Smart Eraser

Project Charter

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Friday, October 26, 2018

ECE 186A - Senior Design I
Fall 2018 - Dr. Aaron Stillmaker

California State University, Fresno
Electrical and Computer Engineering Department

Revision History

Version 1 - finalized October 25, 2018. Changes made by: Heather Libecki, Chris Quesada, Juan Colin. Changes made: the initial rough draft of the Project Charter was created, including the proper sections and figures specified by Dr. Stillmaker.

Abstract

The Smart Eraser is a tool created with the express purpose of making the lives of teachers easier, by allowing them to utilize valuable class time in a productive way. It aims to assist teachers who write lengthy, involved examples on a whiteboard while lecturing on the material they want their students to understand. The Smart Eraser will erase the information written on the whiteboard at the teacher's will, allowing them to continue lecturing without wasting precious class time on erasing the board between examples. This will allow students to learn in an environment with less interruptions and distractions, resulting in improved overall focus and retention.

The project itself, in the simplest terms, is an automatic whiteboard eraser with smart capabilities. The eraser will be on a tracking system that will allow it to cover the x-y plane of the whiteboard's surface, and it will move based on the instructions given to it by the microcontroller it is connected to. This microcontroller will have 4 push-buttons that will be programmed to do 1 of four activities: erase the board using smart processing, erase the entire board from top to bottom without smart processing, stop the eraser's movement in case of emergency, and reset the eraserâĂŹs current process in order to send it back to its stand-by position. A camera will be at a fixed location facing the board to allow the entire whiteboard's image to be recorded. The image recorded will go through an image-processing algorithm, which will accomplish one of two things: it will detect the presence of a person in front of the whiteboard, causing the eraser to stop in its tracks, or it will detect the markings on the board and translate their locations into coordinates. These coordinates will then be processed in an algorithm which will determine the shortest path that needs to be taken in order to erase all the markings. Finally, after all procedures are done, the eraser will return to it's stand-by position.

Table of Contents

You should have a table of contents, which can be generated by a `\tableofcontents` command.

List of Figures

You should have a list of figures, which can be generated by a `\listoffigures` command.

List of Tables

You should have a list of tables, which can be generated by a `\listoftables` command.

I. Introduction

The purpose of the Smart Eraser is to allow class time to be utilized for learning. It will assist teachers who write lengthy, involved examples on a whiteboard while lecturing, by erasing the board in between examples while the teacher continues to lecture. This will allow students to learn in an environment with less interruptions and distractions, which will result in improved overall focus and retention of the information being taught.

The Smart Eraser, in the simplest terms, is an automatic whiteboard eraser. The main deliverable of this project will be an eraser which can move left-to-right on a track, and up-and-down on a linear motion system attached to the track. This system will be able to detect where markings are on a whiteboard through the use of a camera and an image-processing program. The camera will send the image of the whiteboard to a microcontroller which will process the image, detect where the markings are, and convert their locations to a coordinate system that the mechanical aspects of the eraser will be able to read. This coordinate system will essentially convert the locations of the markings into rotations of the stepper motors attached to the tracks, and this will allow the eraser to move. The eraser will then find the quickest route to erase all of the markings, using a sorting algorithm, before returning to its stand-by position. Finally, the eraser will be able to detect an obstruction in front of the whiteboard, specifically the presence of a person, through the use of the camera and motion-detection technology. This will check if there is a person moving in front of the whiteboard, and if there is, the result would be an immediate termination of the process the Smart Eraser was carrying out; this is to ensure the safety of those around the Smart Eraser while it is operating.

The microcontroller that will be controlling the entire system has four push-buttons which will be utilized in the following way: push-button 0 will erase the board using the smart processing method, push-button 1 will erase the entire board without using the smart processing method, push-button 2 will stop the eraser in the middle of whatever process it was performing until it is pressed again, allowing it to resume the process it was carrying out, or until push-button 3 is pressed, which will reset the system and send the eraser back to its stand-by position.

