

# **Automatic Calibration of Mosquito Dissection System for the Production of Malaria Vaccine**

## **Background Reading Presentation**

Team members: Miles Liu

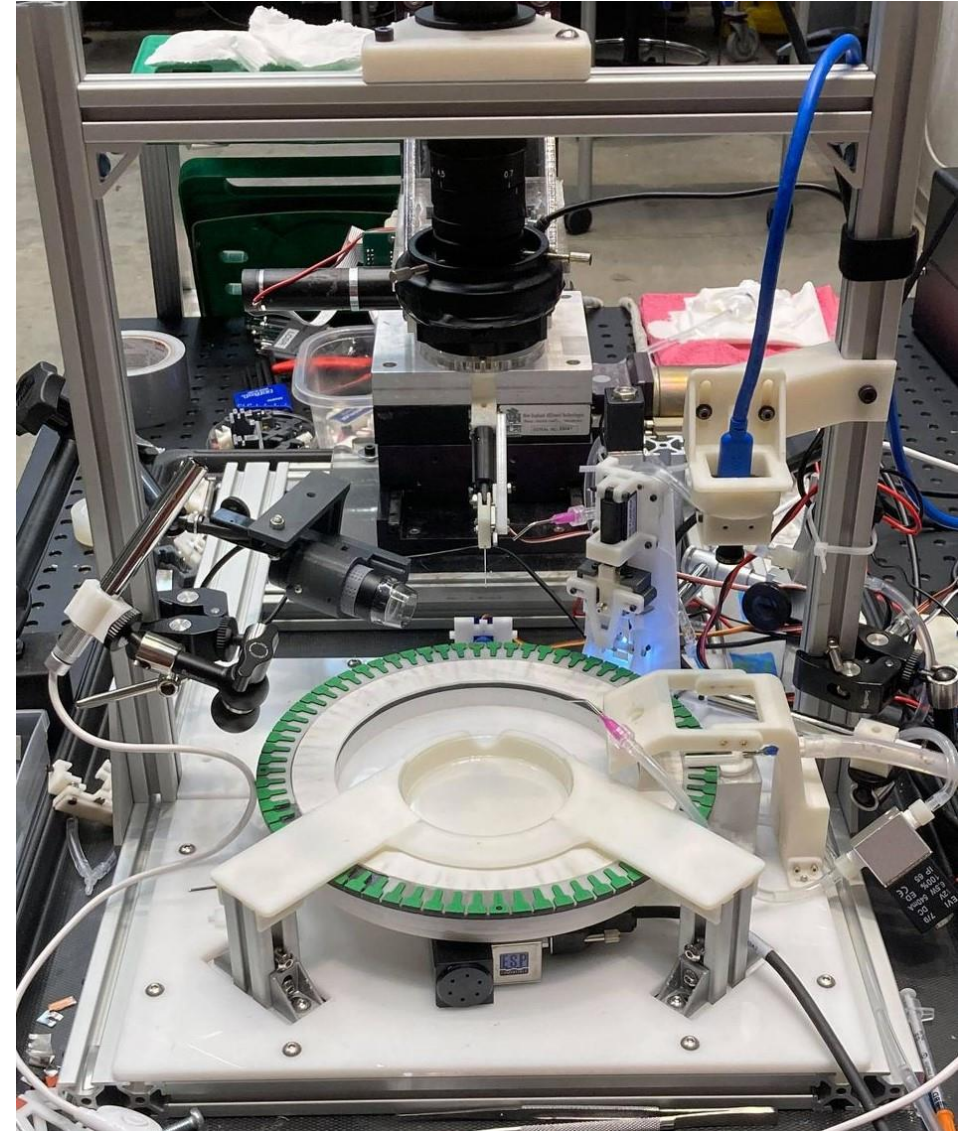
Mentors: Balazs Vagvolgyi, Anna Goodridge

03/08/2022

Computer Integrated Surgery II

# Project Summary

- Part of a larger project to develop a robot platform to automate mosquito salivary gland extraction for malaria vaccine production
- Robot requires frequent, high precision calibrations to perform accurate mosquito microdissection
  - Handeye
  - Workspace definition
  - Robot homing
- **Goal:** Streamline robot calibration routines



# Paper Selection

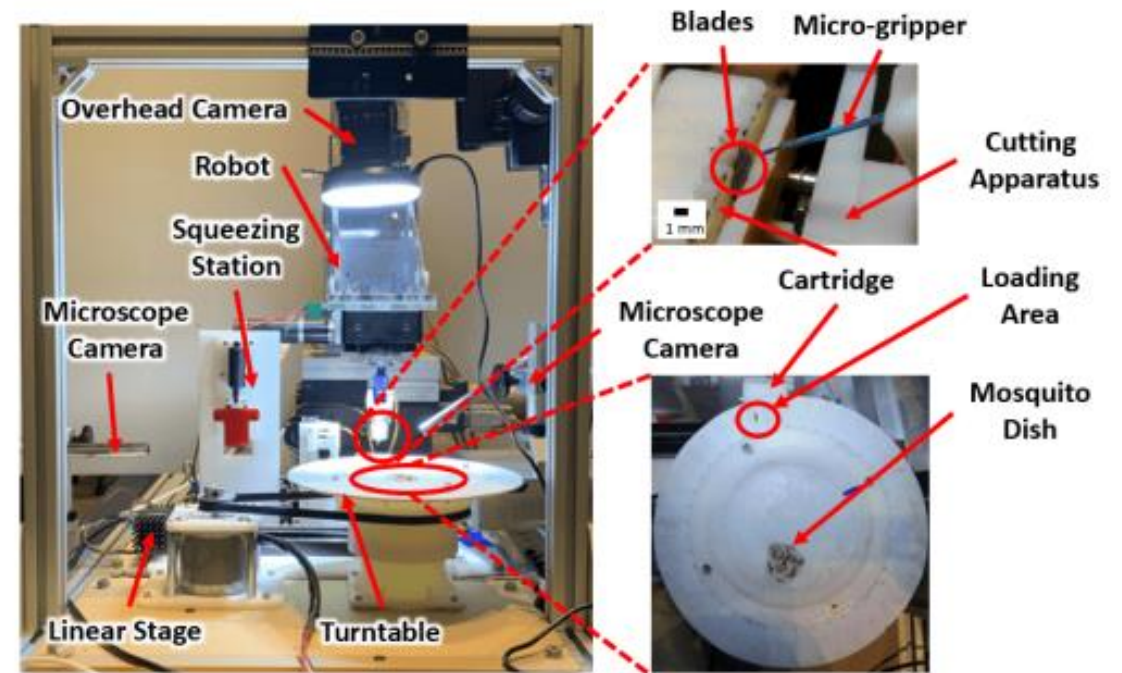
## Automated Mosquito Salivary Gland Extractor for PfSPZ-based Malaria Vaccine Production

