Ballistic Projectile Tracking

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Objectives/Motivation

- ❑ Designing a system that tracks and predicts the trajectory of a small ball launched at an angle
- ❑ Designing a launcher that includes the use of a push/pull solenoid
- ❑ Reliable detection and tracking of high-speed projectile
- ❑ Use of stepper motors and laser pointer to predict the landing of the ball

Introduction

Problem Statement
Ballistic projectile tracking has many wide ranges of applications in computer vision and can be utilized in areas such as surveillance, traffic flow monitoring, and providing protection to soldiers and infrastructure in the battlefield. It is desired to design a system capable of locating and predicting the path of a small ball traveling on a ballistic trajectory through the air and displaying the predicted landing position.

Proposed Solution
A spring-powered launcher fires a small pink ball into the air, which is then tracked by a USB camera utilizing OpenCV. The tracker predicts where the ball will land, and the two-motor laser pointer will move to point on the ground where the ball is predicted to land.

Conclusions

Overall System
- ❑ Final implementation of parts into the overall system proved difficult with errors in system accuracy and response time.

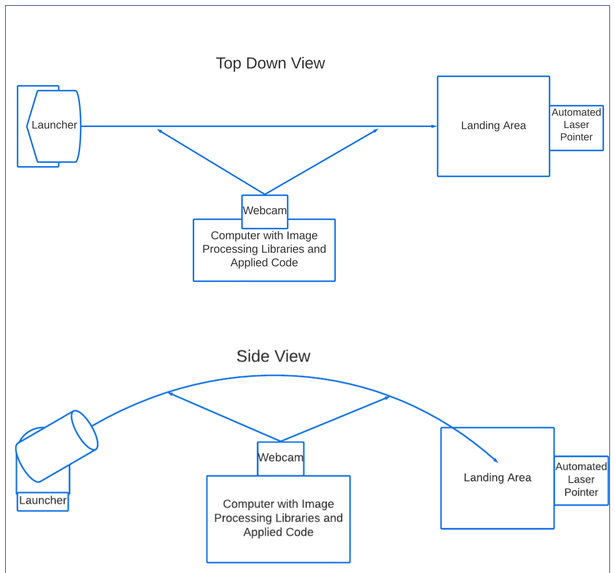
Launcher
- ❑ Spring Constant ≈$105.933\ \frac{N}{m}$
- ❑ Launch distance was consistently between 5ft-6ft

Tracking
- ❑ Calibration is very important in detection.
- ❑ Processing power and timing introduces hard limits to work around.

Laser Pointer
- ❑ Inconsistent rotation in azimuth direction
- ❑ Zenith direction motor works well

Methodology

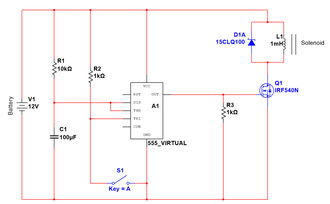
Combined System

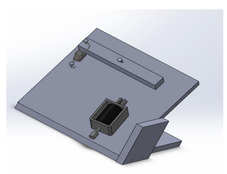


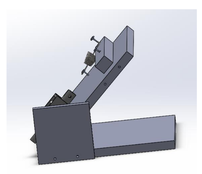
- ❑ The launcher can launch the ball up to 6 feet at varying angles.
- ❑ The camera that tracks the ball is perpendicular to the ball's path, and the laser pointer is at the end of the area the ball can land within.

Launcher Design

- ❑ The purpose of the launcher was to launch a ball at a specific distance that involved the use of solenoid.
- ❑ The launcher currently involves using a spring-powered aluminum bar which is triggered by a solenoid.



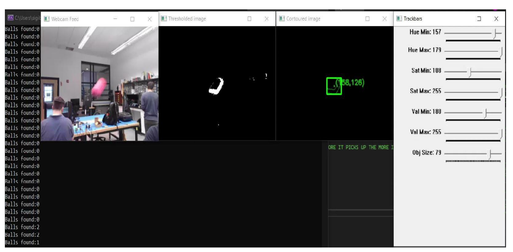




Design Challenges
- ❑ Solenoid launch velocity
- ❑ Solenoid armature current limitation
- ❑ Launcher redesign

Image Processing and Tracking

- ❑ Using OpenCV Image Processing Libraries, incoming video data was processed using various Image Processing Methods to return three object outputs: contrast, threshold, and coordinates.
- ❑ Limitations in processing power require alterations in the acquisition parameters of incoming data, precise calibration of the desired hue, saturation, and color value, and other processing methods.
- ❑ Resulting coordinates allow the predictions of the landing point of the object.
- ❑ Glare introduces a variation in the resulting HSV value that is difficult to work around.

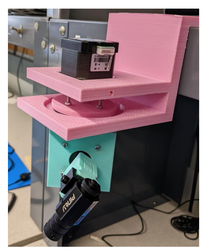


Design Challenges
- ❑ Glare
- ❑ Processing Limitations
- ❑ Hardware Limitations

OpenCV

Automated Laser Pointer

- ❑ Designed to point on the ground where the tracking system is predicting the ball will land.
- ❑ Has two motors; azimuth (for rotating the laser pointer left and right) and zenith (for angling the laser pointer up and down), powered and controlled by Raspberry Pi.
- ❑ Custom 3D printed bracket to hold motors and laser pointer.



Design Challenges
- ❑ 3D printer tolerance issues
- ❑ Friction in laser pointer bracket rotation

Future Work

- ❑ Add extra camera for predicting lateral movement
- ❑ Add thrust ball bearing for launcher bracket
- ❑ Develop better solution for lighting glare issues