FNIRS Brain Scanner Headband

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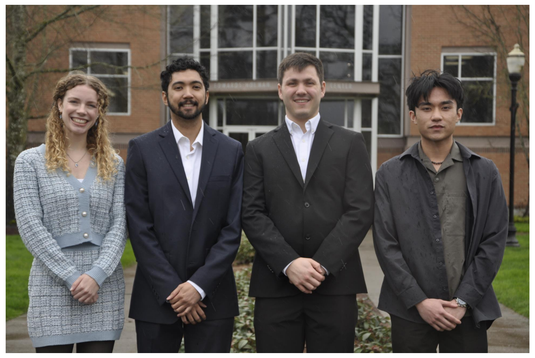
Design Motivation

Researchers require a reliable method to identify active brain regions during psychological experiments. Since blood flow increases in areas of the brain that are active, tracking blood flow can serve as an indicator of brain activity. This can be done via a method called fNIRS, or functional Near-Infrared Spectroscopy.

The Psychology department at George Fox University has requested our assistance to enhance their research capabilities in this area. Most devices used for brain research are restrictive. Researchers need a better tool, something that is mobile, flexible, simple, and easily used while doing day to day tasks.

Project Summary

A DIY fNIRS (functional Near-Infrared Spectroscopy) headband is a low-cost, non-invasive device that measures brain activity by detecting changes in blood oxygen levels using near-infrared light. While less detailed than medical-grade equipment like fMRI, these compact devices offer an affordable option for enthusiasts and researchers interested in exploring brain function, aiding in cognitive research, biofeedback training, and personal experimentation. Assembled from readily available components, DIY fNIRS headbands provide a cost-effective alternative to professional neuroimaging tools, capturing real-time neural activity.



L: Sydney Staley (BME), Ethan Pagan (EE), Oliver Hansen (CE), Darwin Adiao (CS)

Existing Design

We took heavy inspiration from an open-source fNIRS device designed by Joshua Brewster. This design used an ESP32 microcontroller, and a MAX86141 pulse oximeter ADC connected by a flex PCB. His software was also available for use. We set out reimplement his design and modify the headband and code to our clients' specifications.

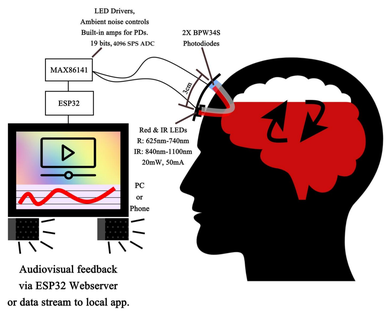


Figure 1. Joshua Brewster's visualization of his fNIRS device.

Design Criteria

Specifications:

1. Accurately measures blood oxygen level on any region of head.
2. Bluetooth connection to transfer and store data
3. Portable, light-weight, comfortable.
4. Simple and easy to use.

Device Use:

1. Potential expansion in nutrition, response time, and overall health for developing countries.
2. Psychological tracking of brain activity during activities in naturalistic environments For both faculty and students.

Acknowledgements

Joshua Brewster (Bubba Skrimp)
https://github.com/joshbrew

Final Design

The final product that was delivered to the client implemented the electronic fNIRS design from Josh Brewster, with an additional battery switch and trimmed down code to only provide the features our client had requested. A new felt headband was designed to house the assembly with an adjustable Velcro strap for maximum comfort. To improve light isolation, a silicone mold was cast to house the sensor board which separated the LEDs from the photodiodes.

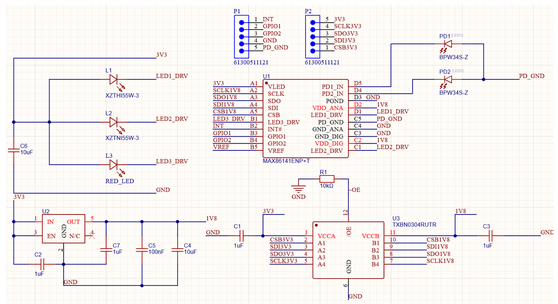


Figure 2. The schematic of the final board.

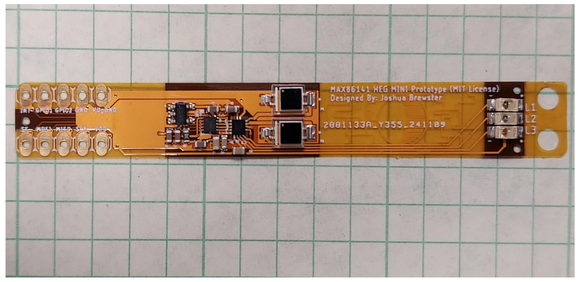


Figure 3. Final sensor board.

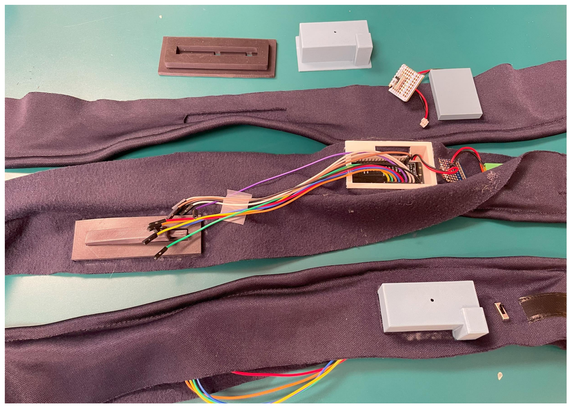


Figure 4. Full headband assembly.

Results

This is a test result through the devices built in web app. The data is computed and plotted as a blood oxygen ratio SPO2, with all raw optical data accessible through serial communication. This test demonstrates a period of normal breathing followed by a period of hyperventilating to show the changes of oxygen in the brain.

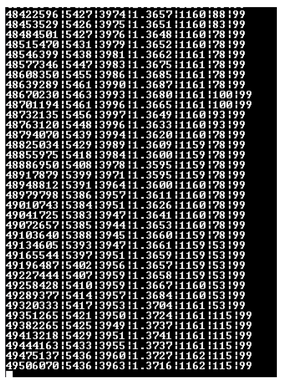


Figure 5. Serial Port Collecting Raw SPO2 Data.

Future Improvements

With additional time and resources, we aim to replace the jumper wires with a flex PCB board, as originally intended. This would include a more user friendly and accessible power switch. We would also include a zipper at the top to streamline and securely contain the parts. This transition will improve user comfort during use due to reduce bulkiness and increase durability.

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