A Wearable Non-Invasive Device for Detecting Cortisol Levels

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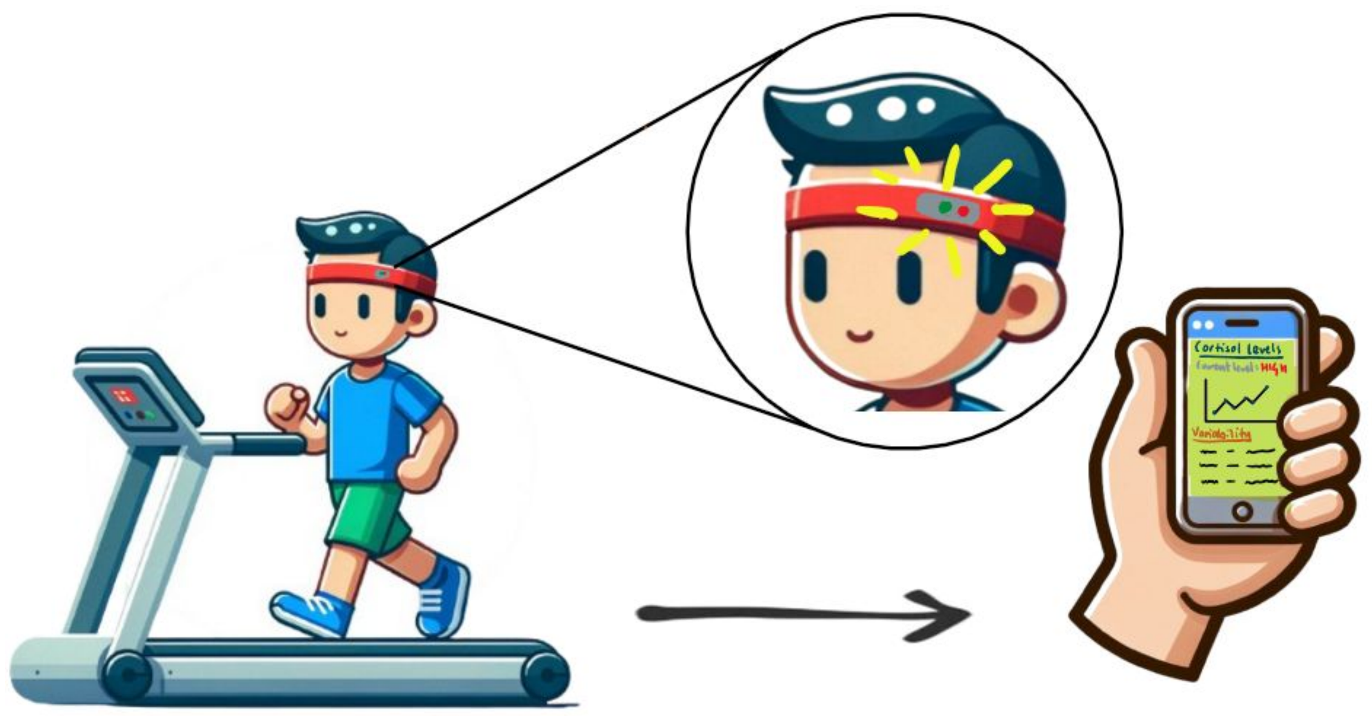
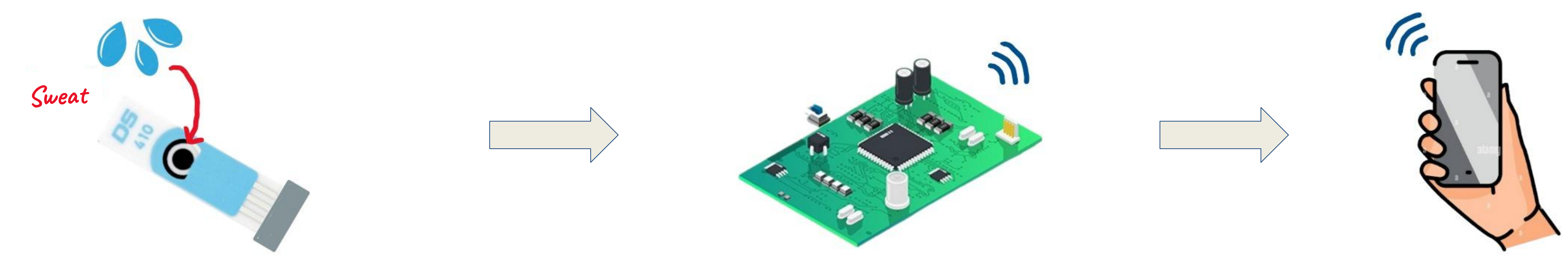
Introduction

