WIRELESS PULSE OXIMETER FOR EMERGENCY MEDICAL APPLICATIONS

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Objective

- Current pulse oximeter designs either are too bulky to be used practically by paramedics or do not detect SpCO and SpMET, measurements that are standard in the medical field.
- So we developed a wireless pulse oximeter that measures SpO2, SpCO, and SpMET before displaying the measurements on a separate computer screen, in real time. This will allow emergency medical teams more flexibility in the field compared to existing devices.

Terminology

SpO2
Blood Oxygen Saturation. The proportion of oxygen carrying red blood cells. Normal levels are between 95% to 99%

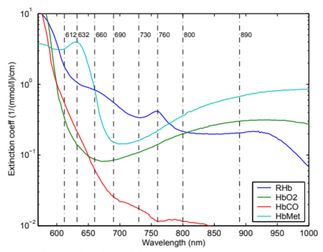
SpCO
Blood carbon monoxide saturation. High levels can indicate carbon monoxide poisoning

SpMET
Methemoglobin saturation, which can indicate various illnesses if too high (anything above 2%).

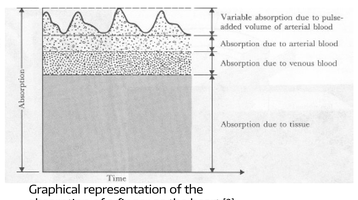
Plethysmograph (Pleth) Waveform
The raw absorption data that correlates to the blood pulsing through the artery. Is used in pulse oximetry to find a heartrate.

Pulse Oximetry

- Pulse oximeters take advantage of the different absorption curves of the Hemoglobin oxidation species, allowing them to detect the different ratios of the species in blood using only light.
- They are important devices that allow for a quick, noninvasive method to measure a patient's SpO2 and heart rate, two important vitals.
- Modern day pulse oximeters also detect SpCO and SpMET by utilizing four or more wavelengths of light. The additional measurements also increase the accuracy of SpO2 readings.
- Pulse oximeters utilize the heart's pulse to distinguish between the absorbance due to arterial blood, and the absorbance due to tissue and venous blood.



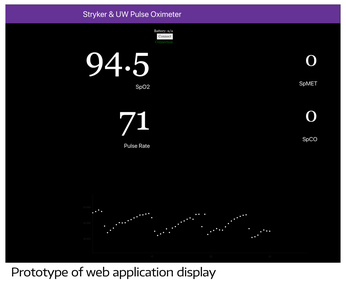
Extinction Coefficients for the different oxidation species [1]



Graphical representation of the absorption of a finger as the heart beats [2]

Wireless Pulse Oximeter Features

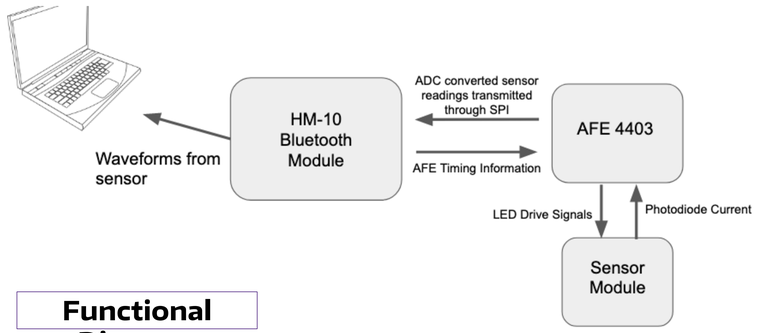
- Measurement and display of SpO2, SpMET, and Pleth waveform
- Minimum sampling rate of 100 Hz
- Wireless communication between pulse oximeter device and display
  - Sensor values held in characteristic and event handler put in place for updates
- Digital data filtering and processing script
- 3D printed housing that blocks most ambient light and holds sensor module in place



Prototype of web application display

Modules

- **AFE 4403 –** an analog front end, from Texas Instruments, equipped for basic pulse oximetry. This chip houses a programmable timer module that controls an ADC, SPI, and a LED driver designed for two LEDs.
- **Custom Sensor Module** – since the AFE 4403 could only drive two LEDs, a custom PCB was made in order to control 3 LEDs with the AFE 4403's LED driver.
- **HM-10 Bluetooth Module –** an Arduino controlled Bluetooth module that would transmit the ADC readings to our display.
- **Web Application Display –** receives ADC readings over Bluetooth from the HM-10 before computing and displaying the SpO2, SpMET, and the pleth waveform.

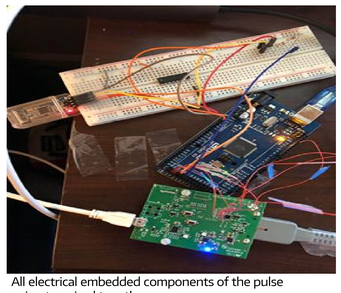


Functional Diagram

Limitations

- Less effective on individuals with a darker skin tone and ineffective on patient's lacking a normal pulse, such as patient's with mechanical hearts.
- Less effective on patients with finger sizes that are extremes compared to the average finger size
- Painted nails or other optical obstructions hinder readings significantly
- Sensitive to physical disturbances

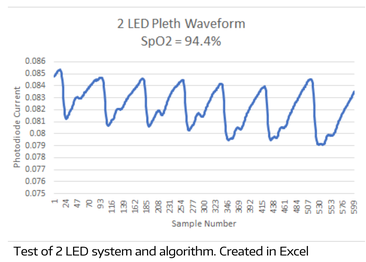
Current Progress



All electrical embedded components of the pulse oximeter wired together

3D printed housing for custom PCB

- Calculations for SpO2 confirmed by readings in the correct range for a healthy adult.
- AFE and Bluetooth modules integrated together to communicate measurements to web application.
- Custom PCB, for 3 LED peripheral sensor, integrated with AFE and used to take Pleth waveforms
- 3D printed prototype for housing has been completed



Test of 2 LED system and algorithm. Created in Excel

Conclusion and Future Work

Though wireless communication complicates the pulse oximetry process, our work has shown that is possible

- We can achieve a sampling rate of 100 Hz by operating at a baud rate of at least 19200
- Post processing of data is time efficient
- The key components for the device are small enough to be housed in an easy to apply cuff

The next steps for this project will be:

- Adjust algorithm for 4 wavelengths and the calculation of SpMET
- Test device for accuracy using a proper pulse oximeter testing setup
- Calibrate pulse oximeter to improve accuracy
- Design and implement a mobile power supply
- Use prototyped 3D printed housing as basis for a final housing unit

Acknowledgments

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[1] K. Urpalainen, 2011.
[2] J. G. Webster, *Medical instrumentation: application and design*, 4th ed. Hoboken,
NJ: Wiley, 2010.

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