CHAPTER 17
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VOICE-ACTIVATED TEXT READER

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INTRODUCTION

A computer program was designed to input text from a scanner or web page and read it through speech synthesis. This system was created to allow a person who is legally blind to gain access to a wide range of written media, both in hard copy and online form. A voice-recognition command approach was used to allow the client to speak an Internet address directly, since he is unable to see the keyboard. This type of command input is not found on any other text reading software.

SUMMARY OF IMPACT

The text reader has allowed the client to read with greater ease and speed than he could before. Before he received the text reader, the client would read using a special magnifying monocle. This would cause eyestrain after long periods of time because only one eye was used to read. Now the client no longer needs his device for reading at home.

TECHNICAL DESCRIPTION

Several components were used to create the text reader. The Microsoft Speech API Software Development kit for Windows was integrated to enable speech synthesis and speech recognition. This free redistributable was installed on the client's computer; the program connected to it through a set of COM (Component Object Model) interfaces. A command-and-control grammar, as opposed to free dictation, was used for the speech control system to allow for better accuracy. The command-and-control mode allows SAPI to only recognize a finite set of words instead of the entire dictionary of the SDK. However, free dictation had to be used for the input of Internet addresses. To prevent the program from attempting to connect to a non-existent address, the user was allowed to listen to the URL he had spoken and confirm or reject it. The ScanSoft OCR development kit was used for the text input from the scanner. This component is a set of import libraries with entry points for image input, preprocessing, and optical character recognition. Its capabilities include recognizing columns and multiple pages, color inversion to read documents in white lettering on a black background (with a reduction in the recognition accuracy), and the rotation of images if a document was put on the scanner perpendicular or at an angle to the normal text direction. This kit interfaced to the client's scanner through the TWAIN protocol. For web page input, an HTML 2.0 compliant parser was created using a Windows implementation of the UNIX tools Lex and Yacc. These programs convert a text file containing a definition of the language to read into C++ source code. To actually retrieve web pages from the Internet required the WinInet API, which is part of Internet Explorer 4.0.

The total cost of the project was $1000 for the ScanSoft kit, and $45 for a headset.

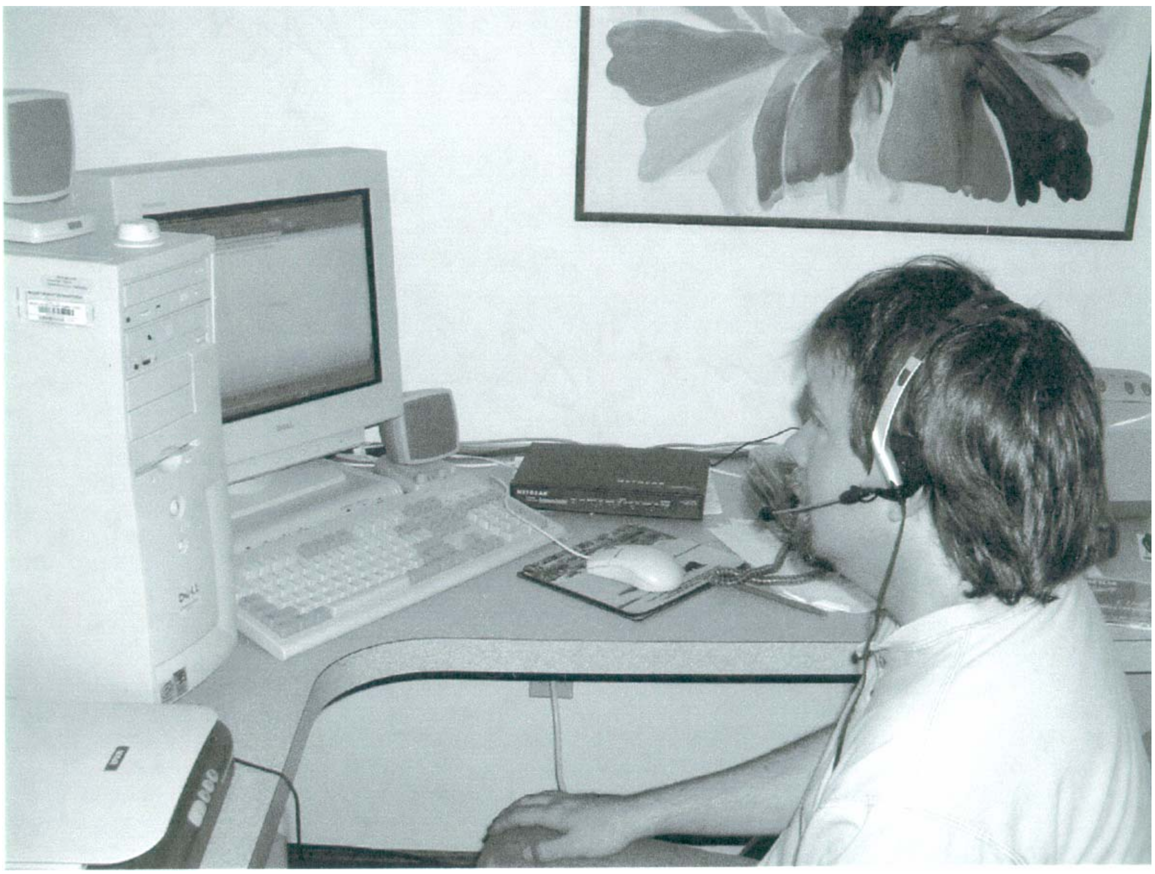

Figure 17.1. Text Reader.

