CHAPTER 13
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CONTROLLING A POWER WHEELCHAIR WITH MACHINE VISION

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INTRODUCTION

The goal of this project is to integrate a machine vision technology into a power wheelchair system so that a client with quadriplegia can control the direction of movement of a wheelchair. The machine vision technology employed was developed at Stony Brook. Professor Chiang originally developed the technology, computer aided speckle interferometry or CASI, for solid mechanics applications. For this project, the students applied this technology to detect the direction of head movement, which is used in turn to control the direction of the wheelchair movement. Compared with existing machine vision technology, CASI has the advantage of being able to detect the movement reliably.

SUMMARY OF IMPACT

The machine vision system is developed using standard PC components and allows a client to control the direction of wheelchair with his head movement.

TECHNICAL DESCRIPTION

The original CASI is developed using special high-resolution CCD camera with expensive image capture board. For the wheelchair application, a CCD webcam (cost around $100) is used along with the standard graphics card in a PC. No special image board is required. The webcam is mounted behind the client's head on the chair. It is used to capture the movement of the back of the client's head. To be most effective, the client needs to wear a hat with a speckle pattern on it. A sample speckle pattern is shown in Fig. 13.1.

A MS Visual Basic software is developed to capture the five images of the speckle pattern during the

(a)

(b)

Figure 13.1: (a) Wheelchair with Vision System. (b) Close-Up with Speckle Pattern.

head movement, extract the displacement information from the image, and send an appropriate command to direct the wheelchair movement. The schematic of the software is shown in Fig. 13.2.

Shown in Fig. 13.3 is a custom designed circuit board used to convert the output from the parallel port to the interface board on the power wheelchair.

The cost of the parts/material is about $2750.00. This includes the power wheelchair (purchased with deep discount at $2,500.00), $150 for electronics, and $100 for the webcam. The Mechanical Engineering Department provided the lap top computer and its accessories.

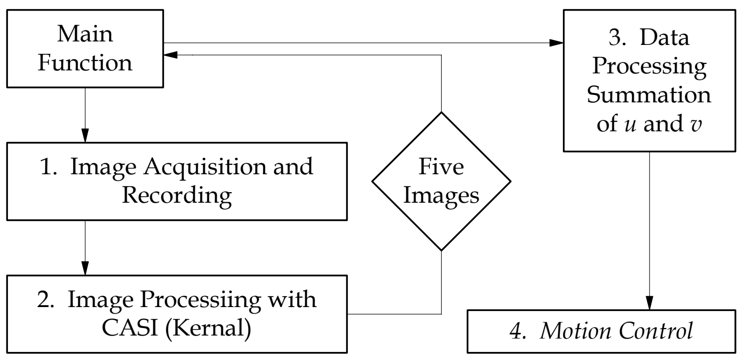

Figure 13.2: Software Architecture.

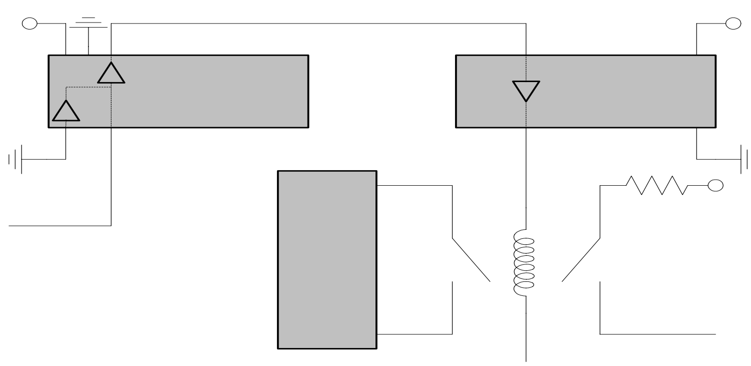

Figure 13.3. Adaptor Circuit.

CONTROLLING A POWER WHEELCHAIR WITH VOICE RECOGNITION TECHNOLOGY

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INTRODUCTION

Instead of using machine vision, this project uses voice recognition technology for controlling wheelchair movements. The voice commands for controlling the movement can be recorded and programmed, and then can be customized to each individual. The hardware system is exactly the same as the vision system. The microphone needed for recording comes with the webcam. Once a voice command has been recognized, an appropriate motion command is sent to the parallel port, which in turn, controls the direction of wheelchair movement through the adaptor circuit shown in Fig. 13.3. In this project, the voice based wheelchair control software is developed using Microsoft Visual Basic with Microsoft's Direct Text to Speech and Direct speech recognition technology.