- Cortisol is a biomarker for stress and various health issues.
- It is traditionally detected via invasive blood, urine or saliva testing.
- Hence, there is a lack of **non-invasive** cortisol detection solutions.
- Addressing the gap, a **non-invasive**, wearable device capable of continuously monitoring cortisol levels in sweat and **wirelessly transferring** the data to a software application was developed.
- The device is designed for medical professionals and the general public to facilitate informed health decisions and diagnoses, making health monitoring more accessible and comprehensive.



Design

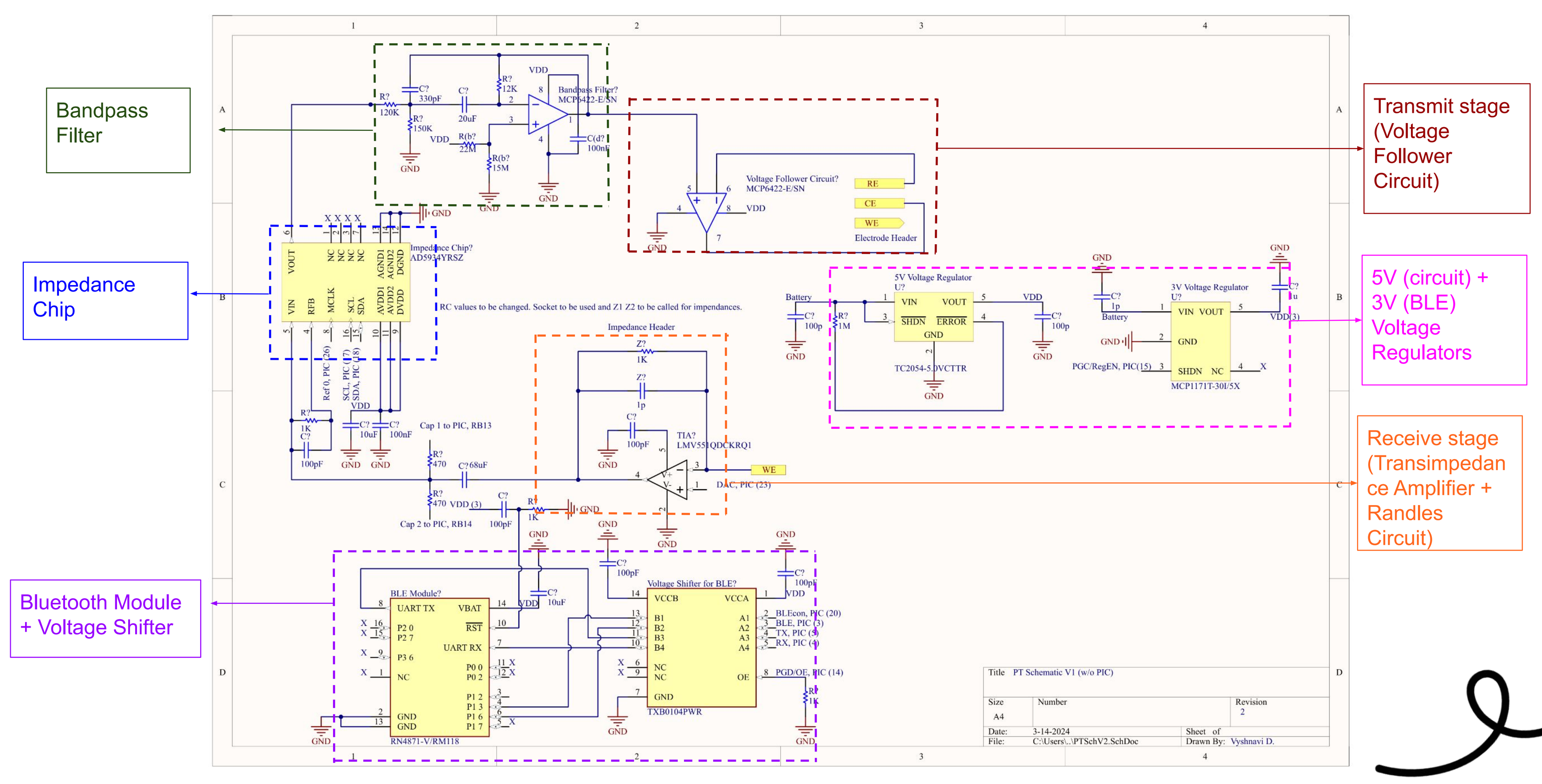
The project is divided into 3 major tasks: development of the molecularly imprinted polymer (MIP) for cortisol detection, development of the hardware to read the impedance of the MIP electrode, and development of the software to map the impedance to a cortisol/stress level and allow for user interaction via app.

