PROPOSAL

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Autonomous Sentry Gun
EEL4665 INTELLIGENT MACHINES DESIGN LABORATORY
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Abstract

I plan to build an autonomous sentry gun that will detect, track, anticipate and engage targets autonomously. Instead of using a webcam as I have done in the past, I plan to use a Kinect, or some other form of 3d-sensing input, to capture the full depth of the turret's field of view. I will use this depth data to anticipate target movement more accurately and to better differentiate between false and valid targets. Instead of using an airsoft or paintball gun as I have done in the past, I will be using a Nerf gun that fires small foam disks. If time permits, I would like to further augment the system by using two Kinect sensors arranged so that together they double the field of view.

Executive Summary

(to be done for the final report)

Introduction

Sentry guns were a favorite weapon of mine as a teenager playing video games. That was the original inspiration for this system. Fortunately a turret that autonomously tracks targets does have a few real-world uses. Law enforcement and the military could use them for close-quarters training. They can serve as an added perk in scenario paintball and airsoft games. Laser-tag facilities could also use them to add new scenarios to their games. For laser-tag in particular an autonomous sentry that only has to fire a laser would be especially low-maintenance. Yet another use could be a system that automatically keeps the person on stage in a video camera's field of view. In addition to that, a small turret with two cameras, a wide-angle camera and a zoomed in camera, could be used as an autonomous security camera system. This type of system would could automatically track and record targets in much more detail than a typical security camera.

The goal of this project is to build an autonomous sentry gun that fires some harmless projectile, which takes advantage of depth data in some advantageous way. Ideally this added dimension (depth) would lead to less noisy target detection, better target filtering, and also provide the data necessary to enable more accurate target anticipation. If time permits, additional goals would be to utilize two Kinect V1's together to double the field of view, get the Kinect V2 working as a replacement for the Kinect V1, or use a completely different sensor, such as a 24GHz Doppler radar from an automotive adaptive cruise control system, or a scanning LIDAR unit.

This paper will go through the organization of the proposed system, including the actuation, application of the different hardware used, the robot's objectives, the characteristics of the sensors and hardware, any relevant drawings, the theory of operation for the system, algorithms used, and lessons learned. The paper will conclude with the summary of work accomplished, including any limitations and future work, any relevant documentation, and the appendix containing any relevant code, diagrams and/or other supplementary material.

Integrated System

The system is comprised of a Kinect V1 sensor, and computer, such as a laptop or a tablet, a servo controller, a turret that is powered by two HS-5645MG hobby servos which can move up, down, left and right, a RC relay for applying power to fire the gun, and a Nerf Vortex gun that fires small foam disks.

Theory of Operation: Software running on Windows will be processing the depth data coming in from the Kinect sensor. It will use this depth data to determine what a valid target is, where it is going, how far to anticipate the target, and when to fire. The software will do this by sending commands to a servo controller. The servo controller will translate and send the translated signals to the two servos, and the RC relay, to aim and fire the Nerf gun.

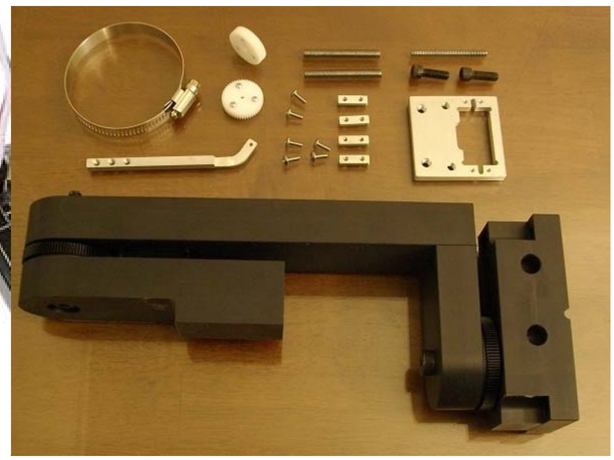
The Kinect sensor will provide the depth data needed by the software. The software will process that data and send the appropriate commands to the servo controller to aim and fire the Nerf gun in such a way that the disks fired from it hit the target. In this way, the proposed system should meet the specifications an objectives outlined in the introduction.

Actuation

The turret is actuated by two Hitec HS-5645MG servos. The servos are mounted in pan/tilt hardware and the pan/tilt hardware holds the nerf gun. In the pan/tilt hardware, one servo moves the gun up and down while the other servo moves the gun left and right. There is also an RC relay from Pololu that takes in servo position commands and flips a relay on or off depending on whether the PWM command is greater than or less than 1500us.