SUMMARY OF IMPACT

This machine vision based system is targeted for patients with quadriplegia.

TECHNICAL DESCRIPTION

The speech recognition engine used in this investigation is Microsoft's Direct Text to Speech and Direct speech recognition. The Program is written in Visual Basic and enables the user to basically operate various functions on the computer by voice activation. Fig. 13.4 is a schematic diagram of the speech recognition control system. The analog sound wave propagates through the microphone and is digitized by the AD board of the computer (sound card). The digitized information is stored in the computer and is processed by the visual basic program. The voice command is then recognized and the analogous directive to that command is executed.

Fig. 13.5 depicts the visual interface of the speech recognition program. The software can access virtually almost all of the computer functions. However, it was noticed that sometimes phrases had to be repeated, and the user had to be close to the microphone when talking. The accuracy was

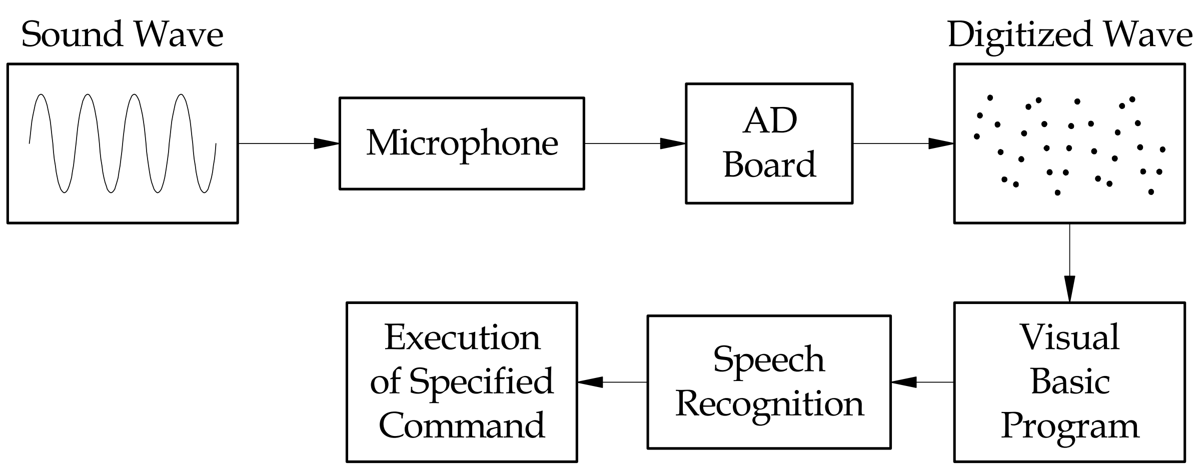

Figure 13.4: Schematic of Voice Recognition System.

drastically improved when the vocabulary was minimized. Archimedes was tested with a vocabulary up to 50 words and phrases, and the resulted accuracy was 78%. However, when the vocabulary was dropped to 10 words or phrases, the accuracy improved significantly to an acceptable performance of 90%. Furthermore, the accuracy increased to 95%when the selected words were phonetically very different. In the targeted application of Archimedes which the automation of a wheelchair, the words that will need to be recognized are "forward"," backward", "left", "right", "stop", "accelerate" and "decelerate". The number of commands is well in the range of acceptable accuracy and they are phonetically dissimilar.

There is no additional cost to this voice based system. The same hardware system is used as the machine vision system.

