Individual Report
CBL Engineering Challenge for Venus (5EID0)

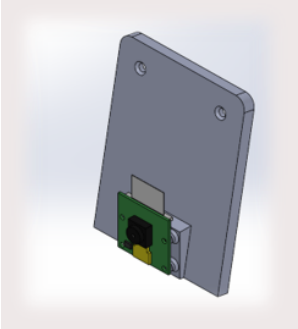
Name: Aarrav Anil
Student Number: 2075970
Team number: 20

Technical Contributions

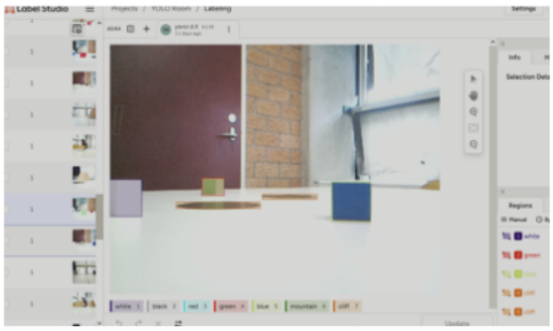
Having some previous experience with Object Detection using a camera, I put forward the idea of using a camera and an algorithm for detecting the rock samples in one of our initial team meetings.

I started off by setting up a Raspberry Pi 4B and connecting it to a Raspberry Pi Camera (Rev1.3). Then, I partnered up with a teammate and we started to test the camera. We performed basic tests like camera quality, frame rate and resolution.

To mount the camera and Raspberry Pi on the robot, I designed a mount in CAD using SolidWorks. While designing, I made sure to take into account the small 10 degree tilt of the front of the robot. I also considered Design for Manufacturability (DFM) for 3D printing by avoiding overhangs to not use support material. Then, printed them out and assembled it along with the camera and Raspberry Pi on the robot. To build a proof of concept, I decided to use OpenCV to perform a gaussian blur, HSV masking and Contour detection to try and detect the rock sample cubes. Unfortunately, this method although requiring less processing power, could not detect the samples accurately. It had several problems like getting influenced by lighting conditions, doesn't work for mountains and cliffs and not consistent.

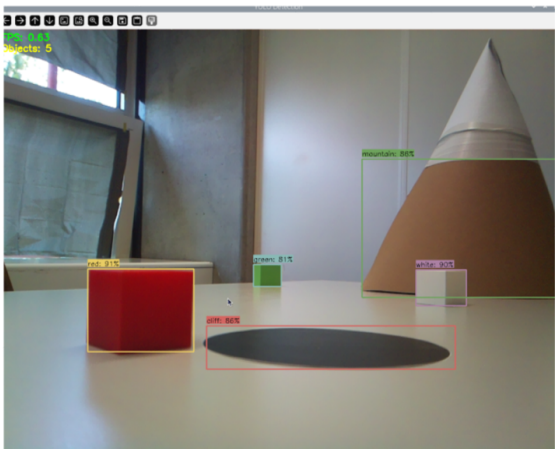


Next, I suggested that we use a custom trained ML model. I was confident that this would be a better option as I had quite a bit of experience with this. So, I involved some of my teammates to help with taking around 150 images to create the dataset.



Next, we used LabelStudio to draw bounding boxes and label each of the images. Using this labelled image dataset, I used Google Colab to train a YOLO model. After this, we tried to run this model on the Raspberry Pi and it was a lot better than the simple OpenCV algorithm. Unfortunately, this model was really processor intensive and it sometimes used to false detect objects.

Although I had experience with this, I was not working solo, rather I involved some teammates in the process, shared my knowledge, mentored them and provided guidance.



Being happy with the results of the YOLO model, I proposed to the team that we use this method and improve upon it.

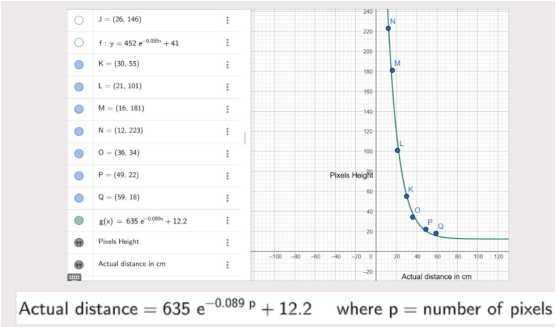
Next, my team and I re-trained the model with more images in the dataset (350 images with variations in lighting condition and position). We implemented this on the Raspberry Pi and it was significantly more accurate than the previous model.

I also worked on the distance measurement and calculation using just a camera. By plotting the actual distance (in cm) and the pixel height on the camera frame of objects, I

estimated a best-fit exponential curve to relate the two parameters.

Next, I worked on integrating the YOLO model, distance calculation and creating a list of detected objects. Then, added the UART communication between the Raspberry Pi and the PYNQ board to transmit this data to the PYNQ.

Along the whole process, I made sure to help and provide technical guidance when my teammates had any questions. For instance, one of my teammates had a problem with the color sensor, I helped her out with the I2C communication and calibration of the sensor.



Design Process

Implementing the V model and Engineering Design Process
during our CBL really helped me to understand the best way to approach a problem, brainstorm a solution, build a prototype and iterate on it.

During one of our team meetings, we discussed about using a color sensor along with a camera. We debated over the pros and cons of using the sensor which I really like about working in a team. Each member in a team has a different perspective and discussing over it as a team helped me understand the benefits and importance of teamwork.

Teamwork Makes the Dream Work!

Planning and project management

I made sure to set clear and strict deadlines for myself when completing tasks. I tried to complete all of my tasks during CBL hours but sometimes, this was not enough time. During the end of the quartile, as we were short on time, I worked on the distance calibration and calculation outside of CBL hours.

Being assigned as the Technical Lead in my team, I made sure to check the progress of each task and also informed my progress to everyone, explaining and involving them during the engineering process. In addition, I made sure that each teammate was assigned tasks and felt comfortable to reach out to me if they had any technical questions.

Reflection towards the future

One aspect I really improved myself during this CBL is Leadership and collaboration with teammates. I also enhanced my hard skills in Machine Learning and Object Detection.

Looking back, one thing I would improve on is the communication among team members and having agendas for meetings to make it more organized and efficient.

Overall, I feel that I made a strong contribution to the group. Being the Technical Lead, working on the camera, ML YOLO model, integration of different components and testing. Also in the aspect of team planning, management and co-ordination.