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ABSTRACT

This final report discusses the outcomes of a project that created a Universal Access System (UAS), a system that gives students with disabilities access to the same computers as their classmates. The project developed a new approach in which the needs of the individual with disabilities are handled separately from the computers and other devices that are to be made accessible (hosts). Each host is fitted with a wireless interface (Universal Access Port or UAP) which provides access to keyboard, mouse, and screen functions in a totally standardized manner. Individuals with disabilities are equipped with personal devices called accessors which interact with UAPs over an infrared light beam. Standardized codes are used on the infrared link so that any accessor can function with any host. This paper describes the concept of UAS, the components of the UAS, how information is transferred between an accessor and a host, types of accessors, and how UAS has provided a cost-effective way to make the campus at the California State University at Northridge (CSUN) computer accessible. Costs of installing UAPs are also addressed. Appendices include a description of UAS, statistics on the CSUN computer labs and student demographics, an evaluation plan, and relevant press releases and articles about the project. (CR)

The Universal Access System

Grantee Organization:

California State University, Northridge
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Northridge, CA 91330
(818).885 2578

FIPSE Grant #:

P116B90830

Project Dates:

Starting Date: October 1, 1990
Ending Date: September 30, 1992
Number of Months : 36

FIPSE Program Officers:

David Holmes
Brian Lekander

Grant Award:

Year 1: $91,428
Year 2: $88,372
Year 3: $88,592

Project Director:

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Report written by:

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Abstract

The Universal Access System

The Universal Access System project has created a universal method for giving disabled students access to the same computers as their classmates. This access is independent of the computer type, the applications software, and the type and severity of the disability. This goal has been achieved by adopting a new approach in which the needs of the disabled individual are handled separately from the computers that are to be made accessible (hosts). Each host is fitted with a wireless interface (Universal Access Port or UAP) which provides access to keyboard, mouse and screen functions in a totally standardized manner. Disabled users are equipped with personal devices called accessors which interact with UAPs over an infrared light beam.

Executive Summary

The Universal Access System

Purpose of the Universal Access System

The goal of the Universal Access System project was to create a universal method for giving disabled students access to the same computers as their classmates. The basic requirements were that access must be independent of the computer type, the applications software, and the type and severity of the disability. This goal has been achieved by adopting a new approach in which the needs of the disabled individual are handled separately from the computers and other devices that are to be made accessible (hosts). Each host is fitted with a wireless interface (Universal Access Port or UAP) which provides access to keyboard, mouse and screen functions in a totally standardized manner. Disabled users are equipped with personal devices called accessors which interact with UAPs over an infrared light beam.

Background and Origins

The CSUN Office of Disabled Student Services (ODSS) operates a Computer Access Lab (CAL) in which students with disabilities have access to a wide variety of specially modified hardware and software. Expert assistance in the CAL provides guidance in the selection of appropriate accommodations and the necessary training. While the CAL solves many of the problems faced by disabled students, it also introduces some new ones. The main limitation is that, being a centralized facility, it limits students to working within the time and resource constraints of the CAL. From the beginning, we knew that students would be better served if access could be provided on the computers already available in classrooms and laboratories. Until now, however, this has been ruled out by the high initial cost and ongoing support required for traditional access techniques.

In October,1989, Neil Scott, an engineer with the ODSS, proposed a new approach to solving the access problem and received a three-year grant from the Fund for the Improvement of Post Secondary Education (FIPSE) to develop a Universal Access System (UAS). The UAS was a totally new concept in which the requirements of the disabled user are separated from the applications performed by the "host" computer. It consists of two main components: a standardized interface to host computers, called a "Universal Access Port" (UAP), and a personal device called an "accessor" which handles the particular access needs of the disabled individual. UAPs and accessors communicate with each other over a wireless, infrared communications link. Standardized codes are used on the infrared link so that any accessor can function with any host.

Methodology

The first year of the project focused on defining the needs of the major disability groups and exploring ways in which those needs could be met. A prototype system was completed in time for the CSUN international conference in March, 1991. After some refinement, this prototype was demonstrated during May 1991 at COMDEX in Atlanta, and to several government and national organizations in Washington D.C. (FIPSE, GSA, NSF, AAAS, NFB, EIA)

Our first prototype of the UAS interfaced to the host computer through a serial communications port and required an internal driver program to interact with the keyboard, mouse and screen. This approach was used to minimize the hardware requirements for the UAS. Extensive testing of this prototype showed us that standardizing on an internal interface is virtually impossible because of the huge variety of computer hardware and software in the marketplace. We also found that not all applications programs follow established programming conventions with the result that strange and unpredictable events would occur when we were interfacing to them. These problems were overcome by adopting a different approach in which all interfacing is performed outside of the host computer. A "Universal Access Port" (UAP) interfaces between the infrared link and the keyboard and mouse ports of the host. The UAP emulates the operation of the host keyboard and mouse, interleaving commands from an accessor with those coming from the real devices. In this way, the user with an accessor has full control of the host system in a totally invisible manner.

A similar approach is being developed for reading text information from the host screen. Whereas our first prototype retrieved screen text information from the internal "video" memory of the host, the final version will read text information directly from the video signal which flows from the host computer to the host display screen. This new approach is necessitated by the great variety of hardware and software techniques used in modern computer display systems. The logic of recovering text in this manner has been worked out, but some serious engineering design is required to implement the system.

Results

The tangible result of this project is a new infrared interface system for computers which dramatically improves access for disabled individuals. Prototypes have been demonstrated and a manufacturer has been licensed to produce and market the system. Genovation, Inc., Irvine, CA, manufactures computer keyboards and a variety of specialized peripheral devices. They have completed preproduction prototypes of a Universal Access System which handles all types of input required by disabled users. These prototypes are soon to be distributed to a variety of consumers for Beta testing. Ten of the systems will be installed at strategic locations on the CSUN campus for evaluation by disabled students. CSUN staff will conduct the evaluation of the units with particular emphasis on how well they solve the problems of creating an accessible campus.

We had intended to complete the evaluation of the system before the grant ended but development problems delayed the delivery of fully functional systems until September, 1992. The CSUN campus evaluation will be carried out during the 1992 Fall semester.

Costs

There are two components to the cost of implementing a Universal Access System. Each host computer that is to be made accessible require the attachment of a Universal Access

Port (UAP) which currently costs about $250. It can be installed in a matter of minutes and does not require any extra software or setting up on the host. Each disabled user requires an accessor which provides the appropriate input and output functions. The complexity, and hence cost, of an accessor depends on the specific needs of each disabled user. Unit costs may vary from a few hundred dollars for a simple switch or keyboard accessor to several thousand dollars for a speech input accessor. In many cases, laptop computers can be used as cost-effective accessors. In the short-term, organizations may be required to carry the cost of accessors as well as UAPs. In the longer-term, however, rehabilitation agencies, educational organizations, foundations and various private sources will be used to provide disabled individuals with personal accessors.

Project Results

Prototypes of the UAS have been widely demonstrated and have received strong acceptance by disabled individuals, disability professionals, funding sources (including the State Department of Rehabilitiation) and employers of disabled people. Preproduction prototypes are about to undergo testing in a variety of locations in which disabled individuals must interface to computers and other information processing equipment.

Evaluation of the UAS in an educational setting will continue at CSUN after the completion of the grant.

Development of the UAS will be continued in the Center for the Study of Language and Information (CSLI) at Stanford University where Neil Scott has accepted an appointment as a Senior Researcher. The first project at CSLI will be to extend the Universal Access System to enable blind and visually impaired people to work with graphically displayed information.

Several companies involved with public access to information are studying the UAS as a method for providing access for disabled clients.

IBM Corporation and North Communications, Inc., are co-developers of information kiosks. They are developing kiosk applications for shopping malls, hotels, transport centers, libraries, and government departments. The greatest problem facing the kiosk developers is finding practical ways to accommodate the needs of disabled users. It appears that UAS is the most promising technology for this application.

Automatic Teller machines (ATMs) are specialized forms of information kiosk. Wells Fargo Bank is studying ATM applications of the UAS.

The Universal Access System received an award in 1991 from the American Association of State Colleges and Universities (AASCU). This national award recognized the Universal Access System as an outstanding and innovative solution to the problems of making campuses accessible to students with disabilities.

The Universal Access System

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Final Report
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Report written by Neil G. Scott

Introduction

Project Overview

The goal of this project was to create a universal method for allowing disabled students to use the same computers as nondisabled students. The basic requirements were that access must be independent of the computer type, the applications software, and the type and severity of the disability. This goal has been achieved by adopting a new approach in which the needs of the disabled individual are handled separately from the computers and other devices that are to be made accessible (hosts). Each host is fitted with a wireless interface (Universal Access Port or UAP) which provides access to keyboard, mouse and screen functions in a totally standardized manner. Disabled users are equipped with personal devices called accessors which interact with UAPs over an infrared light beam. Separating the access functions in this way dramatically effects the cost to organizations for providing access. Instead of being required to provide totally personalized solutions for each disabled employee at each work or study location, organizations can provide identical UAP interfaces for each computer that is to be made accessible. Depending on circumstances, the organization may, or may not, be involved in providing an accessor. As time goes on, it will become increasingly common for disabled individuals to have a single portable, personal accessor for use at home, at school or university, in the workplace, and for access to public information. The Universal Access System therefore provides a truly universal, portable, cost-effective solution since any accessor can operate with any host equipped with a UAP. In the context of this project it provides the potential for truly campus-wide access.

Origin of Project

Three major factors contributed to the idea of creating a universal method for allowing disabled individuals to access computers. The first was an ongoing commitment to find better ways to give disabled students access to computers across the campus. The second related to evolutionary changes in computer hardware and software which were making many of the existing access techniques obsolete. The third was the introduction of a new law requiring federally funded information equipment to be accessible to persons with disabilities.

California State University, Northridge (CSUN), has a large population of disabled students served by a centralized "Computer Access Lab" (CAL). Here they have access to a variety of computers and software specifically adapted to accommodate disabled users. While the CAL has been very successful at providing access to computers, it has not entirely satisfied the needs of the disabled students. Its major shortcomings are the requirement for disabled students to work at a central location, isolated from the rest of the class and the time constraints of only being able to work when the CAL is open. We were searching for a viable way to provide access directly to computers in classrooms and laboratories anywhere on the campus.

Computer hardware and software is evolving, and will continue to evolve, at a rapid pace. For them to remain competitive, it is necessary for manufacturers to exploit new hardware and software capabilities to the utmost. As a result, software applications are becoming increasingly large and complex and often preclude modifications or additions commonly used to accommodate persons with disabilities. We were searching for an access method which would be independent of the characteristics of specific software applications.

Traditional methods for making computers accessible to persons with disabilities require modifications to a specific computer or applications program to accommodate the needs of a particular individual. While this approach generally leads to a usable result, there are many problems. For instance, solving problems on an individual basis is very time consuming. Furthermore, cost usually limits a person to having only one accessible computer, bringing up the questions of whether it should it be at home or at work, or if it should be a portable system. Another problem occurs when several disabled individuals must share a single computer. Unless they all have identical disabilities and needs, each requires different accommodations. Installing more than one type of special access on a single computer, however, can lead to hardware and software conflicts and often results in an expensive system.

Purpose of the Universal Access System Project

The primary purpose of the Universal Access System is to provide disabled individuals with cost-effective access to any computer or electronic equipment.

The UAS project addresses the rapidly increasing need for computers to be made accessible to persons with disabilities. Access problems occur at two different levels.

- At an individual level, people with disabilities are faced with the need to access computers in many different areas of their daily life but they are usually restricted to having only one that has been modified to make it accessible. The UAS allows an individual to use computers in all domains of their life.
- At an institutional level, the passing of the Americans with Disabilities Act (ADA) in 1992 has obligated organizations such as schools, universities, corporations, and public service agencies to make information processing equipment accessible to disabled employees and clients. The uncertainty of knowing which disabilities must be accommodated, at which machines, and at what time, makes this a difficult and expensive task when traditional approaches are used.

In each of these cases, evolutionary advances in the design and application of computers are compounding the problems by rendering obsolete many of the existing access methods.

The UAS was developed to solve access problems for both individual and institutional use of computers. The key element of the UAS concept is that it separates access functions from applications. Access is handled by personalized devices called "accessors" which are tightly matched to the needs and capabilities of each disabled individual. Applications are handled in the normal way by "host" computers to which low-cost, external, "Universal

Access Ports" (UAPs) have been added. The UAP allows any accessor to communicate with the screen, keyboard and mouse ports on the host. Communication between an accessor and a UAP is handled by a high-speed, bidirectional, wireless infrared link.

Accessors may be implemented in many different ways. The simplest implementation is based on a portable laptop or notebook computer which has been equipped with an infrared transceiver. Almost any type of special access can be provided by running appropriate software in the portable computer. Accessors may also be purpose designed to match the needs of a particular type of disability. Blind users, for example, do not need the screen or full keyboard of a notebook computer and can be better served by an accessor which has a small "control" keyboard and a speech synthesizer. Some of the existing computer access devices can also be used as accessors if they are equipped with an infrared transceiver.

Outcomes for the project

The universal solution developed by this project enables individuals with any type of disability to operate any type of host device. While the focus during the project has been on educational applications, i.e., providing disabled students with access to computers on a university campus, the results go far beyond this. Host devices which may be accessed through a UAP include computers, appliances, information kiosks, ATMs, elevators, communication devices, environmental controllers, security devices, industrial controllers, vehicles, and so on.

Concept of a Universal Access System

The Universal Access System project addresses the problems of access in a new way by separating special needs of disabled users from the computers which run applications. A personal "accessor" is prescribed for each disabled user to satisfy his or her exact requirements. Accessors interact with any "host" computer through a low-cost interface called a "Universal Access Port" (UAP) which emulates the physical keyboard and mouse. Communication between an accessor and a UAP is handled by a standardized infrared wireless communications link. As an example of how this system works, consider the process of entering a keystroke into a program on the host: The disabled user selects the key by performing whatever selection process is necessary on the accessor, rather than on the keyboard; the accessor transmits a "keyboard" information packet over the infrared link; the UAP receives the keyboard packet and translates it into a keystroke code for the host; and finally, the UAP sends the keystroke code to the host via the keyboard port. The host is unaware that the keystroke came from anywhere other than the real keyboard. A mouse operation occurs in exactly the same manner. The accessor operation replaces the need to physically use the keyboard and/or the mouse.

Disabled users who require assistance to read information from the screen of the host are served by an equivalent process but in this case, operation is from the host to the accessor. Information displayed on the screen of the host is transmitted to the accessor where it is converted into a form suitable for the particular user. A blind person, for instance, "reads" text with the help of a speech synthesizer which speaks each word or character out loud. A visually impaired person sees a magnified version of screen text. Special accessors are required to perform the necessary transformations of screen information to speech or magnified images.

Background and Origins

California State University (CSUN) has a disabled student population of close to 1,000 out of a total student body of 30,000. At 3% of the total student population, this is one of the highest ratios for any university in the U.S. Catering to the needs of the disabled student population is a priority at CSUN. Services are provided through two departments. The National Center on Deafness looks after approximately 250 deaf and hearing impaired students. The rest of the disabled students are looked after by the Office of Disabled Student Services (ODSS). ODSS provides a wide range of mandated services (assistance with registration, note takers, readers, proctors, and the like), and a variety of non mandated services (testing and counseling for learning disabilities, a laboratory of accessible computers and special equipment, expert technical assistance, art activities, and so on). During the last five years, the Office of Disabled Student Services has established itself as a leader in applying technology to the needs of disabled individuals. It achieved this position through innovative services to disabled students on the CSUN campus, providing rehabilitation training programs throughout the western United States, and organizing and running the largest annual conference in the world on the theme of Technology and Persons with Disabilities. One of the main resources of the ODSS is a Computer Access Lab (CAL) in which students with almost any type of disability are able to use computers in course-related activities. Since its establishment in 1988, this lab has been used as a model by other universities across the country. In June 1992, it was the subject of an award for excellence from the American Association of State Colleges and Universities.

Our experience with the CAL showed that while it provided disabled students with options and capabilities they would not otherwise have, it was not the full answer to their problems. Its principal disadvantage is that, as a centralized facility, it places strong constraints on when and where a disabled student may work. Ideally, disabled students should be able to work alongside their peers in classrooms and laboratories. Traditional access techniques make this impractical. On a large campus the logistics of having the right equipment available at the right place at the right time requires more resources than is available for this type of activity. It is also impractical to leave specially configured equipment in open-access computer labs. Vandalism and theft of components render them useless in a very short period of time. In spite of these problems, however, we were looking for ways in which disabled students could perform computer based activities alongside their classmates. The UAS concept provided the answer we were looking for.