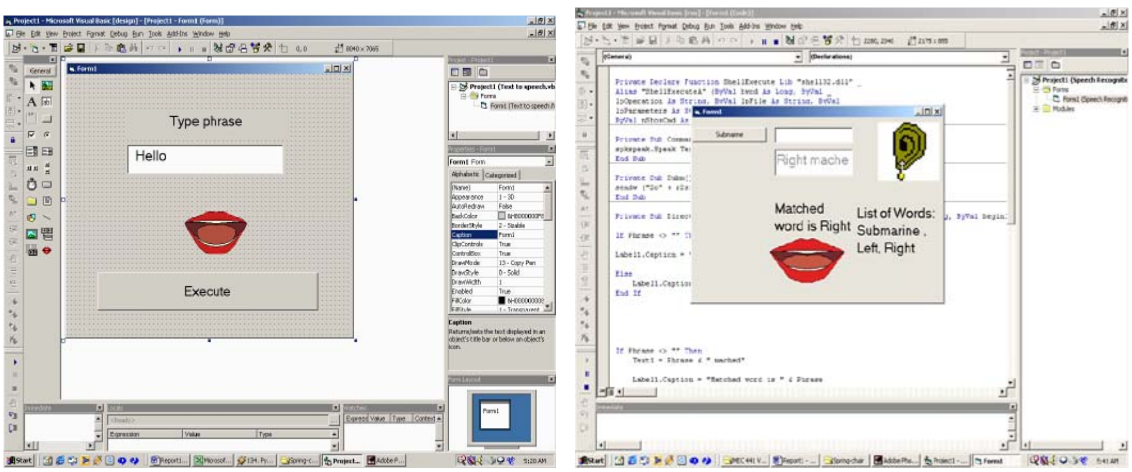

Figure 13.5: Graphical Interface for Voice Recognition System.

PEDALO TRICYCLE

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INTRODUCTION

The Pedalo, shown in Fig. 13.6, is a useful exercise vehicle for children with severe disabilities. It is a combination of platforms, wheels and supports, which are fit together to create a smooth forward and backward motion. Therapists use this mechanism to train children in proper balancing techniques and increase muscle strength. The existing Pedalo is a registered product of Abilitations. It uses the split-axle principle for its operation and can be used by people of any age. This Pedalo can convert a walking-like motion into forward or backward motion but it is not capable of turning. The improved Pedalo will follow this same basic principle, but will have additional features of a steering mechanism. This Pedalo was designed specifically for a child and was customized for his size and needs. Safety and speed were taken into consideration.

SUMMARY OF IMPACT

A custom-made Pedalo tricycle for the client will allow him to move around in the building while getting proper training in balance and muscle strength.

TECHNICAL DESCRIPTION

The final Pedalo design as shown in Fig. 13.7 consists of two platforms connected by a set of double-center wheels. The outer wheels of the original Pedalo were not used for this design. This double-wheeled configuration is connected to three other wheels through a beam joined from the stationary centroid of the inner wheels to the shaft of the driven wheels and the front wheel. These wheels are set up in a tricycle- type configuration, with two wheels at the back and one wheel at the front. A gear chain located at the center of the double wheels is used to drive the shaft of the two back wheels. The front wheel is used for steering. A handlebar type steering mechanism is used to steer the front wheel. Additionally, the client's Pedalo will be equipped with removable side handlebars and foot guards for

Figure 13.6: The Original Pedalo.

Figure 13.7: The Pedalo Tricycle.

safety.

Overall, the design and construction of the Pedalo tricycle was a success. The prototype works in accordance with the design specifications. The only major problem is that the motion is not entirely smooth all the time. Although corrected with the use of a double-chain ring with the rear crank, the problem is not completely solved yet. However, other modifications can be made to this design to increase its safety and performance.

One additional modification would be to add an anti-tipping device to the Pedalo-tricycle. This would entail adding extra supports and side wheels at the left and right side of the mechanism. This would add extra stability and operate similar to training wheels on a bicycle. Another safety feature that can be added is side handlebars. This would provide extra support for balance of the user. Foot guards can also be added to the platforms to keep the child's feet in place to avoid slipping. This would prevent the child from falling and would guide the placement of the child's feet while the Pedalo-tricycle is in use. Other modifications to the design could include the addition of a seat, an adjustable handlebar stem, and electronics to further enhance the safety and features of the Pedalo-tricycle.

The total cost for constructing the Pedalo tricycle is $524.00.

THE ESCHER SKETCHER: A MICROPROCESSOR CONTROLLED ETCH-A-SKETCH

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INTRODUCTION

The purpose of this design project centers on modifying the interface to a popular toy called Etch –a-Sketch as well as adding to its functionality. The ultimate goal is to provide the same enjoyment and satisfaction received from using the toy to someone who might not have the motor skills or bimanual coordination to use it. Additionally, the device could be used as a teaching aid to enhance the cognitive skills of the users. This could help them increase hand-eye coordination, as well as increasing confidence. It would accomplish this by abandoning the existing interface of two small white knobs, instead providing a simpler mechanism such as a keypad, joystick, or palm-activated trackball.

