

# SweetTech

## Potentiostat-based Glucometer Development



**Paulina Bargallo**



**Theertha Vannemreddy**



**Kayla Powell**

**CBE 3300 - Final Demonstration**  
**May 7th, 2025**

# Github Page



# Project Overview

With diabetes on the rise, this project develops a potentiostat-based glucometer using amperometry for glucose detection.

## Project Goals

### 01 Calibration

Development of sufficient redox-mediated calibration between glucose concentration and electrochemically produced measurement appropriate for instrumentation.

### 02 Hardware Development

Ensure compatibility between all components through various prototyping stages.

### 03 User-friendly Design

Design an easy-to-use, durable, portable glucometer.

### 04 Experimental Validation

Final product performs similarly compared to current available second generation glucometer.

# Our Background



**Paulina Bargallo**

- **Main contributions:** GitHub documentation, Arduino GIGA and UI development
- No GitHub experience
- Minimal C++ exposure from 3300A (with Arduino Uno)
- Minimal serial communication exposure from 3300A



**Theertha Vannemreddy**

- **Main contributions:** Mechanical Design, Error grid generation and Display features
- CAD and Solidworks knowledge
- Introductory python knowledge
- Minimal C++ exposure from 3300A



**Kayla Powell**

- **Main contributions:** IO Rodeostat configuration and glucometer operation
- Beginner python user
- Minimal serial communication exposure from 3300A
- Signal processing novice

# Background

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Project Overview

Background

Process

Comparison

Lessons Learnt

# Market Landscape

**537M**

Adults have diabetes globally

**1/10**

Adults need regular glucose monitoring

**1.5M +**

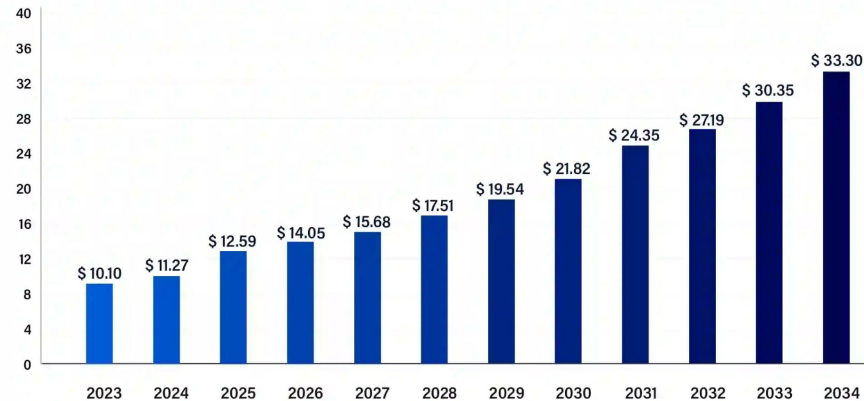
Deaths annually due to diabetes

**\$12.6B**

Global Market Size (2025)

**Precedence**  
RESEARCH

Self-monitoring Blood Glucose Devices Market Size 2023 to 2034 (USD Billion)



Source: <https://www.precedenceresearch.com/self-monitoring-blood-glucose-devices-market>

