Senior Design Report for ECE 477 – Spring 2013

submitted by
Prof. David G. Meyer
May 7, 2013

PURDUE UNIVERSITY
School of Electrical & Computer Engineering

Contents

Course Description

Digital Systems Senior Design Project (ECE 477) is a structured approach to the development and integration of embedded microcontroller hardware and software that provides senior-level students with significant design experience applying microcontrollers to a wide range of embedded systems (e.g., instrumentation, process control, telecommunications, intelligent devices, etc.). The primary objective is to provide practical experience developing integrated hardware and software for embedded microcontroller systems in an environment that models one which students will most likely encounter in industry.

One of the unique features of this course is that each team gets to choose their own specific project (subject to some general constraints) and define specific success criteria germane to that project. In general, this approach to senior design provides students with a sense of project ownership as well as heightened motivation to achieve functionality.

Course web site: https://engineering.purdue.edu/ece477

Course Staff

Name	*Title / Role*	*E-mail Address*
Prof. David Meyer	Faculty / Project Advisor	meyer@purdue.edu
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Lecture Schedule / Course Calendar

ECE 477 – *Digital Systems Senior Design Project* – Spring 2013

COURSE CALENDAR

Monday	Tuesday	Wednesday	Thursday	Friday
Jan 7	Jan 8 Course Introduction 1:30-2:20 PHYS 203	Jan 9 Mods 1 & 2 Digital Design (two divs) MSEE 184	Jan 10 Module 3 uC survey 1:30-2:20 PHYS 203	Jan 11 Preliminary Proposal Due
Jan 14	Jan 15 Module 4 Emb Sys I/F 1:30-2:20 PHYS 203	Jan 16 Module 5 PCB Design (two divs) MSEE 184	Jan 17 Module 6 Pow Sup Des 1:30-2:20 PHYS 203	Jan 18 Final Proposal Due
Jan 21 MLK Day	Jan 22 Module 6 Pow Sup Des 1:30-2:20 PHYS 203	Jan 23 TCSP PSSCs (two divs) MSEE 184	Jan 24 Module 7 Pkg & Cnstr 1:30-2:20 PHYS 203	Jan 25 PCB Tutorial Exercise Due
Jan 28	Jan 29 Module 8 Pass Cmp Sel 1:30-2:20 PHYS 203	Jan 30 TCSP Constr Anal (two divs) MSEE 184	Jan 31 Module 8 Pass Cmp Sel 1:30-2:20 PHYS 203	Feb 1 Design Constraint Analysis Due
Feb 4	Feb 5 Module 9 Doc Stnds 1:30-2:20 PHYS 203	Feb 6 TCSP Packaging (two divs) MSEE 184	Feb 7 Module 10 Software Des 1:30-2:20 PHYS 203	Feb 8 Packaging Design Due
Feb 11 Lab Notebook Evaluation	Feb 12 Module 11 Assem/Solder 1:30-2:20 PHYS 203	Feb 13 TCSP Schematic (two divs) MSEE 184	Feb 14 Module 12 Debugging 1:30-2:20 PHYS 203	Feb 15 Preliminary Schematic and Design Narrative Due
Feb 18	Feb 19	Feb 20 TCSP PCB Design (two divs) MSEE 184	Feb 21	Feb 22 Preliminary PCB Layout and Design Narrative Due
Feb 25 Formal Design Reviews MSEE 184	Feb 26 Formal Design Reviews MSEE 184	Feb 27 Formal Design Reviews MSEE 184	Feb 28 Formal Design Reviews MSEE 184	Mar 1 Formal Design Reviews MSEE 184

Monday	Tuesday	Wednesday	Thursday	Friday
Mar 4	Mar 5	Mar 6 Progress Briefings (two divs) EE 061/063	Mar 7	Mar 8 Proof-of-Parts Final Schematic Final PCB Due
Mar 11 Spring Break	Mar 12 Spring Break	Mar 13 Spring Break	Mar 14 Spring Break	Mar 15 Spring Break
Mar 18 Midterm Peer Evaluation Due	Mar 19 Module 13 Patent Liab 1:30-2:20 PHYS 203	Mar 20 TCSP Software (two divs) MSEE 184	Mar 21 Module 13 Patent Liab 1:30-2:20 PHYS 203	Mar 22 Software Design Narrative Due
Mar 25 Lab Notebook Evaluation	Mar 26 Module 14 Rel/Safe Anal 1:30-2:20 PHYS 203	Mar 27 TCSP Patent Liability (two divs) MSEE 184	Mar 28 Module 14 Rel/Safe Anal 1:30-2:20 PHYS 203	Mar 29 Patent Liability Analysis Due
Apr 1	Apr 2 Module 15 Eth/Env Imp 1:30-2:20 PHYS 203	Apr 3 TCSP Reli & Safety (two divs) MSEE 184	Apr 4 Module 15 Eth/Env Imp 1:30-2:20 PHYS 203	Apr 5 Reliability and Safety Analysis Due
Apr 8	Apr 9	Apr 10 TCSP Eth/Env Imp (two divs) MSEE 184	Apr 11	Apr 12 Ethical and Enviro Impact Analysis Due
Apr 15	Apr 16	Apr 17 Progress Briefings (two divs) EE 061/063	Apr 18	Apr 19 Poster for Royal Design Showcase Due
Apr 22	Apr 23	Apr 24 TCSP PSSC Demos (two divs) MSEE 184	Apr 25	Apr 26 *Royal Design Showcase* 3:00-6:00 PM MSEE ATRIUM

Formal Design Reviews for each team will be scheduled on Feb. 25 – Mar. 1 | Final Presentations will be on May 1, 9 AM - NOON & 1 - 4 PM in MSEE 184

Confidential Peer Review, Final Report, User Manual, and Senior Design Report submitted on-line by 5:00 PM on Monday, April 29

Design Project Specifications / Requirements

Work on the design project is to be completed in teams of four students. The design project topic is flexible, and each group is encouraged to pick a product that uses the strengths and interest areas of their group members. The design must have the following components:

- **Microcontroller:** To help make the project tractable, recommended microcontroller choices include Freescale, PIC, and Atmel variants. Development tools are readily available in lab to support these devices. Further, the devices themselves are relatively low cost and readily available. Optionally, auxiliary processing can be accomplished using a "motherboard". Examples of these directly supported are Intel Atom and ARM-based platforms.
- **Interface to Something:** The embedded system designed must interface to some other device or devices. It could be a computer, smart phone, tablet, or some other embedded device. Interface standards that can be used include: asynchronous or synchronous serial, parallel, Universal Serial Bus (USB), Bluetooth, Xbee, Firewire, Ethernet, Infrared (IR), Radio Frequency (RF), etc. This requirement has a large amount of freedom. To help with some of the more complex interfaces such as Ethernet and USB, dedicated chips which encapsulate the lowest layers of the interface can be utilized. This makes using these interfaces easier to handle but not necessarily trivial. (NOTE: *Interfaces involving A.C. line current require special permission – see the instructor for details.*)
- **Custom printed circuit board:** Through the process of the design, each group will be required to draw a detailed schematic. From the schematic, a two-layer printed circuit board will be created. Board etching will be processed by the ECE Department (the first one is "free", but any subsequent iterations are the team's responsibility). The team is then responsible for populating the board (solder the parts on the board), and for completing the final stages of debugging and testing on their custom board.
- **Be of personal interest to at least two team members:** It is very difficult to devote the time and energy required to successfully complete a major design project in which you and/or your team members have no personal interest. There are *lots* of possibilities, ranging from toys and games to "useful and socially redeeming" household items, like audio signal processors and security systems.
- **Be tractable:** You should have a "basic idea" of how to implement your project, and the relative hardware/software complexity involved. For example, you should not design an "internet appliance" if you have no idea how TCP/IP works. Also, plan to use parts that are reasonably priced, have reasonable footprints, and are *readily available*. Be cognizant of the prototyping limitations associated with surface mount components.
- **Be neatly packaged:** The finished project should be packaged in a reasonably neat, physical sound, environmentally safe fashion. Complete specification and CAD layout of the packaging represents one of the project design components.
- **Not involve a significant amount of "physical" construction:** The primary objective of the project is to learn more about *digital system* design, not mechanical engineering! Therefore, most of the design work for this project should involve digital hardware and software.

Project Proposal: Each group should submit a proposal outlining their design project idea. This proposal should not be wordy or lengthy. It should include your design objectives, design/functionality overview, and project success criteria. The five success criteria common to all projects include the following:

- Create a bill of materials and order/sample all parts needed for the design
- Develop a complete, accurate, readable schematic of the design
- Complete a layout and etch a printed circuit board
- Populate and debug the design on a custom printed circuit board
- Package the finished product and demonstrate its functionality

In addition to the success criteria listed above, a set of **five significant** *project-specific* success criteria should be specified. The degree to which these success criteria are achieved will constitute one component of your team's grade.

Forms for the preliminary and final versions of your team's project proposal are available on the course web site. Use these skeleton files to create your own proposal. Note that the proposal should also include assignment of each team member to one of the design components as well as to one of the professional components of the project.

Group Account and Team Webpage: Each team will be assigned an ECN group account to use as a repository for all their project documentation and for hosting a password-protected team web page. The team web page should contain datasheets for all components utilized, the schematic, board layout, software listings, interim reports, presentation slides, etc. It should also contain the individual lab notebooks for each team member as well as the progress reports (prepared in advance of the weekly progress briefings) for each team member. At the end of the semester, each team website will be archived on the course website.

Design Review: Part way through the design process, there will be a formal design review. This is a critical part of the design process. In industry, this phase of the design process can often make or break your project. A good design review is one where a design is actively discussed and engineers present concur with the current or amended design. The design review is in some cases the last chance to catch errors before the design is frozen, boards are etched, and hardware is purchased. *A friend is not someone who rubber-stamps a design, but rather one who actively challenges the design to confirm the design is correct.*

Approach the design review from a top-down, bottom-up perspective. First, present a block diagram of your design and explain the functional units. Then drop to the bottom level and explain your design at a schematic level. Be prepared to justify every piece of the design; a perfectly valid answer, however, is applying the recommended circuit from an application note. If you do use a circuit from an application note, have the documentation on hand and be able to produce it. *Your grade for the design review will not be based on the number of errors identified in your design.* The best engineers make mistakes, and the purpose of the design review is to *catch them* rather than spend *hours of debugging later* to find them. The design review will be graded primarily on how well the group understands their design and the professionalism with which they present it.

To facilitate the design review process, the class will be split into subgroups that will meet at individually scheduled times. Both the presenters and the assigned reviewers will be evaluated.

Design Project Milestones

Each group is responsible for setting and adhering to their own schedule; however, there are several important milestones, as listed in the table below. Always "expect the unexpected" and allow for some buffer in your schedule. ***Budget your time.*** With proper budgeting, senior design can be a very rewarding and pleasant experience. See **Course Calendar** for due dates.

Week	*Milestone*	*Deliverables*
1	Formulate project ideas: sensors used, microcontroller peripherals needed, motherboard requirements (if applicable), memory requirements, power supply requirements, power source (AC, battery)	Preliminary Project Proposal
2	Research and select major components, including the family of microcontroller (e.g. dsPIC, PIC32, etc.) and power supply components (switching regulator, battery management). Check out a microcontroller development board and write code that exercises various on-chip peripherals (e.g., blink an LED at variable rate specified by analog input voltage, debug via RS 232). Order some parts for prototyping purposes. Formulate PSSC and initial block diagram.	Final Project Proposal
3	Finalize and order major components. Order motherboard (Atom, ARM, etc.) if applicable. Begin prototyping microcontroller interfaces (work on parts of circuit most complex first). Start prototyping power supply circuitry. Begin selecting secondary components (e.g., voltage level translators, specialty diodes, capacitors, resistors, etc.) – note that an RS 232 level translator chip is required for the microcontroller to communicate with a host PC via RS 232).	Eagle PCB Tutorial Exercise
4	Finish power supply prototyping. Be prepared to demonstrate sensor interfaces. Create a detailed BOM.	Design Constraint Analysis Report
5	Start developing schematics and create footprints needed for PCB parts library. Start testing motherboard (if applicable). Create packaging CAD drawings. Continue prototyping interface and support circuitry.	Packaging Report
6	Finalize schematic and begin PCB layout. Check footprints created for PCB library against actual components.	Schematic Report
7	Finalize PCB layout for Design Review. Continue software development and testing. Prepare for Design Review.	PCB Report
8	Practice presentation. Continue software development.	Design Review Presentation
9	Incorporate changes/comments from Design Review.	Proof-of-Parts, Final Schematic, and Final PCB Layout
10	Continue software development and testing.	Software Report
11	Begin populating/testing PCB. Test PCB section-by-section as parts are added, porting software as you go – ***add functions one-by-one so you know what it was that "broke" your code or your board when things stop working.***	Patent Liability Analysis Report
12		Reliability and Safety Analysis Report
13		Ethical/ Environmental Impact Analysis Report
14	Finalize packaging and system integration. Start assembling and editing Final Report.	Poster
15	Create PSSC demo video. Create Poster and Senior Design Report. Finish editing Final Report. Prepare for Final Presentation.	PSSC Demo Video
16	Submit project deliverables. Practice Final Presentation.	Senior Design Report, User Manual, Final Presentation

Learning Outcomes/Objectives and Assessment Procedures

In order to successfully fulfill the course requirements and receive a passing grade, each student is expected to demonstrate the following outcomes:

(i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system
(ii) an understanding of the engineering design process
(iii) an ability to function on a multidisciplinary team
(iv) an awareness of professional and ethical responsibility
(v) an ability to communicate effectively, in both oral and written form

The following instruments will be used to assess the extent to which these outcomes are demonstrated (the forms used to "score" each item are available on the course web site):

Outcome	*Evaluation Instruments Used*
(i)	Design Component Homework
(ii)	Individual Lab Notebooks
(iii)	Success Criteria Satisfaction (general *and* project-specific)
(iv)	Professional Component Homework
(v)	Formal Design Review, Final Presentation, and Final Report

You will receive 1% bonus credit for each course outcome you successfully demonstrate. Demonstration of Outcome (i) will be based on the satisfaction of the design component homework, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (ii) will be based on the individual lab notebook, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (iii) will be based on satisfaction of **100%** of the general success criteria and a minimum of **60%** (3 out of 5) of the project-specific success criteria (PSSC). Note: *If a "motherboard" is used, at least 2 of the 3 "passing PSSC" must involve functions implemented on the custom PCB.* Demonstration of Outcome (iv) will be based on the professional component homework, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (v) will be based on the Design Review, the Final Presentation, and the Final Report. A minimum score of **60%** on the Design Review and a minimum score of **60%** on the Final Report and a minimum score of **60%** on the Final Presentation will be required to establish basic competency.

Course Grade Determination

Homework: Several "homeworks" will be assigned related to key stages of the design project. Some of the assignments will be completed as a team (0, 1, 7, 13, 15, 16, 17), three will be completed individually (2, 8, 14), and the remainder will be completed by a selected team member (one from the set {4, 5, 6, 9} and one from the set {3, 10, 11, 12}).

1. Team Building and Project Idea
2. Project Proposal
3. PCB Tutorial
4. Design Constraint Analysis and Component Selection Rationale
5. Packaging Specifications and Design
6. Hardware Design Narrative/Preliminary Schematic
7. PCB Design Narrative/Preliminary PCB Layout
8. PCB Submission, Final Schematic, and Parts Acquisition/Fit
9. Peer Review – Midterm
10. Software Design Narrative, and Documentation
11. Patent Liability Analysis
12. Reliability and Safety Analysis
13. Ethical/Environmental Impact Analysis
14. User Manual

These assignments are due on the prescribed due dates (typically Fridays) at NOON. The following penalties will be applied for work submitted late:

- 10% if submitted no more than 24 hours late
- 20% if submitted no more than 48 hours late
- 30% if submitted no more than 72 hours late
- 100% if submitted any later

15. Peer Review – Final
16. Senior Design Report
17. Final Report
18. Poster

These assignments are all due on Monday, 4/29, at 5:00 PM. Late penalties will be assessed per above late policy. However, these materials will NOT be accepted at all after 5:00 PM on Thursday, 5/2.

Grade Determination: Your course grade will be based on ***team effort*** **(40%)** as well as your ***individual contributions*** **(60%)**, as follows:

TEAM COMPONENTS (40% of total) distribution of team component:		**INDIVIDUAL COMPONENTS (60% of tot.) distribution of individual component**	
Project Success Criteria Satisfaction*	20.0%	Laboratory Design Notebook*	20.0%
Design Review*	15.0%	Design Component Report*	20.0%
Final Presentation*	15.0%	Professional Component Report*	20.0%
Final Report*	15.0%	Significance of Individual Contribution	15.0%
System Integration and Packaging	10.0%	Design Review and Final Presentation Peer Eval	5.0%
User Manual	7.5%	Confidential Peer Reviews	5.0%
Senior Design Report	7.5%	TCSP Peer Reviews (9)	5.0%
Poster	7.5%	PCB Tutorial	5.0%
PCB Proof-of-Parts	2.5%	Class Participation - Clicker Exercises	2.5%
** items directly related to outcome assessment*		Class Participation - Team Exercises	2.5%

Your **R**aw **W**eighted **P**ercentage (RWP) will be calculated based on the weights, above, and then "curved" (i.e., mean-shifted) with respect to the upper percentile of the class to obtain a **N**ormalized **W**eighted **P**ercentage (NWP). Equal-width cutoffs will then be applied based on the **W**indowed **S**tandard **D**eviation (WSD) of the raw class scores; the minimum **C**utoff **W**idth **F**actor (CWF) used will be 10 (i.e., nominal cutoffs for A-B-C-D will be 90-80-70-60, respectively). Letter grades in the upper 30% of each range will have a "+" designation, and those that fall in the lower 30% of each range will have a "–" designation.

Course Assessment Report

Course:

ECE 477

Instructor/Submitted by:

D. G. Meyer

Please list the course Learning Objectives (Formally Course Outcomes). You can copy and paste from ECE Course Descriptions.

(i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system
(ii) an understanding of the engineering design process
(iii) an ability to function on a multidisciplinary team
(iv) an awareness of professional and ethical responsibility
(v) an ability to communicate effectively, in both oral and written form

It is recommended that at least 90% of students who received a passing grade will have also demonstrated attainment of each Learning Objective.

What was your target percentage? If other than 90%, please explain.

At the senior design level, our expectation is that 100% of the students who receive a passing grade should be able to effectively demonstrate all of the learning objectives based on a passing threshold of 60%. Learning Objective 2 (based on the laboratory design notebook maintained by each student) has perennially been the most troublesome to effectively demonstrate. Frankly, this cohort was not as engaged as it should have been; hence, the unexpectedly high failure rate (15%) for Learning

At the senior design level, our expectation is that 100% of the students who receive a passing grade should be able to effectively demonstrate all of the learning objectives based on a passing threshold of 60%. Learning Objective 2 (based on the laboratory design notebook maintained by each student) has perennially been the most troublesome to effectively demonstrate. This failure rate should be lower.

