Vision Guided Mosquito Dissection for the Production of Malaria Vaccine

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Project Group 5

Checkpoint Presentation

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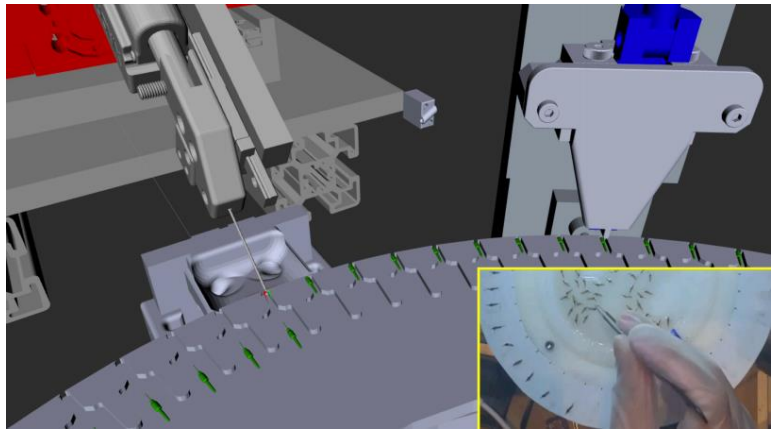
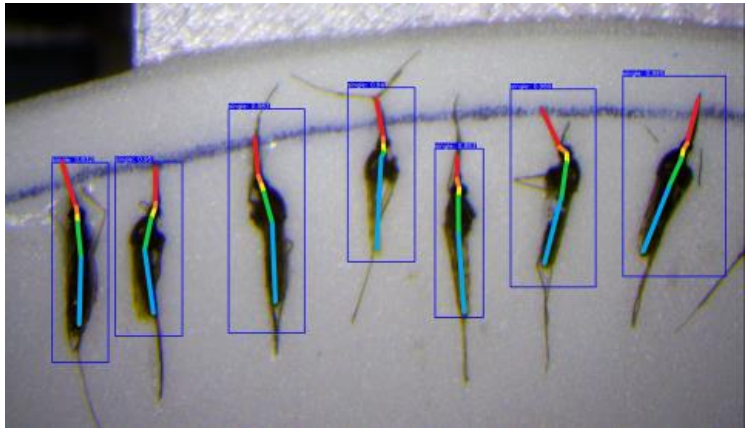
Backgound

image: CNET

- Sanaria has developed practical and effective malaria vaccines which could be critical in the global fight against malaria [2] [3]
- Currently, production of malaria vaccine is heavily bottlenecked by manual extraction of mosquito salivary glands
- Ongoing development of an automated robot system for the mosquito salivary gland extraction

