Vision Integrated Robotic Turret (VIRT)

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Engineering

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Project Goal

The goal of this project is to construct a robotic sentry turret with a computer vision system capable of finding, tracking, and following a target object. The computer vision system is constructed around an FPGA, which can support a more robust CV system than a microprocessor due to its speed and parallel processing capabilities.

Methodology

This project is split into the following two subsystems:

Chassis

- Uses a kiwi drive configuration to enable the base of the chassis to move on the x-y plane and turn the robot 360° with only 3 motors and wheels.
- Uses 3 servo motors for the wheels and 1 servo for the camera arm

Computer Vision

- Uses an OV7670 camera that sends a 640x480px image to a Zybo Z7-10 FPGA for color detection

Engineering Analysis

Chassis

The VIRT chassis is comprised of two main systems: a 3 DOF drivetrain and a 1 DOF camera arm. The drivetrain is a kiwi-drive with 3 48mm omni-wheels, powered by FIT0458 motors. This wheel configuration allows the robot to translate while rotating. The wheels are offset by 120° from each other.

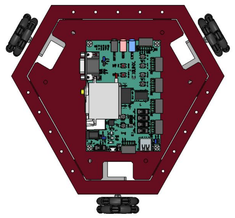

Figure 1. VIRT drivetrain

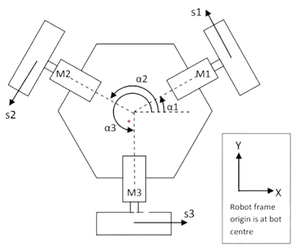

Figure 2. Wheel directions

The arm is used to move the camera and has 120° of motion from vertical in both directions. The arm is actuated by an MG995 servo motor.

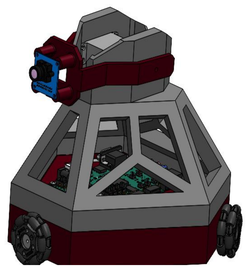

Figure 3. Chassis assembly

Computer Vision

The CV system uses an OV7670 camera to find a target object of a known color and size. Distance from the robot is calculated based on the ratio of colored pixels, and its position on the x-axis is found by determining which vertical image bins the target pixels are found in.

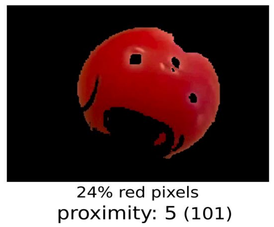

Figure 4. Pixel Proximity

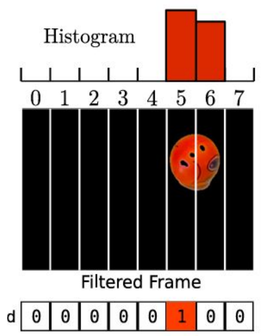

Figure 5. Representation of the centroid calculation from the filtered image.

The robot will turn until the object is centered in the image, then move forward or backwards to maintain a set distance from the target. Figures 4 and 5 are from the paper "Vision-based robotics using open FPGAs" describing a similar project.

Outcomes

VIRT will be able to determine the distance to its target with the use of an OV7670 cameras and will be able to follow the target with the FIT0458 motors and omniwheels. After prototyping, the chassis will be scaled up and use brushless motors for smoother, more precise movement. We also want to use 2 cameras to triangulate distance without knowing the target's size.

Currently, we have designed a smaller, cheaper prototype to use as a software test bed to confirm whether the Zybo is able to control the motors and camera simultaneously, as we may be limited by the number of I/O connections, as well as clock timing.

Future Plans

Build and test prototype chassis

- Implement motor controls
- Implement color detection CV system with both cameras

Design final product

- Design edge detection CV system
- Design larger, more robust chassis with brushless motors