
CHAPTER 16

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Development of a Graphical Communication System for Use as an Augmented Communication System for Individuals with Severe Cognitive Limitations

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INTRODUCTION

While the written word, orthography, is a useful form of communication to a majority of people, there are many individuals who have difficulty with its use. The graphical representation of language has been suggested as an alternative.

Many speech and/or cognitively impaired individuals need a graphical representation of language to communicate. The old saying is "a picture is worth a thousand words," if so, photographs or their equivalent would serve as an efficient means of communication for these individuals.

Much of the problem is that most electric or computer based communication systems do not support the graphical representation of language. Those systems that do support a graphical representation use "abstract" symbol sets.

SUMMARY OF IMPACT

Our project is to develop an application for the graphical representation of language. We chose to use the TIFF (Tagged Image File Format) for the storage of the images used because of its general usage in many PC based image capturing tools and its flexibility of usage. The "features" include the support of black and white, color, and grayscale images as well as the compression of images to minimize disk space usage.

The communication board will allow the user to select from several images on a screen and multiple logical collections of these images screens will be referred to as "boards." This logical collection of images will be referred to as a "board."

The user will be able to select an image by using a mouse. When an image is selected it will also appear at the bottom of the screen in a special area reserved for "sentence" construction.

Moving between screens also will be done with the mouse when the user selects special buttons on the screen that will allow him/ her to go to the next and previous screens. From the application also will be done from one such button and in general all such commands will be button based.

TECHNICAL DESCRIPTION

In the beginning of the project it was thought we would use the Zortech C++ language but as time went on it was decided that it was a little immature for the work we intended to do. Microsoft C 5.1 was the language that the project code was eventually written in.

The first thing that needed to be done was to gain a better understanding of the file format that was to be used for the storage of images. Much of the detailed information of TIFF came from a file, acquired by anonymous FTP, written by Davenport and Vellon. Additional general information came from an article in BYTE magazine describing TIFF and several other graphics file formats.

The first program written was used to read and print the header information for a TIFF image to determine how many tags were present and what each referred to. It was determined that the hand held scanner was not a grayscale scanner as reported in its documentation, but only black and white.

The next step was a program written for the reading and display of an image on the display. Many Microsoft C graphics routines were used to simplify the design. The greatest problem encountered in this program was that during the display the program was written to display column 1 to column $(x+1)$ when it should have only gone to column x . This produced an image on the screen that could be

recognized with a little imagination but was obviously not properly displayed.

The addition of a scaling factor was then added to shrink the image down so multiple images could fit on a screen simultaneously. This was done by simply keeping the *n*th row and column and ignoring the others. This produces an image that is only $1/n$ th as large as the original. This scaling was done when the image was displayed.

This program was followed by one that displayed multiple images on a single screen. Many of the monitor characteristics were hardcoded to work specifically with the one currently in use. The program was designed to display a maximum of eight images on the screen. It was soon expanded to handle multiple boards but had a tendency to crash when more than thirteen images were read in. The problem seems to have been one of running out of memory but no error code was returned from `malloc`. It is believed that something was overwritten by an image. The solution was to scale the images when they are read in and not when they are displayed. This change allowed a larger number of images to be read in since each image was much smaller and the program no longer crashed.

Command buttons were added for moving between screens and for quitting the program. A sentence space was also then added at the bottom of the screen. At first, only one of the four possible image areas was used such that when a user selected multiple images they would overwrite the previously selected images. The program was then expanded to make use of all four possible image areas in the sentence space and then the scrolling of images to the left was added. This allows the user to enter more than four images in his/her sentence. The final version of the program allows a maximum for five boards with each board having a maximum of eight images. The application that was finally developed can support only one limited TIFF format displayable on one type of monitor. The user can select from the images on the presently displayed board or can move to the next or previous boards through the use of special areas of the screen called buttons.

When an image is selected it appears in the sentence space at the bottom of the screen. This area can hold 4 images simultaneously and will "scroll" to the left if more images are added after this limit is reached. The term scroll is used to refer to the fact that when the user selects image five in a sentence

the images presently displayed will move to the left by one to make room for the new image. The first image in the sentence space is lost and scrolling cannot be performed to the right in the present version. The description of a set of boards and of a single board is contained in standard ASCII files. The application expects the user to enter the name of the set of boards by redirecting. The file is read and the individual board files and the images they refer to are then read in. If any of the files cannot be opened the application displays the error and then halts execution. The `board` and `boardset` files are created with the user's favorite editor in the order he/she desires the images and boards to be displayed. It is possible to interface the PowerGlove into the application with the use of a module written by Chris Bryden and Peter Buchanan to replace the standard mouse as an input device.