SUMMARY OF IMPACT

This project develops a microprocessor-controlled platform that allows a bi-manually impaired child to play with the classical Etch-A-Sketch.

TECHNICAL DESCRIPTION

As shown in Fig. 13.8, the mechanical design of the microprocessor-controlled platform expands the Etch-A-Sketch into the shape of a laptop computer. The device would encase the toy inside of its screen half, and control the knobs via small stepper motors mounted on each side. Fine tooth nylon gears, some of which would replace the knobs on the front of the Etch-A-Sketch, would boost torque. The keyboard half of the laptop style design would house a keypad or series of directional control buttons as well as a trackball mounted inside. The entire mechanism would fold up into a flat, easily carried shape. In addition, the screen half would pivot around its center either automatically or manually.

Figure 13.8: Microprocessor Controlled Etch-A-Sketch.

One nice feature was the LCD display which could act as an operator interface during a game, a countdown timer, a screen to read numerical input such as desired X and Y coordinates, or radii of circles.

The full electrical schematic is shown in Fig. 13.9. Power enters the device with a standard three-prong appliance plug similar to the kind commonly found on the back of computers. The 110VAC passes through a double pole switch and a fuse before it heads toward the power supply. Heavy gage, well-insulated wire is used on all high voltage lines. The power connector, power switch, and fuse holder are salvaged from an old, broken printer. When the switch is turned on, the power supply converts the 110VAC into a more usable 5VDC with enough amperage to drive both motors and plenty to spare for power consumption on the circuit board. Once the Basic Stamp receives this five-volt supply, it comes to life and begins automatically running its stored program.

The total cost for the project is $265.50. Some of the components are either donated or salvaged. For example, the joystick is salvaged from a junked plotter.