image: JHU





[7] Jongo et al. 2018
[8] Sanaria

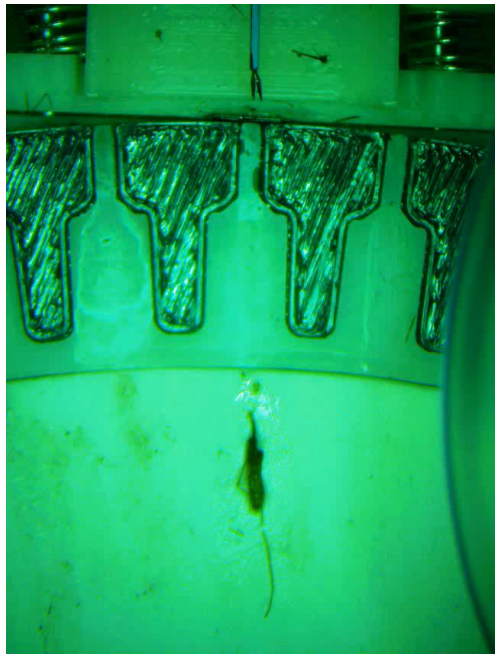
All Images from JHU except where noted

Goals

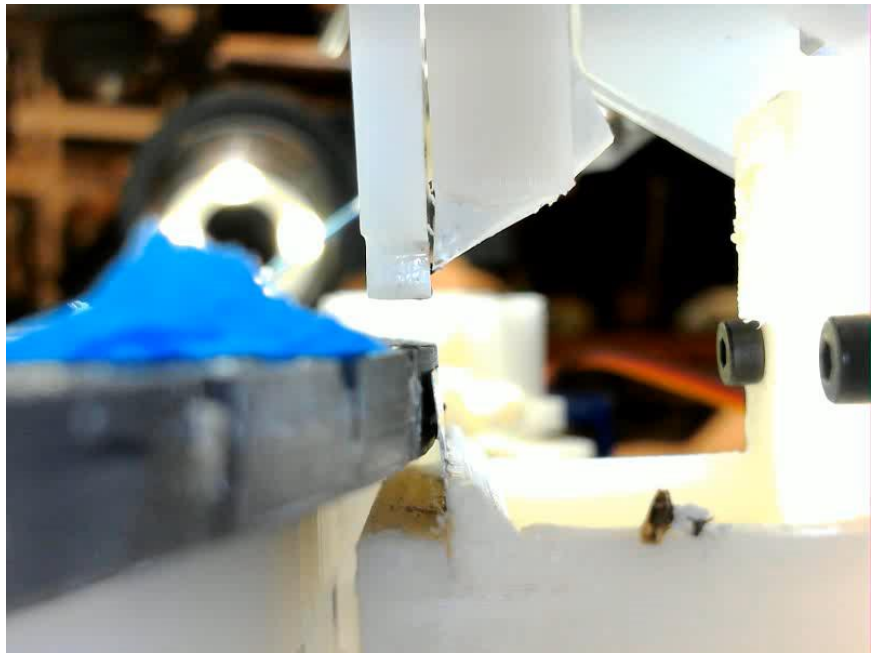
- Implement vision algorithms with both machine learning and conventional image processing:
- Tasks are:
    - Check if turntable cleaning was successful at the cleaning station
    - Check if gripper has mosquito parts stuck to it
    - Estimate the volume of the mosquito extrudate
- Integrate these algorithms with the current system