Heather Libecki is responsible for being the project manager of this project. She will be researching the DE1_SoC microcontroller, its relevant components, the ARM assembly language it uses, and the GPIO pin connections it is capable of. She will also be researching the stepper motors, the drivers needed to operate them, and she will be contributing to the creation of the PCB for the H-bridges. Therefore, she will be in charge of all connections to the DE1_SoC, as well as the connections between the stepper motors, their H-bridge PCBs and drivers, and the additional power needed to make them work properly.

Chris Quesada will be researching the ethernet communication between the DE1_SoC and the camera, as well as the datasheet for the camera itself. He will also be researching the image processing program, how to implement it using the C programming language, and how this program will be able to run on the DE1_SoC. He will then research the motion-detection program, as well as the algorithm for finding the quickest route to the markings on the board, with assistance from Heather. Therefore, he will be in charge of all interactions with the camera and its smart processing capabilities.

Juan Colin will be researching the SDRAM interface standards in order to save images from the camera to the DE1_SoC. He will also Be researching the physical mechanical system, its required connections, and the power system that will need to be created in order to allow it to run properly. He will then need to configure the power system so the mobile parts of the project can move the way they are intended to, and he will also be assisting in the creation of the PCBs for the H-bridges that will be connected to the stepper motors. Therefore, he will be in charge of the entire physical mechanical system of the eraser.

During the project life cycle, there will also be multiple deliverables that will need to be completed and turned in to Dr. Stillmaker. These deliverables will be worked on by all three members of the team to ensure a consistent flow of information throughout all written documentation.

II. Project Objectives and Success Criteria

The description of the Smart Eraser in the Project Description section of this document specifies what the ideal final product will be, so within this section, the actual objectives of the Smart Eraser will be listed.

Main Objectives

- Create a functioning mechanical system that allows the eraser to erase the entire whiteboard.
- Create a coordinate system based on processed image to move eraser to specific markings.
- Create an algorithm to sort the order in which the markings should erase to ensure the shortest path is taken.
- Create a functioning Smart Eraser that erases detected markings in a timely manner.
- Create an image processing program to detect said markings on the whiteboard.
- Create a motion-detection program to check for people obstructing the whiteboard.

In this section, the specific criteria that need to be met in order to consider this project a success will be listed. These criteria will help those contributing to the completion of this project to be able to measure the actual success of the final product. There will be simple success criteria listed, as well as more ambitious success criteria that will describe an ideal version of this project, including additional features that could be added if there is a significant amount of extra time after accomplishing the simple success criteria.

Simple success criteria

- The tracking system moves the eraser to all parts of the board Eraser erases the entire whiteboard with no smart processing (covers entire board)
- Image processing program converts abnormal color changes to array
  - Array converts to location coordinates of the color changes
- Coordinate system, in the form of stepper motor rotations, moves the eraser to a specific part of the board
- Camera connects to DE1_SoC board, image from camera saves to microcontroller SDRAM memory
- Image processing program on DE1_SoC works with camera to process images in real-time
- Location of markings found with camera via image processing convert to necessary coordinates for mechanical system to read
- Motion-detection program creates TRUE signal to be sent to microcontroller if large obstruction (a person) is in front of whiteboard, returns to FALSE when obstruction gone
- TRUE signal from motion-detection program halts the movement of the eraser, resumes the eraserâĂŹs process when FALSE signal received
- Push-buttons on DE1_SoC perform specifications, stated in the Introduction section of this project charter, using interrupts

Ambitious success criteria

- Visual feedback on DE1_SoC boardâĂŹs LEDs, HEX display, or LCD screen on current process being performed by eraser
- Phone or tablet application shows a live feed of the whiteboard from the camera
  - Application can send specific coordinates to the whiteboard in order to âĂIJpick and chooseâĂİ what section of the board to erase
- Attachable spray system applies whiteboard liquid cleaning solution to perform âĂIJfull cleanâĂİ of whiteboard
  - Timer on DE1_SoC tells eraser to perform a âĂIJfull cleanâĂİ during the night, when no one is using the classroom

- Eraser can be raised off of the whiteboard surface and subsequently re-pressed on to the board as needed
- Smart Eraser patent

III. High-Level Requirements

The high-level requirements associated with the completion of this project are outlined in the following list.