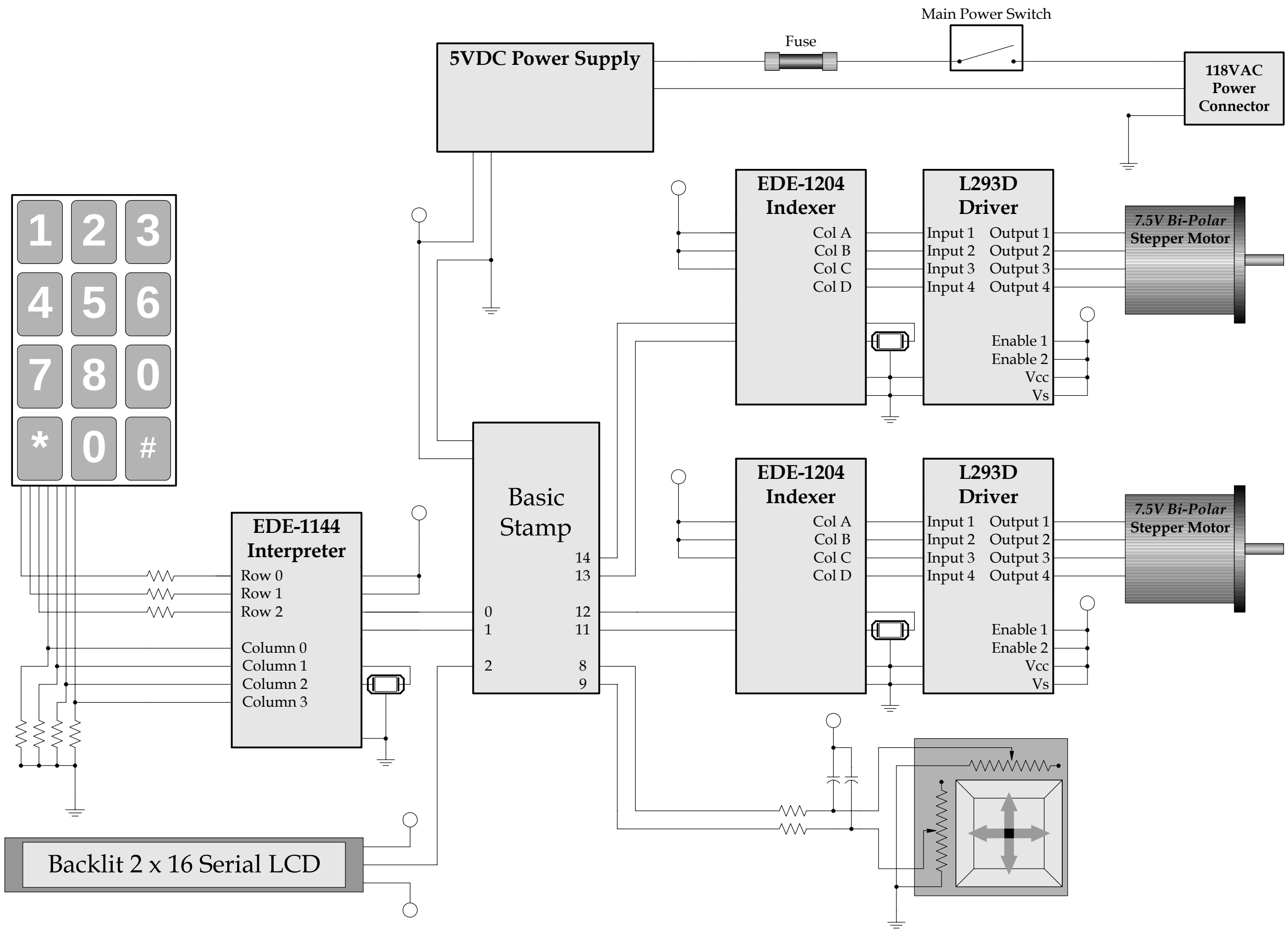

Figure 13.9: Electrical Schematic for Basic Stamp Based Controller.

A MOTORIZED WHEELCHAIR WITH AN OPTICAL GUIDANCE SENSOR SYSTEM

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INTRODUCTION

A low-cost motor assisted wheelchair was designed with an optical sensing device to track on a predetermined path. This device can be used for learning to keep direction under control or just safely riding around. The optical sensing device will serve initially as an alarm system if the wheelchair gets slightly off the track. If the rider keeps riding away from the predetermined path, the motor will shut off immediately. An emergency switch will be placed in the back of the wheelchair, for the supervisor to control, in the event an emergency happen. By switching to off, the power will be shut off to the entire system.

SUMMARY OF IMPACT

This project is a motorized wheelchair with a guidance system for use indoor use.

TECHNICAL DESCRIPTION

The prototype wheelchair developed consists of two DC 24 volts gear motors with their corresponding controllers, a controller interface board, a programmable chip (Basic Stamp 2), LCD display, a joy stick and three sets of optical sensors as input devices. A schematic of the wheelchair system is shown in Fig. 13.10. The general layout of the wheelchair with optical sensors is shown in Fig. 13.11. Fig. 13.12-13.14 show the gear motors, their controllers, and an interface board that receives the signal from the Basic Stamp 2 and sends output to motor controllers for forward and backward motions.

The Programmable Interface Chip (PIC) Basic Stamp 2 is used as the central processing unit. For this particular board, the processor can be programmed by a personal computer using Parallax BASIC (PBASIC) programs. They have fully programmable Input and Output (I/O) pins that can be used to

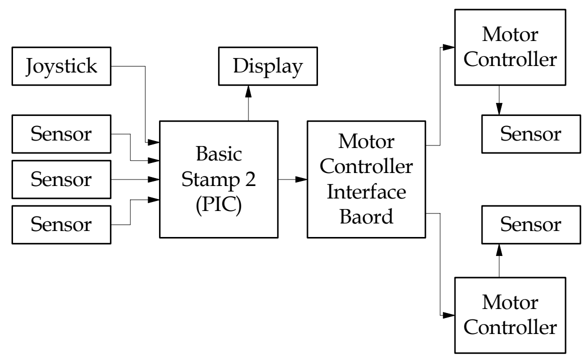

Figure 1310: Schematic of Powered Wheelchair with Optimal Guidance System.

directly interface to TTL-level devices, such as buttons, LEDs, buzzers, and potentiometers.

