# Experiment Automation for an Electrochemical Sensor

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## Introduction

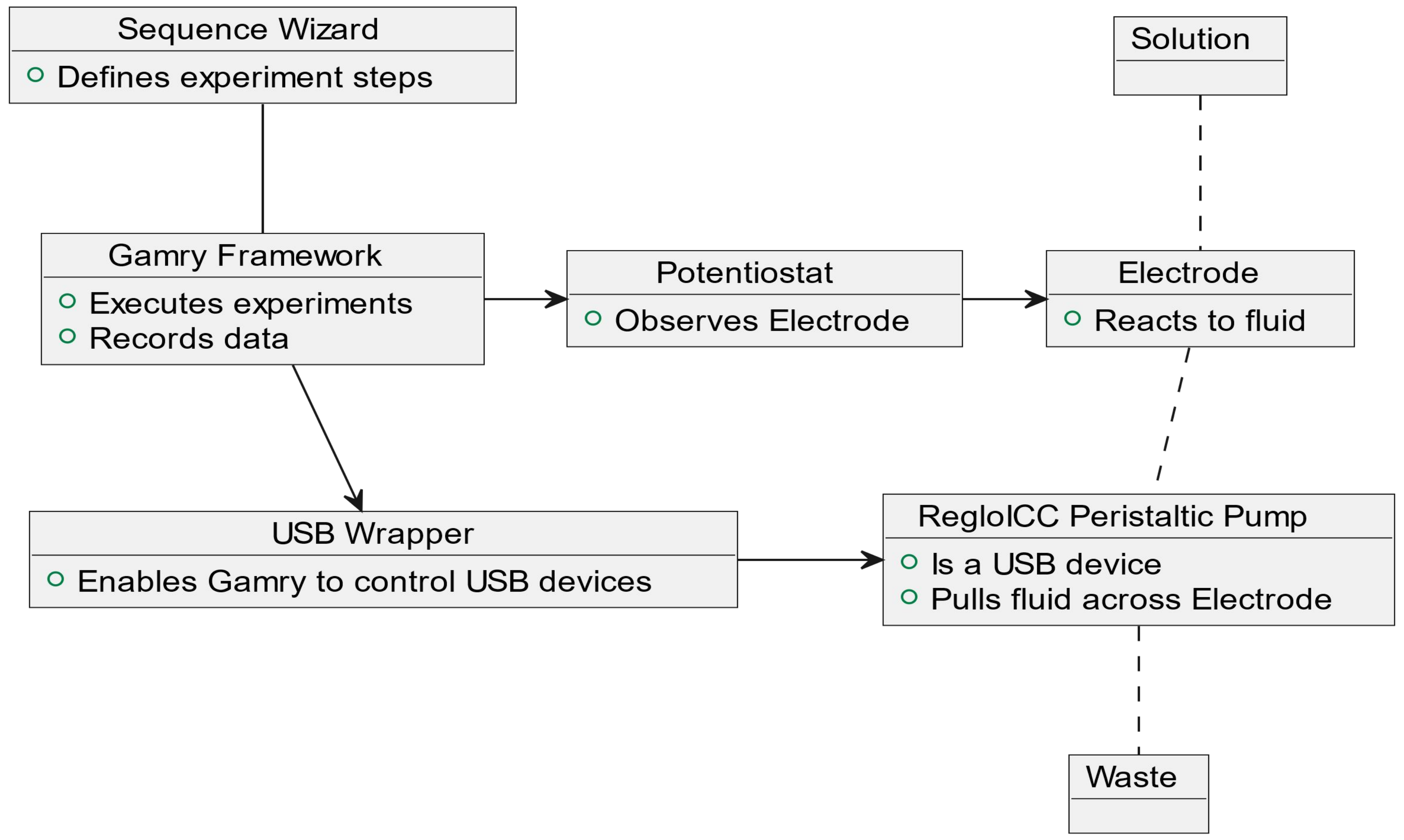
- The composition and properties of bodily fluids like saliva change in response to a variety of illnesses, including sepsis.
- The SEEDS lab intends to create an electrochemical sensor, which combined with machine learning can diagnose sepsis.
- This requires running many experiments with different sensor surfaces, which is labor intensive.
- We will save the SEEDS Lab time by automating the pump used in experiments, and by providing an extendable data analysis application

