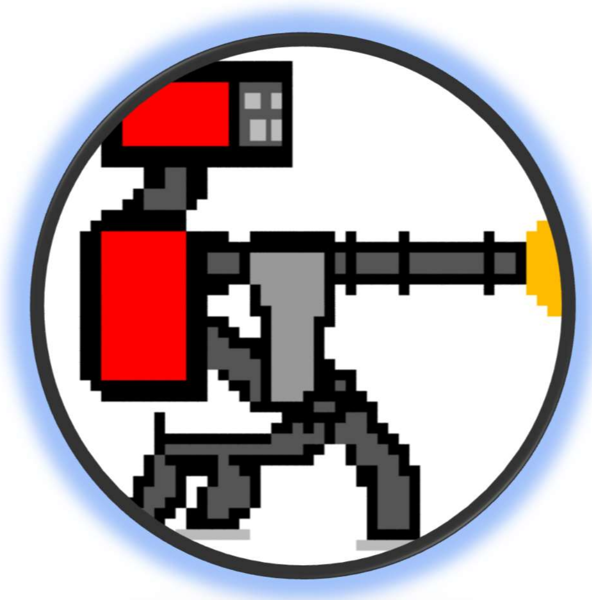
Initial Project and Group Identification Document

ANT-FR

Autonomous NERF Turret with Facial Recognition

A mounted non-expanding recreational foam turret that utilizes facial recognition software to detect and acquire designated targets within a field of vision.



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Narrative

There is a sense of nostalgia when using Non-Expanding Recreational Foam, which is best known as NERF. Throwing around a football or kicking a ball into a net was always a great pastime for children before the internet. In the early 2000's, Hasbro introduced their line of NERF Guns, which incorporated the idea behind super soakers with NERF. Boys and girls of all ages play with these toys daily, and let's be honest, even adults enjoy a friendly game as well. The fond childhood memories that our team has had with these toys is a leading factor as to why we are very passionate about working on this project.

Our project goal will be to design and build a functioning alpha prototype of an Autonomous NERF Turret that utilizes facial recognition software to lock onto targets. One of our intended outcomes for this project would be to bring back that nostalgia we experienced as a child, to other children and adults. To do this, this project needs to have scalability to be incorporated into businesses that have a "fun zone" theme such as: laser tag centers, arcades and makerspace areas. By keeping a strict budget that the average consumer can afford and making the design into modules or kits, we can scale the project to be easily purchased and utilized in businesses or even households, with ease of installation like that of IKEA furniture. Not only can we produce a fun and exciting product for consumers, this project can even be scaled for various training and simulations, which is the second highest grossing industry in the state of Florida. Autonomous turrets can be utilized in the military or police training to simulate real world firing and combat zones. The NERF component could be modified to use paintballs or airsoft pellets, which would add the extra benefit of realism to the training. Our project can have a vast amount of usages, depending on the industry that utilizes this project and the desired outcomes of the company using our design.

There are a few key functions that our project will need to perform to be a successful alpha prototype. By connecting to a database via a Wi-Fi or Bluetooth connection or physically having a large storage capacity, the autonomous turret will need to have the ability to access a database of images, which can be used as "potential targets" depending on the user. Using a mobile device or personal computer, the user will have the ability to upload and delete images from the database and be able to select an image as a target or deselect an image as a target. A target is an image of a person which the autonomous turret will fire NERF projectiles at, if the target comes into the field of vision of the input device used for the facial recognition. Using facial recognition software, the autonomous turret will need to reduce the number of false positives for acquiring a target that walks into the field of vision and be able to successfully hit the target at their center of mass when firing. While a target is within the field of vision and within the autonomous turret's degree of motion, the autonomous turret will have the ability to track a target and follow them until they leave the field of vision. If no targets are in the field of vision for the autonomous turret, the turret will continue to scan for targets without directly pointing at people walking through its field of vision.

The Autonomous NERF Turret with Facial Recognition project is intended to be a fun and exciting design challenge which will have real world applications in either small businesses or an entire industry for training and simulations. Our team will focus on customizing the technology by creating a user-friendly GUI and adding modularity to form kits for ease of installation. Our hope is that this project would be used in the future for professional and personal use.

