Automated Malaria-Ab Colorimetric ELISA Platform Utilizing a Syringe-Based Dispenser and 3D Printed Parts

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Overview

Our goal is to create an automated colorimetric bioassay to find malaria antibodies within humans using an enzyme-linked immunosorbent assay (ELISA). The device is targeted to poorly funded health care facilities where traditional bioassay devices are unavailable. With malaria affecting roughly 229 million people worldwide, and with a disproportionate 94% of cases in Sub-Saharan Africa, a cheaper testing alternative is in demand.

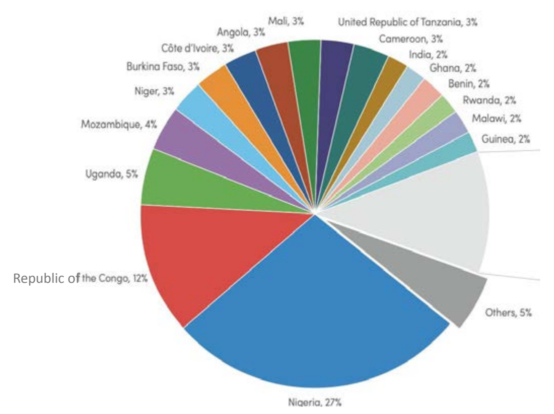

Figure 1.
Malaria Infection prevalence by country

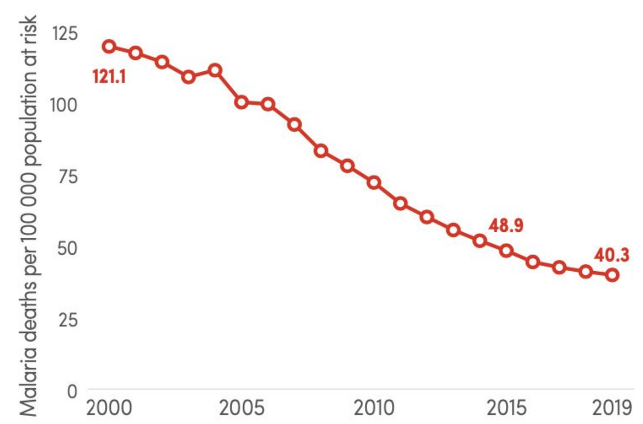

Figure 2.
Mortality rate trend per 100,000 infections

Objective: Provide an inexpensive device for testing for malaria that can easily be expanded to accommodate other ELISA tests.

Challenge: Create an automated biometric assay which provides reliable results while also maintaining a low cost to allow poorly funded facilities to purchase our product.

Existing Solutions

NanoEntek Frend System

- -Lower to mid-range cost for a bioassay
- -Rapid immunoassay tester and analyzer
- -A small sample volume is required for analysis
- -Hefty >**$8,000 price point**

Figure 3
NanoEntek Frend System

Jenway 632621 Spectrophotometer

- -Lower end cost for a bioassay
- -Does not directly test for malaria
- -Uses a pulsed xenon lamp
- -A price tag of **>$2,500**

Figure 4
Jenway 63621

Cost Effectiveness

- On average, $191 for each malaria case treated promptly in Peru
- $31 per **mild** case of malaria treated promptly using testing
- $1,051 per **acute** malaria case averted by testing patients
- $17,655 for each **death avoided** by testing patients
- >400,000 malaria deaths globally in 2018