Wanze Li<sup>1</sup>, Zhuohong He<sup>1</sup>, Parth Vora<sup>1</sup>, Yanzhou Wang<sup>1</sup>, Balazs Vagvolgyi<sup>1</sup>, Simon Leonard<sup>1</sup>, Anna Goodridge<sup>1</sup>, Iulian Iordachita<sup>1</sup>, Stephen L. Hoffman<sup>2</sup>, Sumana Chakravarty<sup>2</sup>, Russell H. Taylor<sup>1</sup>

- Published in August 2021
- Presented at the 2021 International Conference on Robotics and Automation (ICRA)
- **Summary** - Robot platform's development progress and the prototype system's performance
- **Relevance** - In depth understanding of the system can help inform development of calibration procedure
  - Many processes described in the paper are still in use

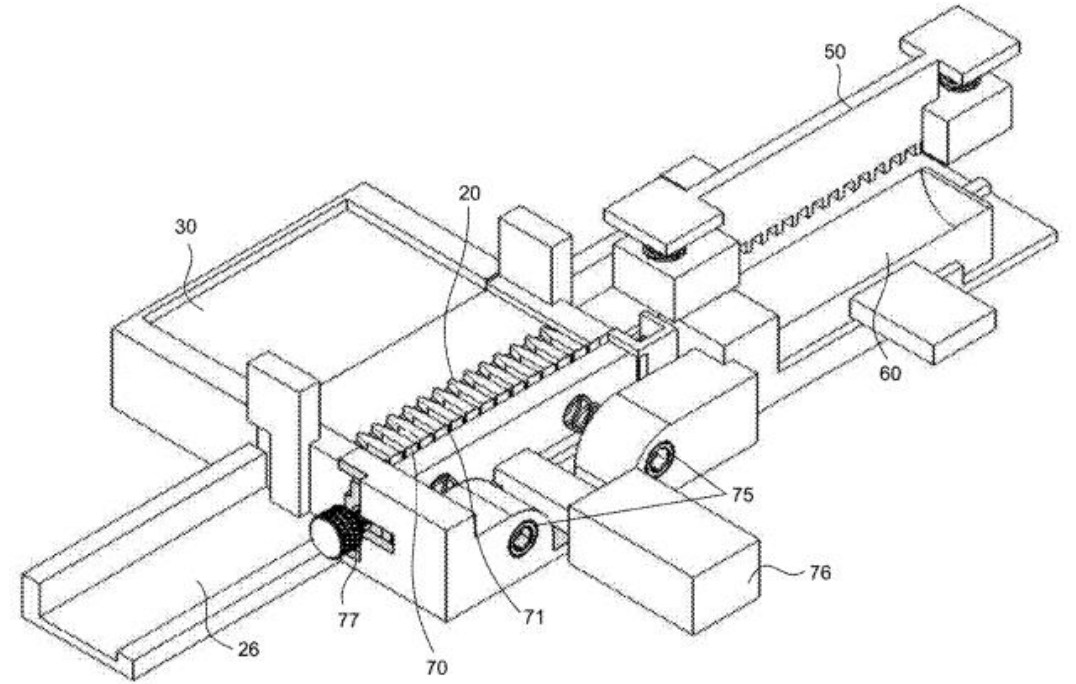
# Problem Summary - Paper

- Main objectives for the developed procedure:
  - More autonomous approach than previous prototypes
  - Maintain high success rates for mosquito manipulation and gland extraction
  - Increase throughput



# Previous Work

- A semi-autonomous mosquito micro-dissection system (sAMMS) was built to streamline mosquito dissection process.
- A manually operated mechanical device that still required specific training and operator skill
- The system described in the paper builds from this workflow, and aims to make the procedure more autonomous



