Project 04:

Vision Guided Mosquito Dissection for the Production of Malaria Vaccine

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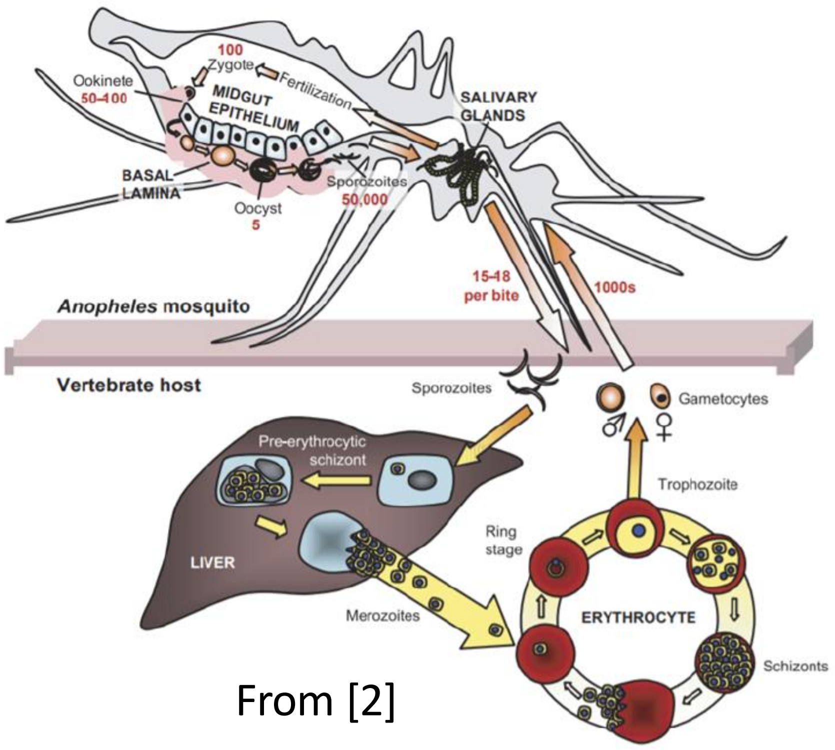
Background and Motivation

- Malaria is a serious and sometimes fatal disease caused by a parasite that commonly infects a certain type of mosquito that feeds on humans.
  - There are over 200 million cases of malaria every year globally which results in more than 400,000 deaths.[1]
  - The disease is caused by a parasite that incubates inside the salivary glands of mosquitoes.
- Extracting these sporozoites from mosquito salivary glands enables the manufacturing of one promising malaria vaccine.
  - The autonomy of the robotic system hinges on sophisticated computer vision methods to detect mosquitoes and their body parts and to provide quality control during the process.