ELECTRONIC TRAVEL AID: A PROXIMITY DETECTOR FOR THE VISUALLY IMPAIRED

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Client Coordinator: Robert Steele, Perkins School for the Blind Outreach Satellite Program, Hyannis, Ma.
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INTRODUCTION

An Electronic Travel Aid (ETA) is a name given to any electronic device that assists a person with visual impairment with mobility. In this case, the device is a handheld ultrasonic rangefinder that reports the range to an object that is in the path of the device. The report is given by a vibratory motor and with an adjustable volume speaker. The motor increases in revolutions per minute as proximity decreases; therefore, the user feels a more intense vibration as proximity to an object decreases. Similarly, the audible output increases in pitch as the proximity decreases. The audible output is adjustable for volume. Upon completion, The ETA will be presented to a visually impaired client His client coordinator considers him a good candidate for such a device since he is young enough to adapt to new technology. The student intends to use this device to help him familiarize himself to new environments and as a supplement to his cane. See Fig. 17.2 for a view of the device.

SUMMARY OF IMPACT

The design criteria for the ETA were defined by the client. The designer was able to demonstrate similar products to the client from which the client, under the supervision of his coordinator, determined his particular specifications. These include a handheld device, a minimum number of buttons and/or knobs, and a range of three meters.

TECHNICAL DESCRIPTION

The function of the device is broken down into the following different components: the ultrasonic sensor and receiver, the motor control module, and the amplifier circuit. The ultrasonic sensor component contains a crystal controlled oscillator that generates a 40 kHz ultrasonic signal that is sent through a crystal transmitter where a receiver

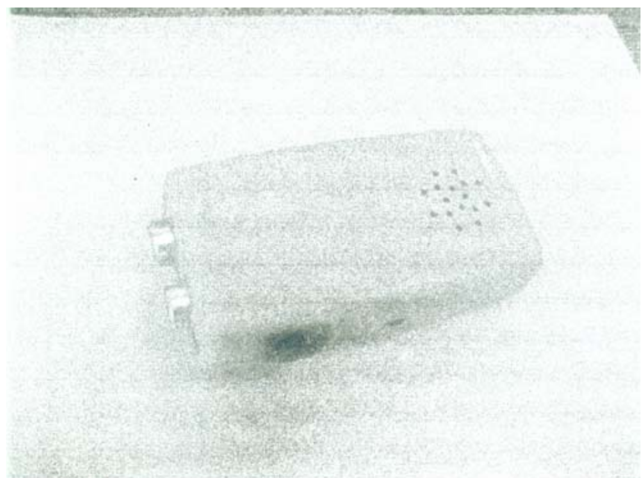

Figure 17.2. The Proximity Detector.

receives the reflected signal. Since the transmitter and receiver are both crystal sensors, tuned to 40 kHz with a bandwidth of ±1.0 kHz, there is no need for any noise filtering. A BASIC STAMP II microprocessor is used to control the output and measure the time elapsed for the signal to return which is stored as a variable. Using that time-elapsed variable, the microprocessor then calculates a distance. The distance value is stored as a variable which is then converted to a decimal value from zero to 255. The decimal value represents a percentage of pulse width modulation in approximately 0.39% increments and an audible frequency output from 30 Hz at its maximum distance to three kHz at its minimum distance. The motor control module is a microprocessor controlled h-bridge designed to work with a microprocessor. The audible frequency is sent to an internally mounted speaker through an amplifier circuit to increase volume and offers volume control. See Fig. 17.3 for a photograph of the internal configuration of the device. The ETA is packaged in a handheld instrument case measuring 12.5 centimeters x 7 centimeters x 3.3 centimeters. The transmitter and receiver are mounted through one end. The on/off and volume switches are mounted on the side of the device. There is an externally accessible nine-volt battery compartment. The speaker is mounted to the inside of the top face. See Fig. 17.2.

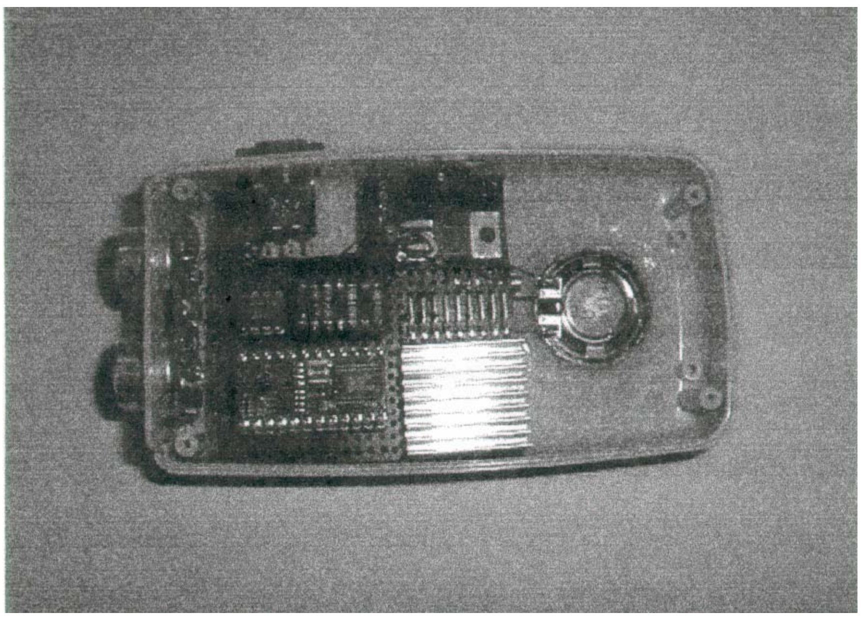

Figure 17.3. Internal Configuration of the Proximity Detector.

