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Controlling a Power Wheelchair with Machine Vision

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(a) (b)

Figure 1: (a) A wheelchair with a vision system. (b) a close-up with speckle pattern.

INTRODUCTION

Quadriplegia is the paralysis of all four limbs, both arms and legs, as from a high spinal cord accident or stroke. Every year 7,800 injuries occur in the United States, which result in spinal cord related disabilities. Furthermore there are 250,000 - 400,000 individuals in the U.S. suffering from spinal cord injury or spinal dysfunction. The inability of these patients to sustain their lives without assistance deprives them of their basic liberties. The development of a device that will result in assisting quadriplegic patients in gaining more freedom is essential.

The goal of this project is to integrate a machine vision technology into a power wheelchair system so that a quadriplegic client and thereby control the direction of movement of a wheelchair. The machine vision technology employed is developed in house at Stony Brook. The technology, called computer aided speckle interferometry or CASI, was originally developed by Professor Chiang for solid mechanics applications. For this project, the students, under the guidance of Professor Chiang, 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 the 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 Figure 1.

A MS Visual Basic software is developed to capture the five images of the speckle pattern during the 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 Figure 2.

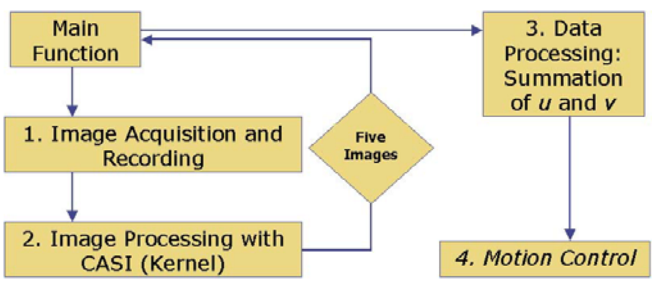

Figure 2: Software architecture.

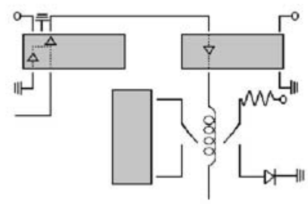

Figure 3: The adaptor circuit.

Shown in Figure 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 was 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 lap top computer and its accessories are provided by the Mechanical Engineering Department.

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 thus can be customized to each individual's accent and choice of voice commands. 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 control the direction of wheelchair movement through the adaptor circuit shown in Figure 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 quadriplegic patients, people that have no motion of all four limbs.

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

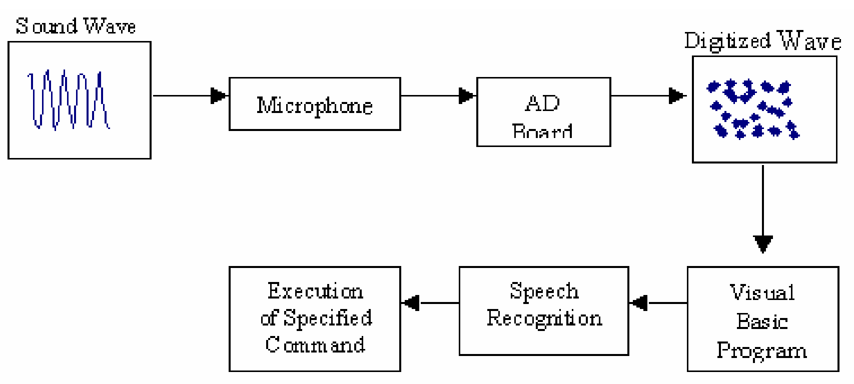

Figure 4: A schematic for the voice recognition system.

activation. Figure 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.

