CHAPTER 16
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Biomedical Engineering
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SPEAK-N-SEE

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INTRODUCTION

Speak-n-See was designed to enable an individual to view effortlessly indoor and outdoor areas of an apartment from any location within the apartment, mainly for reasons of security. The Speak-n-See device is a complete, portable, wireless video-surveillance system. It consists of three inconspicuously mounted video cameras and a wireless Display/Control Unit. The video signals from the cameras are received and displayed on the Display/Control Unit, which is compact and portable. Through the use of speech recognition hardware, the individual controls all modes of the device -- on/off, color, brightness, tint, and contrast of the display, as well as camera selection.

Figure 16.1. Speak N' See

SUMMARY OF IMPACT

The Speak-n-See was designed with respect to the capabilities of the end user, who in this case is paralyzed from the neck down. Because she is currently confined, a device is required for her to be aware of her surroundings, for instance, a person at the door at the door or something transpiring outside her house. The Speak-n-See, through use of its cameras and display unit, allows the user to view her front and back yards as well as the front door without having to call for outside help. The Speak–n-See is voice actuated to accommodate user requirements, and is portable so that it may be used anywhere. Speak-n-See will enhance the security and independence of the client. It may be useful for any security conscious person.

TECHNICAL DESCRIPTION

The indoor, user-interactive Display/Control Unit contains a color 4-in. LCD display and all other necessary hardware: video receiver, voice recognition hardware, microphone, speaker, and rechargeable battery. The unit is packaged in a durable, compact, plastic enclosure. See Fig. 16.2 for a front view of the Display/Control Unit.

Voice recognition capability is provided by Sensory's Voice Direct TM Speech Recognition Kit. Voice Direct is a speaker-dependent speech recognition module. Each time one of the words is recognized, a corresponding output pin on the module is toggled high for one second. Digital logic is employed to interface Voice Direct with the display functions (power, contrast, brightness, tint, and color) and the video receiver functions (channel selection and power).

The user must train Voice Direct to recognize the desired commands. During this training process, speaker-dependent speech templates are created and then stored for comparison during the recognition process. Training consists of speaking a word and then repeating it for confirmation. Pressing the TRAIN switch initiates training and the user speaks each word in response to an audio prompt.

Recognition is initiated when the RECOG button is pressed. A prompt is spoken and the Voice Direct listens to the word spoken. If the spoken word matches a stored template, then the appropriate action is taken.

Circuitry is employed to automatically "press" the RECOG button approximately once every seven seconds (the fastest rate allowed) after the RECOG button is physically pressed once. In addition, circuitry is used to enable the speaker for approximately two minutes after the TRAIN button is depressed, allowing the user to hear the needed prompts during training. The speaker is disabled otherwise. The idea is to eliminate the audible prompt the Voice Direct produces each time the RECOG button is pressed. Instead an LED is used to inform the user when it is acceptable to speak a command during recognition.

An omnidirectional clip-on microphone is used to provide the interface between the user and the Display/Control Unit).

The display is a color 4-in. Sharp LCD display with viewing area of 80.7 mm x 60.6 mm. Four mechanical potentiometers (for contrast, color, brightness, and tint control) are replaced with Xicor digital potentiometers. A Crydom solid-state relay is utilized to control the power supplied to the display. The relay and potentiometers are interfaced with the Voice Direct hardware via digital logic.

A MATCO Inc. 8-channel-selectable, 2.4-GHz FM, wireless video receiver is employed in this device. Digital logic is utilized to interface the receiver to the Voice Direct hardware, allowing the user to select the receiver frequency and thus the desired camera. (Each of the three camera transmitters are set to different frequencies.) The receiver power is controlled in the same manner as the display power.

Power is supplied to the unit by either an AC-to-DC, 12-VDC, 1500-mA power supply, or by a 12-V sealed Lead-Acid rechargeable battery. The battery is externally connected to the unit and is easily removed.

A battery charger circuit, centered on Linear Technology Corporation's LT1512 Battery Charger chip, was constructed and is set internal to the Display/Control Unit. Use of this battery charger allows several types of rechargeable batteries -- NiCd, NiMH, Lead-Acid, or Lithium -- to be used. The charger circuit allows for operation of the system and battery charging simultaneously if the AC-to-DC power supply is used.

The three-position mechanical switch located on the front of the unit is used to switch between battery power or unit off or AC-to-DC adapter/battery charge.

The Display/Control Unit has RCA connectors located at the back for video and audio (left and right) outputs that will allow, for example, connection of the unit to a VCR.

All circuitry, the LCD display, switches, etc., are mounted in a clear, high-impact, ABS polycarbonate enclosure. The dimensions of the Display/Control Unit with battery are 24.8 cm x 11.0 cm x 14.5 cm.

There are three camera/transmitter pairs. One camera is mounted in an indoor room of the client's home and the other two are mounted in outdoor areas. The video transmitters are all mounted

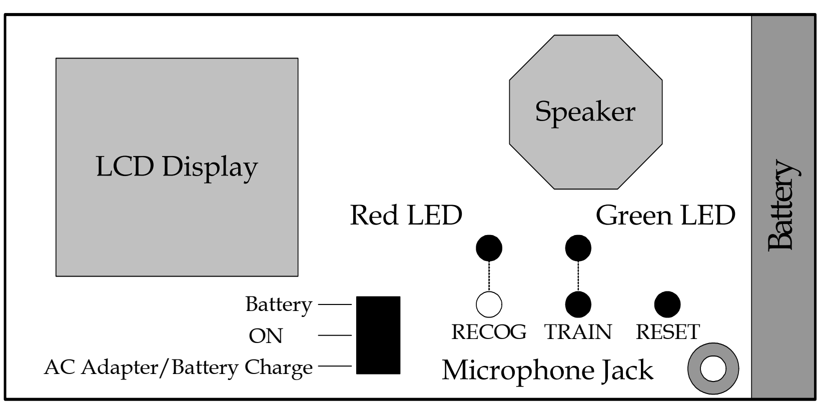

Figure 16.2. Display Unit Front Panel Layout.

indoors.

The indoor camera is an inconspicuous, 1/3" B/W CCD camera. The camera weight is 1.7 oz. and the dimensions are 1 in. x 2.2 in. (diameter x length). The camera is hardwired to the video transmitter. The power supply utilized for both is a 12-VDC, 1000-mA, AC-to-DC supply.

The outdoor cameras are indoor/outdoor CCD cameras. Each camera has a PIR motion detector to activate the camera. In addition, each camera has built-in low-light features and six LED's for low-light visibility. Each also has a built-in microphone and utilizes a 12-VDC, 400-mA supply.

Each transmitter is a MATCO Inc. 8-channel-selectable, 2.4-GHz FM, wireless video transmitter. Each transmitter is set to a different frequency. (The user selects which camera to receive by selecting the corresponding channel on the receiver.) Each transmitter is enclosed in a sturdy plastic 7.8-cm x 14.0-cm x 6.8-cm, wall-mounted enclosure.

The indoor camera is hardwired to its transmitter; however, the other two transmitters have external RCA video and audio connectors so that other types of cameras can be used. The two transmitters that are not hardwired to the cameras each utilize a 12-VDC, 100-mA power supply.

To operate, the user applies main power to the Display/Control Unit by switching the 3-position mechanical switch to the "Battery" or the "AC Adapter/Battery Charge" position. The user must then train the device with appropriate commands (if this is the very first use of the device). Training begins after the TRAIN button is pushed. A total of 10 commands must be trained -- one for video receiver/display power, one for camera selection, two for contrast, two for brightness, two for tint, and two for color. If training is complete (or not needed), the user starts the recognition process by pressing the RECOG button. The user then controls aspects of the device by issuing the appropriate voice command. For example, the user my say "power" to toggle the power to the display and receiver, or the user may say "brighter" or "darker" to adjust the display brightness.

The cost parts/material for Speak-n-See was about $1,100.

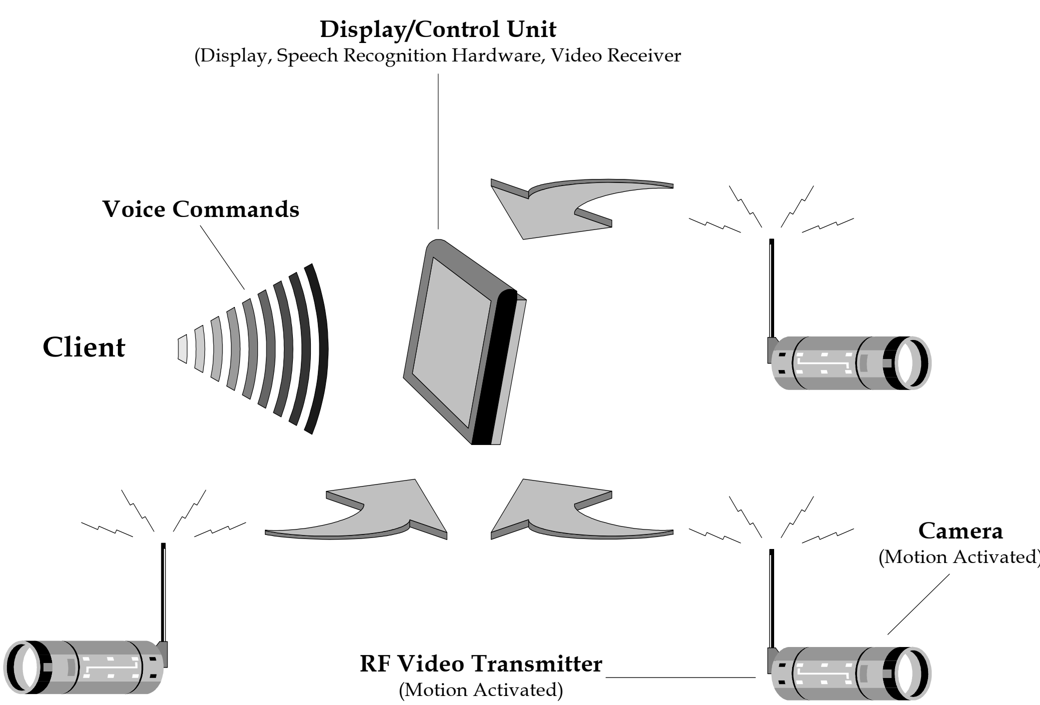

Figure 16.3. Components of the Speak-n-See Device.

