Group 03:

Robot System Control for Automating Mosquito Microdissection

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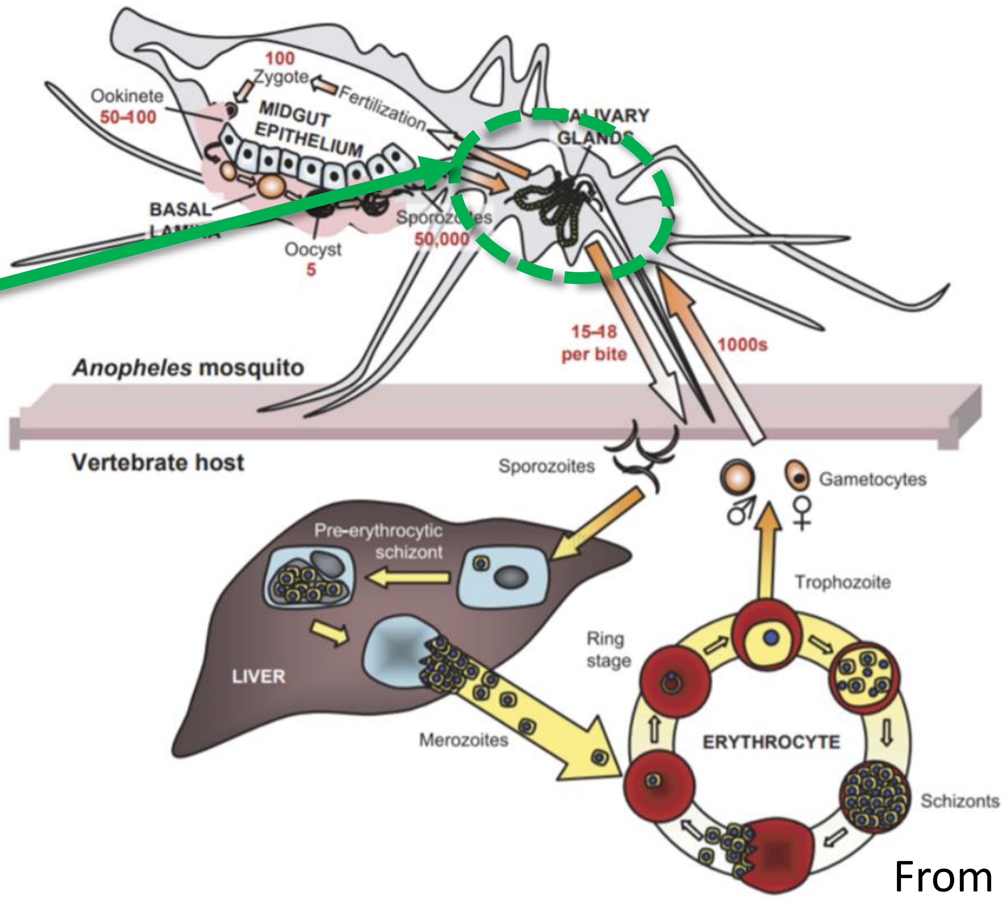
***The information in this presentation is strictly confidential*

Project Background

- Malaria is a parasite responsible for a global disease (228 million infected; 405,000 deaths in 2018) [5]
  - Malaria sporozoites resides in the salivary glands of mosquitoes right before transmission.
  - Current efforts to curb its spread (insecticides and antibiotics) are being undermined by resistant strains of mosquitoes and malaria.
- Sanaria's vaccine has proven to be highly effective with long-lasting protective effects against malaria. [6]
  - Large scale production has challenges.

