Team 13 Project Requirements and Background Research

Section 1: Analysis of certain requirement categories

• Public health, safety, and welfare

Public health safety and welfare should be a priority when we evaluate our project. After applying this project in the industry departments, workers will not need to do fixed distribution work, leading to physical and mental problems. Therefore, it may improve the public health level.

• Global factors/contexts

Increase global trade efficiency and accuracy because the robot can distribute the goods of different colours in the harbour. Moreover, it will also be possible to apply this project to the package distribution if the camera changes to be a barcode or QR code scanner. It will accelerate the communication of products and goods between transportation centres.

• Cultural factors/contexts

This project follows the trend of autonomy. The industry will become more autonomous after applying this project result.

• Social factors/contexts

It may replace the working positions for people who mainly do trivial jobs, such as sorting items all day in the industry. People will not be struggling with tedious works so that the crime rate and safety issues may decline due to reduced mental problems.

• Environmental factors/contexts

Increase the usage of electrical power because the robots need to be powered by electricity to finish tasks. More power stations could be built, which can harm the environment. If the batteries of robots will not be used, these batteries' disposal will pollute the environment.

• Economic factors/contexts (separate from the overall project budget)

Robots' efficiency and accuracy are higher than humans for a long time, so the rate of defective production could be reduced. The company's profit could be increased.

Section 2: Table of Requirements

Number & Category	Requirement statement	Source of statement
1. Functional		
1.1 Rover	It can move on the carpet floor and turn to different directions to bypass obstacles. (see Figure 2)	Project description
1.2 Arm	It can have motions like picking, lifting, and pushing. (see Figure 1)	Project description
1.3 Sensor	It can detect the color of objects and the obstacles in the environment.	Project description
1.4 Dumping	It can dump the targets collected in the boxes on the rover.	Team's specification
1.5 UI	It should tell the user and operator about the correct process and action of the rover and arm. It should give the user a chance to choose some actions. (see Figure 3)	Project description
2. Cost		
2.1 Arm	Less than 100 dollars	Project description
2.2 Accessories (like camera, sensors, basket)	Less than 300 dollars	Project description
3. Schedule		
3.1 Week 1	Get familiar with course guide and software	Course Schedule
3.2 Week 2	Pick up the hardware and get familiar with team	Course Schedule
3.3 Week 3	Simple Example and Block Diagram	Course Schedule

3.4 Week 4	Milestone: Simple code structure and Task Diagram	Course Schedule
3.5 Week 5	Validation Plan	Course Schedule
3.6 Week 6	Milestone: Inter Component communication	Course Schedule
3.7 Week 7	Milestone: Partial component demonstrations	Course Schedule
3.8 Week 8	Milestone: Partial component demonstrations	Course Schedule
3.9 Week 9	Assignment Milestone: Final component demonstrations	Course Schedule
3.10 Week 10	Assignment Milestone: Final component demonstrations	Course Schedule
3.11 Week 11	Assignment Milestone: Final component demonstrations	Course Schedule
3.12 Week 12	Final Team Demonstration	Course Schedule
3.13 Week 13	Final Team Demonstration	Course Schedule
3.14 Week 14	Final Report, Final Exam Video, and Project Poster	Course Schedule
4. Standards		
4.1 UART	Standard used to flash program to boards	Hayes
4.2 HTTP	Standard used to transfer data from outside PC to Rover	IETF
4.3 I2C	Alternative standard for flashing program to boards	Phillips
4.4 HTTPS	Safer way to transfer data	Netscape
5. Ethical & Professional		

5.1 Project Objects	IEEE Code of Ethics	Project description
5.2 Individual Work	Intellectual Property Laws	Project description
7. Global		
7.1 Language	Instruction and UI should be in English	Team's specification
8. Safety		
8.1 Safe device	Not use parts with high voltage or current or those parts should be protected well	Team's specification
9. Environmental		
9.1 Low Power Consumption	Lower than 110 W	Team's specification
9.2 Environmental-Friendly Materials	Arm and bracket avoid using plastic.	Team's specification
10. Economic		
10.1 Effective working hour	Rover should work a more extended time consistently than humans do.	Team's specification
10.2 Budget for industry	Applying rovers should result in a lower budget compared with employing human labors.	Team's specification