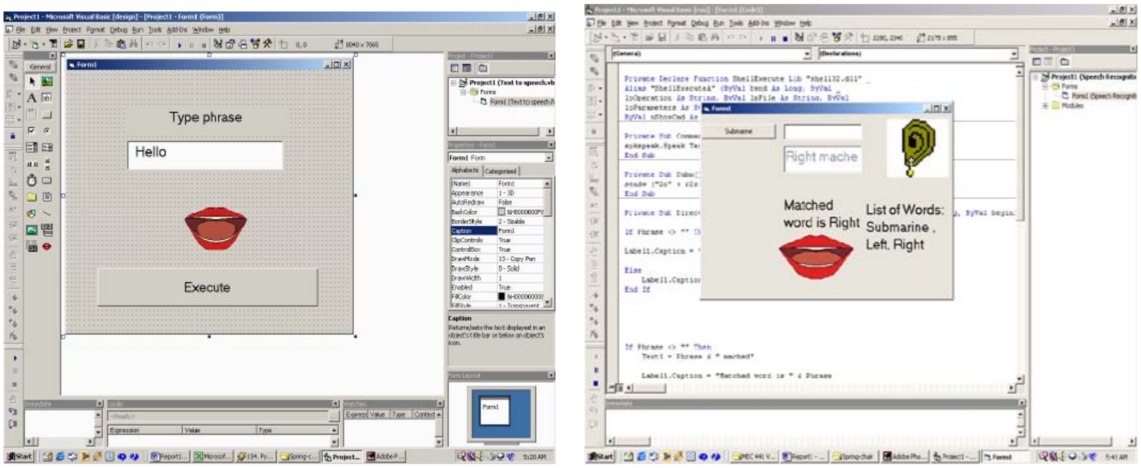

Figure 5: Graphical interface for the voice recognition system.

Figure 5 depicts the visual interface of the speech recognition program. Virtually almost all of computer functions could be accessed by the software. However it was noticed that sometimes phrases had to be repeated and that the user had to be close to the microphone when talking. The accuracy was 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 even more when the selected words were phonetically very different to 95%. 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.

Adam's Pedalo Tricycle

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Supervising Professor: Jeff Ge
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Figure 6: The original Pedalo.

Figure 7: The Pedalo Tricycle.

INTRODUCTION

The pedalo as shown in Figure 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 to increase their 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 would have additional features of a steering mechanism. This pedalo will be designed specifically for a child at the Forest-Brook Learning Center and will be customized for their size and needs. Safety and speed will also be taken into consideration. An overall evaluation of the child's needs and abilities gives the design specifications for the new pedalo.

SUMMARY OF IMPACT

A custom-made Pedalo tricycle for Adam that allows 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 Figure 7 consists of two platforms connected by a set of double-center wheels. The outer wheels of the original pedalo will not be used for this design. This double-wheeled configuration will be 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 will be 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 will be used to drive the shaft of the two back wheels. The front wheel will be used for steering. A handlebar type steering mechanism will be used to steer the front wheel. Additionally, Adam's Pedalo will be equipped with removable side handlebars and foot guards, for 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 being 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. All the problems pertaining to the motion of the pedalo-tricycle will be fixed after the end of the semester. However, other modifications can be made to this design to increase its safety and performance when used at the Forest Brook Learning Center.

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 like 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 off the platforms). 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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Figure 8: A microprocessor controlled Etch-Sketch for the bi-manually impaired.

INTRODUCTION

The purpose of this design project centers on modifying the interface to a popular toy called Etch 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 bi-manual coordination to use it. Additionally, the device could be used as a teaching aid, to enhance the cognitive skills of the users, helping them to increase hand-eye coordination, as well as increasing their confidence. It would accomplish this by abandoning the existing interface of two small white knobs, and in their place provide a simpler mechanism such as a keypad, joystick, or palm-activated trackball. Doing so puts a microprocessor between the user interface and the toy and so opens the door to unimaginable uses and future upgrades. To demonstrate the interactivity of such an enhanced toy, the prototype device will allow the user to play a simple game of tic-tac-toe. From that stage in the device's development, it would not be so difficult to conceive other educational uses or even more complex applications by interfacing the device with a PC.

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 Figure 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. Torque would be boosted by fine tooth nylon gears, some of which would replace the knobs on the front of the Etch-A-Sketch. They 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. One nice feature was the LCD display which could act as an operator interface during a game, or as a countdown timer, or even as a screen to read numerical input such as desired X and Y coordinates, or radii of circles.

The full electrical schematic is shown in Figure 9. Power enters the device with a standard three-prong appliance plug like 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 was used on all high voltage lines. The power connector, power switch, and fuse holder were 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 with plenty to spare for power consumption on the circuit board. Once the Basic Stamp receives this 5-volt supply, it comes to life and begins automatically running its stored program.