The project should:

- Be completed with the outlined budget
- Be implementable within 2 semesters
- Be complex enough to warrant the title âĂIJsenior design projectâĂİ
- Have significant, roughly equal portions of the project be completed by each team member
- Utilize material learned in core and technical elective classes throughout our college careers
- Produce a deliverable that can be presented in the Senior Project Presentation Day event usually held in the Satellite Student Union building on campus
- Be able to be scaled to a bigger surface than the prototype

IV. Assumptions, Constraints, and Standards

Based on the preliminary research conducted on what information, components, and protocols will be useful to know for the completion of this project, the team members wrote a list of their strengths and weaknesses to show what they can each do, and what needs more work. The specific courses with the relevant information needed for this project are also listed.

Heather Libecki

- Strengths: programming (assembly, some verilog), DE1_SoC programming, mathematics, debugging, circuit implementation, problem solving, technical writing, public speaking
- Weaknesses: circuitry design, coding algorithms, power systems, PCB design

Chris Quesada

- Strengths: programming (assembly, verilog), embedded systems, algorithms, brainstorming
- Weaknesses: circuitry design, mathematics, public speaking, ethernet capabilities

Juan Colin

- Strengths: electrical systems, circuitry design, problem solving, power systems, public speaking/relations
- Weaknesses: programming (assembly, verilog), technical writing and spelling

Based on this list, the background information that will need to be further researched is: image processing programs, connecting physical devices for the track of the eraser, camera and DE1_SoC connectivity, PCB design for the stepper motor H-bridges, and other research as necessary. A few possible constraints on the project are the budget funding, the additional power supply needed to make the more powerful stepper motors operate, and the power supply to the camera.

The following list outlines the relevant courses and the material that will be used from them.

- ECE 178 - Embedded Systems
  - Development of algorithms, setting up and using interrupts with the microcontroller, interfacing with peripherals on the microcontroller
- ECE 146 - Computer Networks
  - Ethernet connection between systems and how data is transferred over link

- ECE 90 - Principles of Electrical Circuits
  - Developing the power scheme and parameters for the stepper motors and track system.
- ECE 118 - Microprocessor Architecture and Programming
  - Recursion programming and algorithms developed for shortest-tree path, determining how to store memory in DE1_SoC, working with ARM processor, GPIO connections to DE1_SoC, using stepper motors, H-bridge, and power supply to operate stepper motors with DE1_SoC, programming push-buttons on DE1_SoC
- ECE 85 - Digital Logic Design
  - Developing PCB for H-bridge connections, any state diagrams needed for logic between processes
- ECE 106 - Switching Theory and Logical Design
  - Developing flow charts and block diagrams of the overall system

A. Camera Ethernet Connectivity and Data Transfer

After further research, the original idea of connecting and powering the camera over an Ethernet connection needed to be modified a bit. In order for the camera to be powered through Ethernet, the connection needed to provide 48V to the camera. Since the DE1_SoC can only supply a maximum of 5V to any external device, the camera will now be powered through the included 12V 1A power adapter.

B. Data Storage

The images taken from the camera will need to be saved to the DE1_SoC board in order to allow the image processing program to work on them. The SDRAM on the DE1_SoC board will be utilized, using the load and store commands in the ARM programming language. The coordinate system that will need to be created from the marking locations will also be saved to the memory on the DE1_SoC, as well as the program that connects the stepper motors to the system as well.

C. Image Processing Program Design

After receiving feedback, it was decided that it would be an easier route to abandon trying to interface with the DE1_SoC through MATLAB. This was the initial plan due to MATLAB's extensive image processing libraries. However, it has been decided that C will be more beneficial when using the Altera Monitor program. Further research will be towards learning how to do image processing specifically in C and how detect marks on the whiteboard.

