precise calibration of the system.

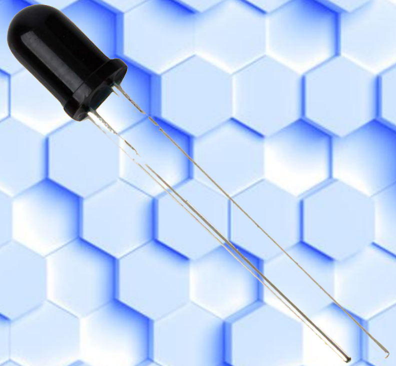
Solution Overview

Combination of an IR emitter and IR receiver

Patient places finger between IR endpoints



IR LED



IR Photodiode

Solution Details

Arduino Uno microcontroller used to

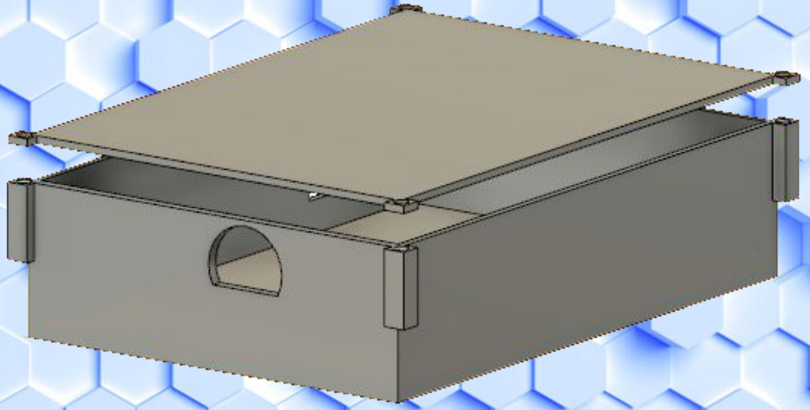
- Take 1-10 K voltage reading from the IR receiver
- Convert the voltage to immittance
- Invert the immittance into absorbance
- Average the absorbance of the 1-10 K readings
- Repeat the process 10 times
- Pick the mode of the 10 readings
- Convert the selected absorbance reading to a Glucose reading using the experimentally derived equation:

$$Glucose = \frac{Absorbance - 0.2671}{0.4665}$$

3D Printed Casing

Circuitry housed in a custom designed 3D-printed PLA housing

- Main Purpose:
  - Minimize outside IR interference
  - Focus the IR through the patients finger
- Added benefits
  - Low Cost
  - Portable
  - Sturdy



Preliminary Results

- Procedures
  - Human subject was tested on both commercial glucose meter and GluMo
  - 5 consecutive measurements were taken by GluMo
  - Results were compared between the two devices
- Results
  - An average accuracy level of 99.2% with
  - 90% confidence
- Further Human Subject Testing not possible at this time due to the COVID-19 pandemic!

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
[Blood glucose], (mg/dL)	113.42	107.92	115.31	119.10	112.48
p-value[1]	0.902	0.002	0.362	0.003	0.523

[1] p-values calculated using two-tailed z test comparing each blood glucose concentration measurement to the average measurement of 113.65mg/dL

Figure 2. Blood glucose concentration measurements and p-values from glucose meter testing.

Future Experiment

- A complete IR spectroscopy of glucose vs water will be conducted in order to identify and select a more suitable IR wavelength
- Glucose solutions ranging from 0 to 250 mg/dL in a 25 mg/dL increment will be exposed to 4 different IR emitters with wavelengths:
  - 1450nm,
  - 1550nm,
  - 1600nm, and
  - The wavelength identified in the conducted spectroscopy

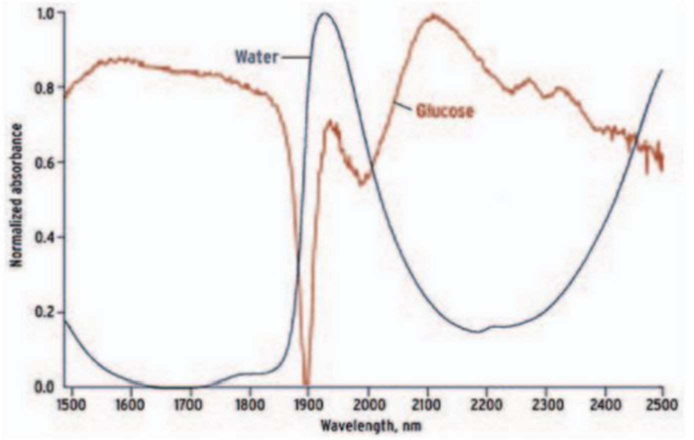
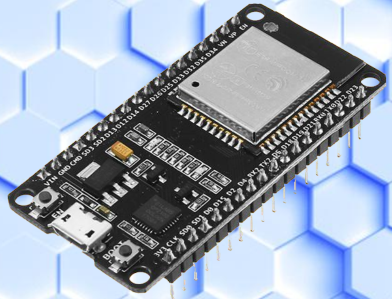


Figure 3. Water and Glucose Solution Absorbance spectra 1500nm – 2500nm. [18]

[18] Graph from paper titled: “Noninvasive blood glucose detection using near infrared sensor” by Rolamjaya Hotmartua et al. published in IEEE 2015 International Conference on Electrical Engineering and Informatics (ICEEI)

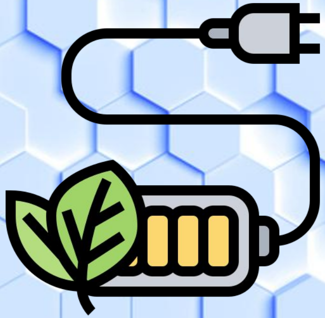
<u>Future Steps</u>

- Build a pocket sized MVP
  - ESP 32
  - 3D-Printed casing
- Add a rechargeable battery and apparatus for USB charging
- Enable wireless communication
  - BLE
  - WiFi
- Develop web and mobile user applications
- Conduct human subject testing

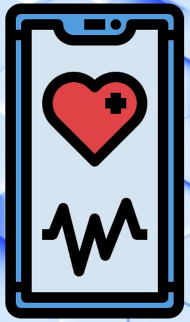


ESP 32

Web App



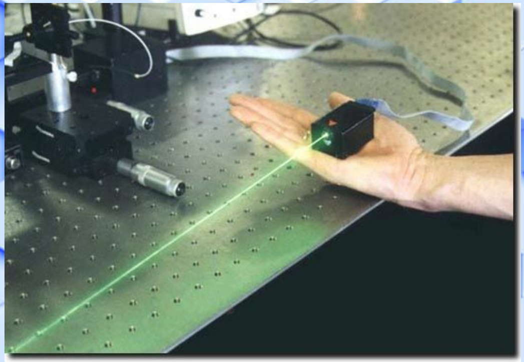
Rechargable



Mobile App

Long term Goals

- Utilization of an Infrared laser inplace of an Infrared led
- Utilization of patches which can extract ionized particles within the sweat through the skin (in discussions with Rotex for use/repurposing of their technology)
- Continuous monitoring (in place of metering) using wearables



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