DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON

PROJECT CHARTER
CSE 4317: SENIOR DESIGN II
SUMMER 2021

PARKING LOT ROVER TEAM
RTK-GPS PARKING ROVER

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Revision History

Revision	Date	Author(s)	Description
0.0	02.19.2021	SW, LD, BB, AP, MS	Document Creation
0.1	02.28.2021	SW, LD, BB, AP, MS	Initial draft
0.2	03.01.2021	SW, LD, BB, AP, MS	Version 1 Completion
0.3	05.02.2021	SW, LD, BB, AP, MS	Version 2 Completion
0.4	08.02.2021	SW, LD, BB, AP, MS	Final Version Completion

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1 Problem Statement

Parking lot striping has increased in demand with newer buildings requiring parking spaces to be available. Many companies, such as Parking Lot Striping Arlington, use manual machines with hydraulic pumps that can paint a parking lot, but require to be pushed manually. This can be an inconvenience with productivity because some machines can be priced at around two-thousand USD to up to 25 thousand USD. The price of these machines can eat up on a company's profits with labor costs and maintenance costs, especially with the manual machines. An automatic painting stripe rover could actually lower costs in total labor and increase efficiency in parking lot striping with lower accuracy and precision errors.

2 Methodology

In order to decrease the costs of labor and increase efficiency in number of parking lots getting striped, we will be designing and building an autonomous robotic rover. This rover will have the capability of painting stripes on a surface, concrete or asphalt, to create a parking lot, or re-stripe a parking lot if necessary. This rover will be at an extremely lower costs than manual machines, especially since the cost of using it will be reduced with no manual usage. It will know where to paint the stripes by following paths compiled by a base station GPS signal directed from the user.

3 Value Proposition

This project is sponsored by Dr. Christopher McMurrough and Dr. Shawn Gieser at the University of Texas at Arlington. This parking lot striping rover can be a potential business necessity for any parking lot striping company, since there are so many companies and competition is on high demand for a better machine. Our sponsors can benefit from this work because parking lot striping is an important factor for building owners, and finding solutions to creating more parking lots with less cost could extremely raise revenue for companies that get hired by these owners.

If selling this project to the highest offer is not an option, one company can be created and be one of the first to use the technology. Many building owners or parking lot owners would have an increased interest in their company instead of competitors based solely on costs and ease of manual labor. With this current pandemic, some interested customers may even prefer an automated rover rather than a company employee having to control the manual machine to decrease person to person interaction. Thus, this rover could essentially reduce both costs of maintenance and increase productivity for both parties involved.

4 Development Milestones

- Project Charter (Version 1) - March 1, 2021
- System Requirements Specification (Version 1) - March 2021
- Architectural Design Specification (Version 1) - April 12, 2021
- Project Website (Version 1) - May 3, 2021
- Project Charter (Version 2) - May 4, 2021
- System Requirements Specification (Version 2) - May 4, 2021 Year
- Architectural Design Specification (Version 2) - May 4, 2021
- CoE Innovation Day poster presentation - July, 2021

- Project Charter (Final Version) - August, 2021
- System Requirements Specification (Final Version) - August, 2021
- Architectural Design Specification (Final Version) - August, 2021
- Project Website (Final Version) - August, 2021
- Final Project Demonstration - August 2021

5 BACKGROUND

In order to create a sustainable and appropriate parking lot, that follows all regulations of the Texas Department of Transportation, parking lot striping companies and parking lot owners must have precise and accurate stripes. These stripes must be separated by a certain width in order to follow the regulations and allow different type of vehicles to utilize the parking space. The current method of painting these stripes is by a worker pushing around a hydraulic pump paint machine. But these machines are costly, and require a lot of manual labor. Manual labor and the cost of maintaining these machines are costly, especially if one machine requires multiple workers and if various machines are needed to finish striping a parking lot. Because of this issue, this current process of striping is lengthy and expensive for companies that utilize these machines.

When a company is requested to complete a parking lot service, either a new parking lot or re-stripe an existing parking lot, the company must estimate the total amount of paint and labor work needed for the service. The cost of paint needed, the labor, and the cost of the service could equal an extremely large amount of money compared to just the cost of paint and the cost of the service with no labor costs.

An autonomous robotic rover would benefit many companies because it would be capable of doing the same quality job, or even better, than a current manual machine. The rover would have a lower margin of error in terms of accuracy and precision compared to a human maneuvered machine where one slight movement could deter the entire service job. A human-made error could cause the entire parking lot striping job to be re-done if even one foot of a line is not straight because it would not follow the Department of Transportation regulations.

