ECE 4950 Project 4
Camera as a Sensor, Life Cycle Analysis, and Employee Training Program

Group 3 "No Induction Needed"
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Executive Summary

The goal of this project was to become familiar with using MATLAB to process images from a camera. A simple USB-connected webcam was used to capture an image that was then processed using a MATLAB system capable of identifying the color and location of stickers on a sheet of paper. It was important that this system function in various lighting conditions because the webcam was often in different lighting environments. It was also pertinent that the system be able to identify the color and position of the stickers quickly because the data from the system was to be used to control a motor in a real-time system. After the system was designed and tested a Life Cycle Analysis of the system was done to evaluate the economic and environmental impact of the system. Finally, an employee training program was created in order to ensure that employees maintained their current skills and obtained new ones.

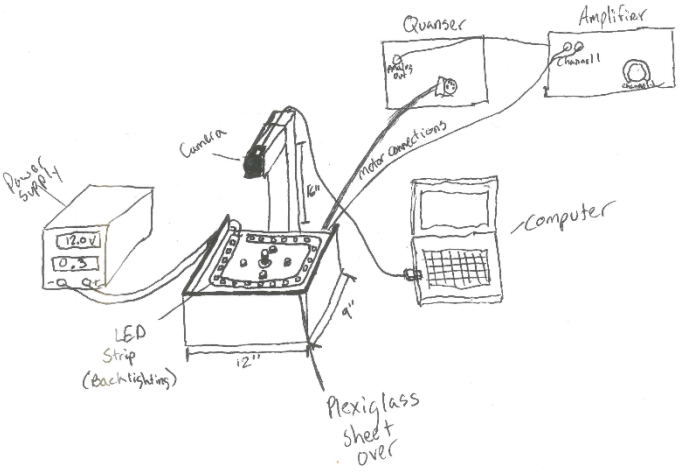
Customer Requirements

The customer has stated that they would like to have a camera that has the ability to identify new items in its field of view as well as distinguishing their specific color. The camera that is to be used will have the image quality of 640 x 480 pixels. Overall the camera should have the capabilities the customer desires and be able to perform them on demand. Although there has been a set budget that can be used, it will limit the performance and image quality of the items detected. Below, Table 1 illustrates the customer and engineering requirements along with a brief description of our product.

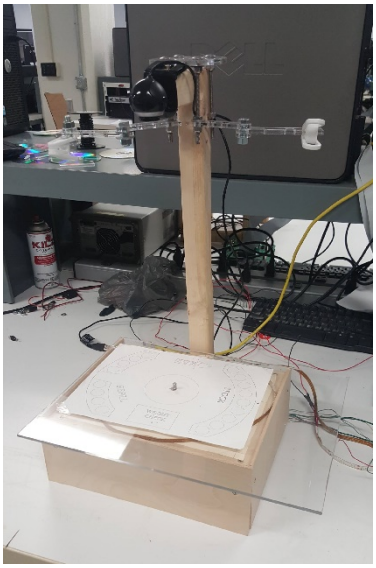
Customer Requirements	Engineering Requirements
Little ambient light interference	▪ Allowing for variation in the range of each color ▪ Proper coding that can filter out the unwanted light
Accuracy of Camera	▪ Proper lens ▪ Able to achieve certain level of correctness each time
Affordable	▪ Falls in line with the laid out budget plan
Pattern Recognition	▪ Background subtraction technique can pick up all foreign items ▪ Proper coding ▪ Correct communication between camera and system
Setup	▪ Easily installed on any device ▪ Non-technical software ▪ Able to be mounted with limited effort
Maintenance	▪ Low amount of deterioration on the camera ▪ Lens function properly over specific period of time

