Auto Aim Laser Turret

Group Number: 06

MODEL DESCRIPTION

The proposed project focuses on developing a ROS2-based automated turret system for real-time target detection and tracking in dynamic environments. The system employs a classical computer vision and geometric control model to achieve fast, reliable, and low-latency performance suitable for real-world deployment. The model is designed to integrate visual perception with mechanical actuation, enabling autonomous alignment of a pan–tilt turret toward a detected target while providing continuous visual feedback by turning the laser on/off.

Vision-Based Detection Model

The vision component of the system uses a classical OpenCV-based detection model to identify the target from live camera input. Incoming video frames are converted into the HSV color space to improve robustness under varying lighting conditions. Color-based segmentation is applied to isolate the target region, followed by morphological processing to reduce noise and refine the detected mask. Contour detection is then performed to identify candidate target regions, and the most prominent contour is selected as the valid target. From this region, a bounding box and centroid are computed to localize the target within the camera frame.

Spatial Coordinate Estimation Model

After detecting the target, the system estimates its spatial position relative to the camera. The horizontal and vertical offsets of the target centroid from the image centre are calculated to obtain planar coordinates. Additionally, the apparent size of the detected object is used to estimate depth information using empirically derived geometric relationships. These computations result in three-dimensional target coordinates (x, y, z), which represent the relative position of the target in the camera's coordinate frame.

Geometric Angle Computation Model

To enable turret actuation, a geometric control model is used to convert the estimated target coordinates into pan and tilt angles. This model applies trigonometric relationships to map the spatial position of the target into corresponding angular commands. Linear offsets and angular corrections are incorporated to account for physical alignment differences between the camera and the turret. The computed angles are constrained within safe operating limits to ensure reliable servo operation.

Tracking and Control Model

The tracking model is responsible for ensuring smooth and stable turret movement. It continuously updates pan and tilt angles based on incoming target coordinates while applying smoothing techniques to reduce abrupt motion and jitter. The model also includes target-loss handling logic, where the turret gradually returns to a neutral position if the target is no longer detected. This approach enhances system stability and prevents unnecessary mechanical stress.

All components of the proposed model are implemented as independent ROS2 nodes that communicate exclusively through topic-based messaging. This modular architecture enables efficient data exchange between perception, tracking, and control modules while maintaining loose coupling between components. The integration of vision processing, geometric computation, and hardware control within a unified ROS2 framework ensures real-time performance and scalability.