CHAPTER 13
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Electronic Eye Gaze Trainer

Designers: Michael J. Coyle, Richard H. Eldridge, and Andrew Ku
Client Coordinator: Penny Polyak, Gorman Elementary School
Supervising Professor: Dr. Chandler A. Phillips
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INTRODUCTION

The Electronic Eye Gaze Trainer is a device used to teach ocular focus and tracking. These skills are necessary to perform more complicated tasks such as reading. The traditional eye gaze training unit is primarily a board upon which several different object or pictures can be mounted. The therapist chooses an object, and then gives verbal and/or nonverbal clues, leading the student to select the object. In this way, the child learns to scan the objects for the appropriate selection, to identify the correct object, and to confirm that he or she has comprehended the therapist's clues.

The shortcomings of previous eye gaze training tools are evident when a student with a speech disorder is using the unit. In some cases, students are unable to use speech to indicate comprehension. Thus, therapists often rely on students' non-verbal communication, such as smiling, to serve as a response indicator. However, neuromuscular problems associated with cerebral palsy initially prevented a particular child from focusing on and tracking objects, and also made it difficult for him to communicate non-verbally. Even reliance on his facial expressions was problematic given the inconsistency of his expressions due to motor control problems. An eye gaze system was developed to enhance his communication ability and to facilitate his oculomotor training.

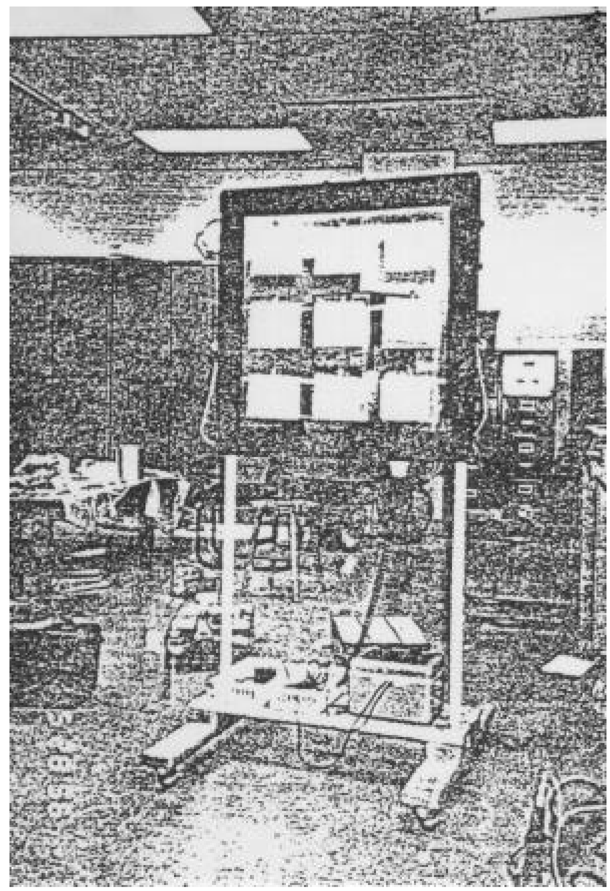

Figure 13.1. Electronic Eye Gazer.

The Electronic Gaze Trainer (shown in Figure 13.1) is a clear, shatter-resistant board upon which are mounted eight clear plastic pockets. An LED is fixed beneath each one.

There are three user interfaces. The first is a simple toggle button for the student. The main control unit provides options for a teacher or therapist to customize lesson plans, by selecting the number of items to be used, adjusting the speed at which the LEDs will cycle through the items, controlling the brightness of the LEDs, and selecting the mode of feedback. There are three modes of operation. Manual Mode allows the student to advance the LEDs one at a time across the display board. Hit-Start/Hit-Stop allows the student to initiate automatic LED progression with an initial hit of the student switch, and to stop the LED cycling with a second hit of the student switch. The Hit-Start/Release-Stop Mode operates under the same principle as the Hit-Start/Hit-Stop mode with the exception that the holding down of the student switch starts the LED cycle, and the release of the student switch stops the cycle. The final user input switch is for the teacher. The teacher switch has a toggle switch much like the student switch except that it forces the LEDs on the display board to do the opposite of what they are currently doing. If the student is in Hit-start/Hit-Stop or Hit-start/Release-Stop mode (i.e., if the LEDs are cycling), and the teacher hits the teacher toggle button, the LEDs will stop cycling. If the student gives a command after this point to stop the cycling, the unit will ignore the command since the LEDs have already stopped cycling. A reset button is provided for cases in which the teacher desires to start the lesson over.

SUMMARY OF IMPACT

The Electronic Gaze Trainer is a very reliable tool for teaching ocular focus and visual tracking. The therapist or teacher now has a consistent method to assess whether or not a student comprehends a lesson. It also allows students to communicate with a teacher by non-verbal means. For example, if one of the plastic pouches contained a picture of a glass of water in it, the student could advance the LEDs to that particular field and communicate with the teacher that he/she is thirsty.

The design of input controls and the unit itself entailed the elimination of unnecessary distractions to help ensure that the student's attention will be focused on the lesson.

TECHNICAL DESCRIPTION

The Electronic Gaze Trainer board is made of Lexan and has the dimensions of 30 by 30 inches. The actual working surface area where the eight, clear, plastic pockets and LEDs are mounted measures 24 by 24 inches. A black felt border around the board provides an attractive boundary to the unit while at the same time covering the wires that run between the board and the control box.