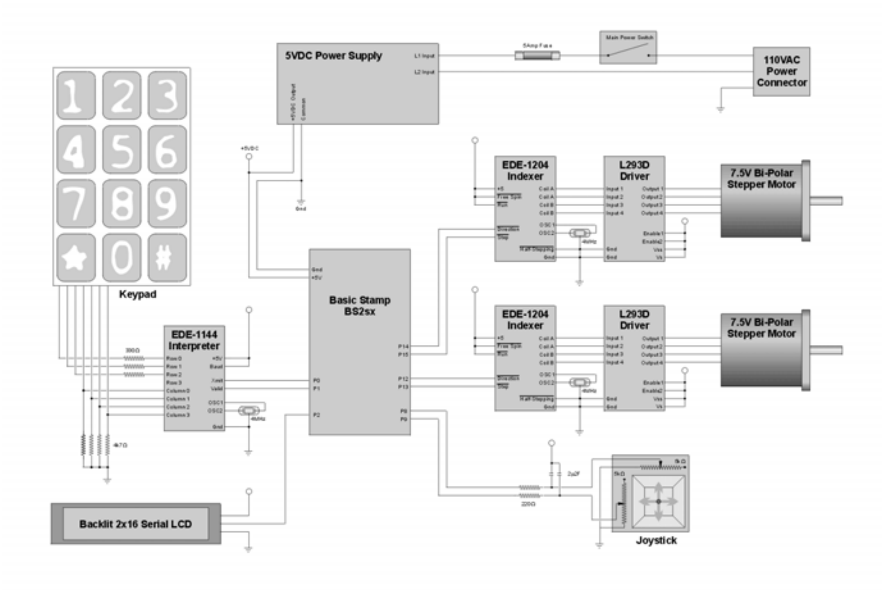

Figure 9: Electrical schematic for the Basic Stamp based controller.

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.

A Motorized Wheelchair with an Optical Guidance Sensor System

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INTRODUCTION

This project seeks to develop a low-cost motor assisted wheelchair with an optical sensing device to track on a predetermined path. This device can be used for learning to keep under control the direction or just safely riding around in the Forest Brook Learning Center. 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 develops a motorized wheelchair with a guidance system for use indoor use in the Forest Brook Learning Center.

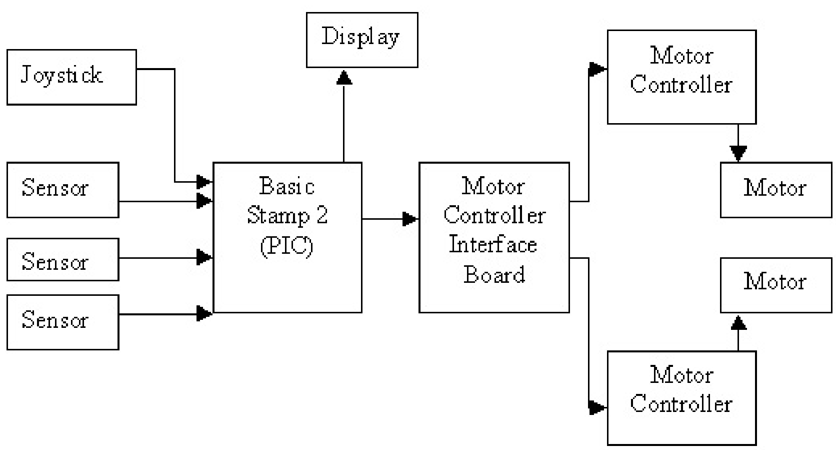

Figure 10: A schematic of the powered wheelchair with optimal guidance system

TECHNICAL DESCRIPTION

The prototype wheelchair we 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, and a joy stick and three sets of optical sensors as input devices. A schematic of the wheelchair system is shown in Figure 10. The general layout of the wheelchair with optical sensors is shown in Figure 11. Figure 12-14 show the gear motors, their controllers, and an interface board that receives the signal from the Basic Stamp 2 and sending output to motor controllers for forward and backward motions.

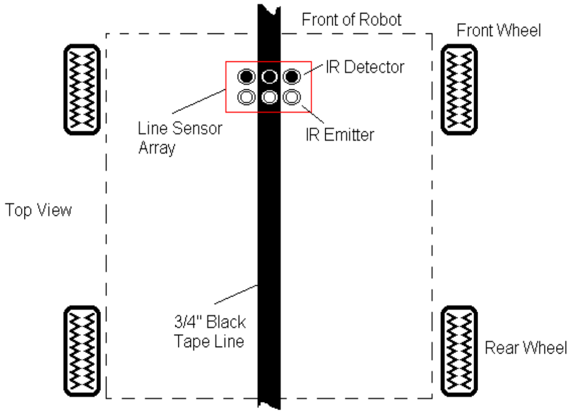

Figure 11: Top view of the wheelchair with 3 pairs of emitters and detectos for line tracking .

