Formal Proposal

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Rebounder

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Abstract

The purpose of Rebounder is to retrieve a small toy basketball after it has been shot and return it either to the user or to a storage area. In order to accomplish this, the robot will consist of a main mobile platform that performs all the work, including ball detection and recovery, and a simple sensor system on the basket to determine when the mobile platform should be deployed (i.e. when the ball has been shot). The mobile platform will use a camera to locate the ball in a crowded environment, utilizing OpenCV for real-time image-processing in order to differentiate the target from other objects.

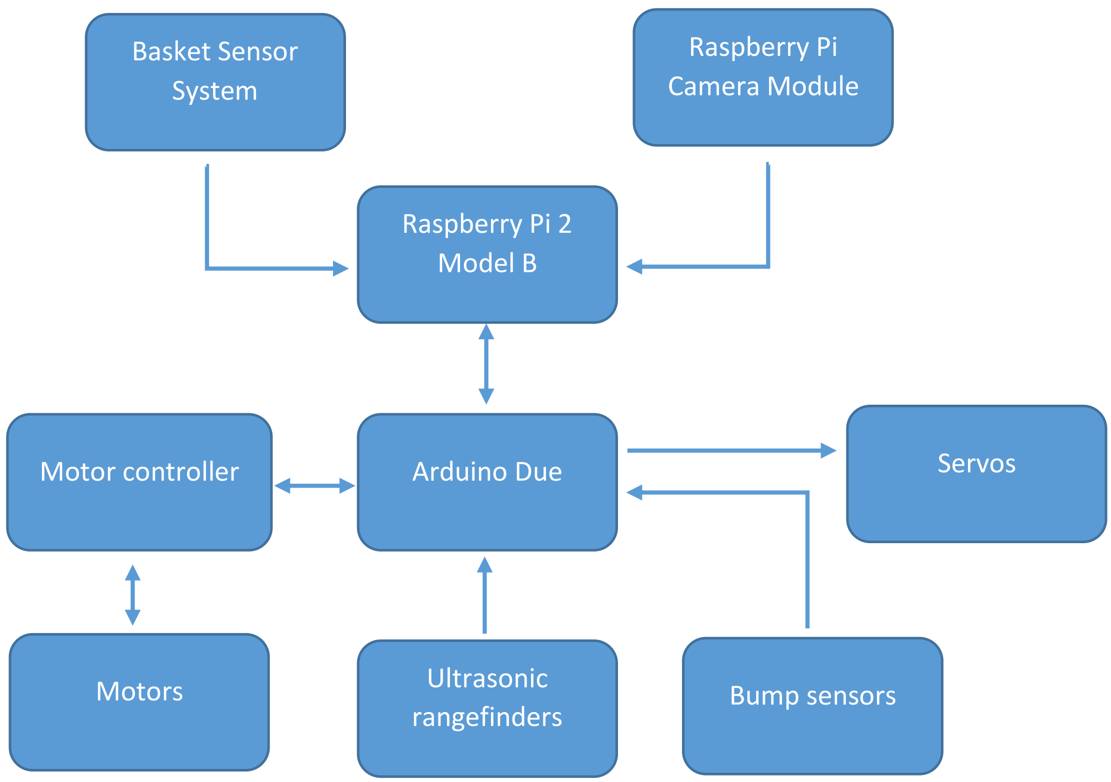
Introduction

Autonomous object retrieval can have applications in numerous different areas. For example, in cases of natural disaster, the ability to access valuable resources may be limited due to dangerous terrain and/or obstacles. In such a case, having a robot that is able to find and rescue the desired object not only makes this task possible, it also greatly reduces any danger to humans who would otherwise have to complete the retrieval themselves.

This same concept is being applied to a relatively simple situation, in which the robot must retrieve a toy basketball. The robot will communicate with a sensor system on the basket to determine if the ball has been shot, and therefore needs recovering, and then uses computer-vision to locate the ball. Once the ball is possessed by the robot, it will either return it to the user or place it in a storage area, depending on a user input. The robot will use various sensors to avoid obstacles while navigating the environment.