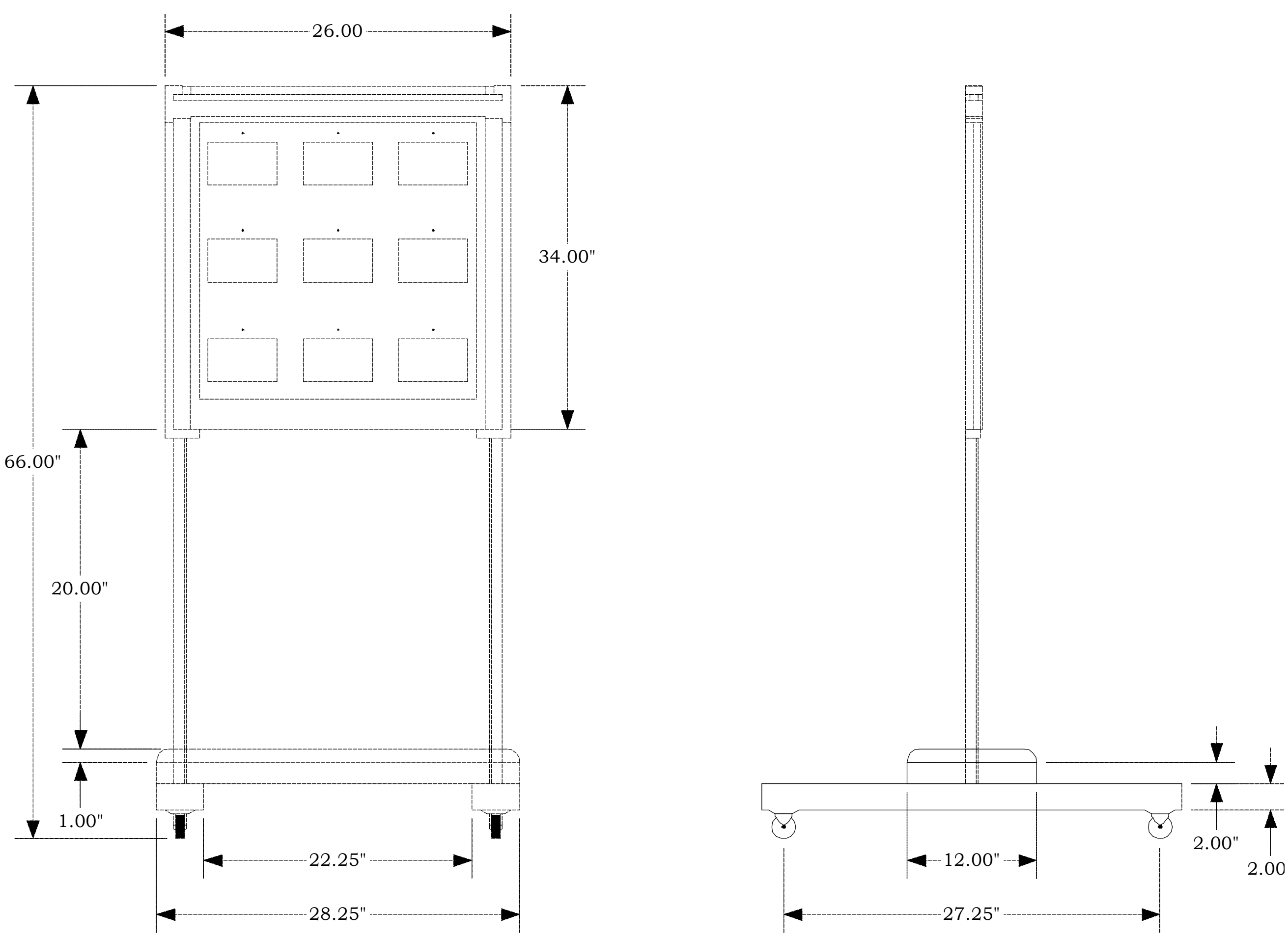

Figure 13.2 Schematic Drawing of the Electronic Eyegaze Trainer.

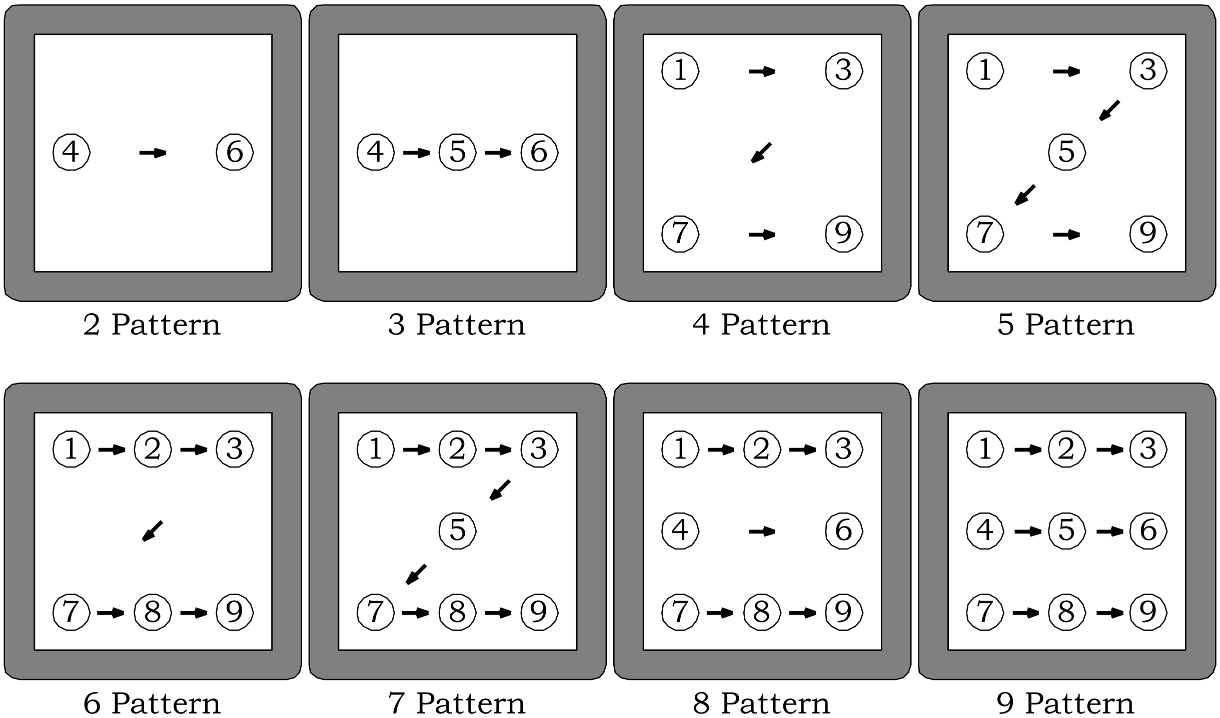

Figure 13.3. Available Patterns

The board is mounted on an adjustable garment rack such that the center of the board can be adjusted from a height of four feet to six and one-half feet. The height of the rack can be adjusted by pulling the lynch pins from the side of the display board's support legs, and raising and lowering the unit according to a marked color coding scheme.

The base of the Electronic Gaze Trainer is composed of two stainless steel legs, two wooden extension legs, a wooden baseboard that lies on top of the extension legs, a wooden crossbar between the two extension legs, four small wooden spacers, and four rubber locking wheels on each end of the extension legs. All wooden parts are coated with polyurethane for a professional appearance and protection from scratching and water damage. (See Figure 13.2 for dimensions.)

In order to operate, the teacher should turn the mode knob, pattern selector knob, speed selector knob, and brightness control dial to the desired positions. Of the three knobs, only the brightness control dial is a smooth turn potentiometer. The speed selector dial sets the time that each LED stays illuminated. These times can vary from one to ten seconds. There are eight patterns available, depending on the number of items to be used. (See Figure 13.3)

The digital hardware of the system is based on the Motorola 68HC11- 811E2 microprocessor. The 'DATA' and 'MAIN' sections of the assembly code set the input/output addresses and subroutine location; they are responsible for the initialization of variables. Once the unit is turned on, the program continually runs and cycles through subroutines that check port E for user inputs. Once user input has been found, the program continues execution. The Electronic Gaze Trainer can run for 50 hours between charges.