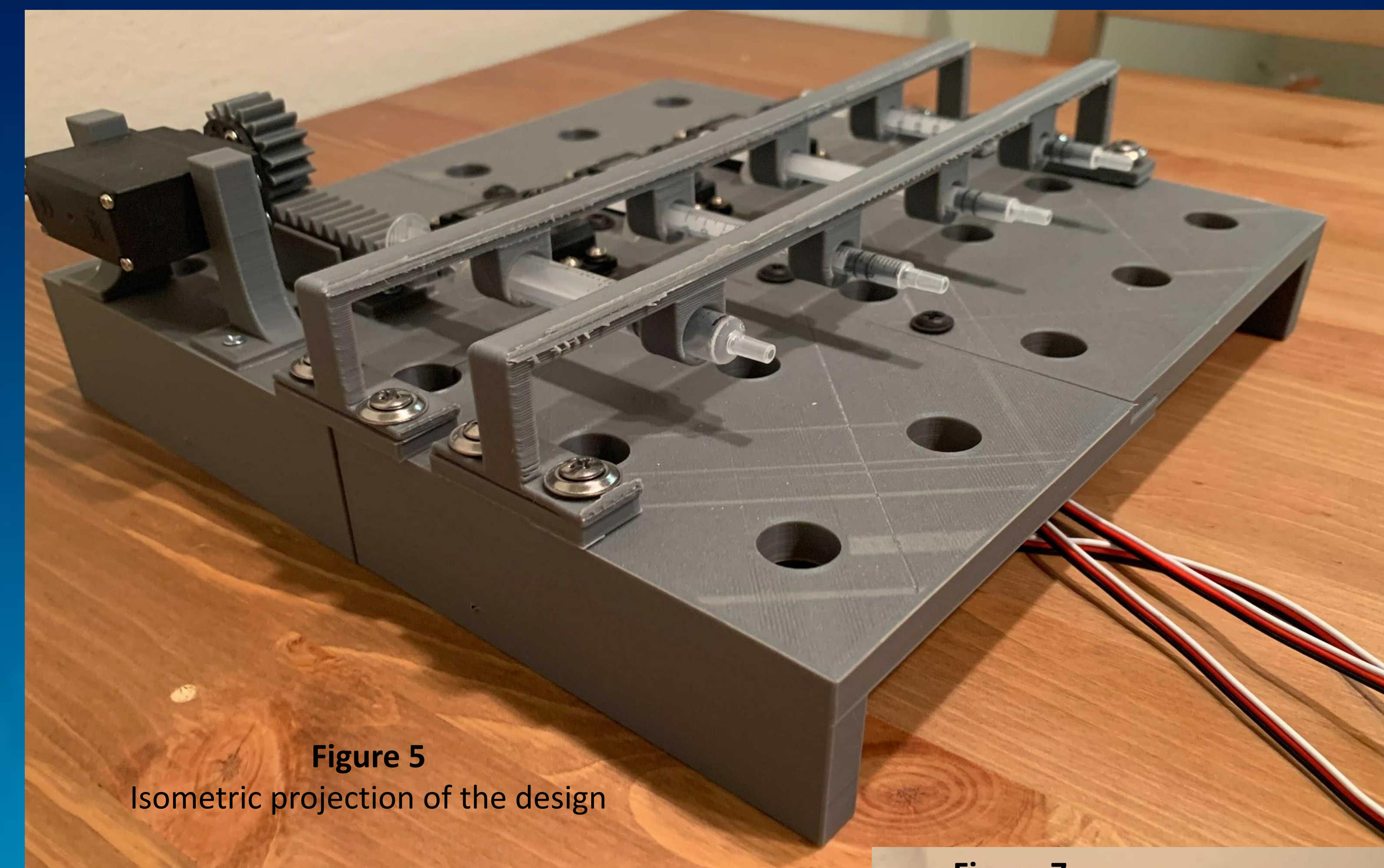

Figure 5
Isometric projection of the design

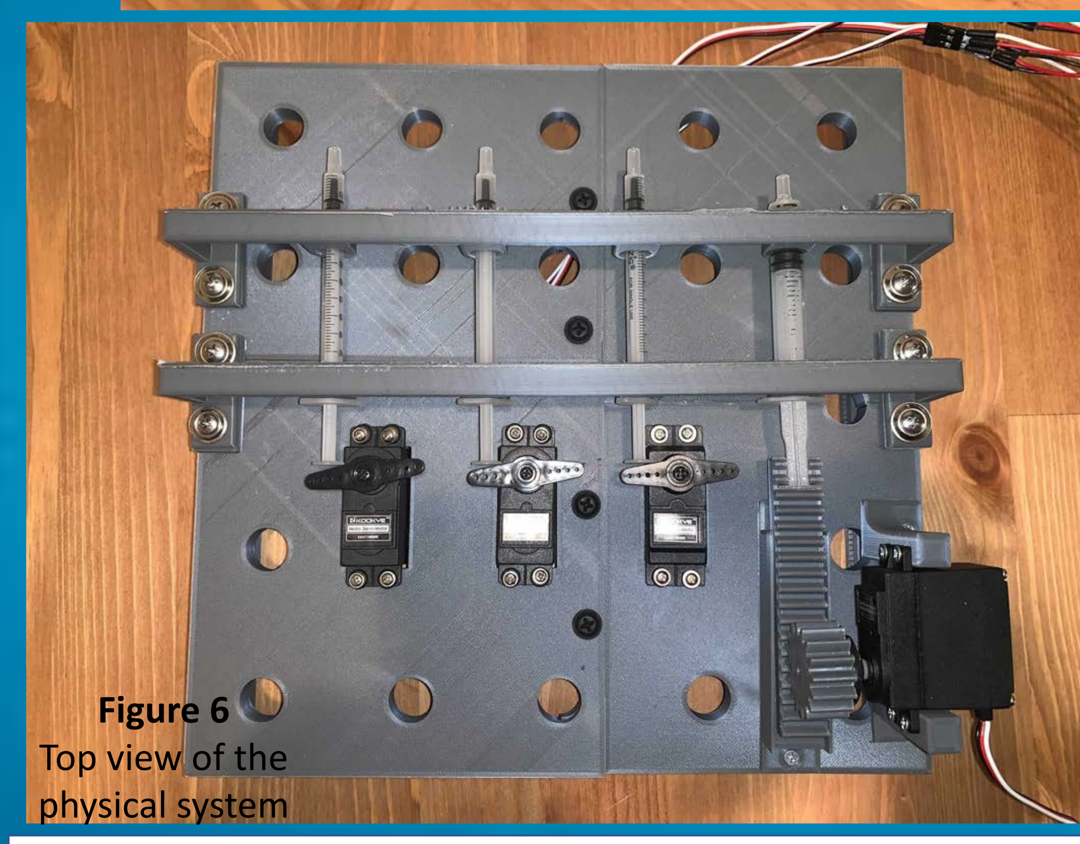

Figure 6
Top view of the physical system

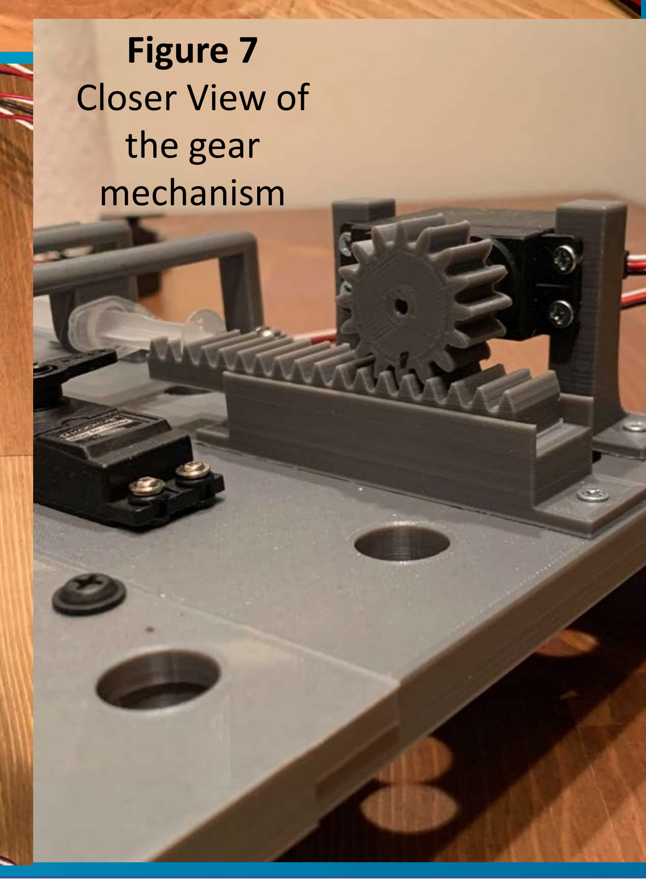

Figure 7
Closer View of the gear mechanism