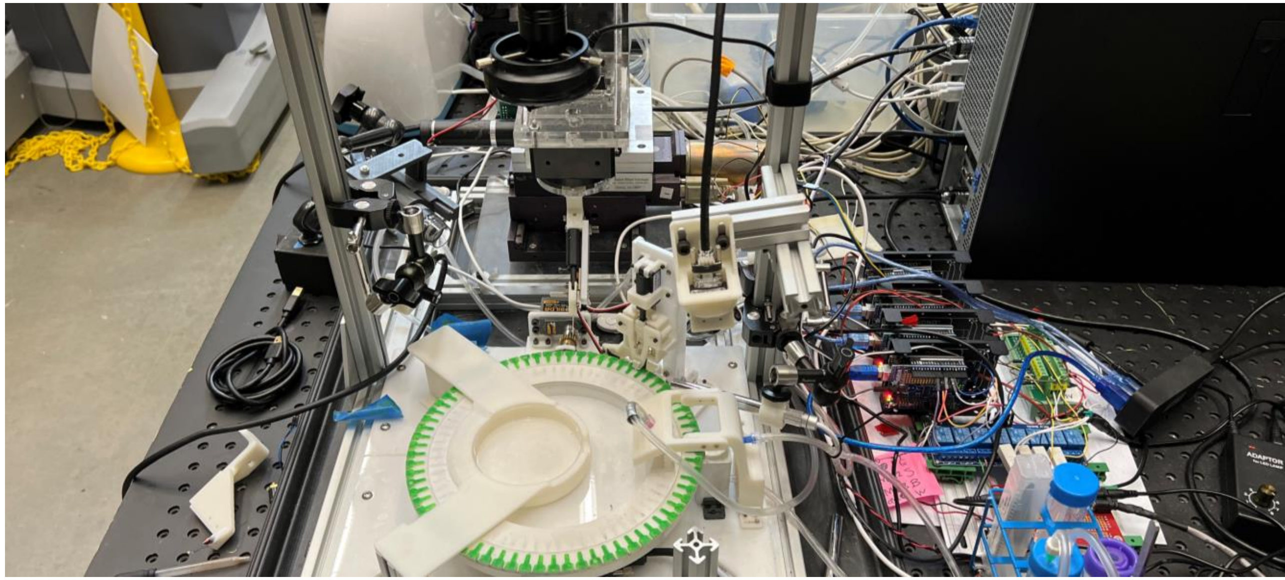


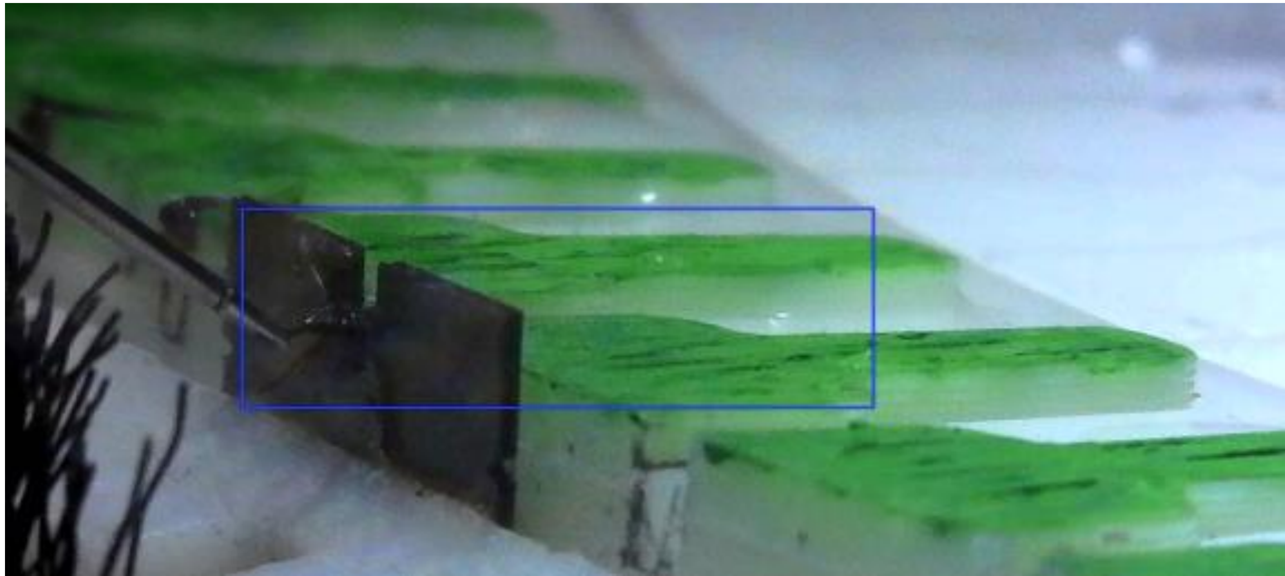
From [2]

Prior Work

Work done in the LCSR :