Table 1: Customer and Engineering Requirements

View of Mount with Connections and Underneath Mount



Picture of Mounting System

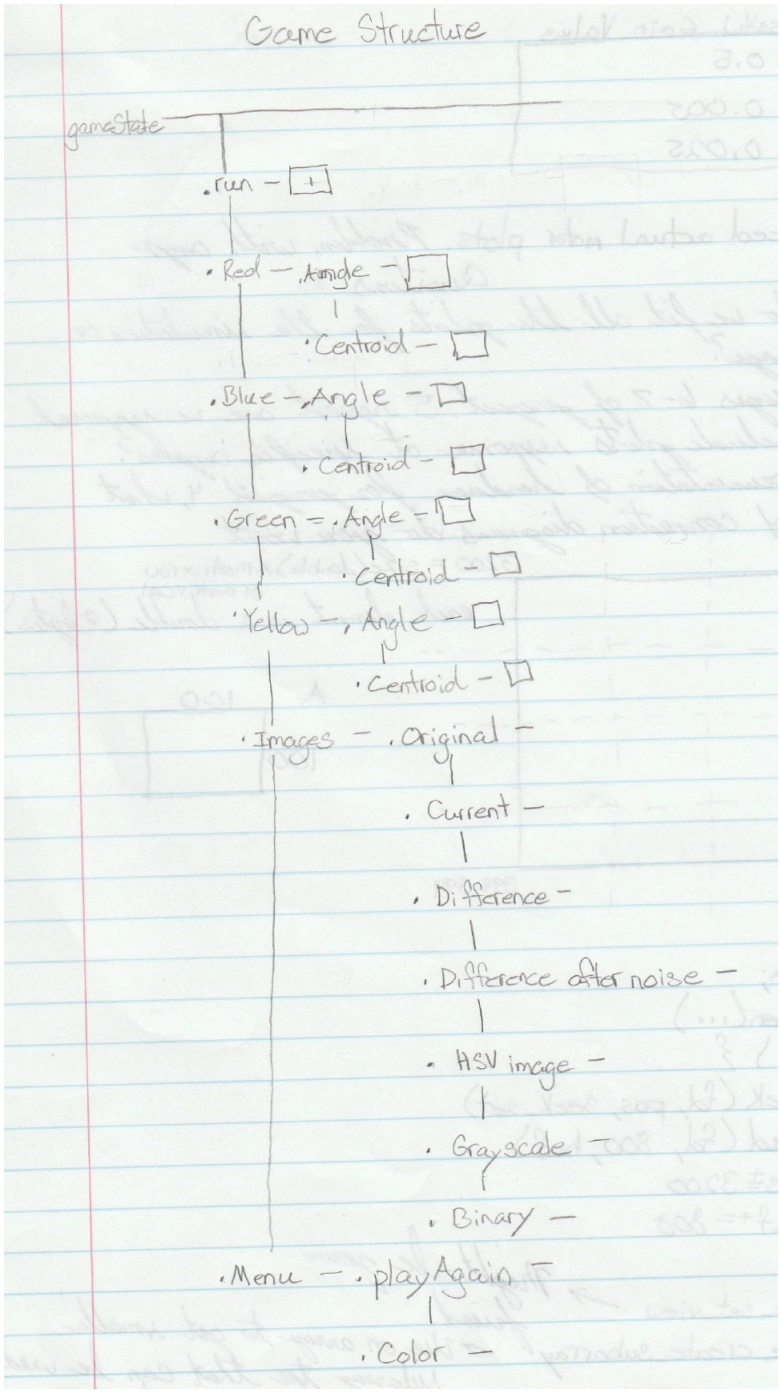


Pixel calculation

Total camera view = 11”x 8” = 88 in.^{2}
Size of dot = .75” diameter circle = $\pi(.75/2)^2$ = .44 in.^{2}
Number of pixels = 640x480 = 307200
(.44/88) * 307200 = 1536 ≈ 1500 pixels per dot

This is a large number of pixels in one dot so this camera is an appropriate sensor for our design.

