AUTOMATION OF BIOLOGICAL ASSAYS USING PYTHON AND HUDSON ROBOTICS

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MOTIVATION

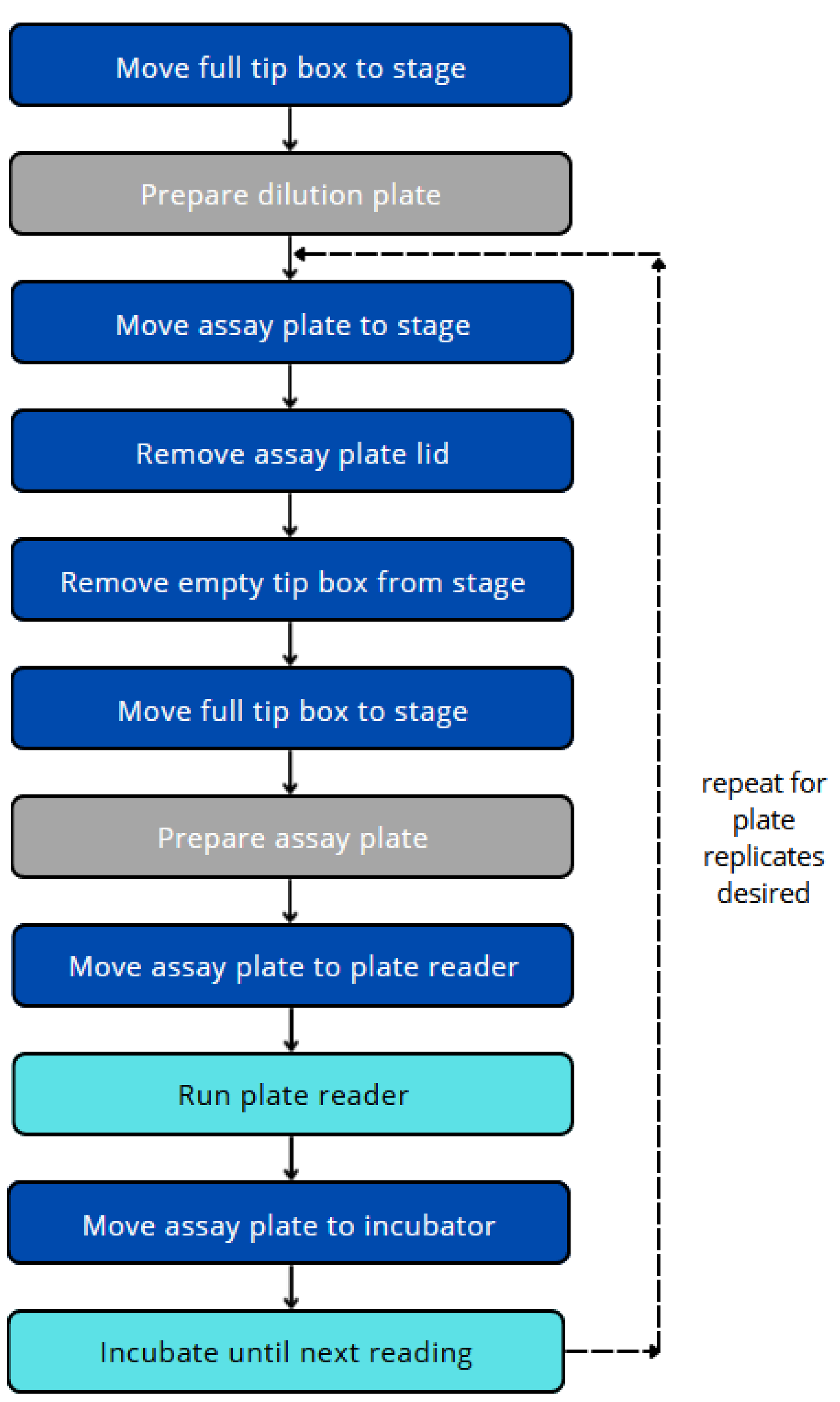
- Manually performed biological experiments are generally time-consuming, low throughput, reagent intensive, and require extensive supervision
- Novel robotics technology is still in development. The benefits of automating a variety of standard biological assays include:
  - Reducing resource consumption per trial
  - Replicating many trials simultaneously
  - Monitoring experiment progress in real-time with automatic adjustments
- Developing open-source protocols will allow biologists without a strong computer science background to rapidly further their research
- Our group aimed to replicate an experiment other researchers implemented on Hamilton liquid handling robots [1,2] on the Hudson liquid handling robots used at Argonne National Laboratory
- Broadly, our group aimed to investigate the reproducibility of automated biotechnology workflows across robotic experimentation platforms

