SoutheastCon Team A

Needs Analysis and Requirements Specification

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1. Executive Summary

This project has one objective: to win the 2015 IEEE SoutheastCon Hardware Competition.

Rules

This year's iteration of the Hardware Competition has a "road trip" theme. Therefore, the event consists of having an autonomous robot complete four traditional road trip games within the confines of a set track. An LED "stoplight" will signal the robot to go and follow the "road", a white line that leads from the starting line to the finish. There will be several branches along the road, each leading to one of four different road trip games. The first game the robot has to play is the popular "Simon Says" game. It is required to play the game for 15 seconds, without making a mistake indicated by an 'error' sound. The second task the robot must accomplish is to write the letters 'IEEE' on an Etch-A-Sketch. Then, the robot has to grab and turn the top of a Rubik's Cube 180 degrees. Finally, the robot needs to pick up a card from a complete deck, and carry it across the finish line. This must all be completed in less than 5 minutes.

Team

The team consists of seven senior engineering students; six from the Department of Electrical and Computer Engineering and one from the Department of Mechanical Engineering. As such, the team will be working closely with the project advisors from both departments to ensure that all requirements for not only the project, but for the course as well are fulfilled.

Needs

As a preliminary design, the robot will be comprised of three subsystems. The chassis will consist of the movement and positioning logic of the robot. This will be responsible for line following and proper alignment with the challenges. The challenge interfaces will be divided into two separate "arms." The first arm will complete the Etch-a-Sketch challenge, as well as pick up and carry the playing card. The second arm will play the Simon Says game, as well as twist the Rubik's Cube.

Testing Schedule

As mentioned above, the robot will be constructed and tested as three separate subsystems. The subsystems will be tested independently, but a complete system should be finished by December. This is to allow for extensive testing during the first months of 2015, so that the robot meets all reliability requirements ahead of the competition.

2. Overview of Design Team

Nils Bjeren

Project Manager and Team Lead

The Project Manager is in charge of overseeing each design aspect of the project and organizing all of the team members working together; He also ensures that all members attend each internal meeting and have set goals to achieve by the end of the meeting. In addition, he communicates between the group and the project advisors to keep them updated on all progress made in the design. Lastly, he will construct and maintain the sensor grid that the robot uses for line following because of his background in sensors.

Background: FPGA's, Programming, and Sensors

Ryan-David Reyes

Head Programmer and Controls Engineer

The Head Programmer evaluates all code that any team member produces for each subsystem before it is implemented into the final realization of the design. His duties as the control engineer include constructing and maintaining the movement and communications systems of the robot, which comprises the motors, motor drivers, and microcontrollers. He will be in charge of incorporating the multiple systems of the robot programmatically. His extensive background in robotics provides invaluable experience needed for the complicated design.

Background: Robotics, Programming, Motors, Microcontrollers

Kurt Marsman

Secretary/Document Control and Systems Engineer

The Secretary is in charge of organizing all of the official paperwork that needs to be submitted to the project coordinator and the mentors. this includes all milestone reports and the needs analysis. The official meeting minutes from each meeting, internal and advisor, are to be taken by the secretary and posted to the team blog on Blackboard in a timely manner. The additional position as a systems engineer allows him to assist any group that needs extra support.

Background: Power Systems, Controls

Julian Velasquez

Financial Advisor and Power Systems Engineer

The Financial Advisor is in charge of the project's budget. Throughout the project they will be in charge of keeping all the expenses in a log and in google drive. Decisions on how much money will be spent have to be approved by the financial advisor. The power systems engineer will evaluate all the power being consumed by the robot as well as the power being provided to the robot. The engineer will be in charge of providing the necessary power at the cheapest, lightest and most efficient way possible. They will also help any team members that require extra hands on their work.

Background: Power Systems, Controls, Financial Management

Chris Lewis

Controls Engineer

The Controls Engineer is responsible all programming associated with the design of the Etch-A-Sketch arm; more specifically, the control law that will govern the movement of the arm and integrating the various sensors involved. His background in programming and in computer vision will prove quite useful for the portions of the design that require sensing.

Background: Programming, Computer Vision

Donovan Carey

Hardware Engineer

The Hardware Engineer is responsible for the design and manufacturing of the Etch-A-Sketch arm and all hardware associated with that area of the design. This task involves determining motor, electronic, and material specifications; as well as constructing the arm itself. The Hardware Engineer is required to have open communication with the Controls, Head Mechanical, and the Head Programmer to ensure the most efficient subsystem capable of production. The primary focus of the hardware engineer is on the mechatronic design of the arm, including programming as necessary.

