Department of Computer Science & Engineering
The University of Texas at Arlington

Architectural Design Specification
CSE 4317: Senior Design II
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Parking Lot Rover Team
GPS-RTK Parking Lot Striping Rover

Sean-Michael Woerner
Abiria Placide
Bryan Bidjocka
Mariane Sanchez
Liliana Diaz

Revision History

Revision	Date	Author(s)	Description
0.1	04.5.2021	SW, AP, BB, MS, LD	Document creation
0.2	04.12.2021	SW, AP, BB, MS, LD	Document completion
0.3	05.4.2021	SW, AP, BB, MS, LD	Document completion
0.4	07.23.2021	SW, AP, BB, MS, LD	Document version 2 completion
0.4	08.02.2021	SW, AP, BB, MS, LD	Final Version Completion

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1 Introduction

The purpose of this project is to design and create a parking lot striping rover. This rover will be autonomous, and will be using GUI interfaces with Bluetooth connections to decrease cost and increase efficiency for parking lot striping. This rover will also have more accuracy and precision in creating lines for the parking lot. The rover will be made utilizing an electric wheelchair base and will use a RKT GPS for getting coordinates of it's current location. A Raspberry Pi will be used to send the commands used for knowing where to go, where to paint, and when to release the paint. There will be three main components for creating the parking lot striping rover. One component will be focused on using GPS, the second component will be focused on the paint, and the third component will be the moving rover as a whole without the actual actions for being a parking lot striping rover.

2 System Overview

This section will describe the overall structure of the software system of the parking lot striping rover. The components will be described as architectural layers that will contain the related elemental capabilities and interactions of the rover. A high-level block diagram of the layers are shown in Figure 1, and a detailed description of the functions of each layer will be shown below.

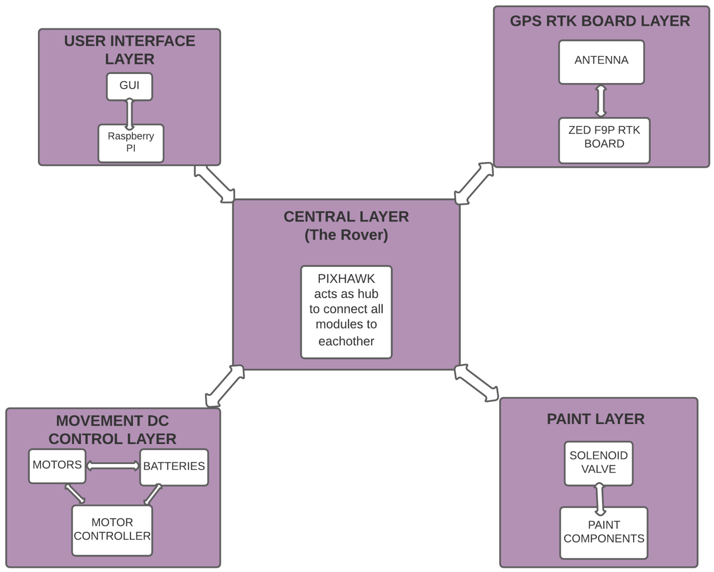

Figure 1: Architectural layer diagram of the GPS-RTK Parking Lot Striping Rover

2.1 Central Layer Description

The central layer's main purpose is to serve as the base between all the layers. This layer will use a PixHawk board, which will be the heart of the system. Since this layer is part of the wheelchair base, it will receive the waypoint data from the UI layer, which will be described below, and then sent to the GPS layer to calculate the coordinates of it's location. This system will receive a signal to move and will power the wheelchair's motors to start moving. This central layer will also have software that will detect any obstructions in order to prevent any collisions. The rover will also be equipped with two 12-volt batteries and two motors that will control the back-wheels.

2.2 User Interface Layer Description

In order to have the rover move, a user will select points on a map from a GUI(graphical user interface) from a remote application, such as a tablet or computer, and will monitor the rover as it stripes lines of paint on the parking lot. The main purpose of the GUI is to receive the inputs from the user to indicate where to go, and where to stop stripe painting, which will all be based on the RTK-GPS signals.