PROGRESS

- Developed and tested protocol for monitoring *E. coli* growth in 80 unique environments (see Fig. 1 below)
- Performed preliminary testing using food dye of three different colors to represent the intended treatments and their relative concentrations
- Edited code for errors, documented, and prepared for trials on live bacteria

```python
'''
prepare assay plate

hso files listed to be run in chronological order and divided into a new list once the
tip box is empty and needs to be replaced
'''

list_of_final_1 = ["cells_assay_1.hso", "cells_assay_2.hso", "control_assay.hso",
                   "dilution_assay_P_1.hso", "dilution_assay_C_1.hso", "dilution_assay_C_2.hso"]
list_of_final_2= ["dilution_assay_N_1.hso", "dilution_assay_N_2.hso"]

for c in list_of_final_1:
    softLinx.soloSoftRun(Path+c)

'''
Plate crane movements:
    remove empty tip box from stage
    place new full tip box on stage
    move plate crane away from possible collision with liquid handler
'''

softLinx.plateCraneMovePlate(["SoftLinx.Solo.Position3"],["SoftLinx.PlateCrane.Stack2"],poolID = 2)
softLinx.plateCraneMovePlate(["SoftLinx.PlateCrane.Stack4"],["SoftLinx.Solo.Position3"],poolID = 4)
softLinx.plateCraneMoveCrane("SoftLinx.PlateCrane.Safe")
```

EXPERIMENTAL DESIGN



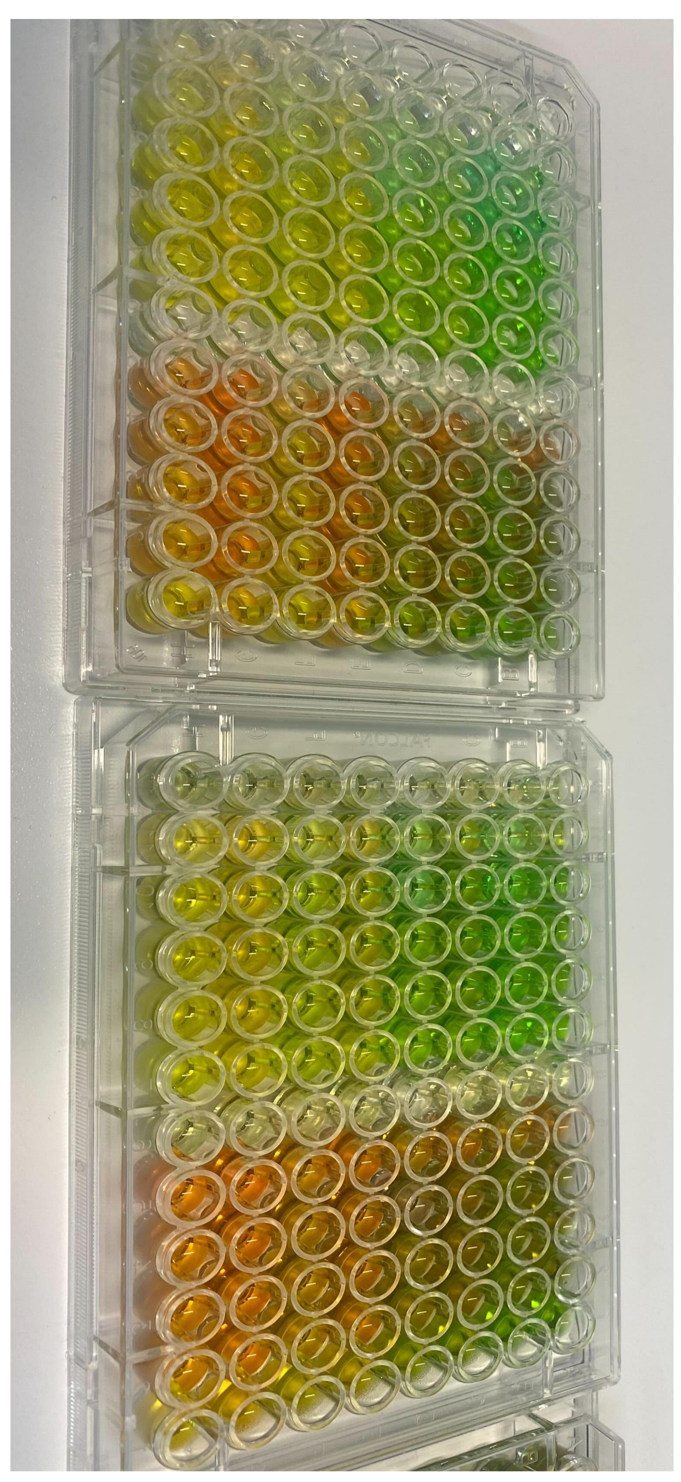


Fig. 1: Two replicates of assay plate. First and seventh rows from top of each plate (columns 6 and 12) act as controls with 1X concentration of each treatment and no cells