The timing for the LED display is handled by an external 555-timer, and the analog-to-digital signal processing is performed by an Instrument-to-Microprocessor-Interface Board (ITMI). The ITMI is a PC board with six primary sections etched onto it, one for each input knob, one for the teacher and student switches, and one to handle the output. The LM555, an oscillating IC configured as an astable multivibrator, handles speed selection by converting the dial-switch input to a one of ten preset resistor values from a resistor bank. Since 555-timer output is low, it is first put through a NPN transistor that acts as a switch between Vss and the microprocessor. The 555-timer output is very close to the lower range of logical high (0.8 Vss to Vss +0.1 volts). The lowest possible logical high would be 4.0

volts. The timer only outputs about 4.3 volts. An additional complication is that the output voltage drops at a steeper rate than Vss itself. In order to account for battery drain, a NPN transistor is used as a switch between Vss and the ITMI board's output. Therefore, the microprocessor always registers 100% Vss as this component's intended logic high.

The microprocessor uses three ports to accommodate the various inputs and outputs required by the design criteria. Port B is devoted entirely to the LED output while Ports C and E deal with the external clock and user inputs as interfaced with the ITMI (see Figure 13.4).

The total cost of the Electronic Eye Gaze Trainer is $564.

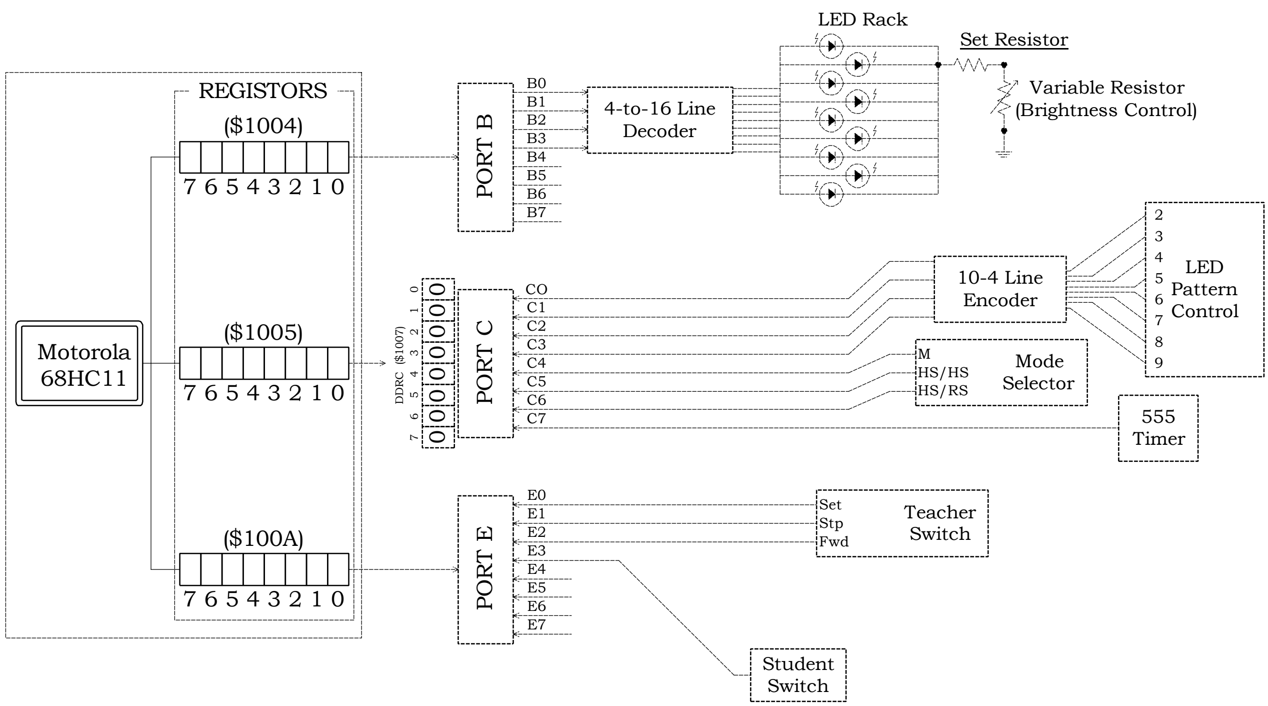

Figure 13.4. Pin Connection for the Motorola Microprocessor.

Dust Mop Lift and Attachment Mechanism for an Electric Wheelchair

Designer: Charles P. Stumpf
Client Coordinator: Terrain Harrison, Meadowdale High School
Supervising Professor: Dr. Reynolds
Department of Biomedical and Human Factors Engineering
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INTRODUCTION

The Dustmop Lift and Attachment Mechanism for an Electric Wheelchair was designed for a student at Meadowdale High School. Part of the education process at Meadowdale involves preparing the students for the work force after graduation from high school. Teachers are helping this client prepare for a janitorial position in which he will sweep hallways and gymnasiums. The teachers at Meadowdale have begun strapping a dustmop onto the front of his wheelchair with bungee cords. The client sweeps the floors by pushing the dust mop up and down the hallway with his electric wheelchair. Because the alignment and position of the dustmop and handle must be constantly monitored, and because another person must raise the dust mop in order to leave the sweepings behind, this method is time consuming for supervising teachers and assistants.

The Dust Mop Lift and Attachment Mechanism for an Electric Wheelchair is easy to install and remove, holds the dustmop in the proper sweeping position, and can be operated independently by the user.

SUMMARY OF IMPACT

The Dustmop Lift and Attachment Mechanism for an Electric Wheelchair met all the design requirements and exceeded the expectations of the project. This product will enable the client to further his vocational skills during his senior year of high school, increasing his independence and potential to graduate with a well-defined skill.

TECHNICAL DESCRIPTION

The moving mechanism responsible for raising and lowering the dust mop is a 12-volt linear actuator affixed to an A-frame attachment mechanism. Two permanent attachment brackets mounted to the cross members beneath the wheelchair provide attachment points for the A-Frame via allen head screws. The brackets are 0.70 inches deep, allowing the cross member to extend 0.05 inches past the back of the bracket.

The CALA 33-150 actuator from SKF International Corp. comes with a force/direction control card capable of limiting the amount of thrust delivered by the actuator. In this case, the actuator was limited to 20 per cent of its 300-pound linear thrust. The actuator operates in the range from 12.5 to 16.5 inches in the closed position, achieving proper clearance of the wheelchair foot rests while providing the needed range of motion to raise and lower the dustmop.