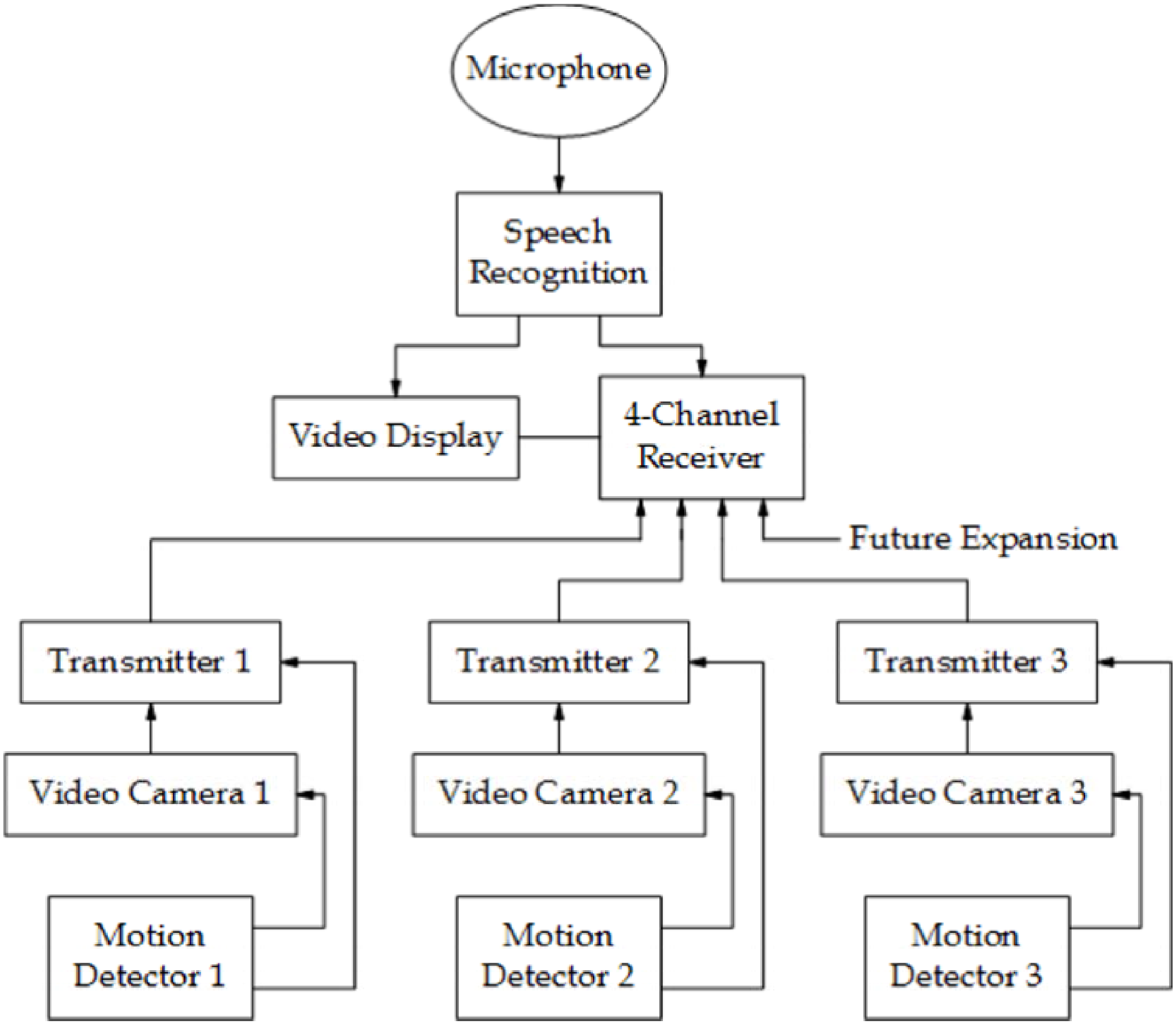

Figure 16.4. Block Diagram of Speak-n-See System.

AUTOMATIC PAGE TURNER

Designer: Ricardo Duncan
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Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Automatic Page Turner is a device that facilitates independent reading for a young girl with multiple sclerosis. The device (Figure 16.5) enables her to turn the pages of a book or any other reading material without the help of an aide. The Automatic Page Turner consists of three major elements. First, an enclosure with a large enough base provides stability for the unit. Second, a rigid book support that can easily be replaced with a binder allows the flexibility of reading either a book or several loose sheets of notes. Lastly, a head switch to activate the device is mounted on the user's chair at a location that does not interfere with the user's range of motion.

SUMMARY OF IMPACT:

Although this device is built to fit a particular client's needs, it can be easily modified to accommodate others with similar physical disabilities. The client is pleased with the device and no longer has to rely on help to turn the page of her reading materials for her.

TECHNICAL DESCRIPTION:

The heart of the Automatic Page Turner is the Z-World Little G (BL 1600) and two Z-World XP 8800 motor control boards. The operating language for these components is Dynamic C.

The microcontroller (BL 1600) detects an input signal from the user that indicates the direction that the user desires to turn a page. The BL 1600 then activates the appropriate outputs. The XP 8800 motor control boards receive these output signals and operate two stepper motors accordingly. These motors have dedicated power supplies since the BL 1600 on-board power supply is insufficient to handle current requirements of the motors.

Miniature vacuums are mounted on the arms of the device. The role of each vacuum consists more specifically of adhering to a page in order to lift it so a third mechanical lever can come behind the page to turn it to the desired location.

The unit itself is a designed enclosure (14" x 13" x 6") with a base wide enough to provide stability to the device. The device weighs about 10 to 13 pounds. On the right side of the device, there are two small openings to connect the head-switch that will activate the mechanism to turn a page.

The cost of parts and materials was about $800.

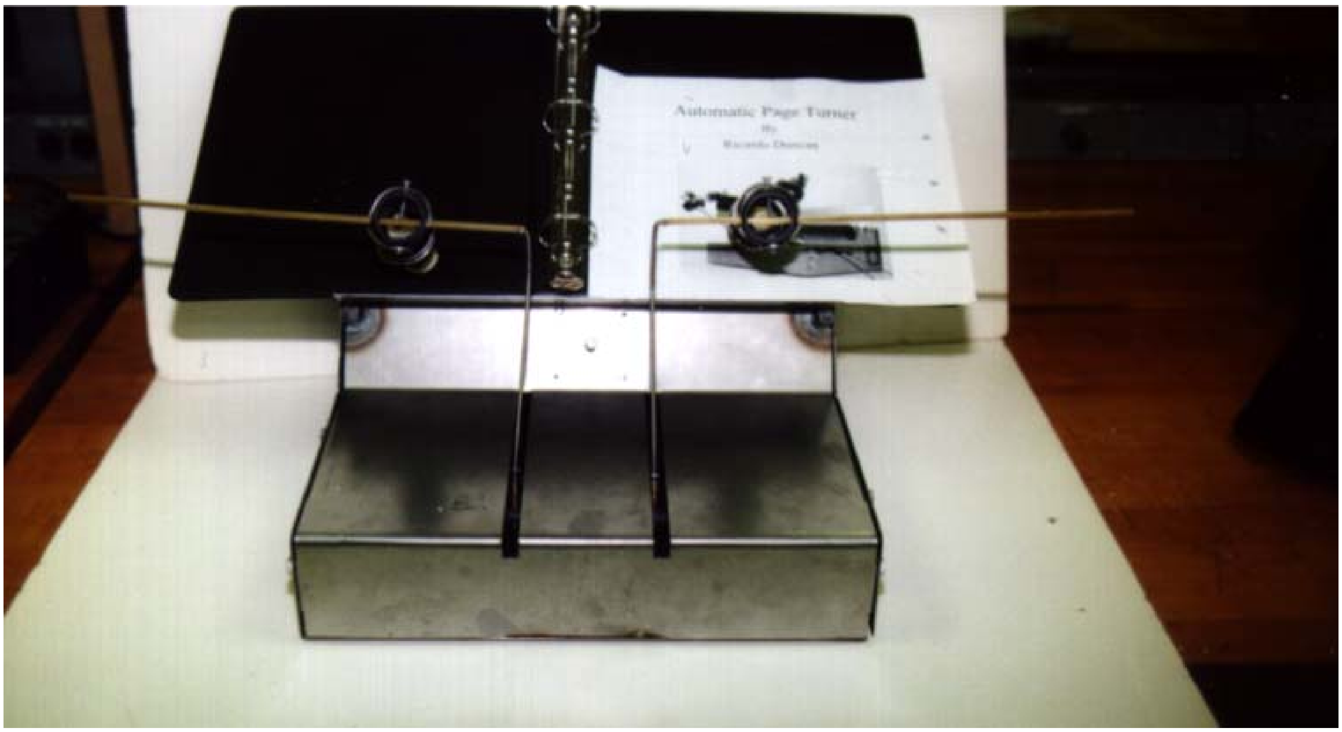

Figure 16.5. Automatic Page Turner.

COMPUTERIZED ENVIRONMENTAL REMOTE CONTROL

Designers: Rushui Guan
Supervising Professor: Dr. John Enderle
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INTRODUCTION

The Computerized Environmental Remote Control Unit (CERC) is designed to help a child with cerebral palsy control appliances such as TV, VCR, and cable. Since the child is not able to speak and cannot completely control her hands and arms, she communicates by typing on a laptop computer, using a special head-switch device. The CERC provides a simple control panel to interface with the user, so that she can simply type in a letter or click once to issue a command.