Integrated System

The mobile platform will use a Raspberry Pi 2 Model B to handle the real-time image-processing, as well as communicate with the sensor system on the basket. The Raspberry Pi will act as the master to an Arduino Due, which will control all motors/servos and communicate with the ultrasonic rangefinders and bump sensors. The basket sensor system will consist of an LED tactile button providing data to a Raspberry Pi Zero, which will communicate to the Raspberry Pi 2 via WiFi.



Mobile Platform

The mobile platform will consist of two sub-platforms: a main platform to house the electronics and sensors, and a secondary platform to provide protection of the electronics and a place to store the ball during transport. The main platform will also act as the base for an arm, which will be used for object retrieval. The secondary platform will sit above the main platform on standoffs. The goal of the mobile platform is to be able to navigate a wide array of environments, and therefore must have high maneuverability in order to travel through tight areas. In order to facilitate this objective, the mobile platform will be driven by a tank tread system, which allows the robot to turn in place. In addition, the mobile platform will have bumpers on the front and back which will allow it to detect if it has collided with an object without damaging any important electrical/mechanical components.

Actuation

Stepper Motors (w/ encoders):

- (x2) – Nema 11 Stepper with 5:1 planetary gearbox; 0.67 A current draw, 12 V; 2 Nm max permissible torque
- Used to drive the tank treads

Servos:

- (x2) – HS-85BB HiTec servo; Pulse width control; 8 mA/idl, 240 mA no load operating current drain at 4.8V; 41.66 oz-in stall torque
- Used to move arm and open/close jaws of arm

Sensors

Raspberry Pi Camera Module (Special Sensor):

- (x1) – 2592x1944 pixels; 1080p30, 720p60, and 640x480p60/90 video modes
- Used for target detection

Ultrasonic Rangefinders:

- (x2) – Parallax PING ultrasonic distance sensor; 2cm to 3 m range; bidirectional TTL pulse interface;
- Used for obstacle avoidance as well as determining distance to target once target has been detected

Bump Sensors:

- (x2) - Single-pole, double-throw (SPDT) switch; rated for 5 A; 20 mm offset lever actuator
- Used to sense if the mobile platform has hit anything

Encoders:

- (x2) – used to measure position and speed of stepper motors

LED Tactile Button:

- (x1) – used to determine if ball has been shot

Behaviors

- Object Detection
  - The robot will be able to distinguish the target object from the rest of the environment, and act accordingly
- Obstacle Avoidance
  - The robot will be able to navigate the environment without colliding with any obstacles
- Idle Mode
  - The mobile platform will idle at a base station until the sensor system detects the ball has been shot

Bill of Materials

Item No.	Qty.	Part/Assembly Name
1	2	Aluminum plate (unsure of size; material may change)
2	2	Nema 11 stepper motor
3	2	HS-85BB HiTec servo
4	2	Tread system
5	1	3D-printed arm assembly
6	4	Aluminum standoffs
7	2	Bumpers (material not yet chosen)
8	1	Arduino Due
9	1	Raspberry Pi 2
10	1	Raspberry Pi Zero
11	1	Parallax PING ultrasonic sensor
12	1	Raspberry Pi Camera Module
13	2	SPDT switch
14	2	Encoder
15	2	LED tactile button

Proposed Timeline

Week	Goals/Tasks
1/11	Order boards and sensors
1/18	Complete SolidWorks model of mobile platform; order actuators; verify board functionality and familiarize with software
1/25	Boards functioning with sensors/actuators; Order materials needed for robot manufacturing
2/1	Robot manufacturing; electronics testing
2/8	Robot manufacturing/assembly; electronics testing
2/15	Robot fully assembled; electronics functioning and mounted
2/22	Obstacle avoidance achieved; testing of complete mobile platform; testing of accelerometer system
2/29	Further testing of complete mobile platform; further testing of accelerometer system
3/7	Accelerometer system functioning; further testing of complete mobile platform
3/14	Further testing of full system; Oral report
3/21	Finalize design; further testing
3/28	Complete software demo; further testing
4/4	Pre-Demo Day
4/11	Final presentation; Demo Day
4/18	Media Day