Context of the UAS Project

The UAS has been developed in a postsecondary educational environment. The primary goal of the project has been to develop a secure, cost-effective method for making computers on a university campus accessible to students with disabilities. In the process of doing so, we have developed a solution that will work equally well for any organization in which computer facilities must be made available to a large number of users, some of whom may have disabilities.

Reasons for undertaking the UAS project

Traditional access solutions, in which individual computers are modified to match the needs of individual users, are impractical on a campus where students, with a variety of disabilities, are required to work with a variety of computers at a variety of different locations.

CSUN's initial method for accommodating the needs of disabled students has been a centralized facility called the Computer Access Lab (CAL). The CAL gives students access to a selection of specially adapted computers and software, and the services of disability and technology specialists. Experience gained from operating the CAL for several years led us to the conclusion that there had to be a more effective way to support disabled students. A study of the options led to the idea of attaching identical interfaces to all computers and accommodating the needs of each disabled individual within a personal portable access device we now call an "Accessor."

There is no other universally applicable method for making computers accessible to a wide variety of disabled users.

This concept was proposed to FIPSE in 1989 and funded for three years, beginning in October, 1989.

Outside support

Some additional support for this project was provided by CSUN's Office of Disabled Student Services in the form of programming assistance, provision of components and access to specialized equipment.

Project Description

Functional description

The Universal Access System enables disabled individuals to remotely control keyboard and/or mouse functions on a host computer and read information displayed on the host screen. The system is designed to operate with any type of computer or computer-based equipment.

- The Universal Access System separates a disabled individual's access functions from the operating system and applications performed by a host computer.

- The Universal Access System is designed to make host computers accessible without changing the normal operation of the host.

- Disabled individuals use a single personal accessor to communicate with any computer or electronic equipment equipped with UAS.
- The Universal Access System provides a standardized interface that allows a host computer to be used by any person equipped with an accessor, regardless of the type of disability.
- The Universal Access System is designed to be portable, thereby enhancing the independence of disabled individuals.

Components of the Universal Access System.

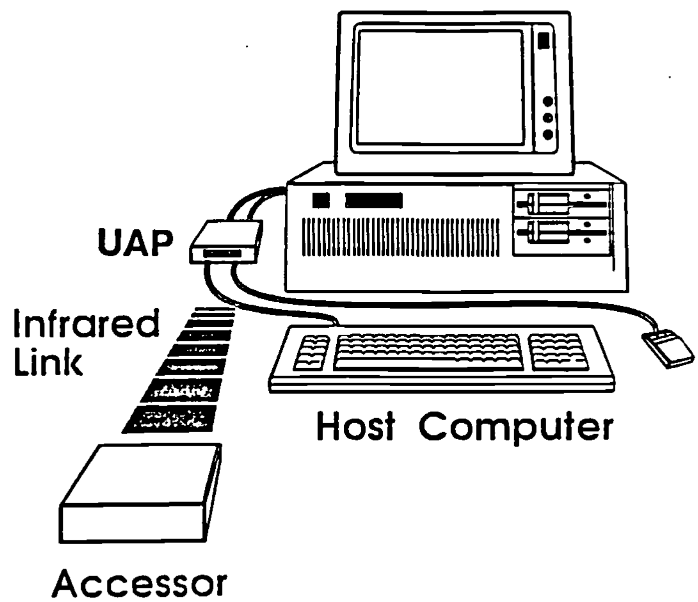

Figure 1. Components of the Universal Access System

As shown in Figure 1, the Universal Access System consists of two major components:

- Universal Access Port (UAP)
- Accessor

Universal Access Port (UAP)

The Universal Access Port connects to a host computer and provides a standardized interface to any accessor. The UAP consists of a microprocessor, an infrared transceiver, and cables which connect it to the host computer. While all UAPs function in the same manner and use the same basic hardware, different versions are required for each of the major computer types (IBM PC, Apple Mac, NeXT, Sun Sparc, and so on). Differences are mainly in the types of connector used and the communication protocols required for each type of host system.

The microprocessor in the UAP performs the following functions:

- **Packet management**
  - Assembling packets for transmission over the infrared link.
  - Disassembling packets received over the infrared link.
  - Routing data to the appropriate host or accessor port.
- **Error handling**
  - Apply error checking to every packet.
  - Correct errors by retransmitting corrupted packets.
- **Data translation**

  The microprocessor translates between the data format used on the infrared link and the data formats used by individual hosts or accessors.
  - At accessor end of the link
    - Accessor keyboard data to UAP keyboard format.
    - Accessor mouse data to UAP mouse format.
    - Accessor video data to UAP display format.
    - Accessor commands to UAP command format.
  - At host computer end of the link
    - UAP keyboard format to host computer keyboard format..
    - UAP mouse format to host mouse format.
    - UAP display format to host video format.

The infrared transceiver provides bidirectional serial data communications, currently at 19,200 Baud. The system is designed to reject interference from strong sunlight, fluorescent lights, and adjacent infrared links. Low power consumption was a major consideration in the design of this system since it will often be necessary to use the transceiver in battery powered accessors.

Cables from the UAP allow it to be connected between the physical keyboard and the host keyboard port; the physical mouse and the host mouse port (serial RS232); and the host video port and host display screen. Different cables and connectors are used to attach the UAP to different host equipment.

An almost identical infrared interface may also be used to add Universal Access System communications capability to an existing access device, thereby making it into an accessor. This accessor interface connects to other devices through a serial RS232 port.

How information is transferred between an accessor and a host

A packet-based, bidirectional communications protocol transfers data between accessors and hosts. Full handshaking and error correction is used to ensure data packets are transferred accurately. The following types of data packets are currently supported by the infrared link (other packet types will be added as required):

- keyboard packets
- mouse packets
- video packets
- data packets
- control packets
- host available packet
- accessor logon packet
- host resource packet
- accessor logoff packet
- video control packet
- video report packet
- accessor to accessor packets

Accessors

An accessor is a personalized device which enables a disabled individual to access any computer or electronic device equipped with a UAP. It is the accessor which gives the Universal Access System its great flexibility because it allows each disabled individual to have precisely the access he or she requires.

- All special needs of the disabled individual are provided through his/her accessor.
- An accessor communicates with any UAP equipped host over a bidirectional infrared communications link.
- There can be many different types of accessor since access strategies are chosen to match the physical needs of individual users. Different types of accessors are required for each type of disability. All accessors can function with any host.
- A person with multiple disabilities may simultaneously use several accessors to accommodate the special requirements of each disability.

There are three methods for implementing accessors:

- **An accessor may be purposely designed** to match the needs of a particular disability. Such a system might use a single microprocessor to handle access functions as well as the infrared communications. For example, the internal microprocessor which controls the infrared transceiver in a UAP can also be programmed to perform all of the processing required for accessors which use special keyboards, scanning, or Morse code.
- **A desktop, laptop, notebook, or palmtop computer** can be transformed into an accessor by adding an infrared accessor interface. Almost any type of disability can be handled by equipping a computer with appropriate software and/or hardware. This approach is particularly useful for locations like libraries, for instance, in which many

individuals with different disabilities require access to the same reference material. A single computer could provide a range of access functions such as: special keyboard configurations, Morse code, scanning selection, speech input, speech output, and enlarged screen displays.

- **Existing assistive technology products**, such as augmentative communications devices, may also be used as acessors. There are two possible approaches for doing this. A manufacturer may incorporate the infrared hardware and communications software in a newly designed version of an existing product, or else they might attach an infrared accessor interface to the serial output port of an existing product.

Types of accessors

The following section describes the types of accessor which can be constructed to accommodate the different types of disability.

- **Disabilities to be accommodated**
  - □ Blindness
  - □ Visual impairment
  - □ Physical disabilities
  - □ Learning disabilities
  - □ Communicative disorders
  - □ Deafness and hearing impaired

Target groups

The following codes are used ot indicate the application areas for each of the accessors described in the following section.

Codes:

- □ P -- Physically disabled
- □ B -- Blind
- □ V -- Visually Impaired
- □ L -- Learning Disabled
- □ D -- Deaf and hearing impaired
- □ C -- Cognitively Impaired

Keyboard accessors

A keyboard accessor is a device in which the primary form of input is direct selection of characters, objects or actions through the operation of one or more keys.

- **Standard keyboards - (P)**

  Standard keyboards can be equipped with infrared communications.
  - ☐ The same keyboard can be used on many different computers.
  - ☐ A user can have easy access to a selection of standard, commercially available keyboards on a single host computer.
  - ☐ The I/R link simplifies experimenting with special mounting arrangements.

- **Enhanced keyboards - (L, P, V, D)**

  An enhanced keyboard provides a variety of acceleration and error protection tools:
  - ☐ On-line spell checker
  - ☐ On-line dictionary
  - ☐ On-line thesaurus
  - ☐ Abbreviation expansion
  - ☐ Word prediction
  - ☐ Word completion
  - ☐ Keyboard macros
  - ☐ On-line reference works
  - ☐ On-line help systems
  - ☐ Audio echo of input characters or words
  - ☐ Input may be previewed before it is sent to the host computer

- **Alternative keyboard configurations**

  There are many parameters on a keyboard which may be modified to make its use easier for particular individuals:
  - ☐ The key legends may be changed
    - – Enlarged keycap legends - (V)
    - – High contrast keycap legends - (V)
    - – Color coding - (V, L)
    - – Tactile (Braille) - (B)
    - – Iconic (P, L)
  - ☐ The key operating force may be increased or decreased - (P)
    - – Different types of key may be used to match the required operating force to the strength of the user.
  - ☐ The keyboard may be larger than normal - (P)
    - – Large keyboards are useful for people who have only gross motor control.
  - ☐ The keyboard may be smaller than normal - (P)
    - – Miniature keyboards are useful for people who have fine motor control but limited range of movement.
  - ☐ Alternative layouts may be used for the keys - (P)
    - – The layout of a keyboard may be modified to group frequently used keys in the most convenient location for a particular user.

- ◻ Special functions may be included - (P)
  - Key sequencing in which the system remembers when shift, control, and alt keys have been pressed and behave as though it was pressed at the same time as the next key.
- ◻ Key filters may be used - (P)
  - The keyboard can be programmed to ignore certain keys or combinations of keys.
  - The system can be programmed to ignore multiple key presses..
- ◻ Timing functions on the keyboard can be changed to match the capabilities of the user - (P, L)
  - Key delay - whereby a key is recognized only after it has been pressed for a preset duration.
  - Typematic delay - whereby automatic key repetition begins after a preset delay
  - Typematic rate - controls the rate at which repeat key strokes are sent to the system.
- ◻ Chordic keyboards (P, V, B, D)

  Chordic keyboards have only a small number of keys (7 to 10 keys). Predefined combinations of keys (chords) are used to represent all of the keys on a conventional keyboard.
  - Single-handed typing is the most obvious application for chordic keyboards and versions are available for either hand. Chordic keyboards are particularly valuable for hemiplegics. Chordic typing can be very fast when left and right hand keyboards are used simultaneously. The increased speed could be a distinct advantage for deaf, blind and visually impaired persons.

- **Morse code accessors - (P)**

  A Morse code accessor enables a person to generate characters using Morse code. Strategies using one, two or three switches may be used.
  - ◻ Formats
    - A self-contained Morse system uses the same microprocessor to interpret the Morse code and to control the infrared communications.
    - Existing Morse code devices can be made into an accessor by adding an infrared interface.
    - Morse software may be run in a notebook or laptop computer equipped with an infrared interface.

- **Scanning accessors - (P)**

  A scanning system presents a screen of options and highlights groups of entries or individual entries in a sequential manner. A selection is made by operating a switch when the desired object is highlighted.
  - ◻ Formats
    - A self-contained scanning system includes switch inputs, a display, and an infrared interface.

- Existing scanning devices can become accessors through the addition of an infrared interface.
- Scanning software may be run in any standard computer equipped with an infrared interface.

- **Pointing accessors - (P)**

  A pointing accessor allows the user to make selections by pointing at objects displayed on a screen. These range from simple systems usisng a mouse through to very complex systems which track eye movement. Universal access allows a person to use a pointing device to work with computers that would not otherwise support such a function.

  - Formats
    - Mouse operated
    - Optical pointers
    - Ultrasonic pointers
    - Eye trackers

- **Speech input accessors - (P, L, B, V, D)**

  Speech recognition systems allow a user to talk directly to a computer. A speech accessor enables a user to perform all keyboard and mouse commands by voice.

  - Formats
    - Limited vocabulary systems recognize a small number of words (typically 1,000 to 2,000 words), each of which must be trained before it can be used. Limited vocabulary speech accessors can be constructed around relatively small portable computers equipped with an infrared interface.
    - Dictation systems have a large vocabulary (30,000 to 100,000 words) which are immediately available to the user. These systems use adaptive training in which the computer learns the characteristics of the user's voice. Dictation speech accessors require a powerful 386 or 486 laptop computer equipped with an infrared interface.

- **Screen reading accessors - (B, V, L, P)**

  Screen readers translate the text displayed on a computer screen into spoken words. The growing complexity of screen displays, and the increasing use of graphical representations for information, is making this function one of the most difficult to perform.

  - Formats
    - Converting text from a non-graphical screen to speech output is relatively straightforward and an accessor based on a laptop computer has been demonstrated as part of this project.
    - Reading graphically displayed text is much more complicated and will require the use of Optical Character Recognition (OCR) to recover text that can be used to generate speech output.
    - Screen graphics are becoming an integral part of computer displays. Among the options for providing non-visual access to graphics are

accessors which produce raised line drawings, and accessors which use three-dimensional sound to represent screen graphics.

- **Screen magnifying accessors - (V, L, P)**
  The problems here are similar to those outlined in the previous paragraph but the solutions are not as complicated.
  - ◻ Formats
    - Text characters read from the host screen are magnified in an accessor for display on either the accessor screen or a section of the host screen.
    - Screen bitmaps may also be converted to enlarged images in an accessor and displayed on either the accessor screen or on a section of the host screen

- **Optical Character Recognition (OCR) accessor - (B, V, L, P)**
  The function of an OCR accessor is to scan printed material into a host application such as a word processor.
  - ◻ Formats
    - A desktop scanning system equipped with an infrared interface can be used as an OCR scanner.
    - A portable OCR accessor consists of a hand-held scanner, OCR software, and a laptop computer equipped with an infrared interface.

Multiple accessors

Individuals with multiple disabilities may require several different types of computer access at the same time. Until now, finding an access system which has just the right mix of capabilities for a particular individual with multiple disabilities has been virtually impossible. The UAS provides a breakthrough in this area by making it possible for a person to use several accessors simultaneously on a single host. Some examples:

- A physically disabled person with visual problems may use one accessor to enter keystrokes and another to magnify the screen.

- A blind, physically disabled person may use a morse code accessor or a speech recognition accessor to enter keystrokes, and a screen reading accessor to hear what is displayed on the screen.

- Several members of a class may have various disabilities. Each could use a personal accessor to interact with one another via a single host.
  - A host can have several accessors logged on simultaneously and interact with each in a transparent manner. To the host computer, all input appears to originate from the same physical keyboard and mouse even when several people are generating inputs from separate accessors.
  - The accessors need not be identical. For example, one person may be using Morse code while another uses speech recognition. Inputs from each user will be interleaved and sent to the host in the order in which they are received.

Special considerations when using multiple accessors

Information passes from one accessor to another via the infrared interface without passing through the host computer. i.e., a UAP receives a packet for one accessor and re-transmits it to another accessor by attaching the appropriate address. In some situations, a cable may be connected between multiple accessors to synchronize their operation and to pass information back and forth.

Interaction between multiple accessors must be automatic:

- Each accessor performs its normal function independently of any other accessors that may be present, i.e., a screen reader speaks information from the host screen, and an alternative keyboard provides input.
- When an individual is simultaneously using more than one accessor, input and output functions of one accessor are supported by the others. For example, a blind, physically disabled person might use a Morse code accessor for input in conjunction with a screen reading accessor for output. Prompts generated by the Morse code accessor, which would normally be displayed on a screen, would be spoken by the screen reading accessor. Similarly, keyboard inputs required to control the screen reader would be generated by the Morse code accessor. In this type of configuration, it is necessary to designate the primary input device and primary output device. After the correct options have been selected, operation of the system is totally automatic.