The CERC also provides a wireless control of devices. Each remote control module can control up to four devices. Multiple remote control modules can be added to the system, so that more devices can be controlled.

SUMMARY OF IMPACT

The CERC is custom designed to meet the needs of the client. It helps the client gain some control of house appliances, and therefore become more independent. Since the client needs to be mobile with her laptop in a wheelchair, wireless control is needed. The CERC will enable her to control any TV or VCR in her house; even they are not in the same room with her. The software that comes with CERC can display multiple control panels; therefore, enabling her to control multiple appliances at the same time. An example of the TV interface is shown in Figure 16.6.

TECHNICAL DESCRIPTION

The CERC has two major parts: software and hardware. The hardware has two sub-components: a transmitter unit and a receiver and remote control unit. The transmitter is connected with the serial port of the computer. The receiver receives the signal, processes it, and then sends the proper commands to a universal remote control IC unit. An impedance matcher circuit is used between the output of the universal remote control IC and the infrared LED. An overall block diagram of the

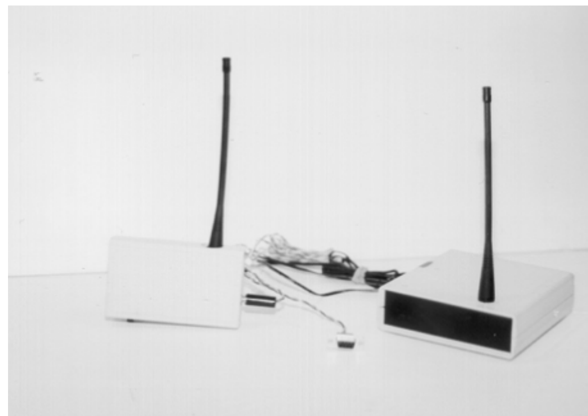

Figure 16.6. The Computerized Environmental Remote Control.

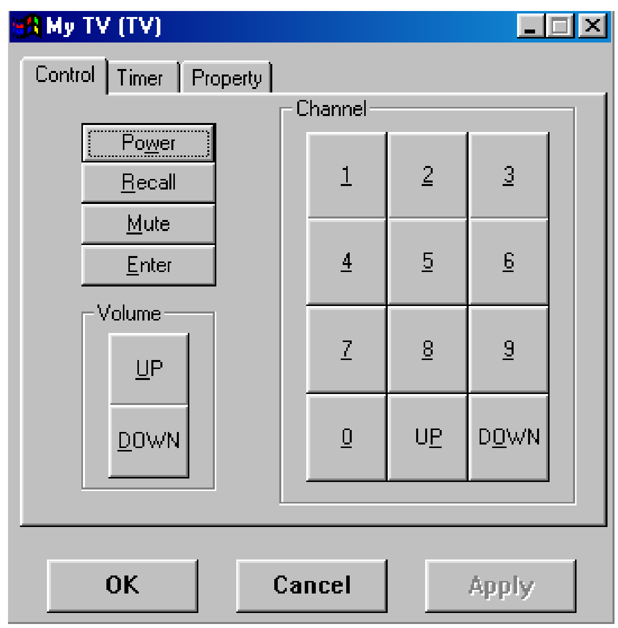

Figure 16.7. TV Interface.

CERC is shown in Figure 16.9.

The software is the interface between the user and the hardware. The software interprets the user input and transmits the proper signal to the serial port. The software was written using Microsoft Visual C++ 6.0 and Microsoft Foundation Class. It is a 32-bit windows program. The user can interface with the program by either mouse clicking or keyboard input. The program requires one available serial port.

Serial communication between the computer and the controlled appliance is facilitated by a PIC16C74A since home appliances such as a TV do not provide any feedback to a remote control. During serial communication, two bytes of data are transmitted. The first byte specifies the ID of the receiver and the second byte specifies the actual command. By assigning an ID to each command, it allows multiple receiver units with different IDs to be added into the system. The structure will also filter out the unwanted RF noise in the air, since the PIC16C74A MCU will simply ignore the noise since it does not have an ID. Once the PIC16C74A receives the data, if the ID of the incoming signal matches the receiver's ID, it sends the second byte (command) to the PP4001 using parallel communication.

The PP4001 is a universal remote control IC unit that is preprogrammed to control most brands of house appliances that have an infrared remote control. Each PP4001 has 4 sources, which means that it can control up to 4 devices at the same time. An infrared configuration dialog box, shown in Figure 16.9, is built in the software to make setting up the PP4001 chip easy. The user can simply choose the brand, and test its available codes. If none of the available codes works, an auto scan feature can be added to scan from the first code to the last.

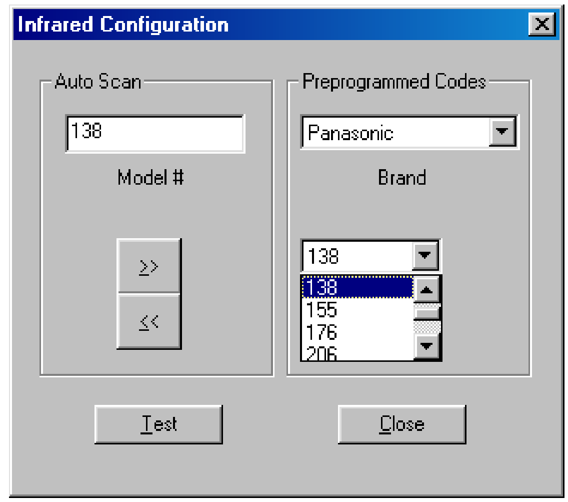

Figure 16.9. Infrared Configuration Dialog Box.

The cost of parts and material was about $500.

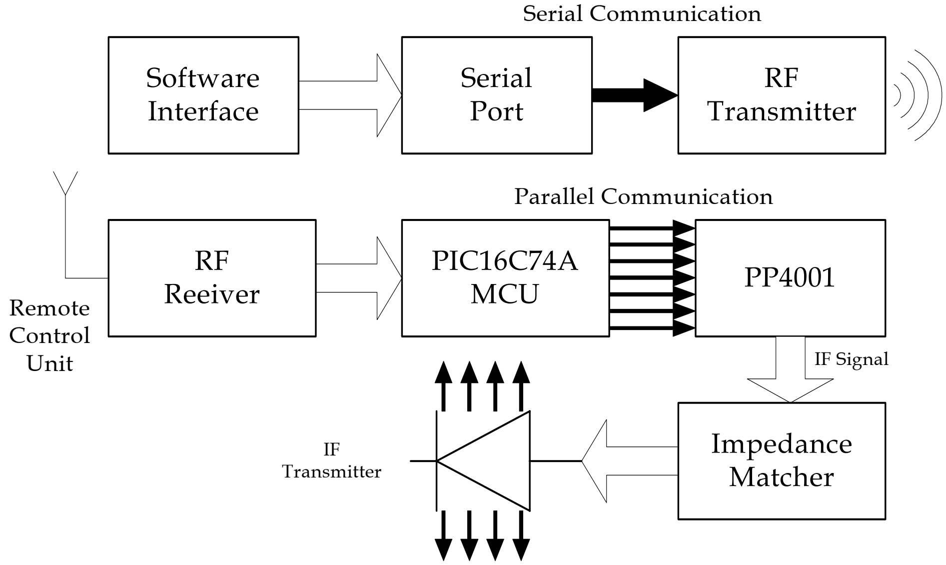

Figure 16.8. Block Diagram of the CERC.

THE LEARNING AIDE FOR COMPUTER-LITERATE CHILDREN WITH AUTISM

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INTRODUCTION

The Learning Aide was designed to provide a form of communication for a child with autism. The Learning Aide incorporates the use of a computer already in the client's school environment. The device utilizes speech conversion software to translate speech input to text output on the screen. This allows the client's teacher to speak with the client through the computer interface. The main purpose of the Learning Aide is to capitalize on the client's fascination with the computer and its speakers. The client pays more attention to the computer when there is an audible stimulus.

SUMMARY OF IMPACT

The client for whom the Learning Aide is designed is an autistic child who is generally not attentive to his teachers. When a teacher speaks, the client repeatedly plugs his ears, especially when verbal communication is trying to be established. However, the client has a fascination for computers and will pay attention to anything presented on or by a computer. The Learning Aide allows the client's teachers, and others, the ability to communicate with him via the computer interface.

TECHNICAL DESCRIPTION

The Learning Aide has three major components. They are the Main Processing Unit, the Remote Communications Module, and the power supply. Please refer to Figure 16.10 at right for a photograph of the Learning Aide.

The main component of the Main Processing Unit (MPU) is a Little G (Z-World BL1600) microcontroller. The Little G interprets what the user wants to accomplish by a pushbutton interface and then operates the appropriate outputs for that desired function. Components in the MPU are powered by the Little G microcontroller that in turn is powered by a transformer and rectifier that converts AC line voltage of 115-volts from the wall outlet to the DC voltage needed for operation.

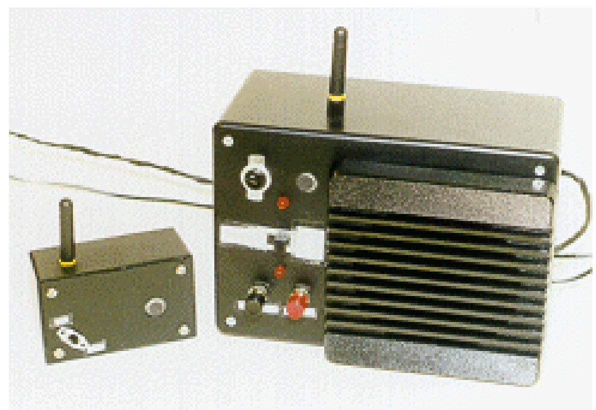

Figure 16.10. Learning Aide.

Voice recording and playback is accomplished using a device supplied by Information Storage Devices (ISD). This device is part of the Chip-corder series and uses non-volatile memory to store analog speech in digitized form. The use of non-volatile memory decreases the need for battery back up. It also has capability to amplify and operate a 16-ohm speaker directly.

