Air Defense Architectural Review

Introductions

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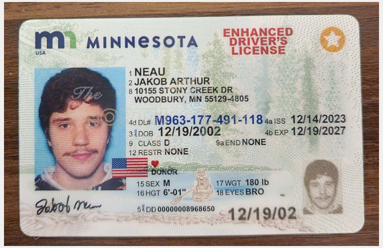

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High Level State Machine

Idle

- Motor mount is centered and we are waiting for a signal from the object detector to start the tracking state

Tracking

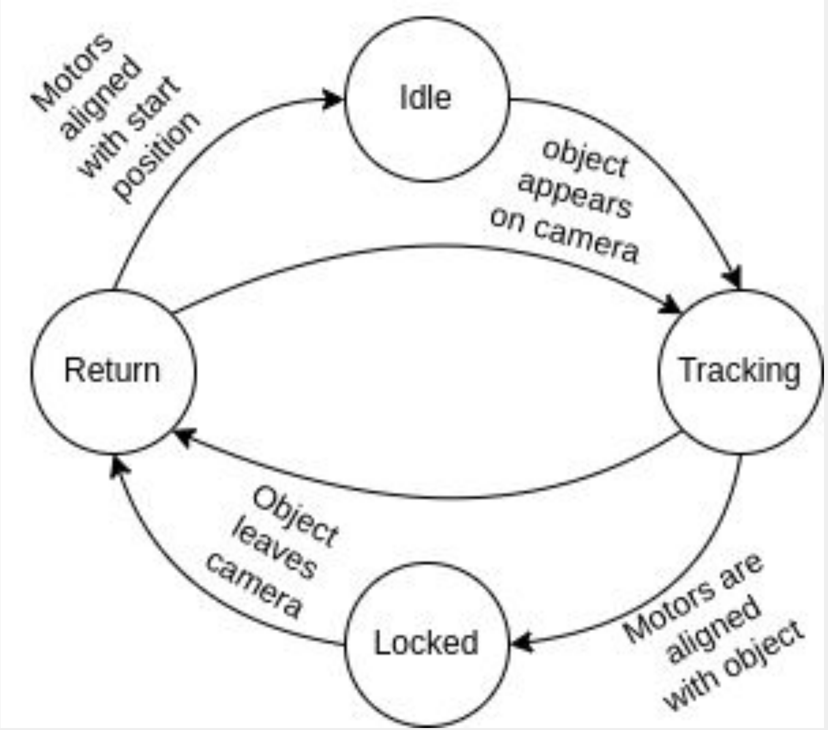
- Once an object is detected, drive the motors to align our laser. We may need to lead the target by a small amount to compensate for any latency from the camera.

Locked

- Once the motors are on target for a to be determined amount of time, turn on the laser. Keep tracking the target.

Return

- Once off screen, drive the motors to the start position, then move back to idle.



High-Level Block Diagram

External Hardware

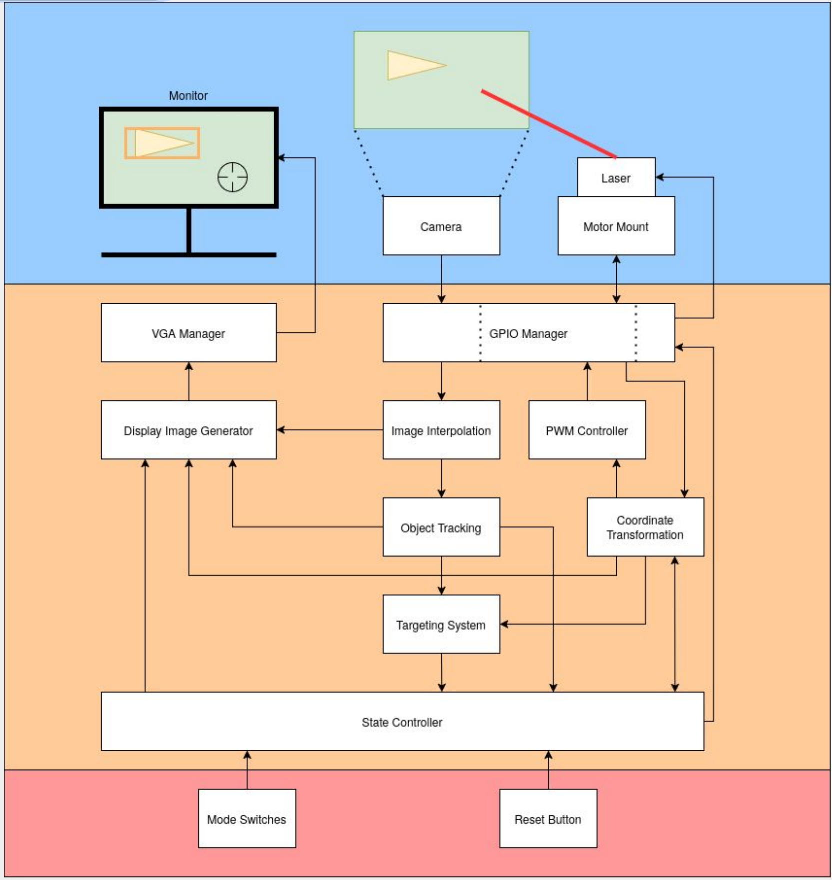
- Camera detects scene
- Monitor displays tracked objects
- Motor and laser track and shoot target

