Boat Navigation and Collision Avoidance System

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Abstract

Currently, there are several ways in which a boat can travel across a body of water, most of which are human driven. Certain repetitive tasks such as taking water samples or dispersing chemicals could be completed autonomously, saving money for a company that would otherwise be paying its employees. Also, some environmental conditions may be hazardous for humans to complete their work. We aim to create a navigational system to autonomously operate a boat in order to improve safety in potentially hazardous job conditions and generate savings for employers. Our design will use several transducers for underwater collision avoidance, along with a Lidar system for above water collision avoidance. Using two compasses, one on the front of the boat and one on the motor, the boat will be able to navigate through the water to a predetermined destination. These compasses will help to ensure that the heading of the boat is correct. This system will also include a program that will plot the course of the boat for later review of the possible position of obstacles. One similar project comes in the form of an autonomous boat traveling across the Atlantic Ocean on a preprogrammed course. The Scout is very similar in accomplishing what we would like to do with our design. The only differences are that we are making a very strong navigation system to withstand harsh conditions, and this boat is traveling a very far distance, where our design won't have enough power to do such a thing. Another project was constructed by Bradley University. In 2013 Bradley University held a competition to create a boat that would navigate a set of buoys without running into them. The focus was to create a pre-programmed boat to obey these commands as well as identify obstacles. Again this design plays a significant role into what we would like to accomplish. The major differences are that this design is set to follow a pre observed course through a set of buoys, where we would like to plot point A and travel to point B avoiding what obstacles it may come across.

Introduction

Prior to designing a solution, the specific criteria and constraints of the problem must be defined. The navigation sub-system must be able to navigate the boat to the desired GPS coordinates with an accuracy of three meters or less. The collision avoidance sub-system must be able to avoid stationary objects above the water with a width of 10 cm or greater and a height of 10 cm or greater above the water, and avoid water with a depth of 1 meter or less measured from the bottom of the boat. The above water components must be splash resistant with an IP rating of IPXX or greater; the below water components must be waterproof with an IP rating of IPXX or greater. Finally, the navigation and avoidance system must be able to run continuously for an hour on a single charge. There were seven criteria, with varying importance, used to choose

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which of the proposed solutions to implement. The most important criteria, with a weight of 35%, is the ability to detect and avoid the shore and shallow water. The location precision of the navigation system is next in importance with a weight of 20%. The ability to detect and avoid above water, or protruding, objects and the overall cost of the system both have a weight of 15%. The final three criteria, each with a weight of 5%, are the ability to detect and avoid underwater objects, the ability to be implemented on boats traveling at a higher speed, and the ability to minimize the inaccuracy due to different weather and water conditions.

The system designed uses signals from several sensors that are placed around the boat. For underwater detection three CruzPro thru-hull transducers are used; one is directed straight down to determine the current depth, and the other two are directed forward of the boat to detect obstacles in the path of the boat. For above water detection a Sick LMS200 Lidar will be mounted on the front of the boat. Two digital compasses are used to detect the current heading of the boat and of the motor; one of the compasses will be mounted on the boat and the other will be mounted on the motor. A GPS will be mounted on the boat to collect the current GPS coordinates of the boat. Two SyREN 25 and 50, motor controllers responsible for the throttle of the boat, or speed, and the direction in which the shaft of the motor will rotate, or direction. But to be safe a radio controlled override system is connected to the controllers to avoid any malfunctions. A netbook running a C# program will be the processor of the system. The system will be implemented on a Pelican Bass Raider 8 boat with a Minn Kota 12 volt trolling motor, both of which the department already has. The boat can be seen below in figure 1 and the layout of the boat can be seen on the next page in figure 2.

Figure 1: Pelican Bass Raider 8 fishing boat

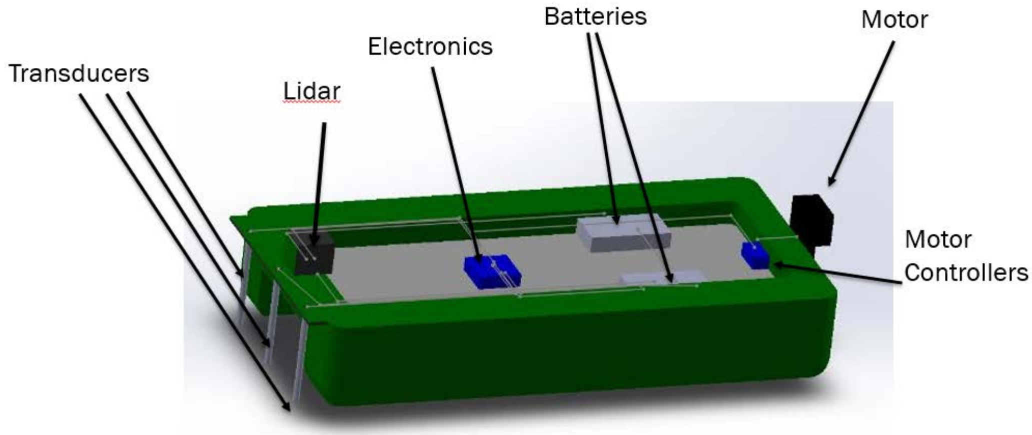

Figure 2: Layout of components

The power of the system is driven by two 12 volt deep cycle marine batteries run in series to provide a total of 24V. The power is distributed by 24V fed to the Lidar, 12V fed to the each of the motor controllers, and 12V fed to the boat motor. The microprocessor of our system will run on the power of the battery. To make sure the power is fed evenly a junction box will run the power to its correct location. Using batteries to provide direct current will cause drain, but each battery is responsible for 115 amp/hours of total use, which is enough to run the system for a feasible amount of time. The layout of power usage can be seen below in table 1:

Table 1: Power Distribution and Component Weight

Device	Fuction	Weight	Voltage	Current Draw
SyREN 25/50	Motor controllers, operate direction and speed	1.9 oz	6-24V nominal, 30V absolute max	up to 10A/25A continuous
SiCK LiDAR RS232	Above water sensor, relay info to avoid obsticles above water	4.5 kg	24 V/ 20 W power consumption	6A
Cruz Pro	Below water sensors, relay info to avoid under water obsticles	.6 kg	12 V max/ 320 watts rms output power	.035A
Samsung N145 Plus	Microprocessor, main gateway of information to direct devices	1.03 kg	19V/ 40 W power consumption	2.1A
Arduino Duemilanove	Controll motor controllers	27 g	min 7V and max 12V	40mA

The control system can be broken into two parts. The first part of the system is the navigation system that operates normally when no obstacles are detected. The system has five inputs and two outputs. The inputs are the signal from the GPS giving the current location, the manual user input for the desired location, the signals from the two compasses giving the current heading of the boat and motor, and a signal from the other part of the program giving if any obstacles are detected. The outputs of the system are for the speed and direction of the motor. The second part of the program is the collision avoidance program. This system has inputs from the underwater transducers and Lidar and has one output signal. The navigational part of the system runs normally, taking a straight line to get to the desired location, but is interrupted when an obstacle is detected. The diagram of the system can be seen below in figure 3:

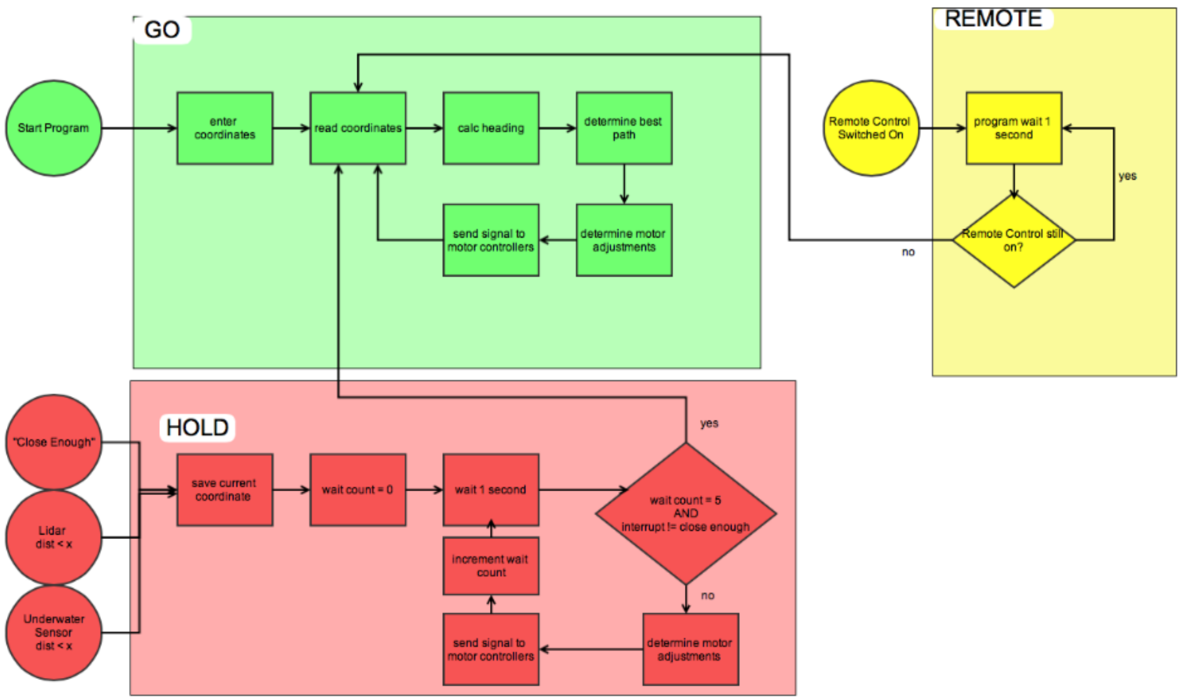

Figure 3: Layout of Control Program Logic

For the system to be considered successful, the system must successfully navigate to the desired coordinates while also detecting and avoiding obstacles. To test if the design successfully meets all the criteria, individual parts will be tested along with the fully constructed system. Prior to installation the underwater components will be submerged in water for 2 hours to ensure the components are waterproof. The above water components will be placed under a shower for 2 minutes to ensure the components are splash resistant. The navigational component of the system will be tested in a small body of water. The coordinates of a known location will be set as the desired location; when the boat reaches its final destination the distance from the exact location will be measured to ensure the accuracy of the system is within 3 meters. To ensure that the object detection and avoidance works, several buoys will be placed in the path between the starting point and the desired location. The system will be successful if the boat does not touch any of the buoys and arrives at the desired coordinates.

At this point in the process, the system is able to be controlled by remote control and user input on a laptop. Currently the sensors, compasses, and GPS are able to acquire relevant data. The next step to completing the project is to have the laptop control the boat without user inputs using the directional inputs from the GPS and compasses. Once this is completed, the sensors will be integrated with the program to allow for obstacle avoidance thus completing the project.