Document Software



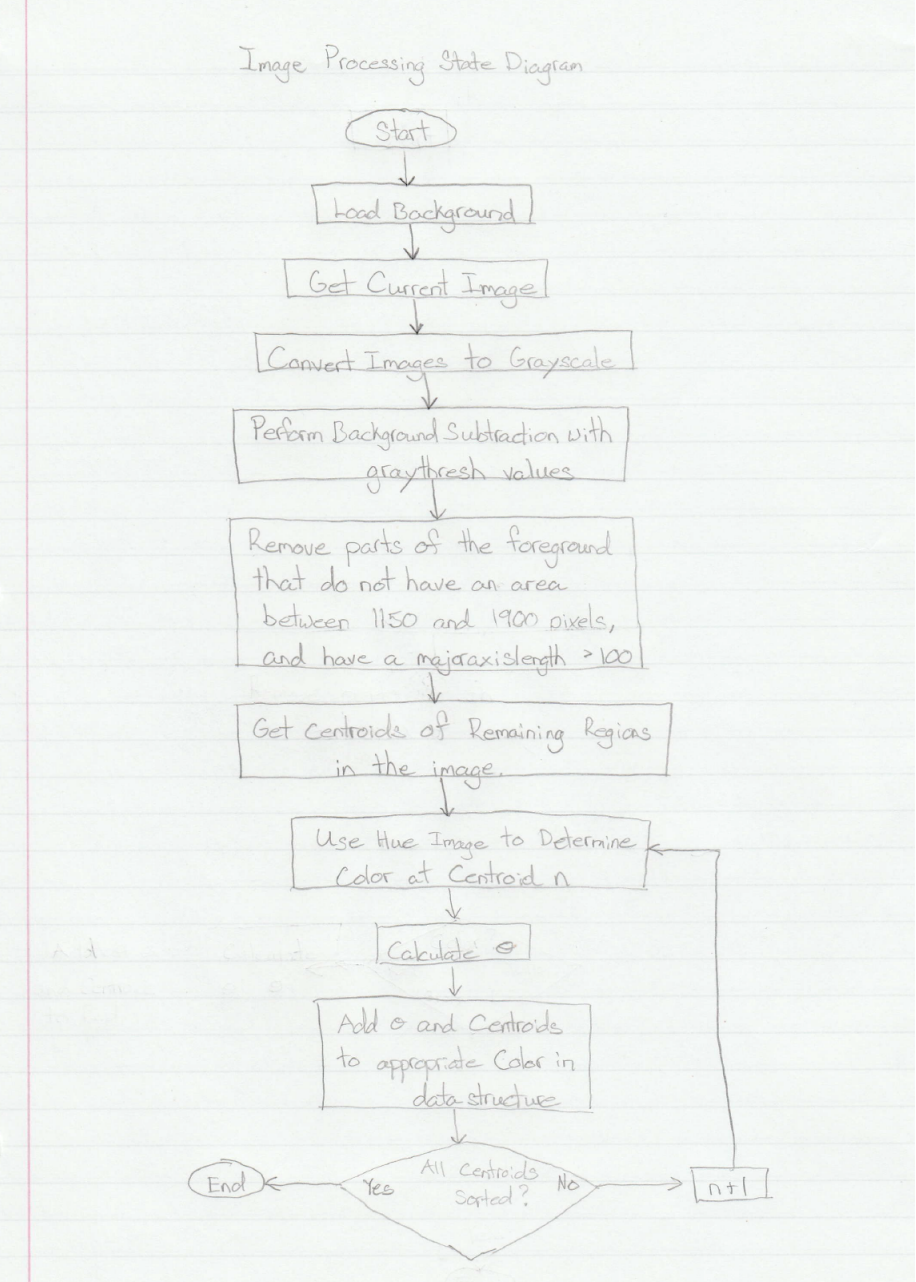


Image Processing State Diagram
Start
Load Background
Get Current Image
Convert Images to Grayscale
Perform Background Subtraction with graythresh values
Remove parts of the foreground that do not have an area between 1150 and 1900 pixels, and have a majoraxislength > 100
Get Centroids of Remaining Regions in the image.
Use Hue Image to Determine Color at Centroid n
Calculate Θ
Add Θ and Centroids to appropriate Color in data structure
All Centroids Sorted?
Yes
No
End
n+1

