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ENTITLED

RSL Autonomous Rover

BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREES OF

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RSL Autonomous Rover

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Submitted in partial fulfillment of the requirements
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Bachelor of Science in Computer Science and Engineering
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Chapter 1

Introduction

The advancement of technology has allowed humans to venture into worlds that 10 years ago would not have even been possible. Increased processing power allows for the creation of more complex control algorithms to manage our evolving systems. These control algorithms may be used in a variety of applications and most notably, the development of autonomous features in vehicles. All vehicles currently have some sort of driver assist function installed: cruise control, anti-locking brakes, and etc. These are pieces of technology that did not exist ten years ago, but now we take them for granted. However, imagine a world where everyone has a vehicle that can reach a destination with minimal human interaction and input. The average American spends approximately 87 minutes behind the wheel each day[1]This is time that could be used for more productive or enjoyable tasks. Autonomous cars will lead to less congestion on our roadways and fewer accidents. Although many like to think that they are good drivers, statistics show that human error is the cause for around 85% of all accidents [2]. These accidentsare usually caused by the driver getting distracted, not adjusting properly to driving conditions or consuming narcotics. The advancement of technology leads to an improvement of life and the dream of self-driving cars are soon to become a reality.

In 2004, the Defense Advanced Research Projects Agency (DARPA) presented a challenge to create an autonomous vehicle with the ability to navigate to different waypoints in a preset course. The challenge was at first unsuccessful, as nobody was able to create a vehicle that was able to navigate the entire course. But in 2005, five teams were able to complete the 130 mile course. Only after one year, there was a significant amount of progress in the field of vehicle autonomy. Imagine what could happen in five. Four states currently have laws that allow for the testing of autonomous vehicles and this number is expected to grow as the technology improves. Google is leading the charge. Their team is headed by 15 engineers, who were people that competed in the DARPA challenge in 2005. Their most recent prototype has no steering wheel or pedals installed; it essentially eliminates the drivers ability to override the vehicles controls. This prototype currently has some limitations, however. It cannot be driven in heavy rain or snow, as those weather conditions interfere with the sensors, and it also has difficulty distinguishing and avoiding potholes and other objects. Google hopes manufacture vehicles that can be used in all conditions.

The motivation behind this project is to use emerging technology in an educational manner to improve the lives of others. Future students and researches will be able to build upon what we have accomplished and make strides to improve this new technology.

1.1 Literature Review

Coming Soon

1.2 Problem Statement

The objective of the RSL Rover is to use the existing drive-by-wire control system and interface for operating an all-terrain vehicle to build an autonomous system for the detection of underground objects. The tasks for the project are three-fold. First, we will implement controllers that will interface with the current system, allowing the rover to be given an objective and independently navigate to complete the task. Second, we will install sensors on the vehicle and develop an algorithm to enhance autonomous driving, and detect underground objects for a variety of applications. Third, we will develop an effective safety mechanism and emergency shutoff method that will prevent the rover from causing injury and damage. The result of this project is a highly capable autonomous vehicle that may be used in a variety of capacities, including the detection of land-mines, underground pipes, and etc, to serve areas that face these obstacles.

1.3 Vehicle Background

This vehicle was originally built to compete in the 2004 & 2005 DARPA challenge by Team Overbot. It failed to qualify for the national competition both years and was eventually donated to a local university where it was used for educational purposes. When the team last year obtained the vehicle, all of the internal components were a mess. They were able to revert most of the changes over the years to set it back to factory standards. On top of that they "...built a hierarchical control system, robust actuator mounts, and an effective safety system" [3] in a flexible manner that will allow for upgrades in the future. With these additions they were able to control the vehicle remotely. Figures 1.1, 1.2 and 1.3 show the existing vehicle.