The Learning Aide incorporates the latest technology in wireless RF communication for analog speech signal communications. This device used is the High Performance (HP) series II module from Linx. These modules are easy to incorporate into a design due to their minimal need for external components, with the exception of an antenna.

The Remote Communications Module (RCM) is a small handheld device that facilitates communication to the client or the computer. Within the RCM resides the transmit side of the aforementioned Linx Technologies RF unit as well as a microphone and power supply.

To operate, the Learning Aide is switched on by flipping the power lever located on the MPU to the ON position. The caregiver or instructor places the microphone switch on the MPU either in the left position (for wireless microphone in the Remote Communications Module) or in the right position for the microphone mounted in the MPU. The user now activates the computer that the device is attached to and loads the Voice Recognition program through standard Windows GUI methodology.

The user now presses the record button on the MPU and records what they want to say, making sure to use the microphone selected in the step above. The Voice chip in the MPU records the voice and stores it in its non-volatile memory module. The Voice Recognition program in the computer also processes the voice and prints on the screen the text of what was just recorded. To end recording, the playback button on the MPU is depressed. For playback, the user presses the black playback button on the MPU.

The cost for parts and material was approximately $300.

ELECTRONIC BASEBALL SCORER

Designer: Greg Mierzejewski
Client Coordinator: Karen Thompson
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The Electronic Baseball Scorer was designed for a client with cerebral palsy. The Electronic Baseball Scorer has an input display that is durable enough for the baseball season. It is a small handheld computer that allows the client to easily score the game. It is also small enough to carry to baseball games.

SUMMARY OF IMPACT

Although he has reduced control of his muscles, he still has the ability to use smaller devices, such as a remote control and the keys on this device. The device enables the client to score a baseball game.

TECHNICAL DESCRIPTION

The Electronic Baseball Scorer displays the statistics of a baseball game on a handheld computer. There is a banner on the top of the display that shows the number of outs, hits, errors, runs, and team names. Below this banner is an electronic version of a score sheet. The mouse or keyboard buttons can be used as input keys.

Baseball is a difficult game to score. For example, if there are two runners on base with two outs and the batter hits a double, but is later thrown out on that play, what should be recorded? The Electronic Baseball Scorer will ask a series of questions to enable the user to properly score the game. This allows the scorer to record the hit in the example, score every run that crossed the plate before the batter was thrown out, and place the remaining runners. The entire baseball program is an executable file compiled from Visual Basic.

When the Electronic Baseball Scorer is started, the user has the option to keep score for one or two teams. The user can then select the option of entering team and player names for one or both teams. The player and team names are both stored to disk which make it easy for the user to select player and team names when using the Electronic Baseball Scorer at a later date. After these data is entered, the scorer is ready to score the game.

There are many features in the program that allow the user to score, make substitutions, and also correct errors. There is a button to reset the balls and strikes counts on the display, and also a button to allow the user to correct any errors made on the last batter recorded. There are standard buttons to score a baseball game such as balls, strikes, outs, hits, and errors. There is also an extra button for complex plays when multiple actions occur on the same play (For example, when an out and error occur on the same play).

The cost of parts and materials was approximately $650.

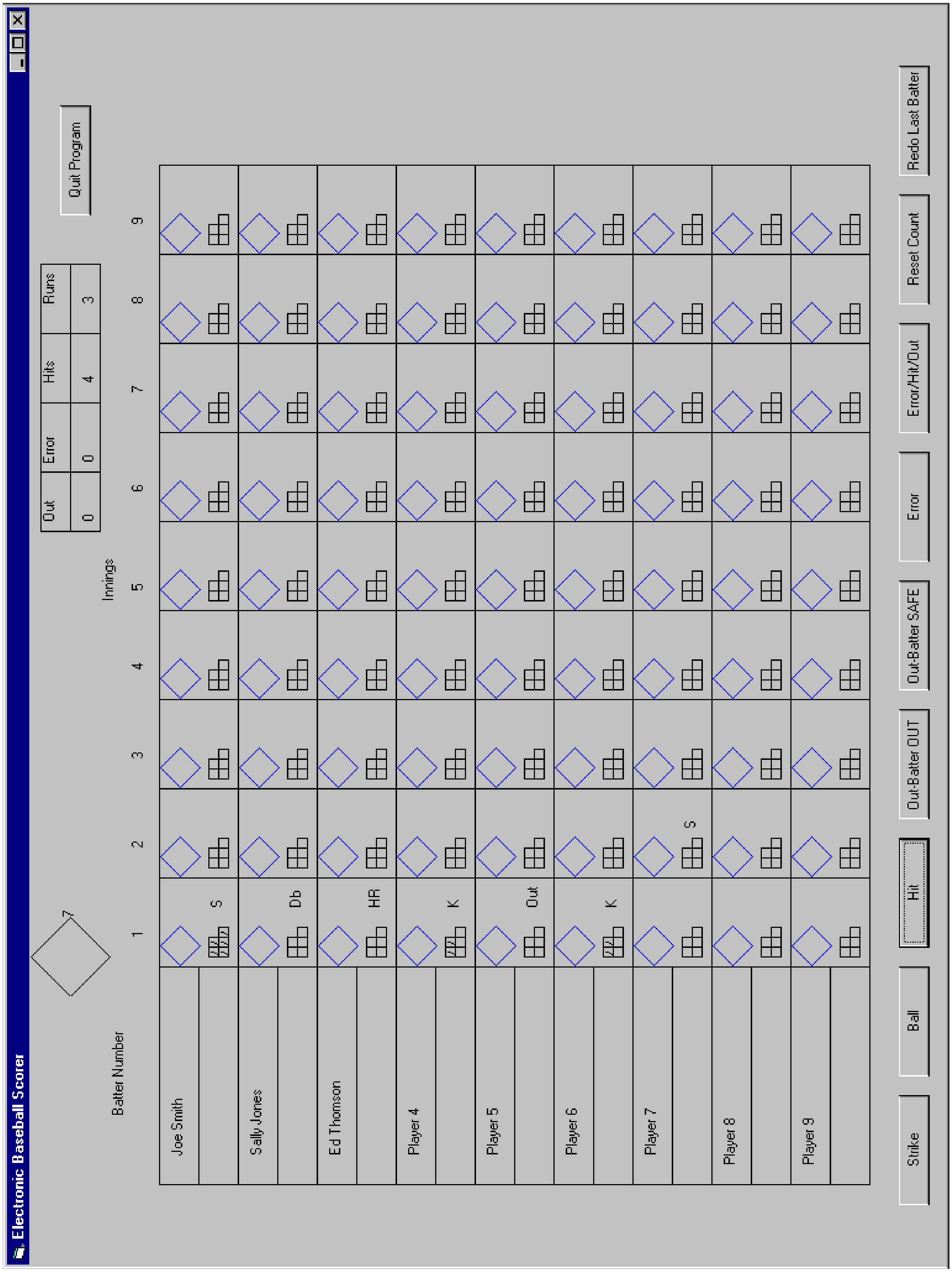

Figure 16.11. Screen Display for the Electronic Baseball Scorer.

TAP-TAP INTERCOM

Designer: April Hiscox
Client Coordinator: Dr. Brooke Hallowell, Ohio University
Supervising Professor: John D. Enderle
Department of Electrical & Computer Engineering
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INTRODUCTION

The Tap-Tap Intercom enables a physically handicapped person to perform everyday tasks without help or supervision. The tap-tap intercom unit creates a method of communicating between two separate buildings: the client's day home and his parents' main house. Previous to this design, communication was only available through a computer, which requires direct supervision of the client.

The device was developed for a client with cerebral palsy. This client has severe a motor control disability, which affects not only his mobility, but also speech functionality. The client also has spasticity, in his hands and arms, making grasping or button pushing difficult.

The Tap-Tap Intercom consists of a transmitter, which can easily be activated by the client's hand or head pointer, and a portable receiver that emits a buzzing sound when the client indicates that he needs help.

SUMMARY OF IMPACT

The usual solution to the lack of remote communication is constant supervision of the patient; this hinders independence and productivity of both the client and his parent. This device allows an individual who would normally need to rely on someone else gain a sense of independence and self worth. The device provides the client the ability to have help immediately when it is needed, but not constantly.

TECHNICAL DESCRIPTION

The technical design of the intercom is simplistic and elegant. The intercom consists of two separate components, the transmitter utilized by the client himself and the receiver used by his parents. Each of these two components can be broken down into separate subunits to be designed, built and tested individually for ease of production and later use and/or repairs. A key feature of the intercom is its one-button use. A single push of the large input button will send the signal for need to the receiver, which will then buzz until a user stops it. Both the transmitter and receiver use disposable batteries for ease of operation and portability. Both units contain a low-battery indicator LED so these batteries can be changed when necessary. Both units also contain power switches so the devices can be turned off when not in use, so that the batteries can last longer.

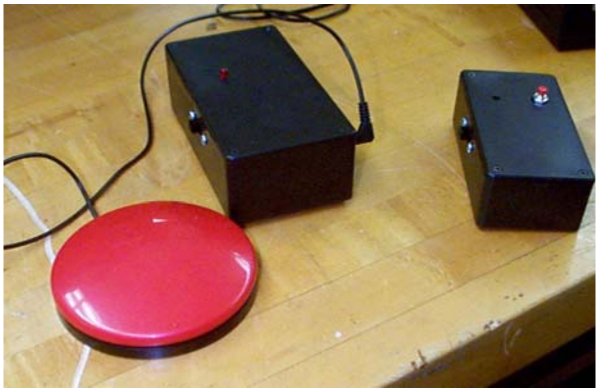

Figure 16.12. Tap-Tap Intercom.

The design of the tap-tap intercom is based on radio frequency transmission at 418 MHz. Linx Technologies, Inc. commercially manufactures the components that achieve this transmission. Small helical antennas were used to maintain the small size of the devices for portability. This ensures that the call for help goes through anytime as long as the receiver is in range.