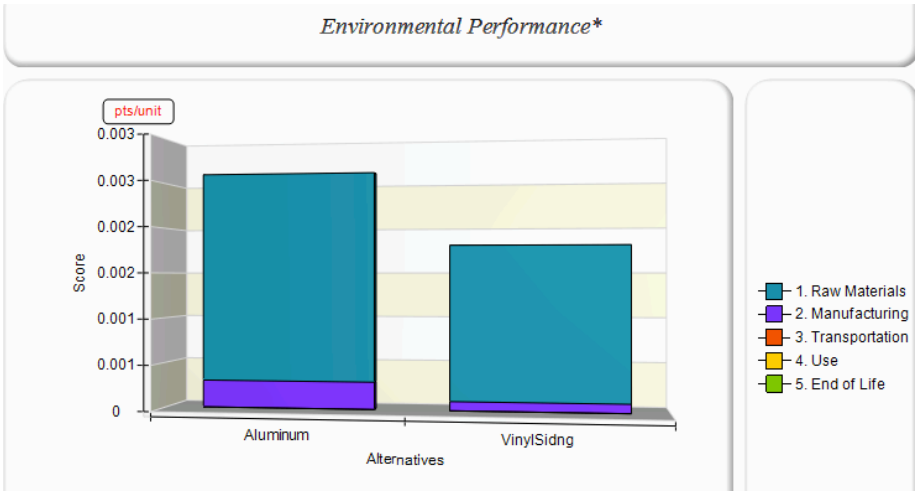
Our software worked by utilizing the data structure defined above and followed the state diagram for determining and locating the colored stickers. After the algorithm has completed the data structure will contain the centroid and angle data for each of the stickers that were found on the board. This allowed us to easily access the data we needed to send to the motor for any color that could have been chosen during the game. If multiple stickers of the same color are placed on the board the algorithm will always select sticker that is closest to the left side of the board.

Does the design meet the Requirements?

Throughout the testing phase the design project there were many practice runs and different evaluation measures that needed to be taken to insure proper camera function. The first in the process was to allow the camera to have a default background image to reference when it was taking photos. When different colored stickers were placed on the in front of the camera it needed to be able to have the ability to not only identify the specific hue of the sticker but to know the placement on the board. It was found to be that during the initial tests the module had trouble with locating items on certain spots of the board, which was a result of the sticker's color or a lighting problem. Underneath the top layer was a string of LED lights that light up the game board and allowed for the camera to overcome the ambient lighting issue. When the final corrections were made to the coding, this allowed for the camera to pick up 100% of the stickers placed on the game board regardless of their individual color. From an initial test given, it showed that all 5 stickers were picked up and identified for each of the 10 runs. Therefore the customer requirements were in check with our current product and layout of the sensor. The camera was proven to be accurate and demonstrate proper pattern recognition, no matter what was displayed in front of it. All of our trials were exact proof of this and allowed us to be able to give this information to the customer to back our statement. Other requirements such as dependability, were able to be tested by intentionally trying to make the sensor get incorrect readings through a filter layer put in front on the lens. This test would be able to show whether or not our product would be able to adapt to new environments and still have accurate data. After altering the code to be able to pick up areas no matter what kind of different surrounding light or ambiguity was around, the camera proved to be effective. From another 10 trial runs of placing stickers in certain points on the board, only 1 of the runs were not 100. When the filter was put into place our camera was able to function properly 90% of the time. Overall when it came down to it, our sensor was willing and able to detect every new item that was not a part of the background reference image without error. The requirements in each different category were met and able to run properly during all of the given trials.