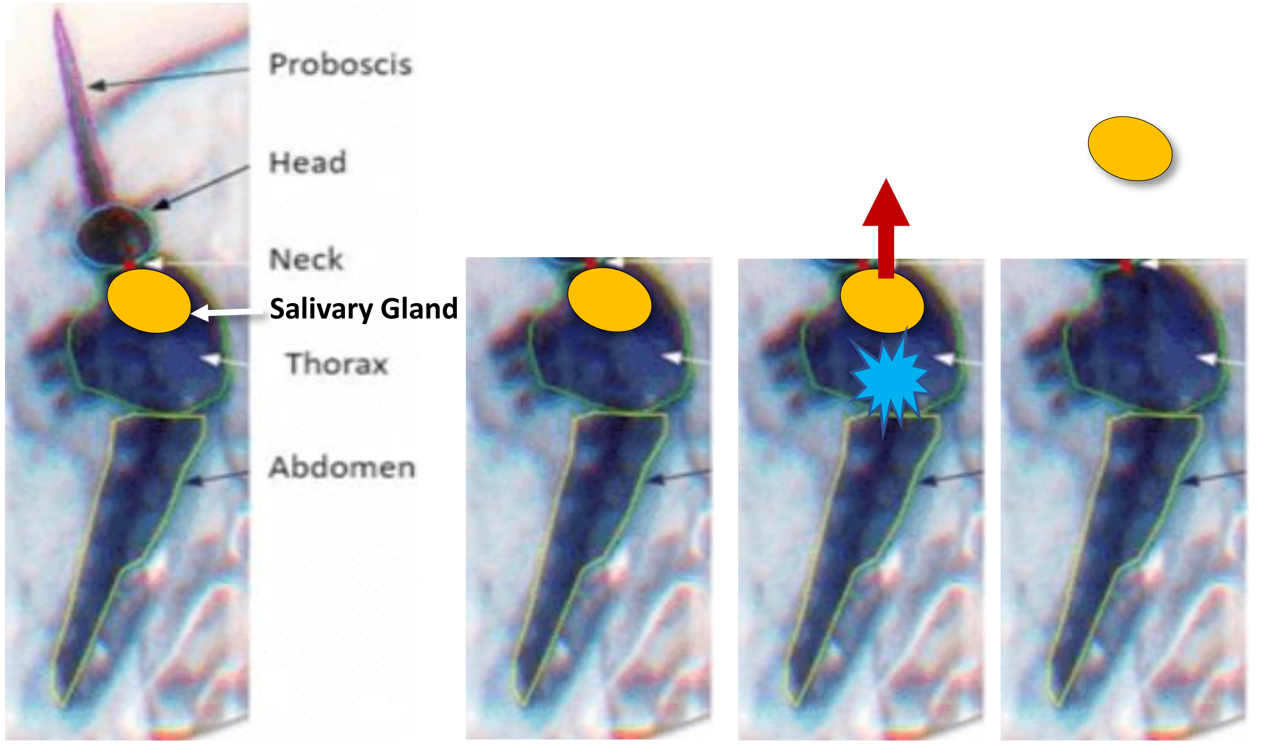


From [3]

Problem Statement

- Salivary gland extraction is the greatest bottlenecks facing large scale production of the Sanaria vaccine. (Currently performed manually)

- Manual Gland Extraction Steps: [1]
    1. Remove mosquito head using edge of hypodermic needle as knife.
    2. Squeeze thorax to extrude salivary gland.
    3. Separate and collect the salivary gland.



Before Step 1 Step 1 Step 2 Step 3

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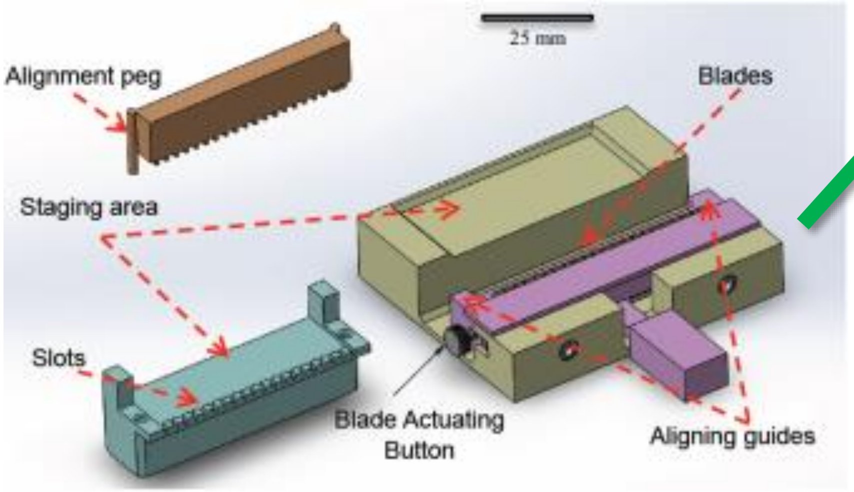
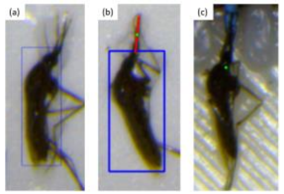
Prior Work

