COMPUTER TECHNOLOGY TO ASSIST INDIVIDUALS WITH DISABILITIES: THE CURRENT STATE AND EMERGING TECHNOLOGIES

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ABSTRACT

The disabilities market consists of 750,000,000 people worldwide and is growing rapidly. About 20% of the population of the Unites States is disabled; 25% of the population of the European Union is disabled. Every demographer is predicting that there will be huge labor shortages in many countries in the near future. It is crucial for firms to find ways to hire more disabled employees since they can be the engine for generating and developing new product ideas for this important group. This paper describes how computer technology can be used to play a role in accommodating individuals with disabilities in the workplace, at home, and in society at large.

INTRODUCTION

Maner [17] asks, "Does there exist any other machine that forces an analogous obligation on us to assist people with disabilities?" Maner's point is that the computer, as a universal machine that uses layers of software systems to adapt it to work in any application area, is already a type of adaptive device. Since it can be easily adapted to accommodate individuals with disabilities, it ought to be. That would be the ethical position. The purpose of this paper is to provide an overview of the many ways that technology has made it possible for many firms to make the workplace disability friendly and thus be able to employ the disabled.

According to the National Organization on Disability (www.nod.org), about 54 million Americans have a disability. This number will continue to increase as the population ages; it is expected to double in the United States in about 15 years. The world market for products for the disabled is estimated at 750,000,000 individuals [18].

Moreover, many of the negative beliefs about the disabled are myths, and not true. The disabled spend more time online than those who are not disabled, they travel a great deal, and they eat out. They do not sit in their homes 24 hours a day [7]. However, only 29% of working-age individuals with disabilities have jobs vs. 79% for those who do not have disabilities [1]. The National Organization on Disability [21] states that two-thirds of the disabled who are unemployed are interested in working. The disabled include our own family members and, possibly, us. After all, we are all getting older.

Assistive technology (AT) devices, such as walkers and hearing aids, are important to this market; one third feel that they would lose their independence without the use of AT devices [21]. A survey by Carlson et al. showed that 16.6 million disabled Americans used AT devices such as canes, walkers, wheelchairs, crutches, equipment to help them dress, eat, use the toilet, shower, and/or get out of the

house [6]. The same study indicated that 14 million disabled Americans lived in homes that were modified in some way to assist them. Many of these AT devices can also enable the disabled to find employment.

Friedman, Lopez-Pumarejo, and Friedman provide several examples of how individuals with disabilities can be very helpful to companies interested in developing new products for the disabled [11]. Most individuals who do not have any disabilities are unaware of the problems that a person with a disability may face. Relatively simple tasks such as climbing stairs and opening jars can be extremely difficult. Harry Herman, a nuclear engineer, broke his ankle and discovered that crutches can cause problems for users; he developed "crutch palsy" which results from nerve damage in the underarms. He started a company, Orthotic Mobility Systems, and developed the "Sure Foot" cane and the "Strutter" crutch. A company that is interested in growth needs diversity for this sort of product innovation, and when it reaches out to employ all multicultural groups, it should include the disabled in this effort [10].

The Americans with Disabilities Act of 1990 may require workplace modification if it is "readily achievable," i.e., not too expensive and relatively easy to do. Information about the ADA and ADA requirements may be found at the ADA website, http://www.usdoj.gov/crt/ada/. The cost of technology has dropped considerably so it should not be that costly to use it to make the workplace more accommodating for the disabled. Computer technology has made it increasingly easy for disabled people to join the workforce. According to the Job Accommodation Network (JAN), a service from the U.S. Department of Labor's Office of Disability Employment Policy, in approximately two thirds of cases, the cost of accommodating the disabled is less than $500 [23].

The number of individuals working from home continues to rise. According to a study by WorldatWork, the number of Americans who telecommute at least one day per month increased from 7.6 million (2004) to 12.4 Million (2006) [25]. Employers are recognizing the advantages of having employees work from home remotely. This trend should also enhance the ability of firms to hire the disabled. Allowing them to work from home can eliminate many problems associated with travel and redesigning the workplace.