Project Overview

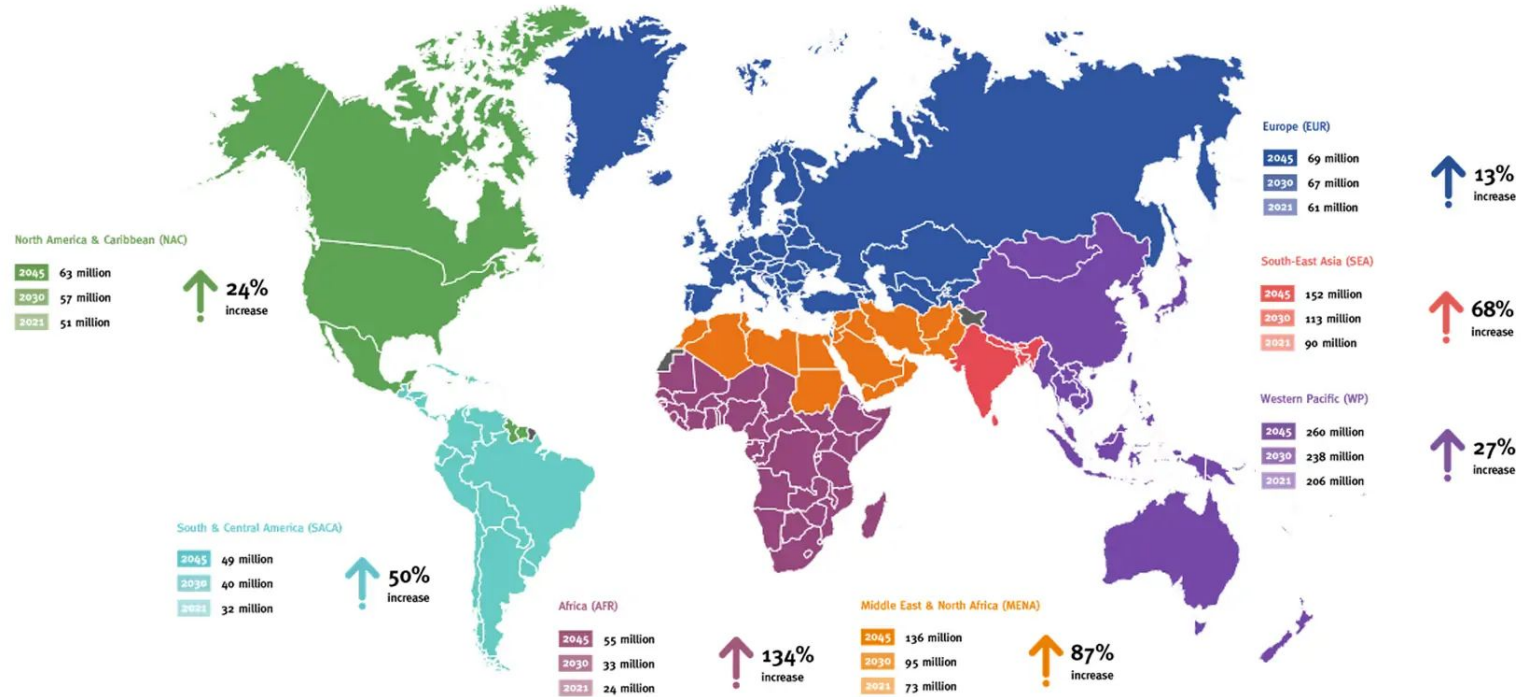
Background

Process

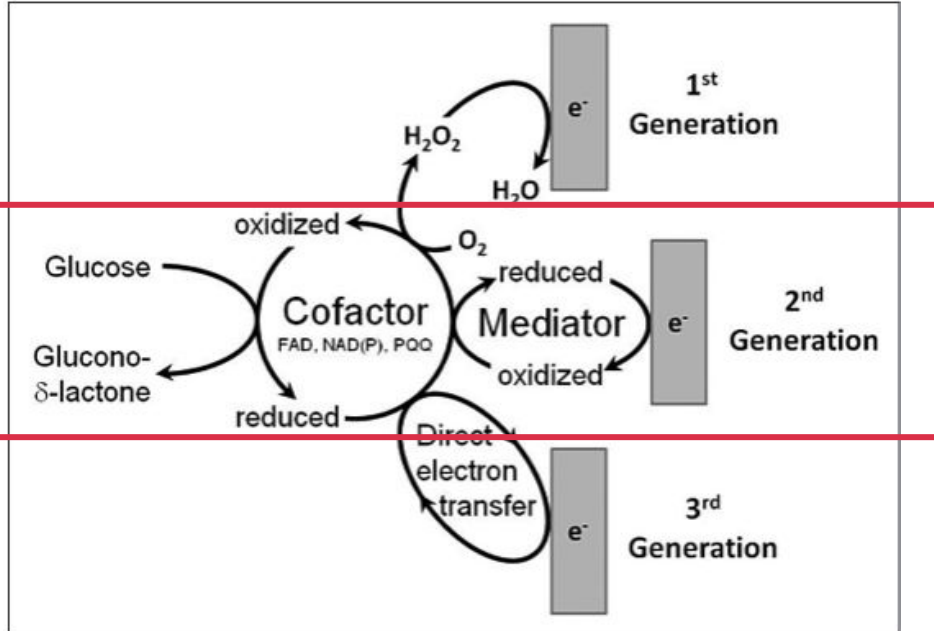
Comparison

Lessons Learnt

# Global glucose monitoring market trends



# How do glucometers work?



## Converting current to concentration

- Electrochemical reactions occur on biosensor
- Redox-mediated electron transfer introduced to improve efficiency, accuracy
- Chronoamperometry for selective re-oxidation of mediator
- Signal analysis using **Cottrell equation**






$$i = \frac{nFAc_j^0 \sqrt{D_j}}{\sqrt{\pi t}} \longrightarrow i \propto \frac{1}{\sqrt{t}}$$