Because the mop is attached to an adjustable-length extension arm with springs, the dust mop attachment accommodates torsional and vertical forces applied during use. The extension arm is attached to the A-Frame mechanism via a removable pin used as a pivot point. When the mop is on the floor in the sweeping position, the extension arm allows the mop to turn 180 degrees while leaving a three-inch clearance in front of the wheels, thus preventing the mop from being caught beneath the chair.

The electrical controls consist of an operational switch, a force control card, position control switches, and a battery. A two-pole momentary switch with two ON positions allows users with limited motor skills room for error in controlling the device. The adjustable control switches keep the range of motion regulated, which prevents the user from driving the mop into the ground, an action that could cause the wheelchair to tip over. The relays provide current direction control thus determining whether the mop is lowered or raised. (See Figure 13.5).

The safety factor for a head-on collision of the unit with a wall or stationary object, based on a user load of 250-pounds traveling at three feet per second, is six. The adjustable extension slide on the extension arm will give way well before the actuator can be damaged.

The total cost of the Dustmop Lift and Attachment Mechanism for an Electric Wheelchair is $1163.

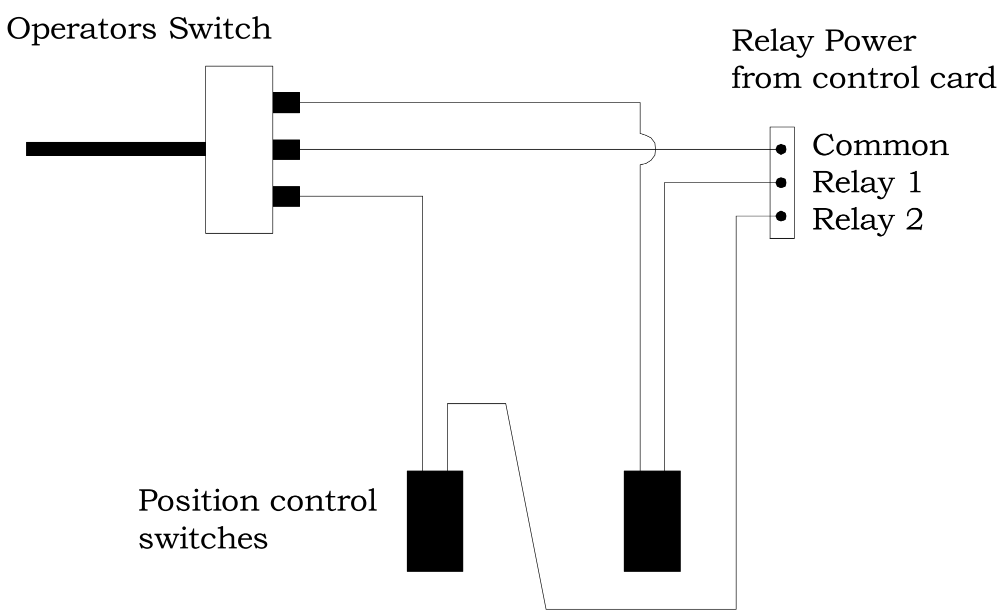

Figure 13.5. Wiring Diagram for Operators Switch and Position Switches.

Upper Extremity Device for a Patient with Brachmann-de Lange's Syndrome

Designers: Dax Pitts, Annette Seger, Sue Seitz, Jason Shearn
Client Coordinator: Debra Vodde
Supervising Professor: Dr. David Reynolds
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INTRODUCTION

This upper extremity device (see Figure 13.6) is a custom made unit designed to assist a student with Brachmann-de-Lange's syndrome. Brachmann-de-Lange's syndrome involves multiple physical malformations, including small arms with hypoplastic forearms flexed at the elbows, and malformed hands and fingers. This device was designed to enable the client to become more independent. Before the device was created, he used his elbows to perform several functions. His performance was awkward and inaccurate. No other assistive devices of this nature have been developed. Traditionally, complete prosthetics have been used for upper extremity deformities. Unlike prosthetics, the Upper Extremity Device for a Patient with Brachmann-de Lange's Syndrome is an adaptive arm device that allows the user to operate in a familiar manner.

Attachment units were designed for the client's right and left arms. The orthotics is made of Bulk Neoprene and is strapped to the child's arms with Velcro. Three metallic stays are sewed into the device, parallel to the client's forearm, for stability. The stays are enclosed in a pocket of material with a small snap at the top, allowing for easy removal. A harness connects the right and left components. The harness runs in a criss-cross fashion across the client's back and chest. D-rings are used to adjust the straps for stability and tightness.

In order to enable the child to become more independent, attachments (i.e., writing utensils, spoons, cups, and paintbrushes) are covered with Velcro and fastened to the upper extremity device. This allows for easy change of the attachments depending on the needs of the user.

SUMMARY OF IMPACT

The Upper Extremity increases the client's independence by enabling him to perform a variety of

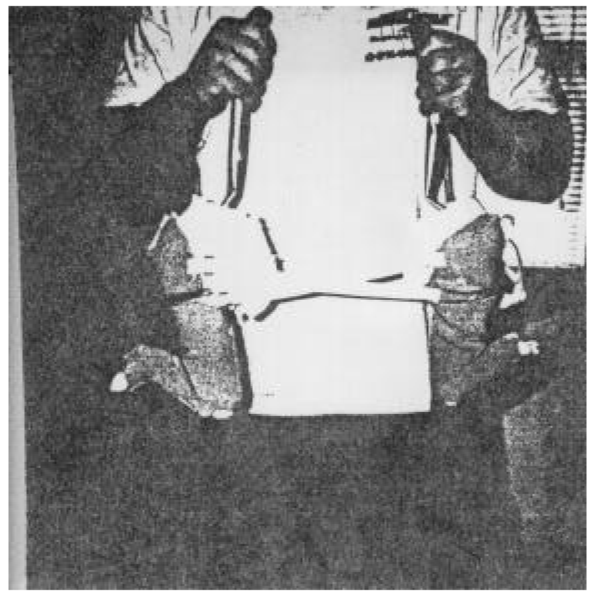

Figure 13.6. Upper Extremity Device for Brachmann-de Lange's Syndrome Patient

tasks such as eating, writing, turning pages of a book, and using a computer keyboard with more accuracy and without additional help from his therapist or teacher.

TECHNICAL DESCRIPTION

The upper extremity environmental interface device is a soft unit designed for comfort and safety. It is made of Velcro loop on one side and neoprene on the other. Attachments can be affixed simply by covering their ends with the opposite-mesh Velcro surface. The sleeves cover the child's arms from his single finger up to his shoulder. The harness and stays are for stability, especially when the sleeves are used to work with heavy objects. The finger area remains open, allowing finger mobility. The elbow area also remains open to allow for sensory input. At the shoulder of the sleeve, a harness is attached with Velcro straps, two in front and two in the back. The straps are criss-crossed in both the front and back and are secured using D-rings (composed of stainless steel rings and Dacron flaps). Three aluminum stays can be snapped inside pockets on the sleeves for stability. The stays are located on the posterior and lateral side of the humerus and the anterior side on the forearm. All of the stays run parallel to the axis of the bones.

