

Mosquito Vision Project Proposal

EN.601.456 Computer Integrated Surgery II
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Mentors: Balazs Vagvolgyi, Dr. Russ Taylor

Background - Malaria

>219 million

Clinical cases¹

435,000 deaths

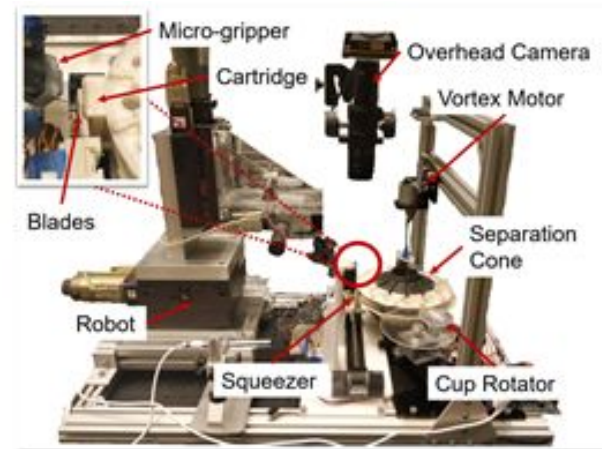
In 2017¹

\$12 billion

Loss annually in Africa¹

Background - Sanaria

- ▷ Development of a live malaria vaccine in mosquitoes
 - 100% protective efficacy against controlled human malaria infection shown in clinical trials¹
- ▷ Extraction of PfSPZ required from mosquitoes
- ▷ Automation of this process can allow for mass manufacturing of the malaria vaccine



Dr Taylor's Slides

¹“Sanaria's Mission.” Sanaria, 2020, sanaria.com/about/.

Background - Proposed Workflow

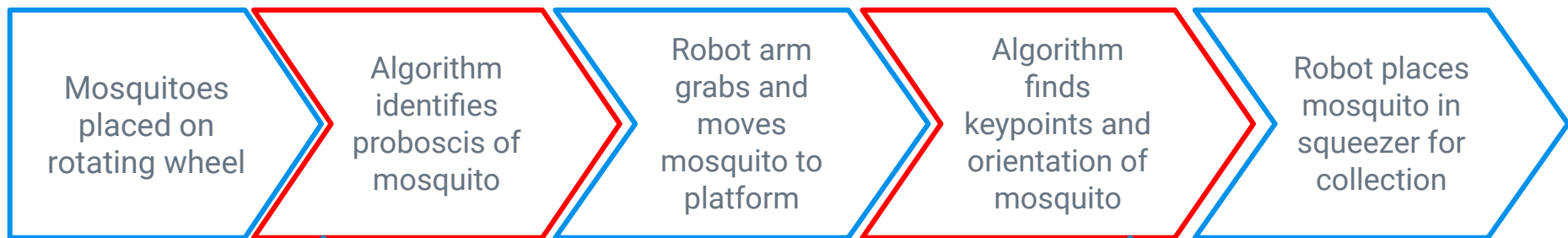


Image Processing

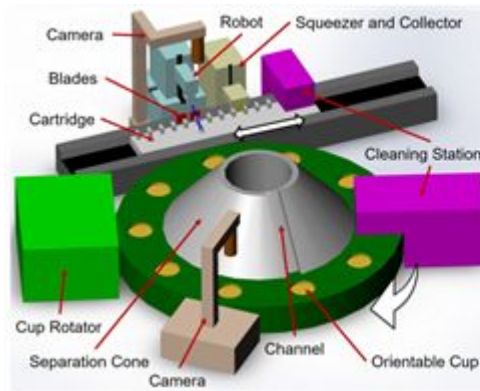


Image Processing
Deep Learning

Past Work

Head/Neck/Proboscis Detection

- ▷ Template matching for head detection
 - ~90% success rate
- ▷ Model-based optimization to find center of neck
 - ~85% success rate
- ▷ Proof of concept for proboscis detection
- ▷ Some integration with ROS

Orientation and Keypoint Detection

- ▷ Logistic network and CNN trained from scratch
 - ~85% accuracy for orientation
- ▷ Previous code for keypoint detection via DL

