GOLFER

The Golf Putting Robot

Written

By
Wing Pan Yuen

For
EEL 5666
Intelligent Machines Design Laboratory

December 05, 1999

Table of Contents

Abstract

The objective of my design is to build a robot that will simulate a golfer playing a game. Rather than unrealistically simulating the whole process of playing a game, this robot will only simulate the putting portion of the game. Of course, assuming the fact that the golfer has successfully put the golf ball onto the putting surface. I shall construct a robot that will successfully search a golf ball, then aligns the golf ball to the cup, and finally putts the golf ball into the cup.

Introduction

Today golf is getting more popular than ever. The game used to be for the rich and famous who can afford to play the game. And that is still true for most of the countries beside the US. Because of recent increase in popularity and decrease in fees, more and more people are starting to play, and enjoy the game. And people from all age spectrums are participating. Golf is the kind of game either you absolutely love or totally do not care for it at all. The robot that I am constructing is not intended to have any practical usage. It is not a device that will help golfers to improve their games. However, it is a robot that will certainly entertain it's audience.

The robot, Golfer, shall be constructed as a rolling device. This means the robot will only travel on ground, more specifically, on flat surface such as a tiled floor. In addition, Golfer is intended to be operated in a controlled environment. The location should be indoors and has a limited boundary. There should be no obstacles, other than the golf balls and the cup themselves. Upon power up, Golfer shall search for one of the golf balls. After successfully located a golf ball, Golfer shall travel towards the ball until it reaches the destination. Golfer shall then search for the cup. Then, it shall align the ball with the cup. And finally, it shall putt the ball into the cup.

Executive Summary

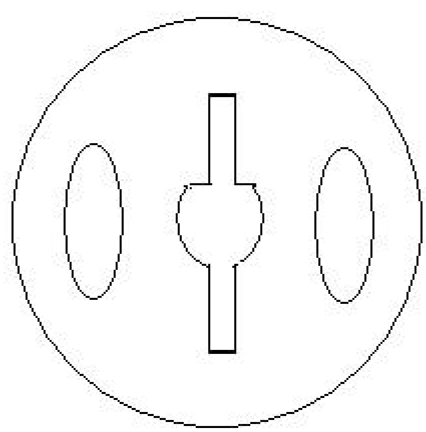
The robot, Golfer, was able to perform the tasks successfully. It was able to randomly search for a golf ball. This is activated by putting the robot in run mode and turning on the power switch. Because of the design, the robot travels in a moderate speed in the search mode. The reason for doing this is because to much speed will allow the robot to strike the golf ball out of range. After successfully detected the golf ball. This detection is accomplished by utilizing break beams underneath the robot. When the golf ball interrupts the IR beam, it transmits a signal indicating a golf ball in located. With the golf ball in the correct location, the robot then rotates in the clockwise direction. The robot is equipped with a different IR for golf cup alignment. When the collimated IR detector detects the IR signal from the beacon that is located at the cup, the robot realizes it is lined up with the cup. It then terminates moving clockwise. At which point the robot will use the putter to strike to golf ball into the cup.

Integrated System

The electronic aspect of the Golfer will be fairly simple. Other than the swinging arm that putts the golf ball into the cup, the rest of the electronic components will be the same as those used by the Talrik robot, except the fact that these components will be solder onto the TJPRO printed circuit board. The Motorola MC68HC11 CPU will be used as the main processor. The RAM memory has also been expanded to 64K. Golfer also contains two(2) 40KHz IR sensors for collision avoidance, two(2) servo motors to drive the wheels, one(1) servo motor to control the swing arm, two(2) 40KHz IR sensors for the break beam to identify the golf ball is in the proper position, (1) 32KHz IR sensor for cup alignment, and a battery pack to supply power to the circuit board and the servo motors. Furthermore, there will be a beacon to identify the cup. It is 32KHz signal that is generated by a 555 timer with 9-volts DC battery for power supply.

