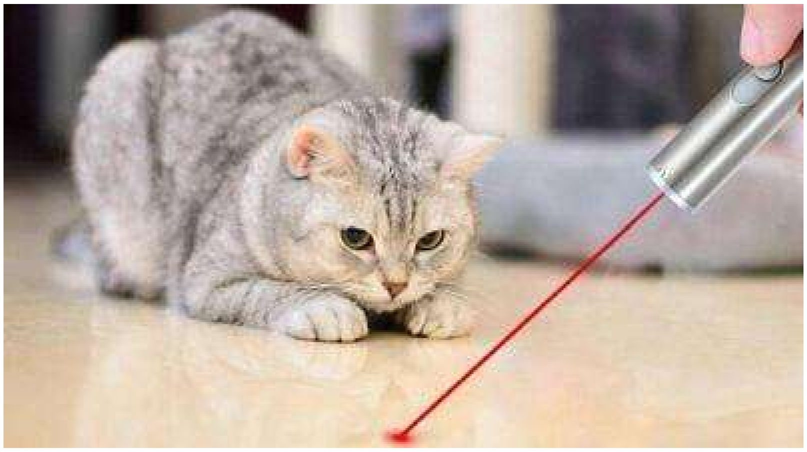
Senior Design I Initial Project Document

Autonomous Pet Entertainment System



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Introduction:

10,000 years ago humanity would make one of its greatest strides towards the world we know today. Before the end of the Stone Age and the advent of bronze working in North Africa and the Middle East a more important stride to technological civilization would be reached: The domestication of the North African Wild Cat. With the creation of large scale agriculture came the infestation of rodents seeking an easy meal source, and with the rodents came cats seeking to turn them into a meal. This mutually beneficial living arrangement of farmer and pest hunter would allow us to domesticate wild cats into the furry friends we see today and that natural predatory instinct would be a source of connection and entertainment between man and feline.

The history of playing with your cat is as old as the history between our two species; from scratching posts to feather dusters, we love to see our little friends chase after and bat at the small things they mistake as prey. This project intends to add onto this tradition with a device that can provide your feline pal with entertainment without you having to lift a finger. While anyone with a laser pointer can give their cats the entertainment the small animals crave, our project intends to be fully autonomous, capable of identifying your cat and able to react to them in a way that gives them a true feeling of hunting down prey.

The main feature of the project will be its laser projection and vision capabilities. The project will primarily track the movement of the subject via webcam to determine the distance and direction the subject is approaching from and respond accordingly. Our goal is to have precise and fluid movement of the pointer to either avoid the subject covering the beam or to attract the subject to engage with the project with rapid movements directed around the area of the subject, having autonomous transition from one mode to the other. The safety of our pets is of the utmost concern so to guarantee this we will keep the laser fixated on the ground at all times and shut it off whenever the product is not in the upright position.

Our project will have a visual stimulus laser output along with the sensor laser. It can be adjusted to various spot sizes using a telescopic lens system, and the laser will also have the ability to draw shapes with a fast adjusting mirror much like a laser show in entertainment venues. Output shape and pattern changed via diffraction gratings will be included in the optical system for the visual stimulus laser.

The project will be capable of autonomous motion, with the ability to relocate itself from one room to the other in search of the subject. This motion will be guided by a system of laser scanning to quickly determine the distance between the project and the environment or the project and the subject and to rapidly adjust its course based on the information acquired from its environment. The ultimate goal of this project will have a seamless transition between luring the pet and distracting the subject with the laser pointer quickly and efficiently.

While there exist numerous autonomous toys for cats on the market, we hope to distinguish our project by integrating optical detection of the cat and the ability to use the laser and the project itself as potential targets for the cat. Our stretch goals of incorporating notifications and remote viewing of the cat through the camera of the project and communication to your pet via audio speakers and mic, we hope to have a project unlike any pet toy on the market today!

Specifications:

Engineering Specifications		
Specification	Value	Unit
Vertical Laser/Camera Movement	135	Degrees
Horizontal Laser/Camera Movement	180	Degrees
Laser Wavelength	532	nm
Laser Power (max)	5	mW
Spot Size Magnification	0.5 - 2	x
Speed	1.5	fps
Battery Requirement	4	AA
Battery life (min)	5	hrs
Obstacle Distance (min)	8	in
Weight	1.5	lbs
Cost	600	$
Radius	5	in
Height	6	in

Table 1: Engineering Specifications

House of Quality

	Size	Development Cost	Laser Movement	Laser Specifications	Speed	Battery Number	Obstacle Distance	Weight
Weight	↑	↑				↑		
Obstacle Distance					↓			
Battery Number	↑		↓		↓			
Speed								
Laser Specifications		↓						
Laser Movement		↓						
Development Cost								
Size								

