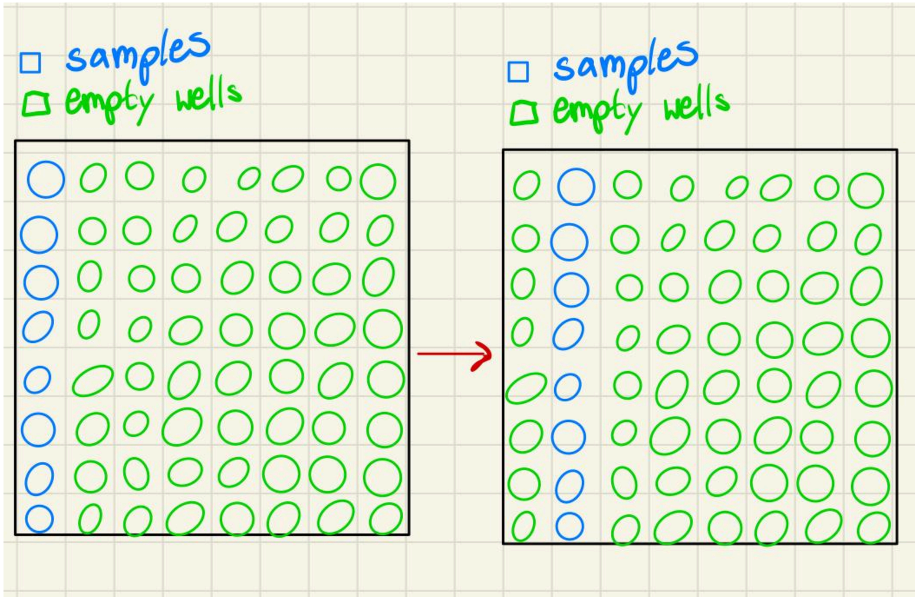
Reliable Organic Sample Testing

Alex Besanceney (Robotic Controls), Mishari Alsabih (PCB Design), Connor Platt (Mechanical Design), Dorjee Tenzing (Software Design), Greg Ziegler (Embedded Systems)

Problem Statement: In Grenada and many parts of South America, the spread of viral diseases such as Dengue poses a significant public health challenge, particularly in areas with limited access to reliable diagnostic tools. Early detection is critical for improving patient survival rates and advancing research into the prevalence, transmission, and treatment of these diseases. Current methods, like ELISA (enzyme-linked immunosorbent assay), are labor-intensive, time-consuming, and prone to inefficiencies such as sample loss and contamination, which compromise both clinical diagnostics and research accuracy. This project seeks to develop an innovative diagnostic system integrating magnetic bead technology and advanced optics to enhance low viral load detection. By optimizing sample mixing and measurement processes, the goal is to create a lightweight, efficient device that minimizes material waste, improves sensitivity and specificity, and supports both healthcare outcomes and robust disease research in resource-limited settings.

Purpose, Value, and background: Threatening nearly half the world's population with an "estimated 100-400 million infections per year," Dengue is a treatable viral infection whose survival rate is closely tied to rates of early detection [1]. Early detection is crucial for helping to prevent severe symptoms. This project was designed in conjunction with Professor Ahmet Yanik and Doctoral Student Gamze Onuker, who are working to design a consistent way of testing for viruses in low concentrations. The experimental procedure necessary to detect viruses in low concentration, called ELISA, currently requires 5 hours of work by a dedicated technician. While it can be done, the work is very time-consuming and often wastes both plastic and biological samples when the pipettes are disposed of. We aim to make this process much faster and reduce the number of labor hours to approximately one.

To automate an ELISA, the machine needs to be capable of moving samples from one testing well to an adjacent well, agitating those samples, and then moving the agitated contents into the next testing well and repeating the process. At a minimum, the machine must have the capacity for eight subsequent tests, ideally with eight tests running at the same time (imagine an 8x8 grid of testing wells where the Y axis is fixed and all eight of the same samples are moved progressively in the X direction, seen below).



The machine must be fairly easy to operate, so researchers and medical professionals can spend their time on something other than training to use it. More than anything, it is essential that this machine can *reliably* agitate and transport samples, transporting the entire contents of each testing well to the next stage without spilling or leaving any droplets behind. If successful, this project could help researchers and medical professionals diagnose viruses much sooner. The technology can be changed to perform many kinds of tests, meaning the machine would benefit from a modular design that allows it to adapt to its use case.

Target end user: This device should be used by nurses in a medical practice or researchers who wish to test organic samples in their experiments. These individuals could be customers, but it is more likely a medical or academic institution would purchase it for their use.

Client Profile: Ahmet Yanik is the client for this project, and he can be reached at yanik@ucsc.edu. He is interested in providing guidance and funding for this project but needs a lab space to offer. While Yanik will oversee the project, we will be answering to Gamze, whose PhD research we will be directly supporting.

Client Objectives: Gamze emphasized a few critical properties of a successful design:

1. Zero loss in transportation - the number one priority of this design is to mitigate the amount of testing material that is lost due to the adhesion of liquids to the testing wells and probes
2. Capacity - needs to fit 8 consecutive tests, ideally with 8 concurrent tests (wide enough to fit 8 wells, with a length of 8 wells, too)
3. Easily transportable - this must be small and accessible enough to distribute around the world, so it needs to be lightweight (<15 lbs)

4. High-precision robotic movement - the machine needs to precisely transport samples from well to well without contaminating or spilling any liquid, mandating a high-precision control algorithm that performs consistently across thousands of tests
5. Easy to use - the user should be trained on this device in a matter of minutes because medical professionals do not have time to regularly learn new software; a stretch goal is designing a phone app that controls the testing machine

Project Location: As mentioned, no lab space is allocated for this project, so we will be using UCSC spaces to design the blood testing machine.

Additional Information:

Team Composition: Robotics Engineer, Software Engineer, Power Engineer, Embedded Systems Engineer, Mechanical Engineer

Potential Solutions: We believe 3D printing robotic controls is a promising place to take design inspiration for our own automated device.

Project Budget & Materials: Yanik did mention a grant related to this project, but it is not specifically for this project. That being said, he was confident he could support the design team with 3D printers, magnets, and testing equipment as necessary.

Project Timeline and Major Milestones: There are no major deadlines to be aware of as of 12/2/24.

Works Cited:

[1] World Health Organization -Dengue and severe dengue:
https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue#:~:text=There%20is%20no%20specific%20treatment,fatality%20rates%20of%20severe%20dengue.