Figure 1.1: *RSL Rover Side View*

Figure 1.2: *RSL Rover Front View*

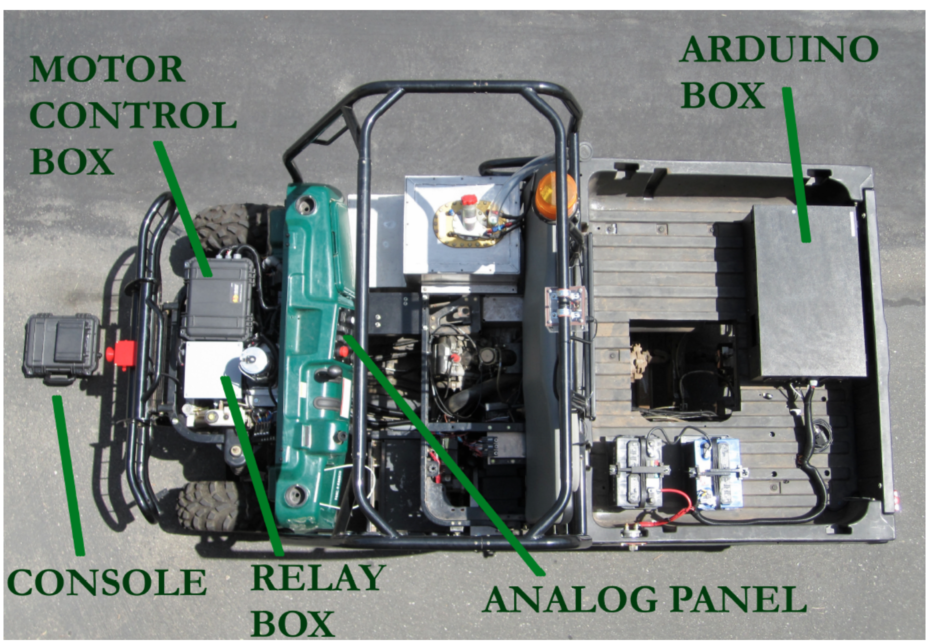

Figure 1.3: *RSL Rover Overhead View*

Chapter 2

System-Level Design

2.1 Overview

The mission architecture of the system is shown in Figure 2.1. This diagram shows the overall goal of the project.The vehicle traverses a field by following a path and avoiding any objects that may be in its way. This will be done with the sensors that are attached to the vehicle, as shown. Information about the status of the sensors, the speed and the vehicles performance will be relayed to the on-board microprocessors (Edison). This information will then be saved and inputted into an autopilot navigation system and obstacle avoidance control algorithm. Multiple Edison microprocessor boards will be necessary so that we do not have any issues with data processing and backlogging. The information saved on the processor will be able to be downloaded as a .txt file to be viewed by the user. This makes troubleshooting easier. A simple breakdown of this process is shown in Figure 2.2. The vehicle will be able to make a decision to change course in a minimal amount of time. Our additions to the vehicle will be able to interface with the previous system. Our Edison processors will interact with the Arduino microcontrollers currently on the board to control the vehicles actuators. Figure 2.3 is the previous years simplified block diagram, and this will help give a general understanding of the entire system.

Figure 2.1: *Shown is system level sketch, or mission architecture.*

2.2 Customer Definition and Needs

The objective of this project is to retrofit the current unmanned land vehicle with sensors and microprocessors to allow the vehicle to have autonomous capabilities. The process of doing so should be well documented and the final product should be easy to use. This is necessary so that future students may use the vehicle with a relatively small learning curve. The vehicle has some built in constraints that are not fixable. These

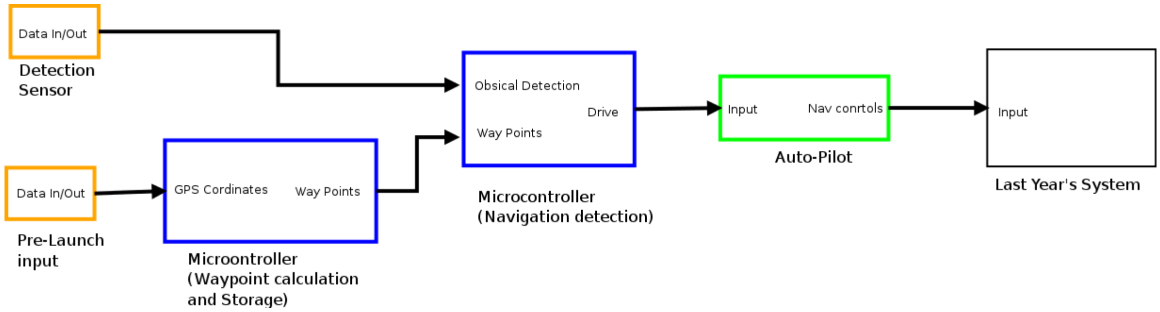

Figure 2.2: *Shown is a simplified component block diagram showing general signal flow. It abstracts away all of the previous years system into a single block on diagram because all work is to be done upstream of their work.*