2.3 GPS Layer Description

In order to correct a GPS signal, the RTK Base station will utilize a ZED F9P board. The RTK board will provide a 1cm accuracy for the way-point tracking of the system. In order to receive the correct data, there will need to be a 500 byte internet signal. There will be two RTK GNSS base stations, one for the main location of the rover, and the other used in case the main base is far away from the rover.

2.4 Paint Layer Description

The paint layer is developed to manage the components of the paint distribution, supply, and storage. The striping component of the rover will be composed of two solenoid valves, one to control the flow of the paint to the spray gun and the second to control the air pressure that activates the spray gun. In order to know how much paint is contained in the paint storage component, there will be software designed to notify the user when the container is empty, or if there is an error in the paint distribution. This paint component will connect with a Bluetooth signal that will be part of the central later.

2.5 Movement DC Control Motor Layer Description

This layer will contain the information of the motors, batteries and the Sabertooth motor controller. The motors and batteries will be connected to a Sabertooth. The Sabertooth will control the power and the speed which will communicate with the PixHawk. Both of these software components in the rover will take inputs on/off signals that will control the rover motors.

3 SUBSYSTEM DEFINITIONS & DATA FLOW

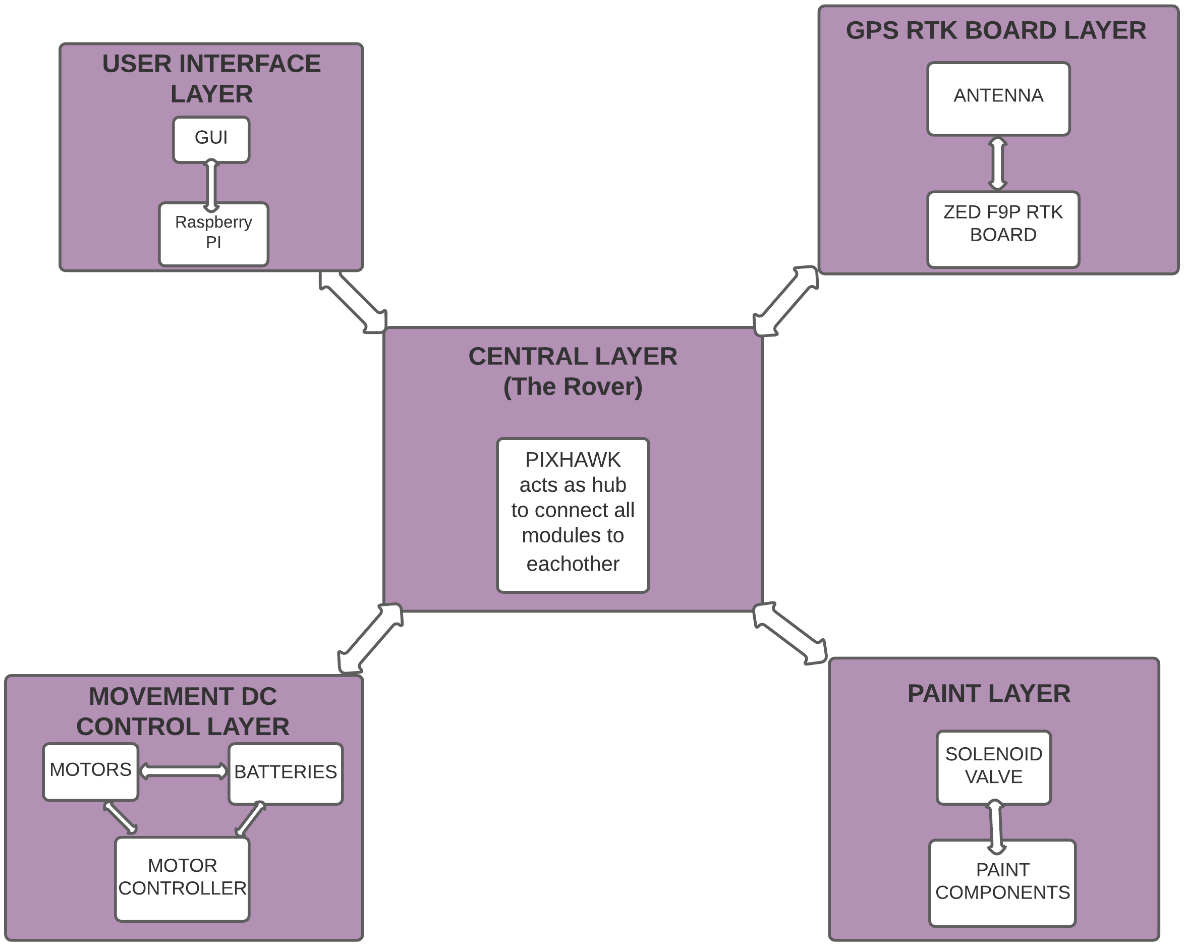

Figure 2: Data flow diagram of the GPS-RTK Parking Lot Striping Rover

4 Central Layer

This is the main layer of the system. It controls other layers.

4.1 PIXHAWK

This subsystem is similar to the CPU of a computer.

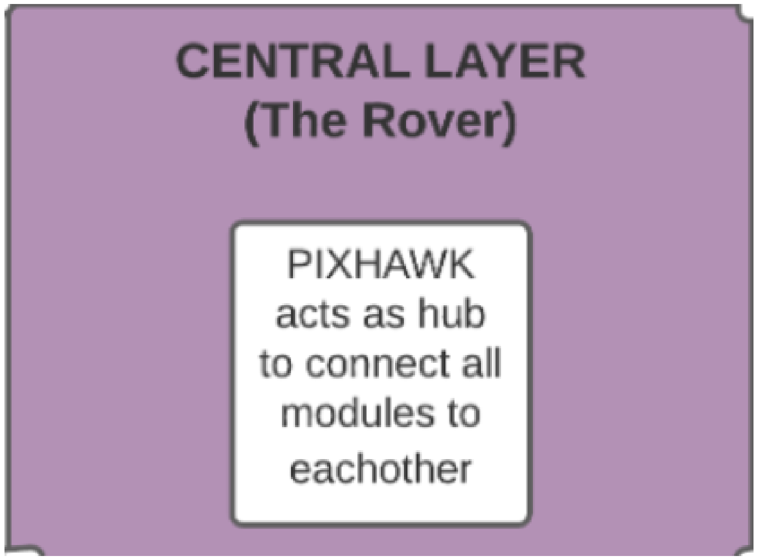

Figure 3: Pixhawk subsystem.

4.1.1 Assumptions

The pixhawk has enough ports to connect to other devices.

4.1.2 Responsibilities

The pixhawk receives data from the User interface layer and sends it to the GPS RTK layer for navigation. The pixhawk receives signals from the GPS and guides the rover to move in a certain direction. It sends the moving commands to the DC controller layer of rover. It also receives data from the collision sensor and sends a signal to the DC controller to stop the rover.

4.1.3 Subsystem Interfaces

Table 2: Subsystem interfaces

ID	Description	Inputs	Outputs
#1	Waypoint data	Input from UI layer	Sends data to GPS
#2	Commands from the UI layer	movement commands	DC controller
#3	The direction from the GPS	GPS data	DC controller
#4	Obstacle data from the sensor	Sensor data	DC controller
#5	Directions from the GPS	GPS data	DC controller

5 PAINT LAYER SUBSYSTEMS

This layer goes over the paint mechanism of the parking lot rover. It includes the paint components (paint reservoir/container, hoses, air compressor, sprayers) and solenoid valves.

