Vision-Based Object Tracking System

By: Brett Beaulieu

1. System Overview

The Vision-Based Object Tracking system enables real-time visual tracking of a red-colored object using a Luxonis OAK-D camera. The camera is connected to a host computer running a Python based script which processes the real time video, identifies the location of the red object and its horizontal position, and transmits a corresponding servo angle to an Arduino microcontroller. The Ardunio actuates a servo motor to follow the object's movements and displays the servo angle on an OLED screen. This system demonstrates the basics of machine vision, mechatronics, and embedded firmware all combined together.

2. System Architecture

2.1 Functional Requirement

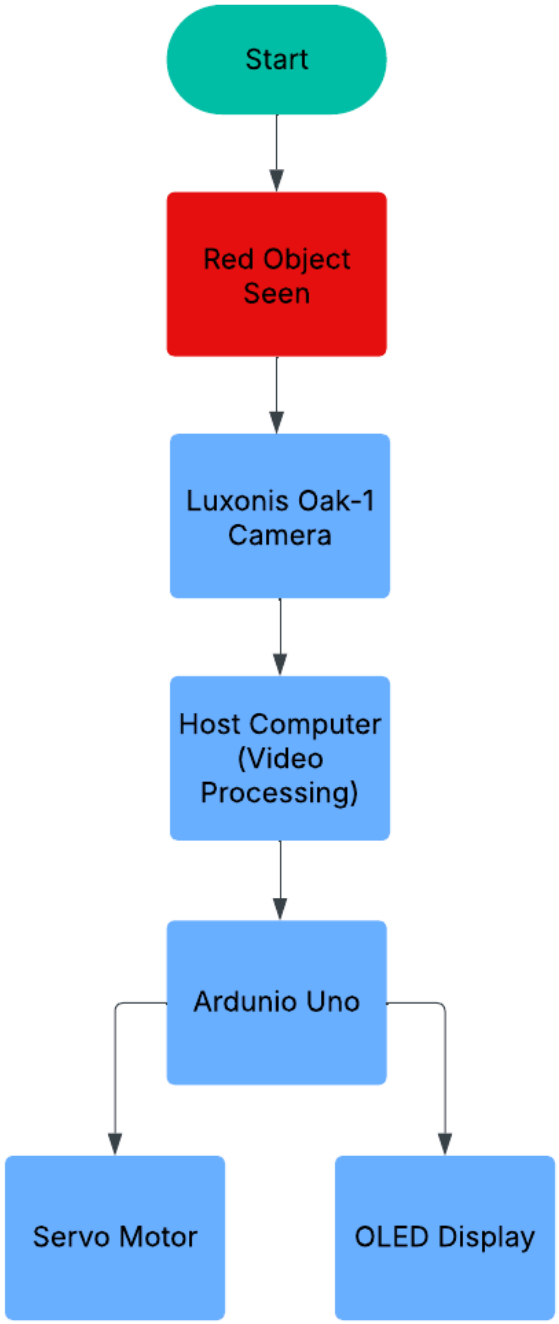
ID	Requirement
FR-1	The system shall detect a red object when in the camera's field of vision
FR-2	The system shall calculate the horizontal position of the object and map it to a 0–180° range.
FR-3	The system shall transmit the angle value to the Arduino via serial connection.
FR-4	The Arduino shall rotate a servo motor to the specified angle.
FR-5	The Arduino shall display the current servo angle on an OLED screen.
FR-6	The OLED shall display no object detected when red object not visible

2.2 Non- Functional Requirement

ID	Requirement
FR-1	The system shall use affordable, low budget parts
FR-2	The system shall be powered using USB
FR-3	The system shall have a quick response time under 500ms.