COMPUTER TECHNOLOGY TO ASSIST SPECIFIC DISABILITIES

The Visually Impaired

There are more than 10,000,000 people in the United States who are either blind or visually impaired [3]. Age-related diseases such as macular degeneration are the major cause of visual impairment. Unfortunately, this means that the number of visually-impaired individuals will increase dramatically as the 77 million baby boomers in the United States become elderly. While age-related macular degeneration and diabetic retinopathy can cause widespread low vision problems and can result in depression and social isolation, there are a number of lifestyle adaptations, adaptive devices, and rehabilitation services that can help improve functioning and productivity [4].

Cantley-Falk [5] describes the types of problems that arise when a firm ignores the needs of the visually impaired. Some products, such as ovens with flat touch screens rather than knobs, are nightmares for the visually impaired. Many products require very slight modifications to make them visually-impaired friendly, e.g., a talking watch or a big button telephone; adding a tiny number that can be felt by the fingertips is also a big plus. A lawsuit currently underway is trying to force Target Stores to make its e-commerce website accessible to blind consumers [9]. In fact, the designers of information technology

systems already test them for usability. After all, it would be folly to create an e-commerce web site that is difficult to use [22]. In the same usability analysis, access for individuals with disabilities should also be considered.

The information technology industry has already done a great deal to make the computer accessible to the blind and visually impaired. This is very reasonable given that they use the Internet and computers to the same degree as the general population [3]. In fact, a large number of blind and visually impaired individuals work in information technology. Large monitors (and larger fonts on websites) enable visually-impaired individuals to use the computer at work. The computer keyboard can easily be made usable for the blind via raised letters and numbers that can be felt by the fingertips. Voice recognition software is also making it easy for the visually impaired to work in numerous industries.

A number of companies have solved the problem of hiring the visually impaired by using devices that include large monitors, screen magnifiers, and speech synthesizers (that convert text to speech). There are "screen reading" programs for those whose vision is so poor that large monitors and/or screen magnification is insufficient. These text readers allow individuals with vision impairments to surf the web. Books have evolved from analog representation – i.e., where a real human being reads the book – to a digital format. Digital talking books (DTB) offer many advantages over the analog media which are linear presentations from first to last page. DTBs allow readers to skip around the way people read articles in a journal or magazine. They also allow highlighting and enable the reader to check footnotes and references selectively. There are scanners made for the visually impaired that read printed material.

The Hearing Impaired

According to the National Center for Health Statistics, 32.5 million adults (15% of adults) have hearing problems [19]. The Rochester Institute of Technology's (RIT) National Technical Institute for the Deaf is targeted to the hearing impaired that are interested in learning IT and is among the top technical schools in the United States. Being deaf is not much of a disadvantage in IT since most communication is via e-mail. The fear that most firms have when it comes to hiring the deaf deals with communication and safety. In this day and age, according to Bruce Jones of Kodak, "Both can be easily dealt with. You can communicate with deaf people by e-mail and through interpreters, which are easy to find. Many deaf people are excellent lip readers. As for safety, there are two-way pagers and visual alarms" [29]

There is a growing market for talking ATMs (using earphones, for security). Fleet bank spokesman, Steven Lubetkin, said: "There are approximately 54 million Americans with disabilities... Web sites that shut out people with disabilities are tuning out a huge part of the consumer market, the people who could benefit from online services the most" [28]. There are a number of disabled employees working in Fleet's Diversity Resource Group. They help the company make better products that are accessible to the disabled. They also help Fleet find and retain employees with disabilities.

For many individuals who are hard of hearing, all they may need to get a job using computer technology is amplified headphones and/or a powerful speaker. There is also simple software that enables a computer to use a flashing signal in lieu of an audible beep.

Speech Impairments

There are numerous possible causes of speech impairment. They include: injuries to the brain, brain tumors, mental retardation, cleft lip or palate, Parkinson's disease, hearing impairments, stroke, MS,

psychological problems, Down's syndrome, throat cancer, and laryngectomy. Speech computers are basically computers with special software to help individuals with speech impairments communicate. Some people with speech impairments simply use a laptop computer as a communication device.

Learning Disabilities

Software that provides the user with a multisensory experience is very helpful for those with learning disabilities. The Kurzweil 3000 was developed by Kurzweil Educational Systems to help students with learning disabilities such as dyslexia. The software displays scanned text on the computer. The words are read aloud and the reader can adjust the reading speed. As the words are read aloud, they are also highlighted to help the reader focus on each word. A demonstration of the system is available at: http://www.sightandsound.co.uk/pages/Kurzweil_3000.htm   Technology of this type can also be modified to help learning disabled individuals perform various reading tasks in the workplace.

