Date: 4/19/2011
Student Name: Paul Earley
TAs : Devin Hughes
Tim Martin
Ryan Stevens
Josh Weaver

Instructors: Dr. A. Antonio Arroyo
Dr. Eric M. Schwartz

University of Florida
Department of Electrical and Computer Engineering
EEL 4665/5666
Intelligent Machines Design Laboratory

Formal Report

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Abstract

My autonomous robot is a four legged (quadruped) walker, named Karlor. The robot will be able to roam around a room by itself avoiding obstacles, and use an attached Bluetooth device to be able to find its target, and interact amusingly, through interpretative dance.

Each of the four legs has three servos giving three degrees of freedom. For navigation, Karlor uses two sonar sensors. The mobile platform was designed in SolidWorks in order to be created using T-Tech.

Executive Summary

Karlor is a four legged walker. The main challenge with a four legged walker is balance. One of the main drawbacks of a four legged walker is limited amount of gaits you are able to design due to needed to keep three legs on the ground at all times in order to maintain balance. However, they are much cheaper to make than a hexapod. This was my main reason for wanted a quadruped over a hexapod. Additionally, quadrupeds do not have the power issues or the need for higher torque servos to combat the weight that are generally a problem with hexapods.

Introduction

My proposed autonomous robot design is a quadruped with three degrees of freedom on each leg. Three degrees of freedom allows Karlor more flexibility with gait design, and also allows the walking motions to look more natural than a simple two degree of freedom design. The legs are controlled with a PVR Xmega128a1 microcontroller board using a table lookup method.

Table lookup is a simple way of allowing multi-legged walkers to move. As the name suggests, there is a hardcoded table that the robot goes through in order to move. For example, the "foward" routine that Karlor has goes through the motion for each leg and how and where it lifts the leg and where it should be placed. This methods takes a lot of time, but had a pleasing result.

It also has a Bluetooth module attached to be able to link up with another robot and allow the two robots to dance together. Once Karlor starts to walk, he will send a letter "Z" to Josh Du's robot, HexKitt. HexKitt will then send a confirmation letter "A" that he is ready to dance, and both robots will begin their dance sequence at 120 beats per minute.

Additionally, sonar sensors will also be used for general obstacle avoidance. Locomotion will be achieved through the use of HS-485HB servos that will be controlled using a table lookup method.

Integrated System

Karlor uses the Pridgen Vermeer Robotics Xmega128 microcontroller to control devices including multiple sensors and servos. Since the robot will be a quadruped with four legs that have three degrees of freedom, there will be a total of 12 servos used to provide locomotion for the robot. Additionally, there is a Bluetooth module which allows for short ranged wireless communication, and two sonar sensors which allows for simple obstacle avoidance. Figure 1 below shows a flow chart for the physical components.

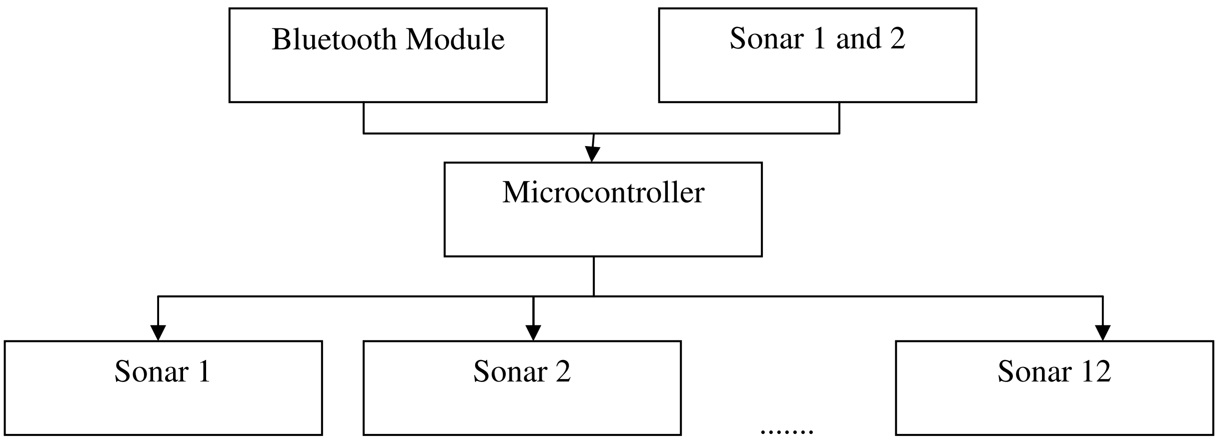


Figure 1: Flow Chart

Kalor will read information from the sonars or from the Bluetooth module and then act accordingly. Karlor can also send information from the Bluetooth, as communication can commands from Karlor or from Hexkitt.

Mobile Platform

The robot platform was design in SolidWorks. The platform needs to be small, lightweight, and in our case, made out of wood. Wood had some limitations, specifically when trying to design a two degree of freedom leg, but overall was a very easy to use material. Figure 2 below shows the design in SolidWorks, and Figure 3 shows the actual robot wood cutouts.