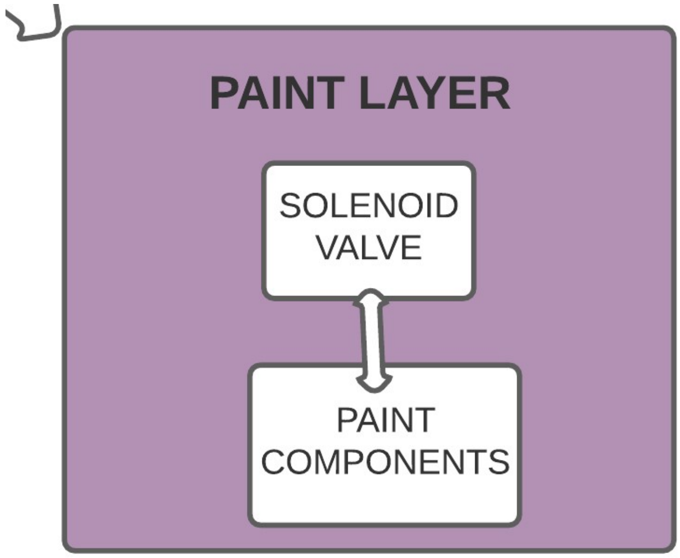

Figure 4: Example subsystem description diagram

5.1 SOLENOID VALVES

The solenoid valve regulates liquid flow. It will be inserted between the paint container and sprayer, connected by hoses.

5.1.1 ASSUMPTIONS

It should act as an autonomous switch to control paint flow.

5.1.2 RESPONSIBILITIES

It releases the paint from the container.

5.1.3 SUBSYSTEM INTERFACES

Table 3: Solenoid subsystem interfaces

ID	Description	Inputs	Outputs
#1	Spray Mechanism	Pressure on the trigger	Paint

5.2 COMPONENTS

Painting components include the compressor, hoses, sprayers, and reservoir/container.

5.2.1 Assumptions

All items are regularly maintained and are in working condition. The container should be free of leaks and be refilled when necessary. The compressor should have the correct amount of pressure.

5.2.2 Responsibilities

The reservoir stores all the paint. The compressor ensures that a consistent amount of paint is being sprayed. The hoses connect the valves between the container and sprayer. The sprayer is responsible for painting straight lines on the ground. The paint flow is controlled by the central layer through the solenoid valve.

5.2.3 Subsystem Interfaces

Table 4: Components subsystem interfaces

ID	Description	Inputs	Outputs
#1	Components	Paint Signal	Air Compressor Starts and Releases Paint

6 User Interface Layer Subsystems

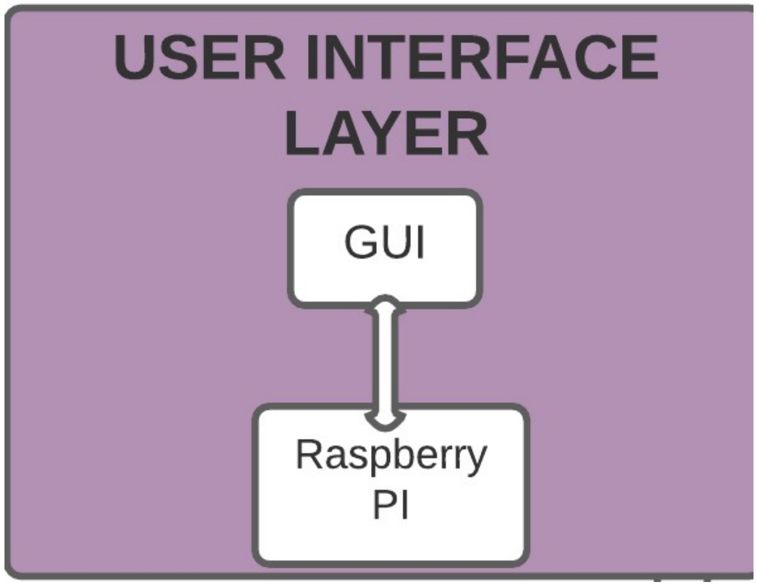

Figure 5: User Interface Layer Diagram

6.1 GUI - Graphical User Interface

6.1.1 Assumptions

The GUI will be allow the user to interact with the rover by entering inputs so that the rover can do tasks that it is given.