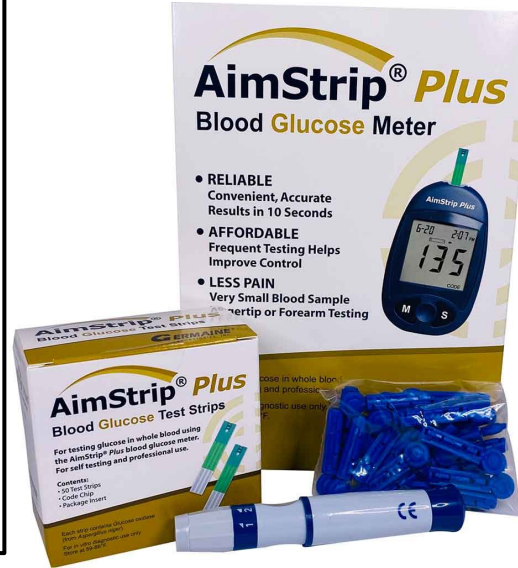
- Current depends on diffusion rate
- Ideal for simple redox events
- slope  $\rightarrow$  concentration calibration
- Relate [Mediator]  $\sim$  [Glucose]



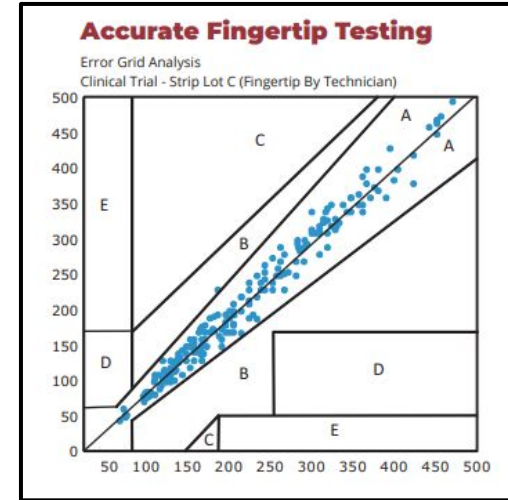
# AimStrip® Plus Glucose Meter and Strips

Important  
meter  
functions

-  Reliable, Accurate Results in 10 Seconds
-  Only 1µL Blood Sample Required from Fingertip or Forearm Testing
-  Single Code Chip for the Life of the Meter
-  Memory Allows up to 300 Records with Date and Time
-  English & Español Instructions



Diagnostic  
performance



The AimStrip® Plus Blood Glucose Test Strips is stored in a sealed vial with desiccant. Each test strip contains the following chemicals:

Glucose Oxidase	<b>CAS Number:</b> 9001-37-0	<b>Concentration:</b> < 25IU
Mediator	<b>CAS Number:</b> 13746-66-2	<b>Concentration:</b> < 30µg