3. System Architecture

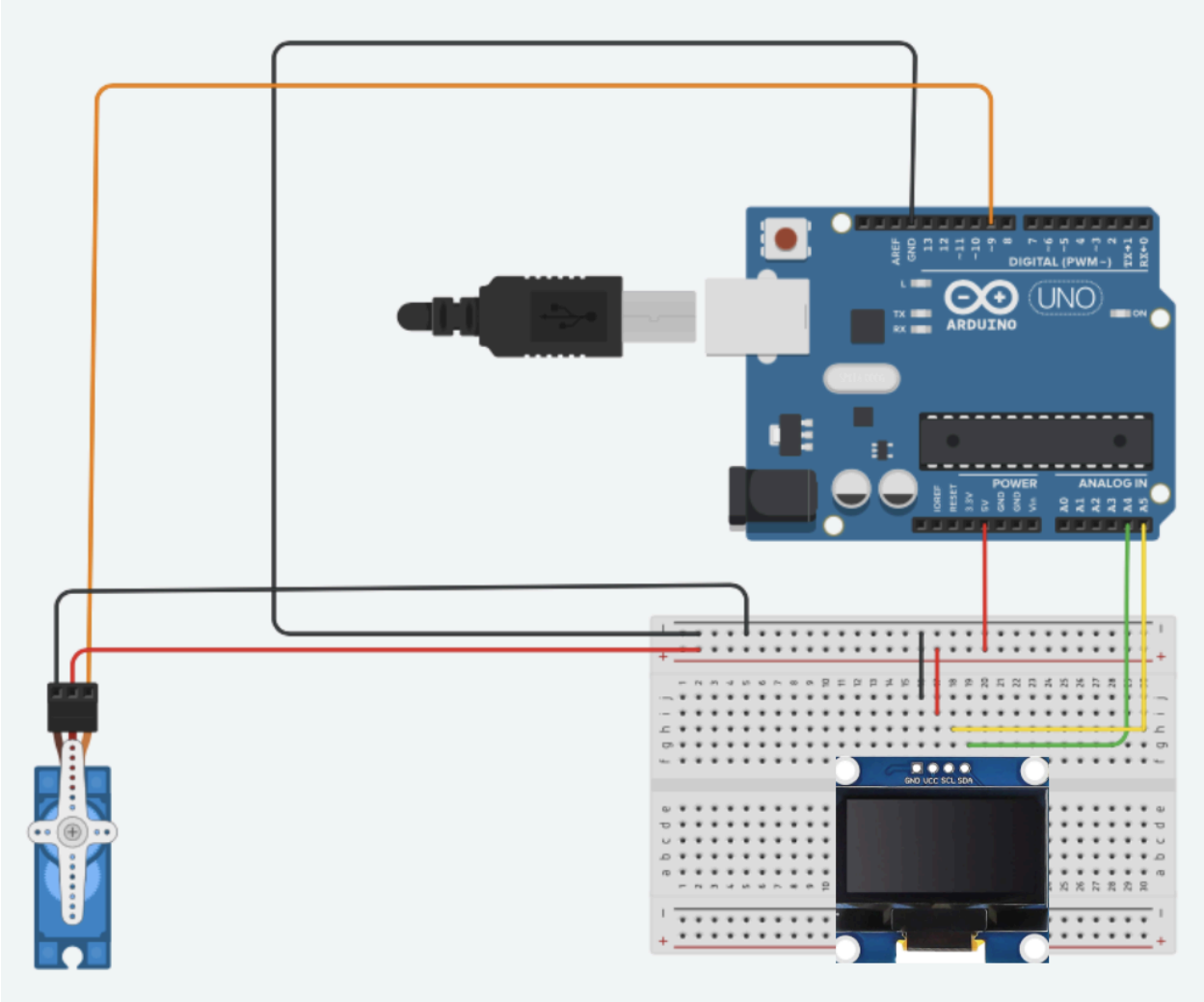
3.1 Block Diagram



4. Hardware Components

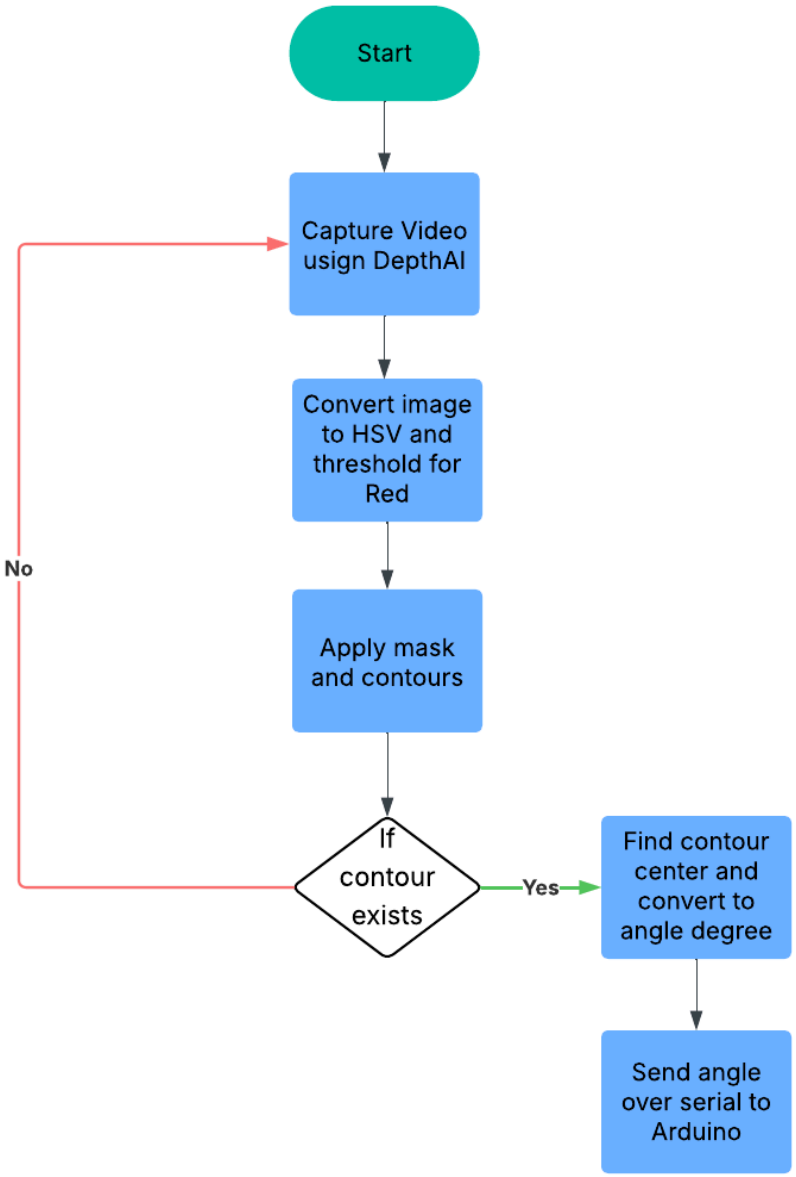
Component	Quantity	Description
Luxonis OAK-D Camera	1	DepthAI Camera via USB
Ardunio UNO	1	Microcontroller for servo and LED display
SG60 Servo Motor	1	180° micro servo motor
0.96" I2C OLED	1	128x64 pixel display via I2C
Jumper Wires	9	Male to male wires to connect components
Breadboard	1	Prototype and wire components
USB-C to USB-A Cable	1	Connect Luxonis Camera to host computer
USB-A to USB-B Cable	1	Connects Arduino Uno to host computer
Host Computer	1	Macbook Pro for video processing and programming