An Accessible Campus

As stated at the beginning of this report, the primary purpose of the Universal Access System project is to make a campus accessible to students with disabilities. Students with disabilities require access to the same computer facilities on a campus as other members of their class. Until now, this access has usually been provided at a centralized location which is equipped with a selection of accessible computers similar to those used in class. While this is a workable solution,disabled students are often penalized by the extra time and travel required to use the centralized facility and may also be deprived of valuable interaction with other class members. The obvious solution for these problems is to make accessible computers available throughout the campus. In almost every situation, however, this is financially and logistically impossible.

The Universal Access System provides a cost-effective way to make campus computers accessible. Computers throughout the campus which must be accessible are equipped with UAPs. Students with disabilities access them with personal accessors. If UAPs are strategically placed throughout a campus, it is not necessary to make every host computer accessible.

Identifying hosts to be made accessible on the CSUN campus

There are just over 1,500 computers available to students at 120 different locations on the CSUN campus. This total breaks down as: 868 IBM compatible PCs, 468 Apple Macintoshes, 108 Apple IIs, 70 terminals to mainframes, 12 Sun workstations, and 52 various other types. Most sites have a single type of computer available but a few have several different types available.

For the purpose of deciding how many host computers need to be made accessible, groups of similar computers provide the best indication. Our assumption is that the same software is available on any of the identical computers in a group. There are 153 groups of similar computers, spread over 120 locations.

Approximately 3 percent of CSUN students have a disability. Assuming this percentage is representative for individual classes, approximately one in every 30 similar computers at any location should be made accessible.

- Up to 30 computers in a group - 1 UAP.
- 31 to 60 computers in a group - 2 UAPs.
- 61 to 90 computers in a group - 3 UAPs.

UAPs required on CSUN campus:

- **Macintosh**
  There are 49 groups, 5 of which have more than 30. This leads to a total requirement for 54 Macintosh UAPs.
- **IBM PC**
  There are 74 groups, 8 of which have more than 30 and two have more than 60. This leads to a total requirement for 84 IBM PC UAPs.
- **Apple II**
  There are 8 groups, 1 of which has more than 30. this gives a total requirement for 9 Apple II UAPs.
- **SUN**
  There are 5 groups with a total requirement for 5 Sun UAPs.
- **Other**
  There are 13 groups of "other" computers with a total or 52 systems. Since we have no knowledge of what computers and applications are represented in this group it is likely that greater than 3 percent of these systems will require UAPs. Assuming 50 percent of the systems will need individual UAPs, this gives a total requirement for 26 UAPs.

These figures suggest that 172 UAPs would provide access to a minimum of three percent of all computers, of any one type, available at any site. There are exceptions to the three percent assumption. For instance, it will be necessary for every computer in the library reference systems to be accessible. Also, specialized equipment like the 12 SUN workstations may all require individual UAPs.

A total of 200 UAPs would provide a workable level of access to all student computers on the CSUN campus.

Factors which may change these estimates

There are three major factors which may modify these assumptions: (1) areas such as the library reference section must have all of their systems available to all potential users; (2) some courses are more popular than others for disabled students, and (3) some computer labs are more popular because they have better physical accessibility or are open for longer periods of time.

- **The most popular majors for disabled students**
  - Psychology - 54
  - Liberal studies - 47
  - Pre business - 35
  - Child development - 24
  - History - 24
  - Speech Communications - 22
  - Ed psych - 19
  - Political science - 19
  - Engineering - 17
  - English - 16
  - Sociology - 15
  - Accounting - 14
  - Pre RTVB - 14
  - Biology - 13
  - Computer science - 13
  - RTVB - 13
  - Journalism - 12
  - Economics - 10
- **Popular computer labs**
  - Engineering 126 - open 24 hours.
  - Engineering 127 - open 24 hours.
  - Oviatt Library, 2nd Floor, East - open during library hours.

Distribution of extra UAPs among the courses and labs which have a higher popularity will depend on experience. If a small reserve is maintained, UAPs can be installed at specific locations on demand.

Costs of installing UAPs on the CSUN campus

The cost of installing the Universal Access System on the CSUN campus falls into two main areas. (1) UAPs are required to make host computers accessible, and (2) accessors are required for use by students with disabilities.

- **Universal Access Ports (UAPs)**

  The cost of a single UAP is currently $250. The design lends itself to significant cost reductions when manufactured in large quantities.

  As shown above, a total of 200 UAPs would provide a workable level of access to all student computers on the CSUN campus. At a unit cost of approximately $250 for each UAP, host computers could be made compliant with ADA computer input access requirements for approximately $50,000. Access to output functions for blind and visually impaired students will need to be provided by conventional access techniques until the final version of the UAP is completed.

  It will also be necessary to consider the cost of installing the UAPs on the host computers. This will be minimal in most cases since it merely requires the withdrawal and reinsertion of two or three plugs.

- **Accessors**

  Accessors are highly variable components which are matched to the specific needs of disabled individuals. Unit costs range from a few hundred dollars for special keyboards through to several thousand dollars for speech recognition or eye-tracking systems. From the viewpoint of a host organization, the cost of accessors must be considered during early stages of implementing a Universal Access System but this will become less of a concern as disabled people are individually equipped through rehabilitation channels. In the short-term, therefore, host organizations are faced with providing a selection of accessors for disabled clients who do not have a personal unit. In spite of this, it will be significantly cheaper to provide a selection of accessors for loan to clients than to attempt to make all host computers accessible to all types of disabled user.

The number of Accessors CSUN will need to provide

The long-term goal of the UAS project is that each person with a disability will be provided with a personal accessor from one of the support agencies such as State Rehabilitation agencies, special education, employers, or parents. Until this happens, however, it will be necessary for disabled individuals, educational organizations, such as CSUN, and employers to provide accessors. In many situations, the most cost-effective solution will be to construct accessors from Laptop computers by equipping them with appropriate software and hardware. The CSUN library, for example, will be best served by a collection of laptop computers set up as accessors. These would be loaned to disabled individuals who wish to access the computers used for electronic catalogs, databases, and the like. Some of the laptop computers would be equipped to perform specialized access functions, such as speech recognition, others would be provided with a suite of commonly used access software such as Morse code or scanning. In addition, the accessors could include a selection of special access techniques, such as automated front-ends for programs commonly used in the library.

Logistical suggestions

The number of accessors required to service the campus depends on:

- Whether accessors are moved about the campus or remain within a specified department.:
- Are accessors redistributed on a daily basis to meet individual requests?
- Are accessors allocated to departments or individuals on a semipermanent basis?

Options include:

- Each department which has accessible hosts holds a selection of accessors which may be loaned to students:
  - For the duration of a single class or study session.
  - For a full day.
  - For a full week.
  - For a full semester.
- The Computer Access Lab holds a selection of accessors which may be loaned to students:
  - For the duration of a single class or study session.
  - For a full day.
  - For a full week.
  - For a full semester.
- The computer center holds a selection of accessors which may be loaned to students for the duration of a class or study session:
  - The student collects the accessor from a central storage facility.
- The computer center provides a pick-up and delivery service to collection centers strategically located throughout the campus.
- The library holds a selection of accessors
  - For use only in the library.
  - For use anywhere on campus.

It is likely that a workable solution is some combination of the above options. There is a tradeoff between capital costs of providing a larger number of accessors, and the ongoing costs of continually moving a smaller number of accessors about the campus.

Evaluation and training.

Disabled students will normally require expert assistance in evaluating their needs, choosing the most appropriate solution, and learning how to use the accessor. At the present time, the Computer Access Lab is the only department at CSUN with staff qualified to evaluate the needs of a disabled user, to select and set up appropriate hardware and software for an accessor, and to provide the necessary training. This assessment and training can be done independently of the academic departments since the use of an accessor isolates disability related training from the training required to operate the applications. Applications training for students who have disabilities can be handled in exactly the same manner as for nondisabled students.

Distribution of accessors

All of the major departmental computer labs should have at least 1 general purpose accessor.

- Business
- Computer Science
- Education
- Physics
- Chemistry
- Journalism
- Geography
- Off-Campus labs (Ventura)
- Library computer labs
- Engineering (10 labs)
- Fine Arts
- Music
- Biology
- Math
- Sociology
- Psychology
- Off-Campus labs (North Campus)

Departments may hold a selection of accessors for use anywhere in the department. This number will vary with:

- Number of computer labs in the department.
- Number of disabled students enrolled each semester.
- The variety of disabilities present.
- The open-hours for specific departments.

The library should have a permanent set of accessors for use with the reference section databases. The library should also have a selection of accessors for use anywhere on campus

An initial selection of approximately fifty accessors would cover the critical areas of the campus and provide some flexibility in where they should be located.

A typical cost for an accessor constructed from a notebook computer will be between $1,000 and $2,000 for all of the necessary hardware and software. New generations of notebooks and palmtop computers will bring this cost down to less than $1,000 relatively quickly.

Project Results

Design notes

The tangible result of this project is a new infrared interface system for computers which dramatically improves access for disabled individuals. As happens with many design projects, a concept which was relatively easy to demonstrate as a prototype turned out to be extremely difficult to implement in a fully practical form. The principal reason was that we were breaking new ground for infrared communications. To achieve the required level of performance, we had to solve several apparently conflicting problems. The basic requirements for this application are high transmission speed, low power consumption, immunity to external infrared interference, extremely low error rate, and low cost. In addition, this performance had to be achieved without requiring precise positioning or alignment of the infrared tranceivers.

Other infrared communications systems have been able to meet some of these goals, but none have been able to meet them all at the same time. High transmission speed, for example, is usually achieved by using high transmission power. In contrast, we have achieved high speed at low transmission power by developing a new type of extremely sensitive receiver. Increasing the sensitivity of the receiver, however, introduced other problems, such as increased susceptibility to stray infrared interference and electrical signal leakage between the local transmitter and receiver. This was solved by careful choice of modulation frequencies and improved filtering of the incoming signals.

The filters were a major design problem because standard filter designs degraded the response speed of the system instead of improving it.

Because we have no control over exactly where users will position themselves relative to the host computer, the transceivers must operate over a range of zero to about eight feet. Achieving full performance over this range was extremely difficult since the change of light intensity follows an inverse square law with regard to distance. The prototype systems were extremely dependent on the distance between the tranceivers and required precise optical alignment of the sending and receiving units. When the units were close together, the signals oveloaded the system. As they were moved apart, the signals rapidly became too weak for reliable reception. The conventional solution to this type of problem is to use an automatic gain control (AGC) in the receiver. AGC systems, however, introduce a time delay between the time a new signal is received and the time when the gain reaches the correct value. In our case, this delay caused several characters to be lost at the start of each message. We therefore developed a new solution based on signal clipping and error correcting software. In the final version, the infrared units provide error-free transmission regardless of whether they are positioned with their front panels touching or separated by up to eight feet.

The need for careful optical alignment has also been eliminated from the final version. Either unit can be rotated through an angle of approximately plus or minus twenty degrees without loss of transmission. This angle was chosen to provide good coverage of a single host installation without having signals spilling over to adjacent systems.

Leakage between the transmitting and receiving sections of a single unit was overcome by careful layout of the electronic components on the printed circuit boards, electrical and optical shielding, and the inclusion of gating software which turns off the receiver whenever the transmitter sends out a pulse.

The tranceiver units are constructed on two printed circuit boards. One board contains the analog components required for the infrared transmitter and receiver. The other board contains the microprocessor and all of the digital support circuits. In order to make the system as small as possible, miniature, surface-mount integrated circuits and components were used throughout.

The Universal Access System has been a most difficult design to perfect.

Functional description of the Universal Access System

There are two basic components in the Universal Access System; an infrared transceiver which couples to a host computer, and an infrared transceiver which couples to an accessor. The unit which connects to the host is called a "Universal Access Port" or UAP. The other unit is called an "accessor interface." Physically, these two units are almost identical, but they use different cables and connectors, and use different software in their internal microprocessors. Figure 2 shows a basic block schematic of the Universal Access System. Note that the UAP interfaces to the host computer via the keyboard and mouse ports. This approach enables the UAP to control the host without the host being able to detect its presence. Different interface cables and switch-selectable software allow UAPs to function with any of the standard host computers. No special software is required in the host computer. Connecting a UAP to a host computer has zero impact on the operation of the host.

Operation of the Universal Access System

Operation of the Universal Access System has been changed several times during its evolution. It started out as a relatively simple communications system, went through a very complex stage while we learned what was needed to achieve the desired performance, and has now evolved into packet-based communications system. The relative simplicity of the

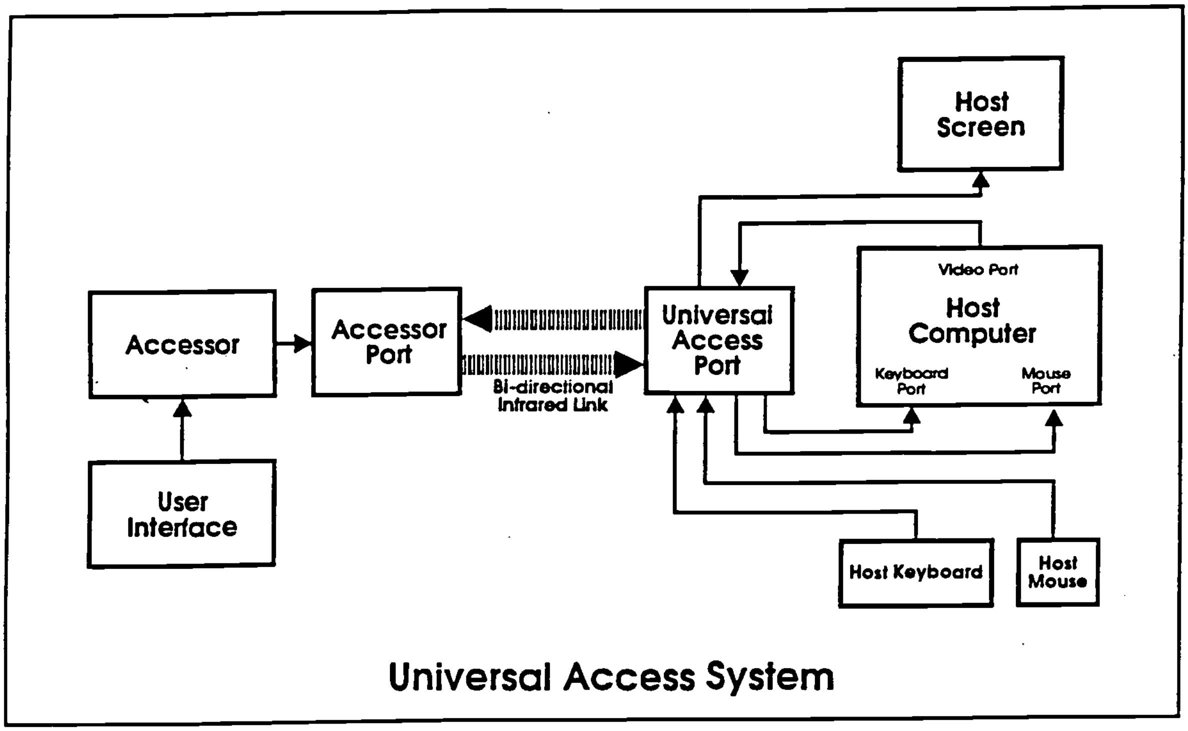

Figure 2. Block diagram of the Universal Access System

final design is the result of an improved understanding of the processes involved and careful tradeoffs between the hardware and software.

Operation of the UAP

A UAP emulates the operation of a keyboard and mouse. Figure 3 shows the components of the UAP. The host keyboard and mouse is normally connected through the UAP to the host input ports. Encoded packets of information from an accessor are received by the infrared receiver and passed to the microprocessor for decoding. The microprocessor performs error checking on the information packet. If an error is detected, a message is sent to the accessor requesting the packet be transmitted again. If there is no error, an "acknowledge" message is sent to the accessor so that it may send the next packet. When an error-free packet is received the microprocessor unpacks the information, determines if it is intended for the keyboard or mouse port, translates it to match the specifications of the host computer, and passes it to the mouse or keyboard port as appropriate. The simulated inputs are injected by electronically switching between the real input and the simulated input. The UAP software buffers the real and simulated input signals to ensure that no information is lost from either source.