All Images from JHU except where noted

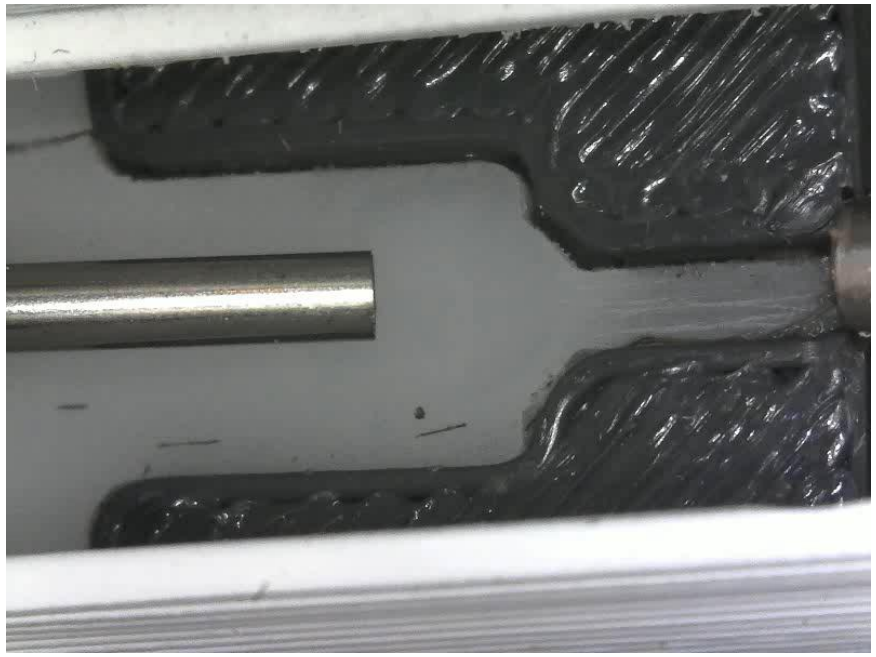
Machine Setup / Demonstration



Cutting Station



Squeezing Station

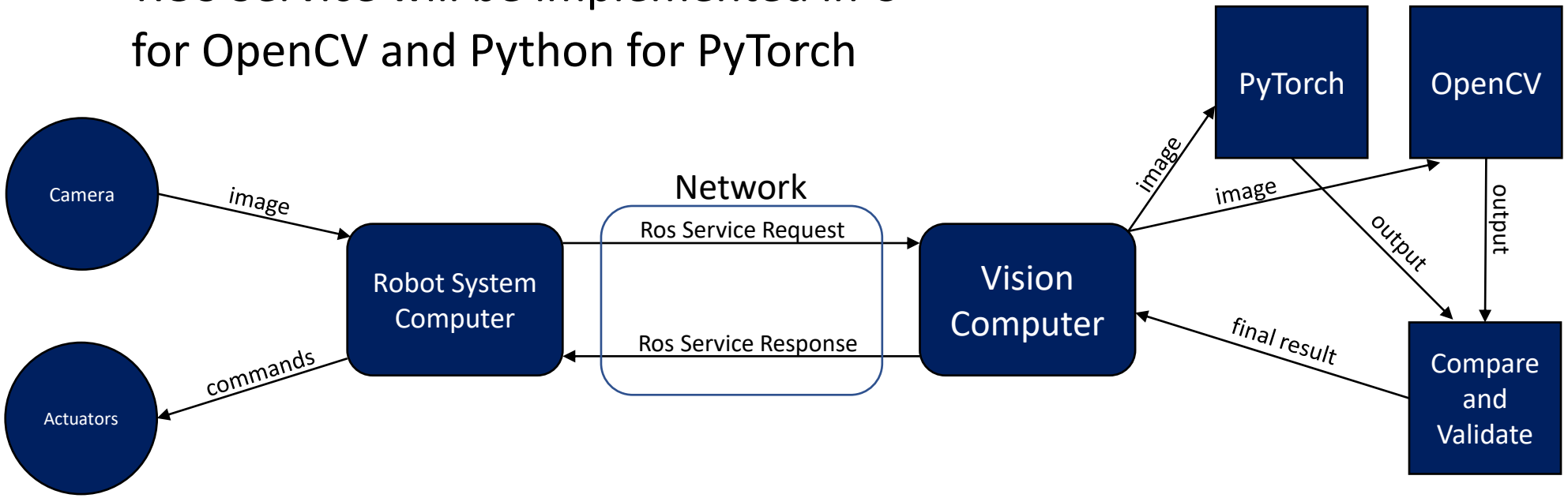


Cleaning Station

All Images from JHU except where noted

System Integration

- The vision algorithms will be integrated with the existing system through the use of ROS Services.
  - ROS Service will be implemented in C++ for OpenCV and Python for PyTorch