Mobile Platform

The body of the robot, Golfer, will be very similar to the one used by the Talrik. If a matter of fact, majority of the platform will be the same. However, there are some differences. In addition to the Talrik platform, a swing arm will be added to the robot so that Golfer could complete the task of putting the golf ball. And the swing arm will be mounted in the center of the robot. Furthermore, two (2) IR break beams will be employ to detect the golf ball. And these break beams will be mounted underneath the robot. Also under the robot, guardrails will allow the golf ball to be guided towards the center of the robot so that the putter will be able to strike it. The guardrails will be positioned in 90 degrees. This design will enable most of the golf balls that are in front of the robot to be lead to the proper position. The putter will be mounted in the center of the robot. The length of the swing arm will be 15 cm. Because the location of the putter, the original Talrik platform will be modified to accommodate this requirement. The center of the platform has to be cut in order for putter to be able to swing freely along the robot heading direction. The height of the platform also has to be adjusted so that the golf ball could fit under the robot. Larger wheels will be used instead of those that were used on the Talrik platform. The reason that this platform is chosen is because it has been used for a long period of time, with proven structure integrity and reliability. There are also other benefits associated with this platform. It is very compact and lightweight. It makes the transportation of the robot very easy.



Top View Of Talrik Platform

Actuation

The mobility of the robot is driven by two servos, which are connected to two wheels. These standard servos were purchased from the IMDL TA. They are fairly inexpensive comparing to the ones that are sold in local hobby stores. These servos were hacked to enhance their functionality. In addition, a third wheel is constructed for stability without servo control. And this third wheel could be purchased from a local home improvement store. The motorized servos are controlled via pulse width modulation (PWM) to provide power, speed, and rotation direction to the wheels. This allows the robot to travel in straight line, changing direction, or traverse at a fixed location. The robot also equipped with a swing arm. This swing arm is also controlled by one of those standard servos purchased from the IMDL TA. But unlike those that were connected to the wheel, this servo is not hacked. After the robot successfully aligned the golf ball to the cup, then the motorized arm provide enough power to hit the golf ball to the cup.

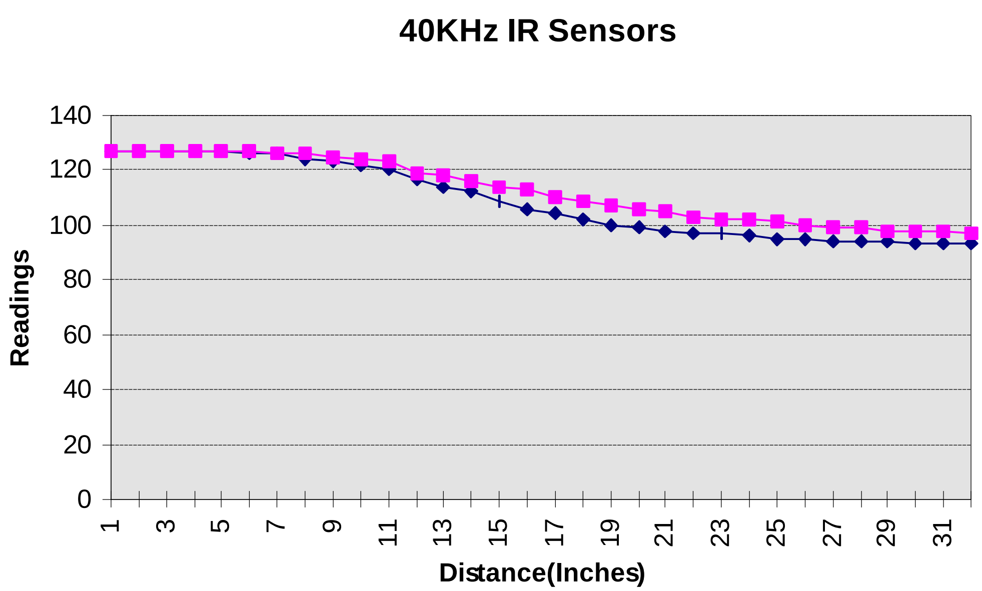
Sensors

<u>Scope</u>

The robot, Golfer, employs two types of sensors to achieve its functionality. It utilities Infrared Sensors (IR) for collision avoidance. The robot is also equipped with break beams to allow the robot to determine whether the golf ball is locate in the correct position for the putter to strike the ball. And finally, the robot has another Infrared Sensor (IR) with different frequency to enable the robot to detect the beacon signal, which identifies the cup.

