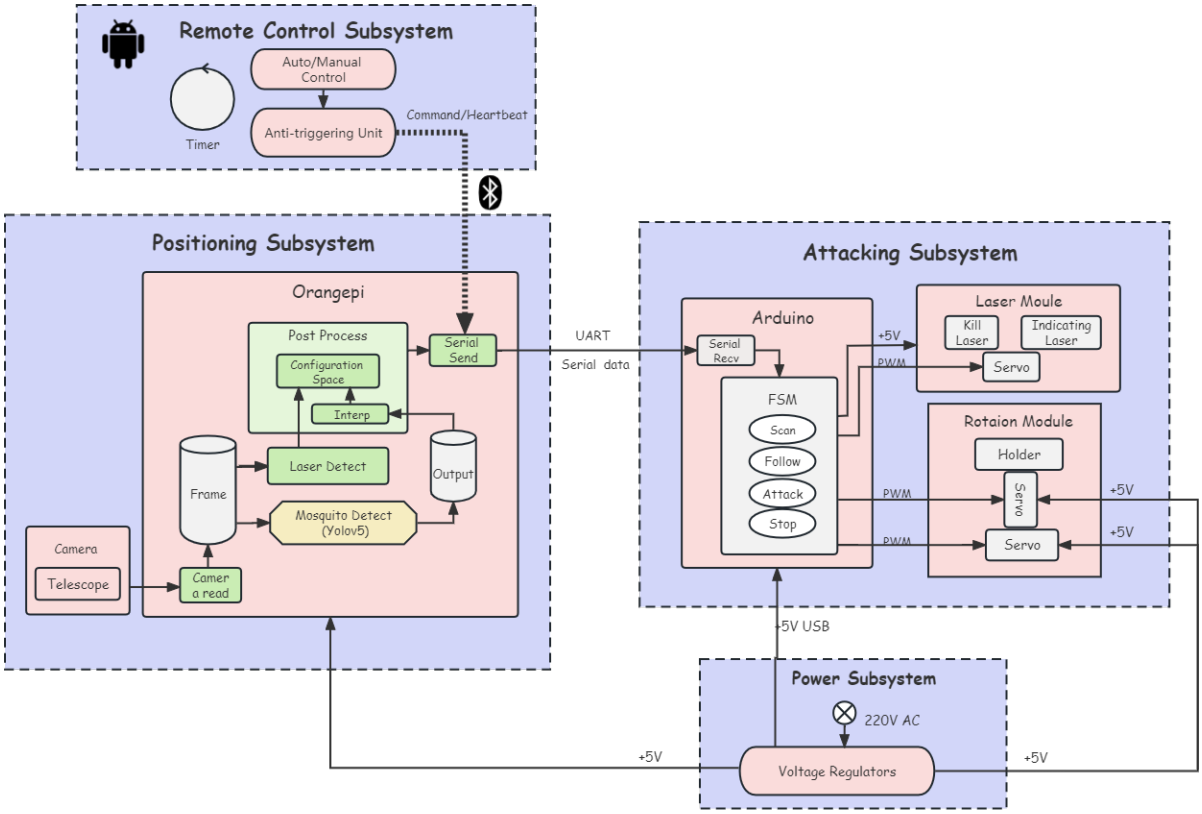
Laser System to Shoot Down Mosquitos

Team 12
Fan Yang, Ruochen Wu, Yuxin Qu, Zhonqi Wu

Block Diagram



High-level Requirements List

1. Our software was able to identify mosquitoes that occupy at least 1/20 the size of the total pixels in the image.
2. The location of the attacking point should not be more than 3 millimeters away from the mosquito to ensure that it will hit the mosquito.
3. The power of the laser should be larger enough to kill mosquitoes, so a 1 W power laser is considered.

Requirements and Verifications

Camera

Requirements	Verification
1. The camera should have resolution higher than 3200(H) x 2100(V). 2. The focal length is larger or equal to 11.54mm.	1. Connect the camera to the processor, and input one image. Check whether the resolution of the image is higher than 3200(H) x 2100(V). 2. Use a paperboard with 1cm height and 1cm width as the target object. Take the picture of this paperboard at the best working distance (300mm). Calculate the focal length of the camera.