In this course, what percentage of students who received a passing grade demonstrated attainment of each Learning Objective? If this is below the target percentage, please explain.

Average Outcome Scores and Outcome Demonstration Statistics for ECE 477

Outcome # 1 Avg Score: 79.4% Passed: 20/ 20 = 100.00% Failed: 0/ 20 = 0.00%

Average Outcome Scores and Outcome Demonstration Statistics for ECE 477

Outcome # 1 Avg Score: 86.3% Passed: 88/ 88 = 100.00% Failed: 0/ 88 = 0.00%

Outcome # 2 Avg Score: 80.0% Passed: 78/ 88 = 88.64% Failed: 10/ 88 = 11.36%

Outcome # 3 Avg Score: 91.4% Passed: 84/ 88 = 95.45% Failed: 4/ 88 = 4.55%

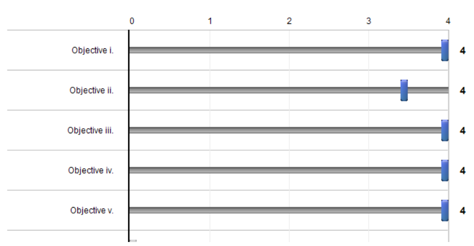
Outcome # 4 Avg Score: 87.7% Passed: 88/ 88 = 100.00% Failed: 0/ 88 = 0.00%

Outcome # 5 Avg Score: 89.5% Passed: 88/ 88 = 100.00% Failed: 0/ 88 = 0.00%

Demonstrated all five outcomes based on assessment instrument(s): 76/ 88 = 86.36%

The expectation is that students who successfully complete a course will demonstrate adequate attainment of each of the course's Learning Objectives.

On a scale from 0 - 4 (0 = not at all, 1 = marginal, 2 = adequate, 3 = good, 4 = very good), please rate the overall extent to which the students in this course have demonstrated attainment of each of the Learning Objectives.



Are the Learning Objectives appropriate? If not, explain.

yes

Are the students adequately prepared for this course and are the course prerequisites and co-requisites appropriate? If not, explain.

yes

Do you have any suggestions for improving this course? If so, explain - especially if the overall attainment of the course Learning Objectives did not meet your expectations.

MORE LAB SPACE!

MORE FACULTY INVOLVEMENT!!

Appendix A:

Senior Design Reports

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	1
Project Title	Wall-E Prototype I

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Zelun Tie	EE	PCB design/software programming	May 11, 2013
Hang Xie	CmpE	Embedded software development	May 11, 2013
Xin Jin	EE	Hardware development/packaging design	May 11, 2013
Ranmin Chen	EE	Software programming/circuitry design	May 11, 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The design project Wall-E Prototype I is an intelligent automated trash collecting robot with obstacle detection capability. The robot responses to either user's direct manual control, or the object tracking software, to locate and collect the targeted trash object. The battery of the Wall-E Prototype I can remain operative for 8 hours after a full charge cycle. The system of the Wall-E Prototype I contains two major parts, the robot and the server. The major electronics installed on the robot including a remote camera, a pic24fj256ga106 microcontroller, an XBee module, a motor drive board, a servo driving robotic arm, an ultrasonic range sensor, a rechargeable 12V Ni-MH battery pack, and a power control circuit. Most of these electronics on the robot are located on a custom 6in * 5in PCB double side PCB. The robot is responsible for data collecting, environment sensing, and the execution of the command sent from the server side for object tracking and collecting. The server side consists of an atom board, a standard key board and mouse set, a display screen and an XBee module for the wireless communication to the robot. The server processes data collected by the robot and generates command for target tracking. This is done with a Python program with SimpleCV and PySerial modules. The Atom board can also be used as the manual interface terminal for direct user manual control over the robot.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

One of the most critical part of the project is the microcontroller. The programing of the microcontroller requires knowledge from ECE362, which introduce basic computer organization, microprocessor instruction sets, assembly language programming, the design of various types of digital as well as analog interfaces, and microprocessor system design considerations. In this project, protocols/peripherals which were introduced in ECE362 such as UART (SCI in another word), PWM were utilized, although they are now on a different microcontroller (pic24F256GA106 instead of Freescale 9S12C32). Addition concept, such as interrupt was also used in the project.

Python and bash programing skills learned from ECE364 are also critical to this senior design project. In order to track the ball and send command to robot from the server, the project uses “simpleCV” (a library in python) to process the video stream, and use “Pyserial” (a module that encapsulates the access for the serial Port.) as a tool for the server to communicate with the robot.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Peripheral Pin Select (PPS) is used in the microcontroller programing, this is the function on the pic24f256ga106 allows the programmer to remap peripheral modules to different microcontroller pin outs. By using this function, all the pwm was able to be mapped to one side of the microcontroller to simplify the PCB design.

“Watch dog” timer is another technical knowledge used in this project. This feature automatically resets the robot to initial setup when the servo stays in the wrong place for beyond a certain length of the time.

Image processing software programming is another new skill required in the project. One of the most important functions of the project is to pick up the red ping-pong ball automatically. To impalement this function, a SimpleCV program is written to run on the Atom board to process the video stream from the remote camera on the robot, for target tracking and command generating.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Just as any engineering project, Wall-E Prototype I is designed to solve a certain problem or improve a certain process. This involves the steps of identifying the problem, objectives, and criteria. This is how the PSSCs were established at the beginning of the project development. Then, based on the objectives established, researches and studies were done to analyze the required hardware and software needs. As soon as the required software and hardware needs are satisfied, preliminary test modules are synthesized, and final product then can be constructed. After the complete project is produced, a series testing and evaluation and adjustments were done to optimize the performance of the product.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: As a prototype, each component of the robot needs to be purchased in small quantity, which increases the unit cost, but also lowers the economic constrain due to the small amount needs. However, economic consideration is still the main factor when choosing high value components, such as the robot platform and the server hardware. One of the main reason the Lynxmotion Tri-Track was chosen as the robot platform is due to its lower cost comparing to the Lynxmotion 4WD robot.

Environmental: Instead of using a disposable battery, the team chose to use a re-chargeable Ni-MH battery pack. Also, the PCB was made as small as possible in the premise of not sacrificing prototype expandability to protect the environment.

Ethical: Although due to its prototyping nature, the robot was not tested thoroughly, it was still tested under various operating conditions to ensure system stability and user safety. The robot was tested under both manual and automatic control, in both in-door and out-door environment, with a different wireless communication range from 2m to 100m. In addition to this, a user manual with instructions and pictures was also produced to help users operating the robot.

Health & Safety: The different testes described in the Ethical constraints are also a consideration for user safety, as well as the design decisions described in the Environmental constrains.

Social: The Wall-E Prototype I project itself was motivated by social benefits. Wall-E Prototype I is an automatic trash collecting robot aimed to improve the currently inefficient mostly manual trash disposal system, and thus reduce the environmental threat caused by man-made wastes, which in turn benefits the human society.

Political: No military/industrial secrets or illegal components/information are involved in the design of the Wall-E Prototype I, and thorough patent research was done on similar products to eliminate potential patent infringement and political issues.

Sustainability: As described in the ethical and environmental consideration sections, the different design decisions and tests done on the project are also mechanisms to increase the sustainability of the product.

Manufacturability: Although many different components were used in the project design, but all of them are easily obtainable. The only fully customized hardware piece is the PCB board on the robot, which was tested for manufacturability even before the prototyping of the board. Therefore, the manufacturability was well considered in the robot design.

(f) Description of the multidisciplinary nature of the project.

As a full automatic robot project, the development and design of the robot requires multidisciplinary knowledge across image processing (CGT), packaging design (industrial designer), software programming (CompE or CS), circuitry design (EE), and also hardware design and packaging (EE). Even more multidisciplinary knowledge were used to resolve the surrounding issues of the project such as potential patent infringement (Law), user safety (Human health), environmental impact (EEE), and so on.

(g) Description of project deliverables and their final status.

The Wall-E Prototype meets all the five success criteria which were set up at the beginning of the semester. More specifically the Wall-E prototype can recognize a red ping pong ball (38mm / 1.58 inch diameter hollow sphere) and show a live video with a red circle enclosing it on a display connected to the Atom board server. Wall-E Prototype I can be controlled manually by the user or the automatic target tracking software to perform the trash collecting/ball tracking task. The product also has the ability to navigate around obstacles and display the remaining battery charge via LED array.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	2
Project Title	Treasure Chess

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Sidharth Malik	CmpE	Hardware Design/Verification	5/12/2013
Brock Caley	CmpE	Packaging/Design	12/15/2013
Jeremy Stork	CmpE	Hardware	12/15/2013
Parul Schroff	CmpE	Software	5/12/2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Our project is a voice-controlled chess game that uses two 16x32 RGB LED matrix panels to display the chess board. A player can input the moves to play through a microphone or a keypad. Thereafter, the game logic checks if the move played is correct or not in two ways: if the square the piece is being moved to is empty or occupied by the opponent's piece, and if the move played by the respective piece is correct – for example rook only travels horizontally or vertically, bishop only travels diagonally, etc. Once the game logic has assessed the move, it then sends the output to the RGB LED matrix panel to display the current state of the chessboard. Our design also has provision for displaying the possible moves for a piece selected by the player to move. Additionally, we will be using OLEDs to display time and other in-game statistics during the game. This project is intended to be used by anyone with a focus on disabled people to provide them a source of entertainment in chess.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project needed a lot of the knowledge we learned about microcontrollers and their peripherals in ECE 362. We also used a lot of concepts that we had learned in ECE 270 about basic circuitry. This project was coded in C and used a lot of knowledge learned from CS 159, ECE 264, and ECE 368.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The first and the foremost thing that we learned was to design the pcb using Eagle design tool. Even though we had started to read datasheets in ECE 362, this course required us to read and understand multiple datasheets on our own. Even understanding of how to interface the peripherals with the microcontroller was enhanced during the project development process.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

We had the basic project concept and idea before the semester started. Once the semester started, we laid out our project specific success criteria and had a clearer idea of what all had to be accomplished. As the project proceeded into synthesis and testing stages we constantly updated our design to incorporate any of the issues we faced. First we tested all the components and the peripherals individually and then integrated the entire project for final testing. Once everything was tested, it was packaged and further tested and debugged.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Our design was within the budget provided to us. The RGB LED matrix panels cost the most but other than that all the other design components were within the reasonable limit. In conclusion, our project is quite economical to manufacture.

Environmental: During the manufacturing phase of our project, most of our components were RoHS compliant that made it environment safe. While the project is being used, majority of the environmental impact is due to the constant power dissipation while the game is on. However, we have a power button that can be turned off when the game is not in use so power can be saved if not unplugged from the external power outlet. However, at disposal stage, it is required that our product is recycled carefully due to heavy use of chemicals in our design components and use of acrylic for packaging.

Ethical: As far as the problems with our hardware and software are concerned, it is very possible that our code might have some bugs that might result in failure to detect the correct legality of the moves played or display all the possible moves. The user is requested to send questions/suggestions related to software issues to us so we are able to update the software and make it error free. Since this is an electronic chess game, any kind of hardware failure is unpredictable but entirely possible. In such cases, it will be recommended to the user to report the complaint to us so we are able to take necessary actions either by trying to fix the existing product the user possesses or by replacing the product if it is in a relatively new condition.

Health & Safety: Even though we are not implementing any safety feature in our design as such, it is still important to make the user aware of the various measures they should take before they start playing this game. Being an electronic game, care should be taken to avoid spilling any liquid on it. Additionally, we recommend not using the game with wet hands because it might cause electric shock as water can conduct electricity. During normal use if the RGB LED matrix fails and starts flashing very bright LEDs at a very high speed, it might cause some kind of stress to the eyes and in extreme cases cause seizure to any user prone to photosensitive epilepsy. We have covered the RGB LED matrices with a black acrylic to prevent any such occurrences but precaution must still be taken.

Social: Our game is targeted for any user who likes to play chess and would like to try an electronic version of this world famous game. Our initial idea to incorporate voice recognition that we could not ultimately implement due to hardware issues, was motivated from the fact that we wanted the game to be playable by disabled people.

Political: Being a digital version of chess, our design does not really have any political impact other than the fact that there are other similar products out there in the market as well.

Sustainability: The project is quite sustainable until the different components fail. However, one major concern could be the voltage regulators and the respective capacitors as they charge and discharge power constantly hence would need to be replaced over time.

Manufacturability: As mentioned above, all of the components in our design are RoHS compliant. The main concern while manufacturing is use of acrylic plastic for packaging our design. That should be manufactured in a closed environment and all the toxic wastes should be neutralized before being released into the atmosphere.

(f) Description of the multidisciplinary nature of the project.

The Printed Circuit Board layout for our project involved learning about the Eagle design tool and also being able to comprehend and incorporate the electrical constraints of each component. Knowledge of how to solder the components onto the pcb was also required. Most of the software was done in C and hence required knowledge about the language. So, the whole project required both software and hardware skills. Finally, the packaging required some artistic skills that made the project look pretty on the outside.

(g) Description of project deliverables and their final status.

Most of the functionalities for our design were achieved except the voice recognition. Input from the keypads was received and then we were able to correctly display the output the current state of the chess board on the RGB LED matrix panels. Possible moves for each piece selected were displayed and any move that was illegal was detected. Finally, we were able to complete 4 out of our 5 project specific success criteria and have a neatly packaged functioning game.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	3
Project Title	The Hackers of Catron

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Josh Hunsberger	EE	Schematic & Embedded Software & Hardware Prototyping	Spring 2013
Spencer Julian	CmpE	Web Programming & Linux	Spring 2013
Ryan Pawling	CmpE	Embedded Software & Hardware Prototyping	Spring 2013
Robert Harris	CmpE	PCB Layout & Web Design	Spring 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Hackers of Catron is an electronic version of the popular board game, the Settlers of Catan. The game is a resource trading game with the goal of getting the most points by having the most cities and settlements placed on the playing surface. The goal of the project was to simplify the game setup and tracking of game status, while still having a physical board game. The intended customers are existing Catan players who want an even better game play experience and people who have never played Catan before. To keep the physical feel of the board game, magnets were attached to the game pieces and Hall Effect sensors were used to track piece placement. An access point serves a web application that displays the game status and enables turn based game play. Resource types were indicated by colored lights and resource rarities by 7 segment displays. After deciding how to approach the problem, the hardware was prototyped and tested. A PCB was then designed and later populated. Finally, software was designed to bring everything together and create the game logic.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project required us to use knowledge from previous courses and to build upon that knowledge. Knowledge gained from ECE 362 (Microprocessor System Design and Interfacing) was vital to the success of the project. Most of our decisions regarding digital hardware were based on skills gained from 362. Basic skills learned in ECE 201 and 202 (Circuit Analysis) were important in picking passive components, as were skills learned in ECE 270 (Digital Circuit Design) for selecting discrete logic devices. ECE 264 (Advanced C Programming) and ECE 364 (Scripting with Python) provided the necessary knowledge for the software side of the project. Also, ECE 362 gave us a good background in embedded software design, which was necessary for programming the microcontroller.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

This project required us to learn several new skills. Most notable among these is PCB layout. Due to the size and complexity of our PCB, many man hours were spent hand-routing our design. Technical knowledge regarding the intricacies of Eagle and calculating appropriate trace sizes was acquired. Software design skills include learning css3 and html5 for a web interface, learning python 3 in a web environment, C for embedded software, and running a wireless access point using a raspberry pi. Other skills learned throughout the course of our planning stage were how to effectively read data sheets, and how to compare and select components. During our construction phase, we acquired valuable knowledge in soldering practices, using a logic analyzer to debug prototypes and the PCB, and writing useful tests to validate the PCB.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

During the first week, selection of the project and its objectives were established. This was done by speaking with Dr. Johnson and TAs about whether the project was feasible or not. For instance, detecting piece position was possible, but detecting the type of piece would be much more difficult. During the analysis phase, the team began to plan how the design would be approached. It was here that a block diagram was produced and major components were researched and selected. After speaking with TAs, it was evident that using a large PCB and multiplexers would be preferable to several small PCBs with their own microcontrollers. During the synthesis phase all the schematic and PCB layout was completed, as well as fully prototyping all the microcontroller interfaces and writing PCB test code. During the construction phase, the PCB was populated and debugged while the webserver was being constructed. After the PCB was populated, embedded code was finished. The testing phase focused on debugging the communication between the webserver and the board. The evaluation phase consisted of playing through the game several times and evaluating how the game met our PSSCs and personal expectations.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: While the project was quite expensive, particularly with such a large PCB, during the initial design phase we were considering alternatives to many of our components, including LCD displays for each hexagon. Even though the final product was expensive, it could have been much more so if we had selected different components.

Environmental: A large PCB does not necessarily bring to mind a very environmentally friendly product, but if the project is taken to a proper electronics recycler, most of the project can be reclaimed for future use.

Ethical: While the game itself does not have any ethical issues, selling the game could. Because the game and its copyrights are owned by Mayfair games, we cannot sell this game without their permission. However, there is no issue in open sourcing it or sharing it with others.

Health & Safety: The board uses lots of magnets, which are fairly dangerous around children. We recommend the board not be played by anybody 14 years of age or under, as swallowing the magnets and small pieces could be dangerous. Otherwise, there are not many realistic health and safety concerns to be aware of in normal operation.

Social: The game is designed for 3-4 players, and is a relatively fun game to watch and simple game to learn. With the rules being enforced by computer, it is more difficult for less honorable players to cheat, and enhances the enjoyment for everyone. With the time that is saved from the automated setup, more time can be spent talking with friends and doing things other than play the game.

Political: As was mentioned in the ethics section, the game is owned by Mayfair games, and if we were to sell the game, they would likely attempt to sue us for copyright infringement. Technically we could sell the game as a parody of the original Settlers of Catan to avoid that, but considering their aggressive stance with their copyright (even going so far as to claim they hold the copyright on the rules, which cannot be copyrighted), they would likely try to sue us anyway just to bankrupt us, regardless of if we won the court case. As such, open sourcing the game seems to be the better option, as there is nothing they can do there.

Sustainability: The project, while not necessarily environmentally friendly, is designed well enough such that it should not break over the course of a few years, with careful use. Additionally, the pieces are all made from sustainable sources of wood and many components that were chosen for their quick availability could be replaced with more sustainable sources, such as the plastics.

Manufacturability: The project would not take too much effort to manufacture. The PCB is large and has a lot of components, but robotically placing components and using a solder flow instead of hand soldering all of the pieces would simplify manufacturing. Additionally, the plastic components and metal components are adhered together with various glues, and are easy to cut and attach to each other.

(f) Description of the multidisciplinary nature of the project.

The project utilized skills learned in a standard electrical engineering and computer engineering curriculum, with development of a PCB and selection of components, along with development of software for the microcontroller. Additionally, the project required some mechanical skill in the design and construction of the packaging and fitting the developed PCB together with the other, external components. Finally, an aesthetic design sense was required, not just for the packaging but also for the labels on the device and the development of the web interface, as it needed to look good and appear consistent.

