Restatement of Project Scope & Plan

EML 4552C – Senior Design – Spring 2012 Deliverable # 1

Team # 17

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Project Sponsor

CISCOR
CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

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EXECUTIVE SUMMARY

The current generation of available assistive walking devices is limited in their functionality and traversable terrain. Many of these devices are manufactured solely for indoor operation and offer little assistance to the user beyond passive structural support. Those individuals who require assistance in walking and wish to travel outdoor can be deterred by small hazards such as grass, gravel, or uneven/sloped terrain. For many individuals, scooters or electric wheelchairs are unnecessary or too expensive for their needs, and they unfortunately offer limited safety and control as well. To further empower the disabled and elderly community, a new class of automated assistive walking devices will be developed.

This project aims to design and create the structural foundation of a fully-functional, highly stable, semi-omni-directional outdoor robotic walker. The walker will be able to operate on sloped ground, up to 10°, as well as on outdoor multi-terrain surfaces, while being able to withstand typical environmental hazards. The prototype will meet the demands of current walkers, adhere to conventional walker dimensions, and increase the safety and mobility of the user. The walker will be an active system, responding directly to the actions of the user. Our final design will be used as a research platform to create a more advanced, highly responsive walker which requires the initial design to be a robust, highly versatile walker.

BACKGROUND

With an ever-increasing life expectancy, there remains a growing reliance on assistive devices for the elderly and disabled. Out of an estimated 13.1 million users of assistive technology devices (Kraus, Gilmartin 1996), users needing mobility assistance accounted for 61.8% of this population. Mobility assistance has traditionally been accomplished through the use of canes, walking sticks, passive walkers and active/passive wheelchairs. Of these devices, walkers rank as the second most used mobility assistive device only behind walking sticks and canes. An estimated 21% of the mobility disabled users of assistive devices uses a walker. However, these figures can be misleading as a large gap in the requirements necessary to operate the aforementioned assistive devices exists.

A powered wheel chair offers the most assistance as it requires limited to no dexterity or muscle strength above the waist. An unpowered wheelchair offers less help as it requires both dexterity and strength in the arms of an individual. There exist several commercially available wheelchairs capable of indoor/outdoor use. A passive walker offers comparably less help as it requires both the strength and balance for an individual to stand upright combined with the strength to operate the walker as well as potentially brace oneself for a fall. Currently there exists no commercially available walker capable of indoor/outdoor use, only models suitable for indoor use. A cane is arguably the hardest to use as there is typically only one contact point with the ground and strength and dexterity is needed in the body as a whole. However, a cane represents arguably the easiest assistive technology to use because of its light weight and small footprint. There exists no product suitable for indoor and outdoor use, for the individual who is able to or simply wants to stand, however, does not necessarily have strength and dexterity to operate a cane or passive walker. To empower and further enable the disabled population, a more versatile and functional design is required.

PROJECT SCOPE

This project aims to create this more versatile and functional design by offering not only increased stability, but also the ability to function in an outdoor environment in such a way that the user will greatly extend their mobility. The walker must be able to traverse over a common road-side curb (approximately 4”) and other similarly-sized objects as well as exhibit an overall “better” assistive walking experience. This experience will be achieved through an interactive control system allowing the user to command the walker in an intuitive manner using the natural motions and forces associated with walking. The walker will provide sufficient support and stability and will assist the user in executing certain maneuvers. The walker should be capable of translation in 45° from the center axis and will be capable of handling various outdoor conditions and terrains. All of the controls will be housed within the walker itself, requiring no additional servicing of the walker.

The walker designed for this project can be segmented into three major sections: frame, wheels, and controls. Each of these segments must meet specific demands to ensure a successful design, as summarized below.

- **Frame**

To make the device more user-friendly and bolster familiarity with the new product, the supportive frame will be comparable dimensions and geometry to the current generation of assistive devices. Current walkers vary greatly in overall design, but many of the physical dimensions remain constant. The standard walker utilizes 1 inch diameter aluminum piping to provide lightweight durability. Most walkers can support up to 300 pounds and have adjustable handle heights between 32 and 39 inches. These specifications will be conserved in the design to ensure a large variety of body-types remain applicable for using the product. 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, however the handles will be adjustable between 14 and 23 inches. 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 walker will exhibit semi omni-directional movement in any 45° 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. Swivel casters will be used to provide nearly unlimited range of motion.