Constraints

The system will be powered using external, rechargeable batteries that can withstand prolonged use, are properly insulated, and will regulate a consistent voltage supply to all necessary components. For the safe operation and recharging of cells, the batteries must comply with international and US standards for safety of operating and recharging cells (ANSI 60086-1). As we do not have a chemical engineer on our team, will not be manufacturing our own power cells, and we will have to rely on both retailer and producer to comply with the appropriate standards. An initial analysis has recommended that a lithium ion battery capable of approximately 14.8V would be ideal for the system, as the intended design runs currently at a minimum of 4V for at least 3 hours.

The chassis of the system must be able to support the weight of all hardware components, barring the stand that elevates the system off the floor, and accommodate the components to prevent self-damage during its intended usage, e.g. power system disconnects and components falling off due to motion. The turret chassis and components will be mounted onto a swivel that allows for movement around a vertical and horizontal axis, in which the position of the turret is controlled with 2-4 servos and will provide variable speed for either rapid or precise adjustments in both axes. The servos will be purchased from retail venues, which we will rely on the manufacturer following US and International standards for servos (e.g., UL 1004-6).

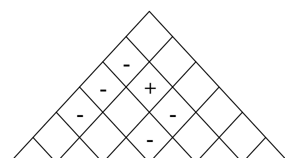
The robotic system would ideally operate within a well-lit, interior environment with level floors where the brightness of light sources is at an average of 800 lumens; however, this may not always be the case. The chassis and swivel will rest atop a stand with a minimum of three 3 legs that provides stabilization and allows the system to be properly leveled. The stand will support the entirety of the robotic system and its related components, as well as remaining firm and unmoving whilst operating. The stand should support approximately 15kg of mass (147N of force at the center and top of the stand) and stand at a height of approximately 145cm when assembled.

The system will make use of a camera with motion detection and facial recognition software to track the movements of potential "targets" and then confirm the target among the list of approved images within a database. The targeting system will communicate via a 2.4GHz 802.11.x Wi-Fi, or Bluetooth, connection to a human operator over an API to relay basic commands and update the list of potential targets with a user-friendly GUI. The system is set to operate in real time and would ideally have an overhead delay below 100ms.

House of Quality

Below in figure 1.1, the house of quality diagram reflects the marketing and primary engineering requirements for the project. Relationship correlation between requirements are represented in the correlation box, above the house of quality. Identifying and managing these correlation tradeoffs is critical, not only for an accurate parts and equipment selection process, but an overall thorough design. Note that project cost and battery longevity act as the leading negative correlators, while response time and range of motion serve as leading positive correlators. Installation time appears to have very little impact on the other correlations.

Correlation	
Positive	+
Negative	−
No Correlation	
Direction of Improvement	
Maximize	↑
Minimize	↓
None	



		Column #	1	2	3	4	5	6
		Direction of Improvement	↓	↓	↑	↓	↑	↓
Row #	Direction of Improvement	Engineering Requirements / General Requirements	Cost	# of False Positives	Battery Life	Response Time	Detection/Firing Range	Installation Time
1	↓	Cost	+		-	-	-	
2	↑	Accuracy		+			+	
3	↑	Power Efficient	-		+	-	-	
4	↑	Communicates Quickly	-		-	+		
5	↑	Range of Motion	-		-	+	+	
6	↑	Ease of Assembly						+
Targets for Engineering Requirements			< $1500	< 10%	> 12 hours	< 100 ms	> 170° Horizontal; > 90 Vertical	< 1 hour
		Column #	1	2	3	4	5	6

Figure 1.1. House of Quality

Block Diagrams

Figure 1.2 below represents the Software Block Diagram which follows the logic of the software from when the system is powered on to when the onboard NERF turret engages the target. The subroutines of the software can be separated into three categories: initialization, recognition, and verification. Initialization would transmit power to the entire system and establish vital connections to all components before operation. The system requires that a connection be established between itself and the database of images before any attempt to locate the target is done. Recognition is the interaction between the data input and the computation. The data from the input, such as the camera, is taken through the facial recognition software and evaluated. Verification takes the output from the facial recognition subroutine as a probability on whether the image sent belongs to a target profile and gives the authorization to the servos and firing mechanism to engage the target. The conditions for interrupts that are in the top right corner of figure 1.2 take priority over all other operations and subroutines. By taking priority, this ensures a proper power cycle, safety standards are met, and that the components revert to their resting state.