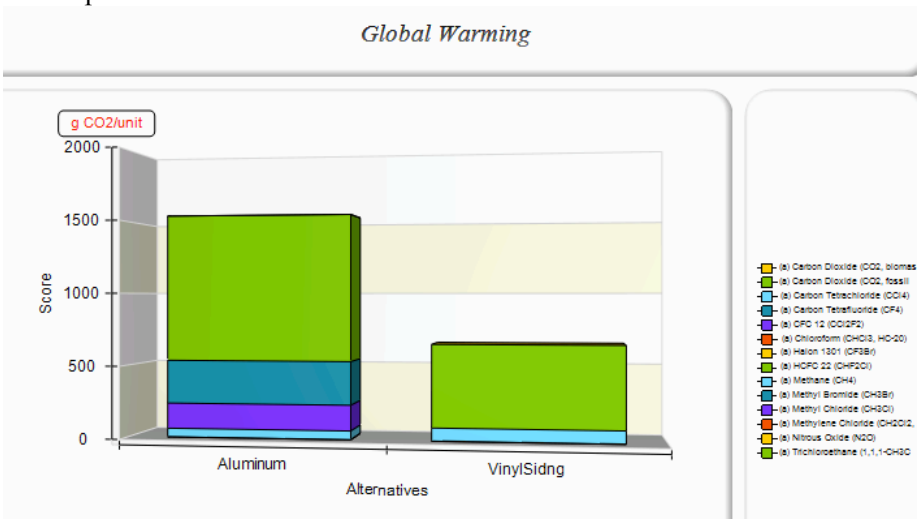
Life-Cycle Analysis

After proper robotic design and demo response for customer requirements has been achieved, appropriate material selection for the construction of the robot and the safe packaging of the unit must be considered. For this particular unit a comparison of vinyl and aluminum siding proved to be the best when rationalizing functionality against cost-effectiveness. The goal is to protect the unit while creating a minimal environmental impact.
The Life-Cycle Analysis Assessment will contrast data of the two possible material's shell. Graphical representation is generated for Environmental Performance, Global Warming, and Embodied Energy by Fuel Usage to use in analysis. Lastly Economic performance will show the current cost and allow us to compare it to future costs associated with impactful construction.



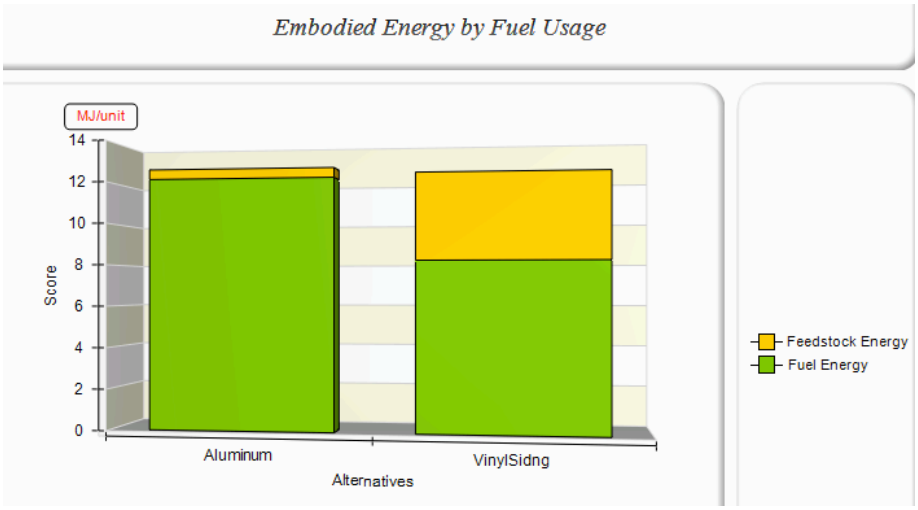
Graph G-a: Comparing Aluminum and Vinyl siding for Environmental Performance

Inspection of the graph signifies vinyl siding requires less manufacturing and less raw materials that impact the environment versus Aluminum.