VOICE ACTIVATED TELEVISION REMOTE CONTROL

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INTRODUCTION

With a voice activated television remote control, a user speaks commands to the remote control, and the remote control executes the commands. A key focus of such technology is the visually impaired population with the verbal ability necessary to control such technology. This can free individuals from the cumbersome responsibility to constantly memorize exact locations of items. Fig. 17.4 shows the completed VR with its cover.

SUMMARY OF IMPACT

The VR is easy to use. The user first trains the kit to recognize the buttons on the remote: power, channel up, channel down, zero through nine, and enter (other options may be used depending on client's necessities). After training, the kit defaults to recognition mode. Then, whenever one of the trained words is spoken into the microphone, the kit recognizes the word and causes the interface circuit to connect appropriate leads. This simulates a button being pressed and the remote begins to transmit data.

The buttons on the remote can all be accessed using voice commands. For example, saying the word "power" causes the television to turn on/off, depending on its previous state. With design and parts in hand, a single person can assemble it in approximately 10 hours. Upon completion, the voice remote (VR) was presented to a visually impaired client.

TECHNICAL DESCRIPTION

The Technology involved in this design consists of three main parts: speech recognition circuit,

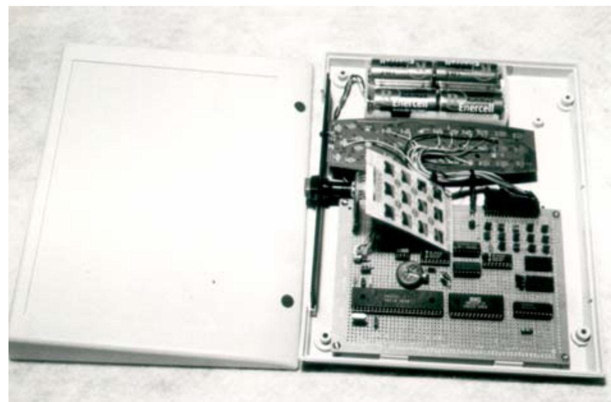

Figure 17.4. The Voice Activated Television Remote Control (VR)

interface circuit, and infrared remote transmitter. The completed speech recognition and interface circuit are shown in Fig. 17.5. The end product consists of the plastic case housing; a voice recognition circuit, a universal remote control, and a microphone. The complete product is 8x10x1.5 inches in size. It is designed to sit in view of the television and within approximately five feet of the user.

The HM2007 speech recognition integrated circuit was chosen because it operates in a stand-alone programmable speech recognition circuit. The IC is trained (programmed) to recognize the specified. It provides the options of recognizing either 40, 0.96-second, words or 20, 1.92-second, words. For memory, the circuit uses an 8K X 8 static RAM. Operating the chip (HM2007) in its manual mode allows the user to have a stand-alone speech recognition board that doesn't require a host computer to utilize speech control.

The interface design requires an eight-bit binary digital output to control the remote functions. This circuit will connect, or interface, the speech circuit with a universal television remote control. The circuit has to take a digital binary output from the latch, 74373, and use it to close specific contacts on the remote control for operation. Using multiple analog multiplexers, CD4051, and transistors, 2N3903, the binary output can be manipulated to control the remote. If the multiplexers common is tied to a positive biasing voltage, then the output can be pointed in the right direction by the binary input (select) lines. If any error messages do occur, a simple data logic circuit can be implemented to turn off the multiplexers, disabling any possible output.

The output from the HM2007 will not trigger the multiplexers because its data duration is too short, 480ns. It is necessary to use a pulse timer (LM555) in such a manner that can pulse the data latch and control the multiplexers. This will create the one second pulsed output that is necessary for the television's remote control. Since the data out of the HM2007 are clocked into the latch, the outputs are only enabled when the control goes low.

Total cost of design is around $70.00, including all parts, components and connectors.