Processor

The embedded development board is a processor for computing.

Requirements	Verification
1. The board needs to have the MIPI CSI interface to receive the data from the camera and image preprocessor. 2. The board should have the ability to receive and process images with a resolution higher than 3200(H) x 2100(V) and a frame rate higher than 6 frames per second (FPS). 3. The board should support to process yolov5 model. 4. Output PWM through the GPIO interface.	1. Connect the processor with the MIPI camera. 2. Input a video with a resolution of 3200(H) x 2100(V) and 6 FPS and operate a known program on this video. Check whether the program works as expected. 3. Operate a known program based on yolov5. Confirm that the program works as expected. 4. Write a program to control PWM and test the output waveform by an oscilloscope.

Power Supply Unit

Requirement	Verification
1. Output 220V AC (actual voltage will be between 215V and 235V)	1. Use the uniform voltage port of 220V 2. Measure the voltage with a voltmeter to make sure the voltage is between 215V to 235V

Adapter

This regulator will transform the 215V-225V voltage to 5V and 12V.

Requirement	Verification
1. Output 12V +/-5% voltage and 5A +/-5% current from a 215V - 235V source.	1. Measure the output current with an oscilloscope to make sure the output current is within 5% of 5A 2. Measure the output voltage with an oscilloscope to make sure the output voltage is within 5% of 12V

Laser

Requirement	Verification
1. The laser can kill the mosquito 2. The laser generator can be put on the holder 3. The generator can switch power immediately once the mode signal received	1. Buy the laser generator with high power at least 1w. 2. Buy the generator at proper size, or use the optical to let the laser move freely 3. Test it with RK3399PRO and make sure it can work immediately.

Servos

Requirement	Verification
1. It can't shake violently while rotating 2. The speed must be slower than 0.032 rad/s 3. It satisfies the above max rotation angle	1. Test it by sending signals to it and make sure it will not shake violently especially when the laser spot is close to the mosquito 2. Fix a mosquito on the wall and make sure it can be reached by the laser spot 3. Make sure servos can reach any direction in space

Holder

Requirement	Verification
It has enough strength to hold the camera and the laser	Make the holder of a load-bearing material.

Computer Vision

Use pretrained model
use the large-scale pretrained model on insects which capture the insects-feature efficiently

Change the architecture of the model
Since the recognizing mosquito belongs to the small object detection, we add an anchor that can capture the feature of small size

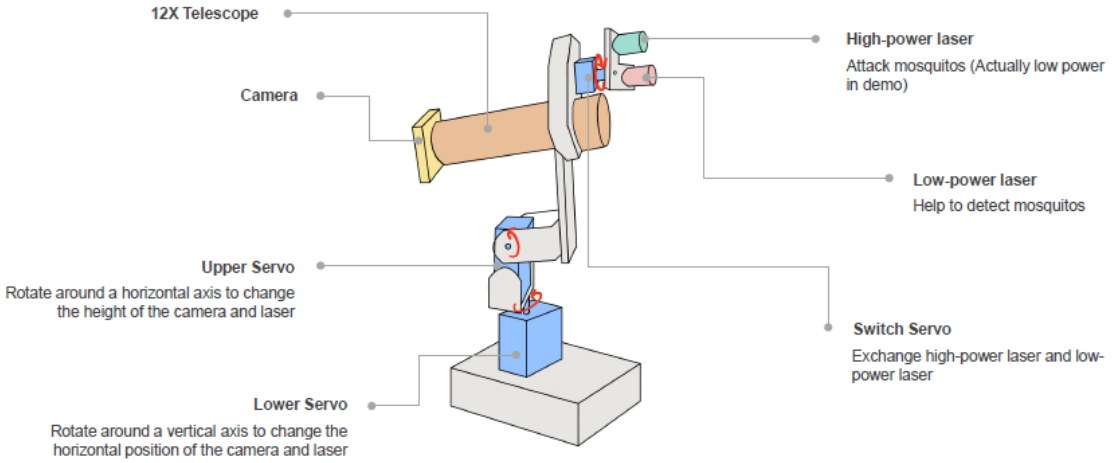
Use edge detection algorithm to recognize laser
Train Yolov5 only on mosquito datasets to enable yolov5 model to capture the feature deeply. Improve the recognition precision and recall rate.