Autism

Usually it is hard for people with autism to keep their attention on one thing; in addition, not everyone interacting with them has the patience to repeat something over and over, which is what they might need. Having a robot interact with them may be a good solution.

Werry and Dautenhahn have done research on using robotics to help the rehabilitation of autistic children [30]. Autism causes an impairment in children's social interaction skills. The use of robotics can be a good treatment since robots can do repetitive actions over and over, which is what these children need done patiently. The robot can be seen as a friendly companion helping the child without appearing as a teacher associated with learning. The hope is that robots can help children get over their fears and help them relax when interacting. The AuRoRA project (Autonomous Robotic platform as a Remedial tool for children with Autism) was developed with interaction as its goal. The robot will not do a specific task, but will do simple actions with expression in order to create a bond between the child and itself. It does this by maintaining the child's attention and being stable, since autistic children want structure and no major environmental changes.

The studies done were on children from Radlett Lodge School, Hertfordshire. They first observed the children's structure of learning. They did this using a robotic doll that copied actions in order to see how the children reacted. Five children then used the robotic platform. They were allowed to interact freely. They showed no fear of the robot and enjoyed it. The children played with it by going away from the robot, and then checking to see if it was following them. Unusually for autistic children, all of these children showed a lot of eye contact with the robots.

Mobility Impairments

Mobility impairment is a term which covers a wide range of disabilities. Mobility impairment could be congenital, caused by an accident, or may be due to such illnesses as cerebral palsy, multiple sclerosis, polio, strokes, diabetes, and muscular dystrophy. Spinal cord injuries that result from automobile accidents and diving accidents can also cause mobility impairment. According to the National Center for Health Statistics, 14.9 million adults – 7.0% of the adult population – find it difficult or impossible to walk a quarter of a mile [19]. More than 19 million adults have trouble climbing a flight of stairs. The market for AT in this area is huge. Getting in and out of a car is difficult for many people, not only

those in wheelchairs. A number of automobile manufacturers are offering inexpensive attachments making it easier for those with disabilities to get in and out of a car.

Consider something as simple as a basic wheelchair. There are approximately 100 to 150 million people in need of wheelchairs worldwide. In the United States, about 1.6 million people are permanent users of wheelchairs (either manual or motorized) or scooters [15].

Having robotic wheelchairs can be very helpful for people who don't have the ability to maneuver a wheelchair very well, as these wheelchairs can move themselves without having the user do as much work as with an ordinary wheelchair.

Yanco discusses different types of robotic wheelchairs [32]. Many robotic wheelchairs were developed in order to help disabled people who cannot drive a regular wheelchair. All robotic wheelchairs must navigate safely, and if there are any failures, it must fail gracefully, so that the user will not be harmed. Also, it must be able to interact effectively with the user. She discusses five different kinds of robotic wheelchairs and highlights their strengths. One example is the TAO Project, whose robotic wheelchairs provide a high level of autonomy. They can avoid collisions, navigate an office, pass through narrow doorways, or leave a crowded spot. Another example of a robotic wheelchair is the Tin Man II, which was developed as a cheaper robotic wheelchair for people with impaired mobility. The wheelchair has four modes of navigation which can be selected. In the first, it can be controlled completely by the human except for situations when there is an obstacle. In the second and third, the person using the wheelchair can turn or move forward while avoiding obstacles. The last is manual mode, where the joystick commands are followed completely with no obstacle detection.

There are other kinds of robots which can help these users as well. It is predicted that 7 million robots will be sold between 2005 and 2008 for consumer use such as cleaning. For example the iRobot Roomba vacuums people's floors for them, and the iRobot Scooba washes them. During that same period, 50,000 service robots for professional use will be installed. Robots are being used worldwide to perform such jobs as assisting surgeons, milking cows, assisting in the preparation and packaging of food, and disposing of toxic waste [13] Japan is considering the use of robots to care for its aging population. In the future, robots will be used to assist the disabled in their homes. These same robots can be used to assist the disabled in performing many tasks in the workplace.

