DOLPHIN: AN AUTONOMOUS WATER ROBOT

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ABSTRACT

Dolphin is an autonomous robot that travels on the water. Dolphin is designed to move freely around a small pool or lake while avoiding obstacles. If Dolphin finds a person in the water with its sensors, it will move towards that person and drop off a small life preserver for that person using a small claw. Dolphin will then move away from that person, and will start moving about the pool.

Dolphin was constructed using a NIKKO(C) radio controlled model boat. It is approximately 1 1/2 feet long and six inches wide. Only the hull, motor, and rudder were used from the original model. A Motorola 68hc11 microprocessor and EVBU board were added to Dolphin in order to control the different sensors and behaviors that Dolphin needed in order to complete its mission.

Dolphin contains a Sharp infra-red detector and an infra-red emitter in order to detect objects at close range. To detect people in the water at far range, Dolphin has a Radio Shack passive IR motion sensor. In order to drop off the life preserver once Dolphin is close to a person, Dolphin has a claw mounted on the rear of the boat that uses a Futaba servo. Dolphin also has a specialized marine motor that requires its own power supply and a motor driver that was specially designed for it.

In order to steer in the water, Dolphin uses an electromagnet that turns a small rudder. Since floatation had become a problem with all of the added circuitry and sensors, an inflatable float was attached around the perimeter of Dolphin.

EXECUTIVE SUMMARY

Dolphin is designed to be a robot that rescues people that are drowning in the water. It does this by detecting a person moving on the water with its passive IR motion detector and moving towards the person. When Dolphin sees the person at close range on its IR collision avoidance subsystem, it drops off a life preserver for the person with its robotic claw and motors away from the person. Although Dolphin has no way to differentiate between persons that are swimming and those who are drowning, a robot like Dolphin could still be very useful in areas such as resivoirs or dangerous areas where swimming is prohibited. In such areas, any person in the water an be assumed to be in danger and in need of Dolphin_s help.

Dolphin is made from a radio controlled model boat. A microprocessor and an EVBU board serve as the "brain" of Dolphin and control all of its sensors and features. Dolphin is programmed in IC and uses several IC library files (including the servo and motor functions). Dolphin uses a small propeller and rudder to maneuver around in the water and an inflatable float to give it enhanced stability.

INTRODUCTION

This paper provides an overview of the sensors, programming and construction of

Dolphin. Dolphin_s accomplished goals and experimental reults shall also be discussed. First, Dolphin_s construction will be described. Then, Dolphin_s sensors will each be discussed. The behaviors and programming of Dolphin will then be described. Finally, Dolphin_s experimental results will be described.

BODY CONSTRUCTION

Dolphin is constructed from a Nikko Sea Ray model radio controlled boat. The radio control unit was completely removed from the original boat. The microprocessor was mounted just aft of amidships in the interior of the boat. The top deck of the boat encloses the microprocessor, motor driver, and all other circuitry in a plastic shell that effectively shields the components from the water. The rudder is a large electromagnet that turns either full right or full reverse; it draws about 1 A of current. The rudder was plugged directly into the motor 0 output on the EVBU board and was driven by the L293NE motor driver. The main motor draws about 5 A of current and was thus too powerful to wire to the motor driver. A darlington transistor was used as a switch that connected the motor directly to the battery(see figure 1).

fig. 1: Darlington transistor used for the main motor.

After extensive testing, it was found that the motor discharged the main battery so quickly that IC would crash on the board after a few minutes with the motor running. A separate battery pack was then added to the robot to alleviate this problem.

The IR collision avoidance sensors are located on a pod towards the front of the boat. This pod contains a large multiwire connector that leads back to the LED output and the A/D converter on the HC11. The purpose of this pod is to shield the sensors from the water.

The passive IR motion detector is mounted on a bar going across the cockpit of the boat. This motion detector also contains a speaker that serves as a siren and goes off when a person is detected. This sensor contains its own nine volt battery that is grounded with the other batteries.

Mounted on the same bar but in the opposite direction is the claw attachment. The claw attachment is driven by a Futaba servo. It also uses an independent battery pack. The claw drags a life preserver along in the water until a person is encountered. When a person is found, the claw opens and the life preserver falls into the water.

The addition of all the sensors and the battery packs caused Dolphin to become very heavy. To aid flotation and stability in the water, a bicycle inner tube was glued with epoxy around the perimeter of Dolphin. A complete diagram of Dolphin can be found in figure 2.

SENSORS IMPLEMENTED

Dolphin utilizes Sharp IR detectors and IR emitters to implement collision avoidance. The emitters are connected to 220 ohm resistors and have an effective range of about 1 1/2 feet. These sensors are located in the front of the robot in the sensor pod.

The passive IR motion detector has a range of about 30 feet. This sensor has a small speaker that sounds whenever motion is detected. To interface this sensor to the EVBU, I used the line that turned on the speaker. I constructed a voltage divider along this line in order to get the voltage going into the A/D converter to about 1 volt. The speaker is still wired to the sensor and is a valuable tool in debugging behaviors. The voltage divider is shown in figure 3.

The robot_s claw uses the servo.c and servo.icb routines found in the IC library. The claw is designed to open about 90 degrees and let the life preserver float into the water.

BEHAVIORS

Dolphin_s rescue behavior can be broken down into three parts. The first state is the "watching" state. In this state, Dolphin waits for a person to appear on its motion detector. When something does appear on the motion detector, Dolphin turns on the main motor and enters the "pursuit" state. In this state, Dolphin continues forward until a person is detected on the IR collision avoidance sensors. When a person is detected, Dolphin enters the drop off state. In this state, the main motor shuts off and a hard right turn is executed. The claw then opens up and the raft falls out of the claw. After a specific delay time, Dolphin starts its main motor and begins to motor around the pool, avoiding obstacles.

EXPERIMENTAL RESULTS

Dolphin_s sensors generally worked well and helped it to fulfill its mission. Dolphin_s collision avoidance system could easily detect walls on the IR sensors and would tell the rudder to turn to avoid these walls. Dolphin had limited mobility, however, and would sometimes bump into walls before it would clear them. A typical path for an experimental run of Dolphin is shown in appendix A. The IR sensors were also used to detect when people were at close range during the rescue behavior state.

The motion detector worked very well and was very sensitive, even at long distances. The signal from the motion detector successfully turned on the engines and moved until a person was seen by the IR detectors. The robot arm then dropped its cargo.

The robot arm was also functional, however, sometimes it would open for no reason when the motors were engaged. I believe this was some sort of noise problem interfering with the enable signal.

CONCLUSIONS

Dolphin was a very informative experiment and I learned much about robotics and robot boat behavior. Obviously, to be a fully functional rescue robot, Dolphin would have to undergo many changes. The motion detector would be more effective if it were omnidirectional or rotating. This would allow Dolphin to spot a person anywhere in the pool instantly. Some sort of sonar or radar system might also be more effective for collision avoidance than the IR system that was used. Most importantly, a reverse gear was never implemented on Dolphin, and I believe that this would have made it much more maneuverable. I wish to continue my research with Dolphin in order to implement these changes.

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