(g) Description of project deliverables and their final status.

The project in its final form implemented the complete game logic of Settlers of Catan with a digital board and an interactive web interface. The game is very entertaining and simplifies game setup, meeting the major goals we had for the project.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	4
Project Title	Dummy Arm

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Chuan He	CmpE	Software/PCB	May 2013
Jun Yao	EE	Communication/Software	May 2013
Yuntian Lu	EE	Software Interface/PCB	May 2013
Wudi Zhou	EE	Package/Hardware	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Project Dummy Arm is a remote controlled robotic arm with 5 degree of freedom. As the user moves their arm, the robotic arm which is located away from the user will perform the same motion in real time. This product is intended to provide user the ability to perform actions remotely when working environment is hazardous to human. In addition to capturing motions, this product also provides the ability to turn on and off each motor individually and record/replay the movements. The motions of human arm are captured by 3 3-axis accelerometers located on control-sleeve which is worn by the user. Motion capture is achieved by calculating the relative angle of each joint to gravity. All measurements are filtered through software to eliminate noise and sent to the robotic arm. A LCD is located on the control box of the control sleeve for displaying the current bending angle of each joint and the pressure on the gripper. The robotic arm will receive the measurements and adjust the PWM duty cycle for the corresponding motor to position the arm. Motion limit is implemented in software to restrict the movement of the robotic arm to normal human arm motions. The robotic arm and control sleeve communicate wirelessly through the XBee modules installed on both side.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project was built upon the knowledge from several previous coursework. During proposal state of the project, the brainstorm skills learned from first year engineering courses helped us generates project ideas efficiently. In the design phase, digital circuit courses, such as ECE 270 and ECE 362, provided us the knowledge of how to use integrates circuit and how to program a microcontroller. The design experience from ECE 362 mini-project taught us how to look-up and use online schematics and specifications. For the software part of the product, CS 159 and ECE 264 gave us programming experience in C. For the hardware part, the hardware debugging experience gained from ECE laboratory courses, such as ECE 207, ECE 208, ECE 270 and ECE 362, helped us on designing and debugging PCB and off-PCB circuitry.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The primary skill acquired from this project is the printed circuit board design. We have learned the knowledge of designing the hardware, drawing the schematics and lay out the printed circuit board in Eagle. Another important skills obtained from this product is soldering. We have learned how to solder both surface-mount and through-hole components on printed circuit board and prototype board. The XBee implementation gave us the experience to develop internal command protocol for achieving data transfer wirelessly. In the process of finishing the project, we have learned the entire product design process from project proposal to final packaging.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

At the beginning of the semester, we brainstormed several project ideas. Based on our knowledge, we narrowed our ideas to Dummy Arm. Then, detailed discussion was held to establish 5 project specific success criteria (PSSCs) with the consideration of our knowledge and time constraint. A preliminary analysis on how to achieve these PSSCs was taken among team members. We first developed a preliminary algorithm to satisfy the PSSCs. Then, major components, including microcontroller and various sensors, were selected based on the need of the design. As we started to construct the prototype, the preliminary design was modified several times as we found problems during prototype testing. We update the schematics and PCB along with the change in our design, including addition of headers, reset button and ADC pull-up resistors. During the software phase of the design, we divided the whole algorithm into several parts and wrote and tested each part separately. Finally, when all the functions work properly individually, we integrated all parts together and tested the product in their final package.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Dummy Arm did involve some expensive components. The major economic consideration is the relative high price of the sensors. Since we used commercial break-out board for sensors, the cost the product is high. During commercialization of the Dummy Arm, these sensors break-out board could be replaced by self-designed PCBs which will bring down the final cost of the product.

Environmental: Environmental impact was taken into consideration during the design of the product. The major environmental impact from Dummy Arm would be the hazardous chemical used when fabricating the PCBs and LCD. To reduce the environmental impact, we designed PCBs of small size and used a LCD which is just enough to display the information needed. Other components in the product are made from metal or plastic which can be recycled to reduce environmental impact.

Ethical: The major ethical concern of this product is safety. The robot arm may cause injury when misused. We added individual switch to control each motor so user can turn off the motors which are not in use to minimize the possibility of unexpected behaviors. In addition, the bending angle of each joint was constrained in software so that the robot arm cannot be controlled unexpectedly.

Health & Safety: As stated above, safety was taken into consideration in the design of the Dummy Arm. We provided users the ability to turn off each motors individually so motors which are not needed will not move unexpectedly when other motors are moving. And the robot arm's movement is constrained to normal human arm movements. In addition, the Dummy Arm will not release hazardous chemical during normal use.

Social: The social impact of Dummy Arm or similar product is broad. It allowed users to control a robotic arm with their normal arm movements. It can be used in many scenarios where the environment is not safe or inconvenient for human.

Political: There are similar products as Dummy Arm in market. Also, there are patents about motion tracking method. If the product were to be manufactured, patent issue may rise.

Sustainability: The parts chosen for Dummy Arm are well tested and have been used in industry for years. This should make Dummy Arm to be used for many years with low failure rate. In the case of replacement, Dummy Arm is majorly made from plastic and metal which can be recycled. The PCB and LCD used in product can be collected to use as spare parts in the future.

Manufacturability: Since this project is the prototype design, there are some temporary fastening methods in the product. These fragile components, such as housing for the control PCB, wrapping of the sensor wires, need to be addressed before it can be manufactured.

(f) Description of the multidisciplinary nature of the project.

The Dummy Arm involves knowledge from various areas. Team members from both electrical engineering and computer engineering worked together to satisfy all PSSCs for the Dummy Arm. Specifically, the robotic arm control requires knowledge about mechanical system to estimate the torque provided by each motors and load can be handled by the arm. The design of the hardware and PCB involves knowledge about circuit design and power consumption calculation. The software development utilizes knowledge from compute engineering and control algorithm development.

(g) Description of project deliverables and their final status.

The final deliverables for this project include two major components: the Control Sleeve and the Robot Arm. Both components come with a control box and a power supply. Wireless communication is used to transfer data between these two components so that the Robot Arm can be located away from the Control Sleeve. The final product can be operated in three different modes: running, recording and replaying. User can switch mode by using the push button located on the Control Sleeve. The Control Sleeve contains sensors which can be worn on users' arm and a control box with LCD screen. The LCD screen is able to display the angle of each arm joint and the current mode of the product. The Robot Arm includes a robotic arm with 5 degree of freedom and dip switches to control each motor located on the robotic arm. In running mode, user can control the motion of the robotic arm by moving their arm. In addition, arm movement can be recorded and replayed when record or replay mode is chosen by the user.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	5
Project Title	myATM

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Yu Chen Lim	EE	Hardware, microcontroller	May 2013
Tung Lun Loo	CmpE	C, C++, Python	May 2013
Chuan Yean Tan	CmpE	C,C++,Python, MySQL	Fall 2013
Xue Yuan Wong	EE	Hardware, microcontroller	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

This project is a new ATM design that uses face recognition algorithm to verify the identity of the bank account user along with 4-digit Personal Identification Number (PIN) authentication. The addition of facial recognition verification adds an extra layer of security to prevent fraud and unauthorized access to user bank account via ATM. The design implements cashless concept in mind such that user can use a cash card to store and retrieve financial information. That includes making payments in store and transferring credits from bank account. Cash card can be read and updated via RFID protocol found in the current ATM design. Next, the design consists of a keypad for user to input PIN and for other transaction purposes. The graphical user interface (GUI) of the ATM system can be controlled by the user via a touchpad. Certain hand gestures such as swipe and double tapping on the touchpad would be recognized by the ATM to control the user interface. Other than that, an occupancy sensor is installed to detect the presence of any user in front of the ATM device.

This primary customer of the project would be bank institutions where ATM is required to provide cash deposit and cash withdrawal services to their own bank customers.
The approach used in the project starts with identifying and forming the problems and objectives of the project. After having the scope of the project locked down, we started design the hardware, software and packaging of the design. Throughout the proposal and design phases, the feedback from course staffs was incorporated into our design considerations. After several iterations of design and testing, the project specific success criteria were met and documented. Throughout the design process, documentations were done in the form of an online notebook.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project requires most of the embedded system design knowledge acquired in ECE 362. The project requires the knowledge of programming and debugging microcontroller designs. For the GUI design of the ATM system, C and C++ knowledge programming skills are necessary to utilize the Qt library, which is a GUI library provided in C++ language. In addition, Object-Oriented Programming (OOP) concept is required as well when coding for the GUI. Most importantly, the fundamental circuit analysis skills (ECE 201) are necessary to construct and test the circuit on Printed Circuit Board (PCB). The ability to read and understand datasheets of electronic chips acquired in laboratory courses (ECE 207, ECE 208, ECE 362) is vital to designing the PCB for this project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The RFID design requires us to learn a lot of new knowledge about the antenna design, the operation concept of RFID, and the RF communication protocol. Sampling data based on timing basis and external interrupt toggling techniques were learned when interpreting RFID output signal to and feeding into the microcontroller. Next, the face recognition part of the design also let the team learned about how to call and use an existing face recognition library to capture an image and compare it with an existing image. During the GUI design, many C++ programming techniques and concepts such as multithreading, events handling and Qt's unique callback functions application (signal-and-slot concept) were learned as well. Besides that, the knowledge of designing an embedded system that interacts between general computing platform (Intel Atom Motherboard) and microcontroller is also something we learned while implementing this design.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

At the first stage of the engineering design process, the team started off by brainstorming ideas for the project. That involved addressing current engineering challenges and choosing a feasible project that can be delivered by the end of the semester. After having several ideas, the team had chosen the best project to work on after receiving feedback from the course stuff. Objectives and project success criteria were then established to further specify the scope of the project. After specifying objectives of the project, the team started to analyze the parts and components (hardware and software) required to build this design. After that, the team started constructing and testing different parts of the project separately. When all the independent peripherals were functioning correctly, the team then entered a combination stage where all separate parts were combined into one to ensure the project flow. Corner cases were tested and iterations of designs were made along the way. After the overall project construction was done and fully integrated, the project then entered the evaluation phase. During the evaluation phase, the project was tested multiple times before it was shown to the course stuff for demo purpose.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The economic constraint of the design was the budget. The team was given $300 on parts purchases. Therefore, prices of every part of the design were put into consideration. The project also had to cost similar or cheaper than the current commercial ATM so that the commercialization of the project was feasible.

Environmental: The design uses electronic components and embedded chips which are RoHS compliant so no hazardous materials will be released to the environment during disposal. PCB dimension is minimized as much as possible to reduce the use of harmful chemical during the manufacturing process. Also, the integration of occupancy sensor allows the device to stay in power saving mode when the device is idle. This can reduce the energy consumption and cut down carbon emission.

Ethical: The facial recognition's algorithm implemented is able to detect if there are more than one face present and a face size consistency to prevent fraud. In addition, the facial recognition is able to detect if a photo on a cell phone has been used and deny user access. The user has only 3 attempts to access his or her account before the access is denied. myATM also provides an option for the user to not utilize facial recognition during account setup.

Health & Safety: For health aspect, there are some health risks associated with RFID emissions. There was research on low frequency RFID that might affect pacemakers [1]. myATM has placed the RFID reader away from the user to prevent user's body to come in close contact with it. In terms of safety consideration, Secure Socket Layer (SSL) connection is established between the ATM and server to minimize unwanted intrusion risk by thefts and exploiters. Meanwhile, data are encrypted before they are stored in the server. Cross-check feature during the RFID write operation would be performed as well to prevent fraud cases.

Social: The project has to be socially redeeming. As ATM is already very common, the design targets to enhance the current ATM system by easing the financial transaction and improving the security. Therefore, face recognition login and a cashless system is designed to avoid unnecessary financial loss due to cash theft.

Political: The design does not involve any political concern and constraint because only the financial institutions and bank users are directly involved.

Sustainability: myATM is manufactured using steel which is solid and long lasting. A typical ATM with a steel frame lasts approximately 5-7 years [2]. In addition, with constant maintenance of myATM's components, myATM is very sustainable because the components that myATM utilized are cheap in cost and easily replaced or the components are relatively long lasting.

Manufacturability: The design uses components which are relatively cheap and widely available in the market. A 17” LCD screen, an Intel Atom Development Board, a custom PCB and packaging are required to form a complete final product. Also, the product does not involve very complicated manufacturing process. So, this can further reduce the manufacturing cost and make the product to be economically practical for deployment at many different locations.

(f) Description of the multidisciplinary nature of the project.

The project requires several integrated multidisciplinary aspects such as Electrical and Computer Engineering, Mechanical Engineering, and Economics. The ECE part of the project includes PCB design, coding, server setup and interface of peripherals such as camera, keypad, touchpad, RFID read/write and the monitor. As for the Mechanical Engineering aspect, the packaging of the design prototype involves accurate measurement of the dimensions of the materials. That includes selecting appropriate materials (different thickness of woods), cutting the right size of each parts of the design and putting them together. The economics nature of the project involves providing services for several common financial transactions similar to the commercial ATM nowadays. The project budget was also controlled so that it costs the same or cheaper than the current ATM’s cost.

(g) Description of project deliverables and their final status.

The project has been done and the prototype is ready to be delivered. The design is now able to detect the presence of user in front of the ATM, read user identity by receiving input from the cash card. PIN input can be done using the keypad and the input can be checked against the PIN stored on the server. The design is now able to use the facial recognition algorithm to authenticate the correct user. The user can also navigate the financial transaction menu by using the touchpad. Besides, the system can also fetch user's bank account information from a server and enable credit transferring between the cash card and the bank. The design is also able to update the RFID cash card with the most current cash balance. All the parts of the design such as screen monitor, keypad, touchpad, camera, cash card scanner and occupancy sensor are also packaged into a wooden container and the design is now able to function like a commercial ATM.

References

[1] U.S. Food and Drug Administration. (2012, May 31). *Radio frequency identification (RFID)* [Online]. Available: http://www.fda.gov/Radiation-EmittingProducts/RadiationSafety/ElectromagneticCompatibilityEMC/ucm116647.htm

[2] ATM Marketplace. (2003, July 22). *ATMIA survey: 5 years is average ATM depreciation period* [Online]. Available: http://www.atmmarketplace.com/article/135689/ATMIA-survey-5-years-is-average-ATM-depreciation-period

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	6
Project Title	Doodle Drive

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Alexander Curtis	EE	Hardware/Microcontroller	May 2013
Peachanok Lertkajornkitti	EE	Android Programming	May 2013
Jun Pan	EE	Hardware/Microcontroller/Android	May 2013
Edward Kidarsa	CmpE	PCB/Software Programming	Dec 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Doodle Drive is an Android mobile device application controlled remote vehicle, where the vehicle houses a Bluetooth transceiver to communicate with the Android mobile device. The Doodle Drive is just a prototype and the final aim is to be able to replace or aid the steering of vehicles such as normal sized cars through two possible modes of control. One mode of control is outdoor mode control in which the user draws a path on the touch screen of the Android device and the remote controlled vehicle will then follow the drawn path. With a small remote vehicle, the movement is not consistently accurate, but this problem would be reduced if the technology was applied to a larger vehicle. The second mode of control utilizes the Android device accelerometers to move the remote vehicle in the direction of the tilt. The Doodle Drive utilizes the Bluetooth transceiver as mentioned, a GPS module and a compass module in order to accomplish these functions. Battery monitoring and collision detection is also featured in the product.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The Doodle Drive required that all the members of the team had gone through the ECE362 course, as all of us had to at least write some code to interface the components that we were testing with the Microcontroller. ECE362 also first exposed us to the need for soldering, which was intensively used in the case of the Doodle Drive, as there were many components to solder. For circuit design and debugging, courses such as ECE207, ECE208 and ECE270 provided knowledge that was essential in order to know where to place discrete components, isolate problems, and know how to solve those problems.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Technical knowledge was gained throughout the design process. The most obvious instance was when creating the printed circuit board. None of the members of the team had ever designed a PCB before, and as such had to learn the entire process with Eagle. In going through the project, we had also had the chance to solder a wide variety of components, ranging from through-hole to surface mount, which helped us acquire more advanced soldering skills. Component-wise, through interfacing and reading through the datasheets of components that we had used in the project, we have also learned about common interfaces such as I2C and UART and how to utilize components that require them. We also learned about the discharge of batteries, and exactly how we can use characteristics such as voltage and accumulated current in order to approximate the remaining battery capacity.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process was incorporated throughout this project. The initial stage included brainstorming ideas, generating our goals for this project (PSSCs), and choosing design components while taking the budget into consideration. We proceeded to the next stage of testing, debugging and problem solving. At this stage, we were systematically testing each component, writing simple code to test and debug functions, and slowly building on to larger functions. The schematic and printed circuit board creation were done concurrently. The work was divided among the team members such that each team member used his or her skills and knowledge to the fullest potential. We concluded our project with finalizing thorough documentation that occurred throughout.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: We considered the Doodle Drive to be a sort of prototype for later upgrade to be able to be used on real cars, and thus did not want to spend too much on it. However, as we did not want to work too much on the mechanical side, we decided to buy a vehicle base. We also had to have an accurate GPS as well as a tilt compensated compass and had to thus spend quite a bit on the above three components.

Environmental: Our major concerns for the environment with regards to our project are the manufacturing of the PCB and the components used, as well as making sure proper disposal methods are used. We considered the environmental impact of the Doodle Drive and have discussed certain disposal methods which will minimize negative environmental impact.

Ethical: The intention of the Doodle Drive is simply for recreational purposes. We have warned users of possible harm or damage to the product if misused in the user manual. It is not suitable to be used under wet weather conditions as the open-PCB will definitely be damaged, but personal injury is virtually impossible under most circumstances.

Health & Safety: There are warnings and precautions in the user manual to prevent any possible harm to the user. The Doodle Drive is not intended to be used by children of age 10 or under since there are some loose wires and non-enclosed PCB.

Social: The final product was a prototype, and thus did not need much packaging to look good, but had to be simple enough to be used easily by users that were not engineers.

Political: There were no significant political constraints.

Sustainability: We have considered the failure rate of this project and have found out that it turns out to be at an acceptable rate. The only concern regarding the failure of the Doodle Drive would be the failure of certain components such as the compass and the microcontroller. If such components fail individually, it can be replaced without having to replace the whole vehicle.

Manufacturability: This project could potentially be manufactured since the components are relatively common to find. The manufacturing process would also be relatively straight-forward and wouldn't be expensive. However, the improvement in the quality of the compass, GPS and Bluetooth range could be considered for a better performance of the project.

(f) Description of the multidisciplinary nature of the project.

The multidisciplinary nature of this project was mainly with the integration of the Android software programming and the embedded programming versus hardware skills. Circuit analysis, typically a function performed by electrical engineers, was utilized in order to determine proper component values as well as power consumption. This is opposed to the programming mentioned, which is typically done by computer engineers. Furthermore, as the project is a vehicle, mechanical components are heavily used although the required mechanical skills were minimized through careful planning.

(g) Description of project deliverables and their final status.