Bulk neoprene is a non-isotropic material, meaning that the orientation of the material determines the properties. The material is sewed together in a fashion that allows the fibers to run parallel to the applied forces. The large Velcro areas increase the Young's modulus of the composite material and provide a large surface for instrument attachment.

The total cost of the Upper Extremity Device for Brachmann-de Lange's Syndrome Patient is $680.

Self-Testing Sorting Bins

Designers: Michael Bristow, Teresa Crase, Kristie Johnston, Rachel Beyer
Client Coordinator: Linda M. Comer, Gorman Elementary
Supervising Professor: Dr. Ping He
Department of Biomedical and Human Factors Engineering
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Introduction

The Self-Testing Sorting Bins (see Figure 13.7) enable children to engage independently in a learning activity. Students sort colored disks into corresponding matching colored bins. The sorting activity is used to teach the students to differentiate between items that are "alike" and "different". When a child correctly sorts an item, he or she hears one of four random affirmative teacher voice recordings. Additionally, green lights are illuminated for correct sorting, and a corrective buzzer and red lights are activated for incorrect sorting.

The device eliminates the need for direct guidance and feedback. Prior sorting bins are based on two colors whereas this system works with two or three colors depending on the instructor. One of the major disadvantages of previous methods was the requirement for teacher feedback regarding the student's object placement. Another disadvantage was the use of colored toys that often distracted the student.

Summary of Impact

The Self-Testing Sorting Bins was successfully implemented as a teaching aid in a classroom. The design goals were met in that the Self-Testing Sorting Bins allows students to select disks of different colors, place them in bins of corresponding colors and respond as to whether or not the correct selection was made. Headphones were provided in order to keep the unit from being a distraction to children not using it. Bright lights provide visual stimulation to those that are visually impaired.

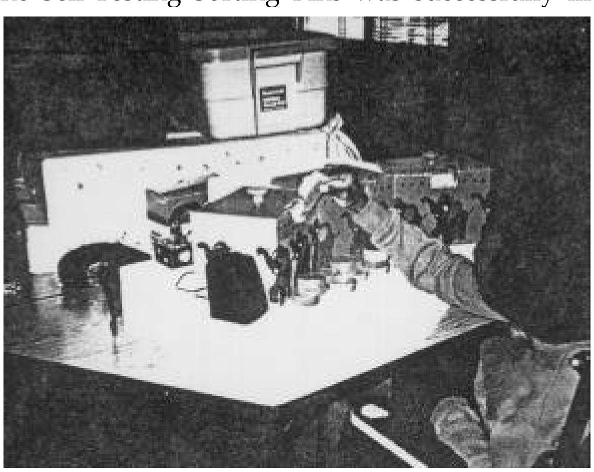

Figure 13.7. Self-Testing Sorting Bins.

Technical Description

The Self-Testing Sorting Bins contains three 6.0 by 8-inch cube boxes of different colors with slots in the front. The bins sit on a four-inch-deep drawer, which catches chips after they have been sorted. The bins are positioned radially to accommodate a child with a 23-inch range of motion (see Figure 13.8). The disks are sorted mechanically based on a very small size differentiation.

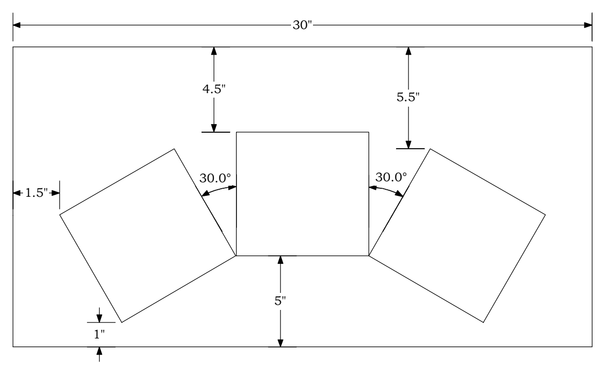

Figure 13.8. Top View of Bin Placement.

All disks are too large to fit in a child's mouth. Disk were made in a series, with each progressively 1/16 of an inch larger in height. The size differences are small enough not to be detected by a child, but sufficient for mechanical differentiation. The disks pass through a series of "bridges." Each time a chip passes a bridge, a switch is closed on the switch circuit (see Figure 13.9) indicating that one of the tests has been successfully completed by the disk. Of the three switches per bin, only one is wired to positive feedback while the other two are wired to negative feedback.

The feedbacks are connected to a sound chip and the lighting circuit. The sound chip enables the teacher to record four messages of two seconds each. One of the four messages is played back as positive feedback for the student.

The total cost of the Self-Testing Sorting Bins is $403.