← GOx with  $K_3[Fe(CN)_6]$

# Development Process

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Project Overview

Background

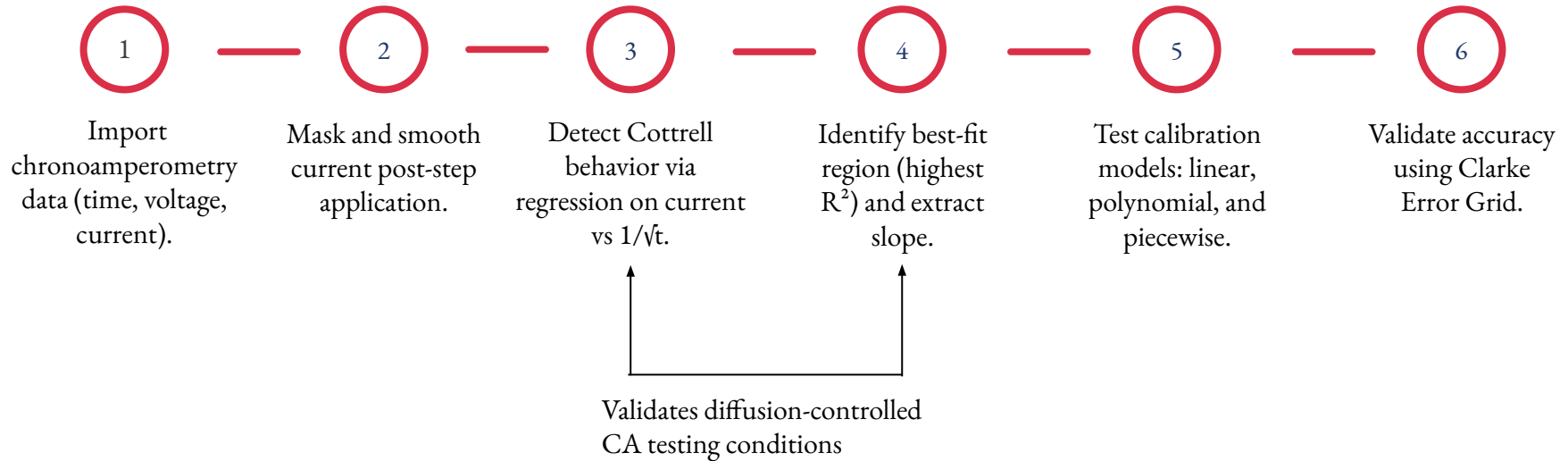
Process

Comparison

Lessons Learnt

# Analysis Flowchart

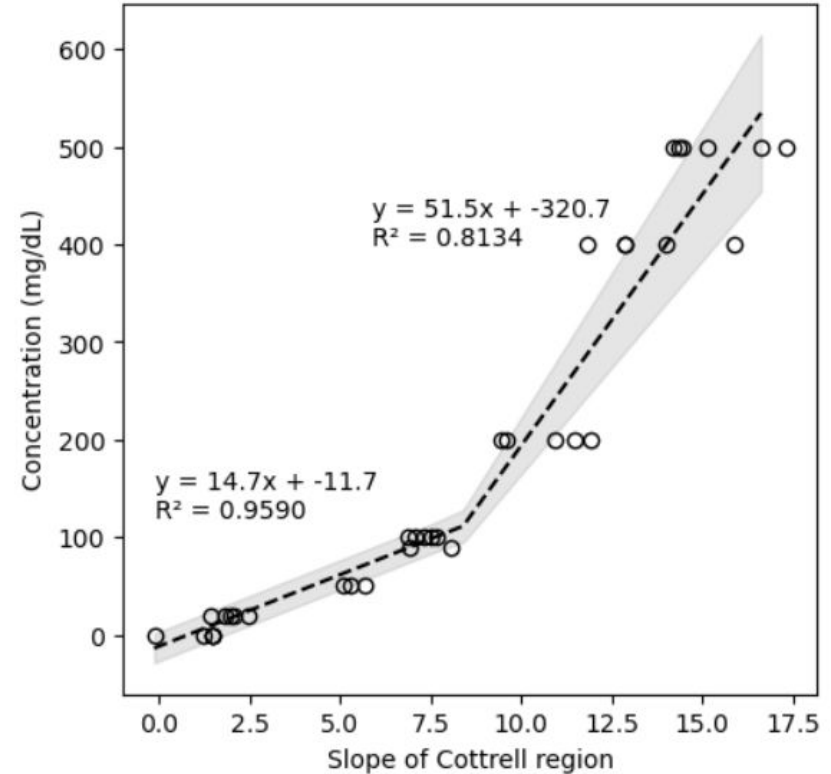
## Data Analysis Workflow



# Analytical Method

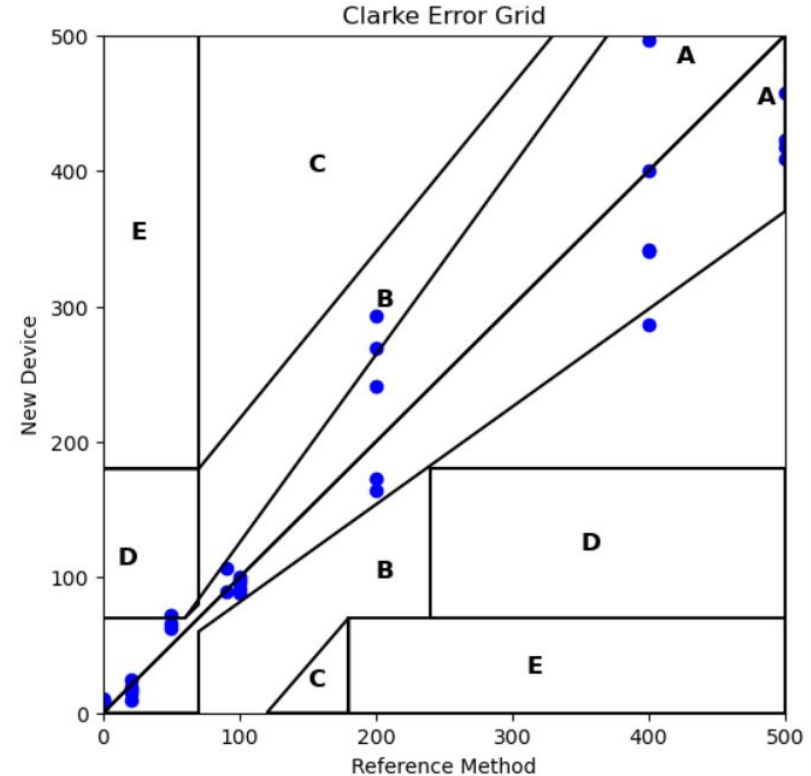
## Final methodology:

1. 6 second quiet time
2. 200 mV constant potential step
3. Collect data once step is applied
  - a. Sample rate 10 Hz
  - b. 50 ms after step
  - c. 500 ms window
4. Smooth data, get linear regression of  $i$  vs  $1/\sqrt{t}$
5. Apply piecewise calibration (slope  $\rightarrow$  glucose concentration)
6. Store data in excel workbook
7. Send glucose reading to Arduino



# Accuracy Standards

- **ISO 15197:2013** (user performance evaluation for 95% of samples)
  - $<100 \text{ mg/dL}: \pm 15 \text{ mg/dL}$
  - $\geq 100 \text{ mg/dL}: \pm 15\% \text{ error}$
- **Clarke Error Grid**
  - Compares new device to reference device
  - Plasma vs whole blood calibration
    - Buffered glucose samples
    - HPLC as reference
  - Still useful calibration validation tool during developmental stages



# Our Glucometer Design

## IO Rodeostat: Open Source Potentiostat

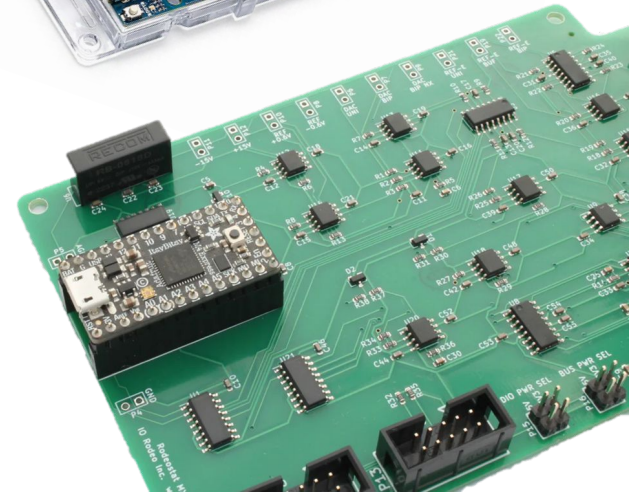
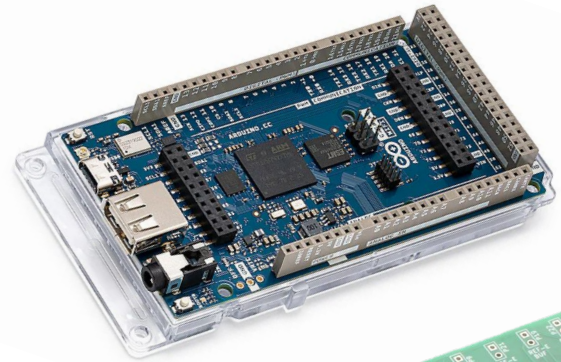
- Digitally-controlled with python Potentiostat library
- Supports chronoamperometry
- Supported by **Adafruit ItsyBitsy M4**

## Hardware selection

- **Arduino GIGA R1 w/ Display Shield**
  - High resolution and touch-screen function
  - Python support for integration
  - 2 MB internal flash memory

## 3D printing

- Test strip connection
- Sturdy design for practical use and secure integration of components