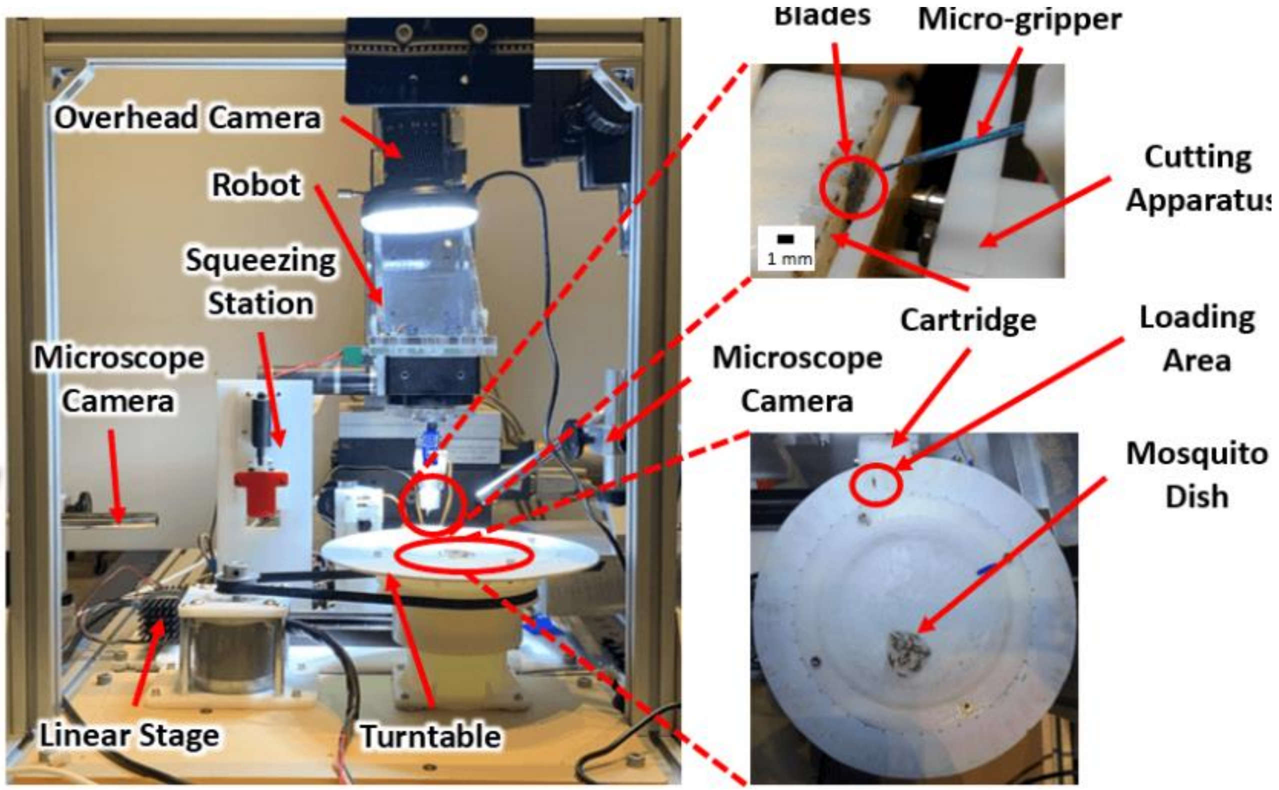
- Work at JHU to improve extraction efficiency:
    1. M. Schrum, A Canezin et al. (Mar 2019) [3]
    2. H. Phalen, P. Vagdargi et al. (Apr 2020) [2]
    3. W. Li, Z. He et al. (under review for ICRA21)



Work 1: sAMMS (2019)

Work 2, 3 (2020-21)