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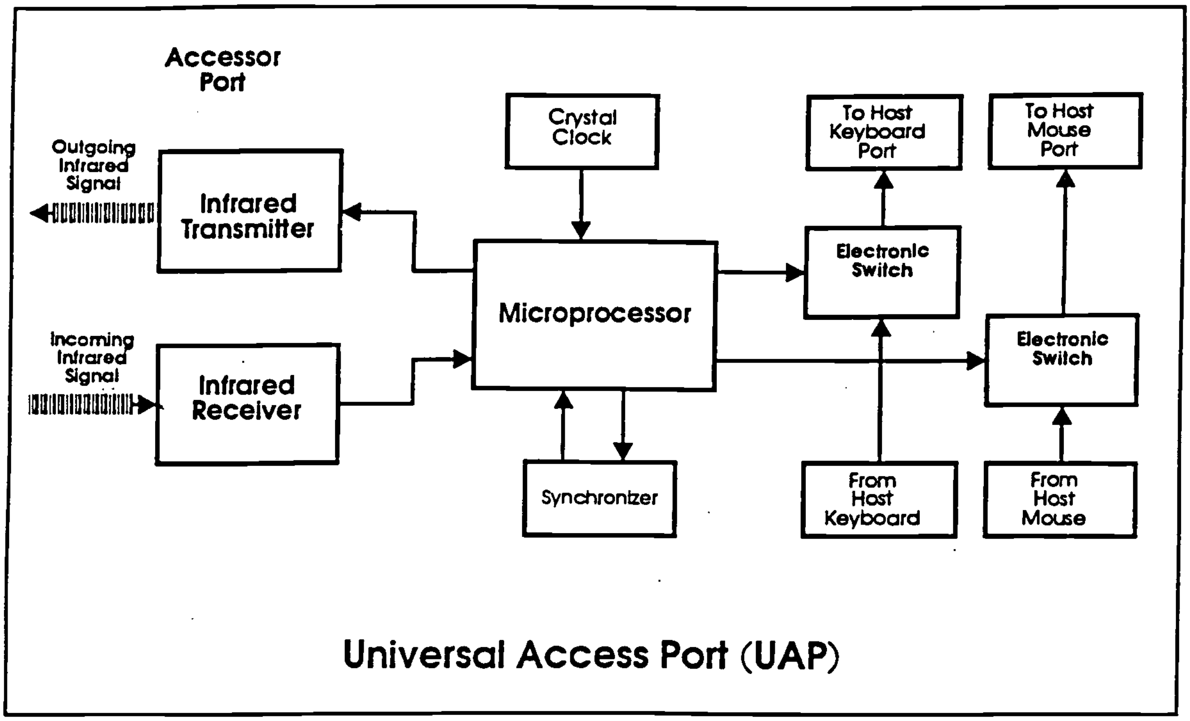

Figure 3.Universal Access Port

Operation of the accessor

Figure 4 shows the components of an accessor. There are three basic parts; a user input system, a microprocessor, and an infrared transceiver. The user input section may take whatever form is appropriate for the particular user. Direct selection, scanning, Morse code, and speech recognition are some of the alternatives. The microprocessor accepts information from the input section, encodes it into packets, and passes it to the infrared transmitter. Each time a packet is transmitted, the microprocessor waits for an acknowledgment from a UAP which signifies that it has been received without error. If the UAP detects an error, the accessor receives a request to retransmit the packet.

During system startup the microprocessors in the accessor and the UAP automatically perform a logon proceedure which establish the infrared communications link.

In most situations, a laptop or notebook computer performs the input functions and transmits information to an accessor interface via a serial RS232 port. (See Figure 5.)The accessor interface transfers the information to the UAP over the infrared link. In simpler types of accessor (direct selection, Morsecode, some scanning systems), a single microprocessor may be used to perform user input functions as well as manage the infrared link. (Recall Figure 4.)

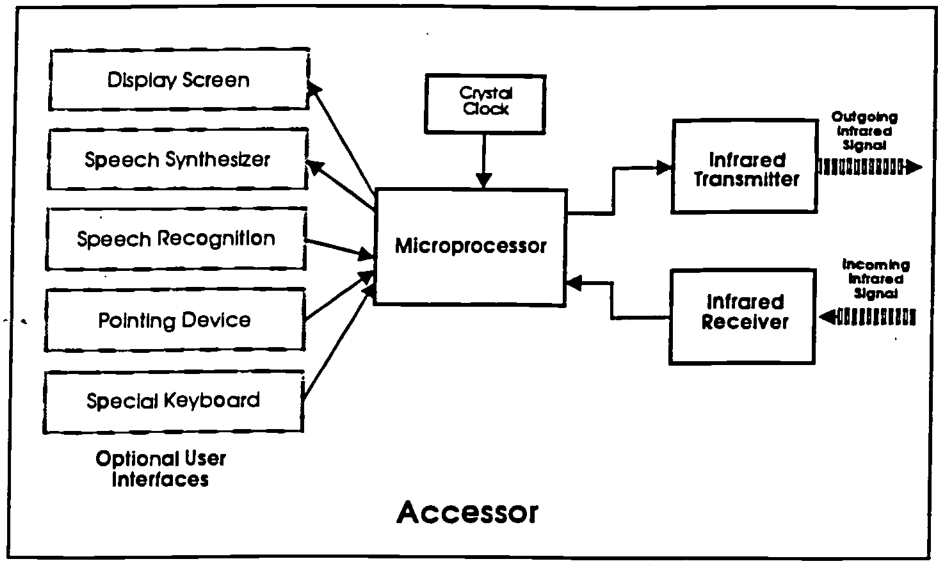

Figure 4. Components of an accessor

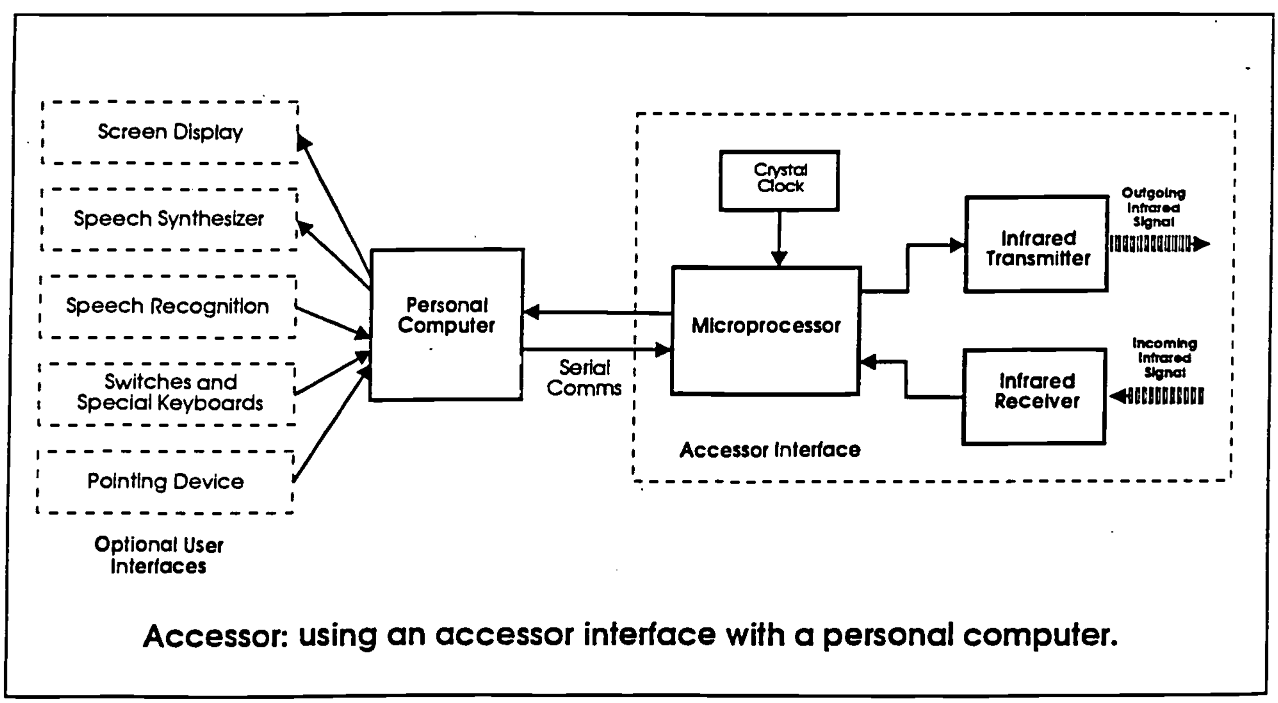

Figure 5. Accessor using a personal computer.

Design and manufacture of UAPs and accessors

The design of the Universal Access System has been a joint development between CSUN and Genovation, Inc. CSUN handled most of the conceptual design and operational software. Genovation have handled the detailed electronics design and the low-level software for the communications link.

Development of the final system took much longer than either CSUN or Genovation contemplated. At each stage of the development, solving one set of problems invariably unearthed others. In most cases, these were due to limitations in the performance of available infrared and electronic components. The sluggish economy has also been a major factor in slowing down development of the final Universal Access System. Genovation funded most of the development out of its own revenues. Money paid by CSUN for a set of ten prototypes falls far short of the development costs paid by Genovation. As an example of the development costs, there have been six different versions of the system. This required the design and production of printed circuit boards at a cost of approximately three thousand dollars for each version.

Final preproduction units have been completed less than one month from the end of the project. As a consequence, we have been unable to perform all of the evaluations that were intended to be completed within the duration of the project. Nevertheless, experience with the prototypes have taught us a great deal about how the system can be used. Differences between the prototypes and the final version have made it necessary to redesign the accessor software.

Learning how to interact with applications

One of the lessons we learned from using prototypes of the Universal Access System is that it takes time and experience to work out strategies for interacting with applications programs. A speech accessor, for example, enables a user to provide keyboard and mouse command by voice. After we developed the mouse interface, however, we found that it was not at all obvious how one talks to a mouse. Several weeks of experimentation were required before we were able to perform mouse operations effectively with voice commands.

Developing user interfaces

Interfacing to text-based programs with the Universal Access System to enter text is extremely straightforward. With appropriate access software running in the accessor, the user generates characters which are directly transferred to the application as if they came from the real keyboard. Acceleration techniques, such as word prediction or abbreviation expansion may be used in the accessor to speed up the rate at which information can be entered.

A mouse interface is much more complicated to design and operate because of the many different steps required to achieve even simple mouse operations. Functions which are easily performed when operating a mouse by hand are often clumsy to perform in a step by step mode, such as when giving direct voice commands. We have found that the best way to overcome this is to use a macro expansion capability. Each applications program requires a set of macros which "know" characteristics of the application such as screen layouts and the duration required for button clicks. Once these macros have been developed, complex mouse operations can be reduced to single "keystrokes" on an accessor, or single utterances in the case of a speech accessor. We have demonstrated a speech interface to a windows program which was easier to operate with the Universal Access System than directly with a mouse.

At this stage, interacting with a Graphical User Interface (GUI) requires the user (or a macro) to drive the cursor to a particular button or icon and to stop it when it is in the correct position. This works well with GUI screens which have fixed screen layouts. Macros can be easily programmed to move the cursor to a particular target on the screen and to operate the mouse buttons without user intervention. This is much more difficult to do on grapical screens in which target objects can be resized and repositioned since the user must guide the cursor to a desired target. This problem will be overcome in the next stage of development when the Universal Access System will be given the ability to recognize screen objects. This will enable macros to instruct the system to find a particular button or icon and to automatically move the cursor to that position.

Relationship to learning

The UAS has only an indirect relationship to learning. While it does not contribute directly to the learning process, it makes learning easier by removing barriers caused by a disability. <u>It is important to recognize the UAS as a tool and, like any tool, its usefulness depends on how well it is used.</u> When used properly, UAS gives disabled students the potential to access information and class exercises in much the same way as other students. In other words, UAS can be thought of as an equalizer rather than an alternative way of learning. The UAS benefits disabled students in a variety of ways:

- They have access to the same information and equipment as everyone else in the class.
- They may save significant amounts of time on tasks that presently take a disproportionate amount of their time and effort.
- They gain the independence to work where and when they want.
- They are able to participate in courses that were "not practical" before UAS was available.

Evaluation of the Universal Access System

The planned evaluation of the final version of the UAS has been delayed because of development problems. These problems have now been solved and ten systems are due for immediate delivery to CSUN. These will be installed in selected sites on the campus for use and evaluation by disabled students. CSUN staff will perform the evaluation during the fall, 1992, semester. Another ten systems will be supplied to Stanford University for ongoing development and evaluation of the system when Neil Scott takes up a senior research appointment in October, 1992.

The evaluation plan that was planned for the Universal Access System is attached as Appendix III.

Dissemination

- Press release, March 1991
  Prototypes of the Universal Access System were demonstrated at a press conference held at California State University, Northridge, on March 23, 1991. See Appendix IV.

- Three hour workshop presentation at the 1991 CSUN annual international conference "Technology and Persons with Disabilities."

- Demonstrated to the general computer community at Spring COMDEX in Atlanta, May 1991. This was one section of a large exhibit called "Minds in Motion." The Minds in Motion pavilion was sponsored by the Boeing Aircraft Corporation to demonstrate leading special access technologies to the mainstream computer community.

- The Universal Access System wsa demonstrated at the Fall, 1991 COMDEX, as part of the Genovation, Inc., booth.

- Every computer magazine in the U.S. has been contacted by Genovation, Inc., to arrange for extensive coverage of the Universal Access System when the final version is announced.

Conference Presentations

- Scott, N. "The Universal Access System." Three-hour presentation at the CSUN Annual Conference, Los Angeles, March, 1991

- Scott, N. "An Overview of The Universal Access System." Half-day seminar at Educational Testing Services," Princeton, New Jersey, May, 1991

- Scott, N. "An Overview of The Universal Access System." Two-hour presentations to each of the following organizations in Washington, D.C., May, 1991:
  - American Association for the Advancement of Science.
  - National Science Foundation.
  - President's Committee for the Employment of the Disabled
  - National Foundation for the Blind.
  - Clearinghouse on Computers at the General Services Administration.
  - Electronics Industry Association.

- Scott, N. "The Universal Access System." One-hour presentation at the American Voice Input/Output Society conference, Atlanta, November, 1991.

- Scott, N. "A Universal Speech Accessor." Four-hour tutorial and one-hour presentation at Speech Tech 1992, New York, February, 1992.

- Scott, N. "How to use the Universal Access System." Three-hour workshop at the CSUN conference, March, 1992.

- Scott, N. "The Universal Access System." One-hour presentation at the Partnerships in Equity conference, Toronto, June, 1992.

- Scott, N. "The Universal Access System and Computer Based Testing." One-hour presentation at ETS conference on computer-based testing, Princeton, NJ, June, 1992.

Plans for continuation and dissemination

Manufacture and marketing of the UAS

Genovation, Inc., Irvine, California, a manufacturer of computer keyboards and special peripheral devices has been licensed to manufacture and market the basic components of the UAS. Genovation's license includes the UAP, infrared communications modules for use in accessors, and accessors in which keyboards are the principal user interface. Other types of accessor will be manufactured under license by companies which focus on specific disabilities.

Major steps that will be taken following completion of the project.

Neil Scott, the inventor and developer of the UAS is moving to Stanford University at the completion of the FIPSE project. As a Senior Researcher in the Center for the Study of Language and Information (CSLI), he will continue development of the UAS. Initial work will focus on the development of accessors for visually impaired and blind computer users, with particular emphasis on accessing the Graphical User Interface (GUI). Ongoing research and development will be aimed at increasing our understanding of how various disabled individuals gather, process and use information. This will lead to development of highly intelligent accessors for each type of disability.

Several companies involved with public access to information are studying the UAS as a method for providing access for disabled clients.

IBM Corporation and North Communications, Inc., are co-developers of information kiosks. They are developing applications for kiosks in shopping malls, hotels, transport centers, libraries, and government departments. Accommodation for disabled users is the single biggest problem facing kiosk developers. Under sponsorship from IBM, some of the ongoing development work at Stanford will be in the area of using UAS to access publicly available information.

The California Department of Health and Human Services is actively promoting the use of information kiosks to streamline public access to government. They are just now completing a trial of the kiosk systems (which did not include access for disabled people) and will soon be releasing an RFP for the supply of accessible kiosks to be introduced throughout the state of California. This proposal includes reference to the UAS as an acceptable method for providing access.

Automatic Teller machines (ATMs) are specialized forms of information kiosk. NCR, one of the largest ATM manufacturers in the world, is looking at how UAS could be incorporated into their ATM designs. Wells Fargo Bank is studying ATM applications of the UAS from a consumer perspective.

Planned conference presentations

UAPs for several types of host computer and a selection of different types of accessor will be displayed at the Fall COMDEX in Las Vegas, November, 1992. Alternative access to keyboard and mouse functions will be demonstrated at this time.