Current Limitations

At present, the greatest limitations are the hardcoding of information about the TIFF files that can be displayed and the monitor characteristics. This was done to ease the complexity of the implementation and can and should be removed in future versions of the application.

Since TIFF contains 35 tags for the description of the image, it can be considered a rich format. The system that was developed can only deal with one very simple TIFF format using only 6 tags. These files are created with a small video camera and accompanying application for the camera control. The use of a small hand held scanner was not implemented because of time constraints and the significantly more complex TIFF implementation used by the scanner, i.e., 12 tags instead of 6.

The only screen that the application will presently work on is an IBM PS/2, or compatible 320 x 200 pixel, 256 color monitor. All other types will cause a premature exit from the application. The dimensions for the board elements, i.e., images, the command buttons, and the sentence area, are all fixed to this particular monitor. The display of the actual images is currently done using Microsoft C graphics routines which limit the speed of the display for the images.

The Design and Implementation for a Telephone Communication System for the Deaf

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INTRODUCTION

Communication for the deaf through telephone lines is becoming increasingly popular to use. No longer do deaf people have to limit themselves to communicating only to people on sight or through visual aids (such as a television). Someone can send a deaf person electronic mail (email) and get a fairly quick response. If a deaf person and the communicator both have the Telephone Device for the Deaf system (TDD), they can communicate outside of their surroundings simultaneously. The ability for a deaf person to communicate outside of their surroundings is essential not only in the workplace but in the home.

One problem with the present state of communication for the deaf is in electronic mail. If someone is sending an email message to deaf person from as far away as California or France, it would take a long time to reach the user. As a result, costly business decisions or family urgencies that need immediate action cannot happen. Another problem is the inability to find people with like machines to communicate. Very few people have TDD machines. Hence, it is virtually impossible for a deaf person to call anyone at random to communicate. Also, a deaf person can only communicate with those computers who have electronic mail or talk capabilities. As a result, a deaf person's communication is limited.

SUMMARY OF IMPACT

A computing device that allows communication through the telephone using the touch tone key pad would aid the deaf person on the job as well as at home. This device would give the deaf person the opportunity to have immediate communication with others in other parts of a building as well as the world. As a result of computing device with this capability, the deaf person would become an asset, not only to the work place but in the home.

A major advantage to having a communication device that works by using the telephone touch tone key pad is it is very accurate and abundant device

that is used very frequently around the world. It is very cheap to use considering the cost for using the phone line and for buying a phone. Also, it allows the deaf person the opportunity to communicate with anyone he/she chooses.

TECHNICAL DESCRIPTION

The system was developed as an extension to the Texas Instruments Speech Board (TI Speech Board). The TI Speech Board is a communication system that can develop speech application programs. The TI Speech Board allows communication between the IBM PC and the telephone. Currently, the TI Speech Board uses several files to produce communication. They are phone.c, pspeech.c, talk.c, and speak.c. The file phone.c handles the direction of the program. The main loop of the program gives the user a prompt and gives the user the opportunity to press a key to determine which option to run. The user has the ability to dial, manual answer, auto answer, or quit the entire program. The pspeech file handles the touchtone key pad input and output. It disambiguates any tones typed by the hearing user on the phone as characters on the screen for the deaf user. The talk and speak files use the TI Speech Board. They have the ability to read phrases and sentences typed in by the deaf person and speak them to the hearing person on the phone.

The methodology of the systems is as follows. The communication system is used by the deaf person in a normal manner. While the communication system is being used, it monitors the status of the type of function the user desires. The user can have the computer dial, manual answer, or auto answer. It then takes the files described above and uses them to perform communication between the user and someone on a touch tone phone.

Auto Answer

The auto answer routine was implemented to give the user the opportunity to have calls answered while he/she was not available to take them. This routine is activated if the user types in an 'a' at the

prompt. The routine first asks the user questions concerning the set up of the calls received then it is set to wait for an incoming phone call. After the phone rings a preselected amount of time, a message is given stating that the user is unavailable and gives the caller the opportunity to leave a message. If the caller decides that he/she wants to leave a message then the caller will type in a series of tones on the line that are disambiguated and stored on the computer in a file.