# System Description

Three major components

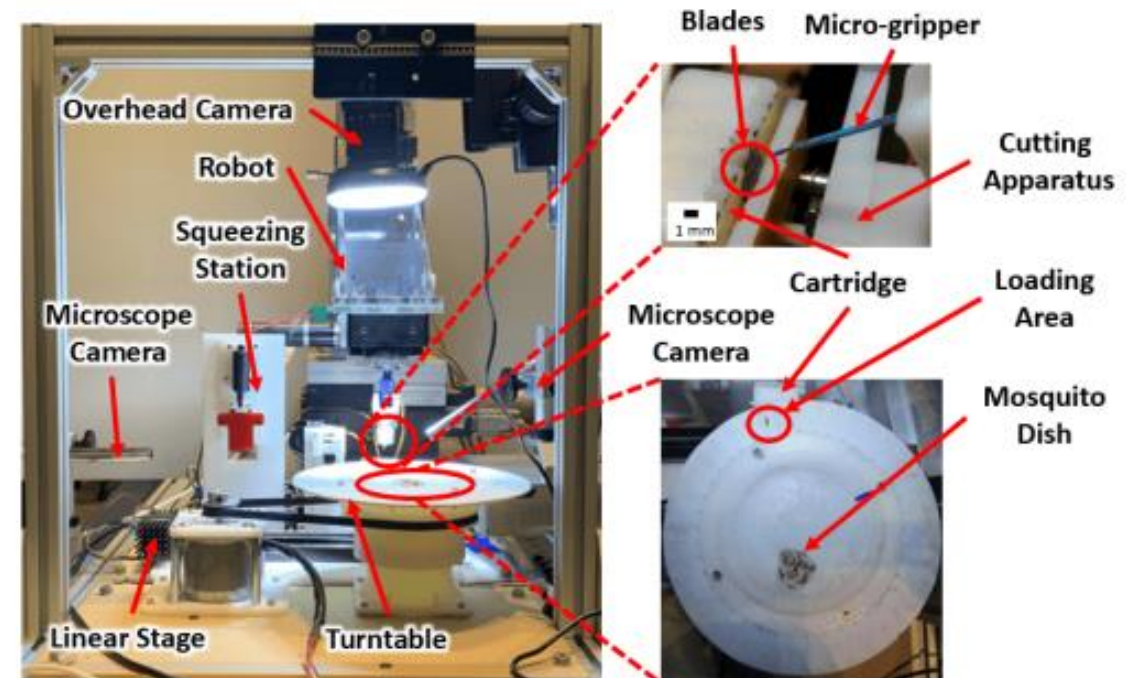
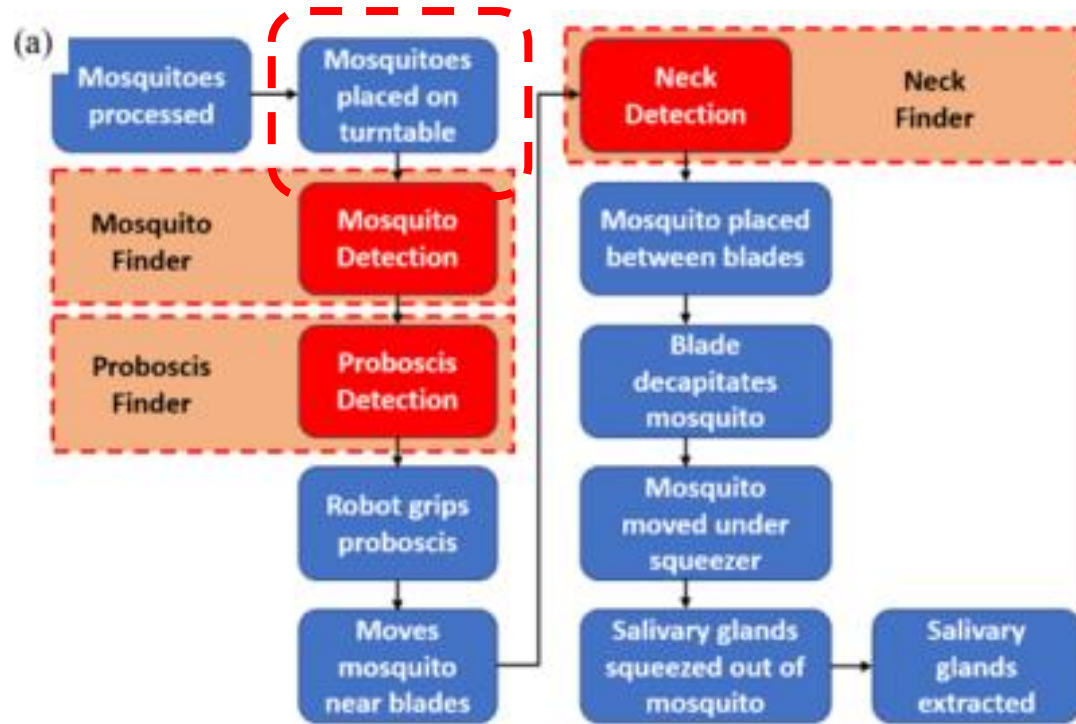
1. Process workflow and physical hardware for transporting, manipulating, dissecting of mosquitos. + extraction of exposed salivary glands
2. Computer vision components used to identify key mosquito anatomic features
3. ROS-based modular software architecture + robot simulation