Legend:
+: Positive Polarity
-: Negative Polarity
↑: Positive Correlation
↑↑: Strong Positive Correlation
↓: Negative Correlation
↓↓: Strong Negative Correlation

Marketing Requirements		Engineering Requirements: Size	Development Cost	Laser Movement	Laser Specifications	Speed	Battery Number	Obstacle Distance	Weight
		-	-	+	+	+	-	+	-
Durability	+	↑	↓			↓			↑
Ease of Use	+					↓	↑		
Battery Life	+					↓	↓↓		
Safety	+	↑			↓↓	↓		↑	↑
Cost	-	↑	↑↑	↓	↓↓				↑
Targets for Engineering Requirements		5" Radius, 6" Height	>$600	135° Vertical, 180° Horizontal	532nm, <5mW	1.5fps	4 AA	>8in	<1.5lbs

Table 2: House of Quality

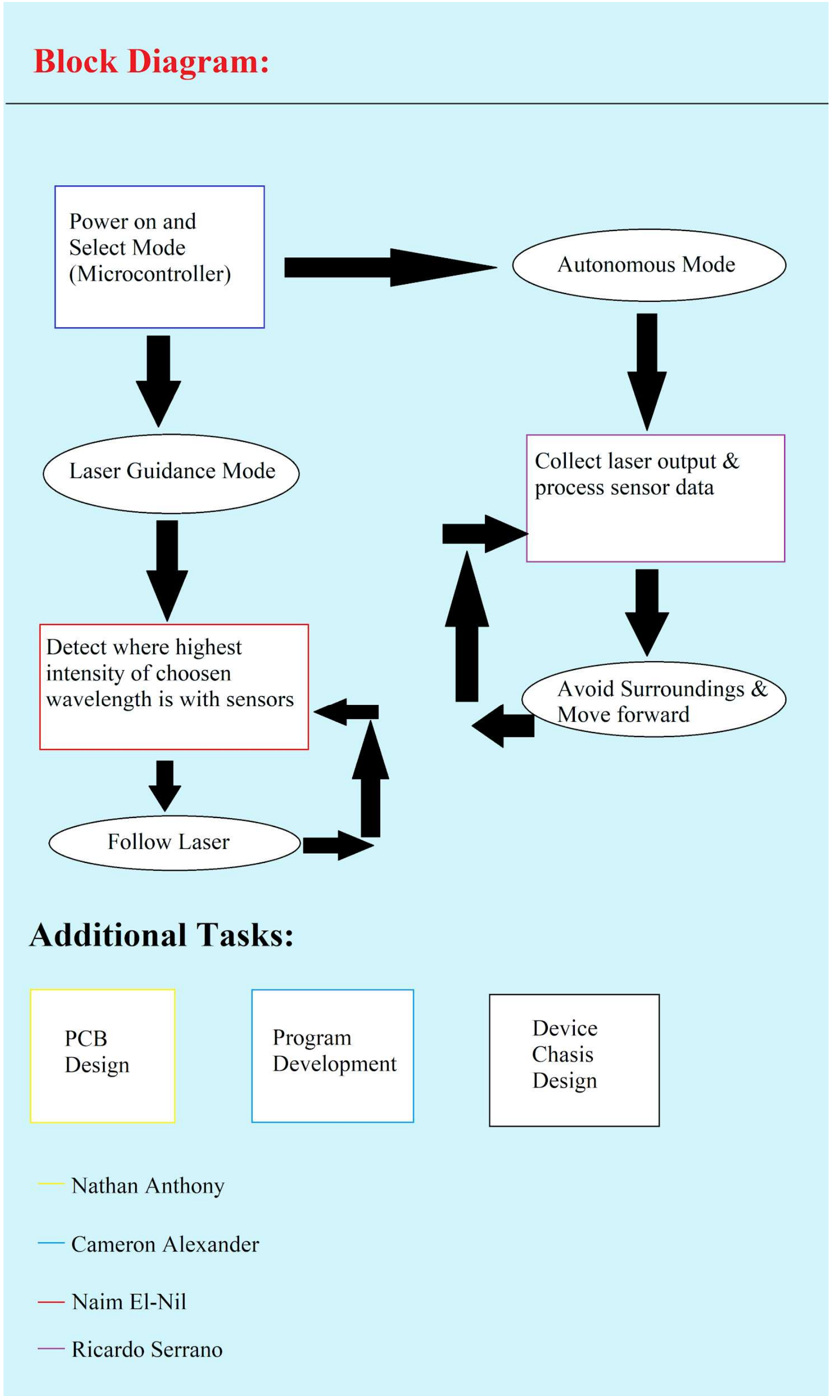

Figure 1: Block Diagram

All blocks in Figures 1 and 3 are currently being researched.