The circuit design is based on a simple encoder and decoder pair coupled with the transmitter and receiver pair from Linx. The encoder reads the parallel information of the button press and converts it to a serial data stream for transmission via the transmitter. This information is then received and decoded. A 555 timer is used to lengthen the output pulse of the receiving circuitry to ensure that the call for help is heard and not forgotten about. The person on the receiving end must acknowledge the signal before the buzzing will stop. Figures 16.13 and 16.14 show the transmitting and receiving circuitry for the intercom.

The design used in this device is highly reliable and simplistic enough to keep the project cost and complexity to a minimum.

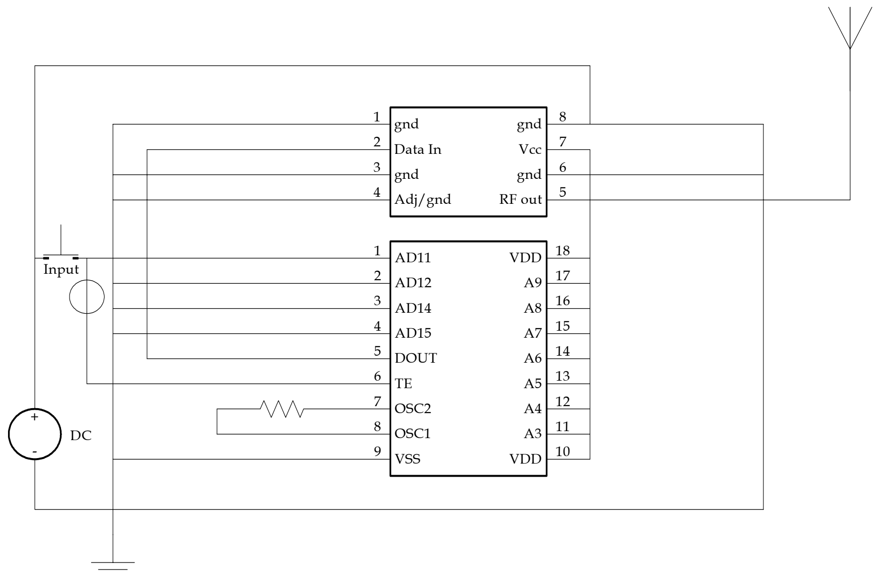

Figure 16.13. Transmitter Circuit.

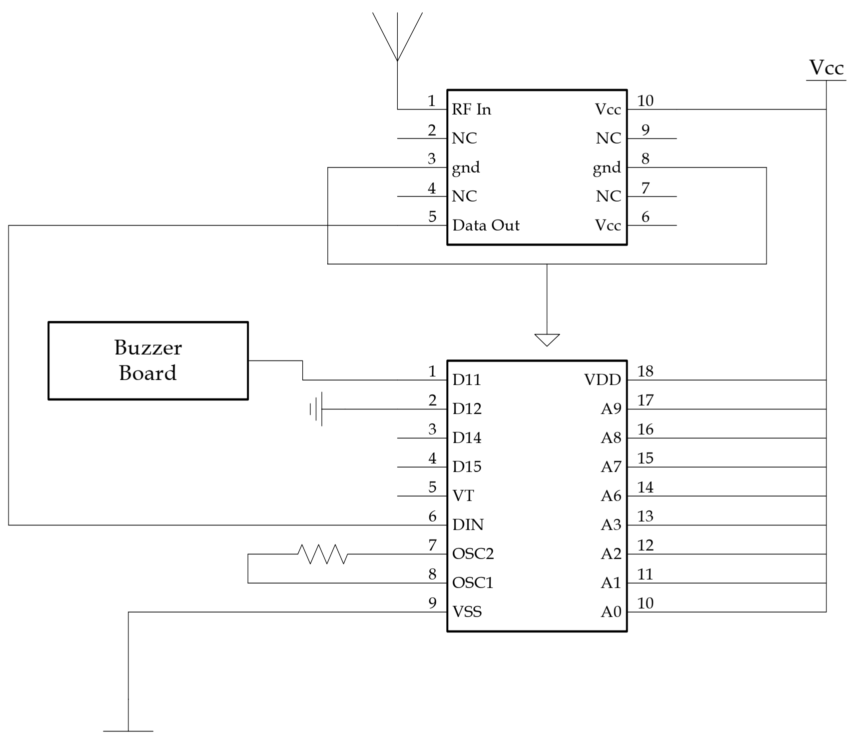

Figure 16.14. Receiver Circuit.

TAP-TAP ENVIRONMENTAL CONTROL UNIT

Designer: April Hiscox
Client Coordinator: Dr. Brooke Hallowell, Ohio University
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The Tap-Tap Environmental Control Unit (ECU) provides reliable control of a TV, VCR, Stereo system and bedroom lights through remote infrared and RF technology. The device is built specifically for a client who has cerebral palsy (CP) and desires independence while listening to music or watching television. His activities are limited to those requiring little to no movement. The control over the devices in his bedroom is achieved through capacitive touch plates, which require only a light contact with human skin to activate their functions. The tap-tap intercom takes advantage of the existing technology of universal remote controls by integrating a commercial remote into the touch plate interface. The touch plate interface has large switches requiring little pressure or muscle control to accommodate the client's weakness and lack of motor control.

SUMMARY OF IMPACT

Having CP has drastically affected the personal freedom of the client. Choosing one's own bedtime is something most people do everyday without thinking about it. Being able to accurately control the volume and channel on a TV, although an insignificant task for most, is a great luxury for others. The Tap-Tap ECU helps to provide that luxury to those who do not have it.

TECHNICAL DESCRIPTION

There are two main technical aspects of the Tap-Tap ECU. The first is the design of the touch plates to create an easy to use interface for those with muscular problems. The touch plate design is based on a timed output of a standard 555 timer. The continuously running oscillator will create an output pulse when a change in capacitance is sensed. The contact of human skin with the metal touch plate creates an additional capacitance in the circuit, prompting an output voltage. This circuit is shown in Figure 16.16.

Figure 16.15. Tap-Tap ECU.

The second main part of this design involves the methods used to interface these touch plates to a commercial universal remote control. The Home Theater Master SL-9000 from Universal Remote Control, Inc. was chosen based on its learning function, which will allow for future upgrades. This device requires a short circuit to activate the switches. The voltage output of the touch plates is transformed into this short circuit via reed relays and current limiting transistors. This is then attached directly to the commercial remote through 30-gauge wire, which was soldered to small vias present on the remote.

This design is functional, although it does not seem to be as reliable as hoped. The touch plates are very sensitive to stray signals, and sometimes show dependence on body temperature. Despite those problems, they are fairly reliable. The major flaw in this design comes in with the reed relays. These relays have a longer switching time than some other available devices, meaning that on occasion a channel or volume level will be skipped on the television. The idea addressed by this project is a large improvement in the client's quality of life. However, the prototype needs a few adjustments to become a desirable product.

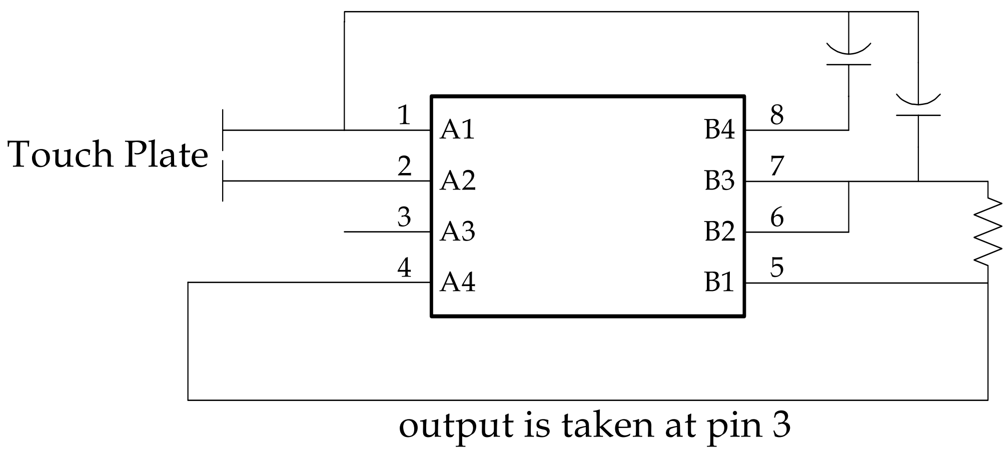

Figure 16.16. Touch Plate Circuit.

PAINTING "EASELY"

Designer: Brian Bemis
Supervising Professor: Dr. John D. Enderle
Dept. of Electrical & Computer Engineering
University of Connecticut
Storrs, CT. 06269-2157

INTODUCTION

The purpose of this project was to design a motorized easel for a painter with post-polio. Since his condition restricts his range of arm movement, he is constrained to paint only small pictures, limiting his artistic talent. He desired a device that would allow him to paint more easily and on much larger canvases.

SUMMARY OF IMPACT

The motorized easel grants the artist the ability to paint large works of art. This easel has the ability to move up and down, tilt back and forth, and adjust to the size of the canvas. It can be controlled using either a remote control or the main control box, both of which could be easily operated by the artist. With this system, the artist is able to move the canvas to his desired location so that he may properly reach certain areas that he would not normally be able to cover with his brush.

TECHNICAL DESCRIPTION

The easel was designed to provide all of the desired functions to the artist, such as the ability to move the canvas up and down, tilt it back and forth, and clamp down to the size of the canvas. To provide these motions, a sturdy frame was designed with a steady motion control in mind. The frame was mainly comprised of lightweight aluminum angle iron and square tubing to establish a solid base. Stainless steel tubing was used as linear slides with pillow blocks riding on top to stabilize the movements. The easel itself can hold up to a 3 1/2 ' tall canvas with almost any size width.

In order to activate the motion, 3 Performance Pak Actuators were employed. These devices move at a constant speed of 1 in/sec and are powered by a 12VDC motor. This motor ties directly into a gearbox to activate a ball screw assembly forcing the actuator to move up and down.