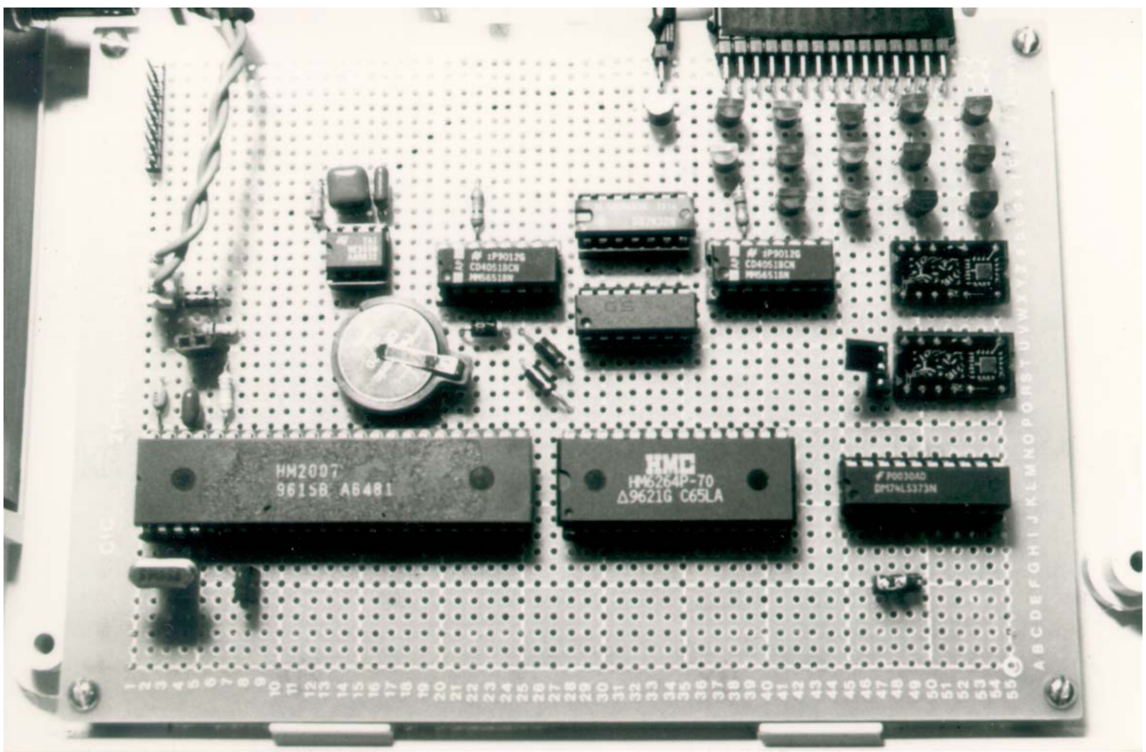

Figure 17.5. Completed Voice Circuit.

SENSORY SYSTEM FOR THE BLIND

Designer: Richard Castle
Client Coordinator: Paula, Lowell Association for the Blind, Lowell , MA
Supervising Professor: Prof. Donn A. Clark
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INTRODUCTION:

The sensory system was designed to provide a comfortable and discrete way for a visually impaired person to move around. This device is a combination of infrared sensors and vibrating motors that alert the person of upcoming objects. The sensors and motors are mounted on a pair of shoes to detect objects in proximity.

SUMMARY OF IMPACT

The system is to be presented to a local center supporting blind people. The people at this center have a strong lack of or no vision at all. Because of lack of sight, visually impaired people have to use a walking stick to find objects in their way. Ultimately, the sensor system will give them a way to "sense" objects.

TECHNICAL DESCRIPTION

The components consist of six infrared sensors, with a transmitter and receiver in each sensor, six vibrating motors, two battery packs (three AAA batteries in each pack), a pair of shoes, and the circuitry. All components are mounted on the pair of shoes. There are three sensors and three motors per shoe. Each sensor coincides with a particular vibrating motor, which will speed up as a object gets closer to it. This way, the client will know from to which direction the object is located and the distance to this object.

To get the sensor to communicate with the motor, a simple negative feedback op amp circuit was used to increase the output voltage coming out of the sensor. The sensor runs off of 4.7 Vdc, which makes three AAA batteries acceptable for the source. The three sensors detect the forward, front side, and upper front direction. The three motors coincide with a particular sensor; this way the client can distinguish what each sensor is taking in.

Figure 17.6. The Sensory System.

There is one battery pack per shoe, which contains three AAA batteries and all of the circuitry needed to power that side of the system. The circuitry consists of six op amps (LM124) and 12 resistors for the entire system. Therefore, in each battery pack there are four op amps (the LM 124 is a quad op amp, one not being used), three AAA batteries and six resistors (varying in value). The front and upper sensor are set and max distance (approximately one meter) and the side sensors are set at approximately half of the max. It seems to be more import to have good range on the front sensors than the side.

The cost of parts and material was just under $300.

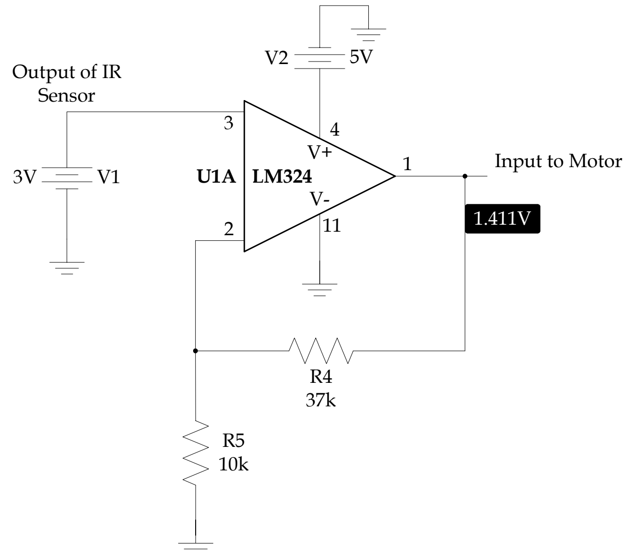

Figure 17.7. Op Amp Circuit of Sensory System.