Dial

The dial routine was implemented to give the user the ability to make phone calls. This routine is activated when the user types a 'd' at the prompt. The program will then ask the user to type in the phone number, number of rings, and silence time on the line. The number is then dialed. If a connection is made, the computer will let the user know and he/she may begin typing the message to the person on the other line. The user terminates the call by pressing the return key. The person who received the call can reply by typing tones in the touch tone key pad. The tones are then disambiguated and the characters are typed on the screen. The receiver can terminate the call by typing a '1'. This conversation loop continues until the deaf user types "goodbye."

Manual Answer

The manual answer routine was implemented to give the user the ability to decide how he/she wants to monitor the phone calls. It is run when the user types a 'm' at the prompt. The program then waits for an incoming call. If an incoming call occurs the routine lets the user know that there is a call waiting. The user then has the option to answer the call or not to answer the call. If the user wants to answer the call they will type 'y' at the prompt. The user will then type in the message and press the enter key to send it to the caller. The caller then types in the message to the user by typing tones that are disambiguated into characters. The characters then appear on the screen. The caller will terminate his/her message by typing a '1' on the touch tone key pad. This loop will continue until the user types "goodbye." If the user does not wish to answer the call he/she types 'n' at the prompt the call is terminated.

Disambiguator

The disambiguator is used to correspond letters to the tones typed in by the person on the telephone. The disambiguator uses the '*', '0', and '#' keys to differentiate which letter corresponds to each number. If the user types '*' and then the number, this sequence will type the first letter on each number pad. For example, if '*2' is typed, an 'A' will appear on the screen. If the user types a '0' and then a number, the sequence will type the second letter on each number pad. In a similar fashion, if a user types '#' and then a number the sequence will print the third number on the telephone key pad. If the phone user types in '**', '00', '##' a blank space is typed on the screen. If the hearing phone user wishes to terminate the message, he/she must type a '1'.

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A Power Glove as a Rehabilitation Device

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INTRODUCTION

As special input devices for various applications become more popular and versatile, the idea of using these input devices for better human-machine interfaces for the disabled becomes more realistic.

The problem addressed by this project is to develop an alternative input device that will allow disabled users to make direct selections of icons and other items displayed on a computer screen. The project has been provided with a Power Glove to be used as the human interface. This product was developed by the firm of AGE Inc. and is currently marketed by the Mattel Co. as an alternative input for the popular Nintendo video game. AGE Inc. has made a number of these available to university research laboratories for experimental use.

SUMMARY OF IMPACT

The Power Glove represents an interesting interface for disabled users. Its deficiencies require that the control strategies be carefully developed in order to maximize the benefit to the user. The work done in this project has provided a set of software drivers that can be used in future explorations of the applicability of this device.

TECHNICAL DESCRIPTION

The Power Glove as provided to the project senses the movement and orientation of the hand and communicates the information via the serial port to a personal computer. The Power Glove uses elastomeric material imbedded in the thumb, index, and middle finger to sense the flexion of the joints. The Glove has an external ultrasonic transmitter that generates signals used by remote microphones to determine the three dimensional and two rotational components of the location of the hand in space. AGE Inc. has designed a prototype serial interface that is not normally available in the Nintendo oriented product. A program was developed in this project that reads the incoming serial data from the Power Glove. This software is written in C and uses the Greenleaf Library of C functions for serial interface. A demonstration program has been written to

interact with another student project involving the display and selection of graphical icons on a PC monitor. The positional information from the Power Glove is matched to the cursor position on the PC monitor. The user calibrates the Power Glove during an initialization phase in which the user is prompted to point to specific locations on the screen. The range of movement on the user is scaled to the screen size. The software allows the Power Glove to perform as a cross between a mouse and a light pen. The Power Glove has the advantage of the mouse in that the user can be remote from the screen. The Power Glove has the important feature to offer the disabled user a one to one relationship between the selection process and the item on the screen. The light pen does offer the one to one selection, but requires close proximity to the screen. The Power Glove and the project developed software appear to be performing as they were designed. The positional information is accurately transferred to the PC and the cursor position is provided. The difficulties remaining are due to the method by which the Power Glove senses the three dimensional position and orientation. The ultrasonic system is reasonably accurate for horizontal (perpendicular to the axis between the glove and microphones) and vertical movements, but is much less sensitive to movements along the axis between the glove and the microphone. The two rotational dimensions (pitch and yaw) are only moderately accurate. There is no roll measurement. These differences in measurement accuracy and sensitivity place restrictions on the use of the glove as a rehabilitation tool. A subjective evaluation of the Nintendo use of the Power Glove shows the same difficulties. In many of the games, the user must exaggerate his movements, or alter the way in which they are made. This makes the glove less than exciting as a game interface.