## Goals

1. Create software tools that can control the pump autonomously
2. Integrate the automation tools into the Sequence Wizard, making them available to researchers
3. Create a MATLAB application for processing the data produced by the experiments and produce visualizations and statistics that can be used to quickly understand the data

## Goal 1: Pump Automation

- The Gamry Framework already controls everything except the pump.
- The pump is a USB device, which is not supported by the Gamry Framework
- We wrap the USB communications with a Python script
- Gamry invokes the Python script, which forwards commands to the pump



Sequence Wizard
○ Defines experiment steps

Solution

Gamry Framework
○ Executes experiments
○ Records data

Potentiostat
○ Observes Electrode

Electrode
○ Reacts to fluid

USB Wrapper
○ Enables Gamry to control USB devices

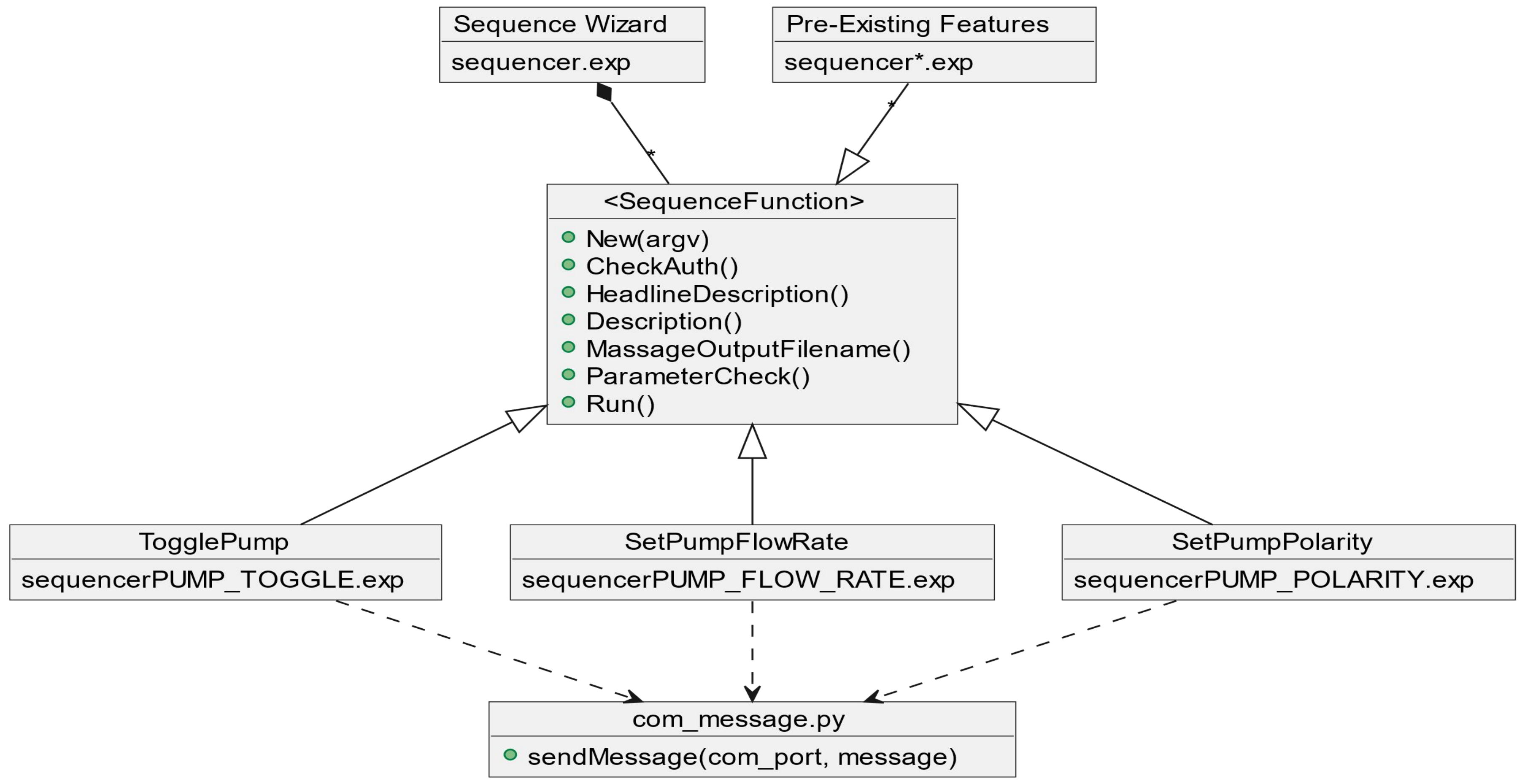
RegloICC Peristaltic Pump
○ Is a USB device
○ Pulls fluid across Electrode