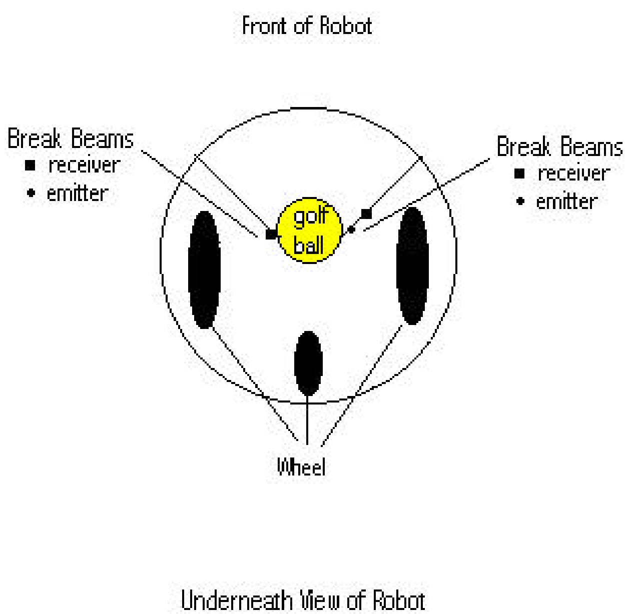
<u>Infrared Sensors</u>

The Infrared Sensors (IR) are comprised of two components. One of the components is the IR emitter, which emits 40KHz infrared signals. And the other component is the IR receiver, which could be logically concluded to receive the 40KHz signal. The IR detectors I purchased are digital devices, they could only produce digital outputs. With the help from the IMDL TA, I was able to modify the IR detectors to make them analog devices. This modification allows me to detect objects and determine how far they are away from the robot. After a few experiments, the resulting data indicated the range of values these IR sensors have varies between about 90 to 127. The main purpose for the IR sensors on the robot is to give the robot the capability to detect objects for collision avoidance. The IR emitters emit signals that will be reflected from the boundary wall of the controlled environment. This allows the robot to calculate the distance between the boundary wall and itself. If the robot concluded that it's too close to the wall, it will then turn the servos to distance itself from the wall. There are total of two pairs of IR sensors constructed on this robot for collision avoidance, each comprised of a emitter and a receiver.