Prototype Tactile Reading System for Blind Individuals

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INTRODUCTION

This project concerns visually impaired individuals who read documents with the help of a computer and synthesized voice output. These devices are helpful, but they lack some flexibility in reading selected portions of the document. This causes a problem because the individual is not allowed to freely choose a particular section of the document to read. We have consulted several visually impaired people who feel limited and frustrated with their current reading systems. They were excited to hear about our project and hope to one day use a system that will allow more convenience and flexibility.

SUMMARY OF IMPACT

The current project is only a simulation. The speech synthesizer and personal computer were capable of performing their tasks quite well. There is currently no page or screen sized tactile display. This project certainly makes the case for the continued development of a screen sized tactile display that is also pressure sensitive. The project currently addresses text that is in electronic form. This could be extended to the use of an optical character reader so that letter and other documents could be converted to electronic form. We evaluated the prototype with several blind students enrolled at the University of Delaware. The users were able to feel the layout and use the simulation to speak selected portions of the text. Users were able to quickly identify the type of text. For the sample letter, users found it convenient to identify the text as a letter (the opening has a distinct layout and when selected begins "Dear..."). The users would quickly feel for the closing (again it had a distinct feel) and identify the author before reading (listening to) the text. The blind consumers made several suggestions as to the applicability of the concept and all encouraged us to continue the project.

TECHNICAL DESCRIPTION

We have simulated a device that will show the feasibility and need of software and hardware that will allow the user to "see" a document with his/her hand. The user will be able to use the device to read selected portions of the text exploiting the format used by the sighted world. An ideal device would allow the user to feel the layout (not the individual letter) of the text on a screen and speak selected portions based on finger pressure. Our goal is to share this interface with others and seek the future development of the concept beyond this prototype. The software was written in C and involves the interaction with two components added to the personal computer. A 386 based PC clone was used to support a touch sensitive table (PowerPad) and a Texas Instruments Speech Option Board. The project could not fabricate a computer controlled tactile display and therefore relied upon a simulation. A number of sample documents were selected to represent different text formats. These included memoranda, letters, report, ect., each of which has a distinct visual layout. The text of each along with the respective layouts were stored in accessible text files. Printer versions of each were produced and physically altered (by adhering liquid plastic over the text passages) to provide a tactile representation of the layout. This simulated the output of a tactile display that would provide dynamic information on text arrangement. These modified pages were placed over the PowerPad. With this system, user could feel the layout of the paragraphs, indentations, headings, closings, ect. The users could select a passage by applying finger pressure through the page to the PowerPad. A data collection program was developed that related the positional information on the PowerPad to the particular segment of text in the sample document. The text was spoken by the Texas Instruments speech synthesizer.

Development of Video Intercom for Deaf Individuals

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INTRODUCTION

The use of manual communication or sign language has shown a marked increase among deaf individuals in the United States. Changes in the perception of sign language have allowed it to be viewed as a language rich in structure rather than as a form of pantomimed **English**. These changes have allowed many deaf individuals to study and use sign language as their primary form of conversation.

Sign language, **like** speech has historically required face to face communication. Telephones and other audio devices have allowed voice to be transmitted over long distances. Sign language conversations have not benefitted from technology in the same way.

Traditional telecommunication systems (telephone, ect.) were designed for the rather narrow bandwidth of speech. In order for visual communication to be transmitted over the same system, the bandwidth must be greatly expanded. The Department of Computer and Information Sciences at the University of Delaware is developing a video telephone that will convey edge detected images at 10 frames per second over residential telephone lines. The cost of such a system remains prohibitively high.

SUMMARY OF IMPACT

The data acquisition rate of the Electrim camera and the host PC limit the number of frames to 10 per second. This has been shown to be sufficient to represent sign language at moderate speeds. At this frame rate, the system requires 400 kbytes per second. This is sufficiently low to allow a number of sign language conversations to occur simultaneously without seriously degrading the network. The use of existing computers and Ethernet provides a very cost effective way to serve the deaf employees and staff.

TECHNICAL DESCRIPTION

This project deals with the development of a video intercom for use within an institutional environ-

ment. The intended users are deaf individuals who wish to communicate in sign language with other deaf people, interpreters, or other signers. While it may be possible to construct a closed circuit television system to accomplish this, such an effort was considered too costly. The number of deaf users in any institution is usually small. It would be difficult to justify the expense of wiring the institution with a dedicated system just for deaf communication. It would also be excessively limiting to install closed circuit television in only a few places accessible to the deaf users.