Use 1280*780 pixels of camera image
We balance the model processing speed and the size of camera image and choose the size that fits most

Use datasets of mosquito of diversity
We use different size, species and pose of mosquito. Blur and change lightness of image to augment the datasets. Finally get a combination of mosquito datasets.

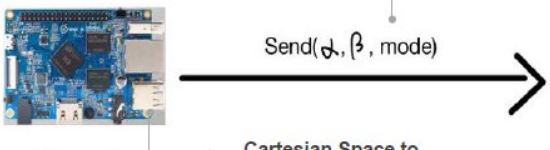
Take full advantage of computing power
Improve the cv model speed since edge detection algorithm can be run on CPU and yolov5 can be run on GPU

Mechanical Structure



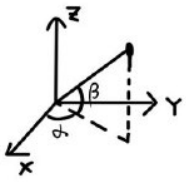
Rotation Module Control

Serial communication between Orangepi and Arduino

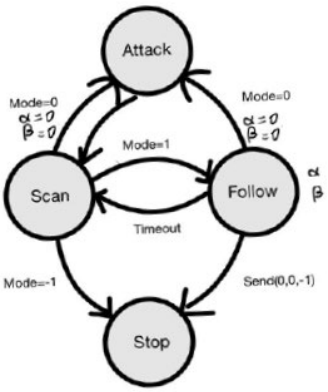


Orangepi

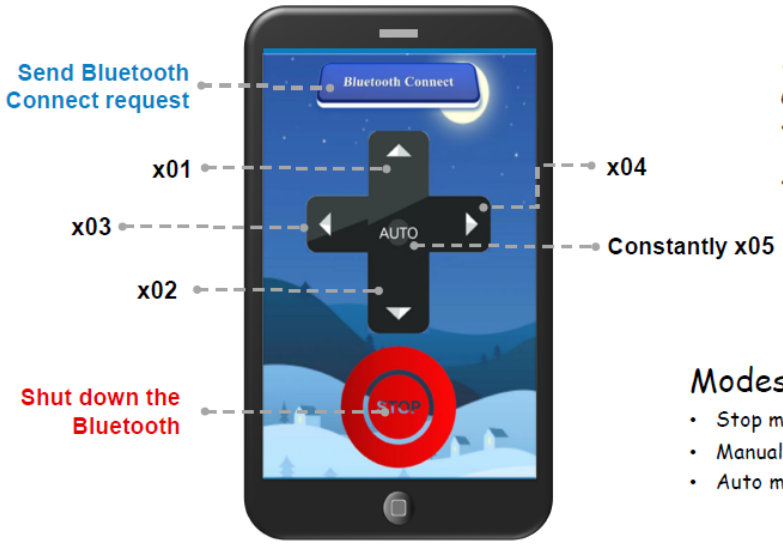
Cartesian Space to Configuration Space



State diagram



Remote Control APP



Anti-triggering

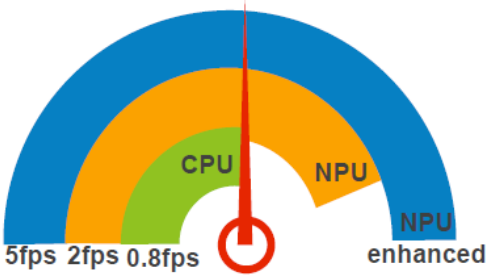
Guarantee controllability

- Idle: send heartbeat x00 to Orangepi
- Busy: send commands

Modes by Priorities

- Stop mode: shutdown
- Manual mode: up down left right
- Auto mode: auto detect and attack

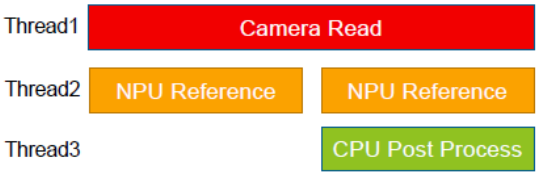
Acceleration Strategy



01 NPU (NerualNetwork Processing Unit)

Credits for https://pin.it/4aepLZ4

02 Asynchronous Post Processing



03 Model Quantization