# Arduino GIGA Set-up

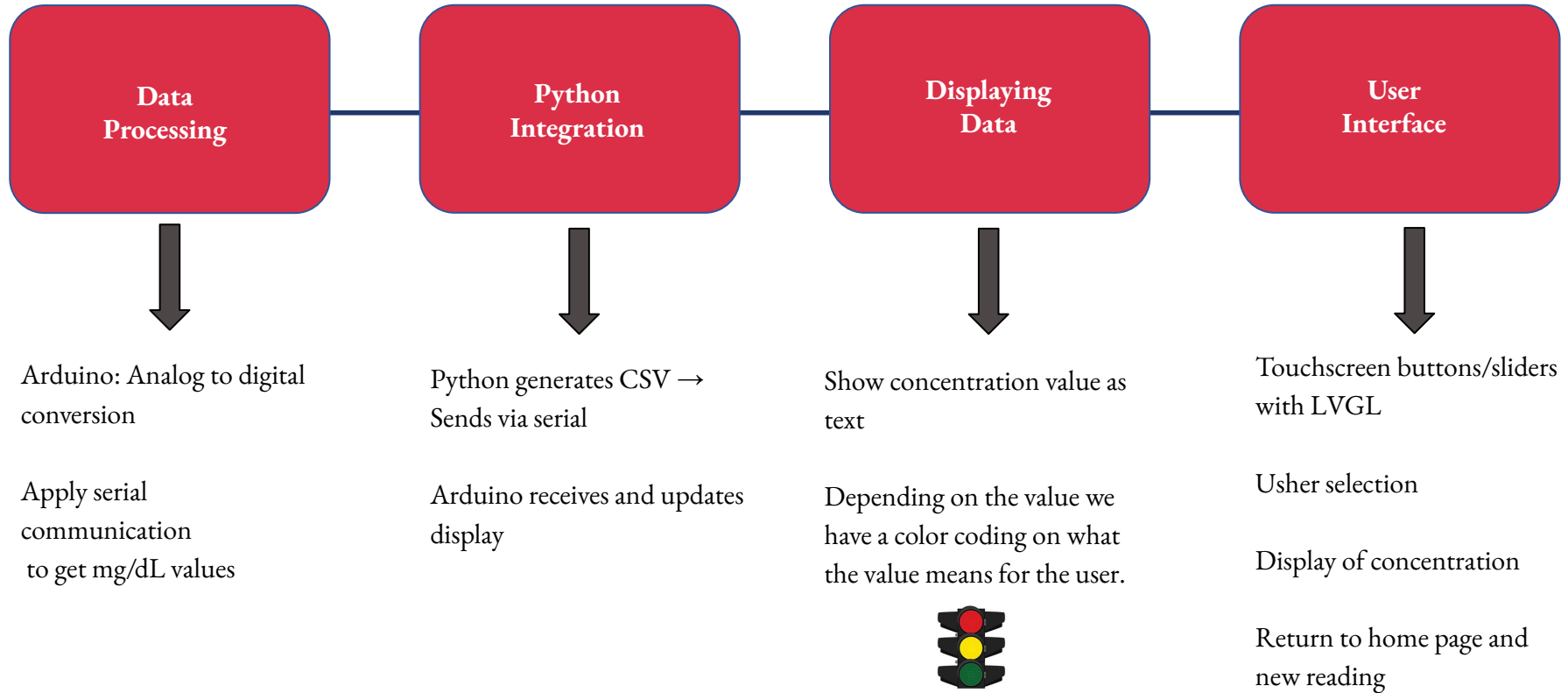
## Hardware

- **Arduino GIGA R1 WiFi Board:** Serves as the main microcontroller.
- **GIGA Display Shield:** Features a 3.97" 480x800 RGB touch screen, mounted on the bottom side of the GIGA R1 WiFi board.

## Software

- 'Arduino Giga Display' libraries.
- Test Examples:
  - RGB LED Test
  - Touch Screen Test
  - LCD Screen Test
  - LVGL Demo: Demonstrates interactive UI elements.
- 2. Development of our own UI based on test samples and our requirements

# Display Logic Overview










# Concentration Display



The glucose concentration display dynamically changes color based on real-time sensor readings. The background of the info panel adjusts to reflect risk zones, providing immediate visual feedback to the user:

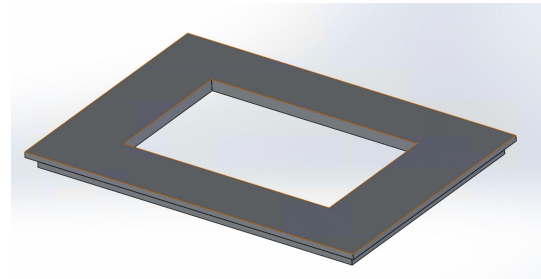
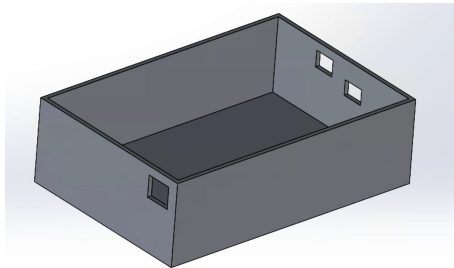
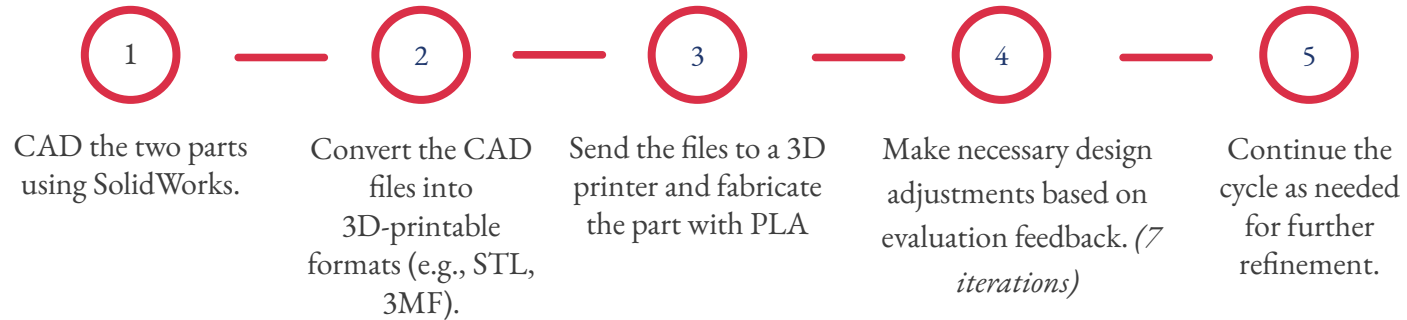
-  Under 70 mg/dL: Hypoglycemia warning (yellow)
-  70–99 mg/dL: Normal fasting (green)
-  100–125 mg/dL: Prediabetic risk (light red)
-  126–250 mg/dL: Diabetic range (deep red)
-  Over 250 mg/dL: Critical level alert (dark red)