Background: Hardware and Electronics

James Pace

Head Mechanical Engineer

The Head Mechanical Engineer is responsible for the structural integrity of the robot and is in charge of making sure that the various subsystems are designed to be mechanically sound. The head mechanical engineer will also perform the necessary torque and material calculations based on the requirements of the competition. He will also act as the team's liaison with the Mechanical Engineering Department, personally guaranteeing that the team meets all Mechanical Engineering Department specific requirements. As a mechanical engineering student, he has had training on mechanical systems and materials which should be an asset to the team.

Background: Dynamics, Mechanical Systems

3. Needs Assessment

3.1. Problem Statement

The final goal of this project is the design and realization of an autonomous robot that will win the 2015 IEEE SoutheastCon Hardware Competition.

3.1.1. Background/Context

The IEEE SoutheastCon is an annual professional and student conference that takes place in Region 3 of the United States. Each year, the IEEE hosts the Hardware Competition, where competitors must build a robot that can complete specified challenges. The FAMU-FSU College of Engineering has entered several times in previous years, and has managed to earn a gold and bronze medal. This year, the Hardware Competition 2015 will be hosted by Nova Southeastern University & Broward College. This year's competition is a step up in terms of complexity compared to the challenges of previous years, with multiple and varied objectives.

3.1.2. Statement of Needs

The needs of a robot that will compete in the aforementioned competition are as follows:

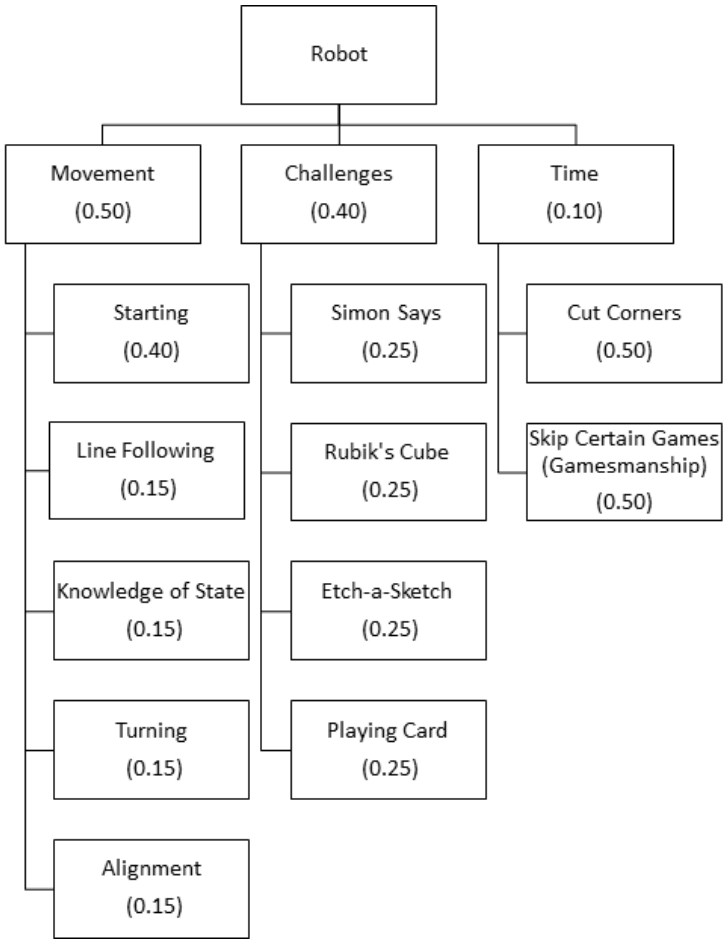
- Robot must be able to reliably exit starting position, once signaled by an LED, and start its runs.
- Robot must be able to follow white lines around the track to get to different challenges
- Robot must be able to complete the following challenges:
    - Write the letters IEEE on an Etch-a-Sketch.
    - Twist one row of a Rubik's Cube 180º.
    - Pick up a single playing card from a deck of 52.
    - Play the game "Simon Says" for 15 seconds.

3.1.3. Supporting Information

- Travel - The conference takes place in Ft. Lauderdale, and travel to this location will need to be arranged.

- Internal competition - There will be an internal competition at the FAMU/FSU College of Engineering. The winner of this competition will represent the college at the IEEE SoutheastCon Hardware Competition

3.1.3. Objective Tree:



3.1.4. Ranking of Needs

Needs	Wants
Reliable Start	Simon Says
Robot Positioning	Sideways Motion
Line Following	Complete Course in Less Than 3 Minutes
Etch-a-Sketch	
Rubik’s Cube	
Playing Card	
Complete Course in Less Than 5 Minutes	

3.1.5. Statement of Objectives

- 3.1.4.1. Preliminary Design Objectives – The primary objective of this project is to build a robot that will win the 2015 SoutheastCon Hardware Competition.