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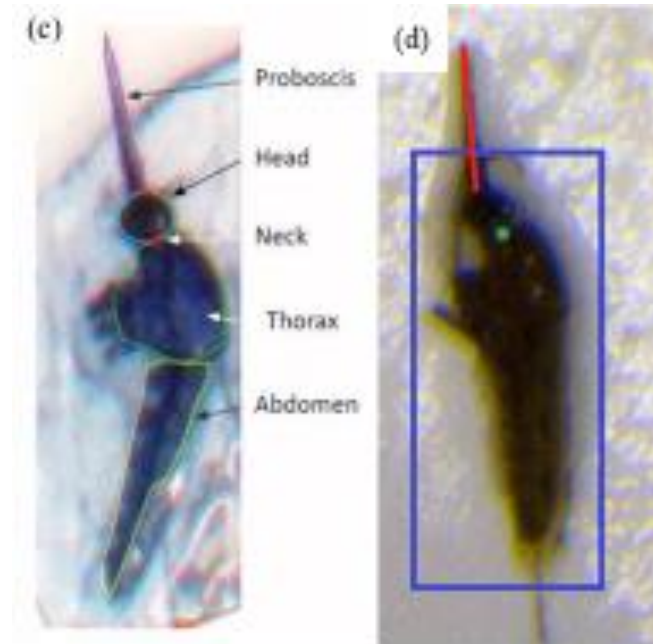
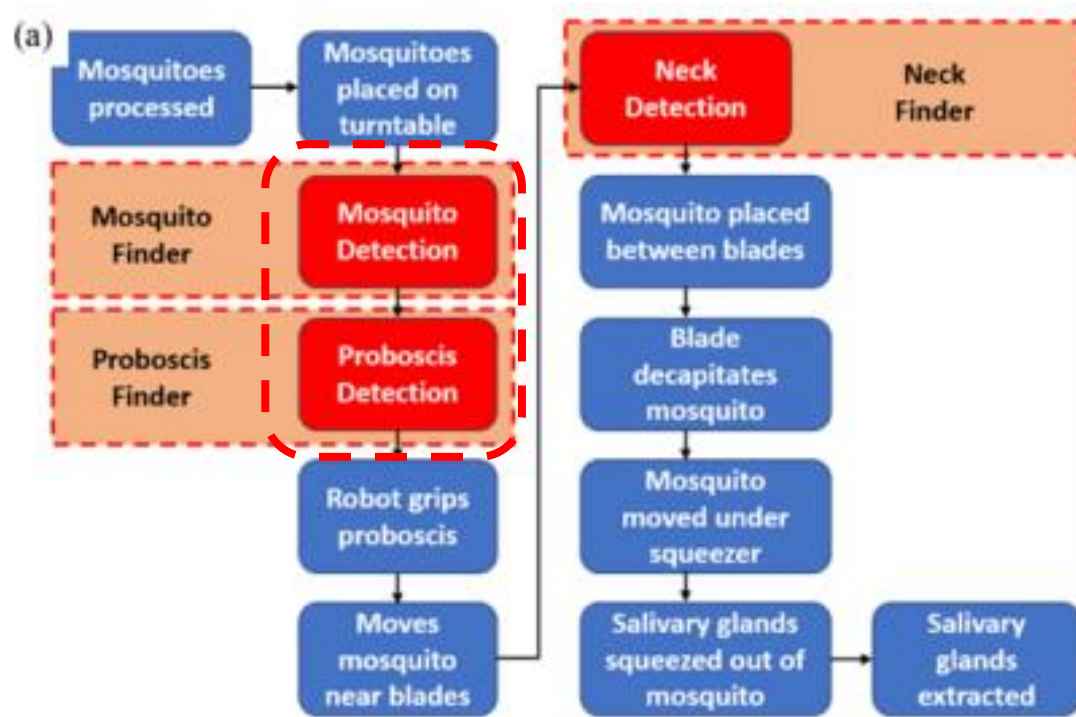
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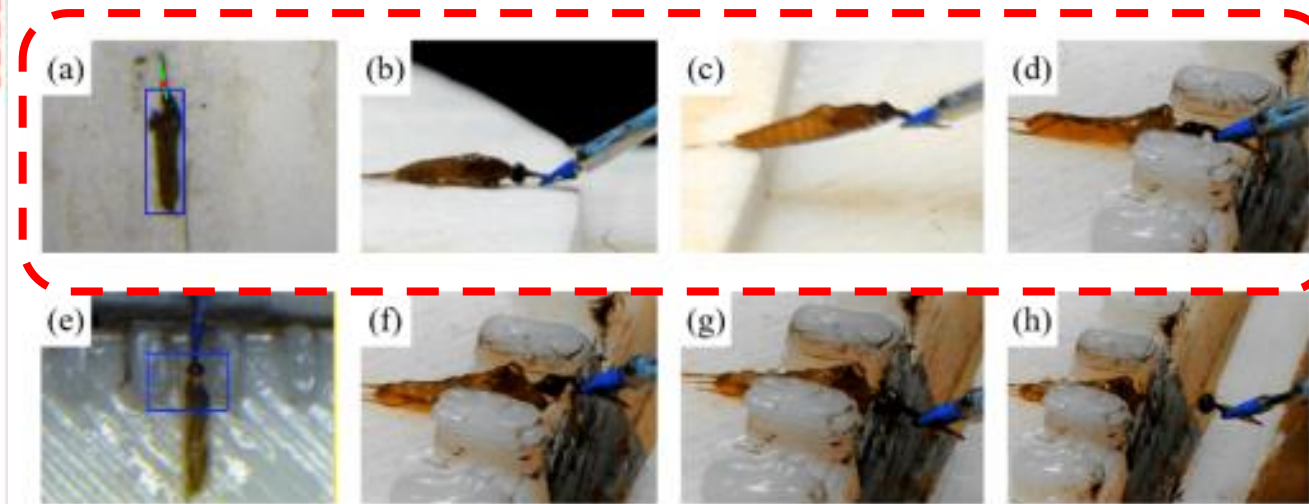
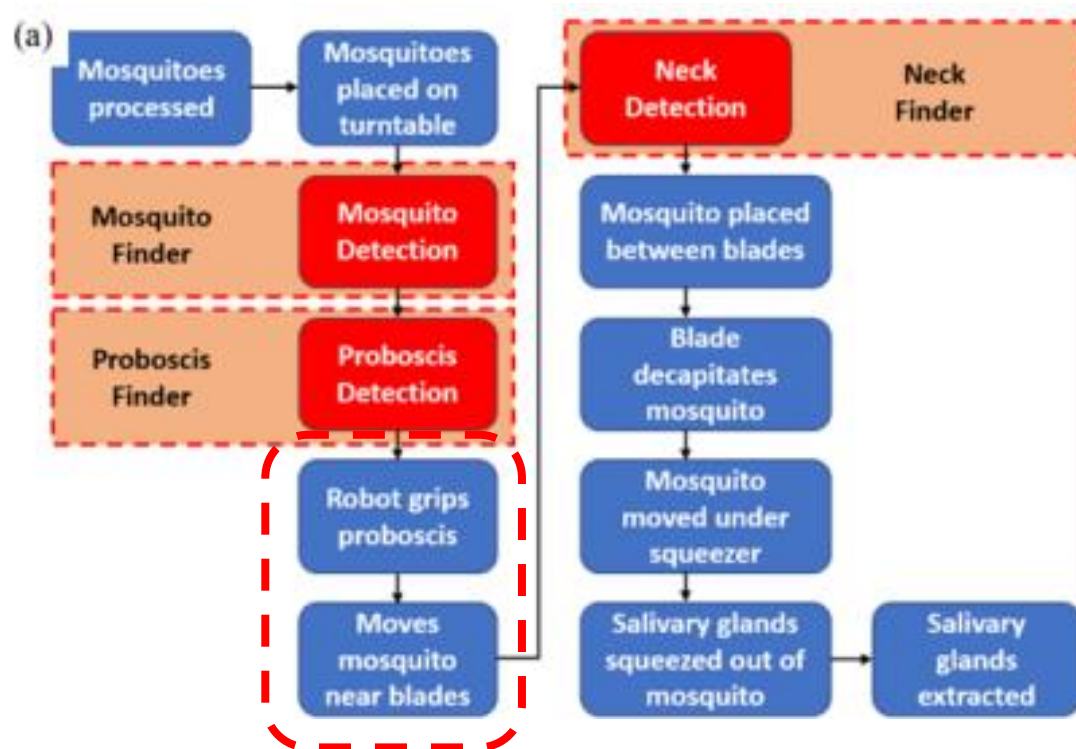
# System Description – Process Workflow