How evaluation activities will continue

Evaluation of the UAS will continue in a variety of settings.

- California State University, (CSUN) will evaluate UAS installations strategically placed throughout the CSUN campus in an ongoing manner. The primary application of these units is to make standard campus facilities accessible to disabled students. Staff from the Computer Access Lab (CAL) will train students in the use of appropriate accessors and monitor the use of computers on the campus which have been equipped with UAS.

- The Center for the Study of Language and Information (CSLI), Stanford, will have an ongoing evaluation program for applications of UAS, particularly in the areas of access by blind and visually impaired users, and access to public information for all types of disability.

- Educational Testing Services (ETS) of Princeton, NJ, are establishing computer-based testing laboratories throughout the United States. Accommodating disabled examinees at these centers is a major concern for ETS. They are currently evaluating UAS as the principal access method for computer-based tests.

- Genovation, Inc., manufacturers of the UAS, are arranging for Beta testing in a variety of corporate, educational and private sites. They plan an ongoing evaluation program to ensure the UAS meets the needs of their customers.

Summary and Conclusions

The goal of this project was to create a universal method for allowing disabled individuals to access computers and computer-based equipment. The basic requirements were that access must be independent of the computer type, the applications software, and the type and severity of the disability. This goal has been achieved by adopting a new approach in which the needs of the disabled individual are handled separately from the computers and other devices that are to be made accessible (hosts). Each host is fitted with a standardized, wireless interface (Universal Access Port or UAP) which provides access to keyboard, mouse and screen functions. Disabled users are equipped with personal devices called accessors which interact with UAPs over an infrared light beam. This provides a truly universal solution since any accessor can operate with any host equipped with a UAP.

The UAP is a low-cost add-on for any standard computer. It may also be incorporated into the design of new computer-based equipment. The UAP functions by (i) emulating the operation of the host keyboard and host mouse, and (ii) reading information from the video signal which drives the host screen. Normal functions of the host are not impacted in any way.

The accessor is a personalized device in which input and output functions are closely matched to the needs and capabilities of individual users. In other words, different accessors are used for different disabilities. Any accessor can function with any UAP. Accessors may be designed for a particular purpose, or they may be assembled from existing devices such as notebook computers.

Activities during the project have included: assessing the needs of disabled individuals; preparing a preliminary specification; designing hardware and software; developing strategies for using accessors; presenting at conferences and to interested organizations; demonstrating prototype systems; licensing the concept to a manufacturer; working with the manufacturer to develop production prototypes; working with manufacturers of other devices to incorporate UAS in their products; and evaluating the UAS system.

The final version of the Universal Access System is deceptively simple. While it incorporates some very sophisicated hardware and software designs, its operation is virtually automatic. Some of the early design concepts were dropped part-way through the project after we gained practical experience with the early prototypes. Our initial approach was based on minimizing the hardware required to connect an accessor to a host by performing most of the interfacing logic in a small program which runs in the host. This turned out to be much more complex than we had anticipated because of the widely differing approaches used by the various host devices. We found that any savings in hardware costs were completely overshadowed by the increased complexity of the software.

We therefore adopted a design in which all interfacing functions are performed by a small microprocessor which functions external to, and independently of, the host. This has resulted in a system which is functionally superior to what was originally proposed. It delivers a much higher level of performance and increases independence between accessors and host devices.

The present UAS provides full input access to all keyboard and mouse functions. Screen reading functions have been developed and demonstrated in a prototype system, but they have yet to be developed to a usable form. The screen reading functions of the UAS will be completed during 1993 at Stanford University under the sponsorship of IBM Corporation and Wells Fargo Banking Corporation. IBM's interest stems from their involvement in the manufacture and marketing of public information kiosks. Wells Fargo is interested because they are obliged to make ATMs accessible to disabled people.

The UAS has been licensed to Genovation, Inc., for manufacture, and for sub-licensing to other manufacturers. Genovation has developed production units which are about to undergo beta testing by a selection of potential customers. They plan to begin marketing the system before the end of 1992.

The UAS provides a simple, cost-effective method for making computers on a university campus accessible to students with disabilities.

A selection of accessor functions have been developed within the framework of notebook computers. Some are using specially written software and some are based on programs previously developed to make desktop computers accessible.

The UAS is potentially one of the most cost-effective methods available for meeting the access requirements of the Americans with Disabilities Act (ADA). Placing a UAP on each item of equipment that is to be made accessible and ensuring that each disabled employee or student has an appropriate accessor will make an employer or educational organization fully ADA compliant with the requirements for access to information processing equipment. The UAS provides a simple, cost-effective method for making computers on a university campus accessible to students with disabilities.

Appendices

Appendix I

Section 508

Section 508 of Public Law 99-506 requires all federally funded information processing equipment to be fully accessible to persons with disabilities. When this became law in October 1989, CSUN's reputation for making computers accessible led to numerous enquiries from manufacturers and user organizations about how they could comply. In most cases they wanted to know what design changes would be necessary to make their computer products accessible to all disability groups. Based on experience, we told them there was no cost effective way in which a single computer could simultaneously support all of the special input and output hardware and software required by different disabilities and applications. They were looking for an access method which would allow their products to be used by people with any type of disability.

The intention behind Section 508 was that any disabled federal employee should be able to use any information processing equipment. From our knowledge of disabilities and special access techniques, we concluded that traditional approaches could not achieve this in a cost-effective manner. We therefore proposed a new approach, called the "Universal Access System," in which access functions required by the disabled user are physically separated from the computer in which applications software is run. Separating the functions in this way dramatically reduces the complexity of the problem. Now, instead of requiring unique solutions for every combination of disability and application, individual access problems are solved independently of the application in a personal device called an "accessor." Any accessor can interact with any computer over a standardized wireless communication link. A low-cost, standardized interface, called a "Universal Access Port" (UAP) transfers information into and out of the host computer.

Appendix II

Description of the UAS

A Universal Access System For Disabled Computer Users

Neil G. Scott

Abstract

This paper describes a new approach to making computers accessible to persons with disabilities. Developed at California State University, Northridge, the Universal Access System enables an individual to operate any computer over an infrared communications link. The system breaks away from usual access methods by performing all access functions outside the computer which runs the application. Applications programs run on an unmodified host computer, and all access functions are handled within a personal access device called an accessor. This separation of functions eliminates many of the problems and limitations inherent in present access systems. Additionally, the Universal Access System has the potential to significantly lower the cost of providing access.

Introduction

The Universal Access System equalizes accessibility to computers, appliances and electronic devices. Traditionally, computers and other electronic devices are made accessible by incorporating special access features, either as an integral part of the hardware and software design, or as external add-ons. In either case, the special access functions must be closely integrated into the normal operation of the system, often resulting in compromised performance. The Universal Access system overcomes the limitations of traditional approaches by performing all input and output functions outside of the host in a personalized "accessor." The host runs the application and the accessor provides the access. Host computers no longer need to be modified in a user-specific manner. Instead, they are made accessible through the addition of a low-cost, standardized "Universal Access Port" or UAP. The UAP provides an interface between the resources of the host and any accessor. Communication between a UAP and an accessor is provided by a high-speed bidirectional infrared wireless link. In simple terms, the UAP allows an accessor to enter information into the host as if it were coming from the host keyboard and mouse, and to read information from the host screen. There is no physical connection between the host and the accessor and the host has no knowledge of how information is generated or used within an accessor.

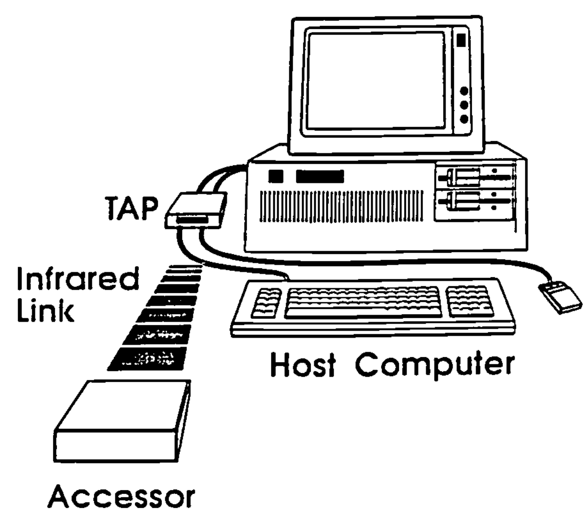

Figure 1. Universal Access System

Potential benefits of adopting the Universal Access System include:

- **Budget stretching** The Universal Access System is cost effective for organizations which must provide accessible equipment for disabled users. On one hand, a personal accessor provides a disabled individual with access to any device equipped with a UAP. On the other hand, educational institutions, employers, and public service providers can make their information processing equipment accessible to clients with disabilities for a very small unit cost.

- Durability Individual solutions based on the UAP and a personal accessor are more durable than present solutions. The accessor doesn't need to be changed as a person's study or work requirements change. An accessor that is correctly matched to an individual's requirements will remain valid for a very long time, thereby leading to significant savings in assessment, counseling, engineering, and training resources.

- **Setting Standards** Adopting standards based on the Universal Access System will make the manufacture of special access equipment more viable because it will lead to increased market sizes.

- **Compliance with the Americans with Disability Act (ADA) and Section 508** The UAP provides a straightforward and low cost method to comply with federal access requirements such as the ADA and Section 508.

The Universal Access System can fully utilize currently available special access products. In fact, incorporating Universal Access Port protocols into existing products will increase their utilization as they automatically inherit the ability to interact with any device equipped with a UAP.

Universal Access has the potential to make any device which uses electronic control accessible. In some cases a UAP will be included as part of the controlled device. Elevators, information kiosks, ATMs, telephones, industrial controls, and home appliances could easily include a UAP. In other cases, interfacing will be possible through an intermediate standard such as the CEBus, which was developed to provide remote control in homes and industrial plants. The same accessor that enables a person to write on a computer can provide full access to environmental control through its interface to the CEBus.

Initial versions of the UAP are designed to interface with IBM compatible computers. An Apple Macintosh version will be implemented next, followed by versions for popular workstations such as Sun and NeXT.

Prototypes of the Universal Access Port are currently being evaluated and demonstrated to interested organizations. Production and marketing of UAPs and a selection of accessors will begin shortly.

Traditional Access Methods

The unique approach of the Universal Access Port becomes apparent by briefly reviewing traditional approaches to providing computer access for disabled users. At the present time, it is usually necessary to modify the host computer in a user-specific manner, providing special hardware, software or both. While this approach is generally satisfactory for disabled individuals who work with a single computer, it is a major problem for institutions in which many comppputers must be used by many different people. For example, California State University, Northridge has nearly four thousand computers which should be accessible to all students. However, with a disabled population of almost one thousand, it is not possible to predict where and when particular types of access will be required. Our present solution is to provide services at a centralized Computer Access Lab. This lab contains about thirty computers and a selection of special hardware and software. Each disability is handled by one or two specially adapted systems. While this lab has achieved its basic aim of assisting disabled students, it is not the perfect solution. Students are restricted to working in a centralized location, suffering inconvenience and unable to work alongside their peers. They often have no access to certain programs. One solution is to equip disabled individuals with an accessible portable computer they take to class. While this works in some situations, there are some severe limitations in its effectiveness. Many of the required programs cannot be run on a portable computer because of memory size, operating speed, storage requirements, lack of particular peripheral devices, or copyright restrictions.

The Universal Access Port Concept

The Universal Access Port builds on the idea of equipping disabled individuals with an accessible portable computer; not to run applications programs, but to use as an extension of the screen and keyboard of a host computer. In this case, the portable computer is referred to as an accessor. The interaction between an accessor and a host is such that the accessor handles all user-specific requirements. Communication between an accessor and a host computer is provided by a bi-directional, wireless, infrared data link. A standardized code is used to pass information back and forth on the link. It is this code which enables any accessor to operate with any type of host and any type of disability. At one end, the link connects to a host computer through a Universal Access Port. At the other end, an accessor provides the interface to a disabled person. Equipped with an appropriate accessor, a person can access any computer which has a UAP. The various requirements of individuals with different disabilities are met by using different accessors.

It is an option, not a requirement, for an accessor to use a portable computer. An accessor can be as small or as large as is necessary to handle the access requirements. For example, a Morse code accessor, can be constructed from a single chip microprocessor at a cost of a few hundred dollars. In contrast, a speech accessor capable of taking dictation requires, as a minimum, a fast 386 computer with at least eight Mb of memory and a hard disk and may cost more than ten thousand dollars. Between these extremes, there are many situations in which a standard portable computer, such as a notebook or laptop, will provide the most cost-effective solution. An important factor, however, is that *each of these accessors can operate the same host computers without any changes being made to the host.*

The following example shows the value of the Universal Access Port: With the traditional approach, a computer to be used by a blind person is equipped with a text review program and a speech synthesizer. While this makes the computer accessible to the blind user, it does nothing for physically or learning disabled users. Separate modifications are required to handle each type of disability. No such limitation exists for systems which use a UAP. All computers equipped with a UAP present an identical interface to accessors. Personal accessors handle the great variety of capabilities required by individuals with different disabilities. For example, accessors for blind users contain a speech synthesizer and software for reading the host computer screen. Accessors for physically disabled persons use special keyboards, pointing devices, Morse code or scanning systems to enter keystrokes into the host computer. Individual accessors are programmed to interact with only those features of the host they are replacing or augmenting. So, accessors for blind or visually impaired users read the screen of the host and either magnify or speak the text. Accessors for physically disabled users will generally send information to the mouse or keyboard of the host and not need to read the screen. An accessor for a person who is blind and physically disabled might include all three of these capabilities.

Description of the Universal Access System

The Universal Access System consists of two basic components: An accessor, and a Universal Access Port.

- Accessor The accessor is a bridge between the specific needs of a disabled individual and a standardized communications protocol which is recognized by a UAP. Accessors can be designed to support any form of input or output that may be required by a disabled user. They may be very simple; i.e. a Morse code generator, or they may be very complex, i.e. a speech recognition system.

- **Universal Access Port** The Universal Access Port consists of an infrared transceiver which communicates with an accessor, and a microprocessor which emulates the keyboard and mouse of the host computer. Standardized access codes from an accessor are translated into the particular keyboard or mouse formats required by the host. The UAP is connected to the keyboard and mouse ports on the host in place of the real keyboard and mouse. The real keyboard and mouse are connected to ports on the UAP. Electronic switches inside the UAP merge the emulated signals from the UAP with those coming from the real keyboard and mouse. The host cannot distinguish between real or emulated signals.

The bidirectional, infrared communications link embodied in the accessors and the UAPs uses a standardized protocol developed for this purpose. The protocol uses a packet system with full error checking and recovery. Packets are defined for system management, keyboard events, mouse events, screen events, and miscellaneous events such as file transfers. Dedicated microprocessors within the UAPs and accessors perform all link-related activities. Communications between an accessor and a host have zero impact on the performance and resources of a host.

Cost Considerations

Compelling reasons for adopting the Universal Access Port are that it provides excellent utilization of resources and it gives disabled individuals a much higher level of independence.

Traditional approaches for providing access are costly because each computer used by a disabled person must be equipped with whatever special hardware and software is necessary. The adaptations are usually non-portable since they cannot be easily moved back and forth between computers at home and at work, for instance. In contrast, a UAP can be attached to any computer for no more than a few hundred dollars and the same accessor can be used with computers at home, school or university, and work.

The cost of providing access goes far beyond the purchase of a particular item of hardware or software. Labor costs include evaluations, development of suitable solutions, funding, and training. Furthermore, many of these costs are repeated each time a disabled person moves from school to school, from school to the workplace, or from one work location to another. This cycle can be broken if a disabled person is equipped with an appropriate accessor at the earliest feasible opportunity. Many recurring labor costs are eliminated. As well, costs to schools and employers are significantly decreased since it is usually only necessary for them to provide a UAP on each computer.

Individuals grow out of computers as situations and skills change. Children at elementary school will most likely use a small computer like the Apple II. When they go on to high school they will be expected to use IBM PCs or Macintoshes. When they continue on to university and work situations, they may also be exposed to workstations and mainframes. All of these require different accessible interfaces under traditional approaches to accommodation. It is not unusual for disabled individuals to be using their fourth or fifth computer system and special interface by the time they reach a work situation. Every one of the computers they have used along the way represents a significant outlay for assessment, adaptations, and retraining on how to use the adaptations. In contrast, the Universal Access System makes it possible to equip disabled individuals with the most appropriate accessor at an early age, and for that accessor to remain with them throughout their education and into the work place.