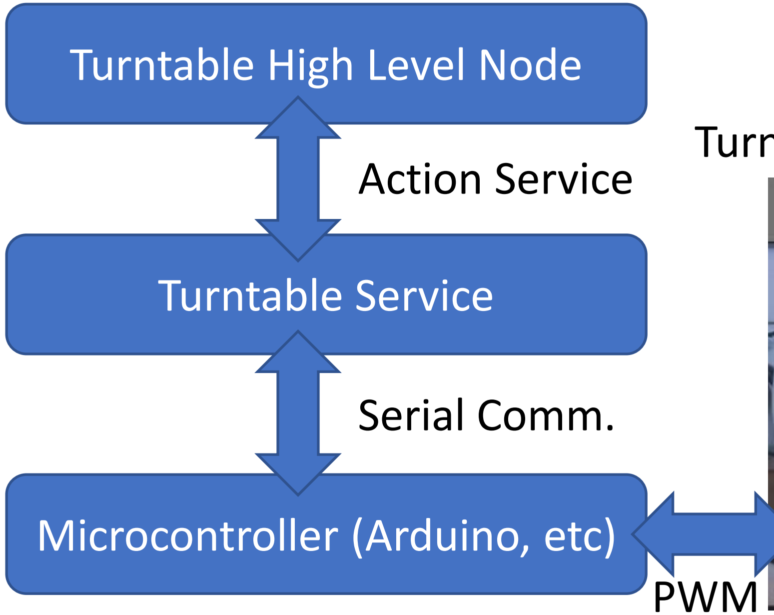
Action	Time	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57
Pick & Move	6																			
Place & Cut	3																			
Home Robot	1																			
Move under Squeezer	20																			
Gland extrusion	3																			
Home cartridge	27																			

My Goal

- Develop a second generation robot system controller that introduces parallel processes, error checking, and error recovery.
- Connect and control new components developed by the mechanical and computer vision teams.
- Test control system and quantify mosquito throughput, error rate, and recovery rate.

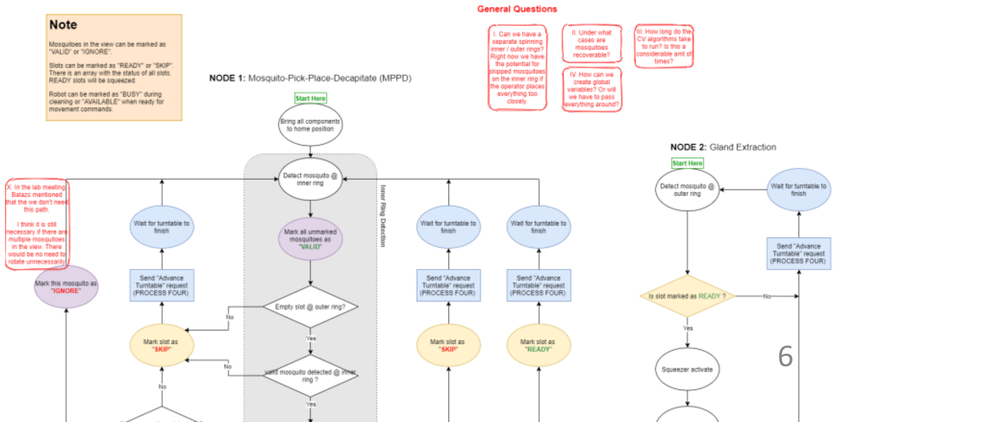
Technologies

- **ROS Nodes** – Independent live modules that are able to send/receive messages and execute procedures.
- **Action Services** – an extension to the traditional ROS msg that allow for live updates between caller and callee nodes.
- **Client-Server Model** -



Turntable & Stepper & Driver

- **Flowchart**
  - 5 parallel High Level nodes
  - Baked in error recovery



Deliverables

	a. Minimum Deliverable	b. Expected Deliverable	c. Maximum Deliverable
1. The Basics	Fully debugged, well documented controller; Create five independent nodes to call services to execute flowchart steps.	Create advanced figures and documentation in the README files and wiki.	Future-proof the system by writing highly generalizable and inheritable code. Create abstract objects, etc.
2. Error & Recovery	Implement the errors & recovery shown in the flowchart. Define / document other errors.		Work with CV team to implement further error handling; one example is dragging detection. Another is ensuring neck is between blades.
3. Integration	Controller operates on the new hardware / setup. Focusing on using placeholders instead of Low-Level Arduino/Galil control.	Write Arduino/Galil code for low level control of hardware. Create working services for the physical robot.	
4. Testing	Visual testing using the simulation	Testing on select hardware on the physical system.	Quantitative testing on the physical system to determine success rate.