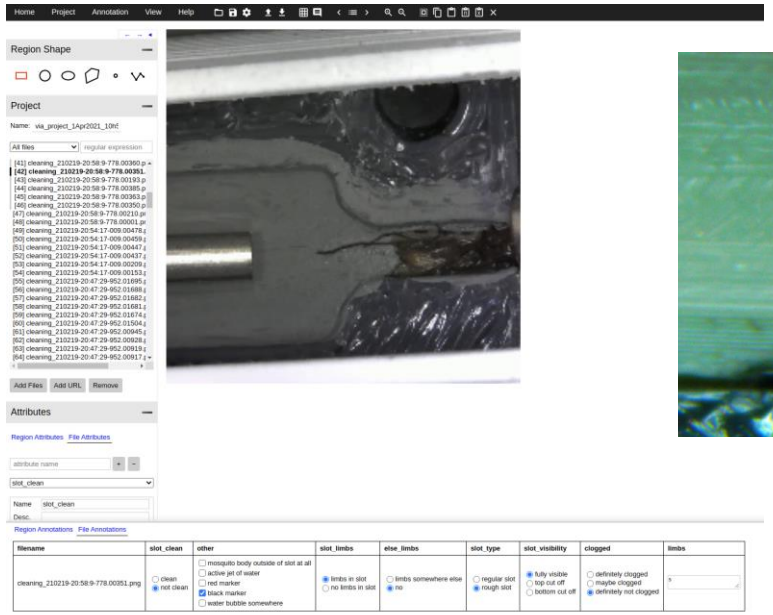
All Images from JHU except where noted

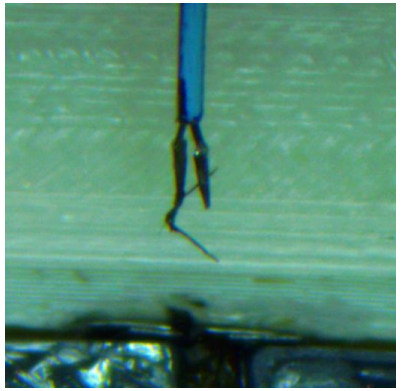
Deliverables

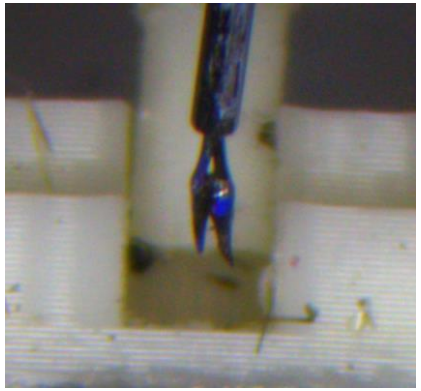
	Activity	Deliverable	Original Expected Deadline	Status	New Deadline
Min	Collect images of cleaning station and annotate	Annotated cleaning station dataset	3/1	Completed (Delayed)	n/a
	Implement image processing method for cleaning station	Functioning image processing based code and high quality documentation in a wiki	3/15	Functional but Missing Documentation	4/5
	Develop and train a neural network on the cleaning station dataset	Trained parameters of a neural network classifier, along with code and high quality documentation in a wiki	3/18	Functional but Missing Documentation	4/5
	Integrate both with the rest of the system using ROS	Working ROS services which can be successfully interfaced with from the robot control computer, and thorough documentation for how to use them in a wiki page	3/22	In Progress	4/7
Expected	Repeat for gripper cleaning	Same deliverables as for turntable cleaning station.	4/7	In Progress	4/14
Max	Discuss with hardware team about collecting exudate data	Plan for collecting exudate ground truth data	4/1	Completed	n/a
	Repeat for exudate volume estimation	Same deliverables as for previous two tasks.	5/1	Won't reach full maximum deliverable in time	5/1

Progress – Dataset

- Cleaning Station Dataset
- All images annotated
  - 293 in total







- Gripper Dataset
  - All images acquired

All Images from JHU except where noted

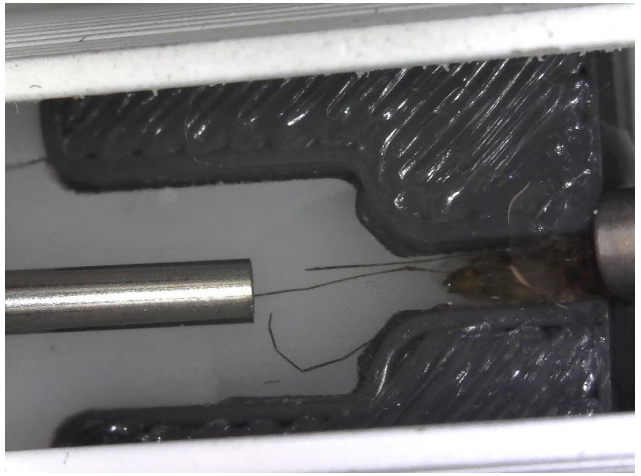
Progress – Image Processing

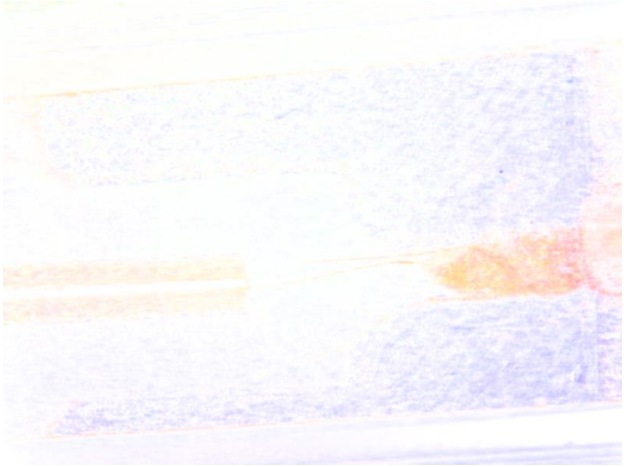
- Image Processing method is 98% accurate on the dataset.
- Mosquitos Segmented by filtering/thresholding
  - Pixel count determines if slot is clean
- Working on a registration method
  - Will improve robustness and accuracy