Two DieHard Lawn and Garden Tractor batteries power the motors and the associated circuitry. A

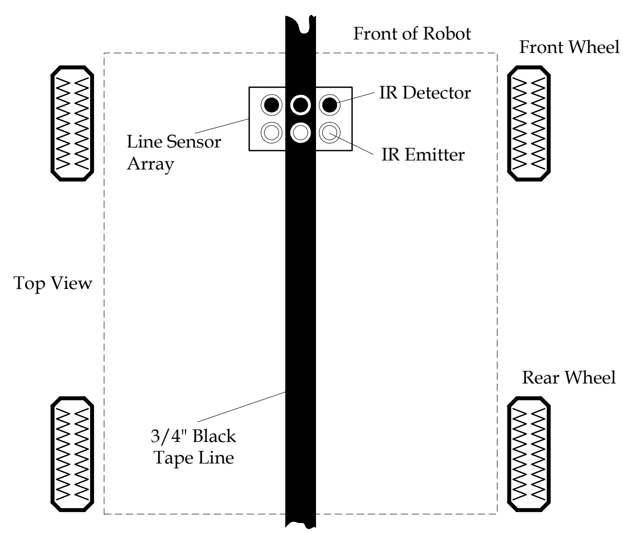

Figure 13.11: Top View of Wheelchair.

Logitech analog joystick is used to control the direction of movement for the wheelchair.

The total cost of the system is $1522.00.

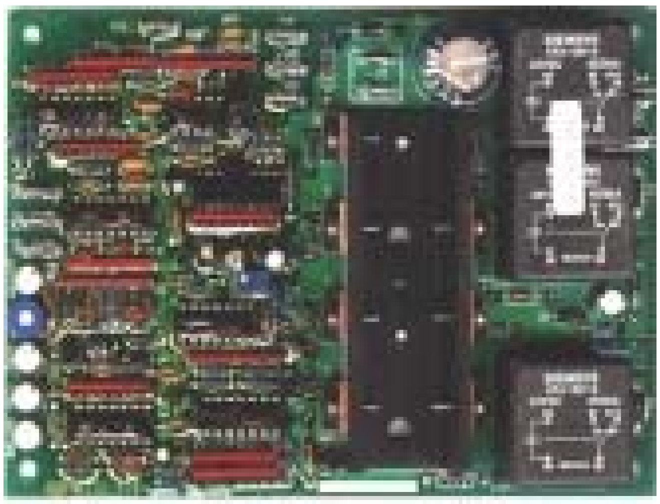

Figure 13.13: Motor Controller MCIPC-24.

Figure 13.12: Two Gear Motors NPC-74038.

Figure 13.14: Motor Controller Interface Board DES 24VMCI2.

R. M. D. WALKER

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INTRODUCTION

The rowing motion driven (RMD) walker is designed for individuals who are incapable of walking for long period of times. The project is designed to help children developing their mobility skills. The individual that this device is intended for has extremely poor motor skills and has a cognitive disability. However, the individual can walk independently but will tend to become fatigued after a certain period. The user can then use the hands for the rowing motion as an alternative for moving the walker. The main goal of this device is to help a single individual become more independent while walking, thus giving the user a greater sense of freedom to move as he wishes. The driving system used to accomplish this task is a four-bar linkage attached to the side of the walker. A literature search for similar products available today in the market revealed that the decision to choose a modified walker is limited. The products available are simple walkers used for walking. The user does not have the option to rest if tired. The alternative is just regular wheelchairs.

SUMMARY OF IMPACT

This project develops a rowing motion driven (RMD) walker/wheelchair combination device. A driving system will assist the individual when he is tired and then the user, seated, can use the rowing motion to move instead of walking.

TECHNICAL DESCRIPTION

The main feature of the RMD walker is the incorporation of a four-bar linkage into a walker that allows the conversion of a rowing motion into the rotation of the wheels. The walker is a Rifton K502 Gait Trainer purchased through a catalog. It is then modified to include two four-bar linkages and two wheels. The main design challenge was to obtain a four-bar linkage that can generate the desired motion and at the same time can be properly and securely mounted on the existing walker. Many design factors have to be considered, such as the Grashof condition, since the four-bar has to be a crank-rocker, no toggle positions present, and the input link rocks the range required to move the walker. We used an Excel spreadsheet to find the most suitable link lengths that met the requirements of the design equations. A plot of input angle vs. output angle was made after the lengths were determined to observe if the movement of the links The simulation software called Working Model was used to simulate the linkage motion (see Fig. 13.16).