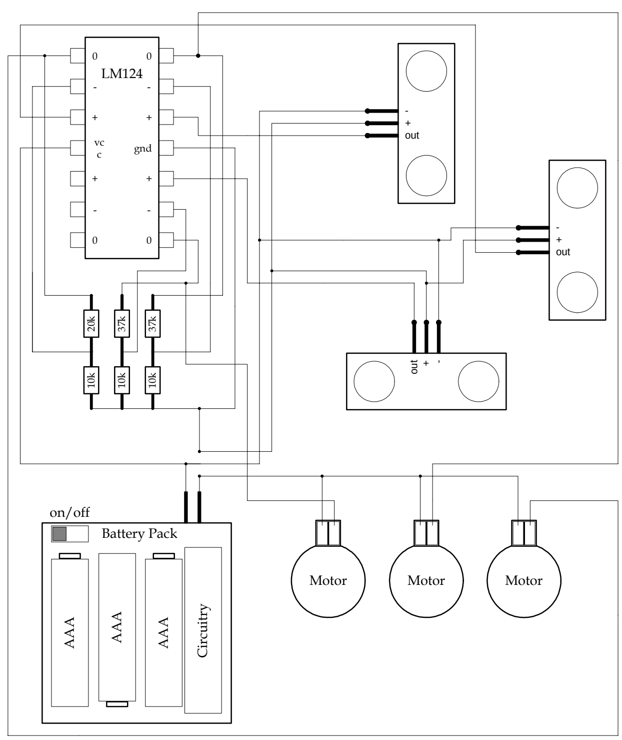

Figure 17.8. Wiring of Sensory System.

VOICE ACTIVATED CALCULATOR FOR THE COMPUTER

Designer: Katherine T. Gerrish
Client Coordinator: Nicole Buddenhagen- CASE Collaborative- John Glenn Middle School, Bedford, MA
Supervising Professor: Prof. Donn Clark
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INTRODUCTION

The voice activated calculator was designed to be a four function calculator: addition, subtraction, multiplication, and division. The calculator has an extra large number display, voice input, and voice output. The calculator was designed to be larger than the traditional Microsoft calculator, in order to help students who are vision impaired and/or those who lack the fine motor skills to operate a handheld calculator. The calculator takes up almost the entire screen with large numbers and symbols on each button. Its display consists of an interactive graphical user interface (GUI), which is controlled by one of three inputs: voice, mouse, or keyboard. The output is displayed on the screen like a regular calculator and is also verbalized.

SUMMARY OF IMPACT

This calculator was designed for any speaking child to use. No keyboard or mouse abilities are needed to use it. All controls for the calculator can be controlled by voice, once the voice recognition software is installed and properly trained.

The device was designed for a middle school class meant to meet the special education needs of students with moderate cognitive delay functioning at approximately the grade three to five level. Students in this class possess the ability to work independently for a significant period of time, to work in cooperative learning groups, and to manage the logistics of a typical environment. The predominant mode of instruction is auditory; the predominant mode of reply is verbal.

TECHNICAL DESCRIPTION

The calculator is developed using Microsoft Visual C++ 6.0. The graphical user interface is designed to be easy to see and easy to use. All buttons are large and the entire calculator takes up the majority of the computer screen. The input to the calculator can come from a combination of three sources: keyboard, mouse, or voice. The output of the calculator is shown on the screen of the calculator as well as spoken to the user. The calculator incorporates the four basic math functions (addition, subtraction, multiplication, and division) as well as a clear button, which resets the output to zero.

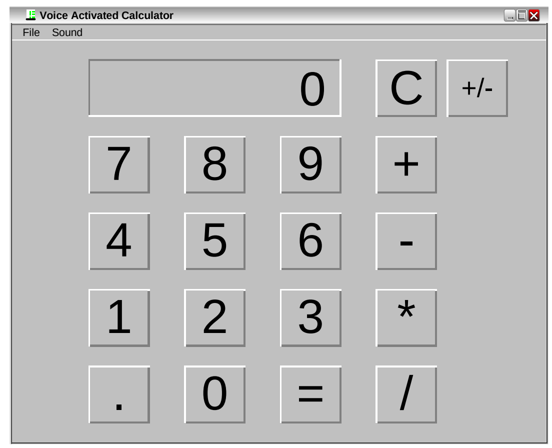

Figure 17.9: The Voice Activated Calculator.

The voice input is accomplished using a software program called Dragon Naturally Speaking Preferred 5. Before Dragon can be used for input to the calculator, the user must go through Dragon's training process to ensure accurate voice recognition. After training Dragon, the user needs to add a few dictation shortcuts so that the correct buttons are clicked when needed. The following words and symbols need to be added to the dictation shortcuts: "is" for '='; "decimal" for '.'; "plus" for '+'; "minus" for '-'; "times" for '*'; and "divide" for '/'.

The voice output is accomplished using the Microsoft Sound SDK package. The sound SDK came with a series of functions that can be used for both voice output and voice recognition. The help files depicted a series of functions that take a CString as input and send it to the speakers as output.

The only cost for this project was the Dragon Naturally Speaking software, which cost $180.

VOICE ACTIVATED REMOTE CONTROL

Designer: Yiu Wong
Client Coordinator: Alan Rux, Technical Coordinator at UMASS Lowell
Supervising Professor: Prof. Donn Clark
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INTRODUCTION

A voice-activated remote control (VARC) has been developed to assist an adult who has limited use of his hands (see Fig. 17.10). This controller allows the user to control the basic functions of TV, Cable and VCR entertainment system by using voice command. This hand free controller device allows people with limited use their hands to be able to control their entertainment system simply by speaking.

SUMMARY OF IMPACT

This VARC has allowed the client, who has no control of his arms and legs, to interact with the remote controller through voice command. For example, when he wants to select channel up on the remote controller, he will simply do so by speaking the phase "channel up" which causes the TV's channel to go up. Once the power is on, this device is always listening for commands, and the user doesn't need to touch the device at all. With the help of VARC, the client is able to control his entertainment system without assistance.

