Project Specifications, Procedure and Plan

EML 4551C – Senior Design – Fall 2011 Deliverable # 3

Team # 17

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Project Sponsor

CISCOR

CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

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Reviewed by Advisor(s):

INTRODUCTION

The goal of this project is to design and create the structural foundation of a fully-functional, highly stable semi-omnidirectional outdoor robotic walker. The walker will be able to operate on sloped ground, up to 10 degrees, as well as on outdoor multi-terrain surfaces. Our final design will be used as a research platform to ultimately create a more advanced, highly responsive walker; requiring us to initially produce a robust, highly versatile walker.

PROJECT SPECIFICATION

The motivation of this project is to aid the motor-disabled population in their outdoor mobility. Currently, all commercially produced walkers are specifically designed for indoor use, with minimal outdoor use. This restriction is the focus of our project. Ideally, the motor-disabled population will easily regain their mobility freedom along with expanding their traversable terrain.

As discussed earlier, the design must be constrained to standard walker dimensions; namely, to fit through a doorway and around tight corners. However, our model will be implemented in such a way to allow significant outdoor functionality. We also want to support the user up to 45 degrees of lateral motion from any central axis. Considering environmental hazards and human error, an inherent resistant force will assure the user constant stability and dependence.

QUALITY FUNCTION DEPLOYMENT

		ENGINEERING REQUIREMENTS							
		Two driving wheels (powered individually)	Four Passive Casters	Passive Suspension	Steering Motor/s	Computer Controls	Force Interaction with User for Control Purposes	Fit through a door	Adjustable Height (Standing or Hunched)
CUSTOMER NEEDS	User Friendly			X		X	X	X	X
	Provide stability to user			X		X			X
	Outdoor Operation	X	X	X	X	X			
	Absorb uneven terrain			X					
	Semi Omni-Directional	X			X	X	X		

FRAME

To make the device more user-friendly, it has been decided that the supportive frame will be similar to current generation products to bolster familiarity with the new product. Current walkers in today's market vary greatly in overall design, but many of the physical dimensions remain constant across the board. The standard walker utilizes 1 inch diameter aluminum piping to provide lightweight durability. Most walkers can support up to 300 pounds and have adjustable heights between 32 and 39 inches. These specifications will all be conserved in our design to ensure a large variety of body-types remain applicable for using the product. Though the height adjustments and supported weight were fairly consistent from model to model, the depth of the handles, width at the base, and width at the grips varied considerably. In more expensive models, more depth is allowed in the handles for the user's convenience and larger widths at the base of the models are required for castered wheels. The proposed design requires the use of large motors and multiple wheels, so a wider base will be necessary. The frame will be designed to be 24 inches wide at the base and narrow to 18 inches at the grip. The grips for our walker will be taken from the standard rubber design currently in use.

With an adjustable height and wider base, our design should be comfortable for people between the heights of 5'4" and 6'6". Based on knowledge of existing walkers and standard manufacturing techniques, it can be estimated that the frame of our product will not weigh more than 25 pounds (not include the weight of motors and control systems). This is slightly higher than traditional walkers, however, our design utilizes more, slightly larger wheels and will also include additional mounting locations for future sensors to be placed. The frame will be made to either interact with a pre-ordered force plate or utilize a spring proportional driving scheme in the grips.

WHEELS

The wheels of a robot are the foundation for which the implementation of the system will be driven. Our walker will exhibit smooth, semi omnidirectional movement in any 45 degree motion from a central axis. The wheels and frame will employ a passive suspension system to reduce system shock and increase durability. In addition to the two centrally located driving wheels there will be four casters used for stability; two casters will be placed in front of the driving wheels and two in back. The caster type must be considered to adequately allow the system to perform to its highest standard. Swivel casters will be used as they will provide nearly unlimited range of motion.

Since we are designing an outdoor robotic walker, all terrains and weather conditions must be accounted for. This is to say, our walker should operate over gravel, sand, dirt, grass etc… With this, a dependable, rigid, and versatile wheel type must be properly selected. There are a few different types of wheels that we can consider for the walker. Standard pneumatic wheels are composed of hard reinforced rubber and are filled with compressed air; most commonly used on motor vehicles and bicycles. Flat-Free tires are designed to resist the effects of deflation when punctured and to enable the user to operate the "vehicle" at reduced speeds, when punctured. Solid wheels are best used as material handling equipment wheels. Lawnmowers, skateboards, golf carts and scooters all use solid wheels to drive the system. Since our system does need to sustain all exterior ambient conditions, based on our initial calculations an air filled rubber tire would suit our needs best. The wheels need to be 30 cm in diameter and fit within the mold of our base structure.