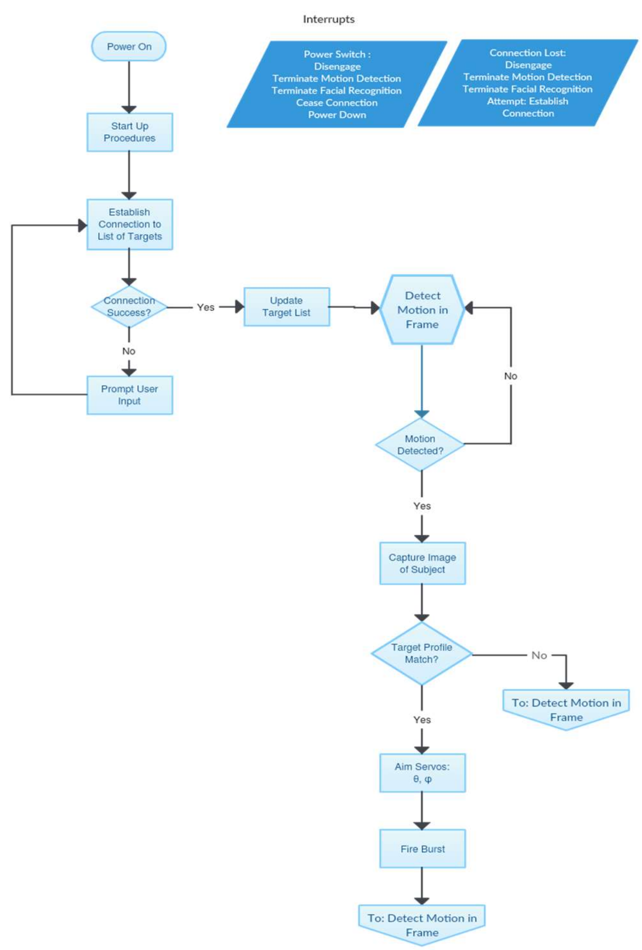


Figure 1.2. Software Block Diagram

Figure 1.3 below represents the Hardware Block Diagram which follows the hardware components required to fire the NERF gun, starting at the power system. On the right-hand side of the hardware block diagram is a breakdown of each module, separated into three stages. The Power System can be broken down into the battery itself, the rechargeable lithium ion cells, and the power regulator, which helps protect the hardware from power surges. After initializing, the voltage is taken to the input of the Printed Circuit Board (PCB), which contains the Wi-Fi/Bluetooth connectors, the camera and motion detection components, and the servo motor outputs. The Wi-Fi/Bluetooth connectors serve as the bridge between the system and the user, allowing commands from the user to be implemented and allowing updates to the database of images. The Camera provides data input that is to be interpreted by the facial recognition software; if recognition is above a certain probability, then the servos are given permission to run. The servo motors aim the turret towards the desired target and fires, if all targeting parameters are fulfilled as outlined in the software block diagram.