TECHNICAL DESCRIPTION

The final VARC structure consists of two parts as shown in Fig. 17.10. A three-in-one universal remote and a eight by five by four inch plastic box containing the voice recognition processor and the logic circuit. The single universal remote can control the TV, VCR and the cable box. There are several buttons located on the top of the box for word training purposes. There is also a speaker located inside the box. The purpose of the speaker is to use speech prompting to report memory status, provide training instruction and notify user when there an error occurs. A microphone is placed on top of the box for the voice recognition processor to recognize voice commands. The unit can be powered either by four AAA batteries or a five Volt DC adapter.

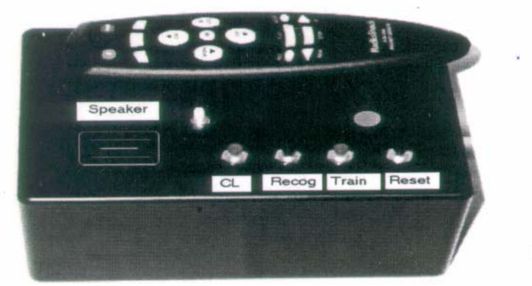

Figure 17.10. The Voice Activated Remote Control.

There are three key parts: a voice recognition system, a universal remote controller, and a logic circuit which connects the two. The remote is modified to have its control wires extending through its plastic cover into the box so that the logic circuit and the relays in the box communicate with the infrared signal processor in the remote. The infrared signal processor of the remote is packaged in a 28 pins IC chip. With correct pin-to-pin connection, an infrared signal corresponding to those pins connections is sent out to appliances. For example, if pin one and pin 11 of the processor are connected together, an infrared signal for POWER ON will be sent to the TV.

The voice recognition processor is the Voice Direct™ 364 from Sensory Inc (shown in Fig. 17.11). Voice Direct™ 364 is a speaker-dependent speech recognition module, allowing training of up to 15 words with duration of 2.5 seconds each. Therefore, the user can use voice commands to control up to 15 functions of the remote. Using sophisticated speech recognition technology, Voice Direct™ 364 maps spoken commands to system control functions.

Each time one of the words is recognized, output pins on the module are toggled high for one second.

A logic circuit is designed for decoding the eight outputs generated by the Voice Direct processor and signifying the specified relays for controlling the modified remote's circuit. Therefore, the remote circuit will send out the appropriate control signal to the entertainment system if corresponding relay is active.

The voice-activated remote is easy to use and is user friendly by providing Speech Prompting Technology. The VARC will tell the user about the current status of the unit such as memory full, word recognized or errors. The unit is small, portable and affordable.

The entire unit including the remote is cost around $120.

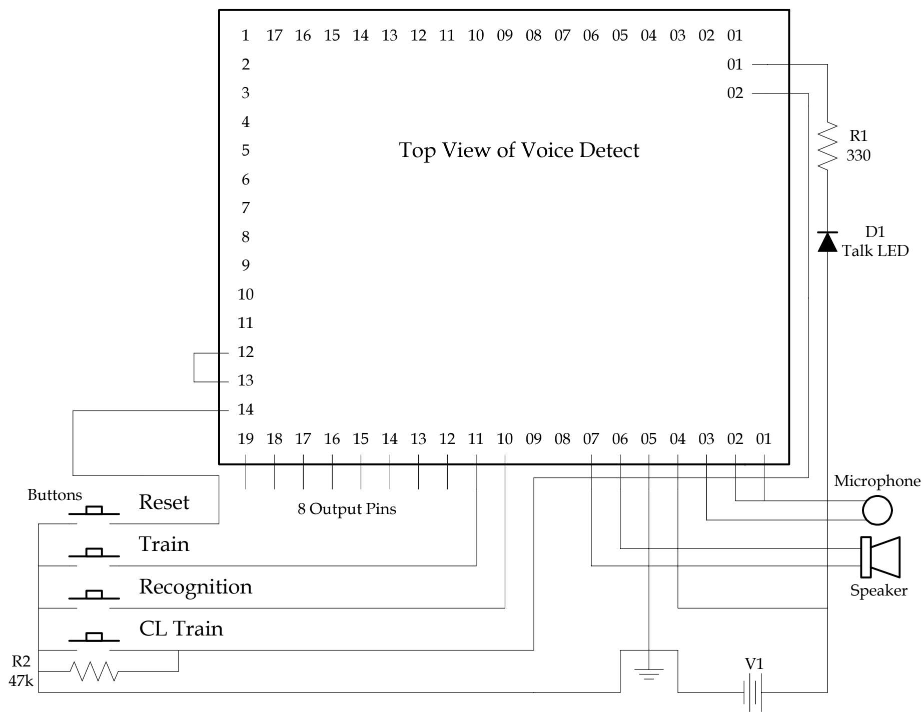

Figure 17.11. Voice Direct Processor Configuration.

VOICE ACTIVATION ENVIRONMENTAL CONTROL SYSTEM

Designers: Brian Hall and James Molloy
Supervising Professor: Professor Donn A. Clark
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INTRODUCTION

The voice activated environmental control system (ECS) was designed to provide voice activation and control of various household lights and appliances for persons with motor disabilities and to increase the awareness of cost effective means of providing such control. This device is simply an application of off-the-shelf components using the well developed but little known and misunderstood X-10 transmission technology combined with a basic voice recognition software platform. Once the system is installed, a person with a disability can the turn appliances and lights on or off by simply using speech commands. The ECS is intended to provide persons with disabilities a sense of independence and control over their surroundings.