IN PRACTICE

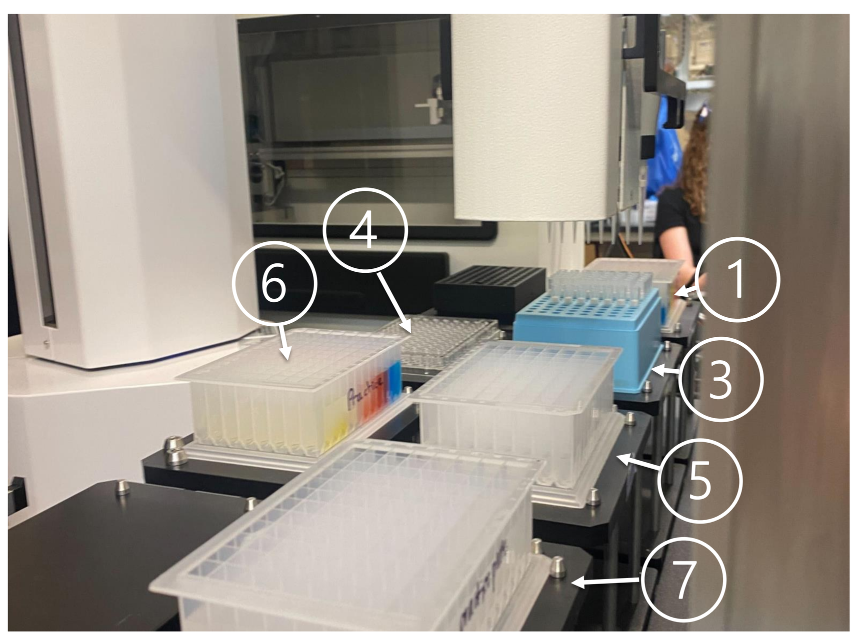


Fig. 2A: Deck layout for protocol with stock treatments (position 1), tip box (position 3), assay plate (position 4), stock media (position 5), dilution plate (position 6), and stock cells (position 7),

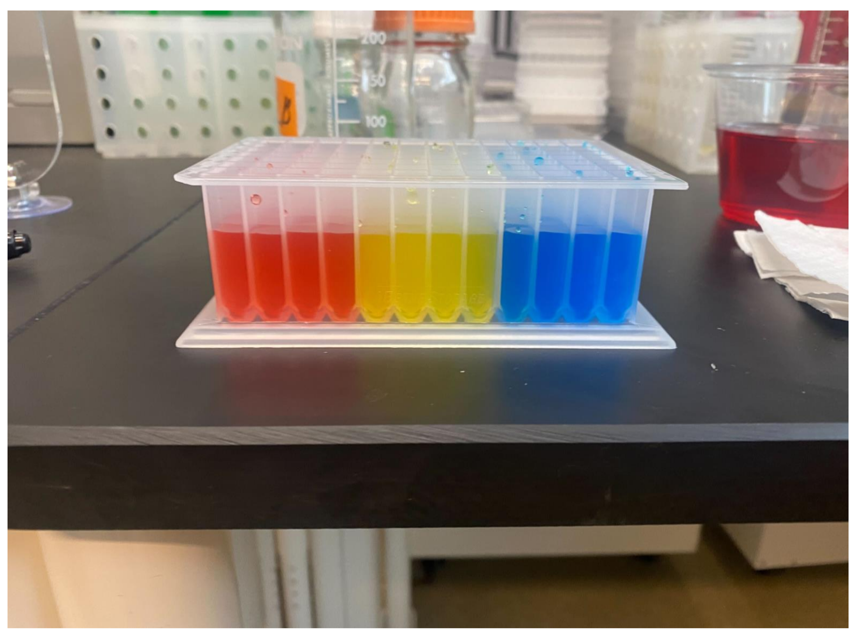


Fig. 2B: Deep well plate representative of stock nutrients (carbon in red, nitrogen in yellow, phosphorus in blue)