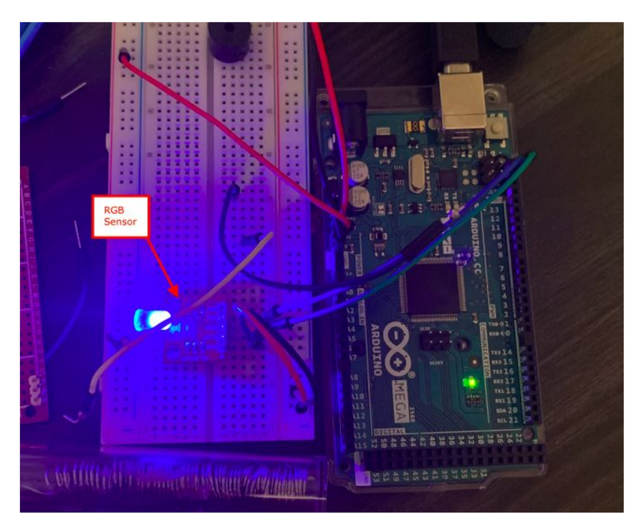

Figure 8
Color sensing using an RGB sensor

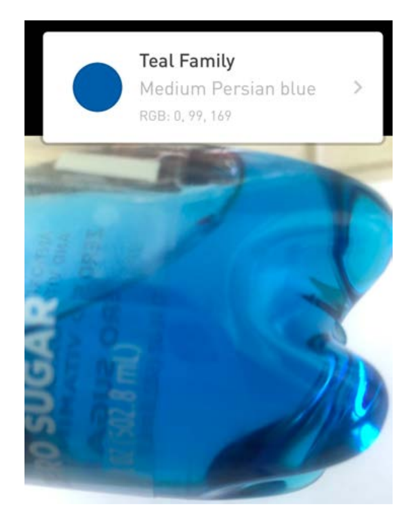

Figure 9
Color sensing using a phone app ("Color Name")

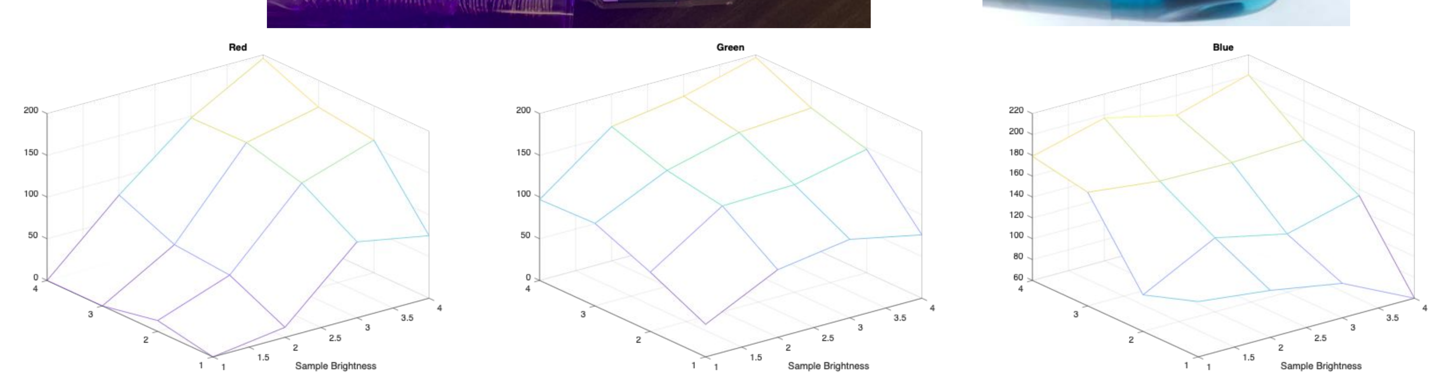

Figure 10
Red, green, and blue response curves to different sample colors and lighting environments

Analysis

The graphs show measured force required to push a syringe (5ml) under conditions similar to the one we're looking at (ours is 1 or 3 ml though), using different speeds and fluids within the syringes.

