ECE 445

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RC Car Alert and Detection System

Project Proposal

Rebecca Cole, Sameeth Gosike, Aaron Sowers

TA: Channing Philbrick

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1 Introduction

1.1 Objective

Often, as a user of an R/C car is enjoying driving, the radio signal from the controller may fall out of range as the car drives away from the controller. When the R/C car falls out of range, the R/C car will no longer move and the controller must either walk in the direction of the car, assuming they know where it is, or must go find the car. This problem can lead to user frustration in the event that they lose sight of the car, or that they must retrieve the car in order to operate it again.

Our proposed solution is to implement a range detection and alerting system for the user. The system will determine when the R/C Car nears the end of its range and will alert the user at that time. This prevents the user from unknowingly letting the R/C car out of range. Additionally, the detection system will be able to determine the direction of the car such that the user knows where to retrieve it from if they do drive the car out of range, or which direction they must drive it such that it comes back in range.

1.2 Background

This project is important because it allows for the user to have more knowledge about the vehicle while still maintaining control of the vehicle. When Professor Oelze pitched a similar project with an R/C boat, we identified a few feasibility issues with his project and modified it to allow for it to be more feasible. While an R/C boat range detection is important, it is not easily tested as there not an accessible lake nearby in which to do testing. Additionally, Professor Oelze wanted a system that would return the boat back to him if/when the boat went out of range. Although this is an interesting feature, the internal components of the R/C must be hacked and modified to allow for this to occur. Another issue we identified with this return feature was that it limited the user's control over the vehicle and that the user may not want that function to occur.

Therefore, we modified Professor Oelze's original pitch to adapt to the problems we observed along with what we felt was feasible. In changing the R/C boat to a car, we are able to test in more accessible areas. When we first tested the R/C car range of the R/C car we plan to implement the system on, we observed that the R/C car we purchased has a range of over 40 meters [1]. Through this, we believe that the user can easily lose sight of the vehicle and as such needs a way to understand where the car is relative to them. In implementing a system that detects the relative location of the car, it is less likely that the user will lose the vehicle and that they will have a greater awareness of where the car is.