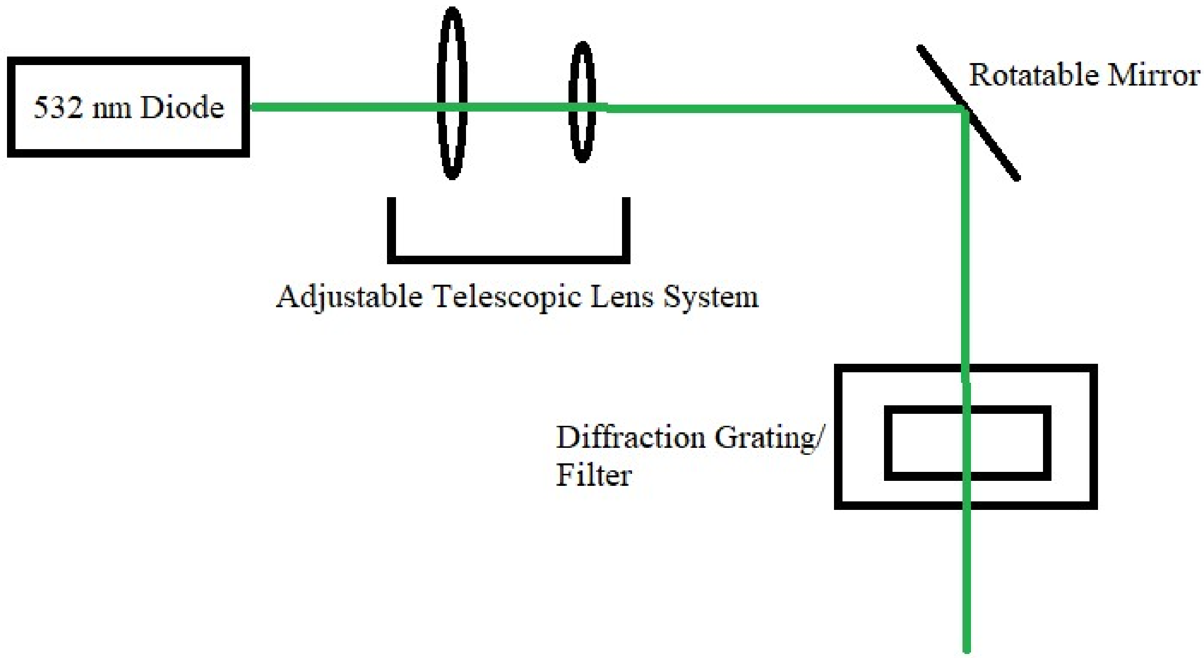

Figure 2: Output Beam Path

The current layout of the visual stimulus laser output beam path is shown in Figure 2. Our system will utilize a telescopic lens system to adjust the beam spot size, a rotatable mirror to draw shapes with the beam, and a diffraction grating or filter to give the output a pattern. Layout of the beam path is subject to change.

Software Flowchart:

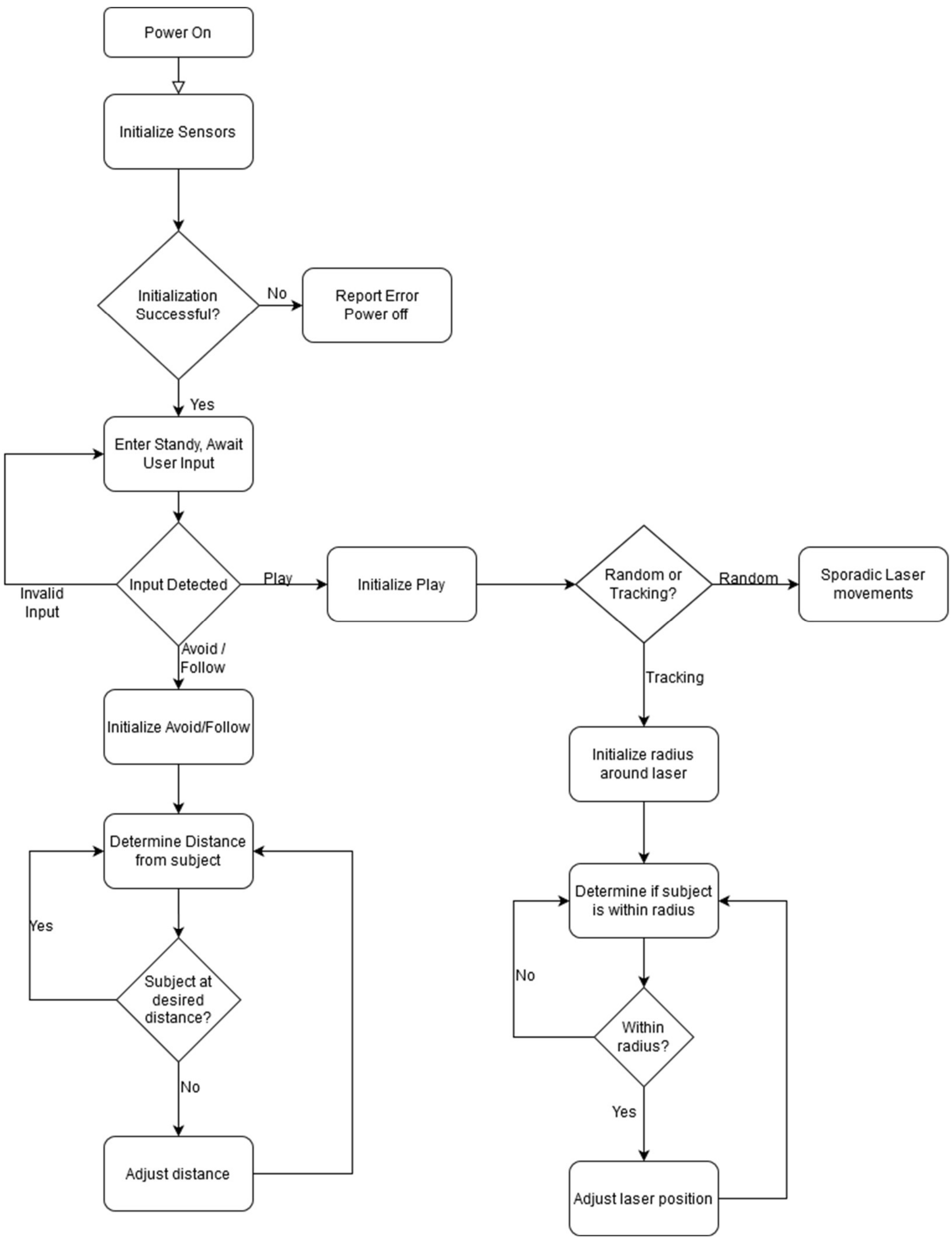

Figure 3: Software Flowchart

Budget and Financing:

Table 3 contains the generalized prices determined for each part we anticipate needing. Based on these, the development of our product should be relatively inexpensive. A sponsorship is currently being investigated and may influence design alterations in the future however, our project is currently self funded.

Budget			
Part	**Quantity**	**Cost (min)**	**Cost (max)**
Microcontroller	1	$0.00	$10.00
Raspberry Pi	1	$30.00	$55.00
Laser Diode	2	$10.00	$100.00
Diffraction Grating	1	$4.00	$160.00
Glass Lenses	2-3	$50.00	$100.00
Mirror	1	$0.25	$100.00
DC motor	3-5	$15.00	$25.00
Wheels	2-4	$0.00	$20.00
Castors	0-2	$0.00	$15.00
Camera	1	$7.00	$30.00
Visible/IR sensors	4-10	$12.00	$30.00
Gyroscope	1	$5.00	$10.00
Servo motor	1-2	$5.00	$10.00
Custom PCB	1-3	$80.00	$240.00
Custom Chassis	1	$10.00	$40.00
Custom Enclosure	1	$20.00	$50.00
Totals	N/A	$248.25	$995.00

Table 3: Project Budget

A note for clarity: Table 3 takes into account the fact that there are details about the final design that are still under discussion and that certain parts are already owned but may or may not be used. For this reason there are wider price and quantity ranges than would be in a final budget assessment.

Based on the max cost derived in the table, we intend to keep the cost of developing our product under $600. This budget will allow for unseen costs and the potential for broken components during testing.

Project Milestones:

Table 4 reflects the current estimations of the technical milestones required to complete the project as well as their expected completion time. All of these estimates are subject to change and serve as guidelines for where we should be putting our effort in order to finish the project in a timely manner.

Projected Project Milestones		
#	Milestone	Anticipated Completion Week
1	Read sensor input via microcontroller	8
2	Interface camera with microcontroller	10
3	Control all motors/servos via microcontroller	12
4	Design/order PCB	15
5	Construct camera/laser mount	18
6	Move laser based on camera input	20
7	Construct main chassis/device base	22
8	Implement algorithms to control object detection and avoidance	24
9	Implement algorithms to move device and laser in reaction to camera input	24
10	Construct main body	26
11	Final testing	28-END

Table 4: Project Milestones