Figure 9 determines the forces required using an energy balance equation with the given conditions.
Figure 10 examines the force required using an assumed mass and friction coefficient.
Figure 11 determines the power and cost of servos we are considering to purchase (first two are the weaker servos, the third is the previous team's old design, and the last is a new, stronger one found).

Our team is in the design phase of the project. For that reason we have not yet directly tested the hardware performance and only have theoretical calculations of the device.

Discussion

Procedure:

1. Incubate 50 μL of sample for 1 hr at room temperature (RT)
2. Flush with 300 μL of wash, 30 second pauses, 3 times, at RT
3. Incubate with 50 μL of malaria conjugate for 30 min at RT
4. Flush with 300 μL of wash, 30 second pauses, 3 times, at RT
5. Incubate with 50 μL of TMB for 15 min at RT
6. Add 50 μL of stop solution at RT and wait 10 seconds
7. Record Image

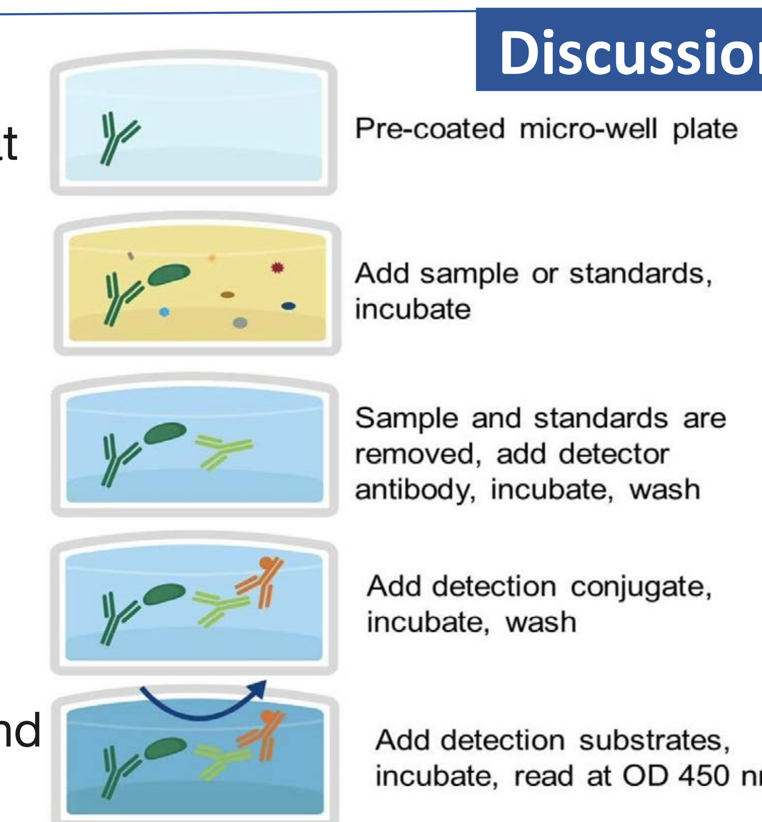

Figure 11
ELISA Test Process

Future Improvements:

- Further optimize the design by creating the most compact design possible. This will allow us to save on material further reducing cost.
- ELISA tests' are very versatile allowing us to test for malaria and other potential targets, such as hormones, allergens, bacteria, antigens, antibodies; allowing our device to have many future applications.
- During our optimization stage we will need to calibrate the sensor to accurately determine the amount of bound antibodies.

Conclusions

Global Scope:

- Our device can be used by many health care facilities where access to testing is limited
- Our target populations are remote communities in Africa and India; it can also be used in rural America where testing is difficult
- We are advocating for human well-being & quality of life improvements

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References

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