The autonomous rover will allow the company using it to save time and resources with a higher spread of distribution to replace current inefficient machines for companies worldwide. Our sponsor Dr. McMurrough has suggested the idea for this project as a business oppurtinity because of his current connections. He has a connection with a parking lot striping company vice-president in the Dallas-Fort Worth area that could potentially put the rover into companies' future investments list.

6 RELATED WORK

Currently, the most popular method of painting stripes in a parking lot is to use a manual push-based machine that uses a hydraulic pump for high-powered paint expulsion to the surface it is being applied to [2]. These machines are used by many companies and are considered state-of-the art when it comes to quality and work output of striping. Companies in the Dallas-Fort Worth area, for example Parking Lot Striping Arlington [1] and Texas Parking Lot Striping [5] use the same machines as seen on their websites.

These machines with hydraulic pumps are currently the solution for parking lot striping. The downside with this however is they are manual machines requiring a person to push them for the entirety of a parking lot. In addition to this, these machines range in price from around 2,000 USD to 25,000 USD [4]. These prices are very high and can potentially eat into a company's profits depending on how many of these machines they own on top of the necessary maintenance to keep them operational.

In compliance with the government, parking lots must follow ADA compliance. This includes features of the parking lot such as: required number of handicapped parking spaces per lot, parking space dimensions, proper signage, and differing pavement markings [3]. All of these factors should be taken into consideration and with the current provided solution on the market for paint striping, there is significant room for inefficiency as a person has to manually paint and mark the whole lot. This takes a significant amount of time as well compared to an automatic rover that can traverse a layout with given coordinates given ahead of time.

Taking all of the above into account, this is why the industry needs a change that goes in the direction of automation along with price reduction and simplicity.

7 System Overview

In order to implement a solution to the problem of inaccurate and costly parking lot striping, we plan on creating an autonomous GPS rover. This rover would be only controlled by a user interface system, that would require a station that could interact with the rover. This module station will connect to a satellite signal to get an accurate read on the GPS location. This location will then be transmitted to the rover and in specific areas will disperse the paint in order to stripe accurately the parking spots. An employee could set up the location where he would like the rover to work, either through an app on a mobile device or laptop computer. The simple system overview could be seen in Figure 1, that shows the architectural layer diagram.

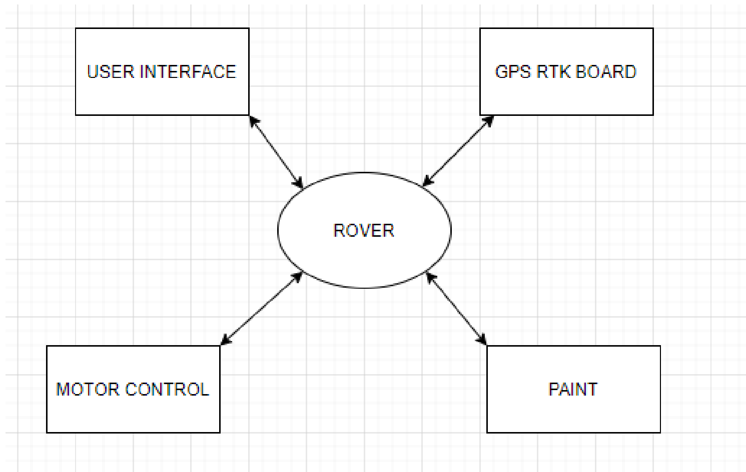

Figure 1: A simple architectural layer diagram

The Central layer, the rover itself, would be the obvious main key component in order to create this project. This rover will utilize a PixHawk that will act as a hub to connect all of the modules needed to each other. The rover will receive signals from the base station for the specific coordinates and area to stripe. This rover will then follow those instructions given by the station, given by the employee or operator. The rover will be fully autonomous, but it could still be controlled manually by a user either through an application on a mobile device or via an external remote controller. For the time being, the rover can be manually controlled through a remote controlled transmitter.

Another key component of the rover would be the module base station that will require a GPS RTK board with connecting minor systems. The main purpose for this is to acquire the rover and parking lot's location, the geographical coordinates, to determine an accurate size and amount of paint that will be needed for striping. The rover will have a base station that will connect with a satellite home base that will be used by a user. A GUI application may be used to send direct coordinates into the rover to determine a smaller area to stripe or for various more purposes that could be determined in the future. The GUI would connect with a Raspberry Pi that the user may also use or the rover operator to add or remove any setting preferences.