SUMMARY OF IMPACT

The design criteria for the ECS were defined by the needs of a person with multiple sclerosis and muscular dystrophy. This person requires constant care, uses a wheelchair, and is incapable of motion outside extremely limited use of one hand. The primary care givers are the individual's parents, along with a state funded caregiver. For times when the individual is required to spend time outside of care, this system can provide him with a means of controlling the surrounding environment and increasing his sense of comfort and security. The client's mother expressed, "...this will make things so much easier for (my son)." Other persons in similar situations will have the capability of installing this type of system into their homes. Also, it can dispel the myths and alleviate the fears of the inner workings, the safety, and the cost of X-10 technology and devices.

TECHNICAL DESCRIPTION

The overall development of the ECS system was dependent upon the availability of standard off the shelf components using X-10 technology. Once the most important appliances were identified for automation need, research was conducted on the best manner and pricing available to obtain the appropriate units. The X-10 modules were easily ascertained via internet shopping at a reasonable cost. Several types of modules and communication interfaces were purchased for the system.

Again, with main focus of the project being the emphasis of simplicity and low-cost to install home automation systems, particular importance was placed on developing a system that was simple to install. Therefore, the core of the system was the CM17A computer interface module. This module is commonly referred to as the Firecracker. This module serves as a low cost X-10 transmitter that can be driven using free downloadable software from the distributor's well-maintained website. Installation of the module is as simple as plugging it into the standard nine-pin serial port on a home computer.

Aside from the CM17A, the core unit needed for the system was the TM751 transceiver module. These units receive a signal generated from the Firecracker module and transmit that signal onto the existing electrical lines within the home. Multiple TM751s were used because the individual's home had an extension built on with an independent electrical wiring circuit. Normally, homes can suffice with a single TM751, but because they cost less than $15 and serve as an appliance module, there is no loss to the benefits of the system if more than one is needed. The TM751 simply plugs into standard electrical home power outlets.

The remaining X-10 modules were all standard items that can be purchased in stores or on the Internet. All modules, regardless of manufacturing, are sufficient in accepting and reacting to control signals generated by the CK17A module and the CK18A Firecracker Control Software. These modules typically plug directly into the home's electrical outlets. Some lamp modules are screwed directly into the lamp socket. The lamp is then screwed into the module. All modules can be set to any of 256 individual address codes allowing for customization of the installation.

Voice recognition software was necessary to allow a person with disabilities to control the Firecracker software. Dragon Naturally Speaking voice recognition software was chosen after investigating currently available software in terms of dependability, availability, system requirements, and price. The voice recognition software was installed onto the system and the end user was trained only for the commands vital for using the Firecracker software and controlling the microphone.

The microphone was found to be the most important part of this system and the most expensive part. The system developed used a Sony WCS-999 wireless microphone with a range of 150 feet. The range is sufficient to allow a person with a wheelchair to travel within their home without loosing control of their ECS. This microphone, while maybe not ideal, is affordable and dependable.

The cost of parts/material was about $500. This included the voice recognition software, the wireless microphone, the X-10 starter kit, and a large hand-full of X-10 modules. Because many people with disabilities already posses voice recognition software and a microphone, wireless or otherwise, the system cost with the same number of modules could be reduced to about $170. Furthermore, a very basic and still very helpful setup could be achieved with just the X-10 starter kit, a few lamp modules, appliance modules, and one universal module for less than $100.

VOICE ACTIVATED TAPE DECK CONTROLLER

Designer: Richard L Roberts
Client Coordinator: Patricia Kirk, Talking Library, Perkins School for the Blind, Watertown, MA.
Supervising Professor: Donn Clark
Director of Assistive Technology
Electrical and Computer Engineering Department
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INTRODUCTION

The voice activated tape deck controller was designed to provide hands-free operation of the Talking Libraries tape decks, which are loaned out along with books on tape, through a mail order system to patrons who meet the eligibility requirements. The patrons of the Talking Library consist largely of individuals with visual and physical disabilities. The Library currently has some methods of assisting patrons with the operation of the tape deck, but they are limited. A remote control can be attached to the tape deck, but its only function is to turn the power on or off. Thus, the tape would already have to be in the play mode for it to start playing when the remote turns it on. The Library also has a mechanical adapter that makes use of levers of different lengths to ease in the operation of the tape deck. Both of these methods, although helpful for some patrons, do not meet the needs of the visually impaired or patrons with limited or no motor skills, such as people with paraplegia, or quadriplegia. Fig. 17.13. shows the voice activated tape deck controller positioned to control a tape deck.

SUMMARY OF IMPACT

For many of the patrons of the Talking Library, the act of enjoying a good book when alone is either impossible or so difficult that the joy usually obtained is lost by the difficulty it presents. The voice activated tape deck controller was designed to eliminate these difficulties. It allows people with visual and or physical disabilities to share in the enjoyment that can be found in literature. Due to its hands-free operation, an individual can operate the tape deck when desired without the need for a physical therapist or outside assistance. Not only does the device help provide a means of entertainment, but it also gives the individual a means of interacting and taking control of their environment. Upon completion, the voice activated tape deck controller was presented to the Talking Library, funded by the Library of congress.