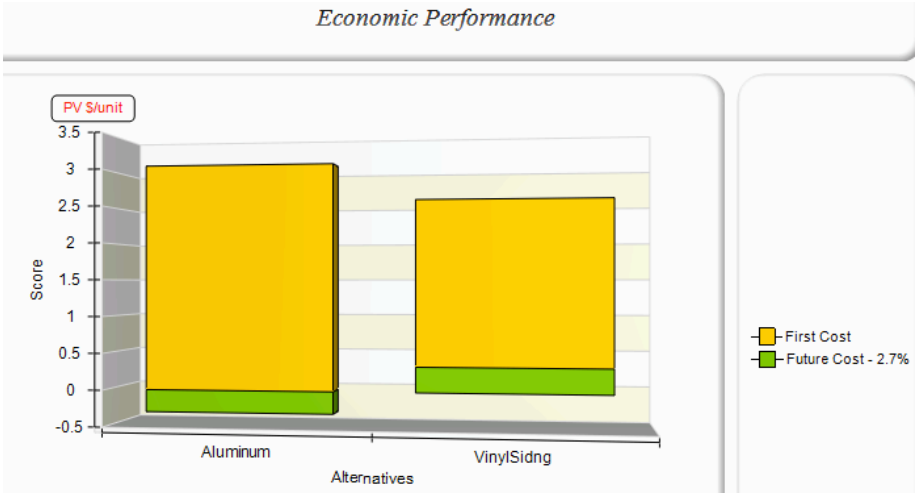
Graph G-b: Comparing Aluminum and Vinyl siding for Global Warming

Vinyl appears to produce less CO_2, but more Methane than Aluminum in Graph b. No other impacts are seen from Vinyl, but Aluminum exhausts harmful levels of Methyl Chloride and CFC_{12}.



Graph G-c: Aluminum and Vinyl siding for Embodied Energy by Fuel Usage

Overall, graph c maintains similar damage. The breakdown shows more fuel energy for aluminum and more feedstock energy for vinyl siding.



Graph G-d: Comparing Aluminum and Vinyl siding for Economic Performance

Category	Aluminum	Vinyl Siding
First Cost	3.05	2.22
Future Cost – 2.7%	-0.30	0.34
Sum	2.75	2.56

Table G: Graph G-a. Defining Aluminum and Vinyl siding original and future costs.

The Economic impacts favor Vinyl Siding over Aluminum, as there is 7% less total cost demonstrated in the table.

Results

Vinyl Siding has shown to be less impactful to the environment in every comparison and is also less expensive than Aluminum. For these reason Vinyl siding will be used for this project.

No Induction Needed Training Program
Research. Build. Refine… Learn. Repeat.

At No Induction Needed we strive to deliver superior automated systems centered on focused research and quality assured testing. This is no easy task and requires continuous work. To ensure success we provide training and continuous education to our employees to promote skill advancement and knowledge expansion. There are two programs for new employees. The first is designed for the newly graduated problem-solving engineer. The second program is intended to guide technical project engineer in a positive managerial role. Below these are summarized in their respected tables.