5. Wiring Diagram

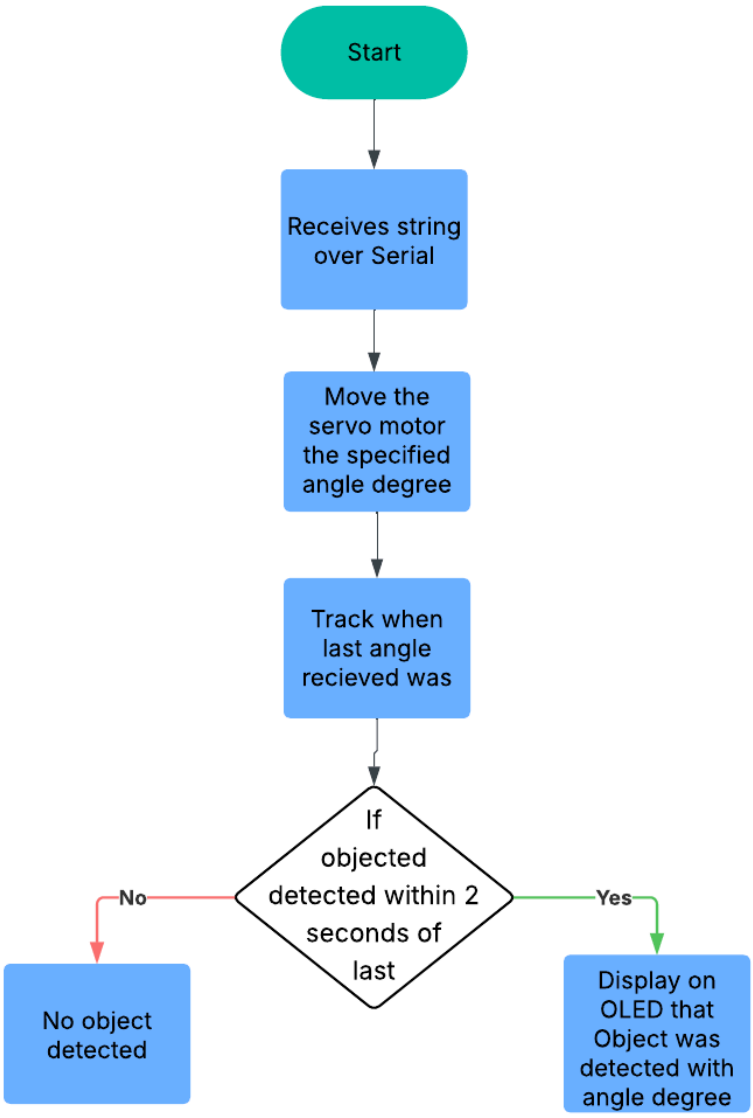


6. Software Design

6.1 Host Computer (Python)



6.2 Arduino Microcontroller



7. Power Considerations

- System powered via USB only.
- Estimated total current:
    - Arduino: ~50 mA
    - SG90 servo (idle/light): ~150–300 mA
    - OLED: ~20 mA
- **Conclusion:** USB 5V (500 mA) is sufficient for basic operation without external battery.

8. Testing & Validation Plan

Test Case	Description	Pass Criteria
TC-1	Red objects appear in front of camera	Servo responds with 0.5 seconds and box appears around object
TC-2	Red object moves from left to right	Servo follows with mapped motion
TC-3	Red object moves from right to left	Servo follows with mapped motion
TC-3	No object in view	Servo stops; OLED displays that no object was found
TC-4	OLED Angle	OLED shows current servo angle correctly and matches video processing display
TC-5	Begin with no red object in view	OLED displays no object was found

9. Future Improvements

- Add a second servo motor for vertical tracking
- Add distance estimation of the robot
- Use a Raspberry Pi for a self-contained system (no PC needed)
- Create a robot arm tracking the object