The Cyclet

A device to predict menstrual cycles by measuring vital signs.

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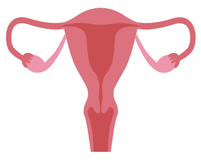
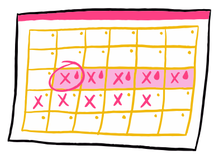
Problem

1.8 billion people in the world regularly menstruate (Rohatgi & Dash, 2023)



Data safety is another concern for people who want to track their cycles, especially with the overturning of Roe v. Wade.



Conventional period tracking methods are not usable by those with disabilities because they are often not accurate and challenge to use for those with irregular periods (Yu et al., 2022).

Objective

Create a device that utilizes body temperature, heart rate, skin conductivity, and a machine-learning algorithm to provide accurate period prediction and data security by storing data locally.

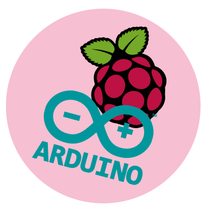
Process/Methods

Understand vital sign patterns during menstruation

Calibrate heart rate and temperature sensors

Develop a conductivity probe using electrodes and a voltmeter

Desing a machine learning model to predict period start date using vital signs indicators



Deploy ML model to Raspberry Pi and establish connection between Arduino sensors, ML model, and display

Assemble the bracelet using all the sensors and circuit boards

Requirements

Type	Requirement Statement	Final Design
Functional	Measures temperature, skin conductivity, and heart rate at the same time everyday	Pass
Functional	The device should predict phases of the menstrual cycle with +/-2-4 days accuracy for regular cycle	Pass
Physical	It should be wearable on the wrist of the user (under 200 g, fits wrist comfortably, and not attached to external devices)	Fail
Documentation	The device shall include a user's manual and design documentation	Pass
User	The device causes no harm to the user (such as skin irritation, etc.)	Pass
User	The device will only store user's data locally on the device	Pass
User	Requires minimal user input (no more than three buttons)	Pass

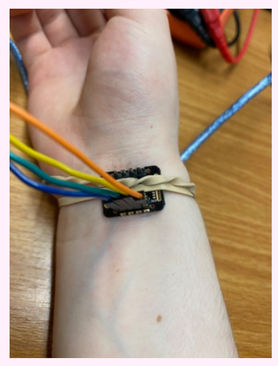
Design Components + Studies

Design 1: Temperature Sensor Testing

- Temperature changes with hormonal fluctuations during a menstrual cycle (Goodale et al., 2019).
- A Grid-EYE AMG8833 sensor was used to collect wrist temperature data
- Distance of the arm from the sensor was varied to observe changes in measured temperature.
- The optimal distance for the sensor placement was determined by comparing the sensor readings to a reliable thermometer reading and finding the least margin of error.

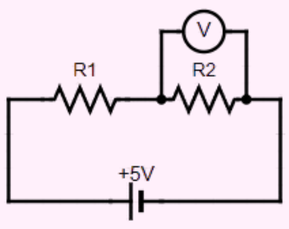
Design 2: Heart Rate Sensor Testing

- Average heart rate also changes with hormonal fluctuations caused by the menstrual cycle (Thiyagarajan et al., 2019).
- A MAX 30102 sensor was used to collect heart rate data.
- The heart rate sensor was calibrated by measuring the heart rate of 8 people at resting and active state and compared with readings of an Apple Watch heart rate sensor to ensure reliability and consistency.



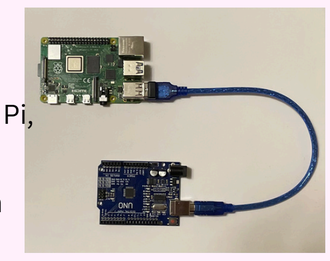
Design 3: Conducvity Probe Sensor Testing

- Voltage dividers are circuits of two resistors in series, where the voltage difference across the second resistor is measured to determine its resistance.
- We designed our electrodes to work like a voltage divider, but the user acts as the second resistor. We can find their skin conductivity using the Arduino's voltmeter.
- We compared the voltage measured by the Arduino to the voltage measured by a known-to-function voltmeter for multiple resistance levels to ensure functionality.



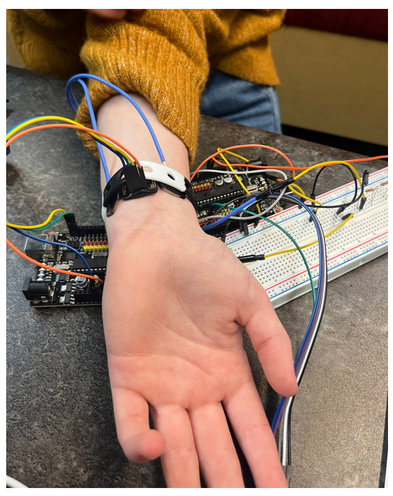
Design 4: Machine Learning + Sensor Communication

- Python was used to code a machine learning model that analyzes the data from the three sensors to predict the next period cycle start date
- Bidirectional serial communication was established between a Raspberry Pi and Arduino UNO. The Raspberry Pi runs the ML model and the Arduino controls the sensors, sends data to the Pi, and displays the result from the ML model.
- It was first ensured that data was being sent properly between the two devices. After this, the machine learning model was tested using plausible fictional data scenarios



Final Design

- All the sensors are enclosed in a silicon bracelet
- Vital sign readings are stored in a SD card and sent to the Raspberry Pi for ML processing
- Results are displayed on a LED display connected to the Arduino.
- All sensors were tested under multiple circumstances to ensure functionality, and the machine-learning model was tested using data sent from the sensors.



Conclusion

Created a device that utilizes heart rate, temperature, skin conductivity, and machine learning to **monitor menstrual cycles**. This device will help people with irregular periods, issues with providing input, and those who are uncomfortable with storing their data on an app to monitor their menstrual cycle.

Future Work

- Improve device wearability by decreasing device size and disconnecting from computers.
- Add and program a button to allow for a user to input when they start their period to improve ML performance.
- Conduct comprehensive data collection and device testing

Citation

Goodale, B. M., Shilaih, M., Falco, L., Dammeier, F., Hamvas, G., & Leeners, B. (2019). Wearable Sensors Reveal Menses-Driven Changes in Physiology and Enable Prediction of the Fertile Window: Observational Study. *Journal of Medical Internet Research*, *21*(4), e13404. https://doi.org/10.2196/13404

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Sides, K., Kilungeja, G., Tapia, M., Kreidl, P., Brinkmann, B. H., & Nasseri, M. (2023). Analyzing physiological signals recorded with a wearable sensor across the menstrual cycle using circular statistics. Frontiers in network physiology, 3, 1227228. https://doi.org/10.3389/fnetp.2023.1227228.

Yu, J., Su, Y., Zhang, C., Jin, L., Lin, X., Chen, L., Huang, H., & Wu, Y. (2022). Tracking of menstrual cycles and prediction of the fertile window via measurements of basal body temperature and heart rate as well as machine-learning algorithms. *Reproductive Biology and Endocrinology*, *20*(1), 118. https://doi.org/10.1186/s12958-022-00993-4