BITS N’ OHMS

Autonomous Walking Robot

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1. ABSTRACT

To design, build, and test a small autonomous robot capable of traversing a flat surface with walls and obstacles as well as climbing stairs to reach the target location. The robot will consist of an embedded controller, sensors, servos all mounted on a chassis. The controller will drive actuation with the use of servos and shall receive feedback from the sensors to correct its path in the case of an obstacle or traverse a set of stairs to reach its destination. The design will meet the specified dimensions of no larger than 7"x7"x7" and will have full autonomy.

2. PROJECT DESCRIPTION

Goals:

The main goal of this project is to build, test, and design a walking robot that will be able to autonomously and successfully navigate through a modified SAE Robot Systems Challenge. It has been modified to a certain degree to ensure the completion of the project in a single semester.

The completed robot must then compete against the other three groups’ robots by traversing through a 9 by 9 grid obstacle course twice, once without stairs and once with stairs. Whichever group is able to finish both courses and achieves the fastest time is the winner.

Intended functions:

- Robot will be able to differentiate an obstacle or a boundary and will act accordingly based off of algorithms of code.
- Robot dimensions will meet spec of 7 x 7 x 7 inches.
- Robot will act completely autonomous without the aid of tethers or human control.
- Robot will successfully traverse a random generated 9 by 9 grid obstacle course.
- Will be powered by rechargeable power supply.

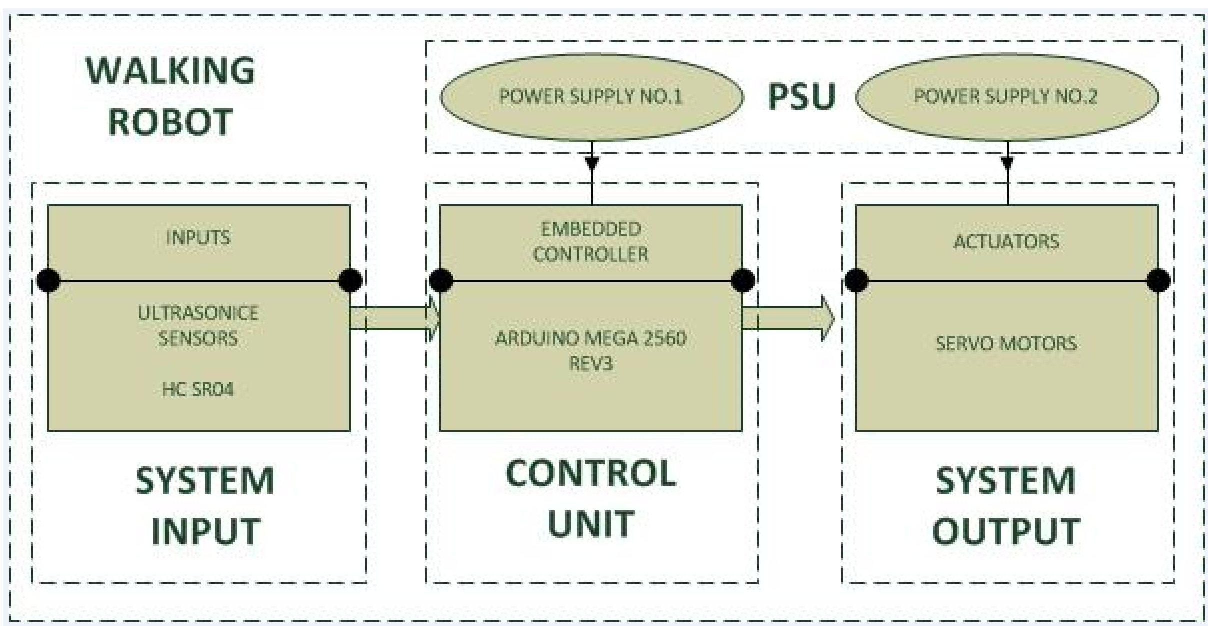
How will design be realized?

- Robot will utilize actuators to walk across flat land, stairs, and avoid walls.
- Actuators will be used facilitate movement of robot.
- Robot will be powered by two separate power supplies for microcontroller and actuators.
- Ultrasonic sensors will be used to extract data to identify obstacles.
- Microcontroller will provide an algorithm for the extracted data to control actuator movement.

3. SYSTEM DESIGN

Block Diagram

The structure of the system can be represented through the following block diagram:



As seen, the walking robot has four main blocks:

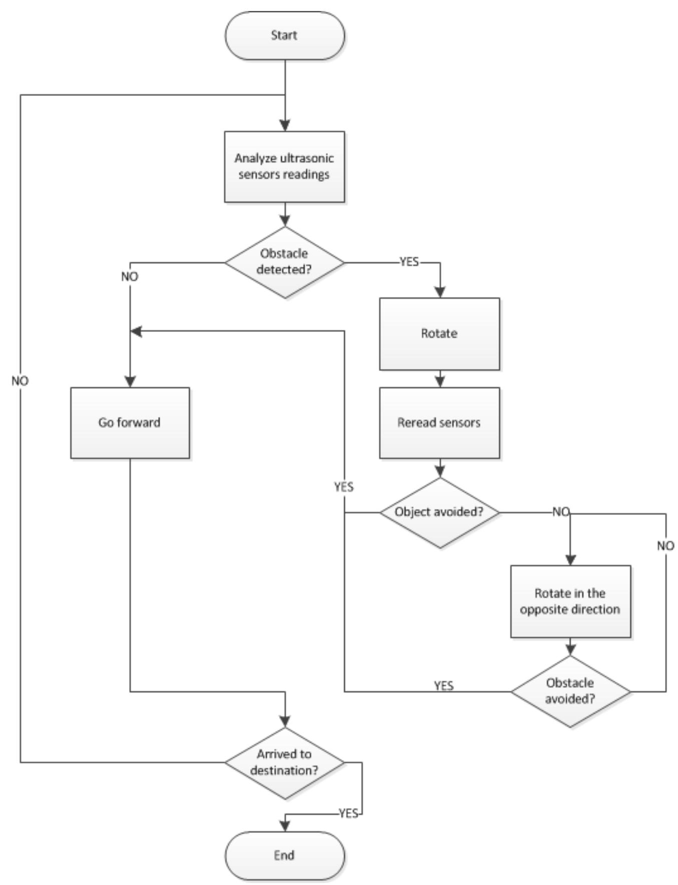
- System input: The input of the system is provided by the ultrasonic sensors (in this case, the HC SR04s) which will measure distance and send the readings to the microcontroller so as the correct decisions are taken. This way, the sensors act as the feedback branch for the system, indicating its status.

- Control unit: The embedded controller chosen so as to act as a the control unit for this project is and Arduino Mega 2560 REV3. All the software of the system will be running on the microcontroller and its main functions are to receive the readings by the sensors and take the optimal decisions so that the optimal output signal for the effectors is generated.

- System output: In this project, the servomotors will act as the actuators, and their main goal is to modify the situation of the system and bring it to the desired position.

- Power supply unit (PSU): The Power Supply Unit is the element in charge of powering the rest of the devices in the system. In this case, there will be two different power supplies, one for the microcontroller and another one for the motors, since the motors require a big amount of current (which may interfere with the correct function of the controller).

A simplified idea of the information flow and decisions taken by the microcontroller can be extracted from the flowchart below:



Performance Requirements

1. Basic walking and turning
2. Obstacle detection and avoidance
3. Ascending and descending a set of stairs
4. Full autonomy
5. Fit within a 7 x 7 x 7 cube
6. No rolling actuation

4. TESTING PROCEDURES AND VERIFICATION

- Test coverage will consist of basic test cases designed to cover fundamental aspects of the robot. They are targeted at power supply limitations, maneuvering, and basic walking.

- Benchmarking will be performed a way to magnify the design strengths and shortcomings

Verify basic walking with no obstacles

Steps	Expected Results
Power on robot and load the program to begin walking	The robot should not have any issues with walking in a straight line
Allow the robot to continue walking	The power supply should not have any issues with powering the 8 servos on the robot. There should not be any stuttering in the servos that indicates a lack of power output.

Verify the robot can perform basic turning

Steps	Expected Results
Power on robot and load the program to begin walking	The robot should not have any issues with walking in a straight line
Let the robot perform its turning function	The robot should be able to turn appropriately and does not involve dragging its feet to face a different direction.

Verify the robot is capable of detecting obstacles

Steps	Expected Results
Power on robot and load the program to begin walking and obstacle detection	The robot should not have any issues powering on and walking
Allow the robot to walk to an obstacle within its detection limits	The robot shall be able to properly detect the obstacle and correct its position to overcome the obstacle and continue walking

Verify ability to detect and traverse the stairs

Steps	Expected Results
Power on robot and load the program to begin walking, obstacle detection and stair detection	The robot should not have any issues with powering on, walking, and detecting obstacles and stairs.
Allow the robot to overcome obstacles to reach a set of stairs	The robot will maneuver away from the obstacles and approach the stairs. The robot should not treat the stairs as an obstacle.

Let the robot analyze the stairs and continue traversing it.	There should be no issues traversing the stairs. The servos should be capable of distributing the load appropriately when ascending and descending the stairs

Verify power supplies are able to withstand the duration of the obstacle course

Steps	Expected Results
Allow the robot to continue walking for 15 minutes	The power supply should not have any issues with powering the robot for the time allotted for the course There should not be any stuttering in the servos that indicates a lack of power output.

Verify ability to recover from an unexpected fall.

