Initial Project and Group Identification Document

Motion-Detecting Sentry

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Senior Design 1

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Project Narrative

Our project idea came about while brainstorming. Initially, we were looking into making a robot that could play cornhole. However, when we started doing a little research and considering the physics, it became apparent that a project of that caliber would become quite costly and physically complex. As a result, we began looking at alternatives that were still in the same scope, and we eventually came to the idea of making a turret. This turret would use paintballs to mark individuals of interest and make them easily identifiable.

Our goal is to create a turret that uses computer vision to identify and hit its targets. The turret should be able to use computer vision to detect when someone is moving within its range and then tag them with a paintball. Our hope for this project is to develop an additional security measure that could be used by businesses to help deter crime, or make the perpetrator easier to identify in the event that criminal trespassing does occur. This product would provide a nonlethal alternative in comparison to using live rounds, while also decreasing risk to security officers.

The outcome of this project will be a lightweight, movable and accurate paintball turret capable of hitting a moving target, all while remaining cost effective.

Hardware Requirements

1. Should be light and small enough for one person to pick up and carry.
2. Should have a camera to find and identify targets
3. Should have a motion sensor to activate the turret's camera
4. Should have a gun (of some nonlethal kind) to fire upon identified targets
5. This gun should be capable of fully automatic fire, with a magazine of at least 20 rounds
6. Should have a turret capable of 180-degree horizontal movement and 45-degree vertical movement
7. Should be able to move the gun while firing to maintain accuracy
8. The gun should have an accuracy of at least 70% even while the target is moving
9. Should have a power cord for constant power
10. Should have internal batteries to continue function without the power cord
11. Should have a robust exterior to protect the turret from retaliatory attacks
12. Should be built with a warning system to indicate the turret is about to fire (a flashing red light)

Software Requirements

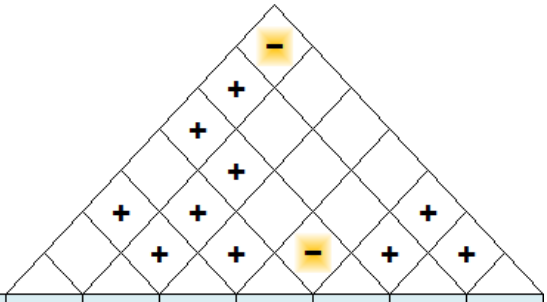
1. Should use computer vision to identify targets
2. Should use motion sensor to activate the camera to check for targets, in order to save energy
3. Should be programmed to aim at and fire upon identified targets when they are within range
4. Should be programmed to stop shooting when a target leaves its range
5. Should be programmed to deactivate the camera after a period of time without apparent targets, to conserve energy
6. Should be programmed to give a warning when a target enters the turret's range
7. Should be programmed to wait five seconds before firing for the target to register the warning and vacate the premises
8. Should be programmed to adjust the turret's aim as the target moves
9. Should be able to identify multiple targets and prioritize them according to distance and time spent trespassing within the turret's range

House of Quality

Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
Strong	↑
Moderate	○
Weak	↓

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



	Column #	1	2	3	4	5	6	7
	Direction of Improvement	▼	▼	▲	◇	▲	▼	▼
Weight (out of 10)	Customer Requirements (Explicit and Implicit) \ Engineering Requirements	Cost of Production	Power Consumption	Processing Speed	Rate of Fire	Range	Size	Weight
6	Design Quality	↑	↓	↓	○	○	↑	↑
4	Durable	↑	○	↓	○	↓	○	○
4	Ease of Setup	○	↓	↓	↓	↓	↑	↑
8	Effective	↑	○	↑	↑	↑	↓	↓
5	Low Cost	↑	○	↑	○	↑	↑	↑
2	Portable Power	↑	↑	↑	↑	↓	↓	↓
10	Safety of Operation	↑	○	○	↑	↑	○	↑
10	Target Recognition	↑	↑	↑	↓	↑	↓	↓