The Universal Access System shares the cost of providing access among the different agencies in a way that more closely follows the way computer resources are provided for nondisabled people. Because accessors represent a more permanent solution than many of the current devices, rehabilitation agencies could invest more heavily in providing individuals with the most appropriate solution. A single accessor could meet the needs of a disabled individual for many years regardless of how his or her computing requirements change during the time. In other words, the job of providing an accessor could be done once, and done well, rather than provided as a series of stop-gap solutions. The provision of host computers for disabled students and employees could be handled by schools, universities and employers in much the same way as for nondisabled students and employees. In fact, the same computers can be shared by disabled and nondisabled users since the Universal Access Port has no impact on a computer when it is not being used by an accessor. The cost of a Universal Access Port is a relatively insignificant portion of the cost of a computer.

Independence

Total access is not limited to computers. Any electronically controlled apparatus can be controlled by an accessor. Appliances, lights, telephones, entertainment equipment, elevators, ATMs, wheelchairs, and so on, can all be controlled by an accessor. This means that a disabled individual can use the same input and output strategies to control all of the equipment with which they normally interact. As a result, it will be much easier for a disabled person to become truly independent.

Design Rationale

The concept of a Universal Access System is basically simple: access functions are handled separately from applications. Among the reasons for adopting this approach are:

- Federal and State laws require all information processing equipment to be made accessible to disabled individuals. This includes: computers, appliances, environmental controllers, elevators, vending machines, automatic teller machines, and other electronically controlled devices

- As the complexity of computer operating systems increases, it becomes extremely difficult to modify software to incorporate special access functions.

- Increased size and complexity of applications programs is making it more difficult to run access software and applications simultaneously.

- Some applications include protection schemes which prevent other programs from running at the same time.

- Different access software and hardware is required for each type of computer and for each type of disability.

- Functions related to providing access need to be separated from those related to running applications.

- Access functions should be portable to enable disabled individuals to use any computer in any location.

- The solution must be cost effective.

- Access solutions must be durable. Changes in the applications used by a disabled person should not render existing access techniques or devices obsolete.

- Access operations should be consistent for any type of host computer or device

Acknowledgements

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Appendix III

CSUN Computer Labs
and
Student Demographics

DISABLED STUDENT DEMOGRAPHICS - SPRING 1992

Primary Disability:

Visual	41
Mobility	260
Learning Dis	301
Functional	179
Communicative	1
Total N	782

Spring 1992 Chancellor's Office VDE Report for CSUN Office of Disabled Student Services

Note: The N = 782 includes 100 students identified as temporary disabled students. Demographic data is not currently available for these 100 temporary disabled students. The demographic data that follows is based upon those students with permanent disabilities with an N = 682

Sex:

Male	289	42.4 %
Female	393	57.6 %
Total N	682	

Age:

Group	Undergrad	Graduate
18-20	81	0
21-23	173	1
24-26	107	21
27-29	34	19
30-32	34	8
33-35	26	7
36-38	28	8
39-41	15	11
42-44	13	8
45-47	12	16
48-50	15	6
51-60	9	9
61-70	7	5
71-80	4	3
81-90	1	1
Totals:	559	123
Total N =	682	

Class Standing:

First Time Freshmen	1
Freshmen	36
Sophomore	55
Junior	181
Senior	286
Graduate	123
Total	682

Ethnic Code:

American Indian or Alaskan Native	11
Black, non hispanic	35
Mexcan American, Mexican, Chicano	28
Central American	1
South American	5
Cuban	0
Puerto Rican	1
Other Latino, Spanish Origin	19
Chinese	5
Japanese	3
Korean	2
Asian Indian	0
Other Asian	7
Cambodian	0
Laotian	0
Vietnamese	1
Thai	0
Other Southeast Asian	1
Guamanian	0
Hawaiian	0
Samoan	0
Other Pacific Islander	1
White	485
Filipino	1
Other	28
No Response	4
Decline to state	43
Total	682

Academic Indicators:

	Average # of Units Passed	Average CSUN Cum GPA	Average Disabled Cum GPA
Undergrads *	91.4	2.51	2.67
Graduates	37.70	3.49	3.60

* First time Freshmen with 0 units were not included in these totals.

Majors:

Accounting	14
Afro Amer	2
Anthropology	1
Art	8
Art 2D	6
Art 3D	4
Art General Studies	2
Art History	2
Athletic Trn	1
Biology	13
Cell Biology	6
Chemistry	1
Child Development	24
Com Disorders	6
Comm/CL PS	1
Computer Science	13
Counseling	2
Crim/Corr	2
Deaf Studies	6
Earth Sciences	1
Economics	10
Education Admin	2
Engineering	17
English Lit	1
English Writing	4
English	16
Environmental Health	5
Environmental Biology	1
EdPsych CCC	1
Ed Psych CMFC	19
Ed Psych CSC	1
Ed Psych CSP	1
Exercise Science	1
Finance	9
Found Educ	2
Geography	4
German	1

Majors (cont):

Graphic Design	6
Health Admin	1
Health Ed	3
Health Science	4
History	24
Home Ec/Bus	3
Home Ec/Diet	4
Home Ec	9
Human Resources	1
Humanities	1
International Business	1
Intrdsplny	1
Journalism	12
Liberal Studies	47
Marketing	3
Mass Communications	3
Math	2
Math Statistics	1
Math Teaching	3
Med Tec	2
Mex-Amer Stu	1
MSA	1
Music	5
Office Systems	1
Organ Sys Mgt	3
PE General Studies	1
Phys Ed	7
Physics	1
Poli Sci	19
Pre Business	35
Pre Comp Sci	3
Pre Econ	2
Pre Engineering	3
Pre RTVB	14
Psychology	54
Public Health	2
Real Estate	1
Recreation	6
RTVB	13
RTVB/Film	1
School Psych	1
SEDCOMPED	1
SEDSSED	1
Soc Welfare	4
Sociology	15
Spanish	1
Spc Com	1
Spc Com SPCMJ	1
SPECIAL	7
Spec Ed	2

Majors (cont):

SPEDDHH	2
SPEDLH	2
Speech Com	22
SPN LN/CUL	1
TEACH/COACH	1
Theatre	4
Therapy Rec	2
Undecided	96
Total	682

Disabled Student Graduates:

Spring 1992 graduates: 58

Appendix A: Computer Lab (Workroom) Summary Sheet

From: Guide To Using Computer Workrooms at CSUN. Johnson, Gail S., Sales, Chris, Computer Center User Services Group, January 1992.

24 Hour, 7 Days a Week Labs

Location	Hardware	Software	Special Notes
Engineering 126 Novell Network PC Lab **24 hour lab**	20 Epson PCs 4 Epson FX-850 printers	dBASE III+, Foxbase+ 2.10. GW-Basic. Kermit, ProComm, Quattro, Lotus 1-2-3, SPSS/PC, Turbo Pascal 5.5, WordPerfect 5.1.**Also available: various legitimate software for specific CSUN classes.**	Requires a Network Startup Disk available for purchase from SS 142.
Engineering 127 Novell Network PC Lab + Dedicated Terminals **24 hour lab**	24 PS/2 Model 30-286x w/HD 5 PS/2 5-1/4" external drives 4 Epson Fx-850 printers	dBASE III+, Foxbase+ 2.10, GW-Basic, Kermit, ProComm, Quattro, Lotus 1-2-3, SPSS/PC, Turbo Pascal 5.5, WordPerfect 5.1.**Also available: various legimate software for specific CSUN classes.**	Requires a Network Startup Disk available for purchase from SS 142. (3-1/2")
	34 VT320 terminals 9 Epson FX-286e printers	See mainframe software list below.	

Labs with Specific Hours

Location	Hardware	Software	Special Notes
Oviatt Library, 2nd FloorEast **Open Lib. hours** Novell Network PC Lab and AppleShare Macintosh Lab	31 Epson Equity II+s 8 Epson Equity	dBASE III+, GW-Basic, Kermit, ProComm, Quattro, SPSS/PC, WordPerfect 5.1. **Also available: various legitimate software for specific CSUN classes.**	Requires a Network Startup Disk available for purchase from SS
	24 Mac Pluses 2 Apple Imagewriter	Disinfectant, HyperCard 1.2.5, Kermit, Microsoft Excel 2.2, Microsoft Word 4.0, WordPerfect 1.0.3.	Requires a Macintosh Startup Disk available from SS 142.
Science 200B PC Mainframe Lab **8:00am-7:00pm**	12 Big PCs w/dual floppy drives 3 Epson FX-286e printers	See mainframe software list below.	Must have own copy of MS-DOS and mainframe communication

Department Labs

Location	Hardware	Software	Special Notes
Fine Arts 131 Macintosh Lab Fine Arts Dept. **Check for hours**	20 Mac IIs w/HD 1 AppleLaser Writer IINTX 1 Microtek Scanner	Microsoft Excel 1.5, MacDraw II, MacPaint, Hypercard 2.0,Microsoft word 4.0, WordPerfect 1.0.3. **Available on specified computers only: CriketGraph, MicrosoftWorks, Canvas, CricketDrew, Digital Darkroom, Draw it again Sam, Mac3D, MacDraft, Modacad, Pixel Paint, VideoWorks.**	Available on a very limited schedule; check postings.
Sierra South 355 Macintosh Network Lab Business Dept. **Check for hours**	24 Mac SEs w/HD 6 ImageWriter II printers	Disinfectant, HyperCard 2.0, Microsoft Excel 2.2, Microsoft Word 4.0, VersaTerm Pro.	Requires a Macintosh Startup Disk available for purchase from SS 142.

North Campus Computer Lab

Location	Hardware	Software	Special Notes
Satellite Student Union North Campus **Check for hours**	2 Macs 2 PS/2 Laser printers	MS Word, Excel	Computer use fee Laser printer fee (Check for Cost)

LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
AD 152	MAC	1050	EDUC EQUITY	1
AD 152	PC	1050	EDUC EQUITY	2
....		1050	EDUC EQUITY	3
AD 202	PC	0991	PLACEMENTS	3
....		0991	PLACEMENTS	3
AD 502D	PC	0074	SCH ARTS	1
....		0074	SCH ARTS	1
AD 504	PC	0079	SCH CHHS	31
....		0079	SCH CHHS	31
ADH 3	APPLE	0692	COMM DISORDERS	20
ADH 3	MAC	0692	COMM DISORDERS	1
ADH 3	PC	0692	COMM DISORDERS	11
....		0692	COMM DISORDERS	32
CHI	MAC	0036	NATL CTR DEAF	1
CHI	PC	0036	NATL CTR DEAF	2
....		0036	NATL CTR DEAF	3
EN 109C	MAC	0081	SCH ENG/COM SCI	4
EN 109C	PC	0237	ELECTRICAL ENG	2
....		0081	SCH ENG/COM SCI	6
EN 125B	MAC	0485	MECHANICAL/CHEM	18
EN 125B	OTHER	0485	MECHANICAL/CHEM	1
EN 125B	PC	0485	MECHANICAL/CHEM	30
....		0485	MECHANICAL/CHEM	49
EN 125C	APPLE	0488	CIAM	16
....		0488	CIAM	16
EN 126	PC	0028	UNIVERSITY LABS	21
....		0028	UNIVERSITY LABS	21
EN 127	PC	0028	UNIVERSITY LABS	27
EN 127	TERM	0028	UNIVERSITY LABS	35
....		0028	UNIVERSITY LABS	62

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LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
========	=====	====	===============	======
EN 129	PC	0485	MECHANICAL/CHEM	1
		====	===============	======
....		0485..	MECHANICAL/CHEM	1
EN 131A	MAC	0237	ELECTRICAL ENG	2
EN 131A	PC	0237	ELECTRICAL ENG	1
EN 131A	SUN	0237	ELECTRICAL ENG	2
		====	===============	======
....		0237..	ELECTRICAL ENG	5
EN 133	APPLE	0237	ELECTRICAL ENG	1
EN 133	OTHER	0237	ELECTRICAL ENG	2
EN 133	SUN	0081	SCH ENG/COM SCI	1
		====	===============	======
....		0081..	SCH ENG/COM SCI	4
EN 134	MAC	0189	COMPUTER SCI	2
EN 134	PC	0189	COMPUTER SCI	14
		====	===============	======
....		0189..	COMPUTER SCI	16
EN 140	MAC	0237	ELECTRICAL ENG	22
EN 140	OTHER	0237	ELECTRICAL ENG	4
EN 140	PC	0237	ELECTRICAL ENG	5
		====	===============	======
....		0237..	ELECTRICAL ENG	31
EN 141	OTHER	0237	ELECTRICAL ENG	16
		====	===============	======
....		0237..	ELECTRICAL ENG	16
EN 150	PC	0237	ELECTRICAL ENG	4
EN 150	SUN	0237	ELECTRICAL ENG	1
		====	===============	======
....		0237..	ELECTRICAL ENG	5
EN 155	PC	0488	CIAM	24
		====	===============	======
....		0488..	CIAM	24
EN 155D	PC	0488	CIAM	12
EN 155D	SUN	0488	CIAM	1
		====	===============	======
....		0488..	CIAM	13
EN 157	MAC	0237	ELECTRICAL ENG	2
		====	===============	======
....		0237..	ELECTRICAL ENG	2
EN 416	PC	0081	SCH ENG/COM SCI	25

LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
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		====	===============	======
....		0081..	SCH ENG/COM SCI	25
EN 416A	OTHER	0189	COMPUTER SCI	1
EN 416A	SUN	0189	COMPUTER SCI	6
		====	===============	======
....		0189..	COMPUTER SCI	7
EN 417	PC	0189	COMPUTER SCI	12
EN 417	TERM	0189	COMPUTER SCI	20
		====	===============	======
....		0189..	COMPUTER SCI	32
EN 417E	MAC	0189	COMPUTER SCI	37
		====	===============	======
....		0189..	COMPUTER SCI	37
FA 100	PC	0106	ART HISTORY	1
		====	===============	======
....		0106..	ART HISTORY	1
FA 103	PC	0136	ART GENERAL	4
		====	===============	======
....		0136..	ART GENERAL	4
FA 118	MAC	0106	ART HISTORY	4
		====	===============	======
....		0106..	ART HISTORY	4
FA 131	MAC	0079	SCH CHHS	21
		====	===============	======
....		0079..	SCH CHHS	21
FA 132A	MAC	0074	SCH ARTS	7
		====	===============	======
....		0074..	SCH ARTS	7
FA 141	MAC	0087	ART 2D MEDIA	12
		====	===============	======
....		0087..	ART 2D MEDIA	12
FA 213	PC	0349	HOME ECONOMICS	6
		====	===============	======
....		0349..	HOME ECONOMICS	6
FA 228	MAC	0087	ART 2D MEDIA	36
		====	===============	======
....		0087..	ART 2D MEDIA	36
FA 322	MAC	0136	ART GENERAL	1
FA 322	OTHER	0136	ART GENERAL	1

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LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
========	=====	====	===============	======
		====	===============	======
....		0136	..ART GENERAL	2
FOB 107	PC	0121	PAN AFRICAN	16
		====	===============	======
....		0121	..PAN AFRICAN	16
FOB 130	PC	0145	BIOLOGY	1
		====	===============	======
....		0145	..BIOLOGY	1
FOB 204	MAC	0675	SOCIOLOGY	1
		====	===============	======
....		0675	..SOCIOLOGY	1
MH LAB	APPLE	0663	SECONDARY ED	20
MH LAB	MAC	0663	SECONDARY ED	3
		====	===============	======
....		0663	..SECONDARY ED	23
MH 219	APPLE	0663	SECONDARY ED	8
		====	===============	======
....		0663	..SECONDARY ED	8
MH 316	PC	0310	GEOLOGICAL SCI	2
		====	===============	======
....		0310	..GEOLOGICAL SCI	2
MH 326	MAC	0310	GEOLOGICAL SCI	1
		====	===============	======
....		0310	..GEOLOGICAL SCI	1
MOD	PC	0337	HEALTH SCIENCE	1
		====	===============	======
....		0337	..HEALTH SCIENCE	1
MOD S	OTHER	0086	DISABLED STDNTS	16
		====	===============	======
....		0086	..DISABLED STDNTS	16
MU 101	MAC	0801	MUSIC	4
		====	===============	======
....		0801	..MUSIC	4
MU 116	MAC	0801	MUSIC	11
MU 116	PC	0801	MUSIC	5
		====	===============	======
....		0801	..MUSIC	16
MU 118	MAC	0801	MUSIC	1