Because the walker is designed for operation in an outdoor environment, all types of terrains and weather conditions must be accounted for. For this reason, a dependable, rigid, and versatile wheel type must be properly selected. 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 the walker does need to withstand extreme outdoor conditions, an air filled rubber tire would be most appropriate. The wheels need to be at least 30 centimeters in diameter to allow the walker to traverse the necessary obstacles 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 both to accurately calculate position, velocity, and acceleration of the driving and steering motors 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.

PROJECT PLAN

This project will follow a four stage process to successfully meet the demands of the sponsor: design, manufacture, controls, and amendment.

- **Design**

The design stage entails meeting with the sponsor to determine the design requirements, performing extensive research on the current field of comparable products to determine basic standards and benchmarks, and compiling this information into a single cohesive design that is congruent with the needs of the sponsor. Majority of the design process will take place in the Fall semester, however continued system adjustments and debugging will require suitable redesigns to our prototype, for the purpose of manufacturing a suitable research platform.

- **Manufacturing**

Manufacturing requires ordering and machining the necessary components and assembling the components into the prototype. This step will begin at the end of Fall with the purchasing of necessary parts and end in Spring, where manufacturing our robot will occur up until our Final Design & Prototype. This part will happen somewhat simultaneously with the Amend/Rebuild part of the design process.

- **Controls**

The controls stage requires the design and implementation of a user-control system to drive the mechanical system in an intuitive and user-friendly fashion. Though this project requires basic a basic control system for the successful operation of the device, the main focus of the project is to design the hardware that will allow the easy implementation of a more advanced control scheme to interact with the user. The main input device will be a force-input handle so the user can both control the speed as well as the orientation of the walker.

- **Amend/Rebuild**

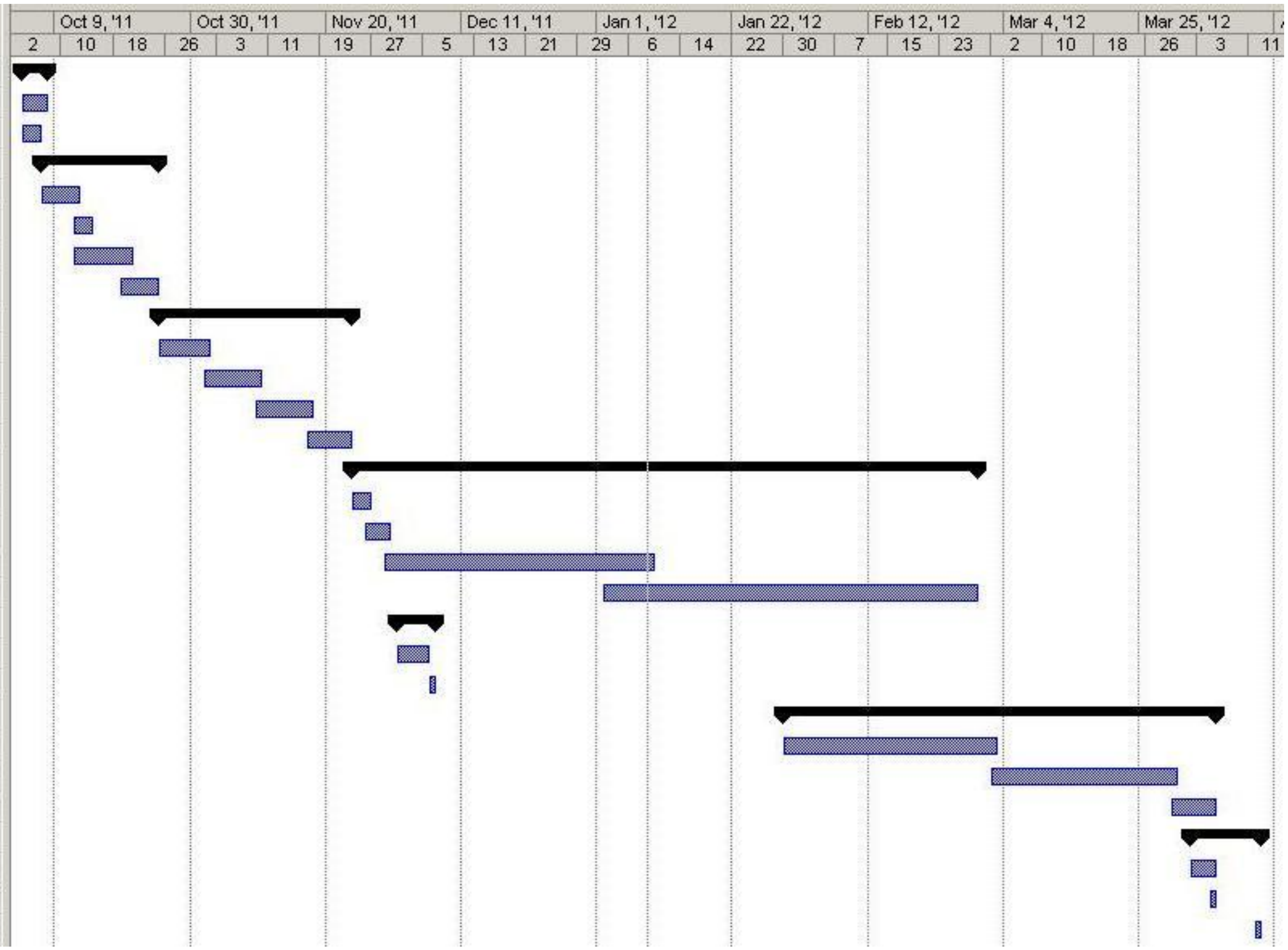
The final stage requires the debugging and redesigning of any control failures and the rebuilding and remanufacturing of any subsequent mechanical failures discovered through testing the prototype. These steps will ensure that the design will be completed on time and meet the demands of the sponsor.