D. Translate Markings to Coordinate System (stepper motor rotations)

Through team collaboration, it was decided that each stepper motor rotation would represent one pixel length. This would be how a coordinate system can be developed. For example, if the image processing algorithm picks up at mark that is 56 pixels from the left of the image, and 178 pixels from the top of the image, this would result in 56 rotations to the right on the x-axis motor and 178 rotations down on the y-axis motor. Further research and configuration would needs to be done towards how many degrees of rotation of the stepper motor would represent 1 pixel length.

E. Stepper Motor System Design

The stepper motors themselves will have attachable components to a pulley system, which will move the components on the board. In order to move the stepper motors, specific drivers will need to be attached to them through an H-bridge. This H-bridge will be designed on a PCB in order to minimize odd connections and spaghetti wires in the final product.

F. Microcontroller Involvement

The pushbuttons will be used to enable different functions of the system and use the HEX 7-seg displays as visual feedback for which actions is be carried out. The microcontroller will be the central hub where all components of the system interact.

G. Shortest Path Algorithm

In order to find the shortest path between all marks detected by the image processing program, Dijkstras algorithm will be applied to the array containing the translated image. This translated image will be contained in an array that represents the detected marks from the board. The algorithm will then start at the top left most mark and traverse the array to find the shortes path between all marks in the array.

H. Motion-Detection Program

Not much research has been looked into for this aspect of the project as it is one of the last items on the GANTT chart. It is assumed that some sort of image processing algorithm will be needed to detect rapid changes in pixels. More research will need to be done.

V. Project Description and Boundaries

Describe your project in detail in this section. List out all of the major components, as well as all of the minor components underneath that. Explain all the major difficulties with the project. List who your technical faculty advisor is, what their area of expertise is, and how you will use that expertise in your project.

Here is where you should **include your block diagrams, flow charts, and circuit diagrams**. Each project should have multiple parts that need to communicate, so you need a diagram that shows the details of the names of the connections, the size of the busses, etc. Those with programs, which I also believe is all, should have outlines of flowcharts for the programs that will be used in your project.

