Vision Integrated Robotic Turret (VIRT)

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Project Goal

VIRT will be a harmless robotic sentry turret with an FPGA-based computer vision system capable of finding, tracking, and following a target object to maintain a set distance from the object with it centered in frame. The goal of this project is to learn how to implement a CV system on an FPGA instead of microprocessor, due to the parallel processing capabilities of FPGAs.

System Overview

This project is split into 3 subsystems:

Chassis

- Kiwi drive enables the base of the chassis to translate and rotate with only 3 DC motors and 48mm omni-wheels.

Motor Controls

- STM32 NUCLEO-G431RB receives UART signal from the Zybo and controls 3 MC33926 motor drivers for the wheels, each driving a FIT0458 DC motor; and 1 MG995 servo for the camera arm.

Computer Vision

- OV7670 camera sends 320x240px @30fps RGB video to a Zybo Z7-10 for color processing, format conversion, and output over HDMI to a monitor.

Chassis

The VIRT chassis includes a 3-DOF kiwi drivetrain and 1-DOF camera arm. The kiwi drive includes 3 omni-wheels offset by 120° from each other.

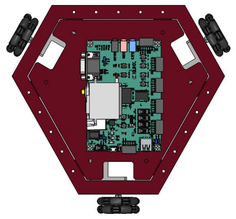

Figure 1. VIRT drivetrain

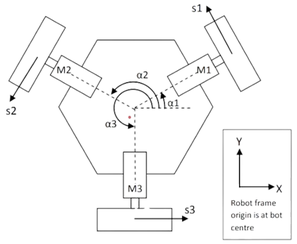

Figure 2. Wheel directions

The camera arm has 120° of vertical rotation.

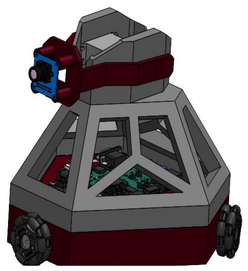

Figure 3. Current chassis assembly

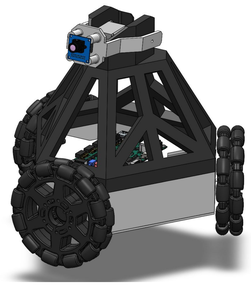

Figure 4. V2 chassis assembly

Controls

All motors are controlled with the STM32, which receives continuous input from the Zybo of when and which direction to move to track the object. The STM32 offloads I/Os from the Zybo for the camera's use.

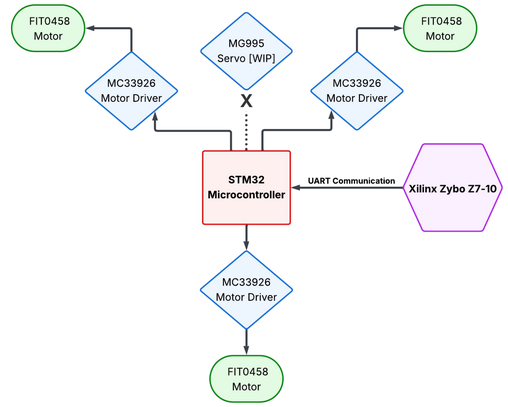

Figure 5. Motor Control System Diagram

Computer Vision

The CV system takes RGB video in, color processes the frames, and converts RGB to DVI format for output over HDMI port.

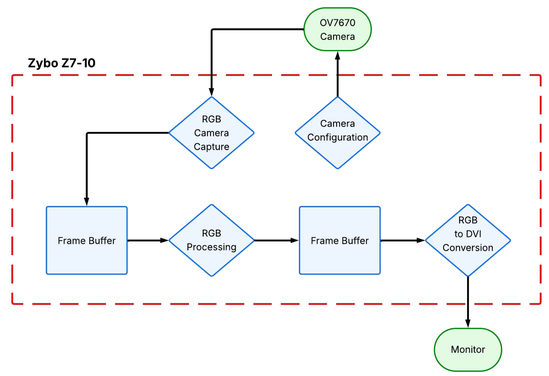

Figure 6. Computer Vision System Diagram

The CV system will find and calculate the position of an object of known color and size, based on the area of colored pixels in the image and which image segments these pixels are found in.

Figure 7. Pixel Proximity[1]

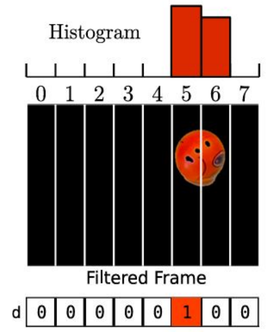

Figure 8. Representation of centroid calculation[1]

Outcomes

Currently, we are using a small prototype to test our controls and CV. We have designed a second, larger chassis for the future with better motors for smoother, more precise movement. We have created test patterns converting RGB to DVI/HDMI and a color filtering module. We are currently developing and debugging our RGB to HDMI output configuration.

Future Plans

- Connect motor controls to CV system
- Implement centroid and distance calculations
- Fabricate and assemble V2 chassis

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.