# User Interface Workflow

## Workflow



# Packaging Design Process



# Comparison and Feasibility

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# Cost Analysis

Component	Cost
IO Rodeo Rodeostat	\$240
Arduino Giga R1 Wifi	\$73
Arduino GIGA Display Shield	\$64
Wires + 3D printing estimates	\$25
Needs a Laptop	\$1000**
<b>Total Cost of SweeTech</b>	~\$402

## Cost of Industry Glucometer



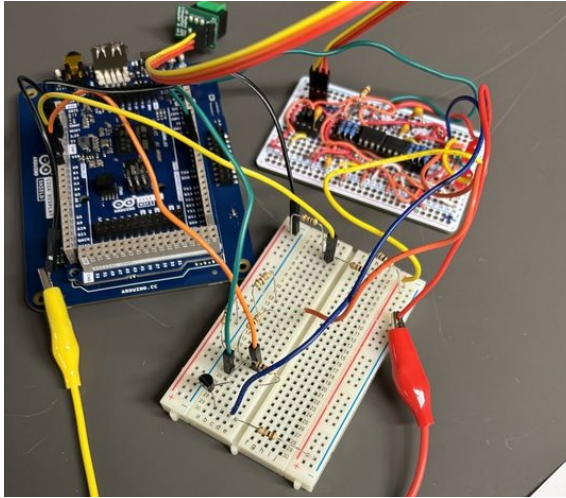
~\$20

Clearly, we are not anywhere close to an industry standard device, but that is okay. We did learn a lot though :)

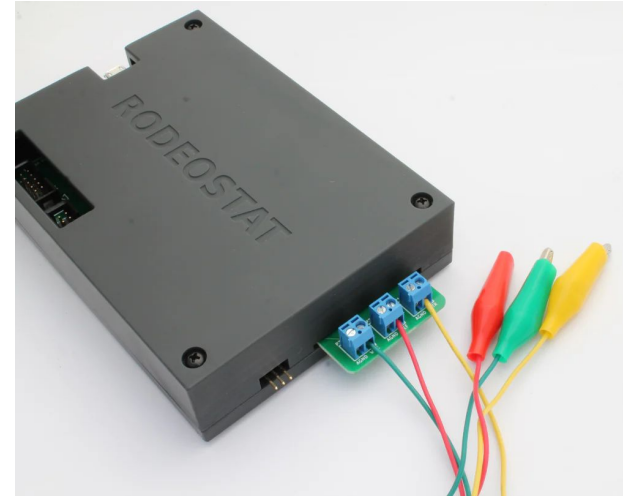
# Conclusion and Lessons Learnt

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# Homemade Potentiostat Vs. IO Rodeo Potentiostat