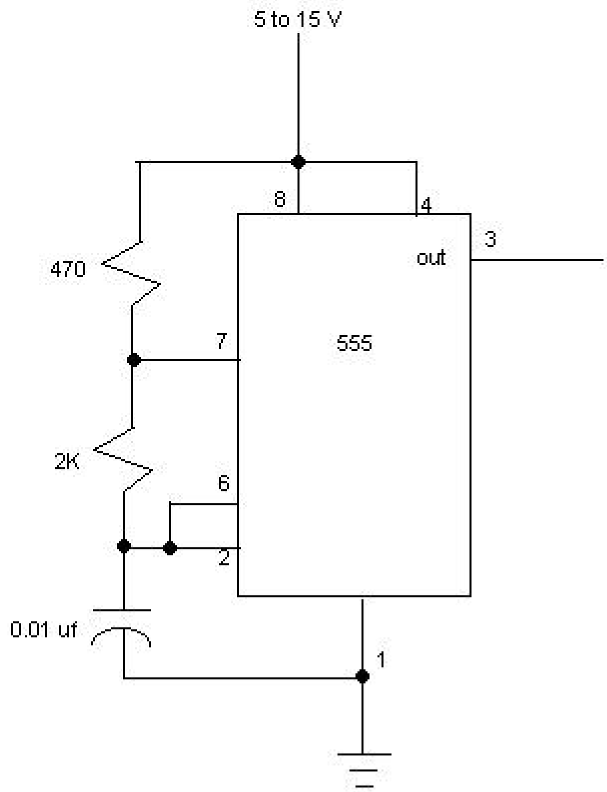
Break Beam

A break beam is an LED device that allows the robot to determine if the golf ball is in the proper position, so that the putter could strike the ball. When the robot maneuvers over the ball, the golf ball will in term in position to break the beam signal indicating there is an object under the robot. This sensor ensures that the golf ball is in a position that the putter can reach. I also chose the 40KHz IR emitters and receivers for the break beams. The reason is being these IR sensors are readily available and very inexpensive. Because I used both 40KHz sensors for both collision avoidance and break beam, there could be potentially interference. To solve this problem, I chose to position all the IR for collision avoidance on the top of the platform, and position the IR for break beams underneath the robot.



Beacon

The Beacon also has two components. It has an emitter, which emits a different frequency signal comparing to the IR that is used for the collision avoidance and break beams. Instead of emitting a 40KHz signal, it emits a 32KHz signal. And it has a receiver to detect the signal, just like the collision avoidance IR. The emitter utilizes a circuitry that employs a 555 timer to generate the 32KHz signal. The reason this is chosen is because this allows the robot to distinguish between the signal from IR that is for collision avoidance and the signal for identifying the cup. In addition, 32KHz receiver are widely available. The beacon enables the robot to identify where the cup is and allows the robot to align itself with the cup after it successfully captures the golf ball. It acts as the flag that is located in the middle of cup.



32KHz emitter for the beacon

Behaviors

Scope

The robot, Golfer, has four primary behaviors. They are collision avoidance, locating a golf ball, aligning with the golf cup, and putting the golf ball. The robot utilizes IR to determine whether it is too close to the boundary wall. If in fact it is too close, the robot will then apply a signal to the processor to change the direction of the robot.

Collision Avoidance

One of the basic behaviors of Golfer is collision avoidance. This task is accomplished by using two 40KHz IR sensors mounting in front of the robot. One of the sensors is located on the left and the other on the right. When any one of these sensors detected that there is a wall in front of the robot, it will then reverse one of the servo motors to change its direction. When the right IR detected an obstacle, the left servo will reverse its direction to cause the robot to turn left. And the left IR will function the opposite way.

Golf Ball Fetching

The primary electronic component that supports the ball-fetching behavior is the break beams. There are total of two break beams. Both of them are mounted on the guardrails that are located under the robot. These break beams employs the standard 40KHz IR sensors. When a golf ball interrupts the signal on the break beam, it informs the robot that a golf ball is detected. At which point the robot is going to terminate its motion. Because these IR had been modified to produce analog outputs, it is then fairly easy to determine how far the golf ball is. A timer is also included in the software to allow the robot to go in a random direction when the robot is unable to locate a golf ball after a set period of time.

Golf Cup Alignment

After successfully located a golf ball, Golfer will then try to locate where the golf cup is. This task is accomplished by using a 32KHz IR sensor. The IR receiver is located on the robot and the emitters are located at the golf cup. The receiver is mounted in the front and middle of the robot so that the golf ball will be able to align with the golf cup. The robot will rotate clockwise until the golf cup is located.

