Chalk Matrix Printer

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Contents

Abstract

Chalk Matrix Printer's intended operation is to take pictures of drawings, convert them into low-resolution black and white copies, and draw them using chalk.

Introduction

As a general rule, printers are large compared to the medium they print on, and require that the medium pass through it. This works fine for documents, but this scheme practically excludes printing on large pre-existing surfaces. The Chalk Matrix Printer is a small printer for large surfaces, with a simple interface that makes it intuitive to operate.

Mobile Platform

The mobile platform consists of a chassis with two hacked analog servos in a differential drive configuration. Main chassis will house drivetrain, computer board, chalk deployment mechanism, and batteries. Drive wheels will be located at the front, and a caster at the rear. Chalk deployment mechanism will be mounted rearward of the caster, along the platform's axis of symmetry.

Sensors

Collision detection will be implemented through use of four whiskers. Two will be mounted near ground level on the platform's forward edge, and another on each side near the rear corners. Collision sensors on the sides of the platform are necessary because the rear of the platform rotates about the front mounted drivetrain during a turn, and may contact a surface at such time. A fifth whisker will be located at the rear of the platform, to the side of the caster wheel. The fifth whisker will be active any time the caster is near or on the ground, allowing the controller to detect tilt and, by extension, chalk deployment.

A rate gyro will be used to detect rotation of the robot, this is important due to the requirement that the controller can accurately and reliably determine when 90 degree turns have been accomplished.

An IR range finder will be located on each of the front corners, pointing away from the center of the platform. These will allow for long range object avoidance.

Owner location and picture taking will be performed through use of a webcam and OpenCV. OpenCV implementation will be based on thresholding. Thresholding will allow the robot to locate its owner, who will be wearing a pink shirt. Thresholding will also be used to trigger the countdown for picture taking.

Actuation

The drivetrain's servos will be hacked for continuous rotation. Because this results in the position of the wheel being unknown, and the servos are likely to operate at slightly different speeds, feedback from the rate gyro will have to be used to determine completion of turns and tune straight line driving.

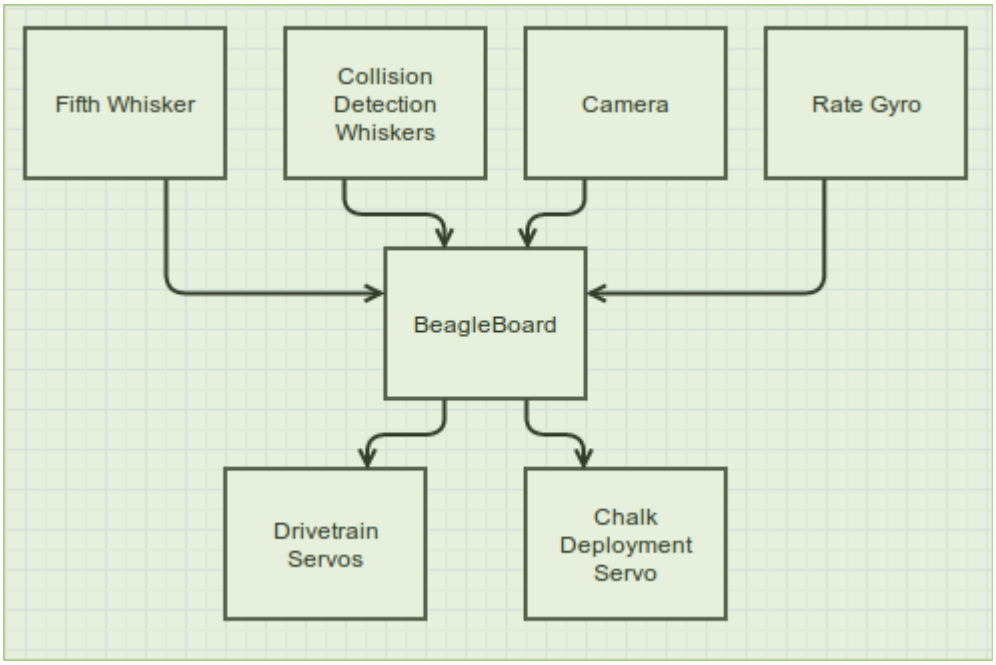
An unmodified servo will actuate the chalk deployment mechanism. This will allow position to be adjusted directly by altering the PWM signal. Target position will be based on input from the fifth whisker.

Behavior

The robot has two distinct operating modes: owner location and drawing. When in owner location mode, the robot makes use of the 4 collision detectors, 2 distance sensors, and the camera to locate, and successfully navigate to, a specific color. After the owner initiates drawing mode, the camera takes one picture, and is then shut down. The collision detectors and distance sensors remain active, but the robot will come to a stop and wait for the offending obstacle to be removed if one is detected. The sensors being used to supply feedback for all other behavior while in this mode are the fifth whisker and the rate gyro. The rate gyro allows the robot to turn exact angles and drive in a straight line, letting it trace out a path resembling a square wave. Based on the picture taken at initiation of drawing mode, and subsequent processing of that picture, chalk will be deployed at certain points along that path in order to “print” the picture. Upon deployment, chalk will be lowered relative to the platform until the fifth whisker loses contact with the ground, indicating the rear caster has been lifted. If the fifth whisker comes into contact with the ground during a deployment event, the chalk will be lowered further, compensating for chalk wear. Once a drawing cycle is completed, the robot will switch back to owner location behavior.

Integrated System

On board computer will be a BeagleBone Black hosting a Linux OS. 5 whiskers, 2 range sensors, a rate gyro, and a webcam will serve as its inputs. 3 servos, 2 hacked for continuous rotation and 1 unmodified, will enable its movement. This block diagram indicates the connections between the components:



Experimental Layout and Results

A critical component to the function of the Printer is the rate gyro. Its output will have to be analyzed carefully to ensure that the board understands it correctly. A test run of the Printer driving a parallel line pattern repeatedly would confirm the system is functioning as it should.

Conclusion

I expect the key hurdle of completing the Chalk Matrix Printer will be making it trace the desired pattern accurately while in drawing mode. As described, the Printer has no way of determining its absolute position or heading. Change in heading is provided by the rate gyro, and distance driven controlled by varying the servo power output and the length of time run. This keeps the number of sensors to a minimum, but may be an insufficient, or incorrect, selection of sensors. It may be necessary to use, either in place of in addition to the rate gyro, a GPS, compass, implementation of the camera as a positioning system, accelerometer, wheel rotation encoders, optical mouse, or other sensor/system to achieve the desired capability.

Documentation

- BeagleBoard Black: beagleboard.org
- Rate Gyro: analog.com

Appendices

- Directional gyro construction: http://www.seattlerobotics.org/encoder/200311/brown/building_a_directional_gyro.html