Autonomous GPS Robot

Preliminary Design Proposal

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Abstract

This paper outlines our design of an autonomous GPS guided robot. Possible application for our project can be extensive. Although as a stand-alone design our project does not serve any purpose, it could be modified to become a starting point for other designs and has tremendous potential for growth such as an autonomous delivery system. The technology used in our project could be implemented on a larger scale with GPS guided ground or air transportation, security robots or robots to be used in dangerous environments for data collection.

Introduction

This is a good project to get started on an understanding of systems engineering. We are making use of a robotic platform controlled by numerous microcontrollers. The robot will interact with two sonar sensors and an electronic compass. The robot will have to not only get to its destination using GPS coordinates and compass information, but do so avoiding collision with obstacles in its path. Our project involves the control of a robot that is making use of feedback from its environment.

What makes this project interesting is that we have to understand many things related to robotic control. We need to know what kind of environment that our robot will be used in. Will the robot receive a good GPS signal? Will it be able to handle rough terrain? Will there be many obstacles and what size will they be? We also need to understand the specifics of how the sensors interact. We need to know the protocol of the GPS and the electronic compass. We also need to know the timing diagram of an LCD display. Is the speed variable? How is it going to turn? These are just samples of many questions we will have to address during our design.

Many of these questions have been answered in our group and by the advising we have had from Dr. Joon Ho Cho. The harder questions lie ahead and so does many ubiquitous technical problems. But by the finish of this project we should have a much better feel for the field of robotics and systems engineering. Our project does not bring any revolutionary ideas to the table, but it lets us build a complex system (robot) that can do something autonomously and has potential applications.

Background

The core of our project is the Global Positioning System (GPS). **The Global Positioning System (GPS)** is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters. GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. And that makes the technology accessible to virtually everyone.

These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, even laptop computers. Soon GPS will become almost as basic as the telephone. Indeed, at Trimble, we think it just may become a universal utility.

Design Criteria

The design of our robot consists of four inputs, a master PIC and two outputs. The four inputs are: GPS, electronic compass, keypad and sonar. The two outputs are: LCD and motor control.

Explicitly, what our robot does is it receives input of destination coordinates from a keypad in the form of latitude and longitude coordinates. It then proceeds to those coordinates. The sonar alerts the robot to any obstacles in its path when it's on its way. The robot then activates its collision avoidance subroutine. When it is clear of the obstacle it then proceeds on to the desired coordinates.

When the robot reaches the desired coordinates it beeps, resets and waits for the next coordinates to be input to the keypad.

Collision avoidance will be implemented with use of two sonar detectors. First one, stationary sonar, is located so it is able scan in front of the robot. Second sonar is mounted on the servo motor on top of the robot. This sonar will point towards the destination coordinates at all times independently of where the robot is facing. Optimally, both sonars point in the same direction meaning that the robot is moving straight towards the destination coordinates. If the robot is in the middle of a collision avoidance operation, the secondary sensor will continuously check the desired direction for obstacles. If no obstacles are in view of the robot in the direction of the destination coordinates, it will stop its current motion and reposition itself to face the destination location.

Design Issues and Considerations

The design issues involved are basically broken into two categories: The interfaces and the control algorithms. The interfaces involve the PIC successfully communicating with the peripheral devices. The algorithms involve the processing of the received information and outputting the proper control.

There are two main algorithms associated with the project. The first is the control algorithm. This is the algorithm that takes the current coordinates and direction and correlates them with the desired coordinates and direction to output proper robot control, such as should it turn, proceed forward or stop.

The second main algorithm is the collision avoidance algorithm. This will handle how the robot behaves in the presence of an obstacle. How far should it turn and long should it drive to avoid the obstacle?

One serious consideration is the GPS accuracy. We've mapped out the engineering quad with the help of Professor Wolf and we found that the quad was roughly divided into a 4 by 6 grid. This was a quick look at its accuracy and it still remains to be seen if we can obtain more optimal resolution.

GPS Details

The GPS is a main factor of a project. It is the component that provides the robot with its position that it can decide which direction to go. So in this section we're providing a little background on the GPS.

The accuracy of GPS today is better than it was more than two years ago when the government made use of Selective Availability. This was put into practice as a defensive maneuver to dissuade technologically-minded zealots from targeting installations with GPS. The error with selective availability was around 100 meters. But thankfully for our project selective availability is no longer in practice and this provides us with an accuracy of hopefully within ten meters. But accuracy is highly variable depending on several parameters so we'll have to wait and see.

There are two ways to increase the accuracy of your GPS unit and these are Wide Area Augmentation System (WAAS) and differential GPS. Sadly we're not able to make use of either one. We cannot use WAAS because of its limited availability. Currently WAAS uses two geostationary satellites, neither of which we would not be able to receive on campus because of ground obstructions and relatively high longitude of our geographic location. We also cannot make use of differential GPS because we do not have access to a differential beacon, which are more widely available in seacoast areas for use in naval navigation.

As mentioned above, our GPS uses a widely understood and documented protocol called NMEA (National Marine Electronic Association) 0183 ASCII interface. We have already activated the GPS unit and decoded its output with NMEA specifications. We've only made use of it in the basement where it gave us a read out of 2503.7182N and 12138.4141E. Which are highly suspect coordinates because of the lack of reception in the SDP laboratory.

Conclusion

Our robot presents many interesting problems for us to tackle, such as the interfaces that we have to implement and the control algorithms that we have to write. The robot itself presents challenges such as how to keep it powered and how to control its turns. All together this project should be a good introduction for all involved into the basics of GPS and also robotic control.

Our goal for the end of the Fall 2003 semester is to have all our components (user interface, GPS, electronic compass, and the robot base) interfaced with the microcontroller so that information from each of the component can be taken in and processed. We will also have the robot-base activated. The mechanics of the speed and turning of the robot will be fully understood and implemented.