Python and GUI Implementation for Internal Optimization and Increased Usability of *in vivo* Glucose Sensing System

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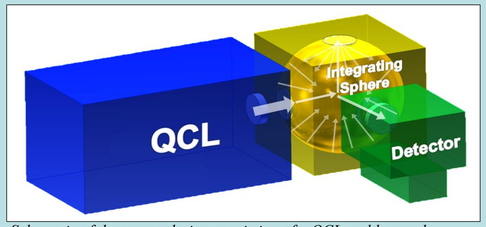
Introduction

Photo Credit to: https://loonylabs.files.wordpress.com/2014/08/blood-sugar.jpg?w=590&h=392

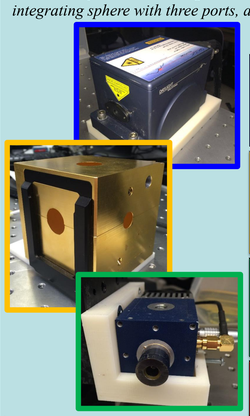
- Diabetes afflicts 9.3% of the entire United States population, remains "the 7th leading cause of death", by to 2014 statistics
- Diabetics must monitor their blood glucose levels to ensure they stay healthy and administer insulin if needed
- Goal is to enhance mid-infrared Quantum Cascade Laser based non-invasive glucose sensor to provide an alternative to obtaining direct blood samples multiple times per day to measure glucose levels.

Setup and Method



Schematic of the sensor design consisting of a QCL, gold coated integrating sphere with three ports, and a TE-cooled detector.

The backscattered light from human wrist is collected by an integrating sphere and directed into a TE-cooled detector. The signal from the detector is used to predict the concentration of glucose in the subject's blood.



QCL
- EC-QCL produced by Daylight Solutions, Inc.
- Light pulsed at 55 kHz with duty cycle of 1%
- Scanned between 1020–1220 cm^{-1}

Integrating Sphere
- Gold coated
- Sphere diameter of 7.62 cm
- Port diameters: Input -> 3 cm, sample -> 2.5 cm, output -> 1.5 cm

Detector
- TE cooled MCT detector
- Mobile
- Specific detectivity of 10^9

Spectral Analysis
- Partial least squares regression
- Accuracy increases with number of calibrations
- Depends on linearly proportional metrics

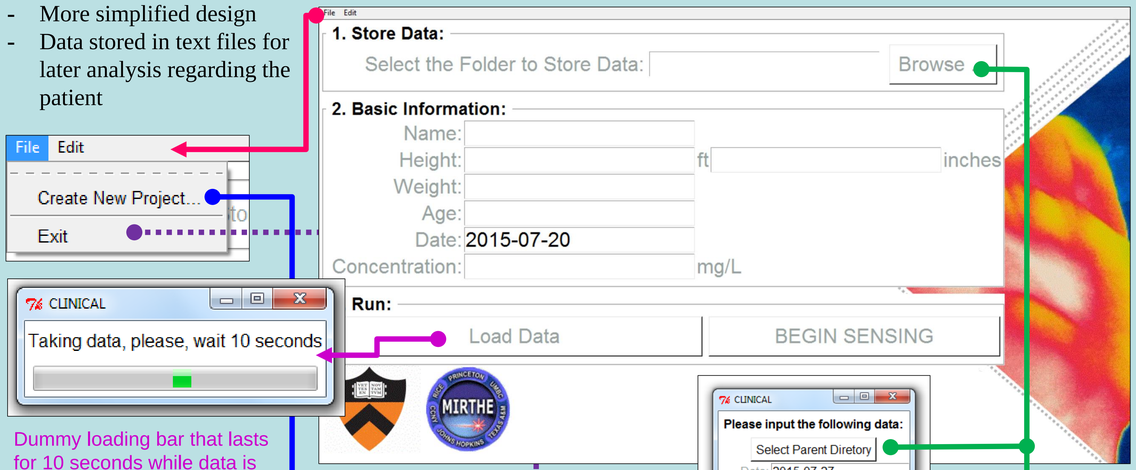
- GUI started up and populated with data
- Number of spectral runs are taken
- Various statistical analyses applied:
  - Wavelet transform
  - Savitzky-Golay Filtering with Differentiation
  - Machine Learning Prediction Algorithm
- Final predicted glucose concentration obtained

GUI Design

The GUI itself was designed to feature two different modes: one for use with clinical trials and one for use in the lab.

