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Formal Report - HexaBob

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Abstract

My autonomous robot, HexaBob has the capabilities to detect a requested object, locate its position, and move over to the object or avoid the object depending on the desired behavoir. It is also able to avoid obstacles using an array of IR sensors and a bump sensor. Movement is handled by a total of 18 servos mounted on the legs that are controlled using preprogrammed gaits. The mobile platform was designed in SolidWorks in order to be created using T-Tech. The special sensor is a wireless camera that communicates with my laptop to provide powerful image processing potential. The laptop then sends data back to the robot using two XBee modules.

Executive Summary

HexaBob is a hexapod that walks, avoids objects, and tracks a desired color. A hexapod is a six legged robot that in this case has three degrees of freedom on each leg. There are a total of 18 servos on the robot, 12 of which are HiTec HS-645 servos to handle the vertical lifting positions on the legs and six of which are HiTec HS-485 servos to handle the horizontal movement of each leg. The platform was designed in SoldidWorks and cut out on a T-Tec machine retrofitted to cut wood. Walking is handled by preprogrammed gaits that are called as separate steps throughout the gait execution. The gaits are broken up into individual steps to allow for reliable obstacle avoidance while walking. If an object is detected mid gait, the robot will reset to its initial servo positions and move according to which sensor detected the object.

To handle avoiding obstacles a total of three sensors were mounted on the front of the platform. A Ping))) Ultrasonic Range Sensor was mounted on the very front to handle avoiding obstacles directly in front of the robot. The manufacturer claims that the sensor has a range of 3 cm to 3.3 meters, but I was only reliably able to get data up to approximately 2.5 meters. Two infrared sensors were mounted to the left and right of the sonar sensor and angled slightly out so they could be used to detect objects at an angle from the front of the robot. The IR sensors used were the Sharp GP2D120XJ00F sensors with a claimed range of 4 cm to 30 cm, but an actual operating range of approximately 4 cm to 20 cm depending on the lighting conditions.

The special sensor on the robot is a wireless image processing system. A wireless camera attached to the front of the robot sends a wireless signal to a receiver that is attached to a laptop in order to capture the image. The image is then run through a RoboRealm macro in order to filter out a desired color. The location of the object is determined relative to the image screen and sent to the robot's microcontroller via two XBee modules. Using a wireless camera instead of a camera like the CMUCam allows for a greater range of potential behaviors and a better quality image to work with. It was observed during demo day that students using the CMUCam had to use red led arrays in order for the CMUCam to recognize the object as red. Using the wireless camera produced a clear image that could then be filtered and adjusted depending on the environment and intensity of the color to track, significantly reducing the threat of poor lighting conditions.

The behaviors of HexaBob depended on several variables. If there is nothing obstructing forward motion the robot moves forward until it either receives a signal from the XBee module saying there is a colored object in the field of view and follows said object or a signal from any of the sensors saying there is something in the way that requires the robot to move left or right. The sensor behavior overrides all other behaviors when called because avoiding any potential object is deemed most important.

Introduction

My proposed autonomous robot design, HexaBob, is a hexapod with three degrees of freedom on each leg. It will be able to detect a specific object, most likely through the use of color, using a camera. The camera will either be a CMUcam or a webcam that streams to my laptop so I can process the image with more capabilities. This camera will end up being my special sensor idea. Once the robot detects a requested object with the camera, it will then move to the object's location and pick it up using a pincer device. The pincer and camera will both be mounted on the robots "head" which will be able to move with two degrees of freedom. IR sensors and bump sensors will also be used for general obstacle detection and avoidance. Locomotion will be achieved through the use of servos that will be controlled using an inverse kinematics method.

Integrated System

This robot uses a BotBoard II microcontroller and a SSC-32 servo controller both bought from Lynxmotion to control an array of devices including multiple sensors and servos. The sensors and XBee module are connected to the BotBoard pins while the servos are all connected to the SSC-32 pins. The BotBoard is programmed to communicate with the SSC-32 and send servo commands when called. Since the robot will be a hexapod with six legs that have three degrees of freedom, there will be a total of 18 servos used to provide locomotion for the robot. There was planned be two servos used on the head of the robot to provide actuation for a camera, but it was found to be unnecessary. A brief summary of the system is shown in Figure 1.