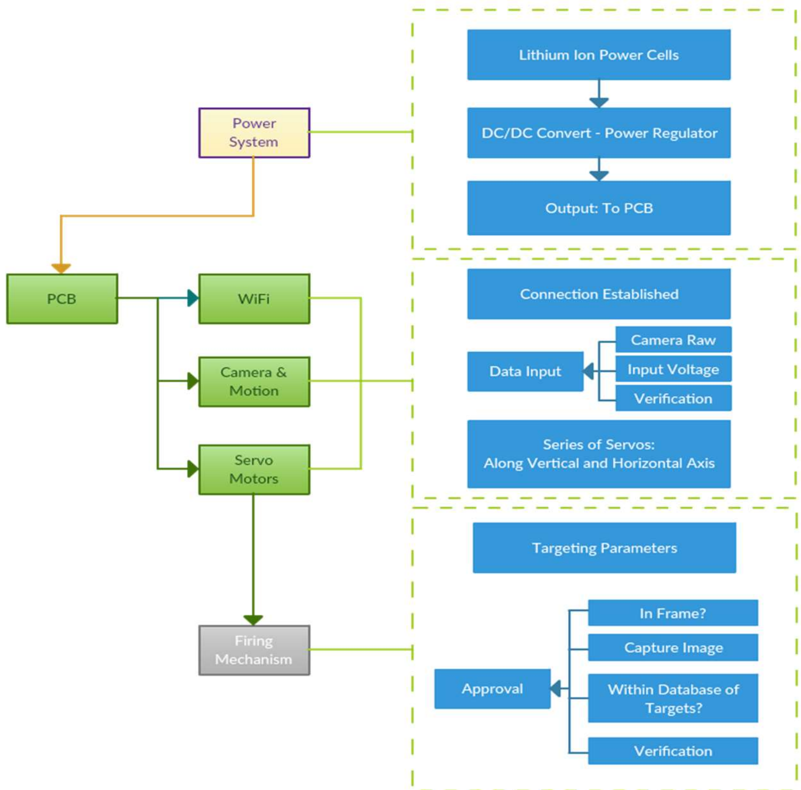


Figure 1.3. Hardware Block Diagram

Budget and Financing

The estimated cost analysis for parts and equipment are listed below in table 2.1 and represents a conservative averaged estimation for the cost of each item from several vendors. Additional product details will be selected deeper into the design process and when a more detailed budget constraint is concluded. Further quantity and price adjustments will be made as the project development life cycle advances. With respect to project financing and equipment, our team is seeking sponsorships through companies such as: Soar Technology, Inc., Epsilon Systems Solutions, Inc., and Valencia College Division of Engineering and Built Environment. If unable to obtain sponsorships, our team would maintain the same project design, but endure the full costs of parts and equipment.

The project finance goal will be to stay within budget constraints while minimizing total costs and staying within the design parameters and desired outcomes. Even though this will be an alpha prototype design, materials and production costs should be minimized and this is critical for future development and scalability. Additionally, the primary hardware components such as: servos, battery packs, printed circuit board design, and foam dart gun are expected to be the highest cost items.

Item Description	Quantity	Price Per Unit	Estimated Cost
Servos	~2-4	$50-75	~$100-300
Camera	1	$70-150	~$70-150
Battery Packs	~2	$50-100	~$100-200
PCB	~2	$50-100	~$100-200
Microcontroller (MCU)	1	$30-100	~$30-100
Foam Dart Gun	1	$100-175	~$100-175
Turn Table	1	$30	$30
Framing Materials	-	$100	$100
Database Domain	1	$20	$20
Miscellaneous Parts		$200	$200
		Estimated Total	**~$850-1475**

Table 2.1. Proposed Project Budget

Milestones

Figure 1.4 below displays our team Gantt chart, which is being compiled using the Asana application. Asana is a web and mobile application designed to help teams organize, track and manage their work. This chart fully details our past, current, and expected future milestones for our project in Senior Design 1 and Senior Design 2. Modifications to the due dates and tasks will be updated as more information and precursors become available.