6.1.2 Responsibilities

The GUI will receive inputs such as GPS coordinate mappings (waypoints), parking lot dimensions, type of stripes to paint, and other relative information needed to complete the task. After the user enters the inputs, they are sent to the Raspberry Pi to perform the logical operations.

6.1.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 5: GUI Subsystem Interfaces

ID	Description	Inputs	Outputs
#1	User enters waypoints	set of waypoints	Data is sent to Raspberry Pi
#2	GPS connection	User selects the connection option	Signals the Raspberry Pi to pair up with the rover GPS
#3	User enters size of parking lot	size (square footage f^2	System makes a grid of where the rover should travel
#4	Amount of parking spaces	User enters the amount of parking spaces that need to be striped	System determines if this is possible given the dimensions of the parking lot and other constraints
#5	User enters the type of parking lines that will be painted	Line types (parallel, perpendicular, slanted)	System generates the lines on a map
	Combination of options entered from above	A combination of the data inputs above	System checks if all inputs combined are possible for operation and will proceed to generate a map of where to paint and how to paint
			If inputs are invalid or impossible to process, system will notify the user via the GUI to change a particular input

6.2 Raspberry Pi

6.2.1 Assumptions

The Raspberry Pi is the operating system of the rover system.

6.2.2 Responsibilities

The Raspberry Pi acts as the brain of the system in order to carry out instructions to other layers of the system. The Raspberry Pi receives inputs from the GUI which are then sent to the PIXHAWK of the rover to request various modules such as GPS coordinates or motor control.

6.2.3 Subsystem Interfaces

Each of the inputs and outputs for the subsystem are defined here.

Table 6: Raspberry Pi subsytem interface

ID	Description	Inputs	Outputs
#1	Raspberrry Pi communicates with GUI	Receives requests from the user	Data is sent to PIXHAWK
#2	GPS connection	Receives connection request from the user	GPS connection message is sent to the PIXHAWK to pair the GPS

7 Movement Layer Subsystems

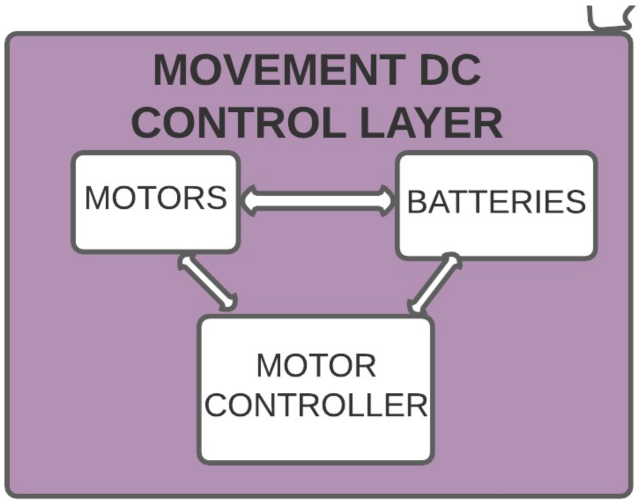

Figure 6: Example subsystem description diagram

7.1 Motor Controller

This subsystem is similar to the CPU of a computer.

7.1.1 Assumptions

The motor controller will take inputs form the PIXHAWK to turn on the desired motors.

7.1.2 Responsibilities

The motor controller converts the high-level logical programming into low-level logical signals that will turn on or off the attached motors.

7.1.3 Subsystem Interfaces

Table 7: Motor controller subsystem interfaces

ID	Description	Inputs	Outputs
#1	Motor controller	Movement commands from the PIXHAWK	Turns on/off the selected motor

7.2 Motor

7.2.1 Assumptions

The motor is the machine that allows the rover's wheels to move

7.2.2 Responsibilities

The motor will make the wheels of the rover to accelerate forwards, backwards, or be able to turn left or right based on the given instructions form the motor controller.