Section 3: Supporting Diagrams/Figures

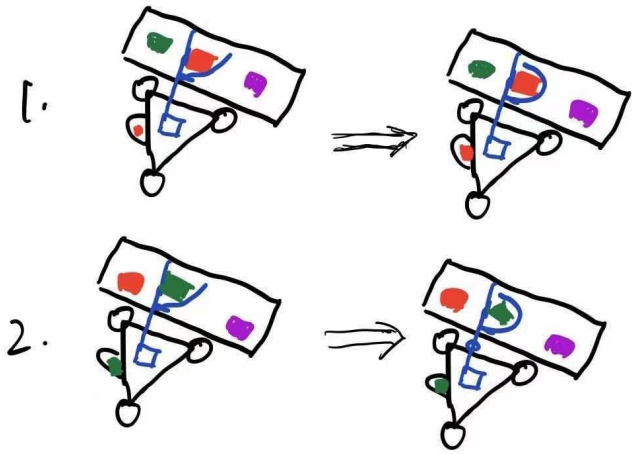

Figure1 - Arm Pick-up diagram

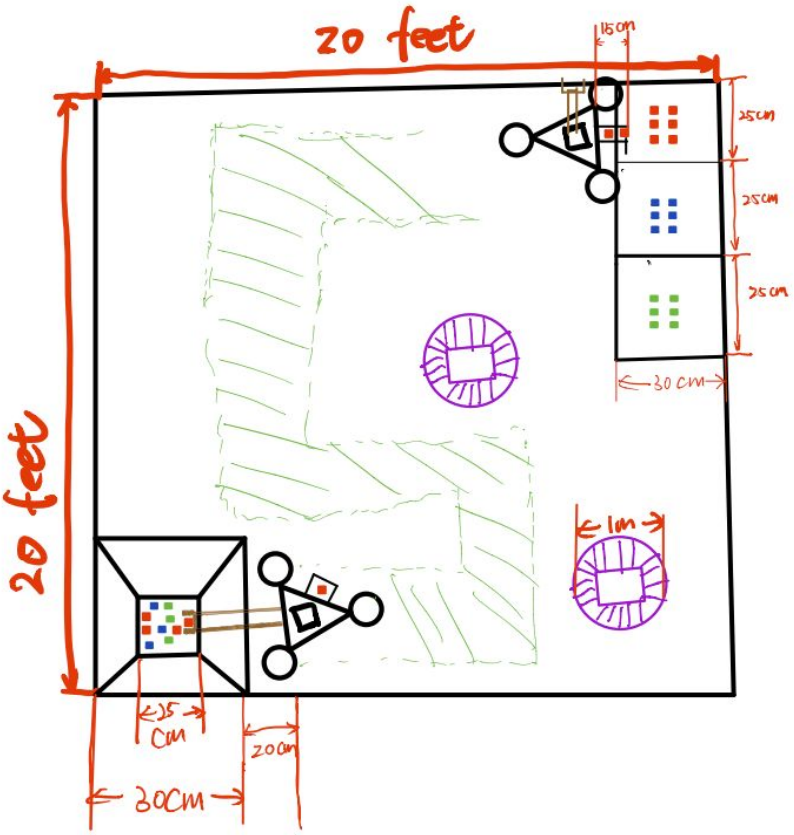

Figure 2 - Playing Field

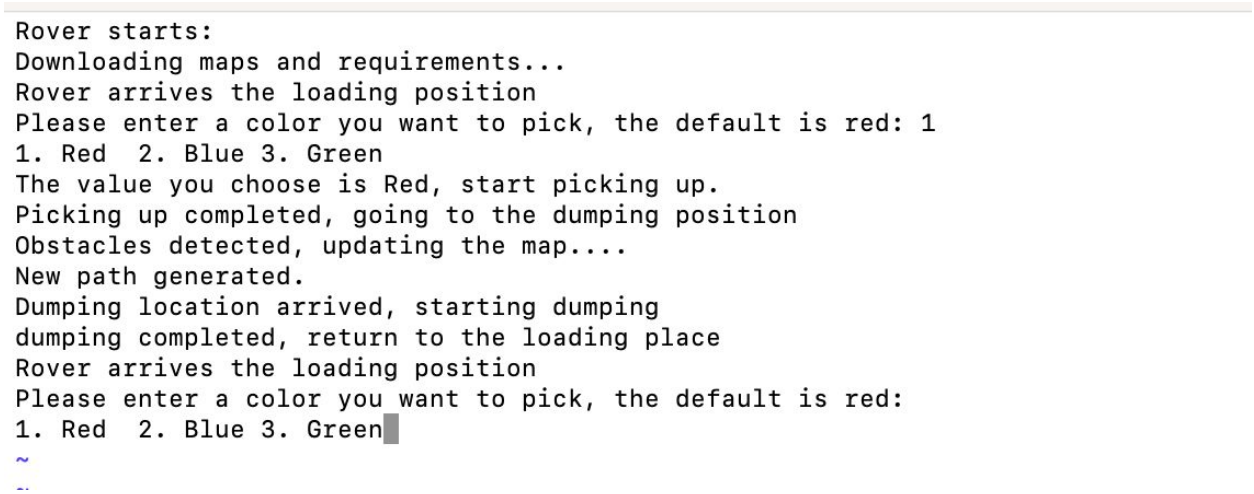

Figure 3 - UI Interface

Section 4: Problem Complexity

Aspect	Present in problem	Explanation
Wide-ranging or conflicting technical issues	Yes	We want it to move faster to be more efficient and use a lower current and voltage for safety concerns. The project requires wide-ranging technical knowledge, like communication, PID control, and artificial intelligence (Reinforcement Learning).
Has no obvious solution	No	
Addressing problems not encompassed by current standards and codes	No	
Diverse groups of stakeholders	No	
Many component parts or sub-problems	Yes	We use multiple parts including Rover, 3 DOF arm and a dump device in our project. There are many sub-problems about the communications and corporations between them.
Involving multiple disciplines	No	
Having significant consequences in a range of contexts	No	

Section 5: Background Research

- Project 1: VT ECE 3574 Graphical Miniature Online Banking App with Concurrency [1]

  This project aims to create a banking GUI application that can perform long-running background tasks using a variety of design techniques, including concurrency(multi-threading), message-safe queue, and event-driven programming.
  This application allows users to select options available appearing in a graphical window such as deposit, withdrawal, and check account balance.
  In this event-driven programming, it contains two threads, one is the user account thread, and the other is GUI-specific thread. The two threads can run concurrently and independently. A message queue is applied for communication between two threads. It is guaranteed to safely input or output messages by implementing thread synchronization using mutexes and lock/unlock mechanisms.

- Project 2: Mask R-CNN for Object Detection and Segmentation [2]

  This project is dedicated to label the objects and make a mask for them on an image. This project trains a set of images using convolution methods to learn each object's characteristics and outlines. The project uses Python 3, Keras, and TensorFlow. They first do anchor sorting and filtering. Then a bounding box refinement process followed with mask generation. They also do some post-detection process about the layer activity, weight histogram and logging to the tensor board. They finally coloured the target object and made a bounding box for each item; the other items shadow even some items.