A third key component will be the paint layer, which will include the usage of a solenoid valve and other paint components to distribute the paint to stripe the parking lot. There will be a certain hardware and software manipulation that will allow to spray the paint at specific coordinates determined by the base station. It will not spray constantly in order to give space for different parking spaces and to follow the regulations of the Department of Transportation. The paint will be stored in a specific container large enough for an entire parking lot and to be connected to the solenoid valve in order to distribute the paint properly.

The final key component of this project would be the movement DC control motor later. This specific layer will control the movement of the rover. Logical signals from the PixHawk will be sent to the motor controller that will dictate whether to accelerate, turn, or to stop. High voltage batteries will power the motor controllers and the rover motors.

8 Roles & Responsibilities

The product owner will be Dr. McMurrough for the duration of this project. Our scrum master will be Sean-Michael Woerner until further notice. Here are the stakeholders of this project:

Sponsors

- Dr. Chris McMurrough - Primary point of contact. Initial sponsor of the Parking Lot Rover project.
- Dr. Shawn Gieser - Secondary point of contact.

Senior Design I Team Members

- Bryan Bidjocka
- Liliana Diaz
- Abiria Placide
- Mariane Sanchez
- Sean-Michael Woerner - Scrum Master/Team Leader

9 Cost Proposal

The majority of the expenses will be spent on the GPS modules, the GPS RTK board and the PixHawk controllers. These two items will be key components to get accurate striping for the parking lot and to not rely on third party modules for satellite access. Though the rover will be built by the previous team, there will still be some "finishing" touches that may require more components. Our current team will focus primarily on software to control the rover and to distribute the paint accordingly and to create a second base station to connect with the rover and the home base station that receives the main GPS signals.

Table 1: Overview Budget

Component	Cost	Quantity
GPS-RTK2 Board	$219.95	2
Mission Planner Software	$0	1
Antennas for RTK boards	$60(varies)	2
PixHawk Versions 2.1 or higher	$260(varies)	1
Lithium Batteries-12V minimum	$80	2

9.1 Preliminary Budget

Refer to Table 1 for a budget table of components, fabrication, software licensees, development hardware, etc. Budget subject to change with full access to the rover with components subject to change. Thus, the overview budget will change in the near future.

9.2 Current & Pending Support

The current funding sources for the project are provided by the Computer Science Department in the amount of $800. But Dr. McMurrough has suggested there may be more funds available through him if necessary. There are currently no new funding sources available for this project.

10 Facilities & Equipment

Though the pandemic has decreased in person interaction, during Senior Design II, we will have complete access to the provided lab space in room 203 of the Engineering Research Building at the University of Texas in Arlington. There will be multiple tools available, such as a 3D-printer, computers, soldering tools, and safety equipment to follow tool safety use.

In order to complete our project, we will require soldering kit, computer, basic tools, and a heating tool to connect any wires. These will be the main tools that will help in building the rover and will be provided by the university and CSE department. Equipment that will have to be purchased will be spray canisters and containers, motors, micro-controller units, GPS modules, servo modules, batteries.

The wheelchair base has already been provided by Dr. Murrough and is currently a work in process to be a functional rover. We will also purchase two F9P GPS modules with antennas and a tripod to build the GPS base station for the project. In order to do any software or hardware testing, we will have access to oscilloscopes, wires, wire cutters, voltmeters and similar equipment that is available in the lab area provided.

11 Assumptions

- The equipment already built by the previous Senior Design II team will be available.
- A suitable outdoor testing location will be available
- The RTK base station will be delivered according to specifications
- The parking lot will be wide enough for the base station to get accurate signals from a satellite.
- The batteries will provide enough electric current to power the rover.

12 Constraints

- Final prototype demonstration must be completed by August 2021.
- The customer will provide no maintenance personnel to assist in on-site installation.
- Customer installation site will only be accessible by development team during normal business hours.
- The rover hardware will only be available to us after the Senior Design II team is done with the implementation.
- Total development costs must not exceed $800.

13 Risks

Risk description	Probability	Loss (days)	Exposure (days)
Availability of rover hardware due to delay from Senior Design II team.	0.50	20	10
Outdoor testing grounds are not available	0.40	14	5.6
Internet access not available at testing site	0.30	9	2.7
Delays in shipping from overseas vendors	0.10	20	2.0
Bad weather conditions at testing site	0.15	1	0.15

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The Project Charter will be maintained and updated every Friday, starting on February 19, 2021. The initial version will be delivered on March 1, 2021 and the final version will be delivered on August 16, 2021.

14.1.2 System Requirements Specification

The System Requirements Specification will be maintained and updated every Friday, starting on March 5, 2021. The initial version will be delivered on March 22, 2021 and the final version will be delivered on August 16, 2021.