Goals

Head/Neck/Proboscis Detection

- ▷ Improve accuracy for head & neck detection
- ▷ Flesh out workflow for proboscis detection (pre-processing, outputs, etc.)
- ▷ Document steps of workflow
- ▷ Integration with ROS

Orientation and Keypoint Detection

- ▷ Improve accuracy for orientation determination
- ▷ Create a DL-based system for keypoint detection
- ▷ Thorough documentation of DL techniques and process
- ▷ Integration with ROS

Approach - Head/Neck/Proboscis Detection

- ▷ Model-based (assumption-driven) computer vision methods
 1. Image processing to isolate correct mosquito, error checking
 2. Template matching, model-based optimization for head/neck localization
 3. Identify region for proboscis search
 - a. Hough line detection for proboscis
 4. Search along proboscis for endpoints
 5. Integration with ROS

Approach - Orientation

- ▷ Texture differences, image processing not possible
- 1. Image processing/cleanup
- 2. Training neural network to classify orientation via PyTorch
 - a. Training a network from scratch
 - i. CNN, fully connected layers
 - b. Transfer learning - pretrained models
 - i. Obtain pretrained models online (from PyTorch)
 - ii. Fine-tune parameters using our training data
- 3. Inference algorithm from image input
- 4. Integration with ROS

Approach - Keypoint Detection - DL

- ▷ Comparison with image processing approach
- 1. Image processing/cleanup, labeling
- 2. Training NN for bounding box detection
 - a. Transfer learning via Mask-RCNN
- 3. Training NN for keypoint detection
 - a. Transfer learning via DeepLabCut
- 4. Integration of bounding box detection with keypoint detection
- 5. Integration with ROS

Deliverables

Minimum

- Documentation of DL algorithms and usage
- Working algorithm on orientation detection
- Framework for training DL algorithm on keypoint detection
- Library for head/neck/proboscis detection

Expected

- Integration of DL model with ROS for real-time classification & detection
- Integration of head/neck/proboscis detection workflow in library
- ROS integration of head/neck/proboscis detection

Maximum

- Creation of library to streamline process of training mosquito keypoint detection
- Fully validated libraries using mosquitos & robot system

Timeline/Critical Milestones

	Milestone	Deadline	Person responsible
1	Environment set up for Deep Learning	02/14/2020	Alan
2	$\geq 95\%$ success rate for orientation detection w/documentation	02/28/2020	Alan
3	$\geq 95\%$ success rate for head & neck localization within 10 pixels	02/28/2020	Akash + Parth
4	$\geq 95\%$ success rate for bounding box detection	03/16/2020	Alan
5	Full implementation of proboscis detection workflow	03/16/2020	Akash + Parth
6	$\geq 90\%$ success rate for keypoint detection within 5 pixels w/documentation	04/15/2020	Alan
7	≥ 95 success rate of proboscis detection within 5 pixels w/documentation	04/15/2020	Akash + Parth
8	Integration with robotic system (ROS)	4/20/2020	All
9	Library creation with full documentation	4/27/2020	All
10	Full system validation with mosquitos & robot system	4/30/2020	All

Dependencies

	Dependency	Solution	Alternative	Progress/ Deadline
1	Mosquito images for image processing	Manually capture images in lab (other lab members)	Manually capture images in lab (self); use old images	Solved
2	Mosquito images for DL (+2000)	Image files present in lab computers	Collection of more images in lab	Solved
3	Computational resources	Lab computer (NVIDIA Titan Xp)	CS Ugrad Servers, Personal Computer	In Progress 2020/02/14
4	Libraries (OpenCV, Pytorch, DL Models)	Free online access/open source	N/A	Solved
5	Integration with robotic system (ROS)	Work with Balazs	Get help from Dr. Simon Leonard	In Progress 2020/03/01
6	Feedback from Mentors	Lab meetings	N/A	Solved
7	Support for robot system validation	Lab group members	N/A	Solved

Team Management

- ▷ Communication
 - Instant messaging services, email
- ▷ Feedback
 - Weekly meetings with mentor (Balazs)
 - Weekly lab meetings for feedback on progress
- ▷ Version Control
 - Code will be on a github repository