The project encompassed a controller, which in this case was a Nexus 7 tablet, and a remote vehicle. The vehicle is able to send its status' back to the controller, including its location, remaining power as well as the direction heading that it is facing. The controller, through the decision of the user, is able to communicate with the vehicle via Bluetooth to either directly tell the vehicle how to move based on the accelerometer values or tell it how to move (as dictated by the user input – a drawn line) based on the GPS latitude and longitude as well as the compass heading. The remaining battery capacity is also displayed on the Android program in 1% intervals. All tasks were successfully accomplished. A great deal of documentation detailing the design process and the considerations that were taken are also among the deliverables.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	7
Project Title	COST Robot

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Eric Osborne	EE	Analog Hardware	May 2013
Bryan Dallas	CmpE	Digital Hardware	May 2013
Andrew Loveless	EE	Microcontroller Interfacing	December 2013
Caroline Trippel	CmpE	Software Design	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The purpose of this project is to design and build a robot that would make a map of a maze, while traversing said maze. After having completed the map, the robot would revisit lights that it had located during the map building stage in a user defined order. At each light it would indicate that it had found that light. After having completed this, the robot could be connected to a computer to upload the map to a C# program for the PC that would visually recreate the map. A possible customer of this design is a company who would like a robot to go in and map out a space and then complete tasks in an order in that space. Examples would be companies who might deal with problems in hazardous spaces. This project was built using 3 short range sensors, 1 long range sensor, a color light sensor, an h-bridge, 2 brushless DC motors, 2 optical isolators, a low dropout linear regulator, a 7.4 V 2800 mAh Li-Ion battery, and a PIC18F4550 microcontroller. The project was built to traverse mazes of 7”x7” blocks with walls 7” high. The maze can only have hallways up to 3 boxes long and the colored light must be on both sides of the hallway. We approached building this project by starting out deciding on how we were going to create the maze and what way would be best to solve that maze. We then discussed the parts needed to build such a robot and ordered them. While waiting on the parts we started to design the PCB and schematic. After this we ordered the PCB and started to work on the software for the robot, which we had started some while building the PCB. When the PCB came in the PCB was populated by a couple and others were working on software. We then finished the software by building small parts of it then we put the parts together.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project built upon the skills of earlier coursework in many ways. First, we were able to use the skills from ECE 362 – Microprocessor System Design and Interfacing, because of the fact that we were once again using a microcontroller in our design. We got to used what we learned in that class and apply it to a new device. Second, it used skills learned in many different classes, such as ECE 201, ECE 202, and ECE 255 for the analysis of the circuits and devices that we used. Also, skills from ECE 270 were used in designing the project so that we would be within the correct margins of error for DC. ECE 311 ideas were also built upon when we were considering the electromagnetic interference of the motors on other components. ECE 433 helped gain a better understanding of H-bridges and options for our power supply systems.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

During the duration of this project we learned an important technical skill. The skill we learned was PCB creation. We learned how to use Eagle to create our PCB footprints for our parts, the schematic of our design and how to physically layout the PCB. Also we learned how to check the PCB and order it online.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

We used the entire design process during our creation of this project. We established objectives and criteria over the first few weeks of the project. We decided what we wanted to create and what objectives it needed to be able to complete (aka PSSCs). Next, we analyzed how we might go about completing this project. We talked about how we would be able to solve the maze and what kind of information we would need from the robot. We also determined the types of sensors we would need to gather that information. Following this we started to synthesize the project. We picked out our microcontroller and started to make a schematic of how our parts went together. We started to create our PCB to put the micro on and made sure we had all the necessary parts. Continuing on we synthesized the actual project. We built the base of the robot and mounted the motors on the base. Next, we started to put the sensors onto the base. Then we soldered parts to our PCB that we designed and put all of it together into the robot. Next, we started testing our robot. We had done this through other stages by testing our microcontroller and the sensors we had. We then on the final robot started to test code we had written and started the movement design. We got the movement working and tested the movement and tested the maze traversal algorithm. Finally, we evaluated the robot…

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The economic constraints of this project were determined by the amount of money we were granted by the class. Therefore we decided to keep the robot within the range of about $300. This was an acceptable range, because we decided that the users of this device would be specialty and willing to pay the price.

Environmental: We tried to make the PCB small so as to reduce the amount of harsh chemicals and difficult to recycle materials that were in our project. Also we used plastic and metal for our base because those materials can be easily recycled.

Ethical: When the actual building of the robot was happening ethical concerns were thought of, and when the device was brought to market we would do the following: put a cover over the robot, and putting a warning in the user manual about overcharging the battery. The cover needs to go over the robot to protect the user from open wires and possible voltages that could potentially harm them. The warning for overcharging the battery would go in to protect the user from harmful chemical burns in the case of overcharging the battery.

Health & Safety: As was stated in the ethical section the robot would need to be covered and a warning for the battery would need to be put in the user manual. As well we would put warnings in for children who are younger not to use it as there would be small parts or other objects that they could swallow that would be harmful to them.

Social: The product was created to small and somewhat astatically pleasing as people will be using the device.

Political: The device does not contain copyright or patent infringement and therefore is free to be marketed.

Sustainability: When we did calculations on the reliability of the device we determined that the product would have a mean time to failure of about 19 years, because this is approximately when the device with the shortest span should fail. When taking this into consideration for the project we decided that this would be a good amount of time, because by that time there would be better technology to use out on the market.

Manufacturability: When building this device we tried to make it easy to create. Therefore we used simple parts. When manufacturing this it would be easy for a computer controlled machine to cut out many octagons from plastic, then have another machine drill holes in specific places in that plastic. Also the devices are easy to mount and can be glued on at that point, which could easily be done by machine or human. In general, the device could be quickly and easily manufactured.

(f) Description of the multidisciplinary nature of the project.

This project has many different discipline incorporated into it. First and foremost this is an electrical and computer engineering project. It uses many different aspects of power usage, and digital design to control the robot and make it work. This project also uses aspects from mechanical engineering. The torque that the motors can provide was an important factor to consider. We had to determine the approximate weight of the device so that we would know how much torque the motors needed to provide.

(g) Description of project deliverables and their final status.

In the end we were able to complete the project and create the robot. The code was completely finished and as functional as it could possibly be. We were unable to make the long range sensor work as reliably as we would like. Its output voltage was incorrect compared to the graph that was in the user manual. As well, we had problems with the motors having unequally balanced torque so that the speeds of the motors had to be balanced in code. This was only somewhat possible, and with more time could have been more refined. As well, the motors were greatly affected by the battery charge and this could have been refined by using the battery state from the fuel gauge to change values as the battery died. In general, the project was functional as was the code, but some of the external devices did not work properly as we would have hoped.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	8
Project Title	Project PRINT

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Vineeth Harikumar	CmpE	Software + Interfacing Hardware	May 2013
Fabian Widyadri	EE	Software Development	May 2013
Sriram Rangaramanujan	EE	Hardware Development	May 2013
Siddharth Bhosale	EE	Hardware/Software	Dec 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Project PRINT is a power management device for printers. The customer for this device is Lexmark Inc, a company that provides a broad range of printing and imaging services. This specific device is meant for their industrial printers. The specifications as requested by the company involved being able to use the existing status LEDs that exist on every Lexmark printer to be able to detect and sense light levels in the room. Based on these light levels being sensed power to the printer had to be turned on or off. It also has to queue up any incoming print jobs to local memory depending on whether the printer is powered on or off. To achieve this, the components were selected and the schematic and the printed circuit board were designed to interface the different components on a PCB. Work on the software and the software drivers were also carried out simultaneously to prototype and interface the different components with the microcontroller. Different techniques and experiments were carried out on the LED to figure out which one gave the most consistent results in regards to the light levels. The different components were then soldered onto the PCB and the software drivers required to run them were also ported over one by them. Finally when they were all ported over to the PCB, it was all packaged up into the final project box as one functional unit.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The success of this project resulted from the knowledge and skills acquired from various ECE courses. The software side of it required the knowledge of digital logic and microcontrollers. This involved specific knowledge of microcontroller register settings, usage of peripherals like UART, PWM, ADC, TIMER and SPI. All these skills were acquired from ECE270 - Digital Logic design and ECE362 - Microcontroller System Design. The hardware side of it required the use of resistors, capacitors, diodes, MOSFETs and operational amplifiers. Understanding and usage of all these components came from classes like ECE201 and ECE202 - which dealt with linear circuit analysis, ECE255 - which dealt with electronic circuit analysis, and the undergraduate labs ECE207 and ECE208 which dealt with learning how to use these components to create useful circuits.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The skills learnt in this project were mostly design skills and the techniques needed to get tasks done in a project. For the most part, the skills that were learned were how to approach a problem that had never been encountered before. The LED sensing is a good example because a lot of research needed to be done into how the LED reacted to light. In addition, developing the amplifier circuit was not just the simple use of an op-amp but it also needed analysis of how an op-amp worked. Debugging problems that arose was another huge skill that was developed because the problems could exist either on the software or hardware side. PCB/Schematic design was another skill that was developed.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The project took a very structured approach overall. When the project was first proposed, the team had to decide what the success criteria of the project would be. This covered the stage of establishing objectives. To show analysis, a lot of research was done into how the problem of LED light sensing would be tackled. The research led to some conclusions being drawn but these needed to be tested, and so some prototyping was done with the LED light sensing. In addition, the other subsystems of the project such as the high-voltage circuitry, the on-board memory and the debugging circuitry needed analysis. During development, the modules were all tested and numerous problems were found with the design. All of this covered the synthesis, construction and testing stages of the project. More analysis needed to be done to complete the modules so as to find out why they were malfunctioning but this was finally completed and the project was for the most part, completed. In evaluation, the project was deemed to be mostly successful since the light sensing was shown to be possible and that it could be implemented in a real-life environment.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: This is one of the most important aspects of the project as Lexmark planned to adopt this function and implement it as an additional function to their existing printers. Therefore, the cost of parts required for the module has to be as low as possible. So the price of the printer is similar as without the module. The components used for project PRINT are not the most powerful or latest products but cheap and limited to the necessary functions.

Environmental: The main function of project PRINT is to save power by making office or personal printer to operate when there are print jobs and set it to sleep mode when not in used. However, hazardous waste materials were created during the manufacturing process. The LCD display also contains hazardous materials that need to be recycled properly.

Ethical: The main ethical challenges that could potentially cause problems is the accessibility of the microSD card. As the microSD card is used as a local storage to store print queues, someone could break the module and access the data from the microSD card. Therefore, the microSD card has to be encrypted and formatted before recycling. Other than that, warning label of high voltage has to be put on the box as the module draws 110VAC to power the printer.

Health & Safety: The module is safe and does not require much handling by the user. Therefore, it is unlikely to injure the user. However, warning label for 110VAC will be placed on the packaging and also disposal instruction will be highlighted on the user manual.

Social: As the module is designed to work effectively with printer, there is a limited consumer market to those who own and use the printer extensively.

Political: There are no significant political concern was considered in this project. Since there is not any patent that overlaps with this module, the project would not infringe any copyright or patent issues.

Sustainability: The project is sustainable as it does not require much handling and interface by the user. The project is made with a consideration that it will only be placed in a room without much direct exposed to the sunlight. However, it has to be located at the proper place. So it can effectively detect the light level in the room.

Manufacturability: The components have to be made as compact as possible and the LED has to be exposed so that Lexmark can implement the module as a part of the printer.

(f) Description of the multidisciplinary nature of the project.

Knowledge and skills acquired from many different disciplines were needed for the successful completion of this project. First of all, planning the entire project, setting long term goals, assigning roles and responsibilities and working towards the end goals required a lot of teamwork and time management skills. Furthermore, the project required a lot of knowledge about microcontrollers and it's peripherals as the PIC32 was a central part of this device. Testing and debugging also required a lot of hardware knowledge as each circuit had to be built from scratch. A good understanding of passive components, data sheets and the individual parts was key to building these circuits. For packaging, the device was place in a black plastic box and slots had to be cut out for the LCD, the 110V connectors the LED and all the other parts that went on to our box. These skills relate to the mechanical engineering discipline.

(g) Description of project deliverables and their final status.

The culmination of hours and hours of hard work led to the creation of this final product. The power management device is finally finished and packaged into a black plastic box. The LCD display, the light sensing LED and the Rotary Pulse Generator are placed on the top of the box. On the right side of the box are the reset switch and the RS232 to USB port. Lastly, on the left side of the box are the input/output 110V connectors that connect to the wall output and the printer. As far as functionality is concerned, the device successfully meets its success criteria as it accurately senses the changes in light levels and is able to display it via the LCD. Moreover, the print jobs are successfully stored into the SD card and forwarded when needed. The device also allows the users to manually adjust the sleep and hibernate timeouts through the device menu. Last but not the least the device cuts off the power to the printer as soon as the lights in the room are turned off.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	9
Project Title	OmniGlove

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Richard Park	CmpE	Pheripherals (H,S)	2013 Summer
Jacob Wiles	EE	Analog Hardware	2013 Spring
Aashish Simha	CmpE	Pheripherals (H,S)	2013 Spring
John Wyant	CmpE	Software	2013 Spring

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The OmniGlove is a device that controls home automation through hand gestures made by the user. The circuitry sits on the back of a glove with flex sensors weaving through the fingers. The flex sensors measure the amount of bend for each finger and a 9-axis sensor on the hand watches for directional movement of the hand. The data from these sensors is then analyzed to determine if a gesture was made. If the movements are recognized, it then sends a command via Bluetooth to the OmniHub (a Raspberry Pi) to carry out that command.

The glove is targeted more towards the visually impaired as an easy means of controlling their household appliances. Full vocal feedback, along with its intuitive hand gestures, make the OmniGlove easy for anyone to use, however.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project required programming skill in languages such as C and Python. Necessary programming knowledge was learned in previous software courses. Along with this software knowledge, debugging knowledge was also necessary. Debugging skills are crucial in getting a project like this functional, and they have been gained through experience in several software courses. The biggest part of the project, however, is dealing with a microcontroller. This requires theoretical knowledge of their structure and operation, as well as experience with their practical application. This knowledge was gained through the microcontroller-based courses like ECE 362 and other embedded project courses at Purdue University. Circuit design skills were needed to design the hardware systems for this project as well. These skills were learned from some of the early electrical engineering classes, as well as more advanced ones like ECE 362. Knowledge of power engineering also went a long way in the project, especially when it came to the power supply.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

A considerable amount of knowledge was gained over the course of the project. Hands-on skills, like sewing, were also honed throughout the construction of OmniGlove. Each member received a fair share of practice with soldering and gained new familiarity with soldering surface mount components. Each group member gained a better concept of what it takes to properly design a PCB. Along with this, everyone's knowledge of component interconnection was expanded. In the same vein, the group got some hands-on experience with hardware debugging.

There was also new knowledge gained in the use of peripheral communication standards such as I2C and Bluetooth. This learning naturally occurred during the process of creating the project, but feedback received during presentations also helped. It should also be noted that new experience was gained in topics such as patent searching, reliability calculations, and device safety analysis.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

At the beginning of the semester there were many ideas which arose for the project. These included a GPS arrow, a drink mixer, and a gesture recognition glove that controls the computer. As the project ideas were being discussed and their difficulty/plausibility considered, it was unanimously decided that the gesture recognition glove would be the most fruitful project in terms of its difficulty, fun, and "wow" factor.

However, as the objectives and criteria were being created, it became apparent that controlling a computer with the gesture recognition glove is not only unoriginal, but has a long history of failure. At this point the team then thought about what could be done with a gesture recognition glove. After giving it some thought, the team decided that it might be a good idea to use the glove as a tool to control appliances throughout the house. After analyzing the capabilities of the glove, it was found that the goals of the project had become more manageable. It would be able to control basic devices such as lights, as well as any infrared devices. It soon became apparent that this device would be particularly useful for the visually impaired, also. Once the team realized this, they also decided to include voice feedback as a way to inform the user of gestures performed, glove status, etc.

At this point creation of the glove began. Flex sensors were selected to measure the amount of bend in an individual finger, a 9-axis sensor for overall hand movement, a Raspberry Pi hub computer for appliance control, and Bluetooth communication to tie the PCB and the Pi together. As parts began functioning as desired on the breadboard, they were combined into a single project on the PCB. Bread-boarding allowed for testing to be performed on a subsystem level as the device was created. This made debugging much easier and more manageable. Upon completion, several points of improvement were noted. If this project were to be created again, potentiometers would be used in place of the flex sensors to track finger movement, the rotary encoder would have been wired differently, the buck converter chip would be replaced with one having a higher current capacity, a voltage regulator would have been added, and an amplifier would not have been included for the speakers.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Since the OmniGlove PCB is very small and compact, it is cheaper to manufacture than a comparable large PCB. A Raspberry Pi was selected as the hub in order to avoid having to use a full desktop computer or laptop. This helped reduce the cost of operating the glove.

Environmental: The glove is created using only materials that are decomposable or recyclable. In order to relay this information to the users, stickers and warnings can be placed where the user will see them. This includes on the physical glove as well as in the user manual. Since the device is as compact as possible, this also reduces the environmental effects of manufacturing it.

Ethical: To ensure an ethical invention, many design considerations must be taken into account. One of the more important things that can be done is the addition of heat monitoring for "high risk" chips, along with safety features which rely on this monitoring. This would prevent the glove from overheating and causing harm to the user. The glove could also be stress tested in an environmental chamber to ensure that the device will be able to survive in many different user environments.

Health & Safety: To maintain the maximum amount of security for the user, the glove would require heat monitoring as mentioned above. This monitoring can be used to warn the user when the glove is getting too hot and even shut the device down in severe cases. There are a few edges on the device that can also be smoothed out to prevent minor scrapes, such as on the flex sensors.

Social: The OmniGlove is designed to allow for greater social integration of the user. As the glove is specifically designed for the visually impaired, it allows them to better entertain guests within their own homes, as well as keep them comfortable by adjusting the room environment.

Political: As long as the glove is well tested before manufacture and decreed as safe for the user and durable, the device does not call any political ramifications upon itself.

Sustainability: The components chosen for the OmniGlove have reasonable lifetimes. The microcontroller has the highest chance of failure, since it has the highest transistor complexity, although its MTTF is still about 26 years. The other components have longer predicted lifetimes than the average human life. Ideally a microcontroller with a lower pin count would be used to increase the MTTF (we have found that the OmniGlove can utilize a micro with a smaller pin count).

Manufacturability: The OmniGlove is highly manufacturable. With some corrections in the PCB, the manufacturing of the glove could easily be automated for mass production.

(f) Description of the multidisciplinary nature of the project.

The project contained many different aspects of electrical and computer engineering as well as other disciplines. For the most part the project was hardware and software intensive. The PCB, part selection, and the custom design of the glove required electrical engineering skills, while setting up the components and creating algorithms to manage them required computer engineering skills. Upon finishing those parts of the project, the team was then required to delve into mechanical engineering to encase the project in a custom box. It also required other skills such as teamwork and presentation ability.

(g) Description of project deliverables and their final status.