Activity	Benefit	Cost
Welcome to No Induction Needed, Inc., an introduction the company and initial training course. Day 1	Provides all the needed Human Resources coverage and educates new employees to Insurance, Benefits, Safety Guidelines and company Standards defined by such organizations as IEEE and OSHA	(HR person)•(4 hrs)=$600 (Safety Mgr)•(2 hrs)=$300 (Shop Mgr)•(2 hrs)=$300 (Trainee)•(8 hrs)=$1200 Lunch =$25/person Total= $2500
$T = \varphi\angle 180°$, Newbie Rotational Period Remaining 1st Week	Understand the role of each employee and how the company is a function of its sum	(Trainee)•(8 hrs)•(4 days) = $4800 Loss of Client Focused Work (Employee)•(2 hrs)•(4 days)= $1200 Total= $6000
IEEE Membership Reimbursement with Robotics and Automation Society privilege	Updated periodicals and publications attainable. Contact to current Research and Technology advances.	Membership Fees = $197/year Robotics and Automation Society Dues = $9/year Total = $206/year
ICRA Event (IEEE Robotics and Automation Society Flagship Conference) 1 Work Week	The conference includes presentations and workshops highlighting the most up-to-date advancements. Tutorials, robot challenges, and new product demos help keep employees informed.	Registration: $720 Flight =$800 Hotel: ($200×4 nights)= $800 Food: ($100×5days)=$500 (Employee)×(5 days)= $6000 Total = $8820
Problem Solving Activity resulting in gained knowledge from Conference. Analyze and fix ineffective system and simulate effective running system. Provide sales pitch on new system. 1 Work Week	Illustrates knowledge gained from seminar. Promotes self-confidence in work abilities. Shows coworkers ability to adapt recently learned information into applicable techniques.	(Employee)×(5 days)= $6000

Table Ta. Training Program designed for a newly graduated technical problem-solving engineer

Activity	Benefit	Cost
Welcome to No Induction Needed, Inc., an introduction the company and initial training course. Day 1	Provides all the needed Human Resources coverage and educates new employees to Insurance, Benefits, Safety Guidelines and company Standards defined by such organizations as IEEE and OSHA	(HR person)•(4 hrs)=$600 (Safety Mgr)•(2 hrs)=$300 (Shop Mgr)•(2 hrs)=$300 (Trainee)•(8 hrs)=$1200 Lunch =$25/person Total= $2500
ω = 360°, the Complete Rotational Experience Four Days of weeks 1 and 2	Understand the role of each employee and how the company is a function of its sum. Allows assessment of each individual, displaying some strengths and opportunities for improvement.	(Trainee)•(8 hrs)•(8 days) = $9600 Loss of Client Focused Work (Employee)•(2 hrs)•(8 days)= $2400 Total = $1200
Outliers Set, the First Managerial Outing, includes Tour of BMW plant, and lunch. Reconvenes at office to confirm all paperwork and HR requirements submitted.	Team building and educational opportunity. Seeing cutting edge manufacturing robotic equipment and top of line automation at work. Discussion and analysis of Rotational Experience	(3 Mgrs)•(8 hrs) + Lunch = ($3600) + ($75) = $3675
IEEE Membership Reimbursement IEEE Membership Reimbursement with Robotics and Automation Society, Control Systems Society and Technology & Engineering Management (TEM) Society privileges	Updated periodicals and publications attainable. Contact to current Research and Technology advances.	Membership Fees = $197/year Robotics and Automation Society Dues = $9/year Control Systems Society Dues = $25/year Engineering Management Society Dues = $35/year Total = $ $266/year
IEEE TEM Society Course: "Stuff you Don't Learn in Engineering School: Management Skills"	Based on the book *Stuff you Don't Learn in Engineering School: Skills for Success in the Real World* (Wiley-IEEE Press, 2004), the course teaches the necessary "soft skills" professionals should develop to be more effective leaders in the workplace.	Book = $32.22 (Amazon)
ICE/IEEE Int'l Conference on Engineering, Technology and Innovation, the flagship conference of the TEM and part of the Int'l Conference on Engineering, Technology and Innovation	Allows Managers to connect and network with the worlds leading engineers and participate in educational seminars and experience advanced technologies.	Registration = $500 Flight =$1500 Hotel:($250×4 nights)= $1000 Food: :($100×5 nights)= $500 (Employee)×(5 days)= $6000 Total= 9500

Table Tb. Training Program designed for a newly graduated technical project-managing engineer