Golf Ball Putting

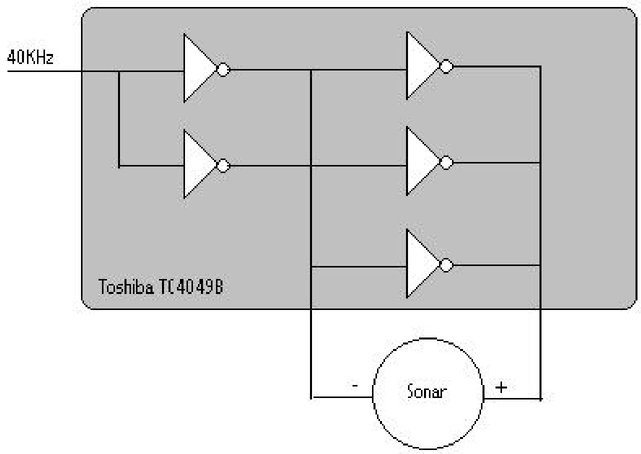
The robot will stop completely after alignment with the golf cup. The only thing left to do is to putt the golf ball. To do that, Golfer sends signals to the servo that is attached to the putter to swing back and then swing forward. This allows the putter to strike the golf ball toward the golf cup.

Experimental Layout and Results

Sonar Sensor

I originally intended to employ a sonar sensor to locate the golf ball. I constructed the sonar receiver unit using the sonar receiver board that was fabricated by the T-Tec machine in the IMDL Lab. I was very disappointed to discover that the range of the sonar signal that reflected off a real golf ball was less than a foot. Comparing to the other students in my class who are using sonar sensor, they were able to get distance over 10 feet. It led me to believe that there was probably error on the receiver board. But after spending sometime troubleshooting the sonar receiver board, I was unable to isolate the cause. Therefore, I decided to change the Maxim 266 filter and that did not improve the result. My suspicion was that something on the T-Tec generated sonar board was causing the problem. And I logically constructed another sonar receiver board without using the T-Tec board. This newly constructed receiver was not giving me the desired result neither. But with limited time, I had to give up the idea using sonar sensor.

Other than the sonar receiver board, there was also problem associated with the sonar emitter board. The existing design, using an audio transformer, apparently generates too much heat. Causing the circuitry to overheat. I was able to find out from a classmate that Eric Anderson, a former student in this class, has an alternative design that does not have the overheating problem. After successfully constructed the emitter unit, I was able to verify the functionality using the oscilloscope.



Sonar Emitter Schematic

<u>32KHz IR Sensor</u>

I chose the 32KHz IR sensor for golf cup alignment. After the robot successfully located a golf ball, it then uses this sensor to line up with the golf cup. However, during testing, I found out that there were interference between the 40KHz IR and the 32KHz IR. Fortunately, because those sensors are used in different phase of the robot behavior, the robot was able to perform its tasks without problem.

<u>Putter</u>

I initially designed the putter with a fairly short moment arm. I was hoping the servo would generate enough speed to strike the golf ball for a long distance. But to my surprise, the servo can only produce very limited speed. The result was that the putter could only putt the ball for about a foot. I was forced to resign the length of the putter. I increase the length of the swing arm from 4.5cm to 11.5cm. With this change, the putting distance appeared to increase substantially.

Authentic Golf Balls

During early stage of this class, I decided to use the real golf ball. However, during the testing phase, I discovered that a real golf ball did not have enough friction for the tiled floor. Rather changing the operation environment for the robot, it was more efficient to use other types of golf balls instead. I was able to find some foam golf balls in a local discount store. Furthermore, these golf balls have the same dimension as the real golf balls and worked out very well for this application.

Conclusion

Overall, I really enjoyed this course. I am very excited that I was able to construct a robot that could complete its tasks. Not only was I able to learn the hardware aspect of constructing a robot, I was also able to integrate the hardware with the software. I fact, I had improved substantially in soldering. I had also learned that communication is a very important part of this course. In several occasions, my classmates had made some very good suggestions that helped me solve some difficulties. It is safe to say that without their assistance, I probably would not have completed the task of constructing a fully functional robot. Another point that I like to mention is that my time management needs to make some improvements. Although I was able to finish my project, but large portion of the work was done in the last two weeks of the course. It is advisable one should establish a schedule and attempt to follow it closely.