Waste

*Figure 1: The Gamry Framework executes the experiment by controlling the Peristaltic Pump, and the Potentiostat. The dashed lines indicate movement of fluid.*

## Goal 2: Sequence Wizard Integration

- Researchers design experiments by selecting steps from a GUI
- Experiment steps are implemented as subclasses of SequenceFunction
- We implement new subclasses to define new experiment steps



Sequence Wizard
sequencer.exp

Pre-Existing Features
sequencer*.exp

<SequenceFunction>
○ New(argv)
○ CheckAuth()
○ HeadlineDescription()
○ Description()
○ MassageOutputFilename()
○ ParameterCheck()
○ Run()

TogglePump
sequencerPUMP_TOGGLE.exp

SetPumpFlowRate
sequencerPUMP_FLOW_RATE.exp

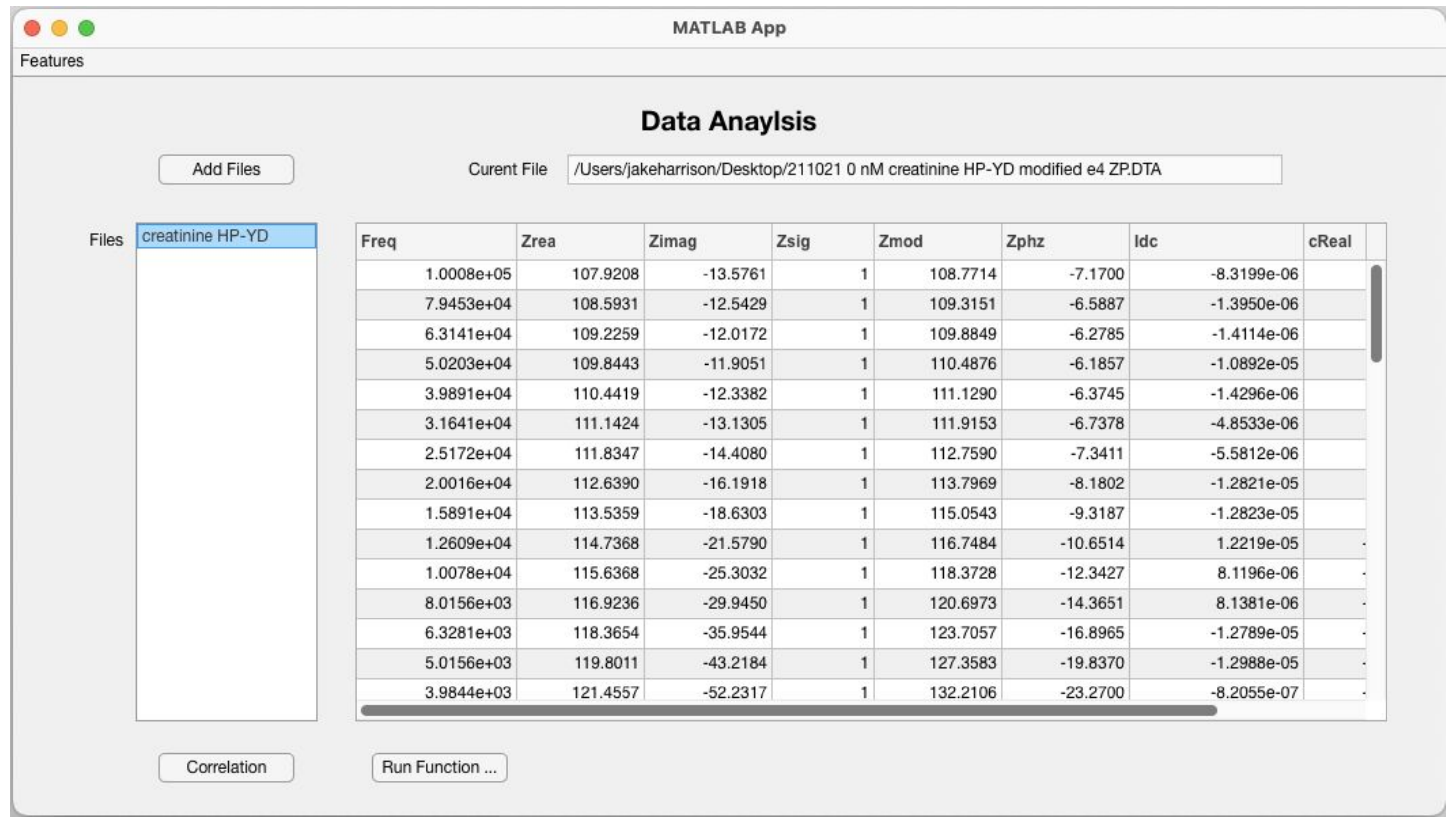
SetPumpPolarity
sequencerPUMP_POLARITY.exp

