ECE 490/491 Capstone Design Project

BallBot: Autonomous Tennis Ball Collector

Design Group Members	Client	Technical Advisor	Year
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Overview

This project aims to create a method of streamlining tennis practices by autonomously collecting tennis balls scattered around the court. Our robot accomplishes this through use of computer vision, inertial measurement, a wireless remote, and a robust intake system all seamlessly integrated together.

Design Specification

1. Robot must be easily portable
2. Autonomously search for tennis balls
3. Travels to and pickup located tennis balls
4. Wireless remote control of robot
5. Home base system for robot to return to

Software

This project is entirely coded using Python 3, which works seamlessly with the Raspberry Pi. Code segments have been created for object detection, motor control, inertial measurement, and wireless communications. The object detection uses the YOLOv11n algorithm to identify tennis balls with an mAP50 of 98.6%. To avoid obstacles such as netting or walls within a tennis court, an ultrasonic sensor is used to calculate the distance. PWM based control is fed to the motor encoders, with IMU code in use for path verification and turn angle monitoring. A return to user feature has been implemented using wireless signal strength to locate the direction of the user once collection is completed.

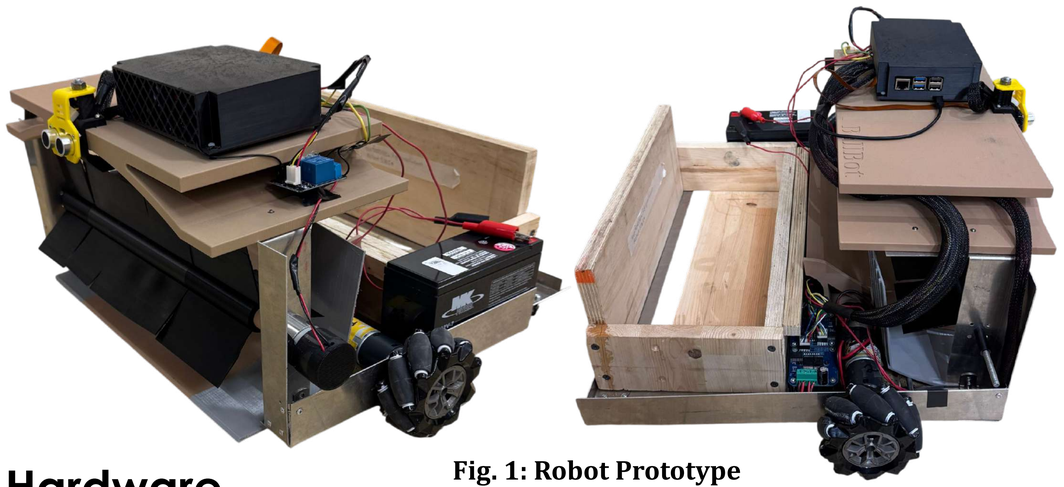

Fig. 1: Robot Prototype

Hardware

The core of this design is the Raspberry Pi 5, which hosts all code and interfaces with all peripherals. These peripherals include two motor encoders, a switching relay, an IMU, and an ultrasonic sensor. An ESP32 serves as the remote with two buttons, one to start the collection process and one as an emergency stop. The intake system consists of a 3D-printed threefold brush and a ramp; the brush sweeps the located tennis ball up the ramp and into the collection area. Power is supplied by a 12 V lead-acid battery, connected through a power distribution PCB. 12V is distributed to the motors and a 12-5V buck converter supplies the Raspberry Pi 5.

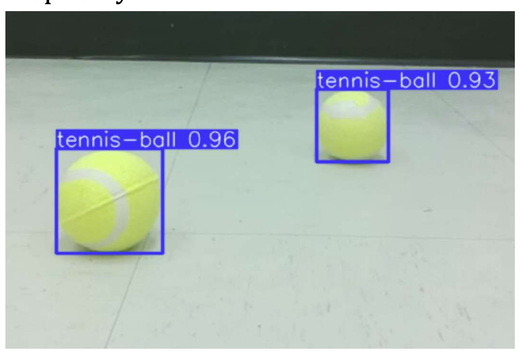

Fig. 3 Object detection example image

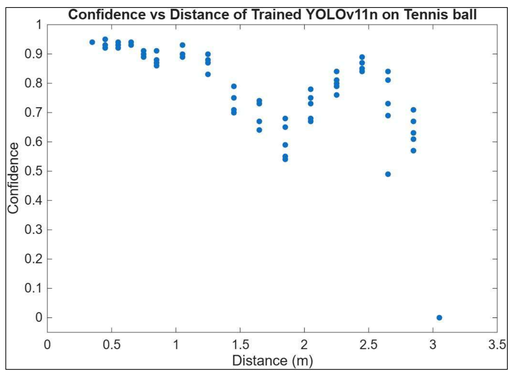

Fig. 4 Image detection confidence over distance

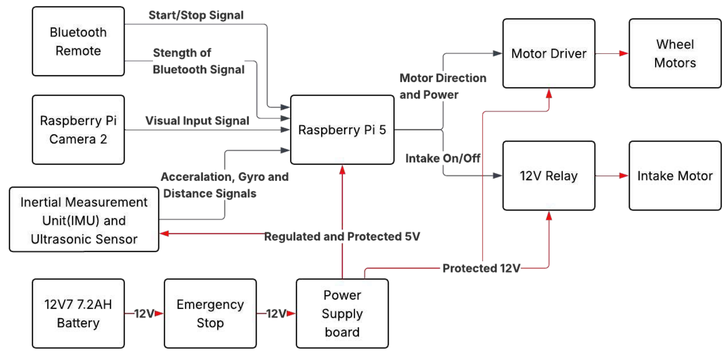

Fig. 2 Block diagram of the Ballbot sensor signals and power delivery

Future Improvements

- Use of a more efficient language than Python to speed up image collection and tennis ball detection.
- Sturdier frame with better grade aluminum to allow for more stable movement
- Increased training of the object detection model to increase the maximum reliable distance a tennis ball could be detected.
- Rearranging of components for better weight distribution

Acknowledgement

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