- An automated robot system for the mosquito dissection and salivary gland extraction
- Vision algorithms (ROI detection/ Gripper tip detection/ Mosquito detection etc.)
- A software framework for integrating vision algorithms into the automated robot system using ROS





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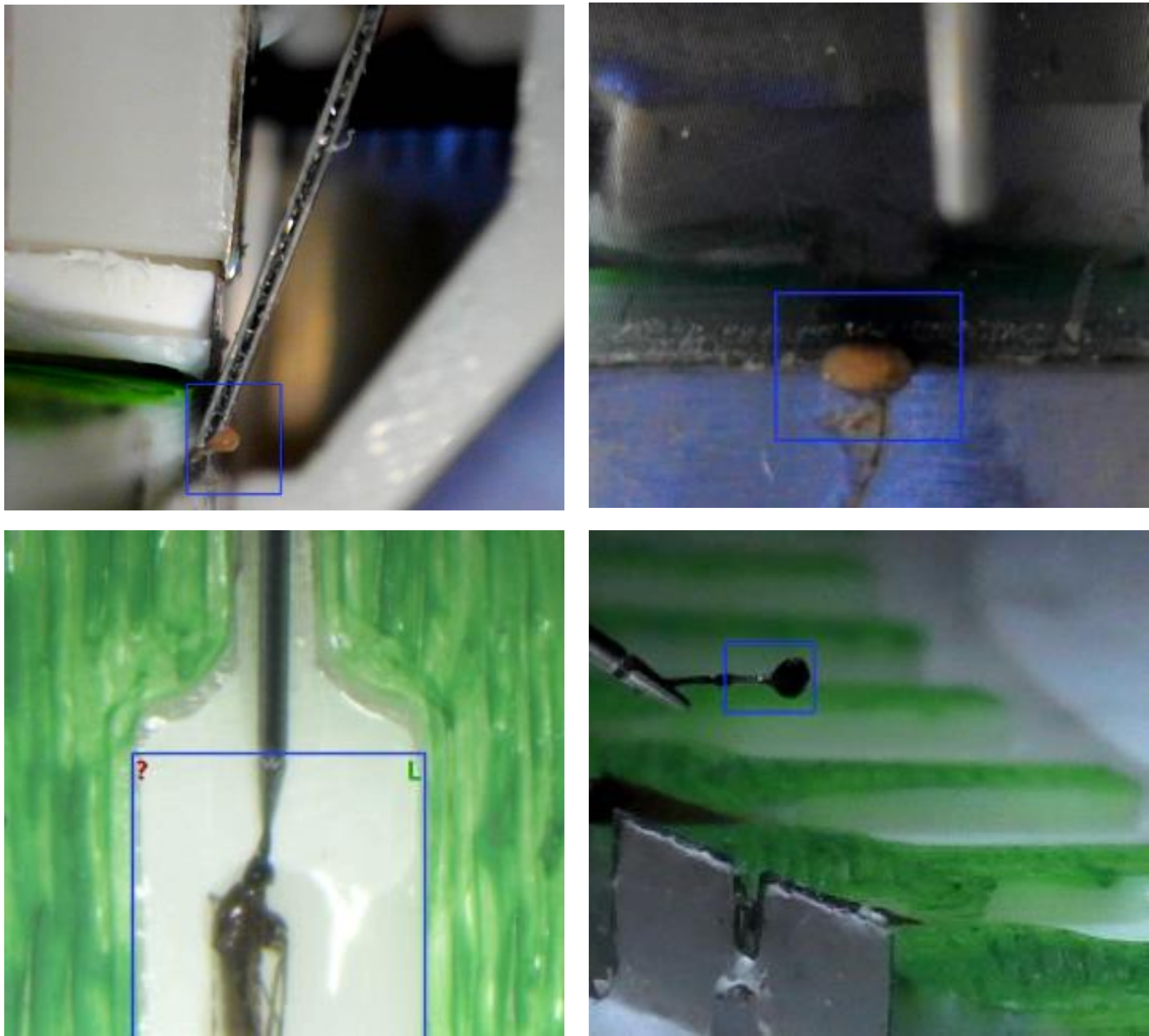
Goal