All Images from JHU except where noted

Segmentation – Image Processing

- Convert Image to HSV color space
- Set value channel to 100%
- Convert back to RGB,
- Threshold by color





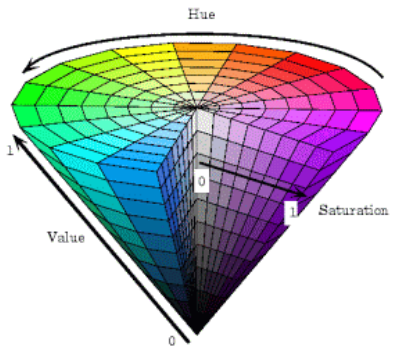
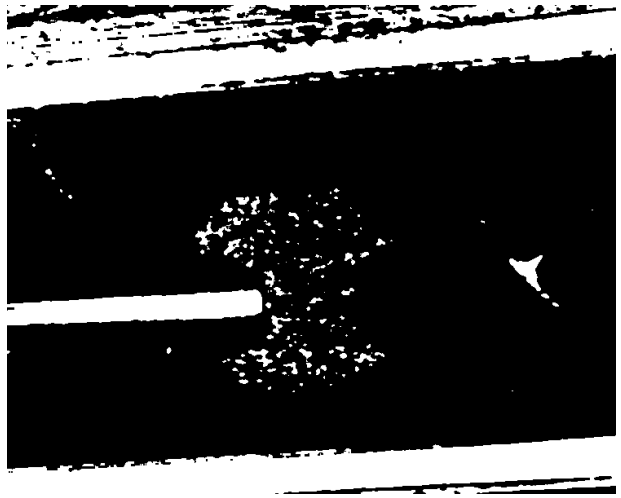


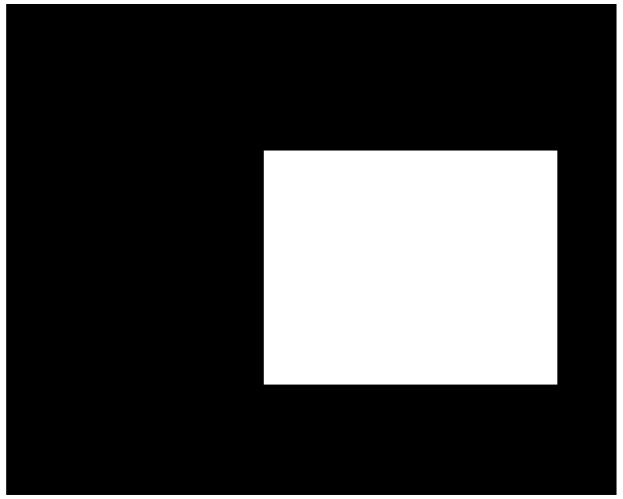
Image Source: http://www.ece.northwestern.edu/

All Images from JHU except where noted

Segmentation – Image Processing

- Perform a brightness threshold and subtract from previous result
  - Remove specular reflections which interfere with the segmentation
- Only consider predefined region of interest
- Gaussian and Median filtering used to clean up the results more