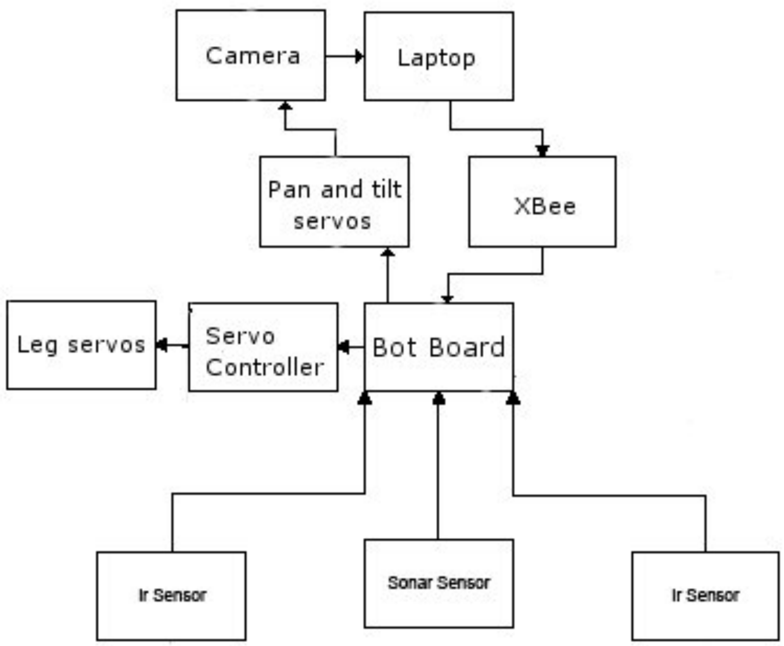

Figure 1 – Integrated system

Mobile Platform

The final mobile platform for my robot was be designed in SolidWorks. Since it is a hexapod, the main body of the platform needs to support six legs while providing space for everything to be mounted on. The legs have to move with the servos so a solid attachment is necessary. I created the basic platform for my robot in SolidWorks and rendered them as images in Figure 1 and Figure 2. This is just the basic shape and sizing for the platform. The legs were not cut out due to time and difficulty of manually cutting out each leg. However, a large hole was cut out in the middle of the platform to allow for easy access to both the microcontroller and servo controller.