There are special keyboard settings that enable disabled individuals who cannot use a mouse to work with the numeric keyboard instead. There are even specially designed computers for quadriplegics. Wooding's website (http://www.tetraplegicliving.com/content/view/17/31/) describes how Mr. Wooding, a quadriplegic, uses a regular computer. All he needs is a Dragon NaturallySpeaking software and a Kensington Expert Pro Mouse. Since he does not have movement in his fingers, he works with the ball in the mouse and turns it. The cost of the software and the mouse is ridiculously low yet enables individuals with all kinds of impairments to find jobs.

In the very near future, quadriplegics will be able to use their thoughts to control a computer. An experiment was already performed by researchers at Brown University in which a quadriplegic individual with a small sensor implanted in his brain was able to move a cursor, open e-mail, change channels on a television set, play Pong (a video game), adjust the volume on a television, and control a robot arm using only his thoughts [24]. Once the technology is improved, it will be very easy to employ the disabled.

Elderly

Robots can make great companions for the elderly. As science is improving, elderly people are living longer. Forlizzi et al.[8] interviewed 17 senior citizens between the ages of 60 – 90 in order to figure out how robotics could help them. One of the things they found was that the elderly wanted products that helped maintain their identity and dignity and would reject products that did not. They also found that activities that encouraged social interaction were important for this group.

Stiehl, et al. [27] have developed a robot companion, The Huggable. Companion animals can be a helpful therapy tool for the elderly. It is, however, not always feasible due to allergies and the availability of an animal therapist. Robotic companions have recently become more available. The Huggable is designed to resemble a teddy bear. It has a soft silicone synthetic skin with over 1000 sensors underneath. These sensors detect force, temperature, etc. It can detect when it is being petted, rubbed, tapped, scratched, or any other interaction. It also has a video camera inside its eyes and microphones inside its ears. The Huggable can transmit data from its embedded PC to a remote PC at a nurse's station. This is can be very helpful, since besides being a companion, the robot can also send useful information to a nurse's desk.

By the robot having these abilities, the elderly can live in their own homes longer. As was said, the elderly desire to preserve their dignity and identity, and having robots in their homes can enable them to live by themselves longer which can help them maintain their independence and dignity.

Mental Health Problems

According to the World Health Organization, about 25% of individuals living in developed or developing countries will develop a mental or behavioral disorder in any typical year [31]. The World Health Organization provides charts indicating the prevalence of many diseases, including psychological ones, by gender and for the world, Africa, and the Americas. Depression is sometimes referred to as the "common cold of mental illness" [31].

According to the National Institute of Mental Health, about 19 million adult Americans (approximately 10%) suffer from depression each year; this includes those suffering from bipolar (manic-depressive) and dysthymic disorders. Nearly two-thirds do not go for help [20]. Yet, 80% can benefit from having the illness treated. Worldwide, about 5.8% of men and 9.5% of women will suffer from depression in a typical year. This translates to 121 million people with the depression [31].

One of the more fascinating emergent areas in which computer technology is used in the service of the disabled is in the study of virtual reality systems to treat phobias and anxiety disorders (see, e.g., [2]). At the very least, computer software might be useful in helping employees to become aware of potential problems such as depression, and to go for treatment.

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CONCLUSION

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President Bill Clinton encouraged government agencies to hire the disabled and to offer more internships to disabled students. President Clinton stated: "We are the nation's largest employer. I want

it to be a model for private industry, and this plan will help to do just that." In 1997, 7.2% of the Federal workforce consisted of disabled individuals; 21,000 were severely disabled [12]. Recent advances in computer technology has made it possible for many firms to make the workplace disability friendly and then be able to employ the disabled. Firms that are unwilling to make the simple adjustments necessary to open up the workplace to the disabled are not only unethical but are also foolish. It is dangerous for any organization to ignore 20% of the population. Most of the fears that employers have about hiring the disabled, e.g., cost of making accommodations, possibility of lawsuits, mediocre performance, and hostility of co-workers are entirely unfounded [26]. What is true is that individuals with disabilities will spread positive feedback to family and friends about firms that make accommodations for the disabled and negative feedback about those that do not [26]. Being insensitive to the needs of the disabled is not the way for a firm to succeed in today's world.

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REFERENCES

Due to space limitations, References are available by email from the authors.