The OmniGlove prototype was successfully completed. There are many changes that the original design group would make if given the opportunity to actually produce the OmniGlove. However, the overall functionality of the glove is adequate.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	10
Project Title	Autonomous Rescue Vehicle

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Vipul Vishnu Bhat	EE	Packaging and software	Dec 2013
Julia Liston	EE	Navigation and software	May 2013
Ruiyang Lin	EE	Motor and power supplies	May 2013
Krithika Iyer	EE	Communication	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Autonomous Rescue Vehicle is a prototype that was created with the intention of retrieving a person who might have gotten lost in a sparsely populated area. Our customers could include anyone from hikers to athletes such as skiers and cross-country runners. The product includes two components, a robot and a transceiver. The transceiver is to be carried by the individual who might get lost. The transceiver consists of a GPS module and an RF unit that it uses to transmit the GPS data to the robot (rescue vehicle). The robot also consists of a GPS module and an RF unit with which it communicates with the transceiver. Furthermore the robot also consists of 3 ultrasonic sensors to facilitate obstacle avoidance. The final product is a robot that is capable of autonomously navigating to the transceiver location and returning to the starting location.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project was designed with the idea that each team member might have something to contribute. Ruiyang Lin had prior experience working on motors and power systems having taken ECE 321 and ECE 423. This was a pretty crucial skill seeing how our robot has 6 motors, each of which draws a significant amount of current. Julia Liston, Krithika Iyer and Vipul Bhat are fairly competent programmers who have taken courses in programming such as ECE 264 and ECE 368. The course that was common to the whole team and played probably the most important role was ECE 362. The course was extremely useful in learning about embedded systems and almost everything that was learned in ECE 362 was utilized in the project. Knowledge from lower level ECE classes, such as ECE 270, were also crucial to the project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

There were quite a few technical skills that were acquired over the last few months that the members of the team weren't exposed to prior to taking ECE 477. Designing a PCB was something new for most of the team. We also became familiar with the development environment for PIC microcontrollers. We learned how to interface components like GPS, RF modules and ultrasonic sensors with microcontrollers. On a less technical level, we also got better at hands on work like soldering, wiring, etc.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Throughout the entire semester, the team experienced the entire process of engineering design. Multiple team meeting were held to formulate the idea of the project and to come up with the PSSCs. Once the idea was formed, the team went through component selection, schematics design and PCB design. After the design review, many aspects of the design were iterated and reconsidered. The design was modified multiple times throughout the semester, which also reflected the real-world design process. The testing and construction phase ran in parallel with the design phase. When a problem came up during testing, modifications were made the design. At the end, the project was tested and evaluated based on how well it satisfied the objectives set at the beginning of the semester.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The user of the robot was defined to be the people certified to carry out rescue missions and not an average household. Therefore the cost of the robot wasn't the most important constraint. The chassis of the robot needed to be robust to be able to handle potential rugged terrains. The GPS and RF module were also relatively expensive. Overall the cost of the robot came out to be around 400 dollars. The transceiver, however, needed to be relatively affordable so that it can be purchased by an average person. The cost of the transceiver came to be around 100 dollars, which was within the price range of most GPS trackers on the market.

Environmental: From an environmental perspective, our design constrains weren't very realistic. To begin with, we have a large chassis for our robot with six motors. The initial reasoning for a larger chassis was to facilitate traversal over rugged terrains and have more room for the components that are essential for the functioning of the robot. The environmental cost of doing so is higher energy consumption and increased pollution in the manufacturing process of the PCB and chassis. Also, although we have chosen the batteries that powered the robot to be rechargeable, disposal of batteries can also lead to damage to the environment.

Ethical: The most important ethical challenge we faced during the design phase was potential misuse of the GPS transceiver. The transceiver could be planted on the person without his or her consent and the person's privacy could be violated.

Health & Safety: The exposed circuit components posed a series of threats to the users, both the controlling the robot and the person being rescued. For example, the H-bridges on the circuit board tended to get quite hot during operation. Touching these components while the robot was in operation could potentially injure the users. To decrease the threat of hot components, heat sinks were placed on all H-bridges and voltage regulators. Also, a remote was included for the user that controls the robot so that the robot could be remotely started and shut down.

Social: We believe that this project will have a very positive impact on the society. Usually, to rescue someone in requires spending many resources, which sometimes includes putting more lives in danger in order to rescue someone. The robot we built was able to carry out such mission without jeopardizing more lives, which we believe will solve many social dilemmas.

Political: The purpose of the project was to save lives so the application of the robot should not raise any political controversies. However, increasing purchase of the robots might increase government spending. However such possibilities were considered to be beyond the scope of this project.

Sustainability: Most of the components selected for this project had very low failure rates. Therefore both robot and transceiver should be able to remain in service for a long period of time. Most of the components were also selected to be RoHS compatible. Therefore when they needed to be replaced they would pose minimal damage to the environment.

Manufacturability: The chassis and motors of the robot were manufactured separately from the electrical components. Therefore, the assembly and maintenance of the robot were very easy. Most of the components, such as the GPS module, RF module and ultrasonic sensors were purchased off-the-shelf. So replacement of these components was also very easy. The packaging of the transceiver was designed to be very simple to reduce the cost. Therefore, it was very easy to manufacture transceivers in massive volumes.

(f) Description of the multidisciplinary nature of the project.

This project involved many aspects of engineering in addition to electrical engineering, chief among which was mechanical engineering. The control of the motors involved considering the friction of different surface conditions and the mechanics of the chassis. The movement of the robot also needed to be considered for optimal placement of the sensors. Last but not least, the packaging of the transceiver involved building an enclosure to make the transceiver as portable as possible while being to house all the components. Multiple machine tools were used to manufacture the enclosure.

(g) Description of project deliverables and their final status.

A robot and a transceiver were delivered at the end of the semester, both packaged. The transceiver was able to receive the GPS coordinates and transmit them through the RF module when power was applied. The robot was able to receive the GPS coordinates and move towards the location of the transceiver. The robot was also able to detect obstacles and avoid them through ultrasonic sensors. When the battery level of the robot gets low, it was able to detect the low battery level and safely shut down the robot. In summary, all PSSCS set forth at the beginning of the semester were satisfied.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	11
Project Title	Aperture Science Automated Sentry Turret

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Michael Sickles	CmpE	Software Developmenet	May 2013
Charles Werner	CmpE	System Design	Dec 2013
Eric Maginn	EE	Electromechanical motion and power electronics	Dec 2013
Brandon Taylor	EE	Software and Soldering	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Our project is an automated defense turret that can track targets as well as play sounds from the game Portal. Our intended customer are hobbyist and collectors who enjoy the game Portal. It's purpose is to provide nostalgia to the game as well as an added bonus of near identical functionality compared to the game version of the sentry turret. We approached in a model of focus on software and functionality first before design. Although we wanted it to look like a portal turret, it would be a failure if it did not function like a portal turret. As a team we figured out the circuit and components then we broke off into two main teams. Brandon and Michael focused on software while Eric and CJ worked on the turret body. We all did work on the body at times as well as contributing to ideas in software. Once the turret body was complete we all tackled the wiring together and putting the components in place.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The major components that ece classes taught us was microcontroller design (ECE362) and circuit design courses. We had to make sure our project had enough current to power each of the components. Mosfets had to be included to switch on powerful components and we learned how to do this in earlier classes. Other classes also taught software design such as ECE264 where we used data structures and optimized algorithms (ECE368) to fit on the microcontroller. ECE337 gave us understanding on how various protocols work and thus facilitated development on various parts of the project. Team skills were also a positive as many ECE classes put people together in teams. We all had to make sure to participate and use our time effectively to make sure the project was a success.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Many technical skills were added to our repertoire as we had to work with some mechanical components in our project. We had to design motor systems as well as work with polystyrene foam to design the body of our turret. Many of us learned how to solder in 477 also. We also have a bigger understanding of mosfets and power systems.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

We started by thinking of many ideas for our project as to what exactly we wanted. We brainstormed functionality that we would like to incorporate as well as what possibles systems we would need to help facilitate functionality. Next we had to determine our PSSC so we took a look at our system and figured out what parts were complicated enough to be considered a Success Criteria. We then went on a research spree to find the various parts we would end up using in our project. We analyzed what kind of power consumption we would see and ordered our power supply. Throughout this time we made many revisions as to how we would do tracking and settled on ultrasonic sensors. As parts came in, we focused on software. Testing was done per system basis. Rather than put it together than test, we focused on testing each part to ensure that it was working flawlessly. Construction started at this time for the body of the turret. Once the body was complete, we added systems to the body and tested them in their final resting place. Finally after all was added we did evaluations as to how effective each system working in our project.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: We wanted to make sure the project was not too expensive. Although our customer base would be collectors, we did not want to make the project unappealing by using expensive components. For this reason we cut out super advanced video tracking.

Environmental: We were limited by our material in which our project could be made up of. We chose a material that could be disposed of and had the structural capacity we needed.

Ethical: A turret may be unethical to some people however since they were not our target audience, we did not have to worry much about them. A turret is going to be liked by some and hated by others no matter what. We did incorporate some fun elements in regards to the body and extra modes.

Health & Safety: We had to be wary since we were designing a turret. For this reason we made sure to use Airsoft guns compared to real guns as a real turret would be very unsafe for something a collector would need. We also had to make sure our turret was able to be controlled effectively 100% with no bugs as a simple mode change could send the turret into a frenzy which people would not like.

Political: The biggest political constraint were laws with airsoft guns and being on campus. We had to be careful where testing the turret. Anyone who purchases the turret will have to make sure to check local laws on use and where it can be set up.

Sustainability: Our turret had to be rigid and secure. Since it is a collector item, we had to make sure all materials used would last a decent amount of time. Our major components were chosen such that failure of turret would not happen for a long time. The body is lightweight and easily portable as well as very secure and protected by an outer protective shell.

Manufacturability: Our target audio is collectors and for that reason it is not something that needs to be mass produced. The turret can be easily manufactured by a small group of people on basis when needed. Complex parts were kept out so that it would simplify the design to an acceptable level.

(f) Description of the multidisciplinary nature of the project.

Our project is quite the mechanical project. We have to open doors and control guns on a motor. We had to be quite artistic when sculpting the body of the turret and designing the legs to match the game. We also had to incorporate materials engineering in researching what type of foam to make our project out of.

(g) Description of project deliverables and their final status.

The turret was built to 90% functionality. The only major part that was not incorporated was effective tracking and opening/closing the doors. Being limited by two ultrasonic sensor, an effective algorithm could not be found. It does track, however it is quite slow. This makes it an ineffective protection device. The turret is covered in duct tape since we ran out of fiberglass to protect the polystyrene foam. The turret offers many modes and places sounds from the game just as intended. As an android capable device it offers many extra features that make it more fun as a collectors' item. Besides tracking, all major systems work with few hiccups. Some bugs still exist in code that can easily be ironed out with more time. Because of time, we had to not use motors to open and close the turret. This is more effective open anyways since our motors could not open the turret fast enough with initial tests.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	12
Project Title	Android Street Car

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Chun Ta Huang	EE	uC software, prototyping	Dec 2013
Libo Dong	EE	Packaging, prototyping	May 2013
Xirong Ye	CmpE	Software on Android	May 2013
Zongyang Zhu	CmpE	Software, circuit/PCB	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

This project is aimed to control a small robot car through wireless link with an Android tablet while the car can provide real time video feedback to the user. Its intention is to serve as a video surveillance robot that can reach to areas that normal personnel cannot enter to gather important information, such as a radiation contaminated area, or an area under earthquake. The customer can potentially include nuclear plants operators, and some disaster assistant organizations. The robot is capable of stream video to the control center through wireless link, in this case, due to availability of access, WiFi is used. The robot is easily maneuverable, and can feedback obstacle information and avoid them. It is also able to provide video information from different angles on the car. The approach used in this design is to first determine the objectives and how to get the desire effects individually through existing components. Once the components are determined, the works are focused on incorporate them into our system to make them work as intended. Several prototyping and testing process are involved to determine the capabilities of the system. Finally, all parts are test together to check overall functionality of the design.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Knowledge of earlier ECE course works including mainly the embedded system design lab, which the previous of experience with microcontroller programming in C and assembly built a basis this project. The interface with various components on the microcontroller used in this design is very similar to the previously used ones with better speed and more functionalities. On the other hand, the previous experience in look through many references and datasheets also helps in this project, as many of the components used in this design are very new, therefore look at the documentations to learn the use of them is very important.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

New knowledge acquired in this design is the use of new microcontroller, in this case, the LPC1768, and how to programming on high level languages on them instead of using assembly as in previous 362 labs. Other skills include programming in Java on android platform, using and programming on the new Raspberry Pi, and debugging with complex circuits.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Our team first came up with project idea, and complete the idea as we entering the design process. The objectives are set at the beginning, but with some modifications made as the project goes along. The criteria are set as we form our PSSCs, which are a subset of our objectives. The team together analyzed the feasibility and determined what components are needed to build the final product. With the decided components, several prototypes are done to verify the components are working as desired. Then the main circuit and PCB are finalized according to various datasheet and results of the prototyping. After the PCB is fabricated, the components are put on to it and the overall debugging and testing of the hardware goes into play. Along with the hardware testing is the software developments, with some debugging process went through to make sure the final software application is working as desired. At the end, the design is tested against the initial objectives and criteria to see how it performs.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The budget of $300 provided by the course is not enough for our design. The robot car itself costs around $200, therefore the design is not very well fit into this constraint. Although sampling from various electronics company are utilized, it does not reduce the cost very much.

Environmental: This design does not raise much of environmental issues, as no hazardous components are used, all devices used are RoHS compliant. The PCB itself might be an issues, however, since it will be retained by the department, likely it will be taken care and not pose any environmental damage.

Ethical: Since this design features a video streaming camera, the product should not be used in sensitive places where privacy is required. This issue cannot be eliminated by some special implementations, but only a moral guideline that the operator needs to comply with.

Health & Safety: As mentioned earlier, this design uses RoHS compliant devices, which the amount of hazardous elements is kept minimum that is safe to the operator. The soldering material, however, might contain hazardous elements, like lead, however, the operator is most likely not going to touch the part of PCB, so it is not a problem. The speed of the car is not going to cause damage to anybody, therefor it is very safe to operate.

Social: This design can be very social friendly and useful if it is used as intended, that is, to obtain information about surrounding place that normal people cannot go, like a surveillance robot, which can be helpful in danger areas such as hazardous element contaminated, or in earthquakes. It can be socially harmful if it is used improperly.

Political: As mentioned above, this can be used as a hard-to-reach area surveillance robot, therefore it might have some political potential.

Sustainability: The mean time to fail obtained for this design is around 30 year, so it is very sustainable based on the failure of the components. However, the battery is not likely to function with this length of period. In general, battery, even charged correctly and operate with care, is likely need to be replace after 1 year. The car can last long, as it is made of aluminum and hard polymer plastics.

Manufacturability: As the components used in this design are all widely used existing products, it is very easier to manufacture. The PCB and components can be manufacture by automatic assembly line, and same with the car. The final products, however, needs human assembler, but overall it is very easy to manufacture in large quantity.

(f) Description of the multidisciplinary nature of the project.

This design does not incorporate much of signal and systems, instead, largely of it is software programming, with difference in depth of algorithms and programming platform. There are communications involved, but are all done with software configurations. The assembly of the car and other components, however, involves some mechanical engineering.

(g) Description of project deliverables and their final status.

The final product of this design, the android street car, is fully functional with all objectives and criteria set at the beginning achieved. It is fully capable of doing the following:
1. Control the car to move in all directions from the user end, in this case, the android tablet.
2. Avoid obstacles and display information about them to the user.
3. Streaming video from the car itself to the user android tablet.
4. Display the battery information to the user.
5. Control the camera to turn certain angle and streaming video in different directions.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	13
Project Title	Vitalis – Wireless Biometric Sensor

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Aakash Lamba	Electrical	System	2013 Spring
Di Mo	Computer	Firmware	2013 Spring
Shantanu Joshi	Computer	Software	2013 Spring
Yi Shen	Electrical	Hardware	2013 Spring

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The project is to design a wrist-mounted wireless health monitoring system for both a hospital and residential settings. The system focuses on monitoring patient vital health parameters (such as pulse rate, SpO_2 and skin temperature). The system transmits data via Wi-Fi for secured remote web access. Other attractive features include an automatic alarm system in the case of anomalous readings, fall detection and a battery management system that displays battery life and allows recharging while the device is still in use. Our device is designed to be portable and is thus battery powered. This makes it important to balance the safety and reliability of the device with methods for conserving power and prolonging the life of the device.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

We utilized basic circuit analysis skills from ECE 201 and ECE 202 to help us start with the hardware design. ECE 207 and ECE 208 gave us a solid skill sets to debug the circuit issues. The C programming skills from ECE 264 and ECE 362 proved to be especially valuable during the entire development stages of the project design. We were able to expand upon our knowledge of interfacing with embedded systems by writing the software for the microcontroller in Embedded C. In addition, CGT 163 provided a good background in using CATIA which facilitated the design modeling and packaging drawing for our project. Utilization of a python programming language obtained in ECE 364 allowed us to build an easy test environment to verify the accuracy of our customized SpO_2 sensor for our project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The team became more comfortable and experienced in soldering skills to a PCB. With regards to embedded systems, technical skills such as programming PDIP package with AVR Dragon board and using Atmel Studio 6 were completely new to the group. In addition, we also gained knowledge for creating a custom PCB by using CadSoft EAGLE. In addition, getting Wi-Fi module setup properly was another big challenge to the team. Luckily, we were able to utilize the development board to make it work eventually. Furthermore, setting up our own customized SpO_2 required a lot research and understanding of the system from both engineering and physiology perspectives. We were able to make our design work properly with very limited prior experiences and well-documented resources available online.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The team established the project conception before the semester started. Then we brainstormed different ideas and formalized the goals into five project criteria for our design. During the brainstorming stage, we came up with different possible prototypes for the project and tried to make our design both innovative and applicable. As the high-level block diagram was finalized, the schematics and PCB were constructed for the project design. At the same time, we worked on implementing each individual peripheral with the PDIP setup. Meanwhile, website was also under construction to ensure that the transmitted data via Wi-Fi can be hosted securely. During the late of the project, functions of the project were implemented individually and tested to be correct. Then we started to integrate one module at a time on the designed PCB. The final system was produced and tested piece by piece on board. Throughout the entire process, various changes were made to allow appropriate integration of different modules.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The project intended to be relatively affordable for our future customers. So the system can be widely distributed among regular hospital and residential settings. The goal was to keep the cost of the system under \$200. The final cost came to be just about \$200, which was below the project budget. This makes our project to be completive with the existing similar commercial products.

Environmental: The PCB for our design contains lead which is harmful to the environment. The OLED screen also contains hazardous chemicals like mercury and needs to be recycled properly. However, the Lithium Polymer battery that we use can be recycled and is environmental friendly. Though the packaging of our project is not biodegradable, the size of our project only fits on the wrist. So the environmental impact is limited as long as the project is properly recycled.