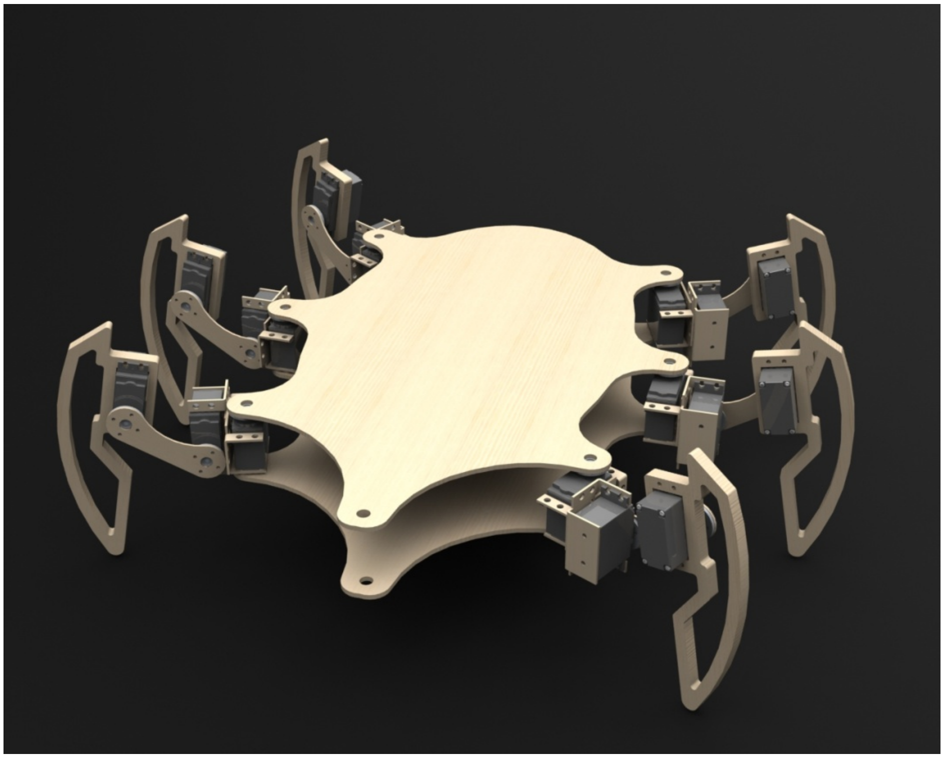

Figure 2

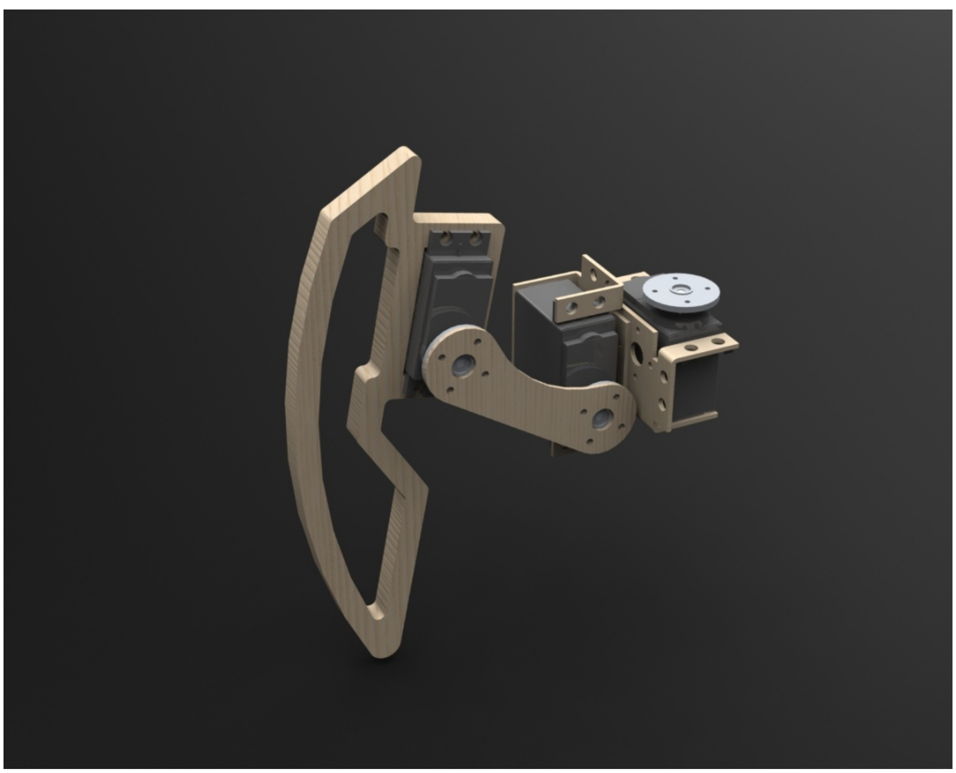

Figure 3

Actuation

Each individual leg has three degrees of freedom thus requiring three servos each. The servos that provide the leg movement are the HiTec HS-645MG and HiTec HS-485HB servos and are controlled by the BotBoard through the SSC-32 servo controller. The legs are moved through preprogrammed gaits, which allow for the various different walking methods. However, due to the overall weight of the robot, it was limited to using a wave gate which individually moves each leg one at a time so that there are always at least five legs supporting the robot at any given time. Ideally, a tripod gait would be used, but the robot is unable to support itself on only three legs and collapses under the weight.

Sensors

There are three different types of sensors on this robot. These include IR sensors, a camera, and sonar. The IR sensors are used for general obstacle avoidance and are Sharp GP2D120XJ00F sensors. The camera, which is a wireless camera that streams an image to my laptop to be processed, detects a colored object in order to output the relative location of that object. The sonar is used on the head of the robot for a more precise distance measurement to aid in avoiding objects. The sonar senor used is a Ping))) Ultrasonic Range Sensor. Another sensor that was considered is pressure sensors on the legs so the robot knows when and what leg is touching the ground at any given time. Figure 4 shows a basic layout for the sensors and serves as a general idea of where items are placed. Placement of the IR sensors has to be considered due to the fact that the position of the front robot legs will change with time. Care has to be taken to insure they don't cross in front of the IR field of view.