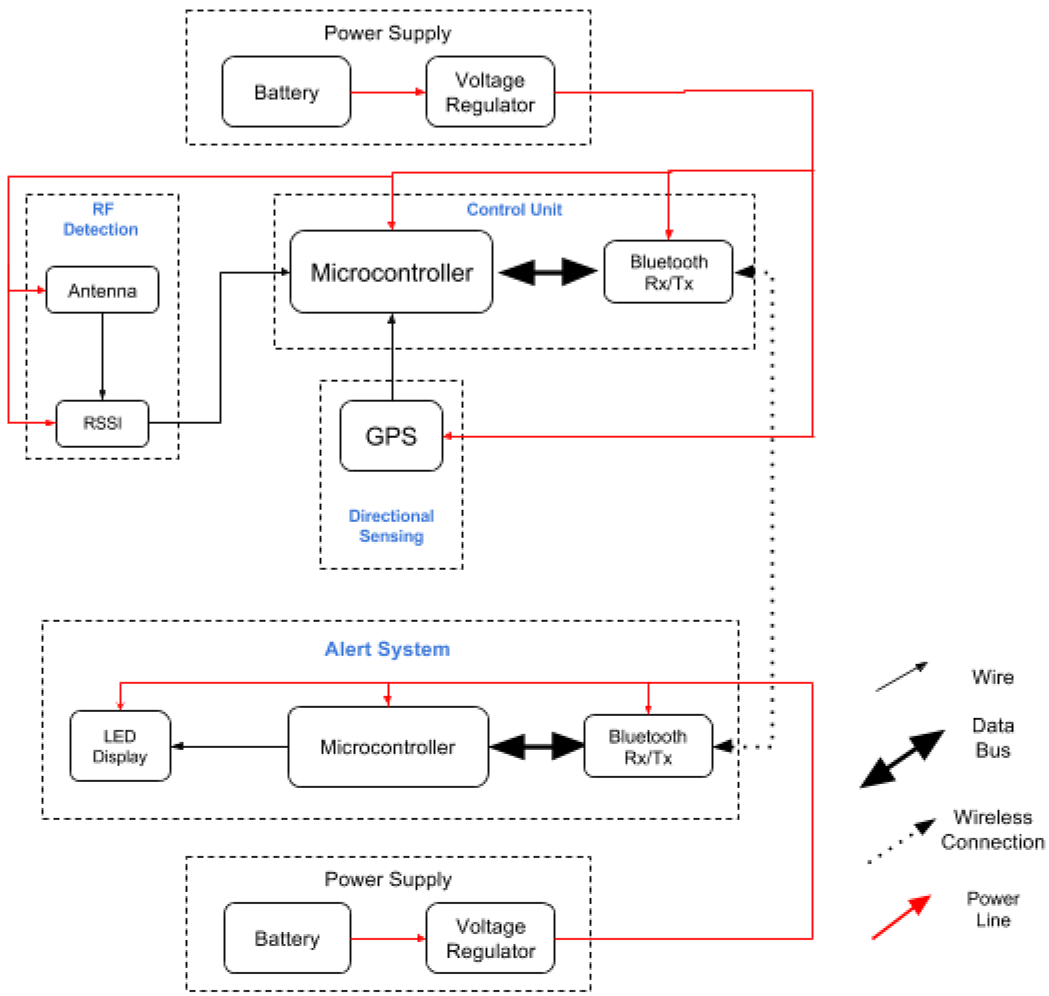
1.3 High-Level Requirements List

For our project, we propose to complete the following three high-level requirements:

1. Detection System - The detection system shall be able to determine the distance from the controller based on the RF signal and shall be able to determine the relative location of the R/C car from the controller..
2. Alerting System - The alerting system should be capable of alerting the user of the R/C car when the R/C Car is nearing the end of the RF range and capable of alerting the user where the relative location of the R/C car is.
3. Communication System - The communication system shall be able to maintain a communication link with the controller over a distance greater than the RF Range of the R/C car (~40m).

2 Design

2.1 Block Diagram



2.2 Physical Design

Figure 2-1 shows the physical R/C Car we will be utilizing for the project. This R/C Car was chosen for its ability to remove the body off of the chassis, allowing for the electronics and battery to be installed underneath such that the system remains discrete in its implementation and operation. Figure 2-2 shows the body separated from the chassis.

For the controller, we will implement a system that can be attached to the current controller. Figure 2-3 shows the controller. The implementation will take into account the orientation of the controller in respect to the user and the size of the PCB board.

Figure 2-1: Physical R/C Car

Figures 2-2 (Left) and 2-3 (Right): The Chassis, Body, and Controller of the R/C Car

2.3 Functional Overview

2.3.1 Power Supply

A power supply is required in both the car and the controller to provide adequate power to each of the blocks and its subcomponents.

2.3.1.1 Battery

The battery must be able to keep the circuits continuously powered during use of RC car, preferably multiple uses.

Requirement 1: The battery must be able to provide at least 160mA at 8.6-9.2V for the duration of 1 hour.

2.3.1.2 Voltage regulator

The integrated voltage regulator supplies the required 3.3 V and/or 5 V to the entire system. The regulator must be able to handle the peak voltage of 9.6 V.

Requirement 1: The voltage regulator must provide 3.3V and/or 5 V +/- 5% from a 8.6-9.2 V source.

2.3.2 Control Unit

The control unit is responsible for obtaining the data from the RSSI to determine RF signal strength as well as from the GPS in order to determine the car's location relative to the user. It will communicate with the remote controller to relay this information.

2.3.2.1 Microcontroller

The microcontroller, chosen to be an 8-bit AVR RISC based controller from Microchip (ATmega328P), will interface with the RSSI, GPS, and Bluetooth modules [2]. It will read the analog signal strength (dB) from the RSSI chip and compare it to a threshold to determine the integrity of the RF signal strength from the controller. The microcontroller is also responsible for relaying the car's location from the GPS relative to the remote controller. This data will be sent via the Bluetooth module to the alert system on the remote controller to alert the user of the car's range and direction.

Requirement 1: The microcontroller must be able to handle peripherals for the RSSI (ADC or Analog Comparator), GPS, and Bluetooth module (UART) [3] [5] [6].

Requirement 2: The microcontroller must be able to refresh the GPS information at a speed no less than 10Hz to keep up with the GPS module's update cycles [6].

2.3.2.2 Bluetooth IC (on car)

The car and the controller will communicate with each other through Bluetooth. The range of the Bluetooth module should be greater than the range of the car, so we chose the RN-41, which has a range of 100 m.

Requirement 1: It must have a greater range than the car.

Requirement 2: It must be able to communicate with the microcontroller over UART.