Figure 12: Two gear motors NPC-74038

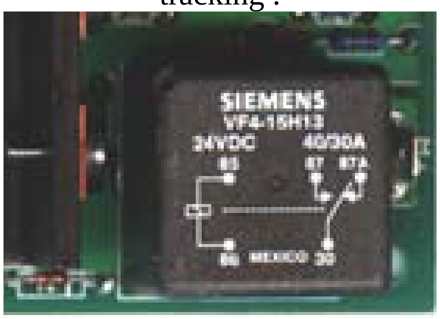

Figure 13: Motor controller MCIPC-24

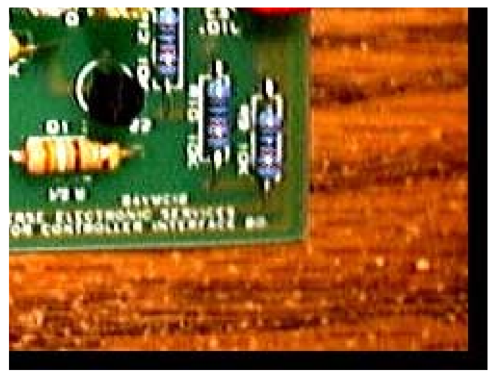

Figure 14: Motor controller interface board *DES 24VMCI2*

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

The motors and the associated circuitry are powered by two DieHard Lawn and Garden Tractor batteries. A Logitech analog joystick is used to control the direction of movement for the wheelchair.

The total cost of the system is $1522.00.

R. M. D. Walker

Students: Marcos Jan Wei Chang, Kim Ng, Paul Redwood
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Figure 15: R.M.D. walker

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 the children at the Forest Brook Learning Center in their mobility skills. The individuals that this device is intended for have extremely poor motor skills and are mentally handicapped. However, the individual can walk independently but will tend to become fatigue 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 they wish. A driving system will assist the individual when he/she is tired and then the user, now seated, can use the rowing motion to move him/her rather than walking. The driving system used to accomplish this particular task is a four-bar linkage attached to the side of the walker. A literature research 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 for the disabled.

SUMMARY OF IMPACT

This project develops a rowing motion driven (RMD) walker/wheelchair combination device for use in the Forest Brook Learning Center.

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 challenger is 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 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 will result in moving the rear wheels. The simulation software called Working Model is used to simulate the linkage motion (see Figure 16).

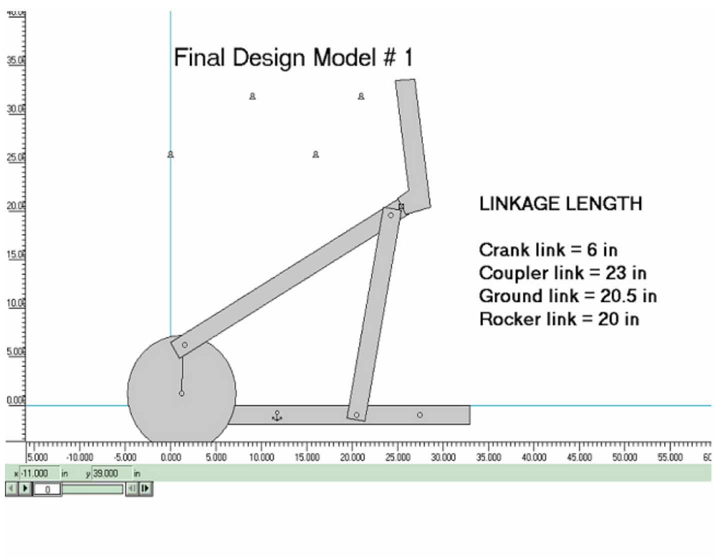

Figure 16: The four-bar linkage in Working Model.

After Working Modeling simulation and verification, the link lengths were determined to be 6-inches, 23-inches, 20.5-inches, and 20-inches.

The total cost of the walker is $900.00.

Design of an Adjustable Roller Racer

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Supervising Professor: Robert Kukta
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Figure 17: The adjustable Roller Racer in original and extended configurations.

INTRODUCTION

The aim of the project is to modify an existing Roller Racer for a handicapped child. The child uses the Roller Racer to move around in the Forest Brook Learning Center. It is basically her only means of moving around independently. The Roller Racer servers also the purpose of physical therapy in strengthening her legs and hips. Since she has outgrown her Roller Racer, this project seeks 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 disabled child as he or 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. In Forest Brook learning center, it is used by a disabled child for her 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, we remove the original handle and replace it with a custom-made, adjustable handle bar. Figure 17 shows the modified Roller Racer in two configurations.

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