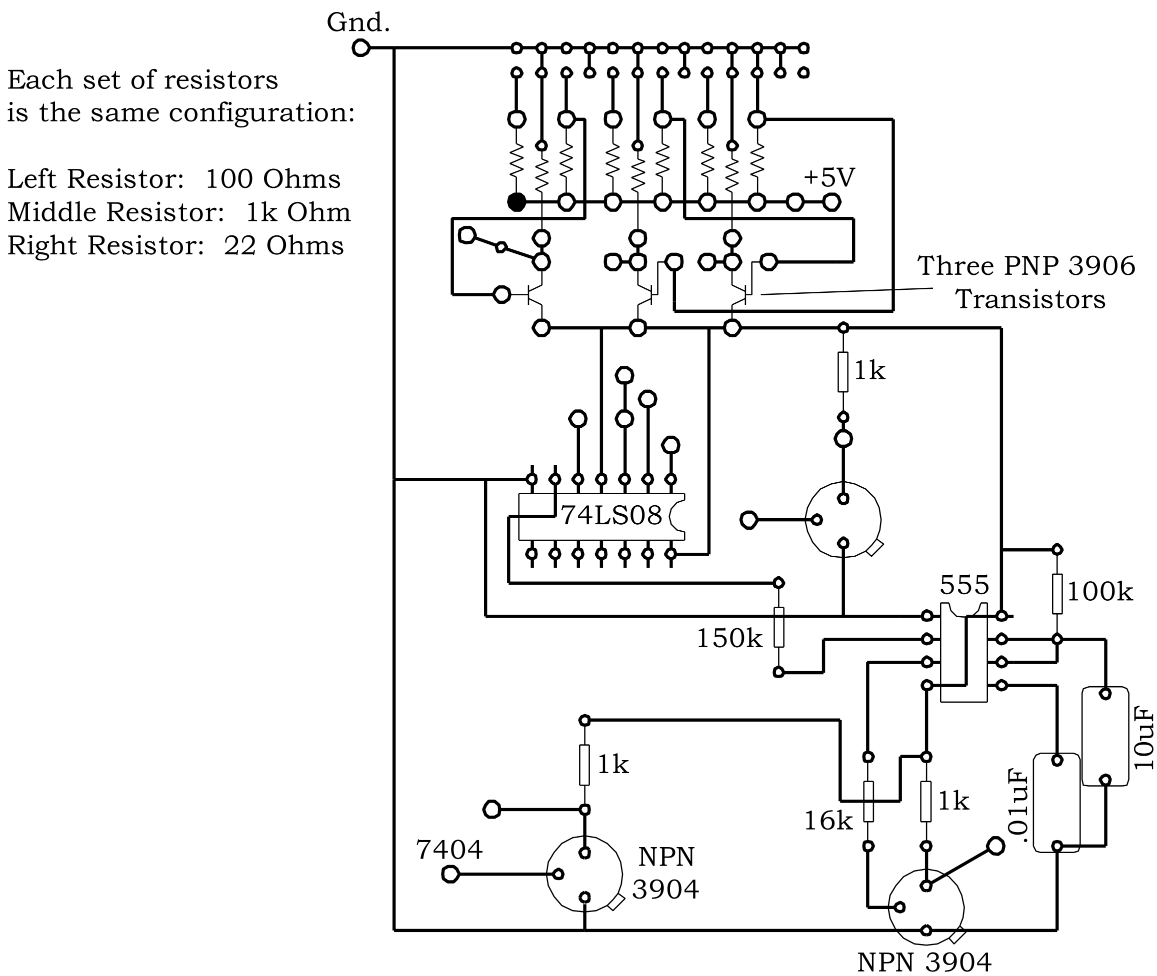

Figure 13.9. Switch Circuit.

Bus Stop Signaling Device: An Example of Audible Signage Technology

Designers: Steve Belcher, Chris Groff, Stephen Tippin
Client Coordinator: Ron Dafler, Miami Valley Regional Transit Authority
Supervising Professor: Dr. Blair Rowley
Department of Biomedical and Human Factors Engineering
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Introduction

The Bus Stop Signaling Device for People with Visual Impairments Project was designed in response to a need communicated by representatives of the Miami Valley Regional Transit Authority (RTA) and its customers. Their aim was to enhance bus stop accessibility and mobility for RTA customers with visual impairments. Currently, people with visual impairments must rely on other people to convey information about buses and bus stop locations, limiting their independence and creating potentially dangerous situations. Existing projects addressing this problem have fallen short in meeting directional/orientation needs, and require a continuous power supply for continuous transmission. They are also too complex for practical purposes and too costly to build and/or install. Further, they do not adjust to ambient volume conditions, and require users to wear headphones or other cumbersome devices.

The Bus Stop Locator enables visually impaired bus riders to locate and identify bus stops through a unit the user carries. The user unit contains two transmitters labeled V (voice) and T (tone). The first transmitter sends out a signal in all directions, which is picked up and decoded by a unit at a bus stop. This bus stop unit then emits an audible sound, thereby allowing the visually impaired person to orient him- or herself and move toward the bus stop. The second user transmitter is for when the visually impaired person has arrived at the bus stop. When the second transmitter is activated, the bus stop unit provides pertinent information audibly, detailing times and routes.

Summary of Impact

The Bus Stop Signaling Device meets the following design requirements: one transmitter unit works with multiple bus stops; radio waves are used for activation; it has a range of 50 feet; it interferes minimally with surrounding radio units; it will hold up under regional weather conditions; sound output creates a minimal disruption for the public; and on the transmitter unit has easily identifiable buttons for visually impaired users.

Technical Description

The bus stop unit contains a small microphone located at the bottom right rear of the box to detect surrounding sound levels. The microphone current of 0.45 volts peak-to-peak is run through the LM386 op amp (possible gain of 200) into the RMS-to-DC converter, which requires an input of five to 12 volts. This CMOS device calculates the root mean square value of a sinusoidal signal and outputs a pre-determined DC level. This signal enters the SMP04, which holds the voltage, until a trigger signal from the user unit is detected. A 555-timer keeps the trigger to the SMP04 high for the duration of the message (approximately 10 seconds). Keeping the trigger high eliminates the need for feedback. Output of the SMP04 directly controls the level of attenuation on the digital message by a NPN transistor and FET. The transistor acts as a voltage inverter for control of the FET attenuation so at small SMP04 outputs attenuation increases, and decreases as SMP04 output levels increase. The signal enters a 1458 summing amplifier after leaving the SMP04. When the user button is depressed, the signal can be seen at the base of a NPN transistor. When there are +12 volts at the collector of the transistor, the sonalert is sounded. The sonalert draws approximately 70 mA and the maximum current limit of the bilateral switch is 25 mA. A transistor is used to allow the sonalert to draw as much current as necessary. (Figure 13.10) The digital message playback chip (VM1110A) holds a message of ten seconds in length. When the chip is activated, a recorded message is sent to the same transistor network mentioned above.

The bus stop unit uses an AC primary power supply with a battery back-up. If the AC source is working, the single-pull double-throw relay is switched to enable current to flow from the AC source. If no AC source can be detected, the switch flips to allow the unit to draw current from the battery. The AC source is the standard 120-volt street supply voltage run through a 16-volt transformer, which then passes through a full wave rectifier to make a DC voltage source. The back-up battery source is a 12-volt, 3Ah gel cell battery, which is recharged through the UC2906 recharging chip.

The cost of the Bus Stop Signaling Device is $298.

