Vision Integrated Robotic Turret (VIRT)

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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 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 and output to HDMI

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.

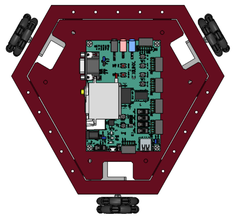

Figure 1. VIRT drivetrain

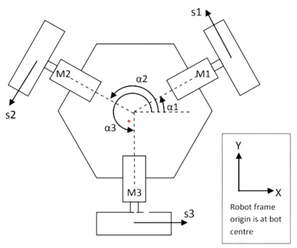

Figure 2. Wheel directions

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.

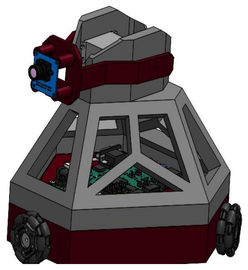

Figure 3. Current chassis assembly

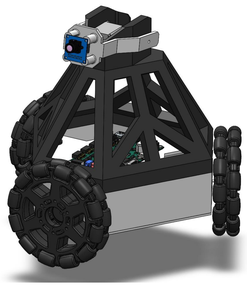

Figure 4. V2 chassis assembly

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 area of colored pixels, and its position on the x-axis is found by determining which vertical image bins the target pixels are found in.

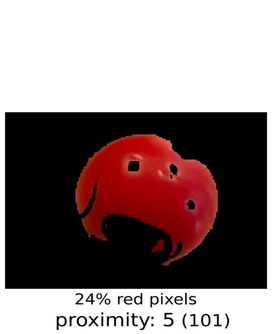

Figure 5. Pixel Proximity[1]

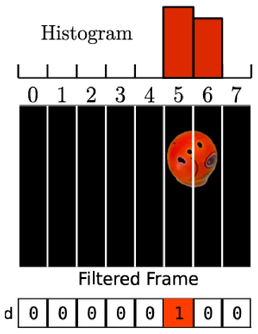

Figure 6. Representation of centroid calculation[1]

VIRT will rotate until the object is centered in the image, then move forward or backwards to maintain a set distance from the target.

Outcomes

Currently, we are using a smaller, cheaper prototype 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 I/O availability and clock timing. We are currently developing and debugging our HDMI output configuration.

We have designed a second, more robust chassis with larger motors for smoother, more precise movement.

Future Plans

Continue testing prototype chassis

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

References

1 Felipe Machado, Rubén Nieto, Jesús Fernández-Conde, David Lobato, and José M. Cañas. “Vision-Based Robotics Using Open FPGAs.” Microprocessors and Microsystems 103 (2023): 104974.

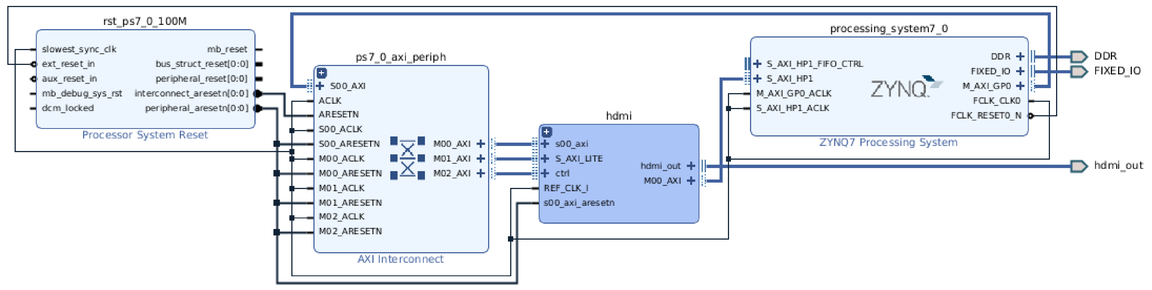

Figure 7. HDMI configuration block diagram