com_message.py
○ sendMessage(com_port, message)

*Figure 2:* describes the class structure of the sequence wizard. We are adding the classes TogglePump, SetPumpFlowRate, and SetPumpPolarity which implement the SequenceFunction interface. These new classes invoke our Python USB wrapper.

## Goal 3: Data Analysis Application

- Application designed to save researchers time by analyzing the output data from the experiment.
- Designed for functions to be added as the understanding of the data changes
- Programmed in MATLAB so the SEEDS lab can maintain the project
- Multiple files can be loaded at once, allowing for complex analysis
- Tags are extracted from file names to identify data from each file



Data Anaylsis

Curent File: /Users/jakeharrison/Desktop/211021 0 nM creatinine HP-YD modified e4 ZP.DTA

Files: creatinine HP-YD

| Freq | Zrea | Zimag | Zsig | Zmod | Zphz | Idc | cReal |
|---|---|---|---|---|---|---|---|
| 1.0008e+05 | 107.9208 | -13.5761 | 1 | 108.7714 | -7.1700 | -8.3199e-06 | |
| 7.9453e+04 | 108.5931 | -12.5429 | 1 | 109.3151 | -6.5887 | -1.3950e-06 | |
| 6.3141e+04 | 109.2259 | -12.0172 | 1 | 109.8849 | -6.2785 | -1.4114e-06 | |
| 5.0203e+04 | 109.8443 | -11.9051 | 1 | 110.4876 | -6.1857 | -1.0892e-05 | |
| 3.9891e+04 | 110.4419 | -12.3382 | 1 | 111.1290 | -6.3745 | -1.4296e-06 | |
| 3.1641e+04 | 111.1424 | -13.1305 | 1 | 111.9153 | -6.7378 | -4.8533e-06 | |
| 2.5172e+04 | 111.8347 | -14.4080 | 1 | 112.7590 | -7.3411 | -5.5812e-06 | |
| 2.0016e+04 | 112.6390 | -16.1918 | 1 | 113.7969 | -8.1802 | -1.2821e-05 | |
| 1.5891e+04 | 113.5359 | -18.6303 | 1 | 115.0543 | -9.3187 | -1.2823e-05 | |
| 1.2609e+04 | 114.7368 | -21.5790 | 1 | 116.7484 | -10.6514 | 1.2219e-05 | - |
| 1.0078e+04 | 115.6368 | -25.3032 | 1 | 118.3728 | -12.3427 | 8.1196e-06 | - |
| 8.0156e+03 | 116.9236 | -29.9450 | 1 | 120.6973 | -14.3651 | 8.1381e-06 | - |
| 6.3281e+03 | 118.3654 | -35.9544 | 1 | 123.7057 | -16.8965 | -1.2789e-05 | - |
| 5.0156e+03 | 119.8011 | -43.2184 | 1 | 127.3583 | -19.8370 | -1.2988e-05 | - |
| 3.9844e+03 | 121.4557 | -52.2317 | 1 | 132.2106 | -23.2700 | -8.2055e-07 | - |

*Figure 3:* UI of Data Analysis application. Currently the application supports adding multiple files and displaying their data.

## Results

**Pump Automation Functionality**

- Turn pump on/off
- Set rotation direction (polarity)
- Set flow rate (ml/min)

**Future Work**

- Extend automation to other pump brands
- Control individual pump "channels" (feature of RegloICC Peristaltic Pump)

**Sequence Wizard Integration**

- Pump control library is integrated
- Our functions can be selected through the Sequence Wizard

**Future Work**

- Simplify setup to a single shell script
- Detect pumps automatically

**Data Analysis Application Functionality**

- Parses experiment data files
- Calculate total capacitance
- Correlation tables

**Future Work**

- ANOVA
- Multivariate analysis
- Hot color plots

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