2.3.3 RF Detection

The remote signal from the controller will be received by an antenna in order to determine the signal strength using a logarithmic detector.

2.3.3.1 Antenna

A 2.4 GHz antenna is responsible for picking up the RF signal from the remote controller. It will be optimized to allow for maximum throughput and maximum range. The range will need to be greater than the range of the car itself.

Requirement 1: The antenna must be matched at 50 Ω +/- 5% between 2402-2484 MHz.

Requirement 2: The antenna must have a greater effective area than the car antenna.

Requirement 3: The antenna must be omnidirectional.

2.3.3.2 RSSI Detector

The RSSI detector must be able to detect signals coming from the antenna at the 2402-2484 MHz range . It will be able to scale the signal logarithmically (dB) to help determine the signal strength [5].

Requirement: It must maintain accurate log conformance for signals in the 2402-2484 MHz range.

2.3.4 Directional Sensing Unit

The location of the car in relation to the controller will be determined using GPS.

2.3.4.1 GPS IC

The GPS IC will be chosen to be similar to the MTK3339 chip on Adafruits FW5632 breakout board [6]. This chip has an update rate of 1-10 Hz. This will provide the user quick enough updates to where the car is in relation to the controller.

Requirement 1: It must have an update rate quick enough to provide meaningful location data.

Requirement 2: It must provide cardinal directions of the direction the car is facing.

2.3.5 Alert System (On Controller)

The alert system will be attached on the controller in view of the user. It will be able to receive data from the car and relay information about the car’s range and relative location to the user.

2.3.51 Microcontroller

The microcontroller here will be the same one used on the car [2]. It is responsible for receiving the data from the car via Bluetooth and sending the correct information to display on the LED display [7].

Requirement 1: Must have peripherals to access LED Display and Bluetooth module (UART) [3] [7] .

Requirement 2: The microcontroller must be able to refresh the GPS information at a speed no less than 10 Hz to keep up with the GPS module's update cycles [6].

2.3.5.2 LED Display

The LED Display will be responsible for giving the user useful information about the car, including if it is about to go out of range and its direction relative to the remote controller [7].

Requirement 1: Must be able to refresh display at at least the rate that new information comes to the remote controller from the Bluetooth module on the car

2.3.5.3 Bluetooth IC

The car and the controller will communicate with each other through Bluetooth. The range of the Bluetooth module should be greater than the range of the car, so we chose the RN-41, which has a range of 100 m.

Requirement 1: It must have a greater range than the car.

Requirement 2: It must be able to communicate with the microcontroller over UART.

2.4 Risk Analysis

The RF detection block poses the greatest risk to the success of the project. Firstly, the antenna must omnidirectional within the 2402-2484 MHz band and have a greater effective range than the car antenna (>> 40 m) in order to pick up the RF signal from the remote controller. It must be matched at 50 Ω +/- 5% so that it can pick up the signal with minimal noise and maximize throughput. These requirements are difficult to meet because it relies on the antenna dimensions and analog frequency design.

3 Ethics and Safety

One of the ethical issues we find with the design and implementation of the R/C car is the user control. We have decided to limit the amount of on board control the microcontroller can have over the car and its ability to direct / manipulate both the motor and the steering. This is because if the car is not properly reading the signal, the user may lose control of the car without their consent and the car can possibly go further out of range. This can also be a safety hazard as there would be no way to stop the car without physically picking up the car while the wheels are running. This would break the IEEE’s Code of Ethics and ACM’s Code of Ethics as it would potentially injure a person [8] [9].

Another ethical issue is that the user must be cognizant and aware that the microcontroller onboard the R/C car is reading the RF signal off of the controller and relaying information back such that the LED can feed information. Since the processing of information includes GPS location and since the perceived GPS signal of the controller provides information about the user’s location, the user should be aware that the information is being utilized.

Due to the use of two 9V batteries in the system, we need to consider the hazard implications 9V batteries pose, especially since one will be located on a moving R/C car. To aid in the safety of everyone using and around the R/C car, the battery will be securely mounted to the chassis of the R/C car underneath the body of the car. This will limit the ability to snag any wires running from the battery to the PCB board and limit the ability for the battery to be jarred off the car and dragged underneath. Additionally, the R/C car will not be operated in environments where there is water. This is due to the limited space availability and the possible inability to waterproof the battery. Since the overall system may have exposed connections to air, and the battery is not to be wet, we do not want the R/C car to be exposed to a potentially dangerous hazard.

4 References

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