CLINICAL TRIALS VERSION

- More simplified design
- Data stored in text files for later analysis regarding the patient



Dummy loading bar that lasts for 10 seconds while data is being taken.

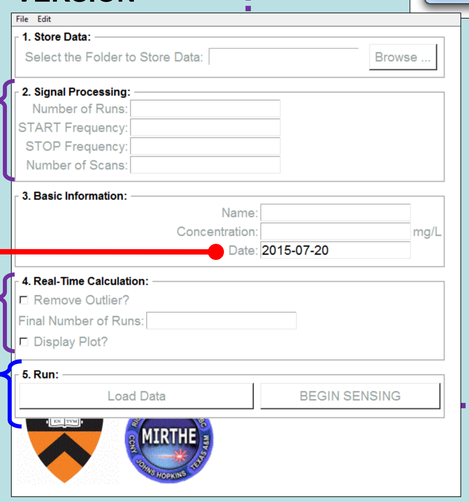
IN-LAB, "SOLUTIONS" VERSION

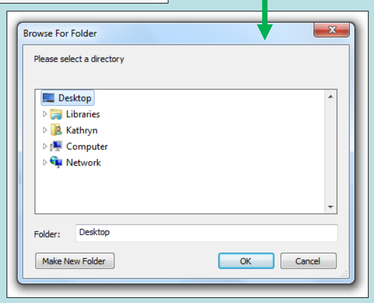
- Designed for more variable manipulation
- Allows for altering signal processing values

All dates are taken using the Python time library, meaning they are automatically printed in entry boxes at startup.

- Options to alter the data processing steps

"Load Data" runs the dummy loading bar (above). "BEGIN SENSING" takes the data. These are to be pressed simultaneously.



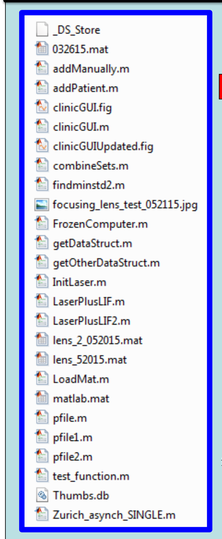


Opens folder dialogue to select where the data will be saved and retrieved.

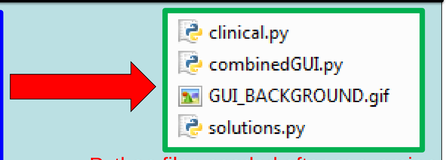
"Exit" safely quits the application.

Michelle Zhang designed and implemented a real-time analysis calculation code, which once completed for Python will be integrated into the GUI code to display an estimate value.

Code Conversion and Examination

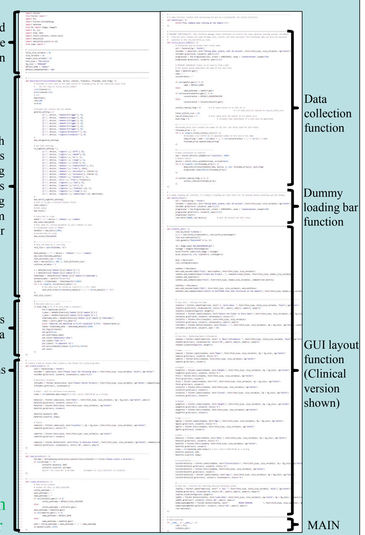


MatLab files needed prior to conversion



Python files needed after conversion

Prior MatLab code contained functions compatible with currently defunct systems and was not properly maintained with comments and structure

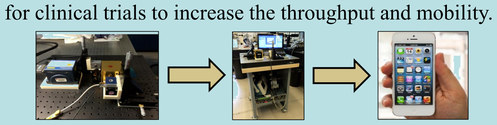


Current Python code in use for the clinical GUI. It measures less than 400 lines and performs all the functions of the prior long MatLab Code.

Rewritten code in Python allowed for:
- prior defunct functions to be removed
- Structure within the code to be established with comments
- additional libraries associated with python to be utilized (ex. Tkinter GUI library)

Future Plans

- Optimize and miniaturize the three key components and place in mobile case for clinical trials to increase the throughput and mobility.



- Integrate the code for real-time data analysis into GUI to produce the scattering data along with the prediction in minimal time
- Soon, we hope to bring our mobile sensor into clinical trials at diagnostic labs to obtain datasets from diabetic users.

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