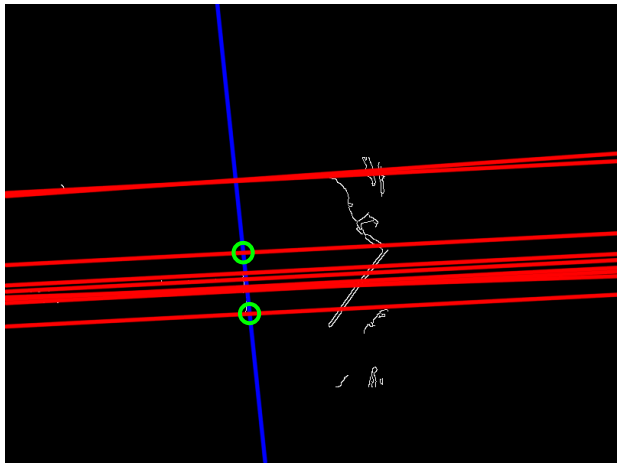
All Images from JHU except where noted

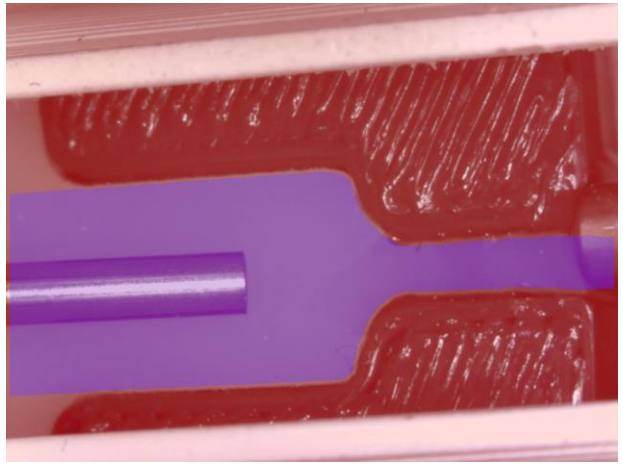
Segmentation Results – Image Processing

All Images from JHU except where noted

More Work – Image Processing

- Camera can move significantly if bumped frame to frame making the region of interest less precise
- Trying to detect features with a Hough Transform to register a more precise mask
- Will wait to finish this because





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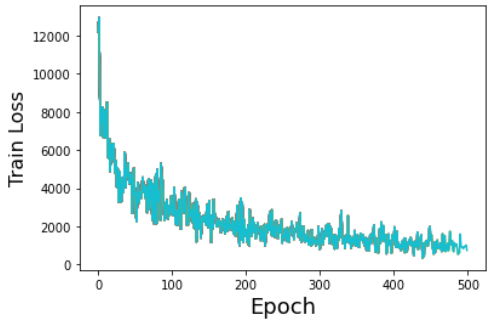
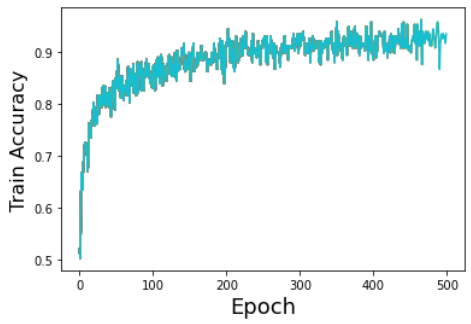
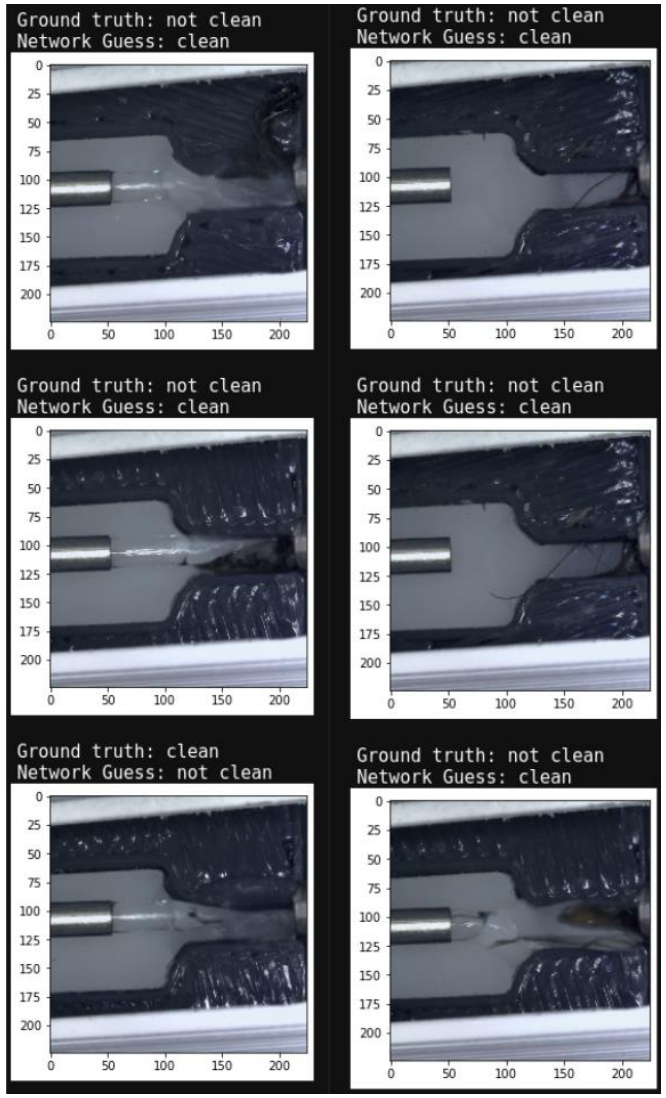
Deep Learning

