Auto Aim Laser Turret

Group Number: 06

Hardware Description

The hardware setup of the proposed system consists of a camera module, a two-axis pan–tilt turret mechanism, servo motors, a laser module, and a processing unit. A USB camera is used to capture live video frames, which serve as the primary input for target detection. The pan–tilt mechanism is driven by two servo motors that allow controlled horizontal (pan) and vertical (tilt) movement of the turret. A laser module is mounted on the turret to indicate the tracked target. The servo motors and laser module are interfaced with the processing unit through GPIO pins and are controlled using PWM signals. The processing unit runs the ROS2 framework and executes all software nodes responsible for vision processing, tracking, and control. This hardware configuration enables real-time sensing, precise actuation, and reliable interaction between perception and control components of the system.

HARDWARE COMPONENTS

1. Camera Module: A USB camera is used to capture live video frames of the environment. The camera continuously provides visual input to the system, which is published as image data and used for real-time target detection and tracking.
2. Servo Motors: Two servo motors are used to control the pan and tilt motions of the turret. The motors receive PWM signals from the processing unit and provide precise angular movement required for accurate target tracking.

3. Laser Module: A laser module is mounted on the turret to visually indicate the tracked target. The laser is controlled through a GPIO pin and is automatically switched ON or OFF based on the turret's movement and tracking status.
4. GPIO Interface: General Purpose Input/Output (GPIO) pins are used to interface the servo motors and laser module with the processing unit. PWM signals generated through GPIO enable controlled motor actuation and laser operation. For this implementation we used Bread boards, jumper wires.
5. Raspberry Pi: A Raspberry Pi is used as the main processing unit to run the ROS2 framework and control the camera, vision pipeline, and turret hardware through GPIO interfaces.
6. Pan–Tilt Mechanism: The pan–tilt mechanism is achieved using two servo motors mounted orthogonally, where one motor controls horizontal rotation (pan) and the other controls vertical rotation (tilt). Servo angles are computed from the detected target coordinates and converted into PWM signals, enabling smooth and precise movement of the turret to continuously align with the target.

Observations During Real-Environment Testing

During real-environment testing, it was observed that deep learning–based object detection approaches such as YOLO introduced noticeable latency in the system. The time required for frame processing and coordinate detection was significantly higher, which resulted in delayed publishing of target coordinates and reduced responsiveness of the turret movement. This delay affected real-time tracking performance, especially when operating under limited computational resources. To address this issue, a classical computer vision–based approach was adopted, which enabled faster frame processing and more consistent real-time performance. The use of color-based segmentation and geometric computation allowed the system to reliably detect targets and publish coordinates with minimal delay, making it more suitable for real-time control applications.