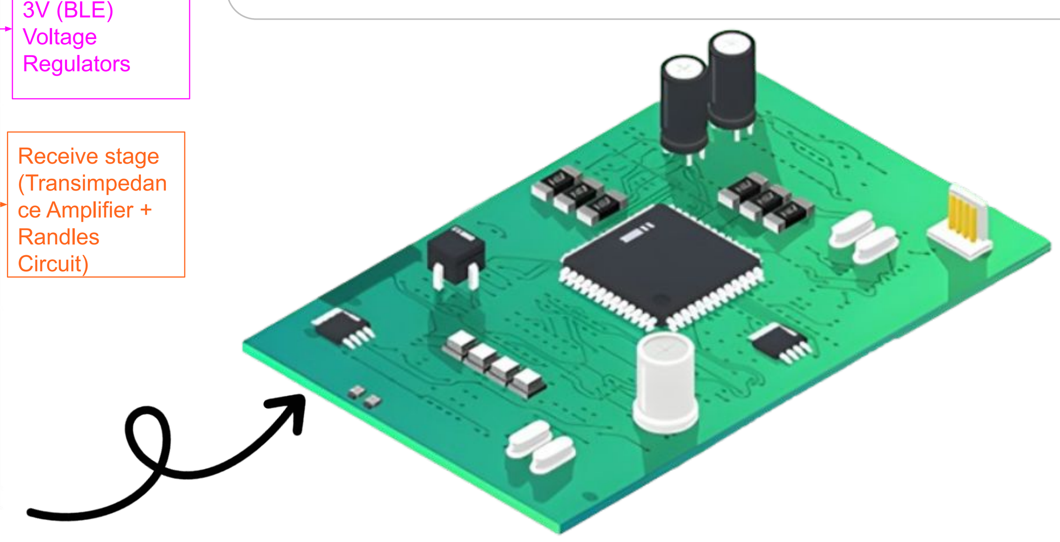


Biosensor	Electronics	Software
Prussian blue nanoparticles (NPs) are first synthesized on the electrode surface through electro-deposition. The target imprinted polymer is then created by electropolymerizing pyrrole in the presence of cortisol and 3-aminophenyl boronic acid (APBA) as a cross-linker. Following electropolymerization, the cortisol template is removed through overoxidation of polypyrrole (PPy), forming cavities matching cortisol's properties (size, shape, and functionality). The electrode is subsequently rinsed three times with ultra-pure water to eliminate agmatine residues from the PPy film and gently dried under a nitrogen stream.	An AC signal sweep is generated by the electronics and undergoes filtering and processing, before being applied to the working electrode of the MIP biosensor. The resultant impedance through the biosensor is received and processed for electrochemical impedance spectroscopy. The frequency-dependent impedance data is then digitized and sent over BLE to the software application.	The BLE module transmits impedance data to an Android app. Using a calibration curve which correlates the impedance values with cortisol concentrations, the app translates the transmitted impedances to cortisol levels which are graphed and displayed for user interpretation. The app also has an interface allowing users to analyze their own stress levels through a questionnaire.