Table 8: Motor subsystem interfaces

ID	Description	Inputs	Outputs
#1	Accelerate tires forwards or backwards	Movement commands from the PIXHAWK	Rotates the wheel forward or backward
#2	Steel the wheel left or right	Movement commands from the PIXHAWK	Steers the wheel left or right

7.3 Batteries

7.3.1 Assumptions

The batteries supply sufficient power needed

7.3.2 Responsibilities

The batteries will supply power for the entire rover to operate

Table 9: Batteries subsystem interfaces

ID	Description	Inputs	Outputs
#1	DC batteries	n/a	Supplies power

8 GPS RTK Board Layer Subsystems

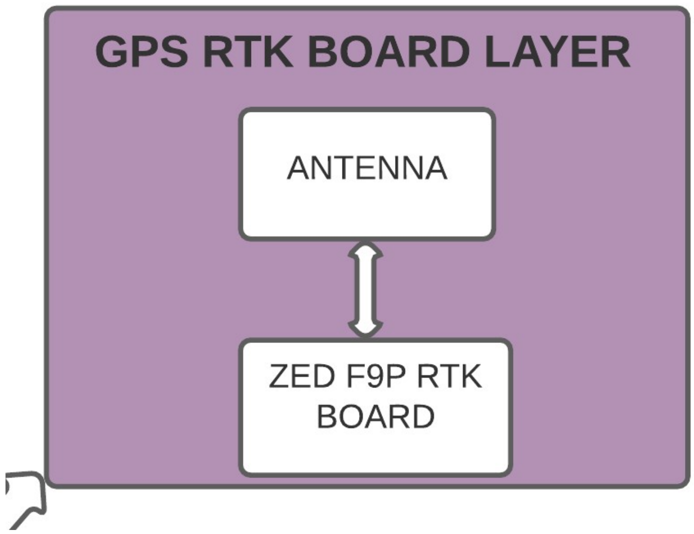

Figure 7: Example subsystem description diagram

8.1 Antenna

This subsystem is similar to the CPU of a computer. It's main purpose is to receive satellite signals what would allow the rover to be maneuvered more efficiently.

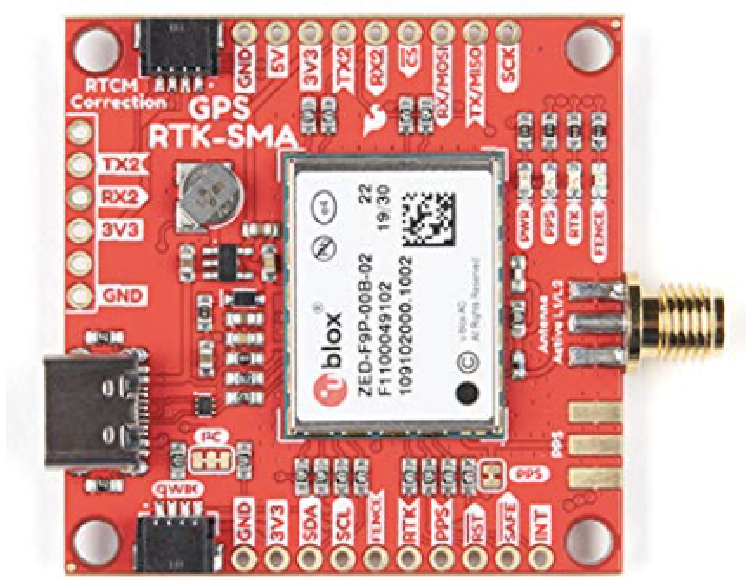

Figure 8: Antenna: ZED F9P RTK BOARD

8.1.1 ASSUMPTIONS

The Board above will receive a correction signal from a base station and use that data to maneuver in space. The signal will then affect what direction the motors will move.

8.1.2 RESPONSIBILITIES

The signal will need to be used to correctly maneuver the rover.

8.1.3 SUBSYSTEM INTERFACES

Table 10: GPS-RTK subsystem interfaces

ID	Description	Inputs	Outputs
#1	ZED F9 BOARD	Receive signal from antenna	Data sent to F9P board

References

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