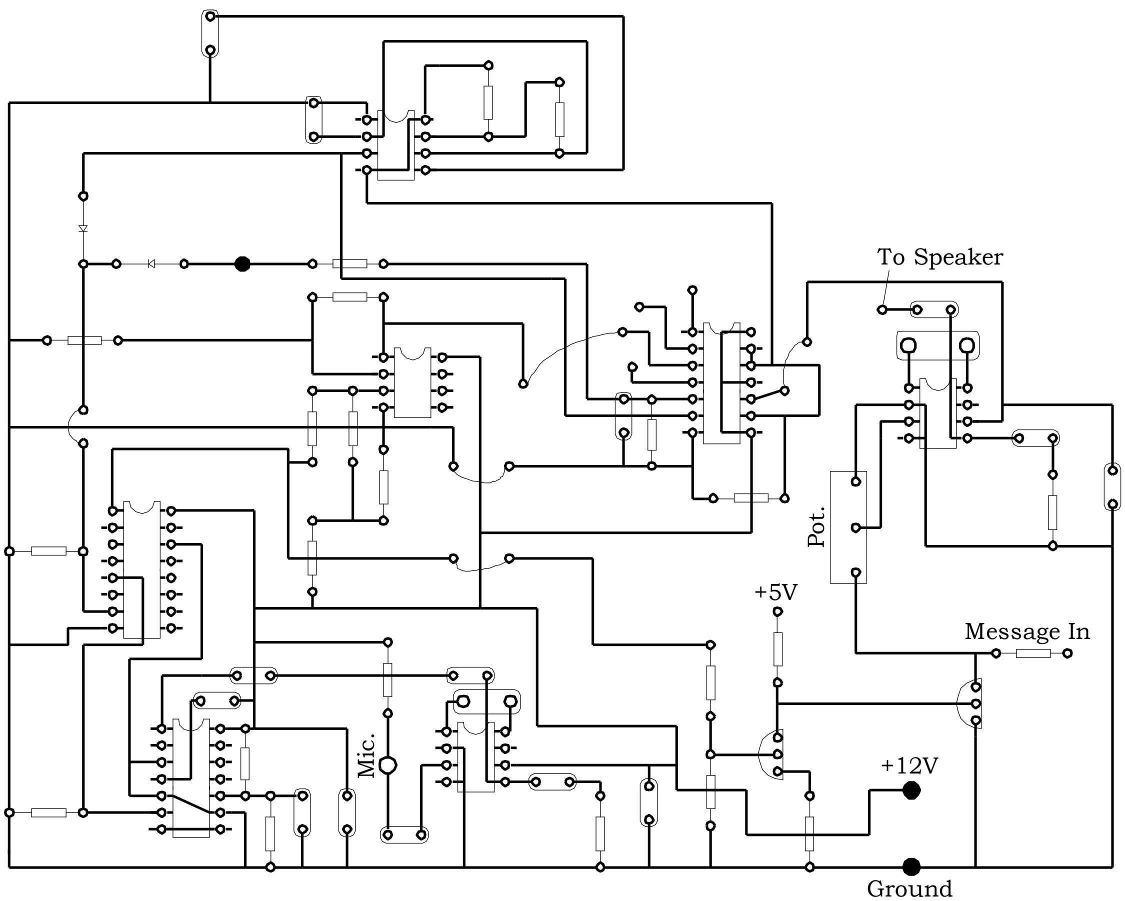

Figure 13.10. Circuit Diagram of Volume Control Circuit.

The Side Kick Environmental Control Unit

Designers: Chris Leigeber, Paul Schaefer, Travis Workman, and Lisa Wurst
Client Coordinator: Dan and Teri Larkin
Supervising Professor: Dr. Blair Rowley
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Introduction

The Side Kick Environmental Control Unit (see Figure 13.11) remotely controls a television, VCR and five sets of lights in the user's home. The unit is designed for a client with cerebral palsy. This condition impairs his movement, thus making him dependent on others to perform common activities, such as turning on lights, and his television and VCR. The Side Kick provides Nathan greater control over his surroundings, thereby increasing his independence.

The majority of environmental control units are of the basic X-10 unit type, which control appliances via radio signals. The Side Kick is a single unit that has seven controls built in for the user. The seven controls perform 16 functions: turns TV on and off, controls TV volume, changes the TV channel, turns the VCR on and off, stops VCR, plays videotape, fast forwards video, rewinds tapes, pauses tapes, and turns hallway, bedroom, kitchen, family room, and bathroom lights on and off. The keyboard part of the control unit has guards around each key, preventing the client from accidentally pressing a non-desired button as he drags his hand across the keyboard surface. The Side Kick is mounted to the wheelchair tray for stability and accessibility

Summary of Impact

The Side Kick environmental control unit has been successfully designed to perform all 16 desired functions. The user is able to learn the key functions quickly, and enjoys operating the environmental control unit. The Side Kick has increased the user's independence, allowing him to control things he was unable to control previously.

Technical Description

The Side Kick's keyboard is made out of plastic and has dimensions of 17.0 by 10.5 inches. There are 16 square keys, one key for each function. Two LEDs are located in the upper right corner of the keyboard. The green LED indicates that power to the

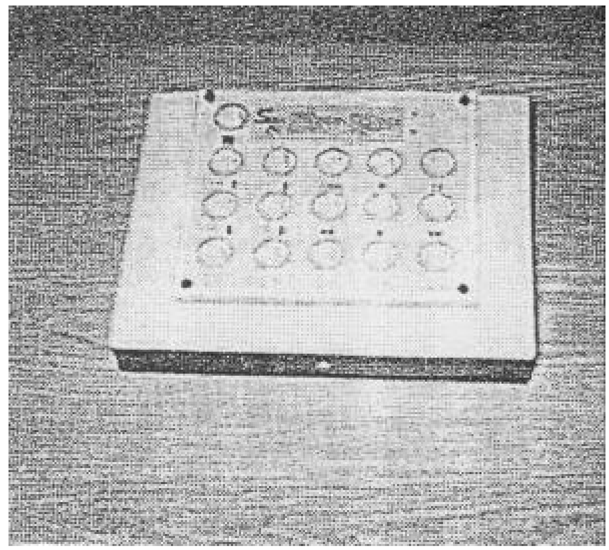

Figure 13.11. The Side Kick Environmental Control Unit.

Side Kick is ON. The red LED provides user feedback as it flashes when a key is pressed. The keyguard is made out of clear plastic with circular holes. The X-10 transmitter, Emerson remote, Leapfrog infrared receiver/radio frequency transmitter, PCB, and power supply are located inside the keyboard. The five X-10 receivers are attached to the respective lights that they control, and the Leapfrog radio frequency receiver/infrared transmitter is positioned with the infrared beam in "line of sight" of the TV and VCR units.

The lights are controlled by the X-10 transmitters/receivers. When the side kick unit triggers the internal X-10 transmitters, a radio frequency signal that is unique to the receiver is transmitted in all directions, eliminating the need for "line of sight." The X-10 receivers are set with a house code and a unit code allowing each to operate independently of any other unit.

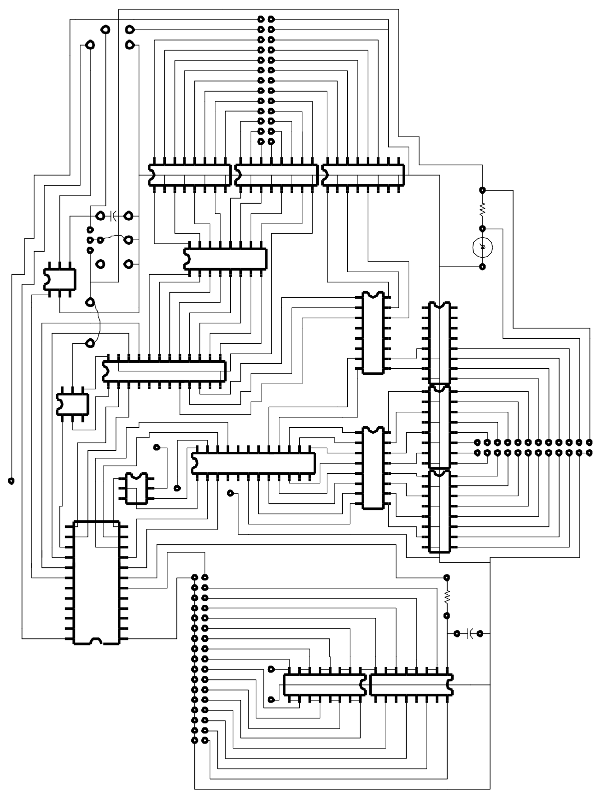

Figure 13.12. Printed Circuit Board Layout of the Environmental Control Unit.