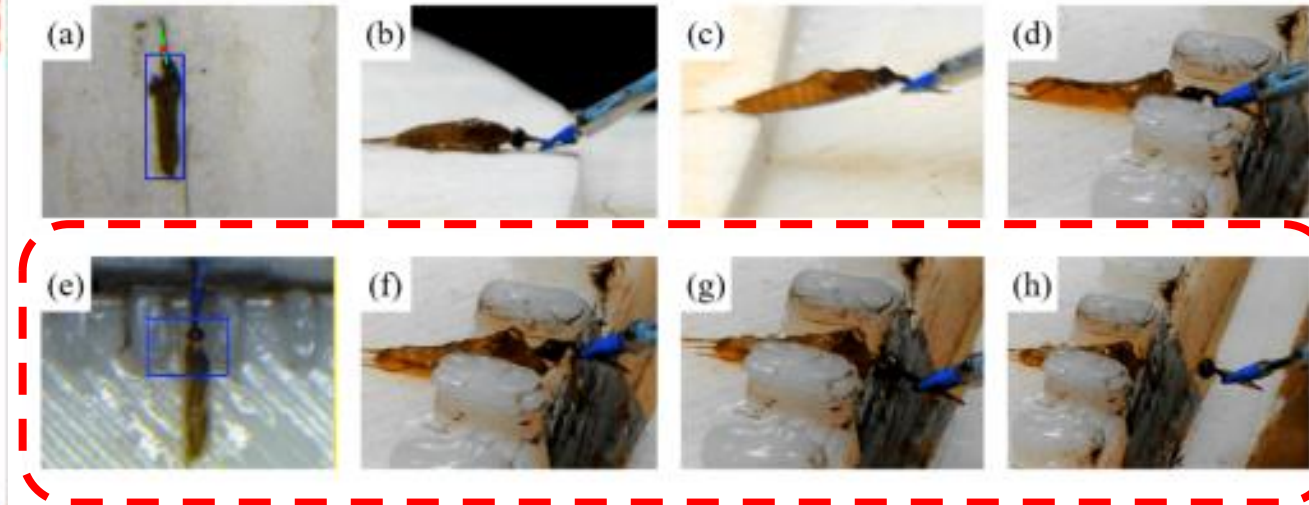
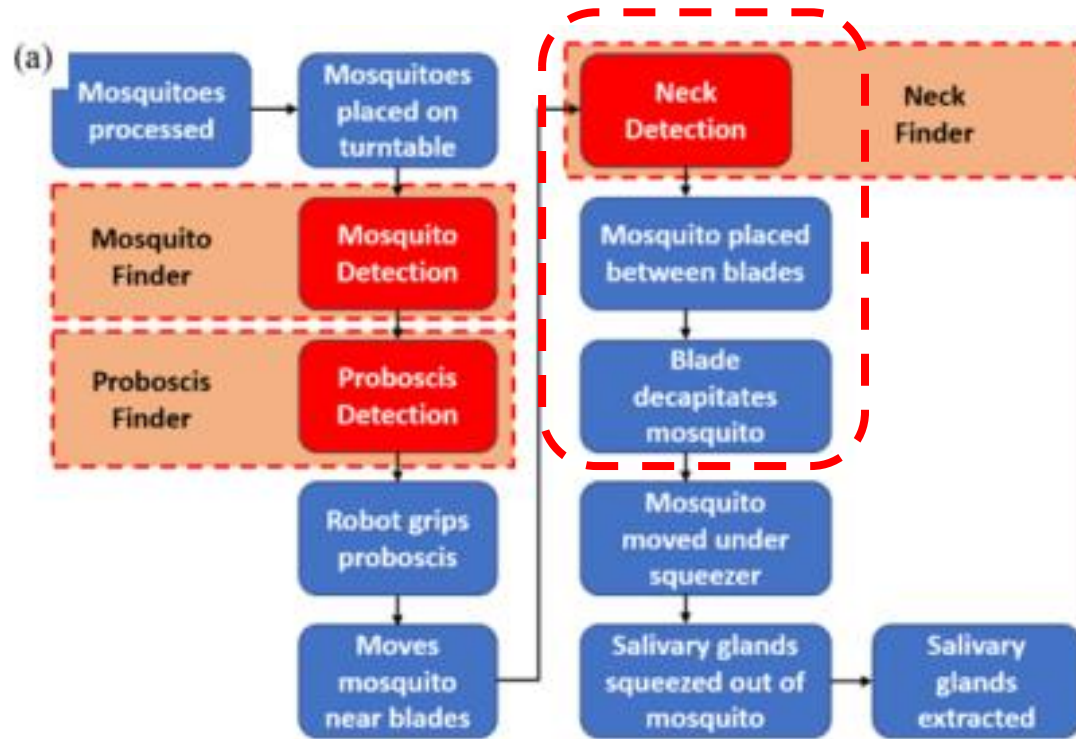
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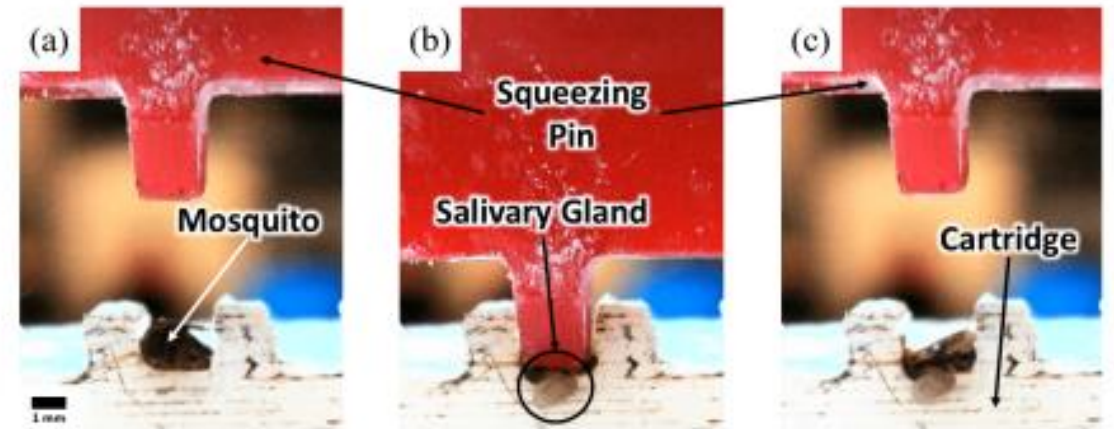
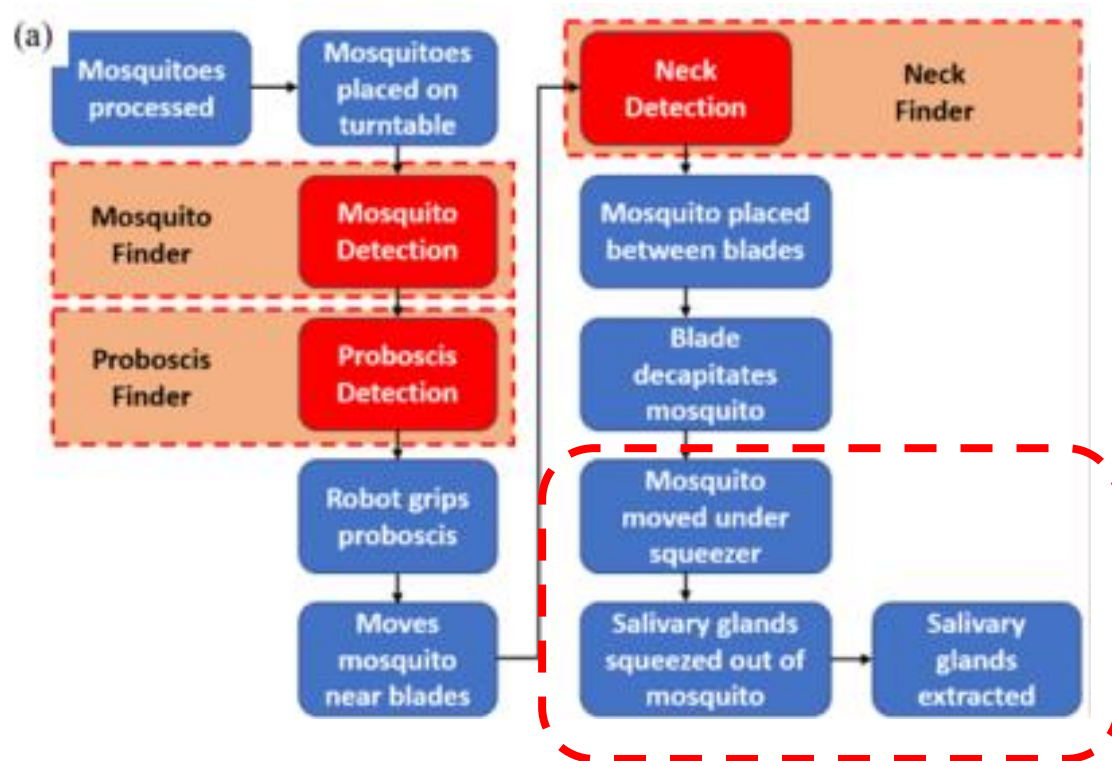
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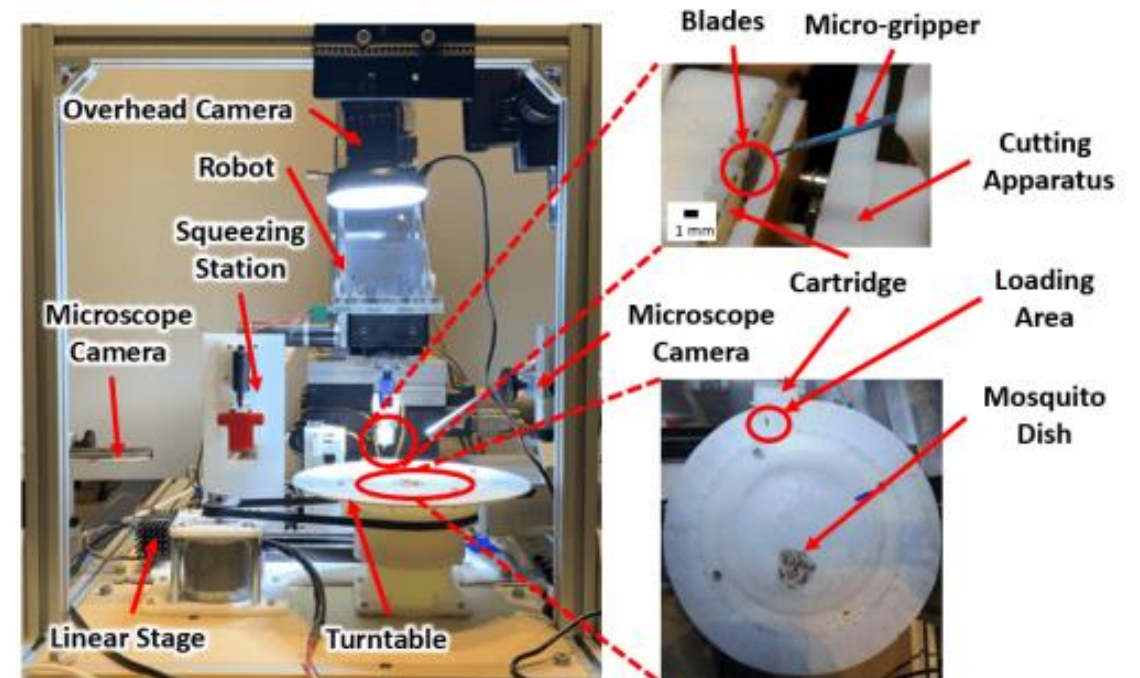