- Transfer learning with VGG16 pretrained on ImageNet
- 100% accuracy on the Test set
- 97% accurate over entire dataset
- Did poorly when water was present







Network Failures

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Dependencies

Dependency	Need	Contingency Plan	Planned Deadline	Hard Deadline	Status
Continued access to GPU	GPU for training neural network	I have a very capable personal GPU	Ongoing	Ongoing	Currently have access to the Diva computer and personal GPU
Cameras for collection of images of each task need to be mounted and integrated	To collect images for annotation	Use existing but less desirable views from the other existing cameras.	3/14	3/22 (for remaining camera)	Completed
Hardware team	300+ images of turntable cleaning station in progress with mosquitos.	Begin working on the image processing methods for the other tasks while waiting for additional training data collection.	3/1	3/7	Delayed but completed slightly after the hard deadline
Hardware team	300+ images of gripper cleaning in progress with mosquitos.	Small Delay: Begin working "out of order" on the image annotation and image processing for the exudate estimation task Long Delay or Expected Failure: Change from the gripper cleaning task to one of the are many remaining vision tasks	3/14	3/22	Completed
Hardware team	Method for ground truth collection of mosquito exudate volume for training images	Abandon neural network approach and only do image processing for this task	3/15	4/1	Discussion completed however the neural network approach needs to be abandoned

Management

- Weekly Monday meetings with the entire mosquito project team
- Additional meetings as needed with the Vision team (likely approximately weekly)

References

[1] Chandrarathne, G., K. Thanikasalam, and A. Pinidiyaarachchi (2020). A comprehensive study on deep image classification with small datasets. In *Advances in Electronics Engineering*, pp. 93–106. Springer.

[2] He, K., X. Zhang, S. Ren, and J. Sun (2016). Deep residual learning for image recognition. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 770–778.

[3] Hinton, G. E., N. Srivastava, A. Krizhevsky, I. Sutskever, and R. R. Salakhutdinov (2012). Improving neural networks by preventing co-adaptation of feature detectors. *arXiv preprint arXiv:1207.0580*.

[4] Krizhevsky, A., G. Hinton, et al. (2009). Learning multiple layers of features from tiny images.

[5] Simonyan, K. and A. Zisserman (2014). Very deep convolutional networks for large-scale image recognition. *arXiv preprint arXiv:1409.1556*.

[6] WHO, 2019. *World Malaria Report 2017*. Geneva, Switzerland: World Health Organization.

[7] Jongo, Said A., Seif A. Shekalaghe, LW Preston Church, Adam J. Ruben, Tobias Schindler, Isabelle Zenklusen, Tobias Rutishauser et al. "Safety, immunogenicity, and protective efficacy against controlled human malaria infection of Plasmodium falciparum sporozoite vaccine in Tanzanian adults." *The American journal of tropical medicine and hygiene* 99, no. 2 (2018): 338-349.

[8] *Sanaria*, Sanaria.com.