Figure 16.17. Side View of Easel.

High power relays were used to control the activation and direction of each of the motors. A single-pole double-throw relay activates the motor, while a double-pole double throw relay controls the direction of the motor. A microcontroller/logic circuit activates these relays. This circuit receives and deciphers signals from the remote control receiver and main control box and then determines what action the painter desires. The remote control and main control box interfaces uses normal 3-position toggle switches for each of the motors. The motors run as long as the toggle switch is in either the up or down positions and turns off immediately once the toggle switch is returned to the center position.

Final tests were made on the device and proved to provide a steady motion in all directions. The ease of use and reliability will allow any artist to move a canvas to the desired position.

The final cost of this project was approximately $2000, including all of the mechanical materials, three actuators, the power supply, and all of the remaining electronic components (including remote control circuitry, relays, and a microcontroller).

Figure 16.18. Remote Control and Main Control Box.

E-GRIP

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Client Coordinator: Dr. Brooke Hallowell
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The E-GRIP grasping device enables the wearer, who has limited manual strength and dexterity, to grip implements with handles. These implements include golf clubs, brooms, rakes, and shovels. The device is voice-controlled for hands-free operation. The gripping element consists of two small linear actuators that pull nylon line woven through the fingers of a glove. These provide the ability to tightly grasp objects when there is not enough physical power in the hand to achieve this alone. The development is unique because it does not require manual strength. The components are small and light. These components work together in the same way that a muscle does, but outside of the hand. Since the design is similar to the normal functions of the hand, wrist, and forearm, the device provides natural movement and strength.

This device is designed to aid a post-stroke patient has reduced strength in his limbs. He complains that the previous device made for him, which is similar to those devices available commercially, is cumbersome, hard for him to put on himself, and it makes him sweat. This device resembles a neoprene ace bandage using Velcro straps to wrap around the wrist. A cylindrical handle can fit into the palm of the hand and a ring or a set of rings is used to stabilize the handle. Most of the devices on the market are wrist splints, gripping surface tape, prosthetic devices, or the same type of support that the client already has, but does not use. These devices do not give strength to the hand or the power to grip objects tightly. Therefore, they are not addressing this client's need.

The only devices that are electrical in nature are prosthetics that are powered by the body itself, which is not an option in this case. The E-GRIP device is small and light so it can easily fit on the client's hand without being cumbersome. Also, the client can put this device on by himself. The materials used are light, and actually draw sweat away from the body.

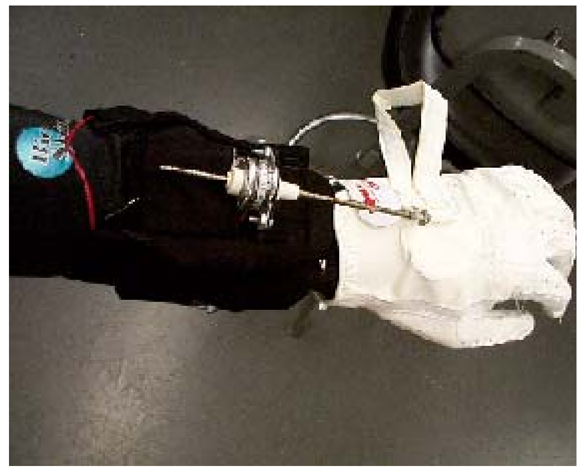

Figure 16.19. E-GRIP.

SUMMARY OF IMPACT

The device was designed for a particular client, but can be adapted for use by any other person with a loss of grip strength.

TECHNICAL DESCRIPTION

The E-GRIP is a five-digit exoskeleton glove that conforms to the hand, easily facilitating a full range of motion from the fingers to the wrist. A 9V DC power supply is used to provide power to each element in the system. A microcontroller controls all device components. A glove is used as the main shell of the device. Woven into the fibers of the glove are nylon wires that are pulled by small linear actuator motors to provide the grip and ungrip motions. The E-GRIP grasping device has four major components: Voice Recognition Module, Control Module, Driver Module, and Grip Module.

The E-GRIP voice recognition module is used to recognize three separate instructions that control the level of grip. The system consists of a speaker-dependent speech recognition kit. This means that only the user is able to activate or deactivate it. The instruction 'firm grip' provides a tighter grip for implements with thinner handles, such as golf clubs. The 'soft grip' instruction provides a looser grip for implements with thicker handles. A final instruction, 'off grip,' provides the force to open the hand.

The E-GRIP module contains a microcontroller that receives one of the three output instructions from the voice module and interprets this input as a voltage to be sent to the rest of the system. A pulse width modulated output is provided to the motor to be moved as well as a direction instruction that moves it in the forward or the reverse direction. The outputs of the voice module toggle for one second. A desired grip activation or deactivation is held constantly with the microcontroller until the next instruction is given.

The current needed to drive the linear actuator motors is approximately 400mA. A bipolar L/R drive is used, as was suggested by the motor manufacturer. A supply voltage of 5.4V is needed for this operation. An adjustable voltage regulator is used with the battery to bring the voltage down to 5.4V.

The linear actuator motors are used for gripping force. These stepper motors are approximately 1" in diameter and push and pull lead screws of 5.25". A set of 5 nylon wires is woven into the glove and clipped onto the end of the lead screw. This allows the wires to be pulled into the grip of the "ungrip" position. The glove is a standard golf glove that also has a 'power loop' attached to the side where a golf club can be placed to provide greater stability to the implement being held. The motors are mounted on a 'Bioskin' armband that is made of a material that is lighter and more sweat-resistant than neoprene.

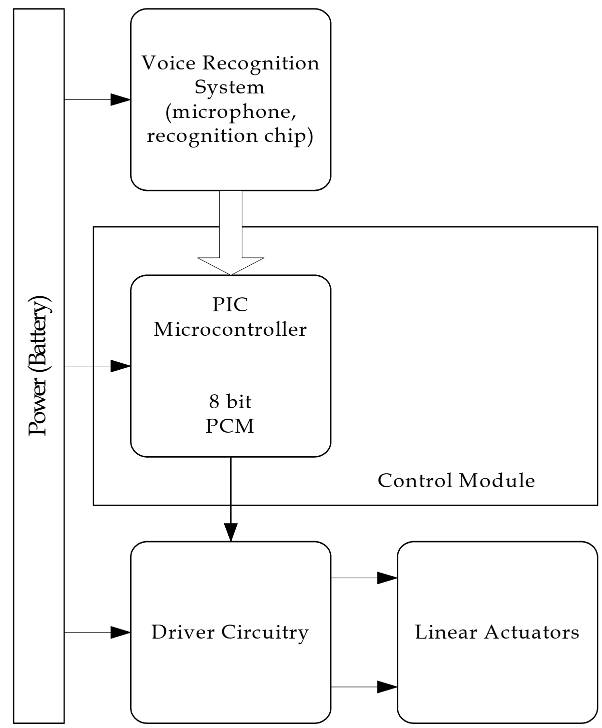

Figure 16.20. Block Diagram of E-GRIP.

The user speaks the desired grip command into the Voice Module to initiate Grip activation. The commands are 'firm grip,' 'soft grip,' and 'off grip.' The microcontroller in the Control Module interprets the command and outputs a current to the Driver Module. If the firm or soft grip commands are used, the motor on the palm side of the hand moves away from the hand and pulls the nylon wires. This causes the fingers to close into the grip position. When the off command is used, the motor on the back side of the hand moves away from the hand while the other motor moves back towards the hand. The nylon wires on the back of the hand are pulled in order to open the grip. A block diagram of the E-Grip is below in Fig. 16.20.

The cost of this project is $250.

ROAMING DIAGNOSTIC STATION

Designers: Katie Grayeck, Kevin Smart
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INTRODUCTION

The Roaming Diagnostic Station (RDS) enables laboratory diagnostic equipment to be transported easily. It consists of two carts, one of which is motorized and operated by remote control; the other is towed. Equipment inside the cases may be used without set-up or disassembly. The client tests, diagnoses, and treats patients with various neurogenic communication disorders, such as those resulting from stroke or other head trauma, which prevent a person from responding to stimuli, particularly verbal, in a normal fashion. Equipment for tracking eye movements is required for the testing. The number of patients the client may assess and treat has been limited to individuals who are able to travel to the client's laboratory because the tracking equipment was too cumbersome to transport. For more patients to receive testing and treatment, the client must be able to transport the equipment to any location. However, due to the size and quantity of equipment, the client must be able to transport it without having to move, connect and disconnect the individual components at each location. Currently, there are no commercially available solutions that fit the client's requirements. Although there are mobile racks on the market, these are either too small to fit the client's needs or would not be able to be moved easily, as they are not motorized.

SUMMARY OF IMPACT

This project has improved the quality of life of persons with disabilities by allowing the client to test and treat a greater number of individuals with neurogenic communication disorders.

TECHNICAL DESCRIPTION

The equipment housed in the carts consists of two complete computer systems, plus peripheral monitoring and measurement equipment. The first system, housed in Cart A, is the Stimulus Presentation System, which is composed of a computer, microphone, camera, scan converter and printer. The second system, housed in Cart B, is the ISCAN system, composed of a computer, Sony eye and scene monitors, eye illumination control, black and gray box adjusters, eye camera and lens unit. The systems, inside their separate cases, are set up side-by-side to allow both the patient and clinician access to their respective equipment simultaneously. The RDS fits through a standard doorway. To meet the requirements for diagnostic testing, the height requirement for the computer monitors and keyboards for both the ISCAN and Stimulus Presentation systems is approximately 29" from the floor. In Cart A, there is space for the monitor to be raised an additional foot to allow eye illumination equipment to be placed in front of the patient.