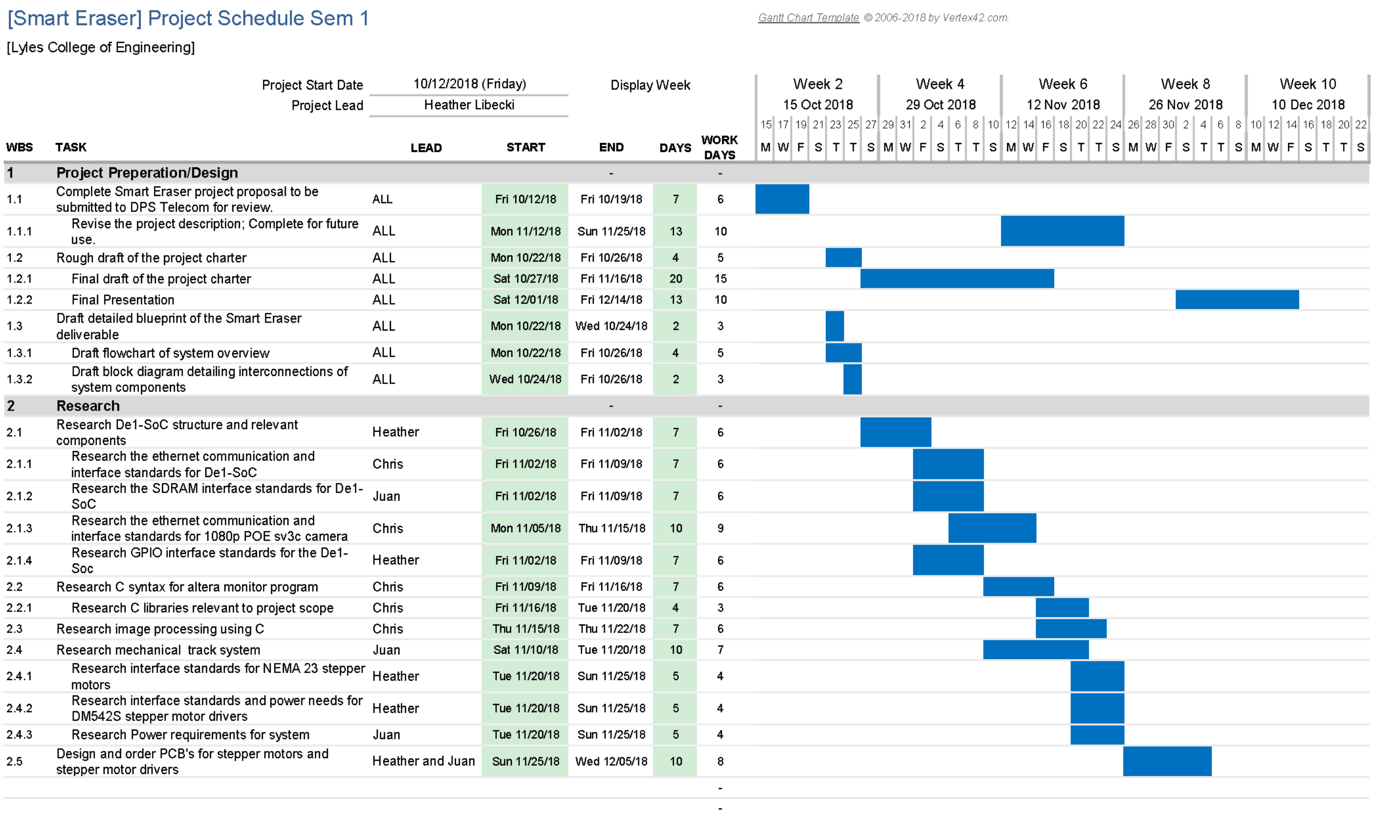
VI. High-Level Risks

What are the risks associated with your project? For most, there are power systems you must be concerned about, or moving parts, or a number of other possibilities. List what these are, and how you are addressing keeping your project development safe.

VII. Milestone Schedule

This should have a list of the milestones, who is in charge of each milestone, and when it should be accomplished.

VIII. Gantt Chart


[Smart Eraser] Project Schedule Sem 1

[Lyles College of Engineering]

Gantt Chart Template © 2006-2018 by Vertex42.com

Project Start Date: 10/12/2018 (Friday)
Project Lead: Heather Libecki
Display Week

WBS	TASK	LEAD	START	END	DAYS	WORK DAYS
1	**Project Preperation/Design**			-		-
1.1	Complete Smart Eraser project proposal to be submitted to DPS Telecom for review.	ALL	Fri 10/12/18	Fri 10/19/18	7	6
1.1.1	Revise the project description; Complete for future use.	ALL	Mon 11/12/18	Sun 11/25/18	13	10
1.2	Rough draft of the project charter	ALL	Mon 10/22/18	Fri 10/26/18	4	5
1.2.1	Final draft of the project charter	ALL	Sat 10/27/18	Fri 11/16/18	20	15
1.2.2	Final Presentation	ALL	Sat 12/01/18	Fri 12/14/18	13	10
1.3	Draft detailed blueprint of the Smart Eraser deliverable	ALL	Mon 10/22/18	Wed 10/24/18	2	3
1.3.1	Draft flowchart of system overview	ALL	Mon 10/22/18	Fri 10/26/18	4	5
1.3.2	Draft block diagram detailing interconnections of system components	ALL	Wed 10/24/18	Fri 10/26/18	2	3
2	**Research**			-		-
2.1	Research De1-SoC structure and relevant components	Heather	Fri 10/26/18	Fri 11/02/18	7	6
2.1.1	Research the ethernet communication and interface standards for De1-SoC	Chris	Fri 11/02/18	Fri 11/09/18	7	6
2.1.2	Research the SDRAM interface standards for De1-SoC	Juan	Fri 11/02/18	Fri 11/09/18	7	6
2.1.3	Research the ethernet communication and interface standards for 1080p POE sv3c camera	Chris	Mon 11/05/18	Thu 11/15/18	10	9
2.1.4	Research GPIO interface standards for the De1-Soc	Heather	Fri 11/02/18	Fri 11/09/18	7	6
2.2	Research C syntax for altera monitor program	Chris	Fri 11/09/18	Fri 11/16/18	7	6
2.2.1	Research C libraries relevant to project scope	Chris	Fri 11/16/18	Tue 11/20/18	4	3
2.3	Research image processing using C	Chris	Thu 11/15/18	Thu 11/22/18	7	6
2.4	Research mechanical track system	Juan	Sat 11/10/18	Tue 11/20/18	10	7
2.4.1	Research interface standards for NEMA 23 stepper motors	Heather	Tue 11/20/18	Sun 11/25/18	5	4
2.4.2	Research interface standards and power needs for DM542S stepper motor drivers	Heather	Tue 11/20/18	Sun 11/25/18	5	4
2.4.3	Research Power requirements for system	Juan	Tue 11/20/18	Sun 11/25/18	5	4
2.5	Design and order PCB's for stepper motors and stepper motor drivers	Heather and Juan	Sun 11/25/18	Wed 12/05/18	10	8
						-
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Fig. 1: GANTT chart for semester 1

