

# Team F2 Remote Statement of Work

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## Project Changes

Our team made a few changes to our project in order to transition to remote work. We divided the rest of the tasks into three main Miniprojects: Gesture Recognition, Robot Manipulation, and 2D to 3D Mapping. Jerry will continue working on gesture recognition and recognize where the point will be in the room. Sean will be in charge of the robot, and will have it set up at his house. Sean will also continue building out the 2D mapping algorithm and working on path finding to a 2D coordinate on the map. Rama will be in charge of the 2D to 3D mapping, and recognizing where the robot and the user are in the camera stream. The stream will be prerecorded videos sent by Sean. We will still run our image processing and webserver on the Xavier board in Pittsburgh, as we can remotely access it via SSH.

As a result of separating our project into these three components, we will not be able to fully integrate our system together. For example, the input to the gesture recognition video stream will be a webcam at Jerry's house, instead of coming from the same room where the robot is at Sean's house. This is so not too much work is put on Sean to continuously gather pose data for model training or debugging. The guidance Professor Savvides recommended was for us to develop each of the components individually, and perform integration via editing of the demo video. So, gesture recognition and mapping will run as individual components remotely, and a stream of commands will be sent to the Roomba to run offline. Because we are separating our project, we will not be able to satisfy our response time requirements. We will try to integrate the system to the best of our ability, but it may be difficult when we are working remotely.

To demonstrate our work, we will create a project video illustrating each component working together through editing. In addition, we will build visualizations for gesture recognition and mapping to show what our project is estimating. For example, we will show an updating 2D map and an annotated camera stream with robot location, human location, and estimated poses.

Our work will also be delayed around 2 weeks for the time it will take to mail the Roomba and other parts to Sean and Jerry. We have rescheduled our schedule appropriately.

## Miniproject: Gesture Recognition

Jerry will be responsible for working on the Gesture Recognition part of the project. His existing work involves using the Xavier board to recognize OpenPose keypoints, optimizing OpenPose performance to 30 FPS, and recognizing simple gestures like arms raised. Jerry will continue his work on using SVM models to classify teleop gestures instead of using heuristics. He is also continuing work on classifying point data, predicting where a user is pointing to in a room. Jerry is still experimenting with different classifiers, including SVMs and neural networks.

Because Jerry cannot access the lab anymore, the environment has to be set up again with the hardware. Jerry will need to re-calibrate OpenPose to work in his room and collect new gesture data to classify. He will leverage existing code to gather the data.

In addition, Jerry will need to build visualization tools for gesture recognition. For example, there will be a pose estimation shown for the user along with the estimated gesture shown for the user. The method for finding the gesture will also be displayed on the screen, whether it is heuristics or ML model. The visualization will also show where the user is pointing in the room, shown with a 2D map of the space in front of the user as a grid of bins and the bin that is pointed to highlighted. The visualization will be used for debugging and also for the final video to

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demonstrate what the gesture recognition is doing.

Jerry also plans on working with both Sean and Rama on the robot and mapping parts of the project, as we originally worked closer together on the design of all aspects of the project.

## **Miniproject: Robot Manipulation**

Sean is responsible for the robot manipulation and any additional planning algorithm that will be put onto the robot. This includes real-time path planning, map modification, etc. The 2D mapping algorithm, which is about 50% complete, will have the highest task priority to not bottleneck future tasks which will require a robust 2D map.

Additionally, since the Roomba will take about 1-2 weeks to arrive at Sean's house, he will work on the algorithms through simulation in the meantime. This is not for a demo or submission, but rather for a preemptive development purpose. Sean will be able to develop algorithms which he can then translate into real manipulation code through fine-tuning once the Roomba arrives. Webots, an open source robot simulator, will be used to simulate the behavior of the Roomba. Although the Roomba model on the Webots library lacks some sensors, it will be sufficient for the purpose of developing basic versions of pathfinding and mapping.

Sean will also have to set up an environment for the robot to move around. The room will also be equipped with a webcam, which will collect video data which can be used in 2D to 3D mapping. All team members will need to communicate closely for this, so Sean can collect video data which are actually useful.

Due to physical distance, the integration of this robot with the rest of the system will be difficult. However, we hope to demonstrate the robot manipulation through some other means, whether that be a webserver command or local control.

## **Miniproject: 2D to 3D Mapping**

Rama will be working on mapping the 2D map of the room to the 3D view provided by the camera. This will also involve identifying the Roomba and user in the camera view. The Roomba will have a flag at a height of four feet that will be identifiable using OpenCV, and the position of the user will be found using OpenPose. This information combined with Roomba movement data sent to the webserver will be used to map the 2D map to the camera view and provide updates the location of the Roomba and user on the map as they move around the room.

Since integration might involve unacceptable latency, the camera video and Roomba movement will be pre-recorded by Sean and sent over for Rama to use on the webserver. The map view will also be part of the visualizations presented to the user to help monitor the state of the system.

Rama will be working closely with Sean to correctly handle the Roomba movement data he will be producing, and will work with Jerry on the map visualization.