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

By: Andrei Kamalov

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Abstract

This paper documents the design and development of an automated carrier robot. The robot, Promethius, is designed for the purpose of carrying upwards of 20 pounds of cargo at speeds up to 3 miles per hour. The user will differentiate themselves by equipping a beacon-like item onto the back of their heel that will assist Promethius in tracking the user's direction and distance. The main goal of Promethius is to follow the user and assist them by carrying their belongings in tow.

Executive Summary

Prometheus was successfully completed and finalized on April 20th, 2009. While the final design had many similarities to the original approach, there have been many changes. Prometheus ended up being a two-plywood-layer robot that received the most vital information through a CMUcam. Prometheus ended up being able to keep pace with an average human's walking speed, but slows down greatly between carrying 10 pounds of cargo, and the originally intended 20. However, The total mass of the platform is also greater than expected.

For the most part, Prometheus maintained his original design and angle of approach. Prometheus used a CMUcam to find its beacon, IR sensors to avoid obstacles, and bump sensors to move away from objects that were not picked up by the IR sensors. However, the cone of vision for the CMUcam was not as great as anticipated, so the original design was modified to add a neck-joint for the CMUcam that allows the camera to change directions rapidly, while keeping track of the blue beacon. The narrow cone of vision also installed greater demands for rapid rotation of the platform.

The new requirements for target tracking required more complicated and better integrated actuation control. The original code was severely extended, and frequently tested to improve actuation control, and allow for smooth, integrated motion of the platform. The original design called for the platform to abruptly accelerate, break, and rotate depending on the location of the beacon. All these actions were exhaustive for the motor driver, and had to be modified for improved energy consumption, motion fluidity, and peak load. At the end of the project, Prometheus turned while moving forward, continued forward motion even when momentarily losing track of the beacon, and would come to a halt less frequently.

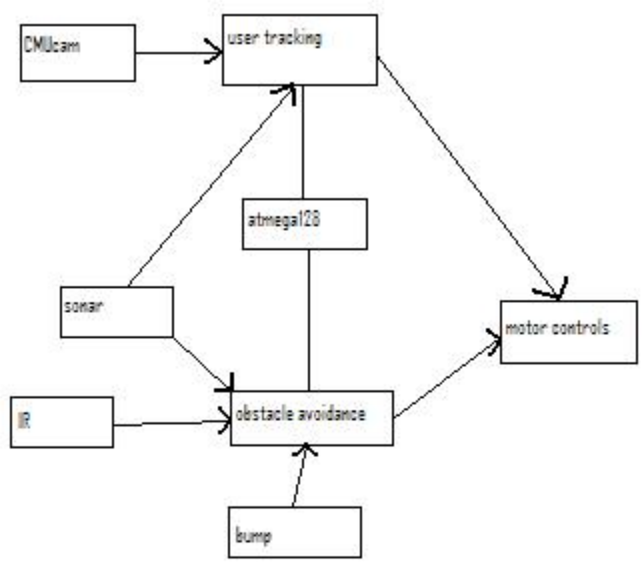
The original design also did not consider the stress exerted onto the drive system. Originally, the engineer planned to use regular foam wheels on a regular chassis. After ordering the originally intended set of foam wheels and realizing the amount of force each wheel would need to handle, the design was changed to equip larger, more durable, aluminum wheels with rubber tires. Thick aluminum stock mounts and thicker plywood were also incorporated into the new design, as well as two DC motors capable of supplying 160 oz * in peak torque. Six heavy duty machine screws and a system of washers, nuts, and stop nuts are used to separate plywood layers and distribute pressure.

The original bump sensors, a network of home-made toggle buttons and resistors, were changed out for tougher, commercial bump detectors. The motor driver also ran into difficulty handling the workload, and would frequently heat up. A computer fan was mounted to cool down the driver.

Introduction

The objective of this project is to develop an assistive robotic platform that will carry personal belongings for the owner. The platform must be able to follow the user autonomously while keeping up with a walking-pace speed, and carrying upwards of 20 pounds of cargo. The user will need to wear a lightweight item on the back of their heel to differentiate themselves from other people in the area. The platform will then lock-on to the beacon, and follow it while keeping a comfortable distance away from the user.

Integrated system



The platform will have two main functions: Obstacle avoidance and user tracking. The robot needs to track the user and control the motors to keep up with the user. To do this, the processor will analyze data from a CMUcam and a sonar sensor to determine the direction and distance to the user. This data will then be used to determine what commands need to be sent to the motor in order to follow the user successfully.

While the platform follows the user, it must also make sure to avoid any obstacles in its way. If the processor gets information about an object in the way from an IR sensor, a bump sensor, or the sonar, the platform must make sure to avoid running into the obstacle while keeping track of the user.

Mobile platform

The requirements of the robot's task require that the platform be sturdy and powerful. The main body of the robot is a "circular" disk of plywood roughly 18 inches in diameter. The platform will rely on 2 Pittman 8000 series motors for actuation. These motors were initially intended to be housed above the main component disk. After a couple weeks of mechanical assembly, mounting the motors on the bottom of the disk seemed like a more practical approach, and became the new approach for the drive system

Another layer is mounted above the main disk, and separated with six heavy duty machine screws. This second layer will serve as the layer on which all cargo is placed.