Figure 1: House of Quality

Block Diagram

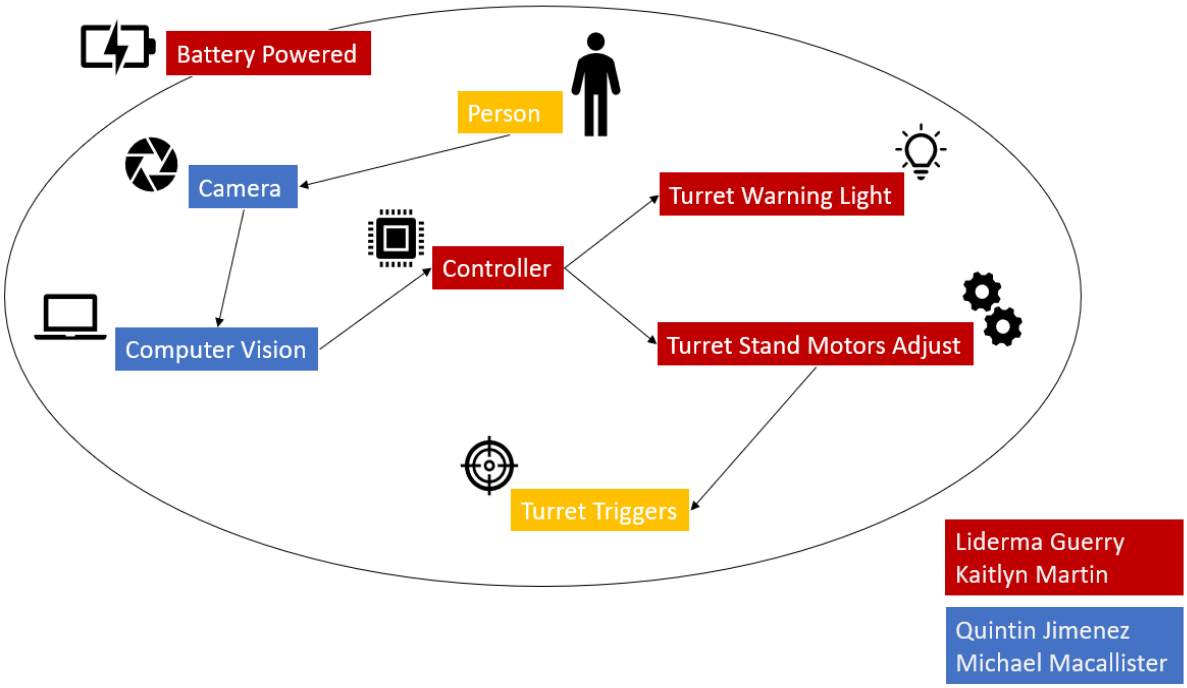


Figure 2: Block Diagram and Responsibilities

Group Breakdown and Responsibilities

Quintin J. – Software Lead (Make sure this person agrees to software decisions)

Kaitlyn M. – Hardware Lead (Make sure this person agrees to hardware decisions)

Michael M. – Computer Vision Specifics, Assist with Hardware/Software

Liderma G. – Assist with Hardware/Software

- All will assist with building decisions; this is not a final decision on responsibilities

Budget and Funding

Our project will be self-funded. The estimates of price breakdown based on project sections and parts are given below, excluding replacements for malfunctions or damages.