- Project 3: VT ECE 4534 Embedded System Design Project (Team 5 of Summer 2020) [3]

  In their project, they use an OpenMV camera to detect the coordinate and distance objects, which is directly relevant to our project because our project also needs a camera to detect the objects that should be picked up. Furthermore, the camera also needs to distinguish the colours of the objects.

For OpenMV Cam, it is a microcontroller board with a camera that uses a program in MicroPython.[4] The most crucial aspect of OpenMV Cam is detecting the colour by running machine visions algorithm.[4]
The camera needs to provide information about the coordinates and distance of objects for the arm's motion to assist the arm to move correctly. The basic process is that the camera firstly collects the object's data and then tells the arm control system the relevant position of the target and the arm. Next, the arm control system will calculate the arm's degree and distance to move to get the target.

Section 6: Autonomous Components

Name of Autonomous Component	Description of the Responsibilities of the Component	Communication Inputs	Communication Outputs
Tri-Rover	Move from the loading point to unloading point, bypass any obstacles if they are on the way	Moving commands for each motors, sensor detecting signals about obstacles	Wheel speed and distance for each motor.
Robotic Arm	Pick the target with correct color and then move it to the container on the rover	Sensor signals about target color and position	Current angle and rotating speed of each motor
Dumping motor	Rotate to dump the targets in the contain of the rover to the correct unloading box	Control signals on whether to release the targets or not	Current angle and rotating speed of the motor, whether the unloading completed

Section 7: References

[1] Sook Shin Ha, Lynn Abbott, ”Fall 2020 ECE 3574 Applied Software Design Project 4: CGMOBA (GMOBA with Concurrency)”, 2020.

[2] W. Abdulla, “Mask R-CNN for object detection and instance segmentation on Keras and TensorFlow,” 2017. [Online]. Available: https://github.com/matterport/Mask_RCNN. [Accessed: 27-Jan-2021].

[3] Virginia Tech ECE 4534 Embedded System Design Project - Hospital Ship - Team 5 - Summer 2020. [Online]. Available: https://www.youtube.com/watch?v=RHIP9vf2idI&t=346s [Accessed: 27-Jan-2021]

[4] A. Industries, “OpenMV Cam H7 - MicroPython Embedded Vision + Machine Learning,” adafruit industries blog RSS. [Online]. Available: https://www.adafruit.com/product/4478?gclid=Cj0KCQiAmL-ABhDFARIsAKywVaf-dfyCtf0lEpkBd3y2ErztNiVdsn7wVH-SZp_yNLcjQW17kiSz80QaAnLVEALw_wcB. [Accessed: 27-Jan-2021].