3.1.6. Preliminary Research on Technologies & Systems

- Line following: Line following is traditionally done using infrared sensors. These are arranged into a grid or a line, and sensor data is used with a microcontroller to stay on the line.
- A traditional way for telling sounds apart (for the Simon Says system) is by sampling the sounds and taking a transform. Transforms that should work well on a microcontroller are the FFT and the FHT, although there may be memory issues.
- The Arduino series of development boards has a large community with many resources available online. Preliminary development has been done using boards based on the ATmega 328 and ATmega 2560 microcontrollers.

4. Requirements Specification

4.1. List of Engineering Requirements

4.1.1. Capabilities, a.k.a. Functional Requirements

- Line following (5 pts)
    - The robot must be able to follow a line that branches at several points. These branches end in white patches containing one of the individual challenges. It must be able to navigate down these branches, then back to the main path and continue from there.
- Play Simon Says for 15 seconds. (15 pts)
    - The robot must be able to play a game of Simon Says for 15 seconds. This involves hitting the start button, determining which buttons the game has indicated, and then hitting those buttons in the correct order.
- Etch-A-Sketch (20 pts, 5 per letter)
    - The robot must be able to turn the knobs on the Etch-A-Sketch, and produce characters that resemble the letters IEEE.
- Rubik's Cube (5 pts)
    - The robot must be able to grasp the Rubik's cube and rotate one of the sides 180 degrees.
- Time until finish (Maximum time is 5 minutes)
    - The robot must be able to complete all challenges within a five minute time limit. Any tasks completed after 5 minutes will not receive a score.

- Sense Red LED in Order to Start Each Run
    - A Red LED will be used to indicate to the robot when time has begun. The robot must be able to sense that the LED has gone out and that it is now ok for the robot to start navigating the course.
- Stay within the confines of the track
    - The robot must be able to stay within the track until it is done with all tasks. Once the robot leaves the track, it may not re-enter the track and finish any more tasks.
- Alignment of the robot with the toys
    - The robot must be able to align the manipulators on the main chassis with the toys to play each game.

4.1.2. Performance Requirements

- Minimum
    - Line followed reliably
    - Games played < 1
    - Playing card successfully carried across the finish line
    - Complete track < 5min
- Maximum
    - Lines followed quickly and perfectly
    - All games played successfully
    - Complete track < 3 min
    - Maximum points awarded

4.1.3. Constraints

The robot will have to be made according to the following constraints as per the competition rules:

- Must fit within a 1’ by 1’ by 1’ box
- Must be self-propelled
- Must be completely autonomous
- All parts of the robot must remain attached
- All toys must remain “outside” the robot at all times

4.1.4. Interface Requirements

Initially, the main robot control will be an Arduino Mega 2560. This will interface with other subsystems using either RS232 (serial) or I2C.

4.1.5. Operating Environment

The main environmental concern is the presence of background noise during the competition. When the robot is performing the Simon Says challenge, the environment will not be entirely quiet. In addition, people around the ring may interfere with the distance sensors the robot will use to align itself with the games. This needs to be tested for before the design is finalized.

4.1.6. Environmental, Health & Safety, and Legal/Regulatory Requirements

As the voltages involved in this design are relatively low, there are few significant health concerns. Care must be taken when disposing the batteries to ensure environmental compliance. Avoid extreme temperature fluctuations that could potentially harm the integrity of the battery.

4.1.7. Reliability, Availability, Durability, Maintainability

There are a few reliability concerns:

- Battery life: The battery of the robot needs to last long enough for the robot to complete the challenges.
- Line following: What happens when line following breaks down? Previous competition teams have had issues with this.
- Is the robot able to position itself correctly every time?
- Repairs: the wiring and electronics organization of the robot has to be well documented enough to fix in an urgent situation

Some of the maintainability concerns are outlined below:

- Many different electronic systems are present on the robot. The wiring between these can get messy, and as such a detailed circuit diagram is essential.
- The Arduino development boards can be sensitive to large currents. This must be taken into account.

4.1.8. Appearance

The robot will be made primarily out of aluminum. The College of Engineering logo, as well as an eventual sponsor's logo, should feature prominently. Other than that, form will follow function.

4.2. Assumptions and Limitations

4.2.1. Assumptions

These needs and requirements have been specified based on the assumption that the rules for the hardware competition do not change from their current state. If they do (which is more than likely), changes will have to be made.