Figure 13.15: R.M.D. Walker.

After Working Modeling simulation and verification, the link lengths were determined to be six-inches, 23-inches, 20.5-inches, and 20-inches.

The total cost of the walker is $900.00.

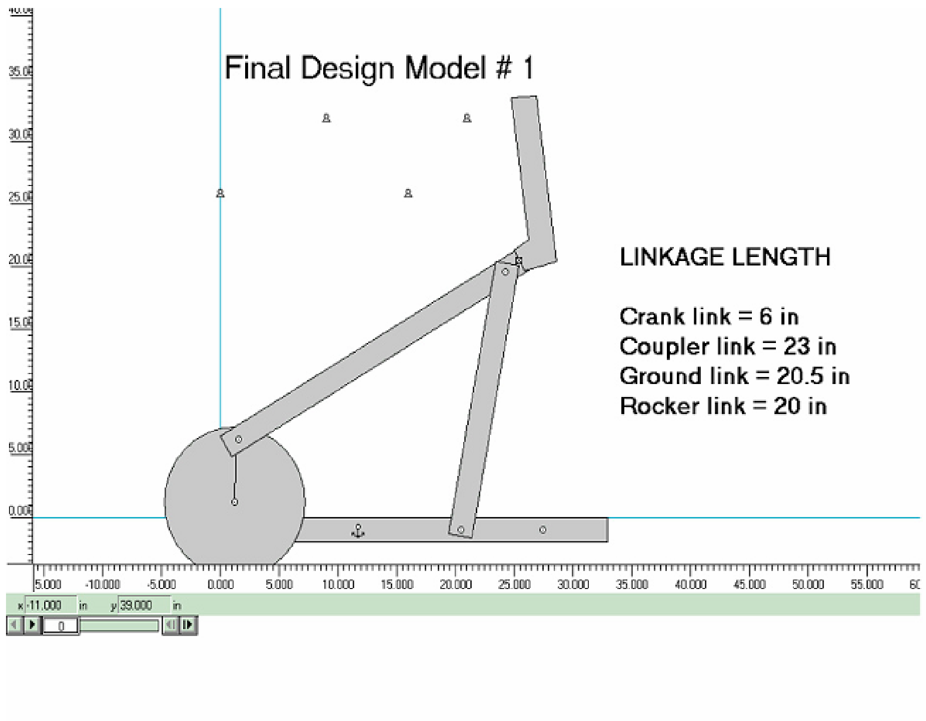

Figure 13.16: The Four-Bar Linkage in Working Model.

ADJUSTABLE ROLLER RACER

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INTRODUCTION

The aim of the project was to modify an existing Roller Racer for a child. The child uses the Roller Racer as her only means of moving around independently. The Roller Racer also contributes to physical therapy goals in strengthening her legs and hips. Since she had outgrown her Roller Racer, this project was intended to make the existing Roller Racer adjustable according to her size.

SUMMARY OF IMPACT

This project modifies an existing roller racer so that it is adjustable and can accommodate the varying size of a child with a disability as she grows up.

TECHNICAL DESCRIPTION

The original Roller Racer is patented by W.E. Hendricks in 1972 and is marketed by the Mason Corporation of Tennessee. It is available in amusement parks as a ride for very young children. A child with a disability uses it to move around in the hallway.

The Roller Racer consists of a triangular platform, a handle bar and four wheels arranged in a triangular configuration. The two wheels in the back are fixed to the base of the triangular platform. The front two wheels are very close to each other and are connected to the handle bar. By rotating the handle bar left and right, the weight of the client is used to push the Roller Racer forward in alternating directions. It works somewhat like a sit-down or lie-down skateboard.

In order to make the Roller Racer adjustable, the original handle is removed and replaced with a custom-made, adjustable handle bar. Fig. 13.17 shows the modified Roller Racer in two configurations.

The total cost of the adjustable Roller Racer including labor is $379.00.

Figure 13.17: Adjustable Roller Racer in Original and Extended Configurations.