Ethical: The project transmits patient's personal information and vital statistics to a secure website. It was a top priority to make sure that only authorized login can be allowed. Protecting the customer's medical records and personal information was a big concern throughout the entire project development.

Health & Safety: The entire project was powered with a single Lithium Polymer battery. So there was no concern for any potential high voltage hazard. In addition, the entire design focuses on building a noninvasive monitoring system. Thus any failure of the components would not involve any direct serious injury/hard to the users.

Social: The project provided another good alternative for hospitals to monitor patient's vital statistics wirelessly. It also simplified the medical care process within the hospital settings and allowed doctors/nurses to follow up with patients very quickly. It is a highly portable and reliable medical system with great socially redeeming value.

Political: There was no political design constraints incorporated into Vitalis wireless biometric sensor system.

Sustainability: The project used a single Lithium Polymer battery to power the entire system. The battery is recyclable and environmental friendly. In addition, all the sensors (temperature, fall detection and SpO_2) can be replaced very easily as they were connected with headers to the main PCB. The design enables for easy and cost-effective maintenance.

Manufacturability: The size of PCBs was designed to be 3.8 x 3.25 (in inch) for the main board and 2.9 x 1.15 (in inch) for the power board. It was also relatively easy to connect peripherals on the PCBs via headers. The board was also designed to have ample space between parts for the soldering of components by hand. However, further reducing the size of the design would require a closer-packing design as well as an easier assembly and integration process.

(f) Description of the multidisciplinary nature of the project.

The entire project expanded largely upon coursework in both electrical and computer engineering. Knowing about physiology helps us prototype much more efficient and user-friendly biomedical systems for the targeted users. In addition, the skills gained through classes in computer graphic technology were used when designing the packaging of the project. In all, the team was able to successfully integrated knowledge of circuit design, packaging design, embedded system interfacing, communication protocols and general programming approaches.

(g) Description of project deliverables and their final status.

The project deliverable is a fully functional wireless biometric sensor system that satisfies all criteria that we established for the project. The system has an ability to (1) determine pulse and SpO_2 readings from blood light absorption, (2) display the users vital statistics (such as pulse rate, SpO_2 and skin temperature) on the LCD screen mounted on the device which is located on the patients wrist, (3) remotely monitor the users medical status from a website via secure login, (4) activate an alarm automatically in response to anomalous reading of the system, (5) detect if the user has suffered a fall.

The finished product includes a customized SpO_2 sensor which was able to read the pulse rate and detect the oxygen concentration level in the blood. The battery management system also allows the system to keep track of the usage of the battery as well as have the capability of recharging the battery at the same time. The website is also able to perform all functions. The Vitalis wireless biometric sensor system is fully functional and in its final packaging.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	14
Project Title	Infrarat

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Jordan Gaines	CmpE	Sensor Interfacing	May 2013
Nathan Begle	CmpE	HW/SW interfacing	May 2013
Chang Yoon Kim	CmpE	PCB Layout Design	May 2013
Jiaqi Jiang	CmpE	Embedded Systems	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Infrarat is a small high speed toy vehicle designed to flee from and follow people in an entertaining manner. The project was designed as an entertainment product. Major specifications include two high-speed motors, four 16x4 IR heat sensor arrays, four ultrasonic rangefinders for navigation, and a Bluetooth communication module for interfacing with an android device.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Utilized knowledge of microcontroller programming and peripheral interfacing learned in ECE 362. Programming the micro utilized the extensive knowledge in C gained throughout the ECE course of study. PCB schematic and layout was aided by our academic experience with digital and analog circuitry.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

An important new skill learned was the ability to design a PCB layout and have a better understanding of layout considerations in real world projects. Experience in utilizing a common embedded device such as Atmel microcontrollers was also gained. We also gained plenty of experience in soldering while assembling the PCB.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

In the initial stages of development consisted of brainstorming ideas which would both result in a useful or entertaining product while maintaining reasonable limitations. The ideas were weighed against the existing objectives and delineated more specific goals which would guide our specific project. Initial analysis consisted of finding components that would be affordable and effective. Once the components were selected, we began initial prototyping and construction. Following that, the process consisted of a cycle of testing, evaluation, and modification until the final design was deemed acceptable

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The project was constrained to be cheap enough to still be marketable as a toy while being robust enough to provide its product objectives (speed, accuracy, etc). Plan was to be under $200. Our initial design did not meet this goal due to high cost IR sensors and miscommunications in part manufacturing, but a second run of the product could likely be greatly reduced in price.

Environmental: The primary sources of environmental danger in our product are the batteries and PCB components. Due to this we minimized battery waste by using a rechargeable Li+ battery pack of a minimal two batteries. The PCB and the vehicle itself was also very minimal in size to act as both an aesthetic choice and a reduction in waste.

Health & Safety: Our product presented danger in only a few ways. One was possible shorts resulting in extreme heat or in unpredictable movement of the vehicle. Our primary safety constraints were to minimize the risk of either of these situations in the event of any component failure.

Social: Design had to appeal to the general populace and our choice of modes was constrained by what would be novel and entertaining as a toy. As a result Manual, Flee, and Follow modes were found to match these criteria.

Political: This device had no reasonable political design constraints.

Sustainability: The project maximizes life-time by using its ultrasonics to avoid collisions in every control mode, even manual. Product also consists of many recyclable parts and replaceable components in case of failure.

Manufacturability: The design of the vehicle consisted of a minimal number of components in the chassis which would aid in minimizing the cost of manufacture. If further developed to be developed en masse, the design would have minimal complexity and resource requirements.

(f) Description of the multidisciplinary nature of the project.

The project was split into many tasks that required different types of skills to complete. The two most obvious ones were hardware and software. Hardware development required knowledge of PCB layout, soldering, and physical debugging. Software required knowledge of microcontroller workings, C programming, and software debugging. There was also the tasks that required research and communications, such as acquiring samples, requesting services, and finding alternative solutions. Different team members utilized their specific skills to accomplish all of these tasks.

(g) Description of project deliverables and their final status.

The final project deliverables consist of the vehicle itself, a wall wart power supply, and the android phone application. The original goals for this product was to be able to flee or follow a person, recharge its internal battery, communicate IR and fuel gauge data to an android device, and avoid obstacle collision. Functionality was fully achieved as specified by our original success criteria and additional elements were added (manual control). We would like to put further time into improving the tracking and flee modes to increase their effectiveness as they are not as impressive as originally hoped, but we consider the result successful.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	15
Project Title	Acoustic Storm

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Justin Lindley	EE	Software and DSP	May 2013
Andrew Batek	EE	DSP and Music Theory	May 2013
Carey Woolet	CmpE	Communication Protocols and Programming	May 2013
Jackson McCorrmick	EE	RF and Power Electronics	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Acoustic Storm is an electrical arc based speaker system capable of recreating MIDI and analog acoustical wave forms. Its purpose is to provide an interesting and unique audio listening experience while still serving the primary purpose of being a speaker system. The project specifications include an ability to process MIDI audio input and process it to create a pulse width modulated signal that can then be output to a controller and driver and ultimately a tesla coil. It is also specified to be able to monitor and react to system status, such as a safety temperature shut off or displaying the current operating mode. Another specification is an ability to filter and direct different segments of the audio waveform to different PWM outputs and on to different coils or an external subwoofer. Our approach to the project was to leverage the extensive hobbyist community's knowledge and create something that we had never seen done, which is to create an entire speaker system from plasma and tesla speakers.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Our project built upon knowledge stretching across a vast number of ECE courses throughout several different focuses. The most obvious ECE focus that our project touched on is the power systems area. The necessary currents and voltages needed to be stepped up using transformers and fairly advanced power circuitry to control and drive the frequency modulation to create the audio. Safety was also a main concern when dealing with this topic and a respect for the power of electricity was instilled throughout our lab coursework. The audio and filtering centered on microprocessor programming, which is a required prerequisite for enrolling in this course. The theory behind the filtering and sampling was learned through coursework in digital signal processing and signal processing. The peripheral interfacing, debugging, and architecture related concerns are directly relevant to topics in higher level data structures and other computer engineering courses. In addition to the coursework itself, the practical nature of going through the design process and producing a physical product built on learned theory and was put into practice. Overall, our project was a very diverse assortment of electrical engineering coursework topics.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Additional technical skill in precision soldering and electrical engineering technology was acquired through carrying out the project. Our problem solving abilities were tested throughout the design process whenever unexpected issues with parts, soldering, or the design in general. Going through the process of specifying, sourcing, and ordering parts was something completely new to every member of the team. We now have a grasp of the logistical burden it is to coordinate a long term project involving deadlines with manufacturing, parts sourcing, software, and multiple deliverables. The ability to manage and work with multiple entities in a businesslike environment was also a skill that was acquired through the course of our project. We had the unique opportunity to work with multiple building organizations and individuals in order to present a safety plan and proposal in order to test our project.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process began before the course started with our establishment of the project and a preliminary idea of our objectives and criteria. Once our project and high level design ideas were finalized, we could move onto the analysis of each of our design constraints. After these design constraints are identified and compiled, they can be synthesized into a working design and carried out. Construction was an ongoing process for our team. We had numerous printed circuit boards, other layouts, and extensive packaging considerations. Construction was probably the longest part of our project. Testing and debugging software and circuits took up a large amount of time as well. Modular and unit testing was employed in order to isolate problems easily and quickly. On the microcontroller board, the MIDI, analog, temperature sensing, and filtering all had to work by itself before attempting to integrate any two of them. The same process goes for the hardware and circuits as well. The evaluation is tied directly to what extent we successfully completed our project specific success criteria. This is the most direct evidence of our teams evaluation, but the safety considerations to which we were held and evaluated also played a tremendous role in our project and offered valuable lessons.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Acoustic Strom ultimately has to be safe and as well relatively generate large amounts of power. Having these two goals make Acoustic Strom uneconomical. The design considerations were to have a 2400W sound system having low, mids and tweeters both left and right channel. Large amounts of copper were required to great the coils and many capacitors to create the voltages necessary. With all this power, even more though was taking into about user safety. Large isolations boxes made out of premier plastic and faraday cages were in place to protect individuals.

Environmental: Team 15 has taken much care into understanding the effects of Acoustic Storm, potential hazards and its overall environmental impact. The team has tried to address the concerns as best as possible to make an environmentally conscious and safe product. Components have been chosen to be RoHS compliant, usage of precious metals and materials have been kept low and most of Acoustic Storm's parts have plans to be recycled or reused.

Ethical: Ethical concerns about Acoustic Strom arise about its dangerous capabilities. Ultimately it is the user who is responsible for the operation of Acoustic Strom. Therefore, Acoustic Strom has multiple fail safes that will protect the user incase of miss operation.

Health & Safety: For the Safety concerns there are issues of strong electrical and magnetic fields, shock and burn, fire, and other bizarre effects. Next is when the product is misused, by accident or otherwise. Acoustic Storm's components have been over designed and over rated to decrease failure. Even further, both a physical and electric magnetic isolation has been incorporated into the packaging. Finally, a 30 page safety document on the operation of Acoustic Strom has been written by the team and then passed by Purdue University officials.

Social: The social impact of Acoustic Strom goes down to the music lover everywhere and the visceral impact of the lightning and sound. Even so, volume control has been implemented to keep the sound to not produce unwanted noise pollution.

Political: The operation of Acoustic Storm is designed for private home. There have been no considerations for regulatory agencies such as the FCC during the design and building phases.

Sustainability: Besides the pollution made from the PCB and plastic manufacturing processes, almost every part of Acoustic Strom can be recycled or reused. The precious metals the transformers, copper winding, and inductors can be recycled/reprocessed. As well the plastic cases can be readily recycled and even more likely reused for other purposes.

Manufacturability: Throughout the design and construction of Acoustic Storm, placements of components were influenced to reduce noise on the PCB and have how power capabilities for the Tesla Coils. This did not always lead to easy assembling. Furthermore, the power supplies for the coils are large and contain well over a couple dozen large parts. These supplies because of the power requirements could not be place on PCB and have to be fly-wired and mounted on an insulator.

(f) Description of the multidisciplinary nature of the project.

The project was one that utilized many different areas of Electrical Engineering including: Computer Engineering (Microprocessor functions), Power Electronics Engineering (High power boost converter design), Acoustical Engineering (Audio modulation of lightning) and RF Engineering (Amplification and modulation of analog signals over an RF transformer). Furthermore, there were mechanical problems in nature such as the problem we addressed with physical isolation of the coils themselves.

(g) Description of project deliverables and their final status.

The Tesla Coils themselves were built and are still waiting to be tested. This depends on the completion of the power supply which was also built but the current control mode chip is not working with the power supply as we intended. The Micro is successfully receiving both MIDI input and Analog input and outputting to PWM. Furthermore, the micro is successfully using FIR filters to output the selected crossover bands to selected Tesla Coils. All of the controller and driver Tesla Coils boards have been built and imported and again need the working power supply to test. The temperature sensors have been tested and shown to accurately read temperature. Most of the deliverables are demonstrable.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	16
Project Title	Project Minotaur

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Scott Stack	CmpE	electrical hardware/embedded software	May 2013
John Hubberts	CmpE	High Level Software	May 2013
Jon Roose	CmpE	High Level Software	May 2013
Neil Kumar	CmpE	electrical hardware/embedded software	Dec 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Project Minotaur is a home security drone that lets users control it from anywhere in the world. Customers can load a web page that enables them to either manually control the drone with a live video feed or set the drone to patrol and alert users of a human being in the frame. Our drone is powered by a 14.8 volt, 4400 mAh battery that powers two 7.2 volt motors, a PIC24F microcontroller, 5 IR Sensors, an Intel ATOM board, and the Microsoft Kinect. Our approach was to create a modular wireless home security drone that allows users to patrol (manually/autonomously) a remote location through a website.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

In order to fulfill the requirements of this project a number of skills acquired from ECE coursework were introduced to the project. First and foremost, knowledge of C from classes such as ECE264 and ECE368 was fundamental to the software design of high performance pieces of the robot. Next, the team made extensive use of Python which was used as a mediary between the web interface and the Minotaur robots themselves; notably this packaged used a variant of the same twisted library utilized extensively within ECE364. In order to design the software algorithms for wall detection a plethora of high-level mathematics took shape in the form of fourier series, polar coordinates, and 3D geometry. The program also made significant use of advanced cache efficiency techniques taught in ECE468 and ECE437. The hardware of the project was based primarily upon knowledge gleaned from the ECE477 class lectures and material taught in ECE362.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

There were several things that we, as a team, needed to learn in order to complete this project. Firstly, the design and fabrication of a PCB was a new concept to all of us. The team had to learn what acceptable parameters were when designing a PCB. For example, acceptable trace widths for signals had to be determined depending on the amount of current running through them, and certain circuits could not be placed in close proximity due to the noise that they create. The team had very little knowledge of power supply design before this project which was used extensively due to the many different power requirements. We had to learn about the different types of power supplies and choose the most appropriate type which was, in this case, switched mode supplies because the robot is battery powered. On the software side of things, none of the team had any experience with video streaming or using the kinect, so those both had to be researched.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

In the initial weeks of the Minotaur's design, it was made necessary to establish feasible and achievable criteria by which to judge the success of our initial design. This required us to first establish what the marketable allure of our robot was, and focus on the key features, in this case movement, web control, video streaming, and obstacle avoidance. We evaluated a number of microcontrollers and motherboards to find a microcontroller suitable for sensor input (5+ ATD channels) and UART communication with the motherboard. Additionally, we had to find a motherboard with sufficient processing power to handle video rendering and live streaming. After judging the criteria and selecting appropriate parts, a PCB was designed to contain all of the residual circuitry (level conversion, H-Bridge, ect), and was populated chip-by-chip in order to identify and isolate any potential problems. Finally, after a few weeks of adapting the high-level code, all of our pre-established success criteria were judged, and shown to be achieved and reproducible.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Economically we were given a $300 budget to obtain all of our parts and fabricate everything. However, we were only able to design our chassis and microcontroller PCB's within this budget because of the large cost of the Intel ATOM board as well as the MIcrosoft Kinect. So as a result the overall cost to produce a prototype of our project costed much more than the initially budgeted $300.

Environmental: Our drone is for the most part very environmentally friendly. Other than the fabrication of the PCB's and Integrated Circuits our project has a very small negative impact on the environment. The Battery, metal from the chassis, motors, encoders, plexiglass platforms, and aluminum shell are all recyclable.

Ethical: Ethically since our drone is wirelessly controlled through the internet we had to find a way to secure the communication between the User and the drone. If this communication line is breached it would potentially give attackers access to control of the drone in a users house and a live video feed of the users hosue. We attempted to secure this by requiring the user to sign in with a unique username and password. We were unable to guarantee encrypted video and control data because the overhead involved in terms of computational power was too much for the server and ATOM board that we have.

Health & Safety: Overall our drone is extremely safe. It poses nearly no threat in terms of physical harm to the user. The one part of the project that could potentially get hot is the H-Bridge that controls the direction of our motors. We are able to ensure that this does not get hot or catch fire by using polyswitches. These Polyswitches act as a resettable fuse that cuts the H-bridge circuit if greater than 1.5 amps is drawn.

Political: Consideration was taken to find any pre-existing patents pertaining the the functionality of our drone. We found a number of patents pertaining the the autonomous movement and room-mapping algorithms, and discussed ways in which we could come to an agreement with the patent holder through licensing or alteration/synthesis of our own hybrid algorithms.

Sustainability: Our drone is fairly sustainable. The highest-risk components on the board have Mean Times to Failure in the order of decades, and those calculations were based on worst-case junction temperatures (for which the average temperature is nearly 100 degrees lower). Additionally, the chassis is very sturdy, and could protect the internal circuitry from a variety of potentially damaging external sources.

Manufacturability: The manufacturing of our product would be very straightforward; all of the utilized integrated circuits and passive components are readily available in the industry, no particularly bizarre materials are used in the construction of the product, and the chassis can be easily formed out of sheets of aluminum, plexiglass, and metal rods (all of which are easily accessible).

(f) Description of the multidisciplinary nature of the project.

Being a robot, this project has many different opportunities for multidisciplinary collaboration. There was a fair amount of electrical engineering involved in designing the power supplies and PCB. The project was also very software intensive which required lots of computer science knowledge as well as computer engineering knowledge for embedded programming. The project could have also benefited from a mechanical engineer to design the chassis, packaging, and drive machinery.

(g) Description of project deliverables and their final status.