# System Description – Process Workflow



# System Description – Hardware

- Apparatus consists of mostly 3D printed parts
- Rotating turntable and 3DoF prismatic robot controlled by Galil motor controller
- Actuator mechanisms controlled by Arduino Microcontroller
  - Gripper
  - Squeezing pin
  - Blades used for decapitation



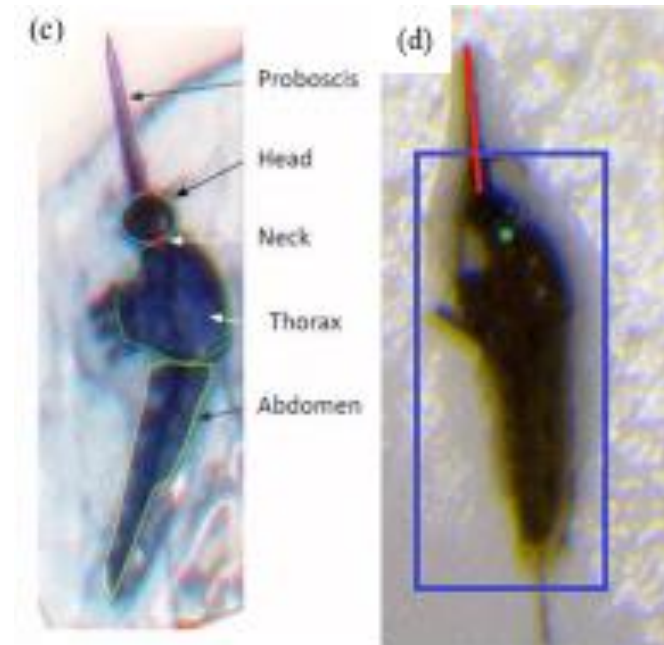
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# System Description – Computer Vision

- CV algorithms are used to identify key mosquito anatomy
  - Position of head, neck, proboscis in image coordinates
- Use image processing to extract image features
- Compare against a manually-labeled evaluation mosquito image dataset
- Image coordinates converted to robot waypoints with calibrated Bernstein polynomial (handeye calibration)