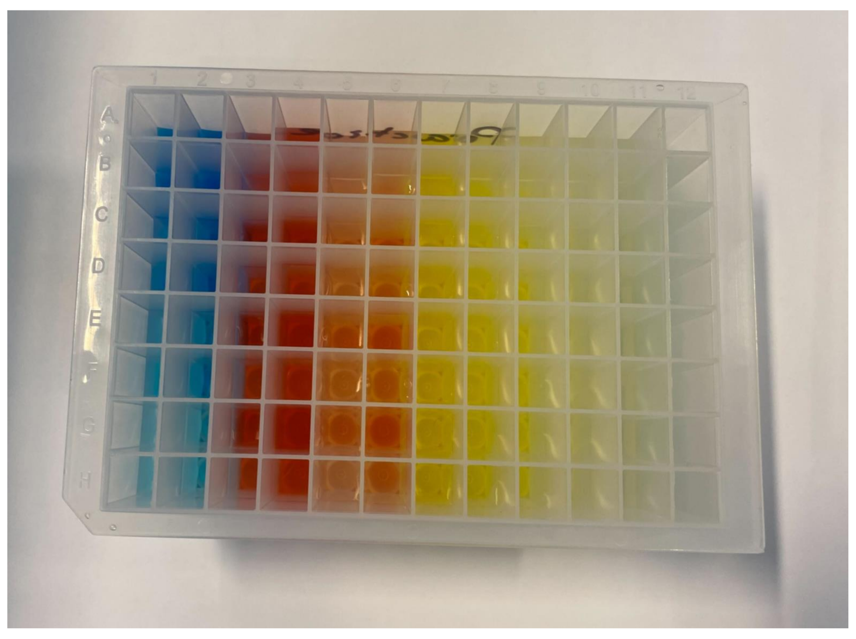


Fig. 2C: Completed dilution plate with color intensity representative of concentration (control in far-right column)

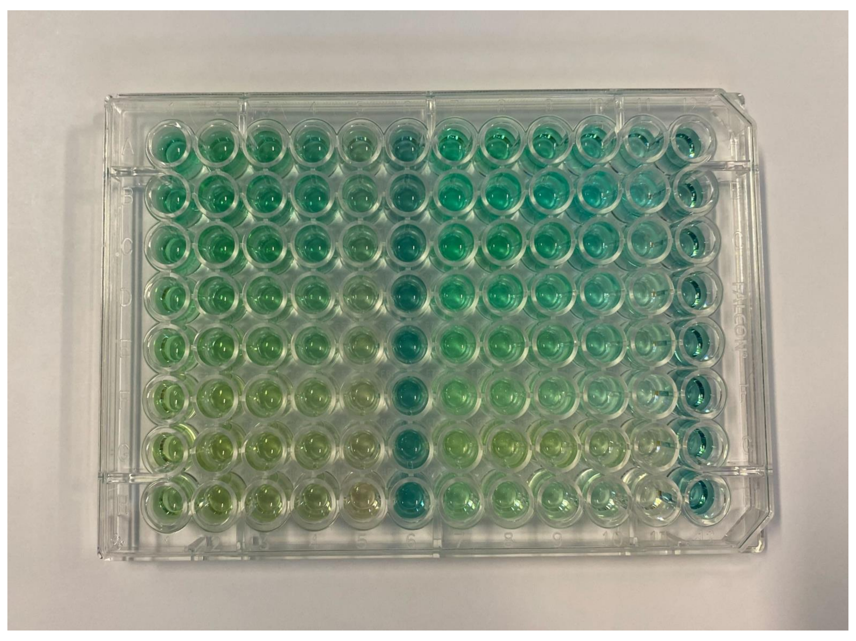


Fig. 2D: Completed assay plate with well hue representative of various combinations of nutrient concentrations

FUTURE DIRECTIONS

- Implementing computer vision to decrease the need for human supervision
- Engineering a feedback loop so that as data is gathered an experiment can be automatically altered
- Creating a user-friendly application for scientists without coding experience to design their experiments
- Allowing experimenters to remotely move equipment throughout a lab space or code these movements into their protocol
- Coding for additional procedures will be crucial to identify where there is room to evolve and how to manipulate available tools for broader use

REFERENCES

- [1] E. J. Chory, D. W. Gretton, E. A. DeBenedictis, and K. M Esvelt, Flexible open-source automation for robotic bioengineering. 2021.
- [2] E. A. DeBenedictis, E. J. Chory, D. Gretton, B. Wang, and K. Esvelt, A high-throughput platform for feedback-controlled directed evolution. 2020.

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