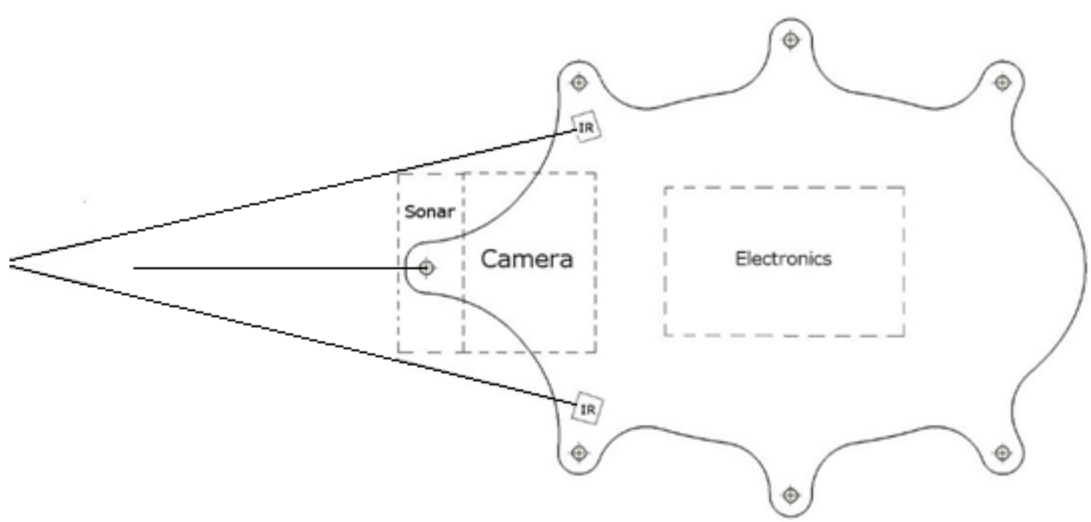

Figure 4

Special Sensor

My special sensor is a Swann Wireless Microcam 3.3 and is mounted on the front of the robot with Velcro to allow for easy access to camera adjustment and testing. The camera sends a wireless signal to a receiver connected to my laptop which will do image processing for the robot. My laptop then communicates with an XBee wireless antenna in order to send information to the microcontroller for controlling the behavior of the robot. For image processing, the software RoboRealm is used due to its ease of use and available documentation. Wireless image processing was chosen because the alternative, the CMUCam, was seen to be a waste of money for what it is and does. Doing the image processing this way allows for dynamic adjustments to be made for different lighting conditions so the robot is still able to detect a color and follow it. Also, there is no preset color to track. The laptop user can decide which color to track real time and change the RoboRealm macro because all that is sent through the XBee module is coordinates of the object.

Behaviors

This robots behavior is based around the ability to detect a desired either avoid or follow the desired object based on its color. It also detects obstacles that obstruct its path and move around them. As a default, the robot walks forward until it either is told there is a colored object to track or there is an obstacle in the way. The dominate behavior is obstacle avoidance so that the robot doesn't bump into something while blindly following a colored object.

Conclusion

Having never built a robot before, I was nervous about how difficult the process will end up becoming. The weight of the robot ended up becoming the downfall of this project. The wireless camera system worked beautifully and was very satisfying to mess around with once it was fully functional. The largest mental roadblock to this project was the cost. Since it's a hexapod and required 18 servos for leg movement and two servos for head movement, most of the cost went into buying the servos. It is fortunate that I did not need to buy books in all my other classes this semester. If I had to do the class over again, I would not choose a hexapod. While I loved working on it and do not regret my choice, money and time are an issue that must be considered. A wheeled platform can host the same wireless image system and move fast at the same time, but it doesn't look quit as cool.

Documentation

Ping))) Ultrasonic Range Sensor: http://www.parallax.com/dl/docs/prod/acc/PingDocs.pdf

Sharp IR sensor: http://www.sparkfun.com/datasheets/Sensors/Infrared/GP2D120XJ00F_SS.pdf

RoboRealm: http://www.roborealm.com/help/index.php

XBee modules: http://www.sparkfun.com/datasheets/Sensors/Infrared/GP2D120XJ00F_SS.pdf

Appendices

Due to the fact that the code is very long, code will be hosted on http://vertigonimdl.wordpress.com/