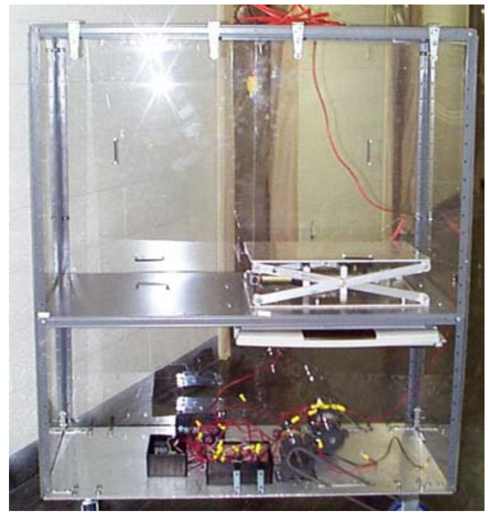

Figure 16.21. Cart A.

A. Carts

The carts are constructed of steel frames with Plexiglas sides. Steel shelving inside the cases holds the equipment. The exceptions to this are the drawers that hold the keyboard and mouse for each computer system. Runners on either side of each drawer allow them to slide out as needed. The same material used to build the frames for the cases is used to create compartments for each piece of equipment to be stored. The shelves, which may be rearranged to accommodate future equipment needs, are bolted into the framing. The rear panel of each case is held in place with bolts and clip-nuts, which replace traditional nuts, so the panel may be easily removed to allow access to the rear of the equipment stored in each cart. The front of the cases has two types of doors. The top portion of each door is attached to hinges on the top of the cases, so the door may be flipped to the top of the case. The doors on the bottom portion of the Cart B open out to the sides. Cart A contains not only the Stimulus Presentation System, but also the drive system and circuitry. Therefore, it has two stationary pieces of Plexiglas attached to the frame in place of doors. This is to prevent any injury to either a user or to the equipment. When closed, the doors on both carts may be locked secure the equipment inside. The carts are connected both electrically and mechanically. The mechanical connection allows Cart A to tow Cart B. The electrical connection between the carts allows the computer systems to communicate with each other. A panel on the outside of each case contains ports for any cables which need to be connected between cases. Any component that requires communication with a component in the other case is connected first to a panel in the side of the originating cart. A second cable connects the panels in the carts, and a third cable connects the panel in the second cart to the second piece of equipment. This arrangement facilitates equipment rearrangement within the carts and reduces strain on connections between components while in transit. Commercial surge suppressors are installed in each case to protect the equipment from dramatic changes in the power supply. These surge suppressors have external connections for a wall outlet. Fans installed in each cart provide air circulation to prevent the equipment from overheating. Adjustable nylon straps with D-rings and Velcro closures, which allow the client to easily move or adjust equipment, securely hold individual components in each case.

B. Motors and Motor Control

Two motors are mounted in Cart A. Each motor drives a single rear wheel of the cart. Steering is accomplished by running one motor forward while the other is stopped. For example, in order to turn right, the left-hand motor is run forward while the other is stopped. This is similar to the control found on a wheelchair, where the user drives the back two wheels, while the front two wheels rotate freely. This design was chosen as the easiest to build and control. Although this may be less maneuverable than other designs, it supplies a turning radius sufficient to enter a room from a hallway. The motors used to drive the carts are DC gear motors powered by a rechargeable battery, which is charged whenever the cases are plugged into a standard wall outlet. The motors are controlled using a radio frequency (RF) remote control featuring a seven-position keypad for user control. The seven options are: Forward High, Forward Low, Left, Right, Reverse, Lift Up, and Lift Down. An RF remote control is preferable over infrared (IR) because RF communication does not require line-of-sight use. Furthermore, it may not be feasible for the user to remain in one position relative to the carts at all times. For example, while traversing a straight hallway, the client may prefer to walk behind the carts. When turning a corner, however, the client may choose to precede the carts in order to better steer and avoid obstacles. The output from the remote control keypad is passed through a PIC microcontroller to encode the signal for transmission. The output from the microcontroller is a four-bit word, transmitted by a LINX transmitter. The pulse train is received by a complementary LINX receiver and decoded by a second PIC microcontroller. The outputs from the PIC are connected to seven relays, two connected to the motor lift, the other five controlling the motors, one for direction, two for speed control, and two for turning the motors on and off for high speed.

The approximate final cost for this project is $1700.

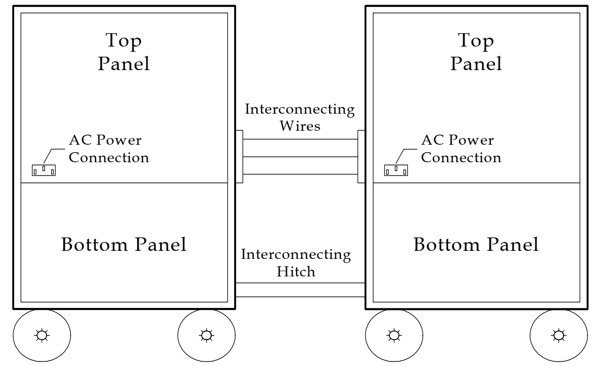

Figure16.22. Diagram of Rear of Carts.

MONITOR LIFT

Designer: Thomas Nowik
Client Coordinator: Dr. Brooke Hallowell
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION:

The Client is in need of a device to lift an 80-pound 21-inch Gateway computer monitor up 12 inches in order to place a 10-inch tall camera in front of it. The camera is required to present diagnostic materials to patients with neurogenic communication disorders. The patients will sit in a chair in front of the computer monitor and a camera will be placed in front of the computer monitor where the keyboard would be. The patient will be looking at the computer screen while the camera is watching the patient's visual response to what is seen on the screen. Employees still have to use this computer when the testing is done. Since they have to look up to see the monitor, it can cause them to strain their necks. Since this is a strenuous and tedious process, the computer monitor is left on a frame that has it permanently raised up 12 inches. Once the test is finished and the patient has left, the camera will be removed and the computer monitor will be lowered back to its starting surface.

The monitor lift is raised and lowered 12 inches by the use of a toggle switch on the side of the Roaming Diagnostic Station and remote control. To raise the monitor, the client presses the raise button on the remote control or switches the toggle switch. When the test is over and the camera is removed, the client then presses the lower button on the remote control or switches the toggle switch to lower the monitor back to the starting surface.

The approach taken was to build a sturdy metal frame with a linear actuator as the motor. Relays were used to control the motor; a remote control and a toggle switch control the relays that control the motor. The Monitor Lift is designed of a sturdy metal frame. The legs function with scissor-like movements via a linear actuator that pulls the legs together or pushes them apart. The frame material is mostly aluminum with some steel. It was built to be easy to use and sturdy enough to hold up to 115 pounds.

Figure 16.23. Monitor Lift inside the Roaming Diagnostic Station.

SUMMARY OF IMPACT:

This project will help clinicians and researchers use diagnostic equipment more easily and efficiently. What was a tedious and difficult process that took a few minutes is now an easy process that takes about 4 seconds. No more time is wasted lifting the monitor by hand, and the diagnostic work is now more enjoyable.

This lift is useful in that it takes minimal effort to raise and lower the lift. The design is simple and should last a long time with proper care.

TECHNICAL DESCRIPTION:

The Monitor Lift consists of three parts: The frame and motor, remote control, and manual controls. The frame was built primarily of aluminum and some steel. The top, bottom, and legs of the frame are aluminum, and the crossbars and wheels are steel. A sketch of the frame is shown in Figure 16.24.

The motor is controlled by Magnacraft relays. These relays control when the motor is turned on or off and the direction of the motor. The remote control has two buttons for the Monitor Lift, one to raise the lift and one to lower it. The manual switch is a three-position toggle switch with a neutral position in the middle. When the switch is switched to the up position, the lift raises, when the switch is switched down, the lift moves down. The motor is a Thomson Saginaw Performance Pak Actuator. It has a 4-inch stroke and runs on 12 volts and up to 22 amps.

The design is simple. It uses a scissor-like motion to raise and lower the lift. It is practical and easy to construct. Aluminum was used to build most of the frame because it is lighter and easier to use then steel. The relay controls were used because they, too, were easy to use and can handle more power then an H-bridge circuit.

The total cost of the Monitor lift was $776. .

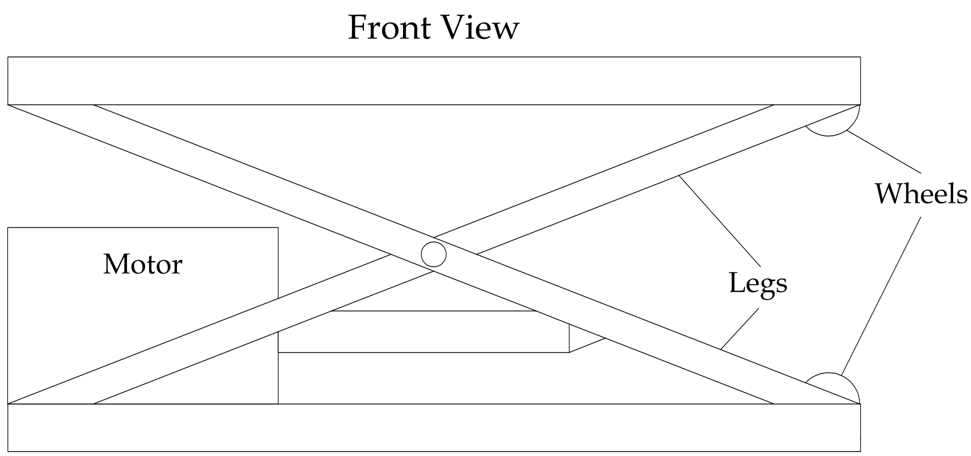

Figure 16.24. Diagram of the Frame.

iREMOTE: REMOTE ENVIRONMENT CONTROL

Designers: Zamir Khan
Client Coordinator: Bill Pruehsner
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The inspiration of iRemote, a remote environment control system, is based upon the need to provide a client with an indoor environment requiring little movement on her part. The system entails the use of radio frequency technology to control the lights, lamps, thermostat, and the locking, unlocking and opening of her front door. The client has reflex sympathetic dystrophy syndrome, which involves intense pain. iRemote will make many of the daily movements within her apartment setting unnecessary. The iRemote includes a digital thermometer, allowing the client to manage the temperature effectively. In addition, due the use of radio frequency technology, the client will not need a line of sight with any of the controllable devices.