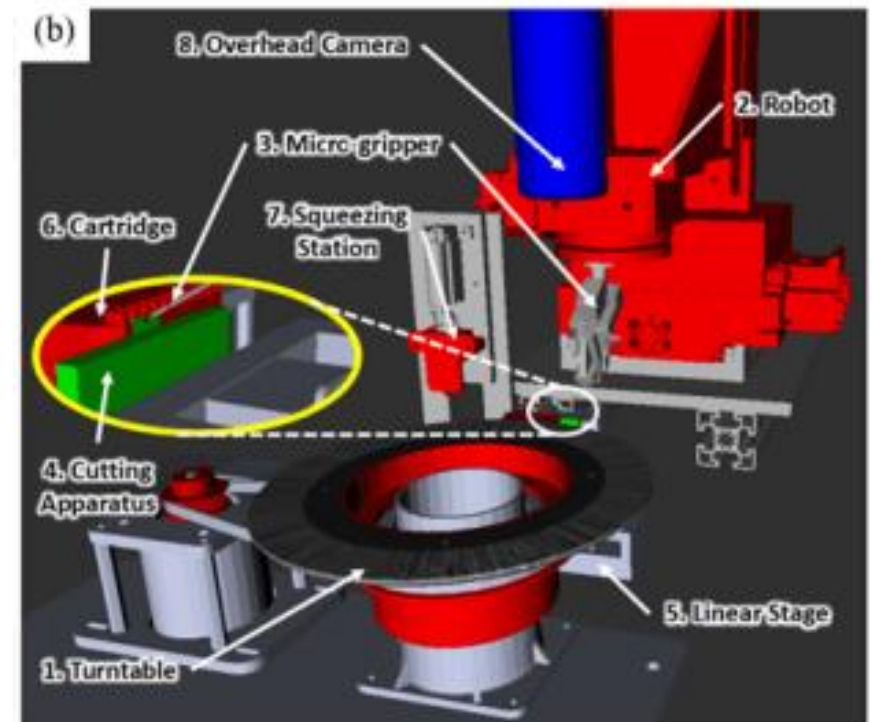
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# System Description – Software Architecture

- Developed in ROS environment
- High level script processes system logic
- Calls on CV subroutines as ROS services
- Allows for a robot simulation with rViz, rqt
  - Used to continue software development when physical robot is not accessible



# Key Results

- 93% success rate for mosquito manipulation
- 87.1% success rate for salivary gland extraction
- Development of robust computer vision processes
- Modularization of robot system components in ROS
- Identification of necessary future improvements

Procedure	Step	Success	Failure	Total	Success Rate
MPPD	Pick-Place	93	7	100	93%
	Decapitate	93	0	93	100%
Gland Extract	Squeezing	81	12	93	87.1%
Overall		81	19	100	81%

# Significance of Key Results

- Successful proof-of-concept for key steps in the greater autonomous procedure
  - Using computer vision to identify and locate mosquito anatomical features
  - Mosquito manipulation techniques
- Promising results, validation for the approaches used in system
- Modularized software architecture will be essential for future work
- Increased understanding of the problem at hand
  - Ex. Importance of mosquito pre-processing and storage

# Critical Assessment – Relevance to Calibration Project

- Provides key insights into how each system component interacts with other components and in the greater system
- Especially for components that are involved in calibration
  - Ex. How computer vision is implemented. Specific methods used determines which camera parameters need to be calibrated
    - Camera exposure, orientation, position, etc.
- What the most prominent failure modes are in the system
  - Incorrect or missing calibration procedure?

# Critical Assessment – Lingerin g questions and critiques

- How the developed procedure fits in the greater task of preparing mosquito glands for vaccine production?
- Scalability and throughput potential?
- Has the team explored other approaches for subcomponents? What are the expected performances/limitations of other methods?
  - Ex. Train a neural network for computer vision instead of using template matching

# Critical Assessment – Potential Next Steps

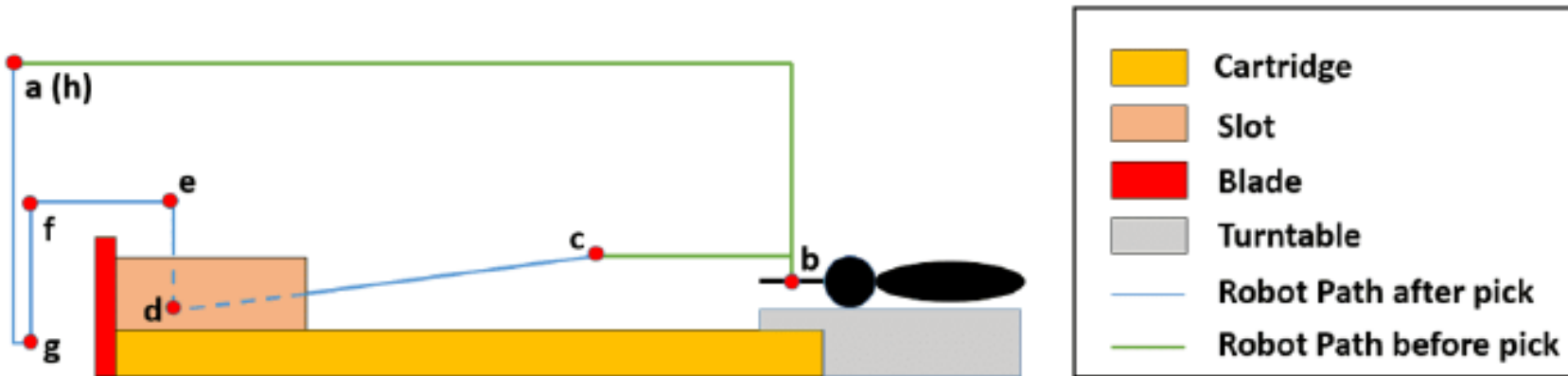
Authors identified key improvements to focus on in the near future:

- Modify layout of platform for better throughput + scalability
- Step verification methods
- Improve CV performance
- Restructuring of processing logic for parallel processing of mosquitos

# Appendix

# Project Goals

- Streamline and simplify calibration routines, including but not limited to:
  - Streamlined handeye calibration
  - Robot homing + robot workspace definition
  - Calibration validation
- Rethink how the robot tool paths are defined, and implement a solution that can be maintained easier by human developers