Proposed Timeline

	a. Minimum Deliverable	b. Expected Deliverable	c. Maximum Deliverable
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	Jan		Feb				Mar					Apr				May				
	18	25	1	8	15	22	1	8	15	22	29	5	12	19	26	3	10	17	24	31
The Basics																				
CISII Project Approval																				
Understand Existing Code																				
Implement Turntable (Node 4)																				
Implement MPPD (Node 1)																				
Implement Gland Extractor (Node 2)																				
Implement Cleaners (Nodes 4, 5)									1a											
Improve documentation														1b						
Error & Recovery																				
Implement Error Recovery											2a									
Testing																				
Simulation Testing									4a											
Physical Testing												3a	4b		4c					

Dependencies

- Development schedule of hardware and computer vision teams. The efficiency will depend on this as well.
  - Solution: Create placeholder (dummy) nodes for missing components.

Roles and Management Plan

- Zhuohong (Zooey) He – Sole Team Member
- Dr. Simon Leonard – Primary Mentor
- Dr. Russell Taylor – Secondary Mentor

Meeting Schedule

- Meeting with Mentor – Fridays
- Lab Meeting (all mentor, partners) - Mondays

Reading List

[1] H. Phalen, P. Vagdargi, M. Schrum, S. Chakravarty, A. Canezin, M. Pozin, S. Coemert, I. Iordachita, S. Hoffman, G. Chirikjian, and R. Taylor, "A mosquito pick-and-place system for pfspz-based malaria vaccine production," *IEEE Transactions on Automation Science and Engineering*, 2020, issn:1545-5955, doi:10.1109/TASE.2020.2992131.

[2] H. Phalen, P. Vagdargi, M. Pozin, S. Chakravarty, G. S. Chirikjian, I. Iordachita, and R. H. Taylor, "Mosquito pick-and-place: Automating a key step in pfspz-based malaria vaccine production," in *2019 IEEE 15th International Conference on Automation Science and Engineering (CASE)*, 2019, pp. 12–17.

[3] M. Schrum, A. Canezin, S. Chakravarty, M. Laskowski, S. Comert, Y. Sevimli, G. S. Chirikjian, S. L. Hoffman, and R. H. Taylor, "An efficient production process for extracting salivary glands from mosquitoes," 2019, arXiv:1903.02532 [q-bio.QM]. [Online]. Available: https://arxiv.org/abs/1903.02532

[4] R. H. Taylor, A. Canezin, M. Schram, I. Iordachita, G. Chirikjian, M. Laskowski, S. Chakravarty, and S. Hoffman, "Mosquito Salivary Gland Extraction Device and Methods of Use," Patent 20 170 355 951, December, 2017. [Online]. Available: https://www.freepatentsonline.com/y2017/0355951.html

Additional References

[5] World Health Organization, “World malaria report 2019,” Dec 2019. [Online]. Available: https://www.who.int/publications-detail/worldmalaria-report-2019

[6] B. Mordmuller, G. Surat, H. Lagler, S. Chakravarty, A. S. Ishizuka, ¨ A. Lalremruata, M. Gmeiner, J. J. Campo, M. Esen, A. J. Ruben, J. Held, C. L. Calle, J. B. Mengue, T. Gebru, J. Iba´nez, ˜ M. Sulyok, E. R. James, P. F. Billingsley, K. C. Natasha, A. Manoj, T. Murshedkar, A. Gunasekera, A. G. Eappen, T. Li, R. E. Stafford, M. Li, P. L. Felgner, R. A. Seder, T. L. Richie, B. K. L. Sim, S. L. Hoffman, and P. G. Kremsner, “Sterile protection against human malaria by chemoattenuated PfSPZ vaccine,” Nature, vol. 542, no. 7642, pp. 445–449, Feb 2017. [Online]. Available: https://doi.org/10.1038/nature21060

Thank You