IX. Equipment and Budget

Component - Production Company	**Est. Price**
DE1-Soc FPGA Development Board - Terasic	$175
CNC stepper motor driver - STEPPERONLINE	$67.90 ($33.95)
Carriage with Stainless Steel Balls; for use with 115RC Linear Tack - Accuride	$67.16 ($33.58 x2)
115RC 47in Linear Motion Aluminum Track Systems -Accuride	$62.68 ($31.34 x2)
Nema 23 CNC 2.8A Stepper Motor - STEPPERONLINE	$52.00 ($26.00)
1080p POE Camera - sv3c	$38.99
Dry Erase Board (prototype) 36" x 24" - VIZ-PRO	$31.90
Stepper Motor Encasing - D.Y Engineering	$25.98 ($12.99 X2)
5 Meter GT2 timing Belt (6mm width) - Mercury	$17.98 ($8.99 X2)
6.35mm GT2 40 Teeth Pulley Flange - uxcell	$14.38 ($7.19 X2)
Nema 23 Stepper Motor Steel Mount Bracket w/ Screws - HobbyUnlimited	$10.99
Dry Erase Whiteboard Block Eraser - Expo	$8.90
PCB for H Bridge (for Stepper Driver) and Stepper Motors, possible LCD screen	Unknown
Various Wires and Connection Cables	Unknown
Total Rough Budget	**$573.86**

TABLE I: Estimated costs of components for project

You should also have a detailed budget of what components you will be purchasing.

[Smart Eraser] Project Schedule Sem 2

[Lyles College of Engineering]

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Project Start Date: 1/1/2019 (Tuesday)
Display Week: 1
Project Lead: Heather Libecki

Week 1 (31 Dec 2018) | Week 4 (21 Jan 2019) | Week 7 (11 Feb 2019) | Week 10 (4 Mar 2019) | Week 13 (25 Mar 2019) | Week 16 (15 Apr 2019) | Week 19 (6 May 2019)

31 3 6 9 12 15 18 21 24 27 30 2 5 8 11 14 17 20 23 26 1 4 7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21 24 27 30 3 6 9 12 15 18 21 24