Item	Quantity	Price Estimate
Camera	1	$40 – $80
Sensor	1	$25
Power Cord	1	$10
Rechargeable Battery	1	$20
Gun	1	$20 – $100
Motors	2	$20
Microcontroller	1	$35
Paint	1	$10
Screws and Washers	2	$20
Adhesive	1	$12
Red Warning Light	1	$5
Materials for Structure	1	$50
Total		$267 – $387

Table 1: Parts and Budget

Project Milestones

Number	Milestone	Planned Completion Week
1	Design phase/ Prototype	6
2	Hardware and Software requirements/ Implementation	7-8
3	Power requirements	9-10
4	Circuit design/ Restrictions	11-13
5	Order parts	14-15
6	Design PCB	16-18
7	Order PCB	19-20
8	Build Prototype	21-23
9	Test/Debug Prototype	24-27
11	Final Product	28

Table 2: Milestones and Weekly Breakdown

Design Idea

The prototype would need to be lightweight yet big enough to house our chosen components. For the structure which houses the paintball gun, it would have the ability to rotate and pivot to find targets with computer vision (see link below). With this in mind, a sturdy material to support the weight of the chosen paintball gun is needed, so the prototype would not bend or sag, as shown in Figure 3. A base would serve as both a support and allow the structure to rotate using a motor. The entire structure with the base would sit on top of a tripod for added stability and portability, refer to Figure 4. The paintball gun used is intended to be non-lethal and would fire paintballs as a deterrent and to mark individuals. The firing action would be done via a motor attached to the trigger of the paintball gun. A camera would be mounted on part of the base to detect targets with computer vision. A sensor would also be used to detect targets to turn on device when in a low powered state. Below are concepts of the prototype for visualization but will not be the final product.

https://hackaday.com/2015/12/06/airsoft-sentry-gun-keeps-your-house-guarded/

This link shows an example of the intended motion of the turret.

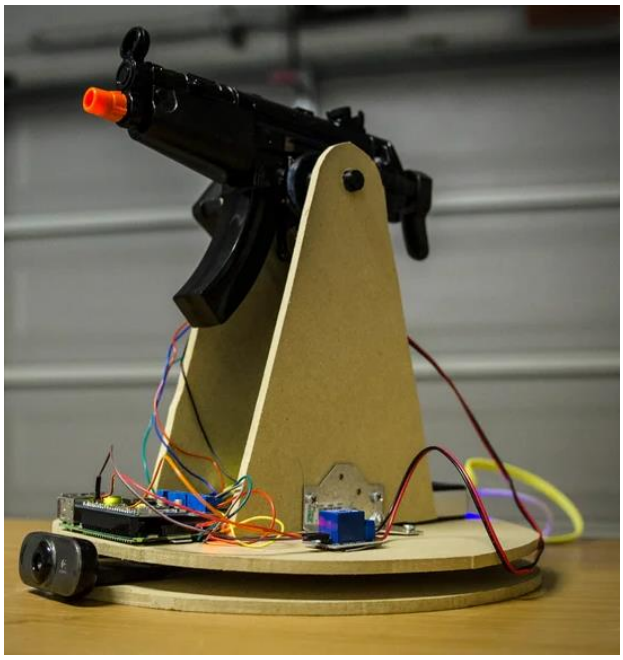


Figure 3: Prototype Concept 1

Figure 4: Prototype Concept 2

Implementation

The sentry turret product will have a variety of implementations, not limited to the prototype's capabilities. As mentioned previously, the sentry turret may be used as crime-deterrent for homeowners and businesses alike; however, the product will be designed with scalability in mind, such that the device can be recreated at a larger scale or used with multiple similar devices for military defense.

The prototype will be designed using motion sensors and computer vision to locate and identify potential targets within a specific range. To avoid unintended activation, the turret will have a unique activation method which is unlikely to be triggered without the intent to do so. In addition, the turret will include an auditory warning system indicating when it is active and ready for use.

Property owners will be able to use this device legally within their limit, assuming they place the product in an appropriate location. To do this, property owners should consider the range on the device when determining where to place it. When activated, the device will use motion sensors to decide if there is a potential target within firing range. Upon detecting motion, the camera connected to the device will turn on and rotate in the direction of the motion. At this point, the processor will begin using computer vision algorithms to determine whether the motion was caused by a human in the vicinity. Once the sentry turret recognizes a human form, the firing device will be aimed toward that individual and fired periodically. For deactivation purposes, the sentry turret will include a remote deactivation method, as well as a manual override.