Discussion and Results

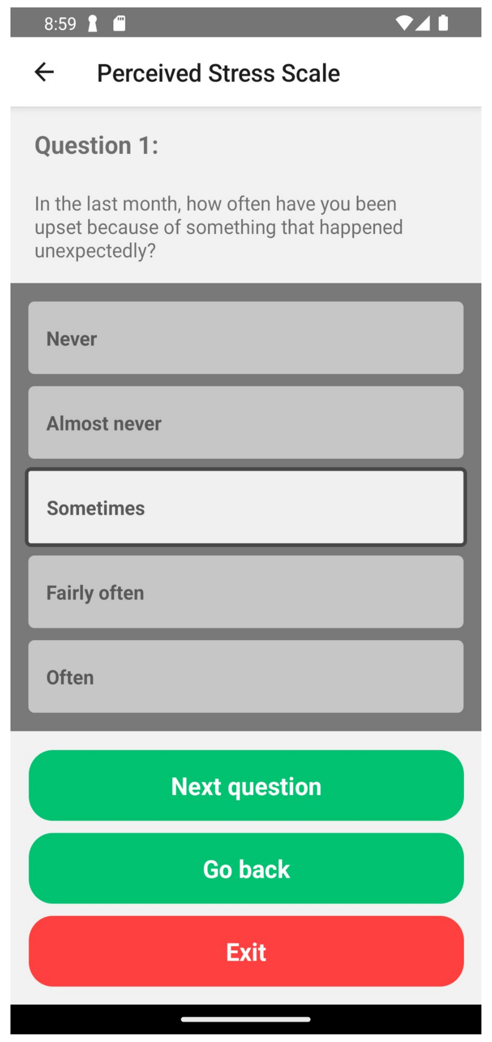
- Manufactured MIP (Molecularly Imprinted Polymer) biosensors capable of continuously detecting variable cortisol levels.
- Developed a potentiostat for performing electrochemical impedance spectroscopy on 3-pin electrode biosensors capable of transmitting impedance values through BLE.
- Android application with survey interface used to assess stress levels in the human body.

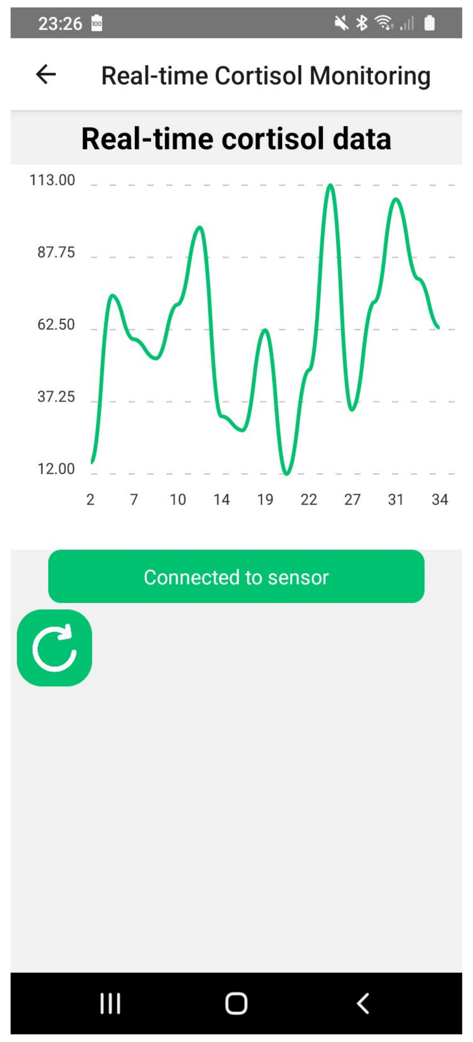




Future Works

- Integration with Sponsor's microfluidic chip for on-body testing.
- Connectivity using NFC and classic Bluetooth.
- Use triboelectric or hybrid nanogenerators for compact power solutions.
- Explore alternative biosensing and microfluidic solutions for easier sweat induction, like angiogenesis.
- Adding additional support for continuous measurement throughout a time period - taking measurements throughout the course of a day.
- Storing cortisol and other stress measurements on a cloud-based database for further analysis.
- Application of artificial intelligence/machine learning to analyze cortisol data for insights and trends.





Conclusions

The solution simplifies cortisol monitoring by enabling easy data collection and wireless transmission to smartphones. Future developments may focus on exploring alternative communication protocols, optimizing power efficiency, and integrating trend analysis.

References

1. Namazi, M. (2024). "SiPM-based Fiber Photometry and EIS for Cortisol Detection: Common Electronics, Distinct Applications." Master's thesis, Faculty of Graduate Studies, University of Calgary.