ECE 445

Project Proposal

Auto-Returning Remote Control Boat

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1. Introduction

Objective:

Professor Oelze presented what seemed to be a very straightforward problem with a model boat of his to the ECE 445 class. He sails this remote control boat on a lake and while the functionality works well, when the boat runs out of battery or the signal from the remote control becomes too weak, he must physically retrieve the boat from the lake. This seems like a very simple issue which could be solved very easily, but actually demands many core concepts and applications of electrical and computer engineering. In order to tackle the problem at hand we will have to create several different modules which will work to ensure that the boat will return to its designated home location. We will have to create a battery management system. This will be done by making a low voltage detector which will act when the battery supply is low and will be used to guide the boat back to shore. The next key module will be the signal strength detector. This component will detect when the boat is in a low signal range and close to having no signal. The goal of this module will be to stop the boat and return to the home location. It will be guided by an IR Receiver. We also plan to implement a PI Controller. This controller will help steady the boat and provide constant feedback control and tracking of the movements of the boat so it can easily be regulated and steered to shore. All of these components will be complemented and controlled by 2 microcontrollers. This is a high level description of the solution. Each technical component will be discussed in much further detail below.

Background:

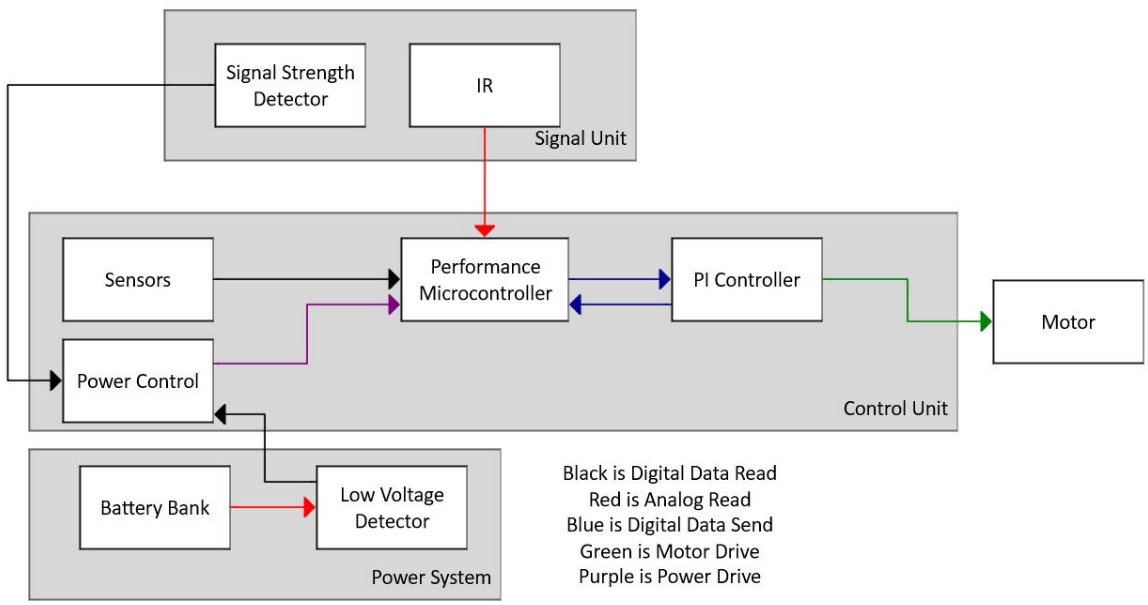
This project was motivated from a real-world issue and can be applied across all children's products. Many of the remote control products are very "low-tech" and have very little fail-safe options for use when conditions are not ideal. When they are used by children they are destroyed after very few uses. This does very little to justify the costs of these products. However, we believe that with some upgrades these types of products can not only last much longer, but also be much more enjoyable when used.

High-Level Requirement List:

1. Requirement 1 is that the boat must be able to detect when it has low battery and be able to have enough reserves to return home.
2. Requirement 2 is that the boat must be able to detect when it is losing signal and be able to reach a stronger signal point or return home.
3. Requirement 3 is that the boat must continue to operate smoothly when either of the previous conditions are triggered and return home.

2. Design

Block Diagram:



PI Controller:

For the control system of the boat we will be using a PI Controller which is the most widely used controller in industry. This controller was chosen because a P Controller was not enough for control of the boat and the PID Controller is unnecessary as the derivative term is not needed. The main benefits of the PI Controller are the eliminated steady state error and the decreased rise time. These capabilities make it the best controller for our boat.