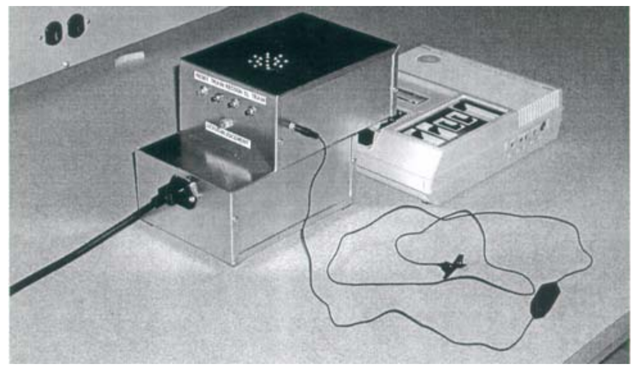

Figure 17.13. Voice Activated Tape Deck Controller and Tape Deck..

TECHNICAL DESCRIPTION

The design criteria for the controller were driven by the device with which it would be interacting and the individuals who would be operating it. Based on the criteria, the controller required four major sections. The first section consists of the Voice Direct 364, a commercially available voice recognition chip produced by Sensory Inc. The voice chip has the ability to store a limited number of voice commands into its memory. The voice chip creates templates by sampling audio sounds during its training mode. Once trained, the chip can then be set into the listening mode where it will sample sound from its environment and compare it to the stored templates. When a match is found, an eight bit output corresponding to the stored template will be transmitted out of the voice chip.

The second major section of the controller is the control circuitry. The voice recognition chip has an eight bit output (but only 16 distinct outputs) and the tape deck has five function keys: stop, rewind, play, fast forward, and eject. Thus, it is necessary to use digital logic circuitry to convert the chips outputs to ones that can be used to control the five function keys. The digital logic is also necessary to overcome two unfavorable behaviors of the voice chip. During initial power up and any time the reset switch is activated, the voice chip will set all of its outputs high for one second. This would result in all function keys being activated at the same time, which could in turn damage the tape player.

Fig. 17.14 depicts the logic circuitry that is used to drive the stop function of the tape player. This same design is used to control the other four functions with the only difference being the order of the inputs.

It can be see from the design that any time bit four is set high and no other bit is high, a high signal can be seen at the output. A high on bit four will operate the stop function. A high on bit five will activate the rewind function. A high on bit six will operate the play function. A high on bit seven will activate the fast forward function. A high on bit eight will operate the eject function. Any time more than one bit is set high, there will be no output on any of the functions. The output of each section of control circuitry is connected to a DC solid state relay which, when biased by the control circuitry, will switch power to the third major section of the controller- a bank of solenoids. Push-type solenoids are positioned over the keys of the cassette player. When the solid state relay is biased 12 volts @ eight amps is supplied to the solenoid providing the 96 watts required to product the force necessary to activate the key. Such a large amount of energy is required because the keys take an average of 2.5 pounds of pressure to be applied over a distance of 0.75 inches.

The final section of the project consists of the two components of the power source. The first component is a dual output switching power supply. The power supply has a five volt 3.5 amp output, which powers the TTL logic and the voice chip. The second output is rated at 12 volts at four amps. Due to size and cost constraints, it was not practical to purchase a power supply that could supply the entire 12 volts at eight amps to the solenoids. To work around this problem, a combination of a reduced power supply in parallel with an 8200 microfarad capacitor was used. The capacitor is charged by the power supply and when discharged, produces the required energy to drive the solenoid. Using this method the physical dimensions of the power supply were reduced from 10x7x3 inches to 5x3x1.5 inches. The power supply, the largest single component in the device, drove the minimum size requirements of the entire unit. Reducing the size of the power supply enabled reducing the overall size of the controller. Using this method also resulted in a substantial cost reduction of $110.00 or approx. ¼ of the total $410.00 required for all parts and materials.

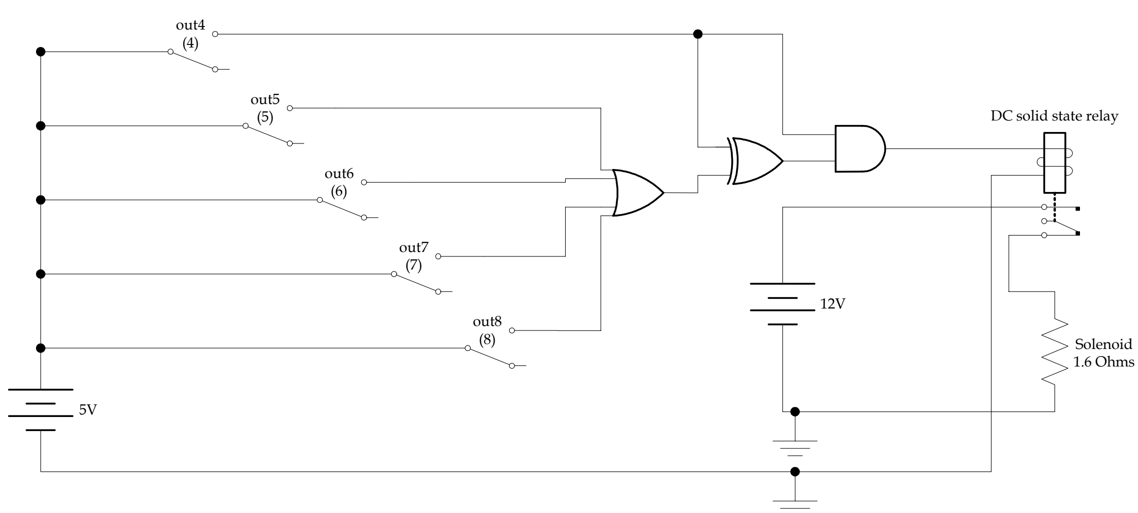

Figure 17.14. Digital Control Circuitry for STOP Function.