Actuation

The wheels that will be used in the final design will be approximately 3.1 inches in diameter, including tires. Two Pittman 8000 series DC motors will provide the power to drive two aluminum-hub, rubber tire wheels. A solarbotics motor driver kit is used to control the motors . I have gotten mixed opinions about the capabilities of my current setup compared to the power demand. To assist the driver with the workload, a 12V computer fan was mounted for cooling purposes, and is powered by a 16V source.

One standard, economic servo is used to act as a panning "neck" for the CMUcam. This will give Promethius better tracking and control capabilities.

The ideal design for Promethius calls for 2 casters, allowing for four points of contact with the ground. This is to reduce the amount of normal force reacting against the tires of the driven wheels. At the conclusion of the project, Prometheus relied on three points of contact, and had a 4^{th} one available, depending on the balancing of the cargo and direction of motion.

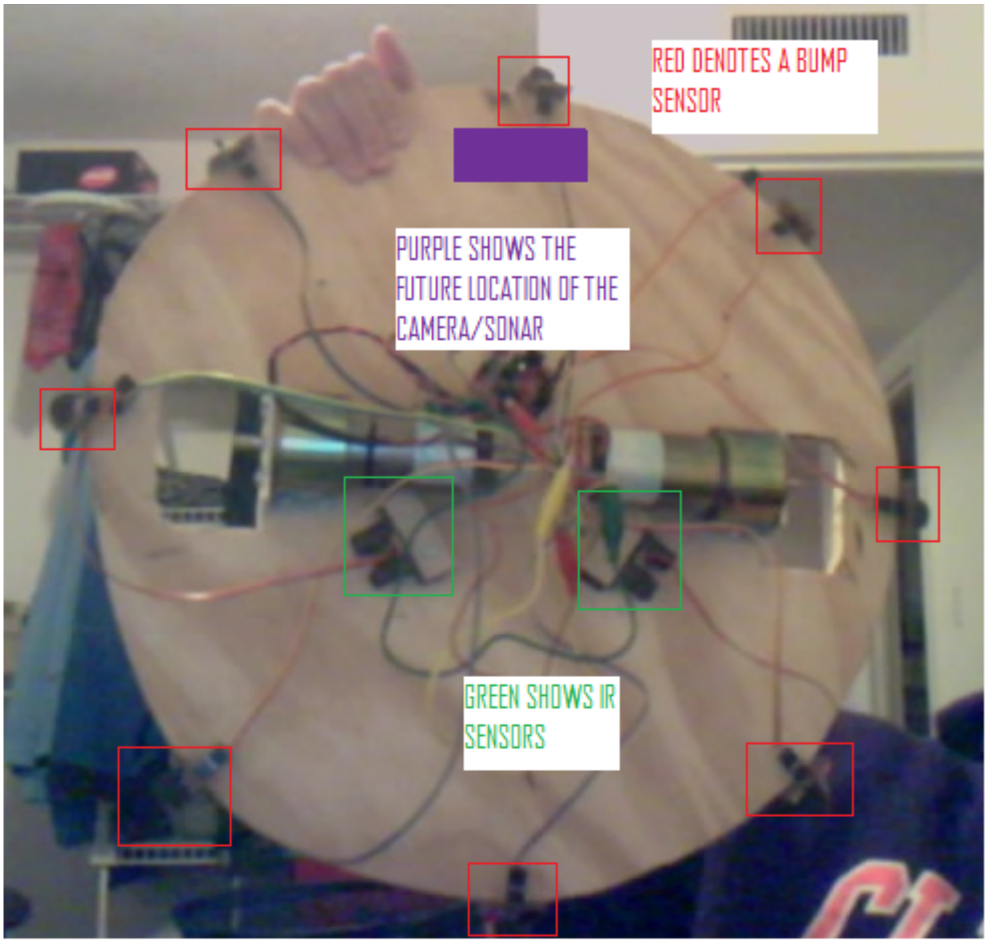
Sensors

There are 4 types of sensors on the robotic platform. IR sensors will be mounted on the sides for the purpose of obstacle avoidance. Bump sensors will be used to detect obstacles if the IR sensors fail to detect an object. A CMUcam and a sonar sensor will be mounted on a rotating servo to locate and track the user. The CMUcam will be used to lock onto the beacon, which will most likely be blue LED's, while the sonar will keep track of the distance to the user to ensure the platform does not come too close to the user or stray too far out.

As of March 19^{th}, the CMUcam has been configured with the atmega128 as desired, and is awaiting a completed mechanical platform (which will be accomplished by the 23^{rd}, easily). The IR and bump sensors have been mounted in their final positions, and are being integrated into an obstacle avoidance algorithm.

-CMUcam mounted onto a servo. Additionally, a sonar will be mounted onto the front of the servo.

-This image displays the original, home-made bump sensors. Eight such sensors lined the exterior of Promethius's circular body. After a couple of weeks of use, the lead engineer decided that these switches were too difficult to maintain, and switched to using commercial bump sensors. Six commercial sensors line the exterior of Prometheus, and are used as a last-resort method of obstacle avoidance.



Behavior

The platform will follow a user at a comfortable distance while carrying their cargo for them.

One of the toughest subcomponents for Prometheus was designing a smooth, working drive algorithm for the platform. The code for actuation required roughly three weeks of implementation and vigorous resting.

Conclusion

Prometheus is done, and ready to haul cargo. He is a relatively large and powerful robot, capable of transporting relatively large amounts of mass for his size.

During the last week and a half of the project, there was a lot of stress on the coder. Consequently, the code was horrendously commented, relatively illegible, and needlessly complicated.