The PI Controller can be built entirely on MATLAB and we plan to place it directly with the microcontroller because they will be directly connected at all times. The PI Controller will also be connected to the motor. The hardware configuration we will utilize will be connecting a Pulse Width Modulator and Electronic Speed Controller Circuit to the DC Motor of the boat. This hardware configuration will give the boat its desired range of motion.

Requirement 1: Ability to find relative distance to shore when triggered by microcontroller *and return to shore*

Requirement 2: Stabilize motion of boat for full range of motion and minor current changes

Power System:

The power system consists of two components:

1. Battery: Six 1.5V AA battery will power the boat and will be connected to the low voltage detector circuit.

Requirement 1: The total output of the batteries must never fall below 5.4 V.

2. Low Voltage Detector Circuit:

A low voltage detector circuit will monitor input from the batteries and communicate with microcontroller to indicate when there is only enough power left for the boat to return to it's starting home location. The circuit will be implemented using resistors, Zener diodes and a battery. Zener diodes unlike other normal diodes, have an added functionality which allows them to conduct electricity in the reverse direction if the applied voltage is reversed and larger than the breakdown voltage.

Requirement 1: The low voltage detector circuit, accurately detects voltage levels within the range of 5.5-9V.

Requirement 2: The low voltage detector circuit successfully communicates with microcontroller when the battery level falls below 5.5 V.

Note: The numbers used in the requirement specifications are based on the conventional battery measurement chart which declares a 1.5V battery outputting 0.9V as dead.

Sensor Unit:

This unit will be a series of sensors used to provide information to the PI Controller. Sensors need to relay information of speed and direction.

Requirement 1: Reliably report the current speed and direction.

Power Control Unit:

This control unit will act to power the Performance Microcontroller when the Low Voltage Detector or Signal Strength Detector has triggered. This will consist of some a trigger detector with memory of which one triggered. If the low voltage detector is triggered the Performance Microcontroller will be powered until it has returned to its starting point. If it's out of range, then once the boat is in range the Power Control Unit will turn off the

Performance Microcontroller so that the user can use the boat again.

Requirement 1: Turn on the Performance Microcontroller when the Signal Strength Detector or the Low Voltage Detector.

Requirement 2: Turn off the Performance Microcontroller when the Signal Strength Detector triggers low if Low Voltage Detector has not triggered.

Performance Microcontroller:

The microcontroller is the primary interface for the control block. This microcontroller needs to be an 8-bit microcontroller to process the Sensor Input accurately. It will only be turned on once the low power microcontroller signals that our performance microcontroller is taking control of the boat, over-riding human input. It interfaces with many parts of our system simultaneously. It's inputs will come from our Sensor, IR unit, and PI control unit. It will output to the PI control unit, and the motor/rudder. The low voltage detector will be used to signal that the microcontroller needs to turn on. This means that once the low voltage detector unit has triggered, the microcontroller will now start reading the input from the other units, as well as perform operations on those inputs. The Sensor Unit inputs will be transformed into a format that the PI Controller can utilize. The microcontroller will also send the information from the IMU to the PI controller for it to calculate our current distance from the starting point. The PI control unit will then send a signal to the microcontroller for it to use in controlling the motor's speed and rudder direction.

Requirement 1: 8-bit Microcontroller needed to process the PI Controller.

Requirement 2: Ability to reliably process and transform Sensor information.

Requirement 3: RAM Capacity of 1kB to store results of sensor information.

3. Risk Analysis

The highest risk in our design is going to come from the IR Unit. IR can be interfered with by numerable things such as rain or the radiation from the sun. This interference can affect the accuracy of the signal, adding error into the control system. Without the signal detection working perfectly, we have no reference of where we are compared to our starting location. Lastly, if the data is flawed we will waste power directing the boat to the wrong location.

4. Ethics & Safety

There are several ethical guidelines from the IEEE Code of Ethics which apply to our project.

We will follow these guidelines as closely as possible. The guidelines include – to be honest regarding all collected data, reject bribery from any source, undertake technological tasks only with the required competence and safety knowledge, not to engage in any acts of discrimination, and assist the professional development of our peers.

There are several safety guidelines that we will adhere to closely as well. First, we will follow all of the given safety guidelines put forth by ECE 445, ECE Illinois, and the University of Illinois while using the laboratory equipment. Seeing that we are also modifying a children's toy with electronics that will be on the water we will take precautions when testing and work under strict supervision at all times.

There are no existing regulations for modifying replica boats, however, there does exist a North America Model Boat Association (NAMBA). This governing body has safety regulations about racing model boats. If there is overlap on any of the technology on our boat with their standard model boat, we will adhere to their regulations.

For testing, we have contacted the Activities and Recreation Center on campus and will look for approval to safely test there.

5. References

http://www.devonbuy.com/checking-battery-voltage-levels/