4.2.2. Limitations

A key limitation of this project is financing. At time of writing, the project is going to receive $750 in funding from the FAMU/FSU College of Engineering. As the budget will very likely exceed this amount, external sponsorship needs to be considered. The financial advisor is currently in contact with at least one external sponsor.

4.3. Needs/Requirements Traceability Matrix

Requirements	Reliable Movement	Completion of Challenges	Optimization of Race Time
Weights	0.5	0.4	0.1
Needs			
Reliable Start	x	x	x
Robot Positioning	x	x	x
Line Following	x	x	x
Etch-a-Sketch		x	
Rubik's Cube		x	
Playing Card		x	
Completion in < 5 min			x
Wants			
Simon Says		x	
Sideways Motion	x		x
Completion in < 3 min			x

Note: The Needs are listed starting with most essential to least essential.

5. Preliminary Testing Plan

Each subsystem of the robot will be tested individually according to the needed performance. There are four major subsystems of the robot, corresponding to the four challenges of the competition: Etch-a-Sketch, Simon Says, Rubik's Cube, Playing card.

- Etch-a-Sketch: The subsystem will have to be capable of using the two knobs on an Etch-a-Sketch in order to write "IEEE." A valid test would be to apply the subsystem to the toy, run a program that applies the appropriate sequential motor commands in order to spin the knobs, and see whether or not IEEE is written on the Etch-a-Sketch. If it is, the test has been passed.
- Simon Says: This subsystem is initially designed around sound detection and frequency analysis. The first step is to make sure that sound sampling works. Then, frequency information needs to be extracted from the sample data. Then, when the frequency of each sound can be identified, mechanical testing can begin. The mechanism for pushing

the buttons needs to be able to push each color button within 6 seconds of the sound signal. Once this has been achieved, the test is passed.

- Rubik's Cube: This subsystem needs to lock the bottom two rows of a Rubik's Cube in place while spinning the top row. This will be tested by making a mechanical device that holds the cube in place, while the top row is spun using either a grabbing claw or a simple motor, relying on torsional friction.
- Playing card: This subsystem simply needs to pick up a playing card. If the robot has a way of lowering something sticky onto the top of a stack of playing cards, this test has been passed.

Once the subsystems all work individually, they need to be integrated into the main robot design. Before the robot itself is ready, line following and placement needs to be tested.

- Line following: Line following is implemented using a grid of infrared sensors. The robot needs to be able to follow a line, make appropriate turns, and stop when needed.
- Placement: The robot needs to stop in front of each challenge in a predictable position. Once it does this, the test has been passed.

The latter two bullet points, as well as the integration of the robot with all its subsystems will be tested using a practice track for the competition itself. The toys will be laid out on this track as they will be in the actual competition, and full runs with the robot will be conducted. Once full runs, with the robot completing each challenge can be reliably completed, this test is complete.

Once the robot runs reliably, all further efforts will go towards decreasing the time a full run takes.

6. Preliminary Project Schedule

Task	**Intended Completion Date/Deadline**
Milestone 1: Needs Analysis	**9/18/14***
Milestone 2: Project Proposal	**10/16/14***
Finish Proof of Concept Robot	11/13/14
Milestone 3: Conceptual/System-Level Design Review	**11/13/14***
Send Remaining Parts to Machine Shop	11/20/14
Be able to Complete Course	12/12/14
Debugging and Correction	Spring Semester
School Level SoutheastCon Competition	**End of February/Early March**
Additional *Debug and Correction*	Remainder of Spring
SoutheastCon 2015	**4/9/15***

***=indicates external deadlines

7. Preliminary Project Budget

A rough estimate for the total cost of the project is $1,200. A preliminary budget is included below:

Category:	Cost:
Wheels	$80.00
Motors	$300.00
Batteries/Chargers	$150.00
Microcontrollers	$300.00
Electronics	$200.00
Misc. Mechanical Parts	$170.00
Total:	**$1,200**

8. Conclusion

The autonomous robot should be able to completely and accurately finish the required tasks in order to win the Southeast Con 2015 hardware competition. The track consists of line following to four different obstacles and eventually to the finish point. The obstacles are: playing Simon Says for 15 seconds while correctly matching the lights and sounds it produces, drawing the letters “IEEE” on an Etch A Sketch, twisting one row of a Rubik’s cube 180 degrees, and picking up a card from a deck of cards and carrying it across the finish line. Time will also be taken into account for scoring.

This project brings with it a vast amount of challenges in the fields of electrical, computer, and mechanical engineering. The robot is being made from scratch, and as such, all circuits and mechanical components need to be custom made. Especially, interfacing with the various toys will lead to mechanical and programming challenges. On a larger scale, this project requires heavy testing, which will let the engineers make use of their problem solving and critical thinking skills.