Steps	Expected Results
Power on robot and load the program to begin walking	The robot should not have any issues with walking in a straight line
Create a disturbance for the robot that will cause it to fall down	The designed function should allow the robot to recover from the fall and continue normal operation

Verify traversal of entire grid with obstacles and stairs randomly placed

Steps	Expected Results
Power on robot and load the completed program	The robot should be able to complete the course and arrive at the target location

Benchmarks

Performance of the robot will be measured through the following operations:

1. Timed dash / straight line
2. Timed dash with obstacles placed randomly
3. Timed dash with stairs
4. Timed dash with stairs and obstacles placed randomly

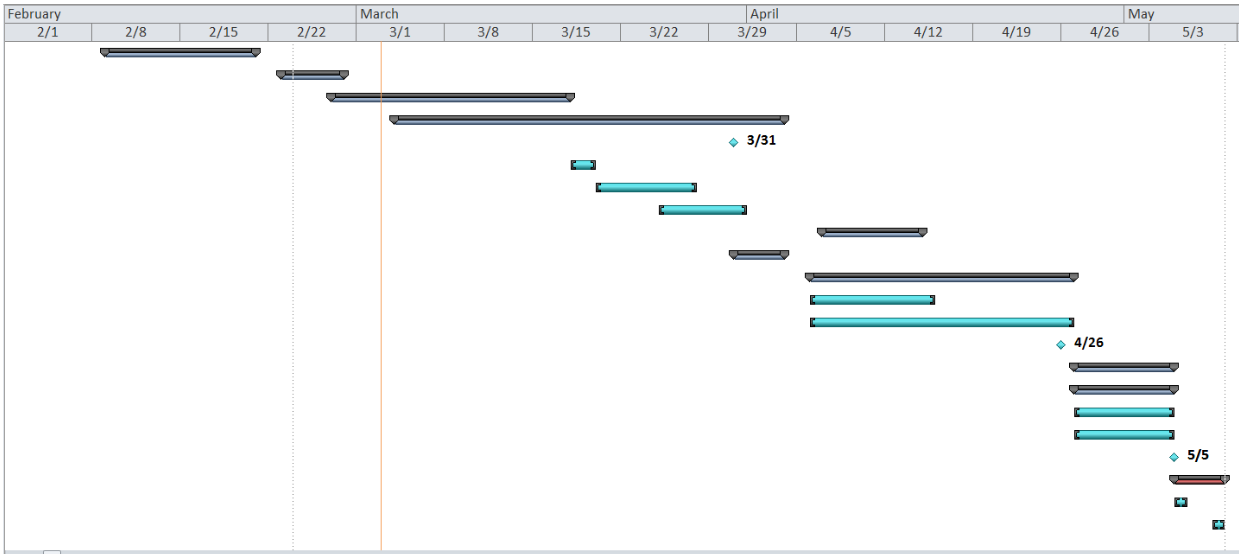
Each of the processes will be run multiple times to compute an average.

5. PROJECT MANAGEMENT

- Project Plan that we will follow for the semester

Research All Components of the Project	**10 days**	**Mon 2/9/15**	**Fri 2/20/15**
Servos			
Sensors			
Microcontroller			
Chassis			
Power Supply			
Rules and Specifications			
Website Templates			
Purchase Main Components	**5 days**	**Mon 2/23/15**	**Fri 2/27/15**
Ultrasonic Sensors			
Ardunio Microprocessor			
QuaBot quadruped robot chasis			
Two Cell Lipo			
Six Volt Servos			
Project Proposals	**13 days**	**Fri 2/27/15**	**Tue 3/17/15**
Design Proposal	5 days	Fri 2/27/15	Thu 3/5/15
Deliver Proposal	1 day	Tue 3/17/15	Tue 3/17/15
System Integration and Test	**23 days**	**Wed 3/4/15**	**Fri 4/3/15**
Assemble	2 days	Wed 3/18/15	Thu 3/19/15
Basic Movement with Sensor	6 days	Fri 3/20/15	Fri 3/27/15
Integration of Caliberation	5 days	Wed 3/25/15	Tue 3/31/15
Progess Reports	**6 days**	**Tue 4/7/15**	**Tue 4/14/15**
Design Progress Report			
Deliver Progress Report			
Adjustments	**4 days**	**Tue 3/31/15**	**Fri 4/3/15**
Part Replacements			
Modify Team Page with Progress			
Test and Debugging	**16 days**	**Mon 4/6/15**	**Sun 4/26/15**
Recaliberate	8 days	Mon 4/6/15	Wed 4/15/15
Test with sample mazes	16 days	Mon 4/6/15	Sun 4/26/15
Deployment	**6 days**	**Mon 4/27/15**	**Mon 5/4/15**
Final preparations	**6 days**	**Mon 4/27/15**	**Mon 5/4/15**
Design Final Document	6 days	Mon 4/27/15	Mon 5/4/15
Modify Webpage with Final Progres	6 days	Mon 4/27/15	Mon 5/4/15
Devlier Product	**4 days**	**Tue 5/5/15**	**Fri 5/8/15**
Final Oral Presentation	1 day	Tue 5/5/15	Tue 5/5/15
Senior Design Day	1 day	Fri 5/8/15	Fri 5/8/15

- Gantt Chart



- Milestones

1. Purchase Main Components 2/23/15
2. System Integration 3/15/15
3. Complete First Challenge 4/15/15
4. Complete Second Challenge 4/30/15
5. Deliver Product 5/8/15

6. BUDGET

- Cost Analysis Diagram

Project Components	Initial Design Costs
Sensor	$8.99
Chassis	$69.95
Microcontroller	$46
Power Supply	$7
Servos	$0
Total Spent	$131.89
Remaining Funds	$168.11

7. PROMOTIONAL FLYER