PROJECT TIMELINE

The Gantt chart below shows the revised timeline for 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. Because of some unforeseen circumstances, part ordering was unfortunately delayed to the New Year, which consequently has condensed the remainder of the timeline. This is not devastating, however, as ample time is still available for manufacturing, assembly, and redesign.

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	Tue 10/4/11	Thu 10/6/11
4	**Concept Generation**	**12 days**	**Fri 10/7/11**	**Mon 10/24/11**
5	Product Specification	4 days	Fri 10/7/11	Wed 10/12/11
6	Brainstorming	3 days	Wed 10/12/11	Fri 10/14/11
7	Cost Analysis	7 days	Wed 10/12/11	Thu 10/20/11
8	Concept Selection	4 days	Wed 10/19/11	Mon 10/24/11
9	**Component Design**	**23 days**	**Tue 10/25/11**	**Wed 11/23/11**
10	Component Specification	7 days	Tue 10/25/11	Tue 11/1/11
11	Component Research	7 days	Tue 11/1/11	Wed 11/9/11
12	Component Integration	7 days	Wed 11/9/11	Thu 11/17/11
13	Component Selection	5 days	Thu 11/17/11	Wed 11/23/11
14	**Part Acquisition**	**70 days**	**Thu 11/24/11**	**Tue 2/28/12**
15	Catalog Research	3 days	Thu 11/24/11	Sat 11/26/11
16	Cost Analysis	3 days	Sat 11/26/11	Tue 11/29/11
17	Part Selection	30 days	Tue 11/29/11	Mon 1/9/12
18	Part Ordering/Receiving	42 days	Mon 1/2/12	Tue 2/28/12
19	**Final Design Presentation**	**4 days**	**Thu 12/1/11**	**Tue 12/6/11**
20	Final Design Presentation Prep	3 days	Thu 12/1/11	Mon 12/5/11
21	Final Design Presentation	1 day	Tue 12/6/11	Tue 12/6/11
22	**Manufacturing**	**49 days**	**Mon 1/30/12**	**Thu 4/5/12**
23	System Assembly	25 days	Mon 1/30/12	Fri 3/2/12
24	Debug/Redesign	21 days	Fri 3/2/12	Fri 3/30/12
25	Final Assembly	5 days	Fri 3/30/12	Thu 4/5/12
26	**Final Submission**	**9 days**	**Mon 4/2/12**	**Thu 4/12/12**
27	Final Presentation Preperation	4 days	Mon 4/2/12	Thu 4/5/12
28	Final Presentation	1 day	Thu 4/5/12	Thu 4/5/12
29	Open House	1 day	Thu 4/12/12	Thu 4/12/12



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