This project aims to create computer vision algorithms for the robot mosquito dissection system, which is an important part of continuing development. Specific aims are to develop new DL-based CV methods and integrate existing CV methods for the mosquito dissection system, which include:

1) Mosquito Orientation Detection
2) Exudate Quality Evaluation
3) Prediction of Dissection Success
4) Exudate Volume Estimation

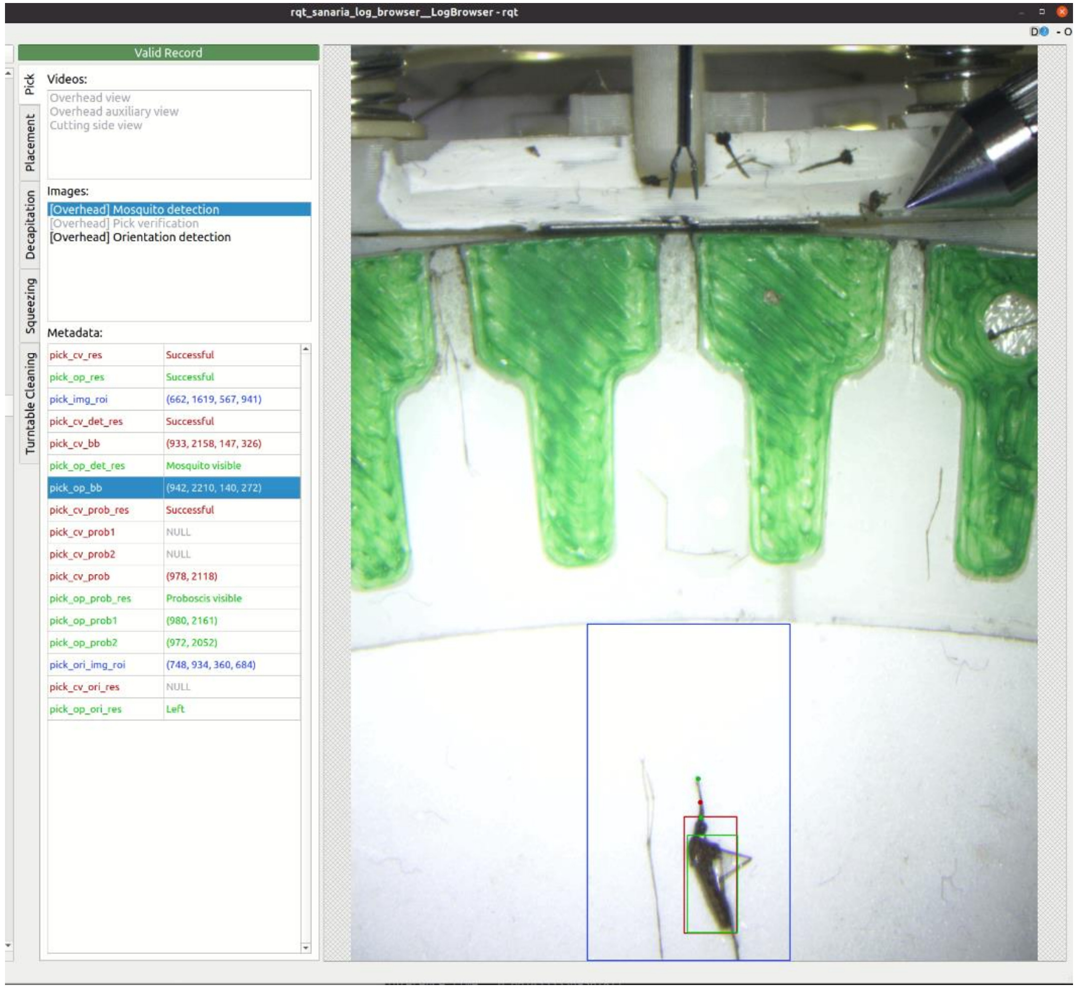


Technical Approach

- Images and Annotations

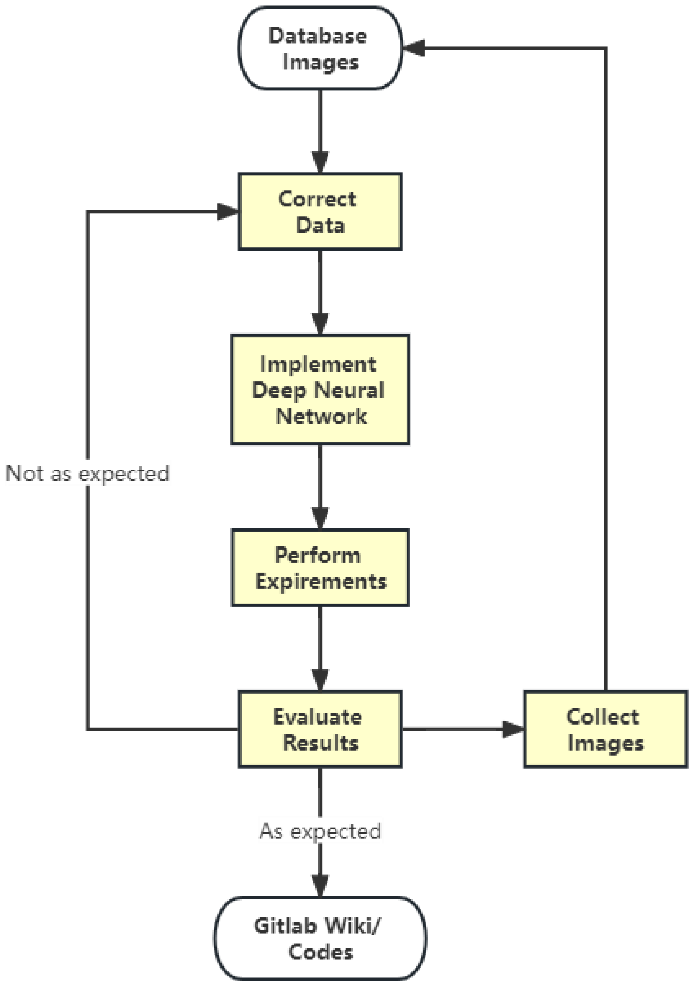
1) The automated robotic system has several cameras with different angles in different positions. Many images have been stored in the database since the system was built. However, not every image has the correct label. Need to correct the label for each image in this database.

2) Extract images and their corresponding annotation information from the database. Perform data type conversion and make training sets. Perform training and validate on the training results.



Technical Approach

- Implementation
  - Use deep neural networks for classification tasks (ResNet/ VGG/ DenseNet).
  - Implement the deep neural networks in Python and Pytorch.
  - Use Git to maintain codes in Gitlab repository.
  - Use Wiki in Gitlab for documentation.
  - Use SSH for remote access to training machine.



Deliverables

	Activity	Deliverable