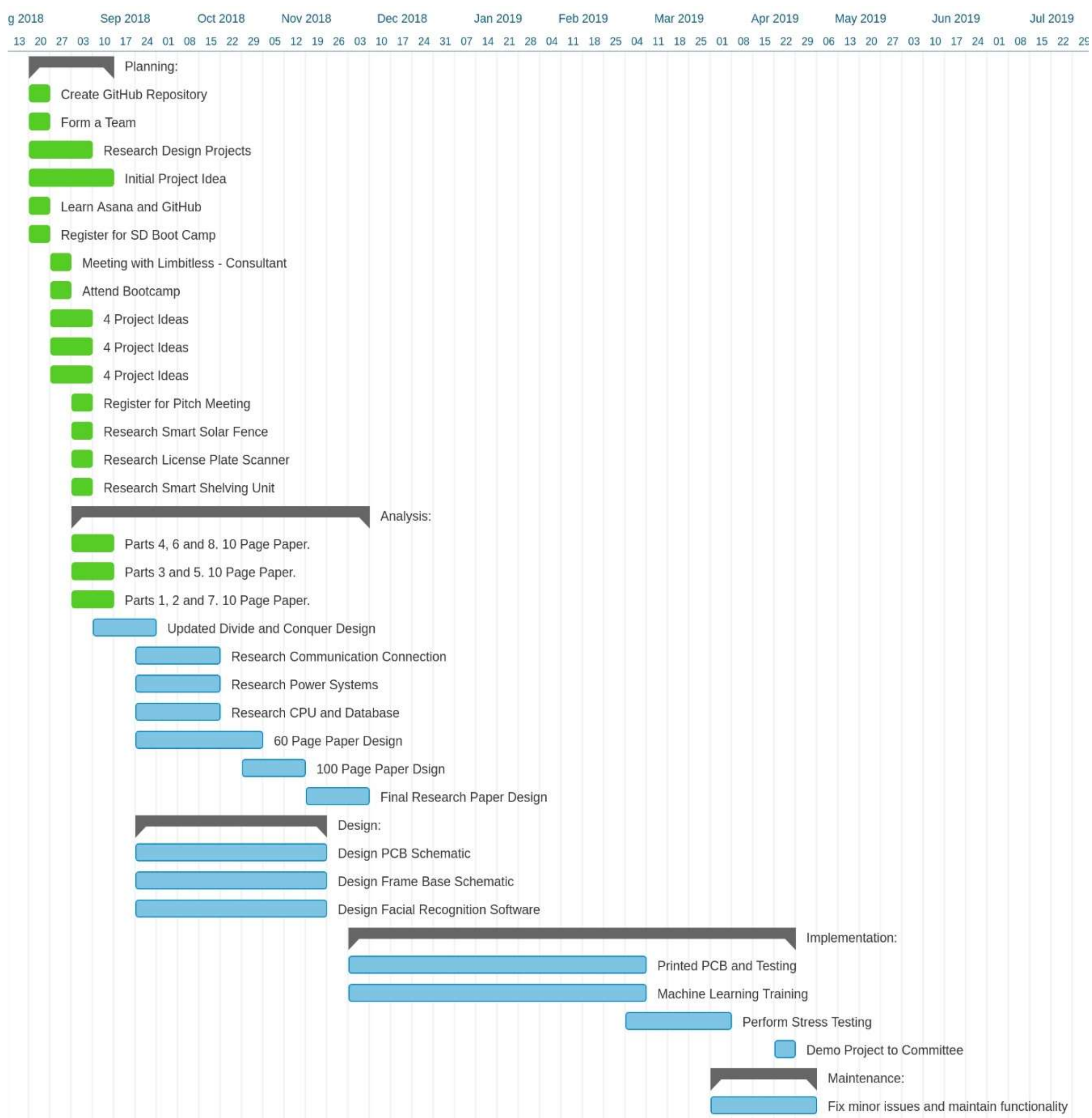


Figure 1.4. Gantt Chart

Decision Matrix

Table 2.2 below details the primary factors considered when selecting this project. The project is weighted against two additional ideas that were proposed by other team members. While only three projects are used for this design matrix, approximately 30 various designs were evaluated before the final decision was made. Cost, scalability, and familiarity with technology carries the heaviest weights among the seven factors. This engineering design received the highest score at 66. Table 2.2a below shows the legend for the design matrix.

		Projects Considered					
	Weight	**Automated Turret**		**License Plate Scan**		**Smart Fence**	
Criterion	**1-5**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Ease of Implementation	3	2	6	1	3	1	3
Maintainability	2	3	6	2	4	2	4
Scalability	4	4	16	4	16	1	4
Low Cost	5	2	10	3	15	0	0
Sponsorship	3	4	12	4	12	1	3
Familiarity of Technology	4	3	12	2	8	1	4
Educational Goals	1	4	4	4	4	3	3
Total	22	22	**66**	20	**62**	9	**21**

Table 2.2. Decision Matrix

Rating	**Description**
0	No fit
1	Low fit
2	Fit
3	Good fit
4	Excellent fit
	Weight Description
1	Low
5	High
	Score = Rating * Weight

Table 2.2a. Decision Matrix Legend