FPGA Programmed Units

- GPIO and VGA managers handle external signal routing
- Display image generator takes frame data and position data to produce image
- Image pipeline tracks a thrown object
- Motor pipeline drives the laser to our desired location

FPGA Board Switches

- Handle reset and setting other modes



Algorithms to Accelerate

Object Tracking

- We need object tracking to get the position of the object for targeting purposes
- We need object detection to set the board to the tracking state when a thrown object appears on screen
- Neural networks can take a (comparatively) long time to generate tracking data, so pipelining this section will be key

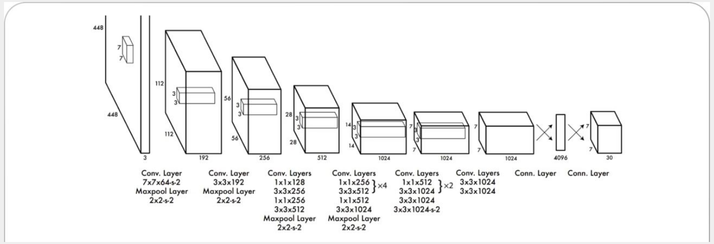
Coordinate Transformation and PWM Controller

- The target values in the detection module will be continuously changing throughout time
- We need to design a module that can react quickly to movement that may not be predictable

Accelerator Implementation

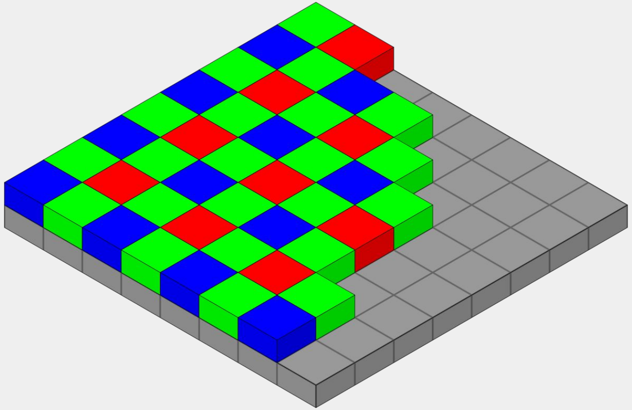
Object detection

- We need to base our hardware on an algorithm that does not take a long time to compute
- YOLO is a candidate for acceleration, but we will need to see if it will fit on our FPGA
- Pipelines can be inserted between layers of the CNN to increase throughput at the cost of latency



Coordinate Transformation

- Accumulate a complete image of pixels (frame) from DE1-SoC Camera module
- Processes frame to determine location of selected object as X and Y coordinates
- Virtual coordinates from the camera will be transformed to Physical coordinates through pre calculated look up table values



External Interfaces

Camera (input)
- Input pixel stream to board
- Camera refresh rate must be greater than the 15fps from minilab

Monitor (output)
- Relay camera image with image proc overlay for feedback

Pan-tilt servo setup (output)
- Board must output 50Hz pwm with variable duty cycle for servo position.
- Exploring increasing pwm freq for quicker response times

Laser Control Signal (output)
- Board will output wire for laser pointer enable

Plan Verification

Laser Movement

- After researching servo drivers, we realized that we no longer require a PID controller to interface with them. We will, however, need extensive drivers in order to produce the PWM signals needed for movement.

Object Identification

- We switched from an object detection model to an object tracking model on the graphical side as it will provide us with a more reliable means of following the object.