ECE495 - Project 4: Camera as a Sensor

Group Name and Members: _____

Score	Pts		ABET Outcomes
	5	General Report Format - Professional Looking Document/Preparation (whole document) a) Fonts, margins (11pt, times new roman, single spaced. 1" margins on all sides). b) Spelling and grammar are correct c) Layout of pictures – all figures need captions and must be referenced in text d) References. Use IEEE reference format. *e) All report components are included in your website* **Page 1: Title, Group Name, Group Members, and Date** **Customer Requirements** Description of what the Customer wants for this project.	g
	5	**Page 2: Customer Requirements and mapping to Engineering Requirements** In the context of just Project 4, developing a camera sensing system (not the full final project), make a two column table that contains a column for Customer Requirements (what are the functions of the sensing system?) and the resulting Engineering Requirements. Each row should contain a specific customer requirement and the resulting engineering requirement. One customer requirement may generate multiple engineering requirements. For example, the customer will want an "accurate" system, the Engineering Requirement could be 99.5% detection success.	c
	20	The following should be a narrative report that describes your design decisions and final design, e.g., don't just have a flowchart without text that explains it. **Page 3: Document Hardware** (1 page) • Connection diagrams • Equipment • Mounting hardware sketches and photograph. Calculation of resolution - pixels per square on board. Is the camera an appropriate sensor? **Page 4-6: Document Software** (3 pages) • Flow charts, state diagrams, data structures, etc. that describe how the software is implemented. Do not include a copy of the source code. **Page 7: Does the design meet the Requirements**? (1 page) • Evaluate your system in regard to achieving the Requirements • Include statistics such as "found green sticker 80 times in 100 trials	c
	10	**Pages 8-9 Life Cycle Analysis** (2 pages) You are proposing a design that consumes resources. Follow the "Life Cycle Assessment (LCA) Exercise" for the shipping box for your project to examine the life cycle for this one part of your design. **Be sure to interpret the results of the computer program**. Complete this section of the report by saying that a similar analysis could be done on the entire project to reduce environmental impact.	h
	50	• Laboratory demonstration of your prototype (evaluated by instructor and TAs See "ECE 495 Project 4 Evaluations" for scoring) • Scenario 1: Five stickers (arbitrary color and location) will be placed on the board with no film over camera. • Scenario 2: Same stickers moved to other locations on the board. One filter sheet will be inserted in the mount and values of recorded variables (color and position) will be noted. **There is no opportunity to acquire a new background image after the filter is added**. • Scenario 3: Repeat with two sheets.	c
		• Quality of the demonstration hardware (~ 10% of score)	

ECE 4950 Integrated System Design I
Project 4

Group: _____ ECE 4950 Project 4 Evaluations

No Sheet	Sticker 1	Position (1 pt)	
		Color (1 pt)	
	Sticker 2	Position (1 pt)	
		Color (1 pt)	
	Sticker 3	Position (1 pt)	
		Color (1 pt)	
	Sticker 4	Position (1 pt)	
		Color (1 pt)	
	Sticker 5	Position (1 pt)	
		Color (1 pt)	
Single Sheet	Sticker 1	Position (2 pt)	
		Color (2 pt)	
	Sticker 2	Position (2 pt)	
		Color (2 pt)	
	Sticker 3	Position (2 pt)	
		Color (2 pt)	
	Sticker 4	Position (2 pt)	
		Color (2 pt)	
	Sticker 5	Position (2 pt)	
		Color (2 pt)	
Two Sheets	Sticker 1	Position (2 pt)	
		Color (2 pt)	
	Sticker 2	Position (2 pt)	
		Color (2 pt)	
	Sticker 3	Position (2 pt)	
		Color (2 pt)	
	Sticker 4	Position (2 pt)	
		Color (2 pt)	
	Sticker 5	Position (2 pt)	
		Color (2 pt)	
Total Score (out of 50)			