The final deliverable is one Minotaur drone, and two USB sticks containing ubuntu 12.10 32-bit, configured for use as the command and control server, and as the operating system for the minotaur drone respectively. Both of these USB sticks will be populated with scripts that allow for the user to easily configure the system to work over their wireless network. Additionally, a link to the web client will be located on the desktop on the command and control server's USB stick.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	17
Project Title	Digi-ton

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Chia Siong Goh	EE	Circuit Design	May 2013
Jun Jun Peh	EE	Software Testing	May 2013
Kian Hui Wong	EE	Hardware Development	May 2013
Wan Qi Choo	EE	Schematic & Packaging	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Digi-ton is a music synthesizer that has 64 buttons arranged in 8x8 matrix pattern with an 8-bit LED located underneath each button. Any of these buttons may be activated in a number of different ways to produce polyphonic tones and light effects based on the grid positions that are selected. It is a musical interface that combines control and display functions in a square matrix of LEDs. Furthermore, it has three modes that each has a unique programmed musical pattern to play the tones selected by user through pressing the grid. Different types of sound, such as guitar, piano, and drumbeats can be selected through the buttons and LCD located at the bottom to present a more complete song. This device is targeted on people who are interested in playing musical instrument regardless of their age. Since the usage of this music box does not require any music background, the targeted market is very wide and anyone is expected to be able to play it easily. This suits our purpose of developing this device, which is to create a digital musical instrument that allows anyone to be a musician. Hence, the music box is targeted to people from all age group who have the desire to play music.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project is chosen due to the fact that everyone in our team is interested in music. We came up with this idea thinking that it could be fun if there is a musical instrument that is easy to learn and can be played by anyone. As some of our team members have had experiences in digital audio generation in previous semester, the skills and knowledge learnt in courses such as ECE 362 and ECE 337 could come in handy in the development of this project. For instance, we learnt to program a microcontroller to carry out various tasks and functions in ECE 362. Specifically in the coding labs that we carried out, we use SPI module to interface with LCD. Besides that, we learnt about audio generation using UART module and constructing test benches in our software testing through taking ECE 337. Back to the basic where we learnt in ECE 270, we learnt to use a shift register in bit shifting to communicate with LCD and to use a potentiometer in varying the voltage level of the circuit, thus controlling the volume of our audio generation.

Besides, the knowledge about oversampling of sound waveform and the unwanted image frequency during sound reproduction that we have learnt in ECE 301 helped us to build the sound synthesizing circuitry. The sample data should be at least as much as twice the fundamental frequency of the tones that we try to play. The output from DAC should be filtered with a low pass filter to reject the images at high frequency during reconstruction. To build the low pass filter, Butterworth design was chosen because that was what we learnt in ECE 202.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

One of the major skills that we acquired through this course is the ability to layout a printed circuit board (PCB) using Eagle software. We learnt to properly construct the board based on the requirements specified such as the the size of each components to be placed on the board respectively and also their placement such that the impact of noise interference can be minimized.. Besides that, we take into account some crucial design considerations such as the separation of digital and analog circuits to reduce the coupling among subsystems, and also make sure that the trace sizes for power and ground are large enough.

In addition, since all of our team members have limited experience in C programming, it is very challenging for us to code the entire program in C. Hence, we spent a good amount of time in researching and picking up this knowledge. For instance, the communications between microcontroller with components such as the LCD, DAC, MIDI, accelerometer, and fuel gauge require the interfaces of SPI and EUSART and these were done in C..

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

For the first step in design process, the objectives and criteria of the project were specified at the early stage. Our goal was to develop an entertainment gadget that would have 64 buttons, where each button should correspond to different tones after being pressed by user. The device would have three different playing modes. The first mode, sweep mode, would have a line sweeping from left to right that scan which button is pressed, and produce the correct pitch for that button(s). Then the sweeping line would be put in a loop to play the button sounds from the beginning. The second mode is memory mode, which basically just play back the tones as pressed by user, and will loop back to the beginning following the sequence pressed by users. The third mode gravity mode will change the pitch and tempo of the playing sounds as the device is tilted top and left respectively. These three modes were specified as our project-specific success criteria, in addition to ability to respond to user's touch by producing sound and light and ability to communicate with external devices through MIDI. During the analysis phase, a lot of considerations were put into choosing the right parts to build the final circuitry. For instance, our microcontroller must have at least 50 I/O pins, 3 ATD channels, SPI and/or I2C protocols and large flash memory in order to support our project functionality. Button pads were chosen over touch screen panel because of the price difference. LED driver ICs would be part of the hardware to have better control of all 64 LEDs. The packaging must be as small and lightweight as possible to promote portability. Then a schematic was carefully drawn to integrate all the components together, followed by laying out the printed circuit board using the guidelines to reduce digital noise. Before constructing the actual circuit, some sections such as power regulator and LED driver were prototyped on breadboard to simulate the operation of the final product. The construction and testing phases were done almost simultaneously for our project. Once the PCB has arrived, surface mount ICs, inductors, capacitors and resistors were soldered onto the board to populate the actual circuit. As one section was completed on the PCB, testing was done for that subsection immediately to ensure the functionality of each section before being integrated with all others for the ease of debugging. For software development, when each new peripheral was initialized, it was also tested on its own, then tested with the operation of other peripherals to make sure they could work together. Lastly as the project was put into the final packaging, all functions and playing modes were tested again before the product was finalized. When everything was done, the music box was tested by our team members and some other users to gather feedback on the product. This could ensure continuous improvement from the evaluation of the final product so that our design is relevant to the consumer market.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Since our product is targeting the general consumer market, it should be affordable to a large group of people. The price should be lower than the existing products, for example the existing product is being sold at roughly $1400, and our product only costs about $200 to get the hardware necessary for production. As we were designing the product, price had always been a concern. Initial plan was to have a large touch screen panel as the input of user's interface. However, as it turned out a resistive touch screen panel alone could cost nearly $200, we opted for the alternative of 8x8 button pads, which only cost about $120 in total.

Environmental: To ensure the sustainability of our environment, our product was designed to be environmental friendly. All ICs chosen were RoHS compliant to minimize the presence of hazardous materials in the final product. The product was also made to last as long as possible to increase the useful lifespan of all the parts. Users would be encouraged to recycle parts such as the PCB and the acrylic casing to help reduce wastes and resources needed to produce new materials.

Ethical: As ethical engineers, we would like to design products that are reliable. Hence a lot of tests were done to the finished product to make sure it will work under various conditions such as under warm condition, during transportation and when power supply rating was exceeded by a little. Another issue was with choosing RoHS compliant ICs to manufacture the product. As it is easy to fall into the trap of choosing cheap but harmful parts for the music box, we only choose parts that are safe to be used for all people. We also would include warnings such as the product contains small parts not suitable for toddler age 3 and below and the danger of not using the supplied power adapter in the user manual to acknowledge users of possible consequences when the product was not used as intended.

Health & Safety: While designing the music box, we have been taking the safety concerns into consideration all the time. We aimed to produce the device such that it is safe to be used by customers of all age group. For instance, user manual is provided with the device such that users would not face any problem damaging the device, which will lead to injury to the user as well. We also make sure that there is enough heat dissipation on the PCB and the circuitry overall so that the device would not heat up too much while operating for a long period. As far as it is to be used by youngsters and children, the music box is safe to be used because all circuitries are embedded and covered by the external acrylic casing, hence ensure that children would be able to play with the music box safely.

Social: In order to prevent intellectual fringing with similar existing products in the market, we will be extremely careful if we decided to commercialize this product. For instance, we will inform the companies manufactured those existing products about our design and try to obtain license from them beforehand. For now, we will only announce this design as a hobbyist project.

Sustainability: The music box is very sustainable in terms of improving and maintaining both its software and hardware. The music box that we came out with this semester is just a prototype and much improvement can be done. For instance, we are thinking of incorporating the SD card module which we could not finish this semester. With the SD card, the device will be able to store and to read the music sequences played. Besides that, the external casing can be easily maintained as well. A transparent rectangular box made up of acrylic board is used to house the circuitry and PCB of the device. We are thinking of painting the box with a nice color and to make the casing more sturdy and durable to scratch and drop. On the other hand, the software of the device can be easily sustained too. The music box has only 3 playing modes currently and each mode can only display single colored LED at one time. If we come up with ideas of more exciting playing modes, we can easily program the microcontroller using the RS-232 serial port.

Manufacturability: The music box is capable to be manufactured in large quantity. All parts of our prototypes are bought via electronic vendors in the market such as Sparkfun, Mouser, and Digikey. Besides that, some IC chips were sampled through major manufacturing companies. Hence, these components and PCB can be ordered in bulk to reduce the manufacturing cost when it is to be mass-produced. The process of manufacturing consists of soldering and wiring components together and onto the PCB, as well as to test the functionality of each part. On the other hand, the external casing is made with several pieces of acrylic board that we assembled ourselves. Therefore, the major parts of this music box can be easily manufactured.

(f) Description of the multidisciplinary nature of the project.

This project incorporated some multidisciplinary nature rather than building solely with electrical engineering skills. One major example is that we have used our passion and knowledge in music to develop the music box. We brainstormed the ideas on making the playing modes more interesting to users. Besides that, a good amount of knowledge about MIDI and acoustic is required while working on the audio generation module. For instance, we generated the musical tones based on the wav file that we extracted from MIDI and further sampled them into data points. We also incorporated design skills in designing and building the external casing of the music box. We sketched the dimension of the case and thought about using acrylic board to build the case artistically.

(g) Description of project deliverables and their final status.

At the end of the semester, we expect to deliver a fully functional music box that satisfies all our PSSCs listed in the early of the semester. The music box should be contained in its casing and can be carried by users when playing the device. Besides that, the music box should have 3 playing modes that we specified, which are the “sweep”, “memory”, and “gravity” modes associated with different music sequences and LED patterns. The music box also has to be able to generate different music tones such as drumbeats, piano, violin, and guitar. Since this is just a prototype of our project, the music box will only incorporate all the core features that we specified initially, while the esthetic value of the music box (appearance) are to be improved. Besides that, more playing modes are to be implemented to induce better user playing experiences. In addition, we will also provide with user manual on the instructions to play the music box and also the ways to maintain the device in a proper manner. Besides that, we will have a transition report (final report listing our progress) at the end of the semester, hoping that the project will be able to continue by people or any of us who are interested in further developing our project design in the future.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	18
Project Title	Humble Hubble

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Tim Brown	CmpE	Embedded software	May 2013
Evan Foote	EE	Analog design, research, soldering	May 2013
Derek Pesyna	CmpE	Android, CAD, packaging	May 2013
Doug Wile	CmpE	Embedded software, PCB layout	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

This project is a self-aiming or “go-to” telescope. The intended customer is the amateur astronomer, especially those just. The purpose is to enable a user to find stars in the sky more easily, and to improve the overall stargazing experience of the user by upgrading and existing telescope into a self-aiming telescope. The project must be attachable to most tripods, and have a generic adapter for the telescope to mount to. We used a GPS chip as well as several on-board sensors to determine the location and position of the telescope, and an Android app as a UI and as a database for star data.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project built heavily upon the experience gained in ECE 362. Instead of using a pre-built micro on a circuit board, we were required to generate the entire board including all peripherals and other devices. It is much closer to industry development, instead of backyard tinkering. It also built upon ECE 368, by testing our knowledge of C and any algorithms we needed to use. Other knowledge that was referenced was from 337.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Knowledge and skills obtained consisted of schematic design and debugging in Eagle, PCB design in Eagle, complex soldering techniques for ICs of varying size and complexity. Other techniques included mechanical skills obtained from designing and building the mount. This included Inventor CAD modeling to get a 1:1 scale CAD model of the mount. Also the skills obtained in cutting and drilling the mount with the end goal of having a fully functional moving mount with VEX motors, gears, and other components. Finally, reinforcement in programming in the Android and PIC microcontroller environments was obtained.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The project started well before the semester began with the simple idea of changing a manual telescope into a complicated GOTO telescope. Once the semester began, the team met to conceptualize the design of the telescope mount and the components involved to realize different designs. The team then determined the scope of the final product; the final product was to be a device that attaches a telescope to a tripod that enables it to automatically point at a target. In order to define the project's success, five separate criteria were established. The scope of the project was further refined to list which components would be required to meet each success criteria, as well as components that could add redundancy to the system in case another component did not work as planned. Shortly thereafter, the team broke these components into separate systems in a block diagram, identified the components that fit within each system, and then found components commercially available that met established criteria.

After finalizing the components, the team designed a schematic based on the block diagram. With the schematic, the team placed each component and routed traces to each system. With feedback and many iterations later, the team finalized the design of the printed circuit board.

Once the printed circuit board was released, the team spent time populating the board and testing each component, and each system. Once an individual component of a system was tested and verified, the team moved on to the next. Several components did not work as designed, parts were found and the components were replaced. The each of the final systems worked as intended, and software was written to get each system to interact with one another.

Finally, after much debugging of software, each of the five success criteria were evaluated and demonstrated to work. After getting the entire product to work, notes were taken about what changed between the printed circuit board and the final product, as well as what could be improved on a future revision.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The project had a specific budget of $300. Since anything over that amount came out of the team's own pocket, the team was very careful to find the lowest cost components and the minimum amount of systems required to make the telescope work. The project was also designed to fill a niche place in the market-place, where a hobbyist might want to upgrade an existing telescope but not purchase a brand new system.

Environmental: The project was designed with energy efficiency in mind. The various hardware components are used as seldom as possible to avoid excessive energy expenditure. For example, the GPS is only used once to get a location fix when the device is powered on and is then turned off to conserve energy. Given further time to work on the project, the energy-saving sleep mode on the micro would be used too. Additionally, although the device does not have any on-board battery-charging capabilities, rechargeable AA batteries were used to develop the device and should be used by the user during normal operation.

Ethical: The major ethical design constraint for this project was one of performance. Specifically, the GPS module has the potential to be corrupted and rendered useless if power is removed during critical moments during operation. To mitigate this risk, the power button on the device does not directly cut power, but sends a signal to the microcontroller which sends a "power down" pulse to the GPS. After 1 second, the GPS should be safely powered down and the power is cut.

Health & Safety: All PCBs and ICs are RoHS compliant which minimizes hazardous components from electronic components. Software breaks were added that limited over rotation of the mount. This minimized the potential of the mount breaking via motors stalling for an extended period of time.

Social: The primary social design constraint in creating this project was the notion of creating a product that is both user-friendly and educational. The goal was to create a device that an amateur astronomer could use to further his or her interest in astronomy. Android was selected as the preferred mobile operating system in part due to its open-source nature, allowing as many users as possible to have access to the capabilities offered by the product.

Sustainability: The designed product can take an existing telescope and upgrade it to a GOTO telescope. Other products in the marketplace do not allow for upgrades; in order to add features users must buy a new system. The materials used to fabricate the product are also largely recyclable or renewable; the mount is made out of wood and the associated hardware is made out of plastic or metal.

Manufacturability: The telescope mount was designed to be fabricated using basic hand tools such as a cordless drill as well as a jigsaw. The design could easily be modified to be mass produced using injection molding techniques, as well as using automated robotic arms for assembly. The components used on the printed circuit board in particular were strictly meant for automatic assembly, but the team was able to successfully solder this by hand.

(f) Description of the multidisciplinary nature of the project.

In designing the Humble Hubble, a range of skills and backgrounds were required. Embedded systems engineering was required for working with the microcontroller and the project as a whole. Software engineering was required for programming the microcontroller as well as developing the Android app. Electrical engineering was required for designing the various analog components of the project such as the power supply. Mechanical engineering was required for designing the mount and gearing system. Knowledge of astronomy was required for translating the absolute celestial coordinates (right ascension and declination) into local horizon coordinates (altitude and azimuth).

(g) Description of project deliverables and their final status.

Our deliverables are a telescope mount and an Android App. We constructed the Telescope mount from plywood, and it worked as intended. There were some loose joints, but we were able to compensate by mounting the telescope off-balance so that it always rests to one side of the slop. We also designed a working PCB. Several components were not mapped correctly, but we were able to get it working. The Power supplies and h-bridges had to be moved off-board because the errors were too great, but other errors could be fly-wired to fix. The Android App was developed for 4.0 and above. The result was a functional version of our design.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	19
Project Title	ECEopoly

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Adam Hendrickson	CmpE	Hardware	May 2013
John Marston	CmpE	Software	Dec 2013
Calvin Mwesigwa	CmpE	Software (Android)	May 2013
Noah Bouillon	CmpE	Software	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

ECEopoly is meant to be an innovative new way to experience Monopoly. The ECEopoly console allows for an android phone to connect via Bluetooth while running a custom Monopoly application on the phone. This application allows up to 7 players to experience Monopoly and allows users to load/save games, roll dice, view properties, and purpose trades. The console processes the data sent to it by the phone via Bluetooth and displays the custom ECEopoly board and updates player positions, property ownership, and player money.

ECEopoly is meant to target a wide customer base that just loves to play the game, but either wants to avoid the hassle of having to set up and clean up, or just wants to experience the gameplay in a new exciting way. The goal of the project was to make the game playable, fun, exciting and customized to ECE.

The project utilized a PIC32 microcontroller which was responsible computing game state and drawing images and text to external SRAM to be displayed on a screen. It communicated to a RN-42 Bluetooth module via UART and was able to send and receive data from an android phone with a custom made monopoly application. A CPLD was used to generate the VGA signals and display images stored in the SRAM buffer.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project tested many skills learned through ECE. The CPLD that was used to display the VGA required a great deal of knowledge in VHDL as well as debugging techniques learned in ECE 337 and 477. The game code on the console was all written in c which allowed for us to quickly write and debug software. The peripherals used in the project such as UART and SPI were covered in both

ECE 337 and ECE 362. Having knowledge of the standard and how they are used helped the team debug the project on the oscilloscope when the Bluetooth module was not responding.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The team acquired many new technical skills including programming in c on Pic32 architecture, making an android application in JAVA, programming, and utilizing a CPLD to handle complex mission critical logic. Most importantly, this project greatly tested the teams debugging skills allowing for great leaps in problem solving.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The team first established project specific success criteria for the ECEopoly so that we would have a good starting point for dividing up work and setting goals. These included "an ability to display game information and accept player information on an android device to play game, an ability to display board and animation on a monitor, an ability to output audio for dice roll and background music, an ability to properly simulate a monopoly game, and an ability to save game to flash memory and load game from saved data." The team then decided on a project requirements and budget, quickly moving on to parts selection. The parts were ordered and the schematic was created followed by the PCB. After receiving the PCB the board was populated a little at a time as each component would be tested. Finally debugging software and then final project code could run on the devices allowing them to work together creating the final product.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Many of the parts utilized in the ECEopoly project were relatively expensive when purchased individually. The CPLD, microcontroller, SRAM, and Bluetooth all added up to over $80 dollars; much more that most would expect to pay for a game in today's market. The price however could be brought down through large scale manufacturing and through using cheaper versions of the parts. The outlook at project conception on memory demand and the size needed to fit the CPLD logic was much higher than the resources actually utilized. Through downsizing the CPLD and getting a cheaper microcontroller this project could be more economically feasible to bring to market.

Environmental: The environmental impact of the ECEopoly game should be very low. There are trace amounts of lead in the solder used and not all parts are RoHS compliant but as long as the console is recycled correctly there should be little impact on the environment. The Bluetooth does produce radio noise but it is certified by the FCC so it is unlikely there will be any harmful radio interference as a result of using ECEopoly.

Ethical: The ECEopoly project does emulate the game of monopoly, however, the patents are expired and as far as our research has indicated, we can produce with new features and names without breaking ethical code. One of the reasons our project utilized the name ECEopoly was to differentiate it from the original board game. The features seen in this project are not known to be in any other version of the game.