Minimum	Review mosquito orientation detection code, complete (if necessary), generate up-to-date training data, train, and evaluate network, make sure method is properly integrated, complete documentation.	Completed mosquito orientation detection code in Gitlab repository/ Documentation in Gitlab Wiki and Readme files.
	Complete exudate quality evaluation. Establish contact with Sanaria expert, review the database, gather exudate images for training from database. Have images classified by Sanaria expert. Train classifier using classified dataset. Evaluate results on training dataset. Possibility: Evaluate exudate quality by Sanaria expert visiting LCSR.	Completed exudate quality evaluation code in Gitlab repository/ Documentation in Gitlab Wiki and Readme files.
Expected	Complete prediction of dissection success. Train classifier using exudate quality classification data, and mosquito images taken at the early stages of processing. Evaluate results on training dataset. Interpret results. Run laboratory experiments to confirm findings.	Completed prediction of dissection success code in Gitlab repository/ Documentation in Gitlab Wiki and Readme files.
	If prediction results are confirmed to be valid, investigate methods to locate specific regions on mosquito images that contribute strongest to variability in exudate quality. Document investigation and results. Present investigation results to hardware design team.	Relevant code in Gitlab repository/ Documentation in Gitlab Wiki and Readme files.
Maximum	Develop exudate volume estimation using deep learning techniques.	Completed exudate volume estimation code in Gitlab repository/ Documentation in Gitlab Wiki and Readme files.