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WBS	TASK	LEAD	START	END	DAYS	WORK DAYS
1	**Development**			-		-
1.1	Configure the De1-SoC ethernet interface	Chris	Tue 1/01/19	Wed 1/02/19	1	2
1.1.1	Test connection between camera and De1-SoC	Chris	Thu 1/03/19	Tue 1/15/19	4	9
1.2	Develop the code for the image processing program.	Chris	Tue 1/01/19	Tue 1/15/19	14	11
1.2.1	Test the image processing program with data from the camera.	Chris	Tue 1/15/19	Fri 1/25/19	4	9
1.2.2	Develop the coordinate system.	Heather	Sat 1/26/19	Fri 2/15/19	20	15
1.2.3	Develop the algorithm to determine the quickest path to erase markings on the board.	Heather & Chris	Sun 2/10/19	Mon 2/25/19	15	11
1.3	Configure the power system for the mechanical parts of the Smart Eraser.	Juan	Tue 1/01/19	Sun 1/06/19	5	4
1.3.1	Build the mechanical system the eraser will be attached to.	Juan	Mon 1/07/19	Tue 1/15/19	8	7
1.3.2	Integrate the microcontroller with the mechanical system.	All	Tue 1/15/19	Fri 1/25/19	10	9
1.3.3	Test the newly formed microcontroller-mechanical system.	All	Fri 1/25/19	Tue 2/05/19	11	8
1.4	Create the motion-detecting program.	Chris	Mon 2/25/19	Fri 3/15/19	18	15
1.4.1	Integrate the motion-detecting program with the camera and microcontroller-mechanical system.	All	Fri 3/15/19	Sat 3/30/19	15	11
1.4.2	Test the motion-detecting program.	All	Sun 3/31/19	Mon 4/15/19	15	11
1.5	Add potential additional features to be decided upon at a later time (if project completion is ahead of schedule).	All	Mon 4/15/19	Thu 4/25/19	10	9
1.6	Final Project Presentation.	All	Thu 4/25/19	Tue 5/14/19	19	14
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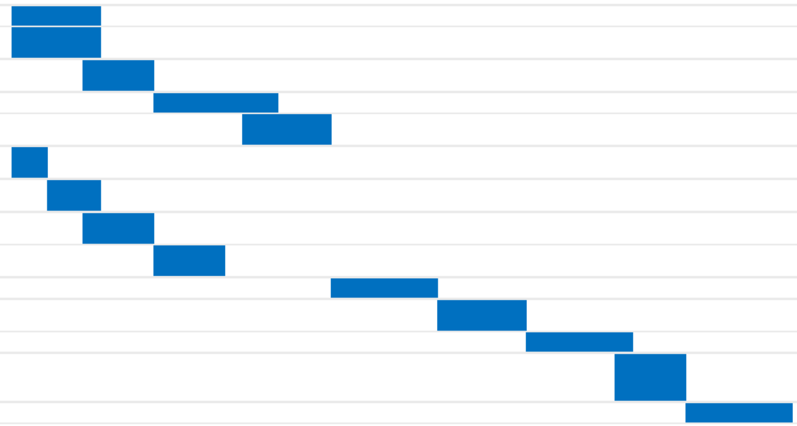

X. Roles of Team Members

Clearly describe each team member, what their strengths are, what their weaknesses are, and what their role is for the project.

XI. Stakeholder List

List all of the stakeholders for your project, including why they are a stakeholder. This should include team members (ECE as well as ME), the instructor (me), your technical advisor, your sponsors (if any), and anyone else that has a stake in the project being successfully completed.

XII. Project Approval Requirements

List what is required for your project to meet the approval of you various stakeholders.

XIII. Approvals

This is a list of signatures of all of the stakeholders.
[1] [2] [3]

References

You will use Bibtex to generate references for all of the material you cited, using [1], to write this report. Use the to generate your references.

Remember, you need to compile your .tex source file once as Latex, then once as Bibtex, then once again as Latex. The first compile determines what the citations are, the second generates the list of references, the third assigns the correct reference numbers.

References

[1] Altera, “DE1-SoC Reference Manual,” http://www.ee.ic.ac.uk/pcheung/teaching/ee2digital/DE1SoCUsermanual.pdf,.
[2] Oyostepper, “23Hs22-2804S data sheet,” https://www.oyostepper.com/images/upload/File/23HS22-2804S.pdf,.
[3] L. Leadshine Technology CO, “DM542 User Manual,” http://robokits.download/datasheets/Leadshine