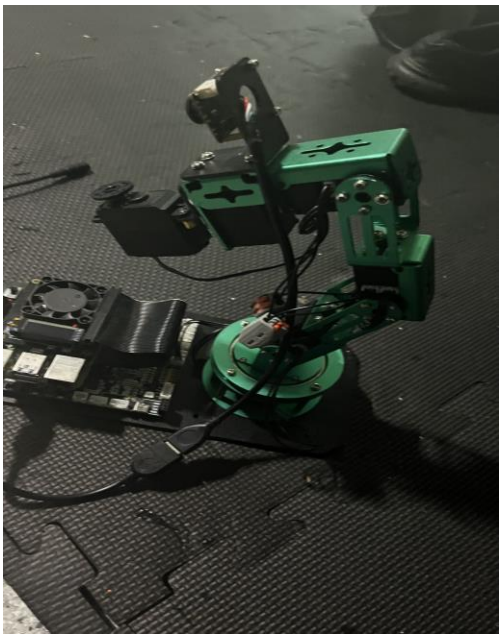

Enhanced Project Proposal: Robotic Arm-Based 3D Object Detection System

Problem Formulation

We propose developing a robotic system combining 4-servo 3-axis movement with computer vision to detect and track objects in physical space. The core challenge involves coordinating mechanical control with real-time image analysis to overcome limitations of fixed-camera systems through dynamic perspective acquisition.

Motivation

While AI object detection has become commonplace, existing solutions face three critical limitations our project addresses:

1. Perspective constraints - Fixed cameras limit observation angles

2. Dataset specificity - Generic training data often lacks application-specific contexts

3. Hardware integration - Few solutions combine active camera positioning with detection algorithms

Our robotic arm implementation enables novel capabilities like multi-angle object scanning and adaptive tracking, with potential applications in quality control, assistive robotics, and automated inventory systems.

Feasibility Study

The project is achievable within course constraints through:

Factor	Assurance
Hardware	Existing 4-servo arm + camera rig
Software	OpenCV/TensorFlow/PyTorch ecosystem
Timeline	Phased development approach
Expertise	Team skills in CV, robotics, and ML

Problem Statement Development

Phase 1 (Data Generation):

- Capture images at 27 positions (3×3×3 grid) in workspace
- Generate dataset covering:
    - X/Y/Z axis variations (±10cm range)
    - Lighting conditions (50-500 lux)
    - Object orientations (0-360° rotation)
- Additional Exportation and customization of files done via software:
    - Sampling and generating image color filters
    - Refactoring image based on needed resolution
    - Creating several variations of train and test data
    - Adding additional customization and formatting to original media

Phase 2 (Model Development):

- Train YOLOv8-based detection model
- Achieve better that 50% accuracy via mAP on static objects

- Implement basic servo control feedback loop

Proposed Tentative Solution

Milestone 1: Core Functionality

1. Servo calibration for precise positioning (±2mm accuracy)
2. Data pipeline for automated image collection
3. Baseline object detection (FPS >15)

Milestone 2: 2D Static Detection

- Detect printed patterns on test cubes
- Implement position logging system
- Develop basic UI for monitoring

Milestone 3: 3D Static Detection

- Extend detection to volumetric objects
- Calculate object dimensions via multi-view analysis
- Implement collision-avoidance protocols

Milestone 4: Human Detection

- Add pre-trained human detection model
- Implement safety shutoff features
- Achieve 80% detection rate at 2m distance

Milestone 5 (Stretch Goal): Dynamic Tracking

- Enable 360° object tracking
- Develop predictive movement algorithms
- Achieve <500ms latency in closed-loop system

This phased approach ensures incremental complexity while maintaining achievable benchmarks, with Phase 1 deliverables providing complete standalone value in case of further complexities found during development that significantly delay delivery.