SUMMARY OF IMPACT

The wireless remote environment control system reduces the need for the client to travel in her wheelchair from place to place within her apartment. The system may be attached to her wheel chair, but is detachable for operation anywhere within the apartment. The system essentially controls all the lights in the client's apartment, as well as her thermostat. In addition, locking and unlocking commands are sent from the remote to an existing door control system (Soni-Key). The system has multiple security codes to prevent interference from other devices, and addresses most security issues pertaining to secured door locks.

TECHNICAL DESCRIPTION

The complete system is managed from a small remote device with large buttons with a user friendly layout. The remote is powered by a rechargeable battery. The client's activity within her home environment will be greatly reduced, and she may find new levels of comfort after the system is implemented.

Figure 16.25. iRemote.

The remote control circuit entails components from a system that has basic radio frequency transmitting and receiving capabilities. Parts of this device were used to ensure the transmitting of the signal to the respected control devices is secured, constant, and efficient. A Powerhouse Wireless Remote Control System was modified with a control circuit that sends an activate signal to the Soni-Key device. This includes a Linx transmitter and receiver surface mount chipset. A pushbutton device included on the generic remote sends the control data. This signal is received by another Linx module, which decodes the signal and activates the door locking mechanism. Consultation with the Soni-Key production team in deciding the approach to this transfer of signals was necessary.

The use of a remote thermostat controller that is compatible with current home thermostats is implemented in iRemote. The device receives a signal from the remote control and the thermostat records the input as though it is at a higher temperature than it is. By activating this, the client is able to turn the thermostat on and off at her discretion without having to move from her current position. The remote is compatible with the existing thermostat system.

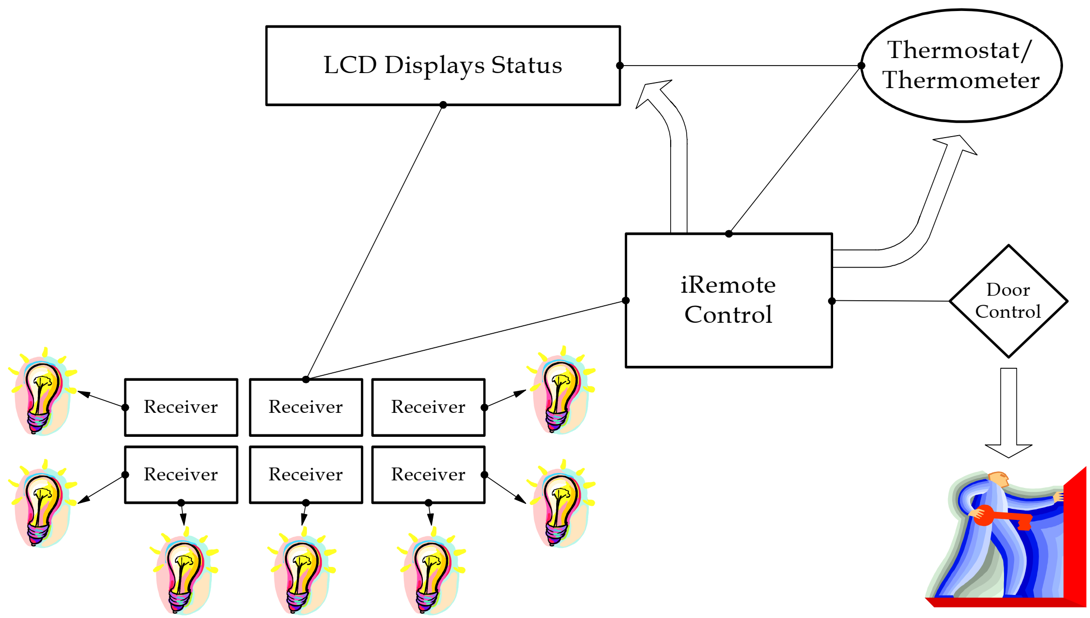

Figure 16.26. Diagram of iRemote.

SONI-KEY VOICE-CONTROLLED DOOR LOCK

Designer: Ethan Phelps
Client Coordinator: William Pruehsner
Supervising Professor: Dr. John D. Enderle
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INTRODUCTION

The SONI-KEY Voice Controlled Door Lock is a door entry system that allows the user to lock, unlock, open, and close the door on which the device is installed, using only voice commands and the touch of a finger to a sensor. The device was designed for a client who has Reflex Sympathetic Dystrophy (RSD), and uses a wheelchair. One symptom of RSD is hypersensitivity, which can make affected parts of the body difficult to use. This device will virtually eliminate any physical manipulation and interaction required in using a door. Current door control systems are in existence, but they are usually part of a complete computer-based home environment control package, which costs, on average, over $4000. The device discussed here is specialized for door control, and costs less than other solutions.

SUMMARY OF IMPACT

The client uses a wheelchair. Prior to having this device, she had difficulty unlocking a door, turning the doorknob, and pushing open the door. With this device, for most operations, the user does not need to touch anything or even get very close to the door. To unlock the door from the outside, the user must simply touch the fingerprint scanner.

TECHNICAL DESCRIPTION

The realization of this door entry system involves the integration of the three output devices (the remote control door lock, the electric door strike, and the door opener) with the input devices (voice recognition, sound detectors, and the fingerprint scanner) and the control logic to control the devices. The power supply for the system is an uninterruptible power supply with 12V and 5V outputs.

The power distribution board receives inputs from the 12V power supply, the 12V 20Ah sealed lead acid battery, and 120 VAC line power to switch a relay. The relay switches between the power supply and the battery in the case of a power outage. There is a large capacitor to stabilize the voltage during the switching time of the relay. There is a 5V regulator, so that the board can provide 5V and 12V outputs.

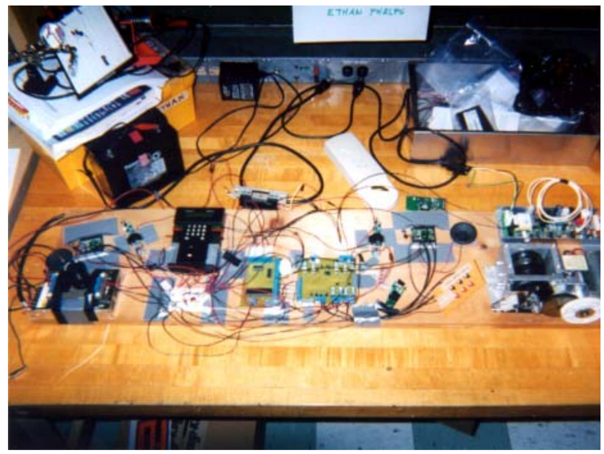

Figure 16.27. SONI-KEY Voice Controlled Door Lock.

The microcontroller board has a ceramic resonator and decoupling capacitors, some pull-up resistors for certain inputs, and two dual 5-input NOR chips to combine inputs from different devices. All inputs from the input devices go to this board, and the microcontroller outputs go to the output driver board.

The output driver board consists mostly of transistors and relays to drive the output devices. The remote control to the door lock requires short circuits across two pairs of terminals, which would normally be produced by pressing a button on the remote. The short circuits are provided by relays. Similarly, activating the fingerprint scanner requires a short circuit to replace pressing a button, also provided by a relay. The door opener and the voice recognition also require short circuits between certain terminals to control them.

The control program for the microcontroller has three main loops: one to represent each of the three main states in the operation of the system. The first state is the ready state, in which the system is waiting for an input from the sound detectors. To make the system less prone to false detection, the control program detects a rising edge of the output from the sound detectors. When this happens, the program goes to the second state. The second state is when the voice recognition has been activated, and the microcontroller is waiting for an output from the voice recognition. Once an input is received, the program decides whether that command is valid, considering the current status of the door (open or fully closed, locked or unlocked). Depending on what command was given, the program either returns to the first state or goes to the third state. The third state is when the system has activated the fingerprint scanner, and is waiting for a positive ID. After the third state, the program returns to the first state.

The control program also involves time-outs to return to the first state if the correct input is not received after a certain amount of time, and also pulse timing for the output pulses.

The only special parts that are integral to the design are the iGuard FPS 110 fingerprint recognition system and the VoiceDirect voice recognition kits obtained from Sensory Inc. The approximate cost of the parts in this complete device is $2,200.

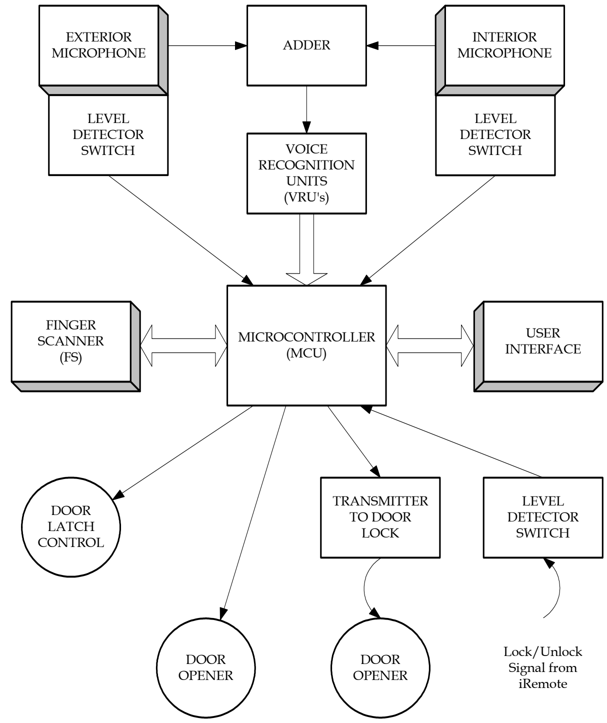

Figure 16.28. Functional Block Diagram.

Figure 16.29. Complete Door Lock System.