Multi-Microscope Malaria Diagnosis Device

B.Sc. (Honours) in Instrument Engineering

Department of Physical Sciences

Student Name: Shane Finn

Supervisors Name: Dr William Whelan Curtin

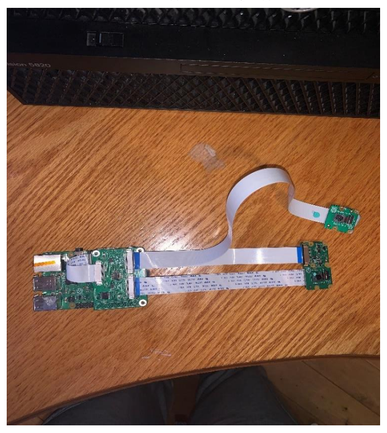
Background to the Project

Project Background

- Regarding the purpose of this project, a unique portable robotic Malaria diagnosis device will be developed. By scanning blood smeared microscope slides, the device will be capable of counting millions of red blood cells per minute.
- Despite many technological improvements and massive amounts of resources invested, Malaria remains a fatal disease. In 2020, there were 240 million cases, 627,000 of these cases resulted in death. Malaria is a treatable disease, and treatment is often inexpensive and readily available, even in underdeveloped countries. However, the majority of Malaria related deaths are caused by the lack of timely Malaria diagnosis, particularly in resource-poor areas.
- This device attempts to improve access to accurate malaria diagnosis, which is a problem that all malaria endemic developing countries face

Arducam Raspberry Pi Multi-Camera Adapter

- The Arducam Raspberry Pi Multi-Camera Adapter allows you to connect multiple camera modules to a single Raspberry Pi CSI camera port. On a single Raspberry Pi board, one adapter board can connect four cameras.
- The Adapter will be mounted onto the raspberry pi module. Three cameras are connected to input ports A, C, and D, and connecting the output port to the raspberry pi board's camera CSI connection.



Resources Required

Python

Stepper Motors

Adafruit Motor Shield

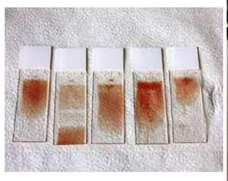
Arduino platform

Raspberry Pi

Stage Materials

RPI Cameras

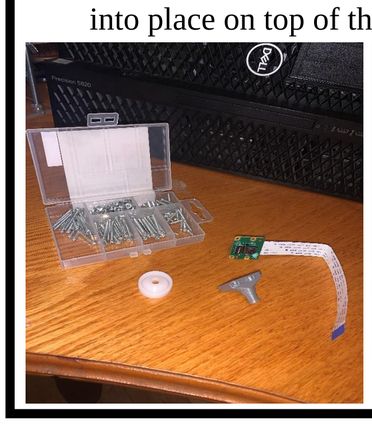
Blood Smears

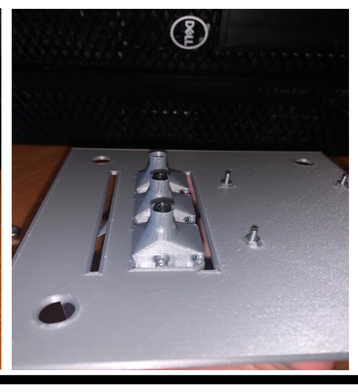


Methodology

Construction of Optics Module

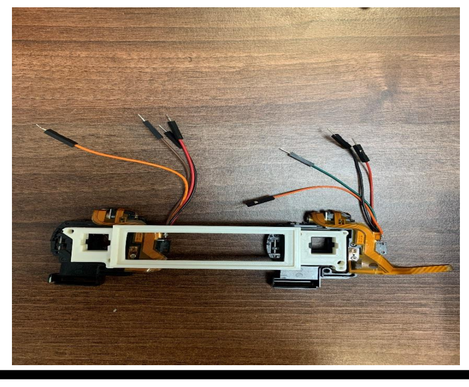
- First, the protective film was carefully removed from the lens.
- Next, the lenses were removed using the circular removal tool and then placed into their respective extension tubes.
- The camera modules were then screwed into place on top of the extension tubes.





Raster Scanning

- Raster scanning is a rectangular pattern of image capture.
- The stepper motors will move 20 steps in a forward direction before going down a step and moving another 20 steps in a backward direction. This process is repeated a number of times until the full scan is completed



How the Project works

- With the optics module placed on top of the stage, serial communication between Python and Arduino will commence.
- The Stepper Motors are connected to the Arduino platform using the Adafruit Motor Shield.
- Python will initiate the communication with the forward command and the raster scanning will commence.
- After each step “AdapterTestDemo.py” command will call the cameras into action, cameras A, C, and D will capture a picture of the blood smear, each one at a different location.
- Numerous images will be captured

USAF Test Target

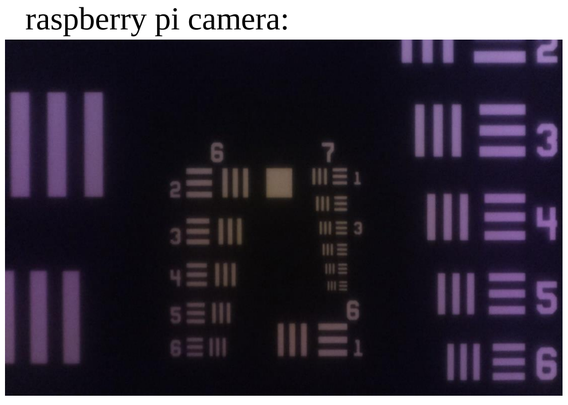
- The target consists of “groups” of six “elements” each. Group numbers are located at the top and element numbers to the side of the target.
- Each element consists of three horizontal and three vertical bars.
- The camera will resolve a chart element if the horizontal and vertical lines can still be recognized and don’t blur into each other.
- The following equation is used to calculate the resolution:

$$\xi\left[\frac{\text{lp}}{\text{mm}}\right] = 2^{\left[G+\left(\frac{E-1}{6}\right)\right]}$$

Results

USAF test target Results

A close up view of the target using the raspberry pi camera:



After entering a value of 7 for G (Group Number) and a value of 6 for E (Element Number) into the previous equation a value of 2.12 μm was calculated.

Hybrid Microscope Blood Smear Results

Raspberry Pi Camera Blood Smear Results

Conclusion

- A functioning Multi-Microscope Malaria Diagnosis device was successfully constructed
- High-quality microscopic images of red blood cells were successfully captured using a Hybrid Microscope and the constructed Raspberry Pi Cameras.
- The rate and efficiency at which numerus images were captured using this device could be extremely advantageous for malaria diagnosis
- With more time, limit switches could have been introduced to the stepper motors. This would lead to a more efficient scanning platform as the positioning of the shaft would be easier to identify.

References

[1] J. T. Collins et al., “Robotic microscopy for everyone: the OpenFlexure microscope,” Biomed Opt Express, vol. 11, no. 5, pp. 2447–2460, Apr. 2020, doi: 10.1364/BOE.385729.,” [Online].

[2] “AI-Powered Microscope Counts Malaria Parasites in Blood Samples,” IEEE Spectrum, Nov. 13, 2017. https://spectrum.ieee.org/aipowered-microscope-counts-malaria-parasites (accessed Feb. 17, 2022).,” [Online].

[3] “https://www.seeedstudio.com/blog/2020/06/18/a-complete-guide-to-help-you-choose-lenses-for-your-raspberry-pi-high-quality-camera-m/,” [Online].