CONTROLS

The control scheme implemented in the walker will determine how different hardware will interact both with the environment and the user. The control structure will be based on a real time, computer based system used to both accurately calculate position, velocity and acceleration of the wheels and steering as well apply the necessary force outputs. The heart of the control system will be a PC104 computer stack. This computer was chosen due to its small size and potential for ample computational power. The computer will also be used to interface with motor drivers which in turn will interact with the three motors. One motor will be used to set and maintain the steering angle of the walker while the other two will be used to provide movement. The motor drivers are quite necessary as the computer does not have the ability to handle the task of delivering power to the motors, only the calculated commands. In order for the user to command the walker, the user will provide a forward or reverse force and possible torque. Two independent parameters will be resolved from this force and torque input, whether forward or reverse travel is requested as well as the angle to which this event will occur.

Connected to this computer will be a counter board which will be used to interface with the multiple encoders on the walker. The encoder provides a pulsed output that relates to the change in position for the encoder disk. With accurate time keeping the velocity and acceleration can be calculated from this position data. This walker will use three encoders; one encoder will be used to accurately calculate the steering angle with respect to the walker structure while each driving (powered) wheel will also have an encoder.

The walker will also have the ability to mount laser scanning for obstacle avoidance or terrain detection. The mount will be located in the front of the walker and will scan 180 degrees in front of the walker. With a swivel mount, the laser can be utilized either for curb or obstacle detection at close distances or for much further obstacles (approx 80 meters). There will also be a laser in the back of the walker that will not scan for obstacles but instead be used to sense user intentions and current position. This sensor will be used for fall prevention as well as assistance in getting up and sitting down. If the position and orientation of the user is known certain control laws can be initiated to maintain a safe and user friendly experience.

BUDGET

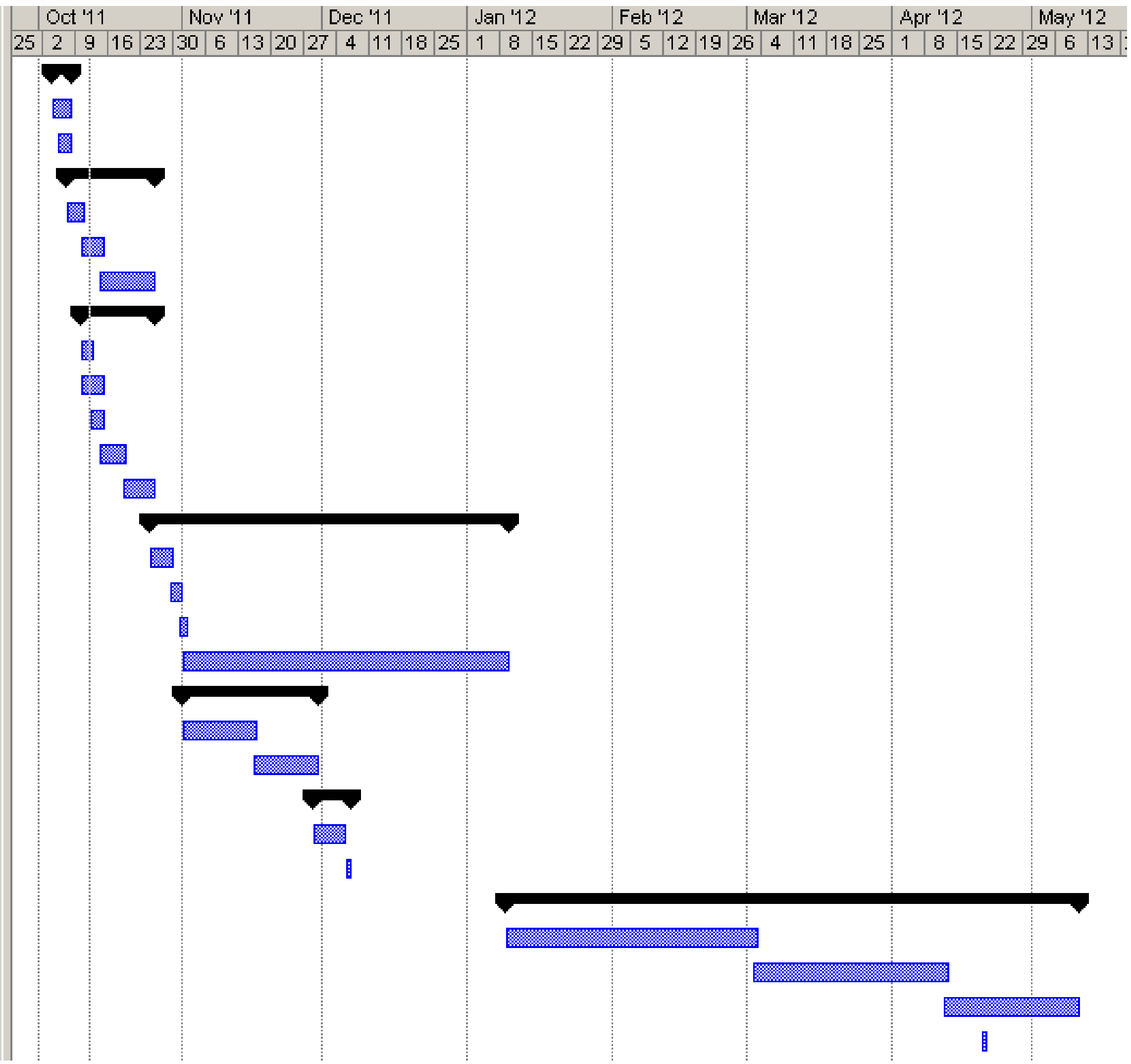
Our project budget allocation from CISCOR is several thousand dollars. While there is no exact amount promised there is an expectation between two and five thousand dollars. However, CISCOR will also graciously provide many of the essential hardware and electrical components necessary in addition to the money provided. With this, our budget will fund any necessary machining or purchasing of extra parts required to build the walker base prototype.