14.1.3 Architectural Design Specification

The Architectural Design Specification will be maintained and updated every Friday, starting on March 5, 2021. The initial version will be delivered on April 12, 2021 and the final version will be delivered on August 16, 2021.

14.1.4 Detailed Design Specification

This project will be maintained and updated at every team meeting where revisions will be discussed. The initial version will be delivered on the March 1st, 2021. The final version will be delivered August 16, 2021.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added as we see fit and the changes needed. Since we will be inheriting the project from a different team, decisions will be made on what to add or remove from the project. Trello is a good platform and we will consider using it to manage our sprints and product backlog items.

14.2.2 Sprint Planning

A sprint will be planned accordingly a week before the end of the current sprint, and before the start of the next sprint. There have been four sprints in the current Spring 2021 semester, and four sprints in the Summer 2021 semester.

14.2.3 Sprint Goal

The spring goal will be determined by our team since no customer will be involved. Though, input from Dr. McMurrough and the Senior Design II team might influence our sprint goals.

14.2.4 Sprint Backlog

Our team as a collective will determine which items make their way into the sprint backlog. The backlog will be maintained using software like Trello.

14.2.5 Task Breakdown

The individual tasks in a sprint backlogs based on team members preferences. We will not be getting any input from a product owner

14.2.6 Sprint Burn Down Charts

Our team as a group will be responsible for generating a burn down chart for each sprint. The burn down chart will be managed on google excel sheets where each member of the team can access it. Figure 1 shows an example burn-down chart.

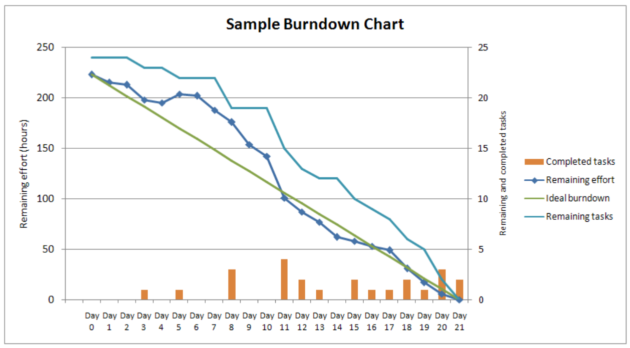

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

The sprint retrospective will be discussed after each sprint 5-7 days after the sprint. As a group we will document want was discussed during the meeting and what could have been improved. As individuals the event and discussion will be recorded in our engineering notebooks.The spring retrospective will be due on March 3, 2021.

14.2.8 Individual Status Reports

Individual status reports will include progress on the tasks given to each team member. They will happen at least once a week. Items contained in the report will include current challenges and successes.

14.2.9 Engineering Notebooks

The engineering notebooks will be updated by all members every Friday during the lab time, 10:00pm - 12:50pm. Each member should strive to fill out a 1/2 - 1 page for each interval. The professor would sign as a witness for each ENB page upon the notebook check.

14.3 Closeout Materials

On top of the major documentation deliverables, a working prototype will be provided to the customer upon project closeout.

14.3.1 System Prototype

In the final system prototype, a working Striping Rover will be demonstrated at a parking on the UTA campus. The rover will have the simple task of striping a parking lot.

14.3.2 Project Poster

The project poster will include a summary of the rover's purpose and background information. Test plans, test requirements and test results will also be included in the project poster with a conclusion of the results. The rover's architectural and design schematic will be in the poster.

14.3.3 Web Page

The project web page would provide specifications on the rover and an overview of the project. It will also include who the sponsors are and the project files. It will be accessible to the public.

14.3.4 Demo Video

The demo video will include footage of the rover doing a task and an explanation of the internals.

14.3.5 Source Code

Source code, if applicable, will be maintained using Git, but it will not be available to the customers. A binary will be available for updating the rover.

14.3.6 Source Code Documentation

Source code documentation will be created using LaTeX and the final form will be in PDF format.

14.3.7 Hardware Schematics

Hardware schematics will be included in the User's Manual that will be provided for future teams.

14.3.8 CAD files

All designs are either electrical or software. So no CAD files will be necessary.

14.3.9 Installation Scripts

Binaries will be provided that can be uploaded to the rover for updating.

14.3.10 User Manual

A printed user manual will be provided but no video setup will be needed since the rover will be already assembled.

References

[1] Line Stripping Arlington. Parking lot striping arlington.

[2] Asphalt Kingdom. Asphalt Kingdom Line Stripers.

[3] National Pavement. Parking Lot Striping: Everything You Should Know, 2019.

[4] New Stripe. Parking Lot Striping Equipment.

[5] Texas Parking Lot Striping. Texas Parking Lot Striping.