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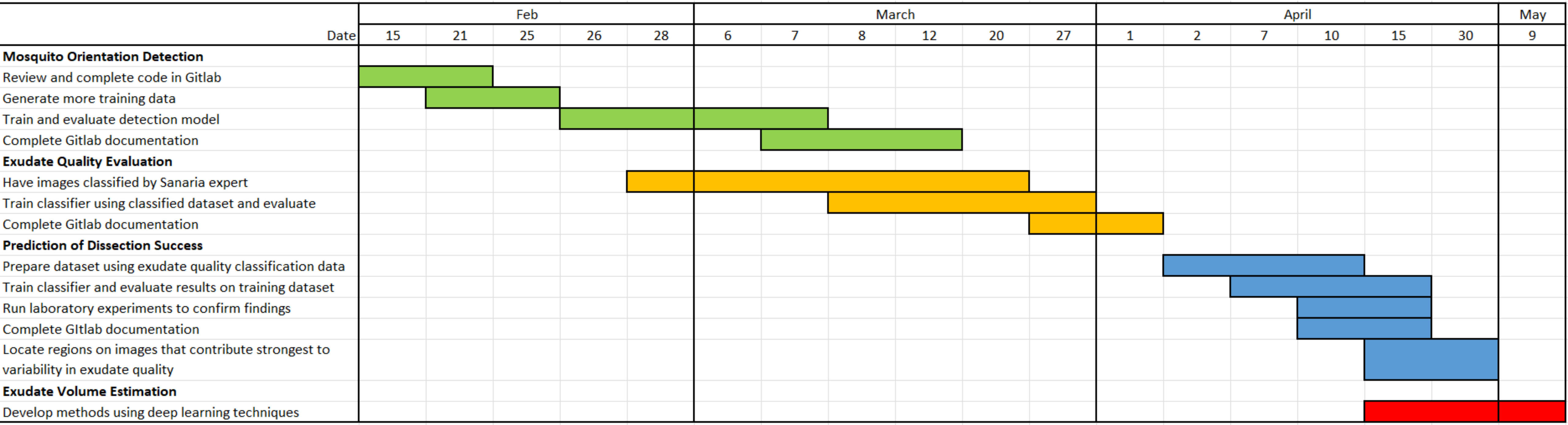
Timeline



Dependencies

Dependency	Need	Status	Follow-up	Contingency Plan
Computing Power	GPU for training neural network	Ready to use	Have access to Sanaria PC	N/A
Training images in log database	For annotation and training	In progress	Review available data in database, fix data labels if needed	If amount of data is inadequate, then run laboratory experiments with mosquitos to generate more data.
Sanaria expert needs to evaluate exudate images and classify them	Use correctly labeled exudate images for the exudate quality evaluation task	In progress	N/A	If evaluation results are not received on time from expert, come up with own classification. Continue other steps.

Roles

- Yutai Wang –Team Member
- Mr. Balazs Vagvolgyi – Mentor

Management plan

Meeting Schedule:

- Monday 9:00pm – 10:00pm: Meet with the project team over Zoom.
- Monday 11:00pm – 12:00pm: Meet with mentor in person.

Communication:
Email and text message.

References

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

[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