The Side Kick incorporates an Emerson TV/VCR remote to control the respective units. The Leapfrog device, consists of the infrared receiver/radio frequency transmitter housed within the unit and a radio frequency receiver/infrared transmitter located in the TV/VCR's line of sight.

The Basic Stamp II Parallax microprocessor acts as the main control mechanism of the unit. There are 16 I/O pins and an EPROM on the Basic Stamp II microprocessor. RC values are used to determine which key is pressed, thereby enabling 16 inputs and 16 outputs. The program of the microprocessor is in BASIC and continually runs once the unit has been turned on. The microprocessor continually reads RC values to determine which key, if any, has been pressed.

The output from the Basic Stamp II is run through decoders that change the hexadecimal number into a specific signal for the outputting units. The optoisolator switches to the remotes and X-10 units signal when a key has been successfully pressed. The final circuit board layout is shown in Figure 13.2.

A 12-volt 2.3 Ah rechargeable camcorder provides 19.76 days of Side Kick operation when it is left on for three hours per day with a continuous key stroke.

The total cost of the Side Kick Environmental Control unit is $390.

Prosthetic Hand with Electric Motors and Force and Position Sensors

Designers: Joseph Katuin, Angela Slaughter, Donna Jo Therrien, Jeanne Uy
Client Coordinator: Dr. Kuldip Rattan
Supervising Professor: Dr. David Reynolds
Department of Biomedical and Human Factors Engineering
Wright State University
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Introduction

The current project was designed to permit a set of capabilities not available in prosthetic hands currently on the market, that is allowance for: independent movement of each finger; the capacity to "learn" tasks such as writing; safety; a reasonable price; and adaptability to different microprocessors. Prosthetic hands that meet most of these specifications rely on pneumatics to move the fingers, requiring the user to carry compressed air tanks, which may be dangerous.

The Prosthetic Hand with Electric Motors and Force and Position Sensors has three fingers (see Figure 13.13), one of which is opposable, is capable of fine motor skills, contains position and force sensors for feedback, and is interfaced with a microprocessor unit to maximize control and feedback processing. The circuitry has a basic slot-and card layout with lines going back to the microprocessor parallel port. A/D converters with built-in multiplexing further reduce the complexity of the circuitry. Geared motors that supply sufficient torque to move the weight of the finger component and turn slowly enough to minimize overshoot were selected.

This prosthetic hand is unique in that the fingers contain the motor, such that they do not rely on pulleys and pneumatics remote from the fingers. The motors operate on screw drive system, where a fixed bolt is attached to one end of the joint, while a screw head on a motor runs through the bolt and is attached to the other joint end.

Summary of Impact

The prototype Prosthetic Hand with Electric Motors and Force and Position Sensors yielded valuable data with respect to optimizing finger locations, motor positions, ranges of sensors, and the hand's ability to neglect input from the computer, which would result in damage to the unit. The prototype is portable and capable of learning and remembering tasks via a microprocessor.

Technical Description

The motor speeds of the Prosthetic Hand with Electric Motors and Sensors are controlled by non-inverting summing amplifiers, which provide positive voltages to the microprocessor. Velocity is measured based on the position sensor input correlated with the internal microprocessor clock. Motor direction is controlled by relays that are capable of turning the motors completely on or off. As mentioned earlier, the torque is delivered by a screw drive motor installation. The motors are oriented to point towards each other, and one motor carriage assembly is used as a finger tip.

The 0.5-inch diameter Interlink Force Sensing Resistors fit well on the tip of the finger and provide a large enough area for a range of objects to be manipulated. The fingers are made of stamped 18-grade stainless steel (0.0478 inches thick), chosen for its tensile strength.

An interface unit controls six motors, three force sensors, and six position sensors in the hand. A bi-directional parallel printer port from a standard IBM-compatible computer exchanges information. This approach is more cost effective and error-proof than the design of a new card to interface the computer with the prosthetic.

The cost of the prototype Prosthetic Hand with Electric Motors and Force and Position Sensors is $718.

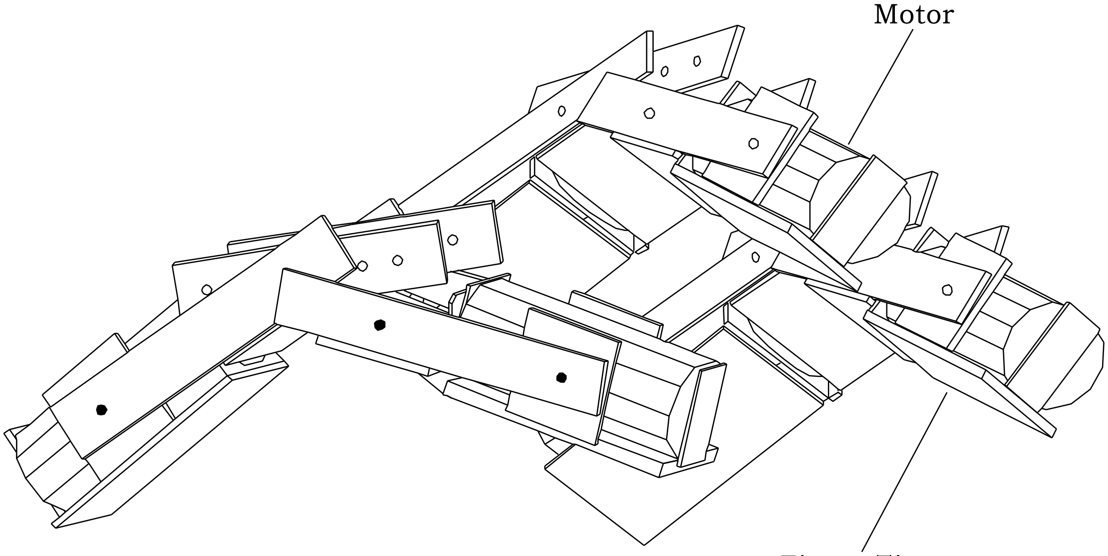

Figure 13.13. Prosthetic Hand with Electric Motors and Force and Position Sensors