CIRPST

LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
....		0801	..MUSIC	1
MU 220	MAC	0641	RADIO TV FILM	1
....		0641	..RADIO TV FILM	1
OL 1	PC	0021	LIBRARY	8
....		0021	..LIBRARY	8
OL 120	PC	0021	LIBRARY	12
....		0021	..LIBRARY	12
OL 2ND	PC	0028	UNIVERSITY LABS	32
....		0028	..UNIVERSITY LABS	32
OL 219	PC	0021	LIBRARY	2
....		0021	..LIBRARY	2
OL 28	PC	0026	INSTR MEDIA CTR	1
....		0026	..INSTR MEDIA CTR	1
OL 3RD	APPLE	0663	SECONDARY ED	31
OL 3RD	PC	0035	LEARN RESOURCE	3
....		0035	..LEARN RESOURCE	34
OL 4TH	MAC	0028	UNIVERSITY LABS	23
OL 4TH	SUN	0028	UNIVERSITY LABS	3
....		0028	..UNIVERSITY LABS	26
OL 7	PC	0021	LIBRARY	2
....		0021	..LIBRARY	2
PE BIO	OTHER	0562	PHYS EDUCATION	1
....		0562	..PHYS EDUCATION	1
PE 104	MAC	0562	PHYS EDUCATION	1
PE 104	PC	0562	PHYS EDUCATION	8
....		0562	..PHYS EDUCATION	9
SC 108	OTHER	0572	PHYSICS/ASTRON	1

CIRPST

LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
========	=====	====	===============	======
		====	===============	======
....		0572	..PHYSICS/ASTRON	1
SC 113A	PC	0572	PHYSICS/ASTRON	3
		====	===============	======
....		0572	..PHYSICS/ASTRON	3
SC 128	PC	0572	PHYSICS/ASTRON	40
		====	===============	======
....		0572	..PHYSICS/ASTRON	40
SC 133	MAC	0572	PHYSICS/ASTRON	1
SC 133	PC	0572	PHYSICS/ASTRON	11
		====	===============	======
....		0572	..PHYSICS/ASTRON	12
SC 134A	MAC	0572	PHYSICS/ASTRON	1
		====	===============	======
....		0572	..PHYSICS/ASTRON	1
SC 134E	PC	0572	PHYSICS/ASTRON	3
		====	===============	======
....		0572	..PHYSICS/ASTRON	3
SC 200	PC	0028	UNIVERSITY LABS	12
		====	===============	======
....		0028	..UNIVERSITY LABS	12
SC 215	PC	0145	BIOLOGY	19
		====	===============	======
....		0145	..BIOLOGY	19
SC 226	MAC	0145	BIOLOGY	2
		====	===============	======
....		0145	..BIOLOGY	2
SC 240	MAC	0145	BIOLOGY	65
SC 240	OTHER	0145	BIOLOGY	2
SC 240	PC	0145	BIOLOGY	34
		====	===============	======
....		0145	..BIOLOGY	101
SC 314	OTHER	0487	MATHEMATICS	1
		====	===============	======
....		0487	..MATHEMATICS	1
SC 315	PC	0310	GEOLOGICAL SCI	9
		====	===============	======
....		0310	..GEOLOGICAL SCI	9
SC 324	PC	0178	CHEMISTRY	1

CIRPST

LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
========	=====	====	===============	======
		====	===============	======
....		0178..	CHEMISTRY	1
SC 326	PC	0178	CHEMISTRY	20
		====	===============	======
....		0178..	CHEMISTRY	20
SC 327	PC	0178	CHEMISTRY	2
		====	===============	======
....		0178..	CHEMISTRY	2
SC 340	PC	0145	BIOLOGY	30
		====	===============	======
....		0145..	BIOLOGY	30
SCI 314	APPLE	0487	MATHEMATICS	11
		====	===============	======
....		0487..	MATHEMATICS	11
SCN 131	PC	0145	BIOLOGY	2
		====	===============	======
....		0145..	BIOLOGY	2
SCN 137	PC	0145	BIOLOGY	7
		====	===============	======
....		0145..	BIOLOGY	7
SCN 240	MAC	0145	BIOLOGY	20
		====	===============	======
....		0145..	BIOLOGY	20
SD 104	PC	0710	THEATRE	3
		====	===============	======
....		0710..	THEATRE	3
SD 110	MAC	0710	THEATRE	1
		====	===============	======
....		0710..	THEATRE	1
SD 140	PC	0641	RADIO TV FILM	1
		====	===============	======
....		0641..	RADIO TV FILM	1
SD 207	MAC	0641	RADIO TV FILM	1
		====	===============	======
....		0641..	RADIO TV FILM	1
SFO	PC	0572	PHYSICS/ASTRON	1
		====	===============	======
....		0572..	PHYSICS/ASTRON	1
SN 105	MAC	0494	CHICANO STUDIES	1

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LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
SN 105	PC	0494	CHICANO STUDIES	2
		0494	CHICANO STUDIES	3
SN 106	PC	0494	CHICANO STUDIES	2
		0494	CHICANO STUDIES	2
SN 119C	PC	0075	SCH SOC & BS	6
		0075	SCH SOC & BS	6
SN 204	MAC	0411	JOURNALISM	55
		0411	JOURNALISM	55
SN 210	PC	0254	ENGLISH	26
		0254	ENGLISH	26
SN 222	MAC	0411	JOURNALISM	7
		0411	JOURNALISM	7
SN 306	MAC	0281	FOR LANG & LIT	2
		0281	FOR LANG & LIT	2
SN 308	APPLE	0487	MATHEMATICS	1
SN 308	MAC	0487	MATHEMATICS	9
		0487	MATHEMATICS	10
SS 107	MAC	0675	SOCIOLOGY	1
SS 107	PC	0675	SOCIOLOGY	40
SS 107	TERM	0675	SOCIOLOGY	14
		0675	SOCIOLOGY	55
SS 112	MAC	0305	GEOGRAPHY	29
SS 112	PC	0305	GEOGRAPHY	3
		0305	GEOGRAPHY	32
SS 113B	MAC	0305	GEOGRAPHY	1
		0305	GEOGRAPHY	1
SS 116	PC	0732	URBAN STUDIES	1
		0732	URBAN STUDIES	1

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LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
SS 117	MAC	0305	GEOGRAPHY	1
....		0305	GEOGRAPHY	1
SS 141	MAC	0305	GEOGRAPHY	1
....		0305	GEOGRAPHY	1
SS 142	PC	0078	SCH BUS & ECON	63
....		0078	SCH BUS & ECON	63
SS 143	PC	0078	SCH BUS & ECON	2
....		0078	SCH BUS & ECON	2
SS 144	PC	0101	ACCOUNTING-MIS	26
....		0101	ACCOUNTING-MIS	26
SS 216	PC	0075	SCH SOC & BS	8
....		0075	SCH SOC & BS	8
SS 221	OTHER	0134	ANTHROPOLOGY	1
....		0134	ANTHROPOLOGY	1
SS 223	OTHER	0265	FINANCE	5
....		0265	FINANCE	5
SS 302	PC	0028	UNIVERSITY LABS	33
....		0028	UNIVERSITY LABS	33
SS 305	MAC	0536	OFF SYS/BUS ED	1
SS 305	PC	0078	SCH BUS & ECON	32
....		0078	SCH BUS & ECON	33
SS 320H	MAC	0590	PSYCHOLOGY	1
....		0590	PSYCHOLOGY	1
SS 330	MAC	0590	PSYCHOLOGY	1
....		0590	PSYCHOLOGY	1
SS 332	PC	0688	SPEECH COMM	3

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LOCATION	BRNAM	DEPT CODE	DEPARTMENT NAME	QUAN
....		0688	..SPEECH COMM	3
SS 350	PC	0590	PSYCHOLOGY	36
SS 350	TERM	0590	PSYCHOLOGY	1
....		0590	..PSYCHOLOGY	37
SS 355	MAC	0028	UNIVERSITY LABS	24
....		0028	..UNIVERSITY LABS	24
ST 508	PC	0281	FOR LANG & LIT	8
....		0281	..FOR LANG & LIT	8
ST 603	PC	0348	HISTORY	2
....		0348	..HISTORY	2
ST 611	OTHER	0348	HISTORY	1
....		0348	..HISTORY	1
ST 613	MAC	0348	HISTORY	1
....		0348	..HISTORY	1
ST 617	MAC	0348	HISTORY	2
....		0348	..HISTORY	2
ST 709	OTHER	0254	ENGLISH	1
....		0254	..ENGLISH	1
ST 813	PC	0580	POLITICAL SCI	6
....		0580	..POLITICAL SCI	6
VEN	MAC	1210	VENTURA LRN CTR	24
VEN	PC	1210	VENTURA LRN CTR	15
....		1210	..VENTURA LRN CTR	39
VEN 140	PC	1210	VENTURA LRN CTR	1
....		1210	..VENTURA LRN CTR	1
***		0021	LIBRARY	1560

TOTAL STUDENT STATIONS
CIRPST

Appendix IV

Press Release
and
Information about Disabilities

California State University, Northridge
Office of Public Affairs—OPA
18111 Nordhoff Street
Northridge, California 91330
(818) 885-2129

News Release

FOR IMMEDIATE RELEASE

March 5, 1991

Contact: Ann Salisbury
Kaine Thompson

Computer gear to give severely disabled people unprecedented freedom in pursing education, entertainment and employment will be introduced at 10 a.m., Tuesday, March 19, at the California State University, Northridge (CSUN) University Club.

The technology, called the Universal Access System, is also expected to save millions of dollars for employers who must now comply with the Americans With Disabilities Act signed by President Bush last July.

The Universal Access System is a standardized method of enabling disabled individuals to use computers or software provided in schools, offices or in the home so that they can function fully in any setting.

With specific software packages disabled users then are able to pursue virtually any field of interest such as biology, music, graphic design, word processing, astronomy, or even full-color graphic design.

Developed under the direction of Harry Murphy, director of the Office of Disabled Student Services at California State University, Northridge (CSUN) the project was conceived in the Computer Access Laboratory by Special Projects Engineer Neil Scott. Manufacture of the system is expected to begin this spring by an Irvine firm.

"With the implementation of this concept, there is no reason for any disabled individual to be barred from activities that give

--more--

would make one initial investment with minimal additional follow up systems.

"At present within school systems that educate the disabled, you have specialized learning equipment changing with each disability," he continued. "When a school district purchases the equipment it is costly and probably unsuitable for use by any other disabled students who subsequently or simultaneously may be enrolled."

With this system, only the universal link stays with the school system. The accessor stays with the student from preschool through college, thereby letting the student gain complete mastery of the equipment and ensuring a consistent learning growth pattern since there will be no need for constantly having to adapt to different technologies as environments change.

"By the time the students get to the university, they will just wheel in the door and start working," said Scott.

To reach the University Club, turn north onto Zelzah from Nordhoff, and turn immediately right on Dearborn. The entrance to the University Club is through the orange grove, half a block down on the left.

--30--

System Allows the Disabled to Use Computers

By DAVID L. WILSON

NORTHRIDGE, CAL.

To use computer equipment, college students with disabilities frequently must work on special workstations in a central location on their campus. The handicapped students often find the arrangement inconvenient.

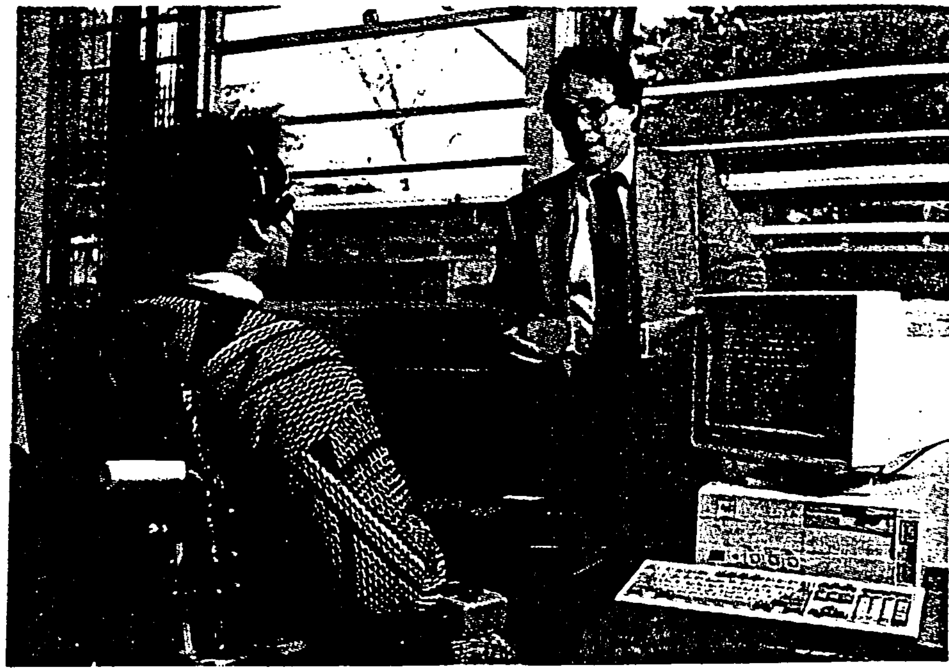
But because many disabled students need special hardware and software, an institution cannot hope to equip every computer on its campus with every device on the market available to assist the disabled, says Neil G. Scott, special-projects engineer with the Office of Disabled Student Services at California State University's campus here. "That would be far too expensive."

According to Mr. Scott, institutions are searching for an inexpensive way to give students better access to computing systems, as required under the new Americans With Disabilities Act.

Voice Recognition Used

The Northridge campus is developing a Universal Access System designed to allow any person to operate any computer using invisible beams of infrared light.

The system would require two computers. The host machine would be the standard computer found in laboratories, libraries, or public computing facilities, and would contain software needed for a given task. A student writing a paper, for example, would use a computer with a word-processing program.



NANCY KAYE FOR THE CHRONICLE

Northridge's Neil G. Scott holds an infrared unit above a portable computer equipped with voice-recognition capability.

The second computer would probably be a portable machine equipped with whatever devices needed to assist the disabled user. A student who is extensively paralyzed, for example, would have voice-recognition technology on the portable.

The Universal Access System would link the two computers. Because infrared beams would relay information between the two machines, there would be no wires to connect. Special software would make the system operate.

Using voice-recognition technology in the portable, a disabled student could create a paper on the host computer. Since the host would contain only the word-processing software, any student—disabled or not—could use it once the paralyzed student was finished.

"A blind student who has voice-synthesis technology on his portable could use the same host computer," says Mr. Scott. In that instance, the portable would read aloud the material as it appeared on the host machine's screen.

If such a system came into widespread use, Mr. Scott says, disabled people could carry portable computers with them everywhere, using customized technology to operate automatic teller machines, elevators, and even appliances.

Expected to Cost Under $200

Genovation Inc., a computer-equipment manufacturing company in Irvine, Cal., is making a prototype of the system and negotiating with manufacturers to build the system into future computers. Mr. Scott estimates that adding such a system to two existing computers—the infrared sensing devices plug into openings on most machines—would cost under $200.

"This is going to give disabled individuals a strong measure of independence, and allow colleges and universities to make much better use of their limited resources," he says. ■

Survey of Disabilities in the American Population

Estimates of the number of disabled persons in the United States vary between 30 and 50 million. The exact figure is difficult to obtain because of differences in the way disabilities are defined, and inconsistencies in the methods used for making surveys.

- The most commonly used estimates for the number of Americans with disabilities are between 36 and 40 million.
- Approximately 4.5 million children and youths between the ages of 3 and 21 receive special educational services.
- At least 1 in every 8 people in America has a disability.
- The Federal Government spends over $60 Billion on disabilities annually.

Breakdown of disability types

Physical disabilities		**44%**
Nonparallytic orthopedic impairments	29%	
Neuromotor and neuromuscular impairments	7%	
Brain disfunction / memory loss / senility	6%	
Other physical disabilities	2%	
Sensory impairments		**13%**
Blindness / visual impairment	7%	
Hearing / speech / language impairments	6%	
Mental disabilities		**6%**
Mental retardation/development disabilities	3%	
Mental illness	3%	
Other serious health impairments		**32%**
Heart / blood / blood vessel disease	16%	
Respiratory or pulmonary disease	5%	
Cancer / diabetes / kidney disease / others	11%	
Unspecified disabilities		**5%**

Employment

- Only 32% of working age persons with disabilities have jobs, i.e. two-thirds of people with disaabilities of working age are jobless.
- The impact of of joblessness is that disabled Americans are much poorer than are nondisabled Americans. One-fourth of people with disabilities live in households with an annual income of $7,500 or less.
- There are severe problems with self-perception of non-working people with disabilities.