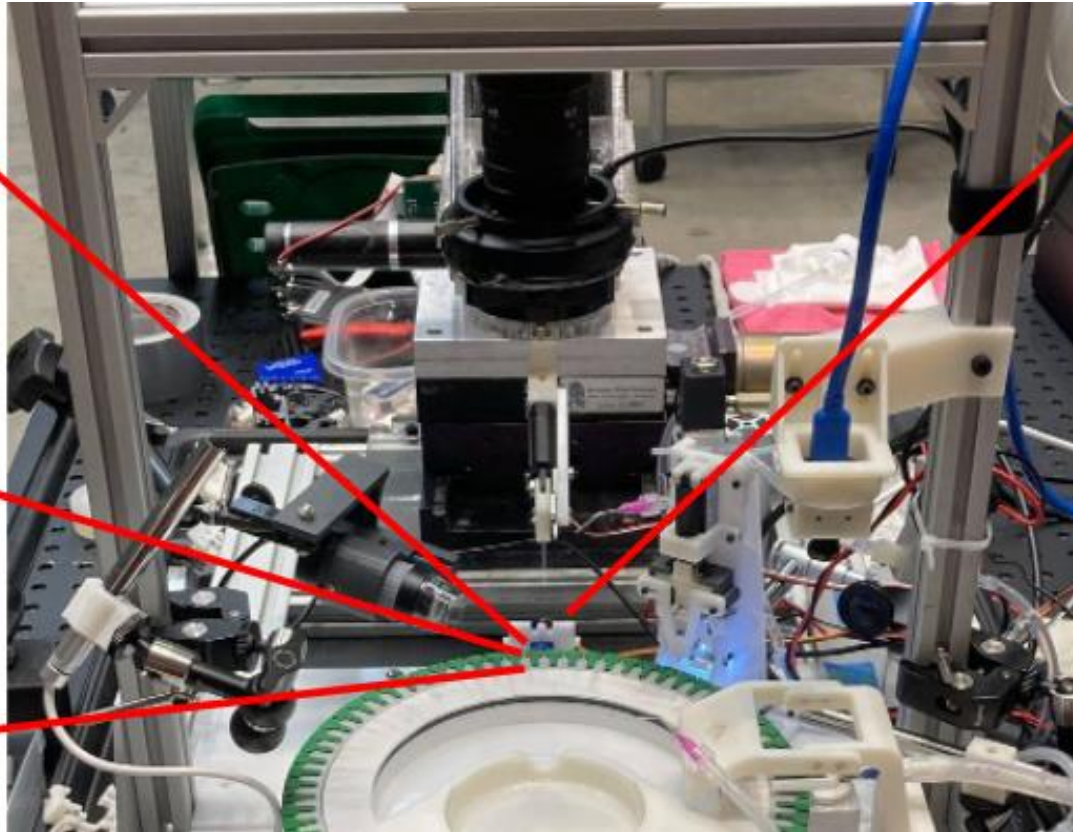


An example robot gripper path (not currently in use)

4 - CV finds mosquito neck

3 - Robot arm grips and moves mosquito into station

2 - CV finds mosquito body and proboscis



5 - Robot arm brings mosquito to blades, decapitates mosquito

## Project focus area: Decapitation station

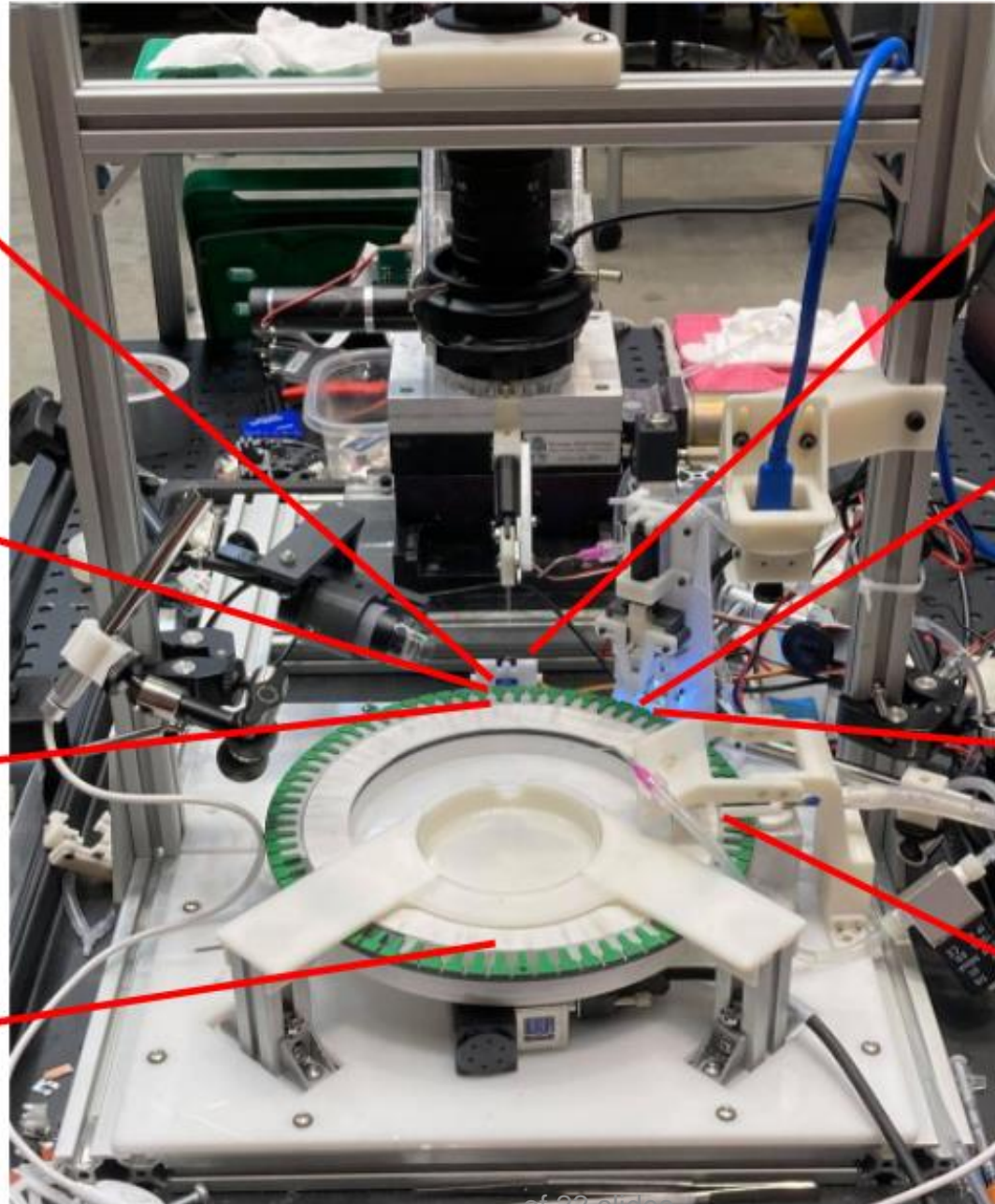
- CV used to identify mosquito anatomy
- 3 DoF prismatic robot to manipulate mosquitos

4 - CV finds mosquito neck

3 - Robot arm grips and moves mosquito into station

2 - CV finds mosquito body and proboscis

1 - Operator places mosquito here



5 - Robot arm brings mosquito to blades, decapitates mosquito

6 - Squeezer presses on torso and exposes salivary gland

7 - Pressurized tube collects exposed gland

8 - Mosquito torso disposed and robot cleaned