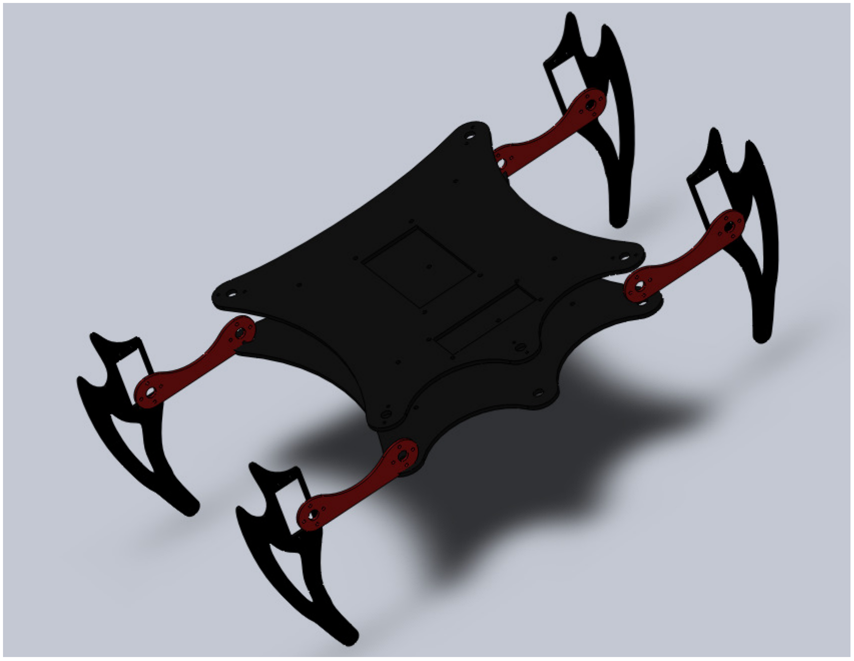


Figure 2: SolidWorks Design

Figure 3: Wood Cutouts

Actuation

Each individual leg has three degrees of freedom thus requiring 3 servos each. The servos that will be providing the leg movement will be the Hitec HS-485HB servos. The legs are controlled through table lookup which allows for a simple method for each leg to be "looked up" in a table for each routine.

Sensors

There are two different types of sensors on this robot. These include two sonar sensors, as well as the Bluetooth module. The sonar sensors will be used for general obstacle avoidance. The Bluetooth module, will be used to connect to Josh Du's Hexkitt and allows from them to communicate.

The two sonars are the EZ1 modules available all over the internet. This are very inexpensive yet very effective sonars. Sonars were chosen over IR sensors purely from an expandability standpoint. If, at some point in the future, I want to take Karlor outside and allows him to walk, sonar sensors are much more effective because they do not have the interference with light that an IR sensor would.

The other sensors is the BTM-182 Bluetooth available from Sparkfun.com. This module was also very cheap but was extremely each to set up and connect to other Bluetooth modules. This also has expandability options as I can control Karlor with my computer, and hopefully in the future, with my Bluetooth enabled. iPhone.

Behaviors

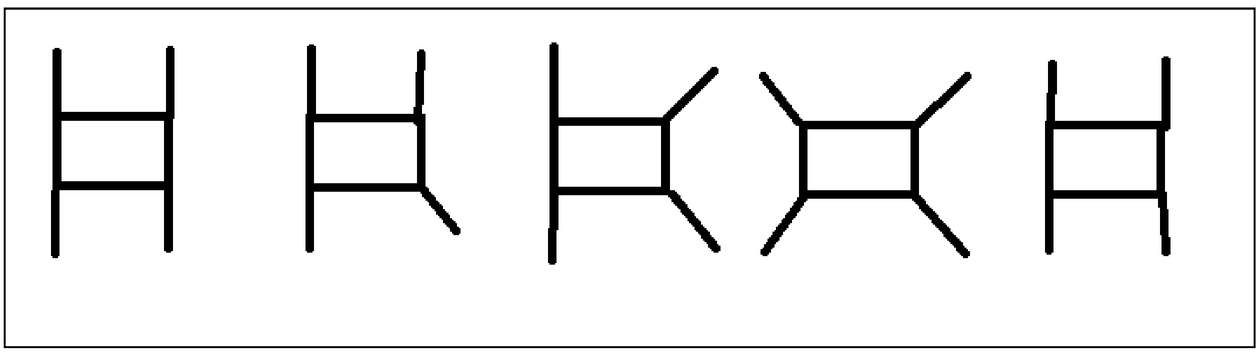
Karlor's behaviors are very simple. After he is switched on, he will lift himself up and quickly begin his walking routine. He will roam around, avoiding everything in his path, until he randomly decides to send a "Z" to his partner, Hexxkit. Hexxkit sends a command back and the two robots go through their dance routines.

Currently there are several routines including; forward, reverse, sideways left, sideways right, turn right, and turn left. There is also a dance routine used to interact with Hexkitt.

Experimental Layout and Results

Karlor's main objective to find the required object depends solely on his ability to walk. Currently, Karlor moves not through inverse kinematics (which offer a much more robust means of maneuverability and flexibility), but more through a guess and check. All the motions are hard coded into Karlor, and when something is detected, such as a wall, Karlor simply goes into an "if" statement which will turn himself around. While this works easily enough, there are certain balance issues, as well as robustness issues. I'm currently working on implementing a inverse kinematic method, but that is both very complicated and time consuming.

Currently, Karlor walks forward through four main "states";



Conclusion

Having only built one robot before that used wheels for locomotion, I am nervous about how difficult the process will end up becoming. Locomotion will make or break my robot, so I will have to be sure to fine tune movement. The largest mental roadblock to this project is the cost. Since it's a quadruped and will require 12 servos for leg movement. Most of the cost is going to go into buying the servos.

What I enjoy most about this project is the expandability that it offers. I'm currently working on a program to connect the iPhone to the Bluetooth on Karlor and control him in this way. The iPhone Bluetooth, as I have found out, is not very good and very finicky.

Appendices

The code for this project is far too long, and is located on Karlor's website:
https://sites.google.com/site/paulerly/