The widespread use of computers has led many institutions to install local area networks for high speed data transmission among personal computers. The typical Ethernet local area network (LAN) allows peak data rates of 10 megabits per second. In addition to the speed, there is a trend to provide network connections to nearly every office within an establishment.

This project proposes to make low cost additions to a personal computer and allow it to transmit data representing video pictures over existing LANs. The project has employed a small, \$400 video camera manufactured by Electrim Inc. This unit connects to the standard PC bus and captures 192 x 165 pixel video pictures ten times per second.

The project has developed software (a combination of C and assembly language) that can read successive images from the camera. Similar software has been written to display image with six bits of gray scale on a VGA monitor. Combined with the capture and display software are several data compression schema. While the bandwidth of the LAN is broad in comparison to the residential telephone, attempts must be made to reduce the load on the network.

The image size is first reduced to 100 x 100 pixels. This provides approximately a 3:1 data reduction over the original image size. The capture software also performs a simple difference compression as the data is acquired. The full value of the first pixel of each line is transmitted. All subsequent pixels in

the line are sent as differences between their actual value and that of their predecessor in the line. This provides an additional 2:1 data reduction. Each frame is described by 5 kbytes.

The project also developed software to transmit the image data on the Ethernet using a library of commercial network functions.

Environmental Control System for Handicapped Individual with Infrared Remotely Controlled Devices

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INTRODUCTION

The computer is often used as an educational tool by handicapped individuals, and has the potential to be a great help in many other aspects of their lives. If the computer could be programmed to help control their environment, they could gain a sense of freedom that they would otherwise be without. This is the basis of our project.

The first decision involved choosing those aspects of the environment the computer could control. We chose to concentrate on creating a system to control devices with infrared remote controllers. Such a system would need to have the ability to control any device of this type. This would provide the handicapped user with precisely the central control that he/she could benefit from.

An important consideration in the development of any system for specific population is the interface between the system and the user. Since we are considering a system for individuals with extremely limited motor control, we needed an interface that would take as little effort as possible.

TECHNICAL DESCRIPTION

The system was developed in two main components. The peripheral hardware had to be designed to model existing remote controllers. Infrared remote control devices use a binary code in the form of a block wave (1). A 40 kHz oscillating signal comprises the "ones" in the code and no transmission denotes a "zero." A commercially available parallel digital interface produced by Metrabyte (model PIO-24) is the link between the computer and our hardware. This product provides read and write control over three 8-bit ports that can be used to monitor or control digital electronic circuits. The software for the system is the other main component. This was again divided into two parts. The first part drives the hardware and was developed simultaneously in order to aid in testing. The second part of the software is the part to be run by the

user and was developed independently from the other components.

The hardware consists of two main circuits. The first is the input circuit. This is simply an infrared phototransistor. By monitoring the voltage flowing through the transistor, the block wave can be sent to the computer and interpreted. The other circuit provides the means to produce the infrared block signal. One part of this circuit is an oscillator running at 40 kHz (2). This is combined with the computer generated signal using a NAND IC chip. The resulting signal is used to drive an infrared LED, thus creating the block wave signal that would normally be sent by a remote control. An important part of the software to handle the signals of remote controllers is a stop watch program developed here at the Institute (3). After modifying the original millisecond timer to time in twentieths of a millisecond, we implemented it to record the durations of the blocks in the signal. The procedure to input a signal captures a half of a second of the block wave signal. This is then written to disk as the series of times corresponding to the durations of each "one" or "zero" in the signal. The procedure to output a signal accepts a series of times that it uses to generate the signal to be sent to the output circuit, which in turn reconstructs the block wave.

The user interface consists of a series of menus that allows the user to control appliances, learn new functions, and remove existing functions. From the main menu, the user has the ability to control devices that have previously stored functions. First the device is chosen. Next, a menu containing all the functions for that device is displayed. If any of these functions are chosen, the procedure to output a signal is used to perform that function. When the user is done using that device, he/she "exits" the function menu and is returned to the main menu. In both the main menu and each of the device function menus, single keystrokes activate the desired option. Another choice from the main menu is to "learn" a new function. This allows new

devices and their functions to be added to the system. The user is prompted to name what he/she is entering, then the procedure to input a signal is used to store the signal for the new function. The “remove” option on the main menu allows functions and/or devices to be removed from the system. This, in conjunction with “learn,” allows for a constantly up to date system.

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