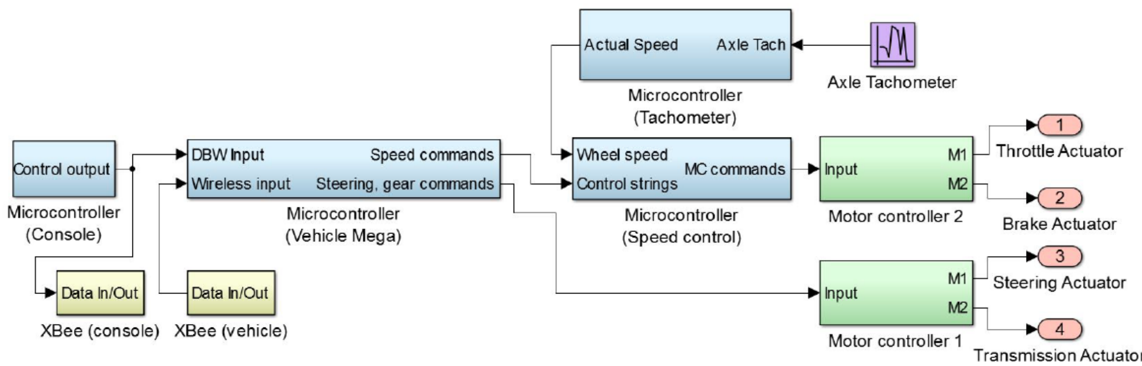

Figure 2.3: *Simplified block diagram of previous work.*

include: the weight, size, engine power, etc. However, the vehicle is still relatively flexible. Our team will be able to customize the type of sensors we use and determine the user interface, the vehicle speed, accuracy, robustness, and cost to fit in line with the customer needs.

There are two customers in mind for our project. The first one is the Robotics Systems Laboratory. Future undergraduate, graduate and Ph.D. students will be able to use the vehicle to expand their knowledge of control systems, vehicle control, and etc. Our second customer is a group of farmers in rural locations in California. Their lack of resources makes it hard for them to compete versus large farming corporations. We hope that our vehicle will be able to assist them in the detection of underground pipes that may be hidden in their plots of land. The final product needs to be easy to use and understandable. Thus, the algorithms used to control the vehicle to be simple and robust enough that users with limited knowledge will not have any issues. A friendly user interface will allow the user to control aspects of the vehicle without actually having to change the code. Quality of the parts is also an issue. We want to retrofit the system with the best parts that our budget allows us; this will decrease the maintenance needed in the future and make it easier for the customer to trust the system. Also, by using parts manufactured by well-establish companies, the components being used will become less likely to be obsolete in the future.

Safety is a large concern for us. Because this system will be autonomous, extra precautions must be takenbecause a mistake could result in a serious injury or even death. Several safety systems will be implemented to protect both the user and the vehicle. These include "dead man" switches that shut off the system if the connection to a sensor is lost, warning signals/sounds from the vehicle, and a maximum speed limit of the vehicle in relation to he environmental conditions and sensor quality. The safety of the end user is our primary concern.

2.3 System Level Requirements

The system requirements from the previous year are still valid. The project will have four focuses:

- Navigation Control: Vehicle will take in GPS coordinates and use those to traverse a plot of land or path. When following a predetermined route, the vehicle will not deviate more than 0.5 meters. A closed loop feedback control system will be implemented to read the feedback and make adjustments if necessary.
- Velocity Control: The vehicle will try to maintain a 10 mph speed which equates to approximately to 3.6 acres per hour. The speed can be adjusted depending on the terrain, weather conditions and visibility. The maximum speed will not exceed 13 mph.
- Sensor Control: Limit the amount of false alarms from the RADAR system to 1%. Sensors will be managed by a control algorithm. The information will be sent to the micro-processors, ideally only one or two sensors per microprocessor to prevent a backup of information. The latency between the sensor and microprocessor should be less than 500ms.
- Interface/Data Storage: To make troubleshooting easy, we wish to have the vehicle generate a .txt file every time the vehicle and status.

2.4 Benchmarking Results

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2.5 Functional Analysis

The project is broken into four major subsystem:

1. Navigation
2. Sensor Interfacing

3. User Interface

4. Safety

All of these subsections are intertwined in some way, but its easier to understand the work that needs to be done on each one if it is broken down. This also helps us prioritize which one these we find the most important and how they affect the other subsystems.

The first subsystem, is the Navigation system. We will be using an off the shelf auto pilot system. This APM comes built in with GPS capabilities and a compass. The APM will be interfaced with the pre-existing Arduinos that control the actuators. The information that is being sent to the APM will be interpreted and used to perform the correct actions.

The second subsystem are how the sensors are going to interface with each other. We will have several array of sensors in order to limit the amount of false alarms and get the most precise information possible. The information will be sent to the Edison boards for processing and that information will be relayed to the APM system.

The third subsystem is the user interface. We want our project to be easy to use for people that do not have a large amount of technical data, so we need to remove any of the unnecessary information that may be presented. We will be using the open-source software that comes with the APM that allows you to set your path. We also will allow the users to pull data from the Edison boards after the vehicle has completed its task for system diagnostics.

The fourth subsystem is safety. This includes hardwires and software automatic shutoffs. Because the system is autonomous we need to have a way to stop the process from a safe distance if the vehicle malfunctions. We will also implement code that will shut off the system if any of our sensors are unable to send information to the Edison. How the wiring is done is also important to safety; it must be made sure that none of those connections will come loose in the driving process.

2.6 System Level Issues and Trade-offs

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2.7 Team and Project Management

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