Health & Safety: Health and safety concerns were considered when designing this project. A heat sink was added to the power supply even though it was operating within normal temperature limits to reduce the risk of fire or plastic melting. The wires on the inside have been wrapped in electrical tape to prevent shorts and unintentional contact. The box has been sealed with four screws so that it cannot accidentally open and expose the customer to the circuitry. When playing this game like any other television based game, eye strain is a possibility and breaks should be taken periodically.

Social: ECEopoly is a fun game for the whole family and given the right atmosphere on a rainy day, it may just bring family and friends closer together. This product does not represent any foreseeable social nuisance.

Political: ECEopoly is not intended to serve any political agenda and property names and images were chosen for the sake of fun and entertainment. We did not seek Purdue's ECE department's permission to include instructor's names as players or famous Purdue sites.

Sustainability: The vast majority of the components in the ECEopoly game are recyclable. The PCB, chips, plastic casing, and wires should all be recycled by the user rather than thrown away once product has reached the end of its usefulness.

Manufacturability: The parts used in this project were chosen for their extra room for uncertainty in the features required. The PCB was intentionally made larger to allow for easier placement of parts. The packaging was two plastic boxes glued together to accommodate large PCB. If product was to be mass produced, cheaper parts may be chosen and PCB could be downsized so it would fit in a standard packaging.

(f) Description of the multidisciplinary nature of the project.

The ECEopoly team consisted of all CmpEs. We divided up project work into several sections to allow project goals to be met quicker. One team member specialized in hardware which handled part select and device interfacing as well as low level programming. Two team members on the embedded software which involved getting the game up and running and writing a driver for the Bluetooth. The fourth team member specialized in android software and was responsible for getting the android Java code running. The schematic and PCB were put together by two different people, which allowed for two different sets of eyes to double check every connection. Those same team members also performed the soldering. Overall dividing up work to each team member's individual skill sets make work go much faster and produced better quality results.

(g) Description of project deliverables and their final status.

1. An ability to display game information and accept player information on android device to play game. (complete)
2. An ability to display board and animation on a monitor. (complete)
3. An ability to output audio for dice roll and background music. (works on phone)
4. An ability to properly simulate monopoly game (keep track of money, property, position). (complete)
5. An ability to save game to flash memory and load game from saved data. (complete)

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	20
Project Title	Marble Maze

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Mark Sears	EE	Circuit Layout, Eagle	May, 2013
Justin Spencer	CmpE	Software, packaging	May, 2013
John Jachna	CmpE	iPhone app, packaging	Dec, 2013
Jordan Wagner	CmpE	Software, System Interfacing	May, 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

A smart phone controlled mechanized marble maze. This product is meant as a fun pastime for children, but is certainly entertaining to adults as well. The basic structure is a heavily modified store bought game, with electronics and high resolution stepper motors added on. The tilt of the maze is dictated by the orientation of an iPhone, utilizing the accelerometer in the phone and translating that motion into motion on the board. There are also joysticks to play the game, in the absence of an iPhone. The board runs off a 9V power supply, and keeps track of player statistics and high scores.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project utilized knowledge of microcontrollers and their capabilities. Peripherals learned in ECE 362 and applied to this project include ADC, timers, LCD control, interrupts, polling loops, and much more. But when populating the board, knowledge from earlier courses like ECE207 and 208 were used. Knowing how the voltage and current were acting and why was essential to the debugging process. Knowing how to correctly use all the electrical tools and measurement was imperative. For the web server and iPhone app, classes such as ECE 362 (Software Engineering Tools) and ECE 30862 (Object Oriented Software Design) were very useful in helping to design and program the software components of this course.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

As for new knowledge, working with Eagle to create a real, working PCB from scratch was fairly new territory. All the tools, techniques and procedures used in the design and construction of the PCB gave us a new skillset. Another major part was learning to use a new microcontroller. From learning what pins to connect to program it, to how to initialize and write to pins, it was a process of reading documentation and finding what we needed to know. Also, a lot of learning went on to effectively control the stepper motors without killing the rest of the circuit. Learned about wireless routing capabilities of Linux, web servers and services, and interfacing several applications together in order to connect the iPhone to the RPi and the MCU.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process was incorporated into all aspects of our project, from the early design phases to the final assembly. When establishing objectives and criteria, we tried to look at how feasible each one was and how it would impact our design. We considered if each criteria could be modularized and separated from the other criteria. During the analysis phase, we applied the engineering design process by considering various solutions to building our design and the pros and cons of each. During synthesis, various solutions were tested on a development board to find the best fit for our design. We also bread boarded various components to ensure they worked as expected. While testing, we first tested each section separately, then added component testing together until we were testing the entire product at once. We fixed any problems we encountered as we encountered them, then ensured that everything still functioned correctly with the fix. While evaluating, we used our success criteria as a basis for evaluation, then built upon that by ensuring the product worked as it would be used by a consumer who purchased it.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: While designing our Marble Maze, we tried to choose parts that were functional and allowed for future expansion, but did not cost too much. We tried not to include any unnecessary features and design our game so that future models could be manufactured cheaply.

Environmental: We tried to limit the environmental impact of our marble maze game by modifying an existing Marble Maze instead of assembling a new one. We also limited any unnecessary components in our design to minimize the footprint our design caused in the event that it was discarded.

Ethical: Our biggest ethical challenge was to provide a sustainable game while minimizing costs. We wanted to design a fun game that could be enjoyed by all, but that was not too expensive. Our design reflects this challenge.

Health & Safety: While designing for safety, some of our concerns were that all the parts were within their recommended operating specifications so that nothing got too hot or created a short circuit. Because our circuit was enclosed in a wooden box, heat dissipation was a large concern of ours, and we designed our circuit to minimize the amount that parts heated up.

Social: The Marble Maze offers an update to an old but well-loved game. It offers an opportunity for children and adults alike to bond with a fun activity that everyone can enjoy.

Sustainability: In designing for sustainability, we chose parts that were rated as reliable and would last over the lifetime of our product. Our biggest concern was with our choice of marble maze, we wanted a sturdy maze that would not break easily and could withstand wear and tear over years of use. We also did not want the motors to burn out, especially if they trying to rotate the board farther than it could turn.

Manufacturability: In designing for manufacturability, we chose parts that were readily available, designed so that our PCB could be reproducible, and tried not to make extensive changes to our game board, so that if we used the same pre-bought game board to manufacture our Marble Maze it would not be too difficult to reproduce.

(f) Description of the multidisciplinary nature of the project.

Our project incorporated many different aspects of engineering, much more than what would typically be found in an undergraduate ECE course. Our project spanned many fields, requiring motors and physical board alteration, iPhone application programming, wireless network setup, network programming, PCB design and manufacture, and embedded microcontroller programming. We also had to incorporate management skills to have our team meetings run smoothly and keep in mind that this product was being designed so that it could eventually be manufactured and sold as a game to consumers. Each individual also brought a unique skill set to the team which allowed us to divide work evenly and fairly based on what a certain team member enjoyed and was talented at, all while allowing them to teach the other team members some of what they knew.

(g) Description of project deliverables and their final status.

We successfully built our marble maze game and had it working with a joystick. The game board was modified to include motors and the holes were filed, creating a game based off of time. We could communicate with the iPhone application, accurately time the game based on when a game passed through the initial start IR gate and when it passed through the ending gate. This was displayed on an LCD and the iPhone played an appropriate tone. A list of the top five times through the maze was stored, in order, in flash memory. After each game, the list was checked against the new time and updated appropriately. The top five scores were also transmitted to the iPhone, which kept a list of high scores that the user could view. However, during the final packaging phase, our circuit shorted and failed, and we were not able to restore it, as we had run out of spare microcontrollers.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	21
Project Title	Pop ‘em Drop ‘em Robots

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Thomas Pansino	CmpE	Software/Hardware	May 2013
Jacqueline Greer	CmpE	Software	May 2013
Mark Tubergen	EE	Motors and Packaging	May 2013
Duncan Swartz	EE	PCB, Hardware, Web	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

“Drop’em Pop’em Robots” is an electronic version of the classic game “Rock’em Sock’em Robots”. Up to two players can play the game at one time, each controlling the movements of one of two boxing robots using Nintendo WiiMotes. Player punches are detected using the WiiMotes’ accelerometers and their dodges are detected based on inputs to the Wii Nunchuk’s analog stick. The punches and dodges are then translated into robot movements using linear actuators and stepper motors. “Hits” on an opponent are recorded using Hall-effect sensors and magnets mounted on the ends of the arms of each robot and the robots’ chests respectively. These “hits” are recorded and the hit player’s health value reduced until either player’s health bar value reaches zero, at which point the player with a non-zero health value remaining is declared the winner. The game also features selectable battle music and a single-player “practice” mode in which the player is able to compete against the computer. The device is designed for use in an arcade or home entertainment environment.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project required us to use knowledge and skills gained from a number of ECE courses. Knowledge of microcontroller peripherals and interfacing from ECE 362 was essential, as was C and Python programming from courses such as ECE 264, 364, 368, and 404. ECE 270 skills with circuit wiring and debugging techniques, as well as knowledge of how to read a datasheet, were also key. Knowledge of how to use an oscilloscope, required in ECE 207 and 208, was helpful when debugging circuit signals and timing. Finally, the ability to work and communicate in teams was a critical skill developed in a number of ECE courses which was essential to completion of the project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The design and development process of this project also gave our team several new skills. Team members who worked closely on the schematic and PCB layout gained a familiarity with the EAGLE PCB software, as well as proper PCB layout techniques. Those who worked on the hardware and packaging assembly gained experience soldering and working with various power tools. Those team members involved with the software development gained experience learning to read and build upon code implemented by others. All team members gained significant experience with prototyping, debugging, and testing circuit components. We also collectively gained much more experience with reading component datasheets and comparing features and performance factors of similar components to make the best selection.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

We struggled in the first weeks of the class coming up with appropriate criteria for our original project idea, which led us to come up with a new project that we could establish feasible criteria for success. After defining our criteria, we conducted research into various parts and determined which ones would work together and be best suited for each criterion. After reviewing peer feedback, we began to prototype our parts on breakout boards as proof of concept. This testing made us reevaluate some of our previous choices so we revisited some of our criteria and changed it, as well as the parts we would need to complete it. Once everything was in place, we began to construct our PCB and incorporate the software that we had been working out. Throughout this entire process, we found some new changes that we needed to make and repeated previous tests using new methods. We kept track of our progress over the course of the semester and checked off points along the way once they were completed. At the end of the semester, everything came together after numerous iterations. We evaluated our final design by comparing it to the latest set of criteria we had determined, and found our project to be a successful demonstration of the effectiveness of the engineering process.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: We made our product one that utilizes devices that some people may already own in order to reduce costs. If one owns a Nintendo Wii with two Wiimotes and nunchucks, they only need to purchase the game itself to have everything needed to play the game. However, our product does use a modified version of Rock 'Em Sock 'Em Robots as well as a Raspberry Pi, which would significantly increase the asking price of the game. Alternatives could potentially be designed to replaces these components with more task-focused parts that are less expensive and do only what we need them to do, but in reality it seems that this game would be best suited for arcades. Hundreds of people spending quarters at the allure of battling a friend at the arcade would garner more profit in the long run than a single family spending upwards of $100 on the game alone, or $200 if the Wiimotes need to be purchased as well.

Environmental: Most of the environmental considerations involved in our project were based in the materials used in manufacturing, and thus are out of our control. The hazardous chemicals used in manufacturing the PCB and LCDs could have a negative environmental impact if handled or disposed of improperly. Also, the plastic used for the game arena is not biodegradable. Another consideration we had was the power consumed by the product. Two power supplies are required, one for the Raspberry Pi, and one for the microcontroller. This along with the 1 A the actuators draw can consume a lot of power.

Ethical: The main ethical considerations to take into account in our project are making the product as safe as possible and providing information about proper use to the users. With a market audience of children, it is very important to put warning labels in prominent places in the interest of their safety, as well as giving clear and simple instructions in the user manual on how to use the product properly.

Health & Safety: The safety of our project is fairly high, mostly because everything that can be a problem is enclosed within the wooden packaging. Therefore, under normal operating conditions, there is no viable threat of electrocution, fire, or other physical harm to the user. The only exception would be with device failure, but the FMECA conducted shows that health risk from device failure is small relative to the criticality of the failure. It was not seen that any failure in the project could result in harm to the user.

Social: The main social consideration of our product is to make it a fun game for users. By incorporating the Nintendo WiiMotes into the classic Rock ‘Em Sock ‘Em Robots game, we brought an element of physical action to it that was absent before. In our opinion, this along with the selectable battle music makes our product a very fun game.

Political: The only political consideration we had was to make sure that the product is compliant with all standards required of it by law.

Sustainability: It was important to take the lifetime of the product into consideration in order to reduce the environmental impact from the hazardous chemicals involved. The main way to lengthen the life of the product is to use parts that take longer to wear down, causing the product to break and be thrown out.

Manufacturability: One of the challenging aspects of this product would be manufacturing it. It was difficult to prototype because we simply made modifications to an existing product. Given the extent of our modifications, this would not be a pragmatic way to create the game on a mass scale. We would need to change several design aspects and have new pieces made for us if we were to put our product into large scale manufacturing.

(f) Description of the multidisciplinary nature of the project.

Our project combined various software and hardware challenges. We ran out gameplay through software on our Raspberry Pi, which communicated with WiiMotes and the microcontroller. We then had the challenge of translating all of that software into commands for our electromechanical devices, which we also had to design the system for. We were able to build a very multidisciplinary project because our varied interests allowed us to come up with a product that was multifaceted. This project required material from essentially all of our core curriculum.

(g) Description of project deliverables and their final status.

Our first deliverable was the proof of concept for our parts before we submitted the PCB, which was another deliverable. One of the first deliverables we completed was showing that the LCDs worked, however it would take some time before we succeeded controlling the LCDs through the microcontroller on the PCB. We struggled to produce a deliverable using the Kinect, so when we switched to WiiMotes, we were able to show that we could translate the user input into commands for the microcontroller. Our other deliverables were actuating the arms, and rotating the robots, which we completed preliminarily before spring break, and finally completed it through the PCB in the final weeks of the semester. Our final deliverable was a completed project which we succeeded in doing and completed all of our PSSCs.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2013
Advisors	Prof. Meyer and Dr. Johnson
Team Number	22
Project Title	Text Message DJ

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Kyle Brown	EE	Server-side Software	May 2013
John Doherty	EE	Micro Programming	May 2013
Chris McCabe	EE	Power	May 2014
Garrett Strzelecki	CompE	CAD/Hardware	May 2013

Project Description: Provide a brief technical description of the design project, as outlined below.

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

There are primarily two target customer segments for the Text Message DJ. The first target demographic is young adults ages 18-30 who are likely to have social gatherings. The second target is business owners that utilize prerecorded music and allow patrons to request songs. The purpose of the project was to provide a low cost alternative to having a live DJ or having to self-manage music at a party or other social gathering. The project was targeted for low cost, small size, ease of use and simplicity of design and manufacture. The engineering design process was followed for this project with hardware design completed directly before software design.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project primarily built upon the concepts learned from ECE 362. Experience in microcontroller programming and project design was critical to completing the project in an efficient manner. Familiarity with utilizes built in microcontroller peripherals also contributed greatly to the success of the project. ECE 270 also contributed heavily as the bread boarding and troubleshooting skills were helpful during the initial design and testing phases of the project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

For the programmers, an improvement in Python and C expertise was noted. Everyone on the team learned a great deal about PCB design especially in regards to making traces of the appropriate size and spacing of components to allow for effective trace routing. Additionally, part placement for heat dissipation, debugging and ease of customer use were skills acquired.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

After deciding on a general idea for the project, the team immediately moved into establishing objectives and criteria. These took the form of the five project specific success criteria. These PSSCs were iterated at every point in the design process based upon feedback from outside sources and an analysis of the available components and solution path. Once various components and potential implementations had been researched, specific components were selected and ordered based on the synthesis of possible solutions that seemed to have the highest likely success rate. Once components arrived construction and testing of the device on bread boards took place. Once all the individual subsystems were working and verified, the final PCB was constructed. After the fully assembled PCB was ready, software implementation and testing began. Upon completion of the software and hardware integration, the evaluation phase began. Initially each PSSC was verified individually. After establishing each PSSC independently, the final unit was tested to ensure all PSSCs were satisfied simultaneously.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: In the initial part of the design phase while objectives and criteria were still being established, similar existing products were researched. Utilizing this research a price point of approximately $100 was targeted based on the success/failure of the similar products at various price points. For prototyping purposes, a budget of $300 was set as a cap to prevent the need for extreme cost cutting measures late in the design process.

Environmental: For the prototype, lead solder was used due to its availability. Most components, however, are ROHS compliant. Switching to an alternative solder was discussed as a potential future option, but additional design work is needed to eliminate the potential effects such as tin whiskers.

Ethical: The primary ethical concern addressed during the design of this product was the widespread abuse of workers in the manufacture of electronic components. The parts selected were chosen due to their widespread availability in order to increase the chances that a suitable United States supplier would be found. This helps alleviate the ethical concern due to stricter laws in the United States regarding labor conditions.

Health & Safety: Safety was an important factor considered especially due to the potential hazard presented by the strobe lights. As such, warning labels are essential to properly informing the consumer of the potential safety hazards. The product was also designed to minimize the amount of heat put off to in turn minimize the hazard that would arise as a result.

Social: The Text Message DJ was designed for use in a very social environment, but runs the risk of being seen as a detriment if improperly marketed. The product needs to avoid establishing a connection to the negative aspects of the ‘party’ scene.

Political: Political considerations were not taken into account because the product was designed with solely recreation purposes in mind.

Sustainability: Sustainability was considered to a moderate extent as the lifecycle of the product is meant to be extremely long and labeling will carefully outline proper disposal and recycling of the product.

Manufacturability: Widely available parts were selected in the design of the product in order to allow for easy establishment of a supply chain once manufacturing was to begin. The initial prototype was designed for hand soldering, so a new parts analysis would be required in order to transition to a more efficient machine manufacturing process if widespread production commenced. If smaller scale production is targeted, the process for manufacture is already established.

(f) Description of the multidisciplinary nature of the project.

The project focused primarily on the electrical and computer engineering areas of expertise, but also utilized a little bit of mechanical engineering experience in order to realize the final product. Electrical engineering skills were used in order to build the circuit and make the component selections. Computer engineering skills were useful for software design and implementation. Finally, the mechanical engineering expertise was useful in designing and construction the packaging for the product.

(g) Description of project deliverables and their final status.

The final project deliverable successfully met all of the project specific success criteria. The final deliverable was a standalone unit able to receive and parse text messages, maintain a playlist based on votes, load a config file from an SD card, play music from the internet and control a DMX 512 strobe light. Additional functionality could have been established in some areas, such as allowing for more complex config files, but all the minimum requirements were met or exceeded.