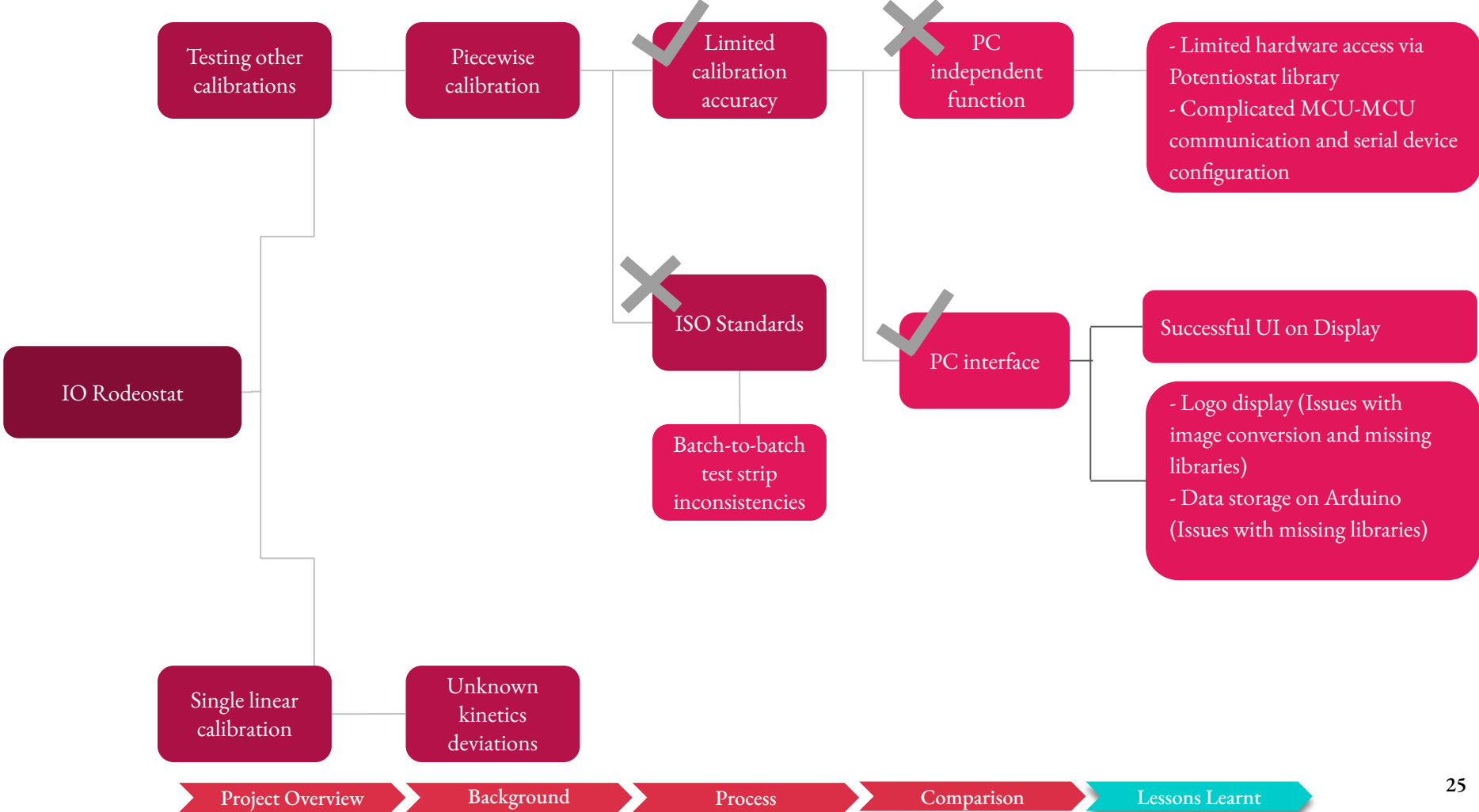
Vs.



# Challenges We Faced and Design Choice Workflow







# Conclusion

**A potentiostat CAN be used to create a glucometer ✓**

## Innovative Design

- Developed glucometer using a potentiostat and CA for real-time glucose detection.
- Integrated electrochemical sensing for improved sensitivity

## Feasibility and Scalability

- Ideal for academic settings.
- Not currently scalable for consumer use due to manual operation, bulkiness, and lack of automation.

## Impact

- Valuable as a learning tool
- Encourages multidisciplinary thinking by blending hardware design, coding, and analytical chemistry.

## Improvements

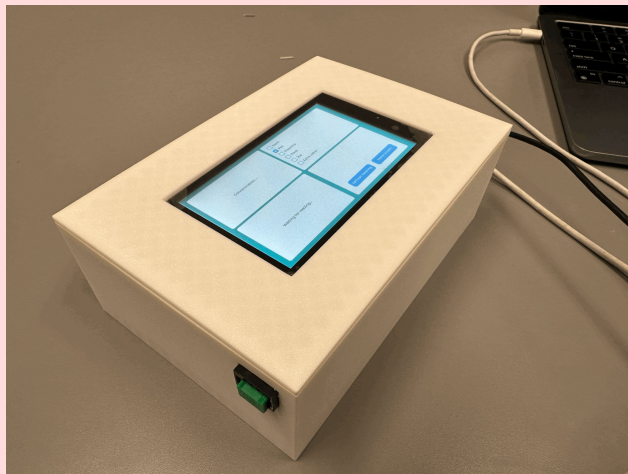
- Get rid of need for a laptop
- Miniaturize hardware
- Automate workflow
- Calibrate to blood
- Include flash memory storage

## Potentiostat-Based Glucose Meter



# Thank You!

Any Questions?



CBE 3300  
Team SweetTech