PROJECT TIMELINE

The Gantt chart below shows the preliminary timeline for the entirety of the project. Because this project is based on a preconceived concept, little additional concept generation is required. Instead, individual components are ideated and designed in a concurrent fashion, resulting in an expedited design process. This provides us ample time for both delivery of atypical system components and manufacturing preparation. Through the professional experience of our faculty mentor, it is assumed that this additional preparation time will be beneficial to our project. The remainder of the chart shows a less detailed breakdown of the manufacturing process as unforeseen problems may arise. It is the belief of this group, however, that we have allowed for ample time to compensate for any project roadblocks.

GANTT CHART

	Task Name	Duration	Start	Finish
1	**Preliminary Research**	**4 days**	**Tue 10/4/11**	**Fri 10/7/11**
2	Existing Technology	4 days	Tue 10/4/11	Fri 10/7/11
3	Industry Benchmarks	3 days	Wed 10/5/11	Fri 10/7/11
4	**Concept Generation**	**13 days**	**Fri 10/7/11**	**Tue 10/25/11**
5	Product Specification	2 days	Fri 10/7/11	Mon 10/10/11
6	Brainstorming	5 days	Mon 10/10/11	Fri 10/14/11
7	Concept Selection	8 days	Fri 10/14/11	Tue 10/25/11
8	**Component Design**	**12 days**	**Mon 10/10/11**	**Tue 10/25/11**
9	Inventory of Available Parts	3 days	Mon 10/10/11	Wed 10/12/11
10	Component Research	5 days	Mon 10/10/11	Fri 10/14/11
11	Inventory of Necessary Parts	3 days	Wed 10/12/11	Fri 10/14/11
12	Component Design	4 days	Fri 10/14/11	Wed 10/19/11
13	Component Specification	5 days	Wed 10/19/11	Tue 10/25/11
14	**Part Acquisition**	**57 days**	**Tue 10/25/11**	**Mon 1/9/12**
15	Research/Analysis	5 days	Tue 10/25/11	Sat 10/29/11
16	Part Selection	2 days	Sat 10/29/11	Mon 10/31/11
17	Part Ordering	2 days	Mon 10/31/11	Tue 11/1/11
18	Receive Parts	51 days	Tue 11/1/11	Mon 1/9/12
19	**Preparation**	**22 days**	**Tue 11/1/11**	**Tue 11/29/11**
20	Modeling	12 days	Tue 11/1/11	Wed 11/16/11
21	Simulation	11 days	Wed 11/16/11	Tue 11/29/11
22	**Final Design Presentation**	**6 days**	**Tue 11/29/11**	**Tue 12/6/11**
23	Preperation	5 days	Tue 11/29/11	Mon 12/5/11
24	Final Design Presentation	1 day	Tue 12/6/11	Tue 12/6/11
25	**Manufacturing**	**89 days**	**Mon 1/9/12**	**Thu 5/10/12**
26	System Assembly	40 days	Mon 1/9/12	Fri 3/2/12
27	Debug/Redesign	30 days	Fri 3/2/12	Thu 4/12/12
28	Final Assembly	21 days	Thu 4/12/12	Thu 5/10/12
29	Competition Submission (If Possible)	1 day	Fri 4/20/12	Fri 4/20/12



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