Barriers to working

One survey of working-age disabled Americans who are not working, or working part-time, showed:

- 47% of the group say that employers won't recognize that they are capable of doing a full-time job.
- 40% of the group say that there is a lack of jobs in their line of work.
- 38% of the group say that under-education and lack of marketable skills are important reasons for why they are not working full-time.
- 28% of the group say that lack of accessible or affordable transportation is an important reason for why they are not working full-time.
- 23% of the group say that lack of suitable equipment or access devices to help them work easier or communicate better with other workers. One in four disabled persons of working age says that they have encountered job discrimination because of their disabilities.
- 35% of employed people with disabilities say that their employers made special accommodations for them in the workplace.
- 75% of disabled persons prefer to work outside of the home.

Education

Undereducation is a major problem for most disabled Americans. Whereas 85% of nondisabled Americans have a high school education, only 60% of disabled Americans have some high school education. Similarly, 48% of the nondisabled population have some college education compared to only 29% of the disabled population. There is a high degree of correlation between education, income and employment.

California State University, Northridge
Office of Public Affairs—OPA
18111 Nordhoff Street
Northridge, California 91330
(818) 885-2129

News Release

PHYSICAL DISABILITIES

Number of people affected: Approximately 33 million.

Conditions include: Multiple sclerosis, amyothropic lateral sclerosis, spinal cord injury, traumatic brain injury, cerebral palsy, muscular dystrophy, Parkinson's disease, numerous neuro-muscular disorders, amputation, stroke, repetitive strain injuries such as carpal tunnel syndrome, and/or temporary disabilities such as broken bones or strained muscles.

Problems faced by people with this disability: Inability to perform normal motor functions such as eating, hygiene, grooming, walking, sitting, writing, and speaking; severe restrictions on everyday activities and limited independence; and, respiratory malfunctions often requiring use of external respirators.

Traditional solutions: There is no single solution. A wide assortment and often confusing array of technology has been developed to meet the variety of needs of physically disabled individuals. Basic requirements include environmental control, mobility, and computer access.

Environmental Control Units (ECU) make possible many daily living tasks such as turning on and off lights and appliances, opening and closing doors, windows, and drapes, and controlling entertainment equipment. ECUs are usually dedicated systems controlled by switches, pointing devices, and spoken commands.

Mobility aids include walkers, manual and power wheelchairs, and specially modified vans and automobiles. Devices such as mobile arm supports provide mobility for individual limbs for specific tasks. There are some limited applications of mobility aids which use Functional Electrical Stimulation (FES) to enable disabled people to achieve activities approximating non-disabled performance. FES uses a computer control system to stimulate muscle movements through tiny electrical shocks.

Computer access utilizes a variety of techniques which are dependent on the type, and severity of the disability. Wherever possible, the computer keyboard is used. This sometimes requires special hardware and/or software modifications either to make it easier to select certain combinations of keys or else to prevent unwanted key entries. Alternatives to the keyboard include special software and external devices which emulate the functions of the keyboard (keyboard emulators).

Limitations of existing solutions: Many individuals end up with a collection of separate devices to handle their daily work, study, living, and environmental needs. This approach is often clumsy, bulky, and costly, and often requires mastery of a variety of different operating procedures. Funding of technology is often a problem.

What the Universal Access System offers: A single accessor will be able to communicate with all of the devices a disabled person needs to control. This will provide a consistent interface for the disabled user and will lead to lower costs for the other devices since each can be designed to perform its primary function without needing to cater to all of the variations necessitated by different disabilities.

News Release

California State University, Northridge
Office of Public Affairs—OPA
18111 Nordhoff Street
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DEAFNESS AND HEARING IMPAIRMENTS

Number of people affected: Approximately 28 million.

Conditions include: Complete or partial loss of hearing due to injury, illness, and/or congenital causes

Problems faced by people with this disability: Orientation, language deficits, speech impairment, difficulty using the telephone, personal safety, availability of interpreters, and social isolation.

Traditional solutions: Hearing aids, cochlear implants, language therapy, auditory training (depending on degree of loss), sign language, speech therapy, TDD (Telecom Device for the Deaf) phone communication, and computer modifications such as replacement of sound cues with visual cues (e.g. objects or text may flash, blink, or change color as a signal to users).

Limitations of existing solutions: Dependence on interpreters to bridge the communication gaps, funding for hearing aids, cochlear implants, and other technologies such as the TDD telephone access.

What the Universal Access System offers: A Universal Access System for deaf and hearing impaired users will enable them to use synthesized speech to speak into a telephone. They can receive information over the telephone through the use of software which enables the caller to code replies, using the telephone's touch-tone pad. Speech recognition with visual feedback to the user and synthesized speech output, will translate a deaf or hearing impaired person's voice into understandable speech. Speech to sign language systems have been demonstrated and could be incorporated into an accessor. In few years, we will have speech recognition capable of translating a stranger's voice into text for the deaf person to read. The Universal Access System will make the introduction of such systems easier and cheaper.

News Release

California State University, Northridge
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VISUAL IMPAIRMENTS

Number of people affected: Approximately 16 million.

Conditions include: Congenital limitation of sight or partial loss of sight due to: cataracts, glaucoma, macular degeneration, diabetes, retinitis pigmentosa, visual field defects, and/or head injury.

Problems faced by people with this disability: Orientation, mobility, reading and writing traditional text, coping with activities of daily living (ADL), using computers, safety, and operation of mechanical and electrical devices.

Traditional solutions: Mobility training, magnifiers, braille training for some, use of tape recorders, enlarged print (for books, keyboard symbols, computer screens, signs, etc.), adjusting color and contrast (of objects, text, computer displays, etc.), and use of various technologies such as closed circuit television, enlarged text on computer monitors, optical character recognition (OCR) systems, screen readers, and speech synthesis.

Limitations of existing solutions: Compatibility of the various technologies such as text enlargement hardware and software, screen readers, and OCR, and the applications programs which are also required to run in the computer. Funding of technology is often a problem.

What the Universal Access System offers: A typical accessor for a visually impaired user consists of a computer equipped with a character magnification program. It may also include a text review program, a speech synthesizer, a graphics scanner, and optical character recognition software. Because there is no limit on the size of the programs that may be run in an accessor, it will be possible to provide sophisticated programs for interpreting graphics screens through OCR and holographic sound imaging. It is very difficult to perform such tasks in existing screen reader programs because of the amount of processing required. Simple accessors can interact with talking signs. Sophisticated accessors based on virtual reality offer dramatic possibilities for visualizing graphical information and implementing navigational systems.

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BLINDNESS

Number of people affected: Almost 1 million legally blind.

Conditions include: Total lack of sight, and, in some cases, some residual sensitivity to light and dark. Medical diagnoses that can result in blindness include: diabetes, retinitis pigmentosa, eye injury, and premature birth with overexposure to pure oxygen.

Problems faced by people with this disability: Mobility, orientation, difficulty operating mechanical and electrical devices, safety, delayed language development as a child, reading and writing traditiona text, access to printed information, and difficulty learning and performing many of the activities of daily living (ADL).

Traditional solutions: Special training is provided for blind people in areas such as mobility, orientation, language therapy for children, visual training for orientation and language, Braille, typing, use of tape recorders and record players, and special-purpose equipment such as Perkins Brailler and Opticon. Computer access includes Braille keyboards and displays, screen reading programs, speech synthesizers, and optical character recognition (OCR) systems. Braille printing is still a mainstay for providing blind people with access to printed text.

Limitations of existing solutions: The blind community has been at the forefront of using computer technology to solve many of their needs. Screen reading programs coupled with speech synthesis provides access to text-based computer applications. However, a blind person is restricted to using a particular computer which has been equipped with appropriate speech hardware and text review software. Compatibility of text review software with other applications is often a problem. Complete books are available on cassette tape or computer disk. However, finding a particular passage from a full tape or disk is often difficult due to the serial nature of the recording. Portable computers are widely used to provide ready access to functions such as notebooks, calendars, thermometers, calculators, and the like. A growing problem for blind computer users is that applications programs are becoming larger and more complex, thereby making it increasingly difficult to simultaneously run sophisticated text review software. The increasing popularity of graphical interfaces, which do not lend themselves to text-based interpretation, is creating a new set of problems for blind computer users. A number of technologies such as talking signs and navigation systems have been developed for blind users but have not been viable because of the cost of the necessary readout devices. Funding of technology is often a problem.

What the Universal Access System offers: A typical accessor for a blind user consists of a computer equipped with a text review program and a speech synthesizer. It may also include a graphics scanner and optical character recognition software. Because there is no limit on the size of the programs that may be run in an accessor, it will be possible to provide sophisicated programs for interpreting graphics screens through OCR and holographic sound imaging. It is very difficult to perform such tasks in existing screen reader programs because of the amount of processing required. Simple accessors can interact with talking signs. Sophisticated accessors based on virtual reality offer dramatic possibilities for visualizing graphical information and implementing navigational systems.

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COMMUNICATION IMPAIRMENTS

Number of people affected: Approximately 2 1/2 million.

Conditions include: (1) Articulation disorders due to impairment of speech production which results in distortions, omissions, additions, and substitutions of sounds. (2) Stuttering which produces impaired speech fluency. (3) Voice disorders due to impairments in phonation, volume, pitch, and/or tone. (4) Language disorders due to impairment in receptive and/or expressive language.

Problems faced by people with this disability: Communicating effectively, social acceptability, writing, understanding speech and language of others, communicating at same rate, and often, severe respiratory limitations.

Traditional solutions: Speech and/or language therapy; for nonspeaking, aided and/or unaided communication systems; and, for laryngectomy, surgery for implantation of artificial larynx or electrolarynx, or development of esophageal speech.

Limitations of existing solutions: Difficulty maintaining same communication rate as normal population of speakers, and, social isolation because of difficulty people have in understanding them. Funding of technology is often a problem.

What the Universal Access System offers: This depends on whether the communication impairment is isolated or accompanied by other disabilities. If there is only a communication disorder, there are many dedicated solutions for providing alternative communications. However, if there is another disability, for instance a physical disability, then an accessor will provide access to computers, wheelchairs, appliances, and other devices as well as provide the communication function.

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COGNITIVE IMPAIRMENTS (mentally retarded)

Number of people affected: Approximately 1 million.

Conditions include: Limited intellectual capability, reduced comprehension, reduced language expression, mild motor impairment, and/or coordination deficits.

Problems faced by people with this disability: Reduced language comprehension, reduced language expression, and speech impairment. Severe limitations exist in vocational and employment opportunities because of difficulties experienced in learning and performing tasks.

Traditional solutions: Speech and language therapy, sheltered workshops, supportive employment, specially adapted tools and machines, and use of computers in educational settings.

Limitations of existing solutions: In sheltered workshops wages are low and the environment is restrictive. Computers are not used as widely as they might be, partly due to complexity and partly due to a lack of suitable software.

What the Universal Access System offers: Many of the concepts developed for other disabilities lend themselves to this area but will need some adaptation. For example, the Universal Access System will enable each machine in a sheltered workshop to be controlled by accessors which are matched to the specific needs of individuals. Accessors can be made very intelligent to effectively reduce the amount of skill required to perform a particular control task. By standardizing the interfaces to machines and placing all special requirements in the accessor, it will be possible for individuals with widely varying skill levels to perform the same work functions.

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TRAUMATIC BRAIN INJURIES

Number of people affected: Approximately 2 million.

Conditions include: Injury to the head. Often results in multifaceted problems which may or may not include cognitive deficits, memory deficits, and/or motor deficits.

Problems faced by people with this disability: TBI may result in deficits in one or more of the following areas: memory, concentration, initiation, problem solving, reasoning, motor, speech and visual deficits.

Traditional solutions: Calendars, organizers, computers for cognitive retraining, watches with timers, augmentative communication devices where speech is affected, and environmental control units (ECU).

Limitations of existing solutions: An individual often requires an array of assistive devices to compensate for the different problems. They often have problems remembering to use the aids that are provided. For example, they might not remember to look at or bring their watches, calendars, organizers, etc., and are likely to leave them in the last place they used them. Some devices frustrate them. For instance, augmentative communication devices are much slower than a normal speaker.

What the Universal Access System offers: An accessor can bring together all of the assistive devices and techniques required by a person with TBI. Devices and strategies developed for other disabilities can be easily incorporated into a single accessor. When an accessor is used to perform a variety of functions it has the advantage of providing a consistent interface, eliminating the need for the user to learn how to use a variety of different interfaces. This simplification is particulaly important for TBI.

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LEARNING DISABILITIES

Number of people affected: Estimates vary from 5% to 10% of the poulation, i.e., 10 to 25 million.

Conditions include: Perceptual, language, memory, motor, cognition, nonverbal, and/or attention deficit disorders.

Problems faced by people with this disability: Difficulties in reading, writing, math, speaking, listening, memory, organization, inter-personal relationships (at home, school, work, etc.), social skills, academic achievement, self-concept, self-esteem, and, finding and keeping a job.

Traditional solutions: Remedial training, specialized tutoring, therapy, and teaching of compensatory strategies.

Limitations of existing solutions: Individuals may experience problems in a variety of different areas. As a consequence, they may be faced with providing, learning, and using a diverse collection of compensatory devices and strategies. Cost is often a factor because funding agencies are sometimes unable to recognize LD as easily as other disabilities.

What the Universal Access System offers: The Universal Access System makes it easier to bring together new strategies and techniques developed specifically for learning disabled users and others that have been developed for other disability groups. A single accessor can make available all of the resources required by a particular individual at home, work, and school. When an accessor is used to perform a variety of functions it has the advantage of providing a consistent interface, eliminating the need for the user to learn how to use a variety of different interfaces. This simplification is particulaly important for LD.

Appendix V

Evaluation Plan for the UAS

Evaluation

This is the evaluation plan that was to be used to verify the operation of the UAS. Delays in receiving the completed UAS devices prevented the plan being put into operation prior to the end of the grant period.

Purposes of this evaluation

- To show the effectiveness of using the UAS to provide computer access for persons with disabilities.
- To compare the costs of using UAS with existing access strategies
- To determine the educational benefits of using UAS

Areas to be evaluated

- Access
- Educational
- Technical
- Financial
- Acceptance by:
  - Disabled users
  - Manufacturers
  - Service providers

Groups involved

- Disabled CSUN students
- ODSS staff
- CSUN campus computing services
- Computer sites on CSUN campus
- CSUN Faculty

Measuring the level of access

- **Selecting a set of access criteria to be applied to all of the computers that are to be accessed**
  - Special keyboard accessors
  - Pointing accessors
  - Scanning accessors
  - Morse code accessors
  - Speech input accessors

- **Comparing the process of providing equivalent access on a selection of machines**
  - Standalone IBM PC
  - Networked IBM PC
  - IBM PC connected to a mainframe
  - Standalone Apple Macintosh
  - Networked Apple Macintosh

- **Comparing the effectiveness of the access provided in each case**
  - Educational factors
    - ☐ Time - Computer activities are done at the same time as the rest of the class
    - ☐ Place - Access is provided to the computers used by the rest of the class
    - ☐ Speed - Whether the access technique allows the disabled person to keep up with other class members
    - ☐ Tools - access to computer tools which makes the learning process easier
    - ☐ Independence - ability to work at own pace, location, and with whatever method the user chooses

- **Technical Factors**
  - ☐ Quality of access provided by UAS
    - Better than existing methods
    - Equivalent to existing methods
    - Worse than existing methods
  - ☐ Operation of the UAS
    - Ease of installation
    - Ease of setting up
    - Ease of operation
    - Consistency of the user interface
  - ☐ Learning to use the system
    - Easier than existing systems
    - Equivalent to existing systems
    - More difficult than existing systems
  - ☐ Reliability of the system
    - Does it break down
    - Is it erratic in its behavior

- **Financial Factors**
  - ◻ Identify and separate initial costs and ongoing costs
  - ◻ Compare costs for providing access in a selection of situations.
    - Costs to the disabled individual
    - Costs to the educational institution
    - Costs to rehab support services

- **Acceptance of the UAS**
  - **Acceptance by users**
  - Acceptance by providers of disability-related services and equipment
    - ◻ Personal attendants
    - ◻ Support staff
  - Acceptance by providers of computer resources.

Case Studies

- **Mac access**

  The Geography Department has an extensive collection of Macintosh hardware and software for studying all aspects of map production and usage. They have a physically disabled student who needs to access this system as part of his course. Staff from the Computer Access Lab have been helping the Geography department to provide access. It is planned that a Macintosh version of the UAS will be installed in this lab and used as the basis for a case study.