Servo

RC Relay



Turret Hardware

Motor Type:	3 Pole
Bearing Type:	Dual Ball Bearing
Speed (4.8V/6.0V):	0.23 / 0.18
Torque oz./in. (4.8V/6.0V):	143 / 168
Torque kg./cm. (4.8V/6.0V):	10.3 / 12.1
Size in Inches:	1.59 x 0.77 x 1.48
Size in Millimeters:	40.39 x 19.56 x 37.59
Weight ounces:	2.11
Weight grams:	59.82

Servo Specs

Sensors

The only sensor used currently is a Kinect V1. (You could say that the potentiometers inside the servos used to give position feedback are also sensors.) The Kinect V1 has a horizontal field of view of 57 degrees and a vertical field of view of 43 degrees. It produces a 320x240 depth map and has a range of about 20-30 feet. The Kinect V1 uses an infrared laser projector to project a non-uniform dot pattern. The position of the dots as detected by the camera tell the Kinect how far away each point is. The main disadvantage of the Kinect though is that it generally does not work outdoors, since IR light from the sun easily blinds it, and that the range is only about 4.5 meters.

Behaviors

The autonomous sentry gun has a few different modes with corresponding behaviors for each mode.

Calibration Mode: This mode can used to manually move the turret using sliders but is intended to be used to perform the calibration procedure. Calibration of this system results in the mapping of each pixel to an X and Y servo position.

Mouse Aiming Mode: In this mode, the turret will aim at the mouse's position when the mouse is over the camera window. It can be used as a more efficient way to manually aim and fire (by clicking) the turret but its purpose is to act as a means to verify the correctness of calibration.

Auto Aim Mode: In this mode, the turret will automatically engage targets based on the settings set by the user.

Target Track Mode: While in this mode, the user can click on a spot in the image and the turret will lock onto it and engage that target even as the lighting and orientation of the target changes. This mode will likely not be of any used for this project.

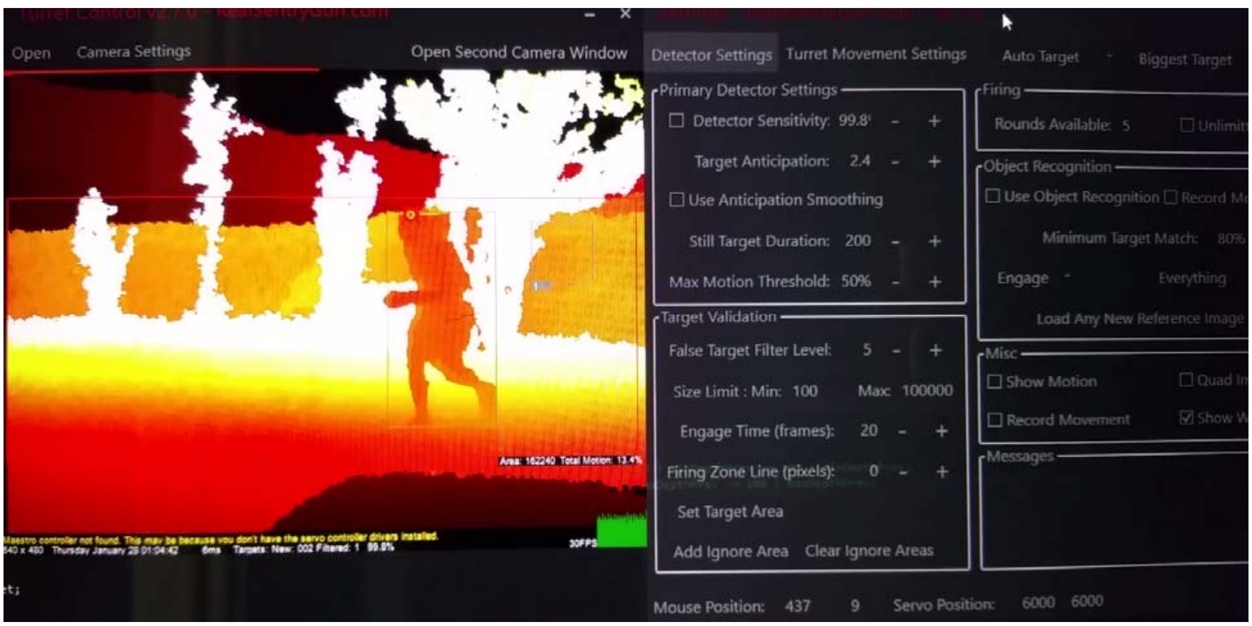
There are also additional modes and behaviors of lesser importance. There are different target priority modes: biggest, fastest, approaching, and timed target cycling, and different firing modes: semi-auto, full-auto, camcorder-mode, and semi-auto with unlimited rounds.

Experimental Layout and Results

Experiments were done in an indoor environment due the Kinect’s handicap in outdoor, daylight environments. In these experiments the best way to handle the depth data was examined and tested. New ways to detect and filter targets were experimented with and the target anticipation algorithm was implemented and tested at different ranges.

There were some key benefits to depth data in the target detection field. Since the data was depth data and not the typical image data, there were no issues with changes in lighting, shadows, or any of the other typical motion detection issues.

Target anticipation accuracy also improved from the added depth data. The previous algorithm just used a general multiplier that the user would adjust until the hit rate was as high as possible. Now the system can adjust the anticipation based on depth which leads to a far better hit rate.



Conclusion

(to be done for the final report)

Documentation

(to be done for the final report)

Appendices

(to be done for the final report)