COMPUTER ASSISTIVE TECHNOLOGIES FOR PHYSICALLY AND COGNITIVELY CHALLENGED USERS

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(Volume 2)

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PREFACE

This book aims to collate the methods and literature related to techniques that will aid the life of cognitively challenged individuals. A cognitive impairment (also known as an intellectual disability) is a term used when a person has certain mental functioning limitations and skills, such as communication, self-help, and social skills.

The content presented in this book discusses the range of methods/techniques that will improve the life of a person with cognition problems. The range of topics like the ontology of cognitive devices, accessibility hardware and software, assistive technologies for Vision impairment, hearing impairment and communication impairment has been detailed extensively. This edited book also sheds light on upcoming trends, challenges, and future research directions in assistive technologies for cognitively challenged users. We editors believe this book will help researchers, students, academicians and medical practitioners know and adopt state-of-the-art technologies in cognitive disability. We extend our heartfelt thanks to our reviewers, who have extended their support despite their busy schedules. A special thanks to all our authors for submitting the work. Our sincere thanks to Bentham Science publishers for accepting our proposal for editing this book and supporting us extensively during the editing process. Our thanks to one and all who have directly or indirectly rendered support for completing this edited book.

We believe the efforts we rendered for editing the book are worthwhile only if this book is of any use to the ordinary end-users of our society. This satisfaction will fuel us to come up with more edited books that will be useful for society at large.

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CHAPTER 1

Overview, Category and Ontology of Assistive Devices

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Abstract: The majority of physically challenged and elderly people demand a lot of care when it comes to assistive technologies that can provide tailored services to their needs. The primary concern of advancement in Assistive technology is to address a wide variety of disabilities and intellectual impairments for societal benefits by reducing welfare costs and allowing for an efficient workforce. To better respond to changes brought on by modernity, it is necessary to understand how assistive technology interacts in that group. The broad range of assistive devices in the continuum of assistive technology can help people with various impairments. Based on the underlying technology, the Categorization of assistive devices has important implications for clinical usage when examined through the perspective of social phenomenon. In the realm of Assistive Technology, a consistent focus on the relationship between the individual and the supported activity within certain contexts is essential. Assistive technology can be viewed from the perspective of various performance areas. The Ontology-based Assistive Devices that are among the finest within common, everyday contexts for more relevant applications are interesting. This chapter explores all those essential elementary and general considerations of assistive devices that form the bases of Assistive technology and brings out the categories of assistive devices and the various application domains where assistive devices can be served as a derivative of a particular ontology. The chapter focuses on the various performance areas by addressing the issues associated with Assistive technology Practice.

Keywords: Accessibility, Assistive technology, Cognitive impairment, Information and Communication Technology (ICT), Ontology, Self-management.

INTRODUCTION

The population of aging adults is expected to reach more than two billion by 2050. In a society where the life expectancy and increasing need for assistance are

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advancing, it is becoming more likely that elderly people will need the technology to accomplish critical and necessary tasks. Assistive technology is the most prominent and prime solution that exemplifies how technologies can be used to meet the requirements of the elderly. People with disabilities, those who live longer, those with non-communicable disorders, and those needing recovery are all potential beneficiaries of assistive technologies, which help them live independently and enable them to maintain their dignity. In a broader sense, assistive technology is needed for all people with cognitive/physical disabilities, mental health disorders, progressive functional impairment, non-communicable diseases, *etc.* Assistive technology aims to ensure that any artificial aid a patient takes, requires no external dependence. For the moral well-being of the patients, it is important that they feel independent and can manage the majority of their tasks on their own.

Assistive Technology (AT) is either an element or a piece of equipment used to enhance, preserve, or expand the associated support of an impaired individual's life. Reasonable assistive technology may also help individuals accommodate a disability, at least partially. Traditionally, the word “assistive technology” has been used to refer to computer software and hardware, as well as digital equipment.

Assistive Technology is a broad term that refers to a range of low- to high-tech devices whose major intention is to enhance a person's individual functioning and mobility in order to maximize involvement and greatly improve quality of life. Mobility aids, such as prosthetic devices and orthotic devices, cognitive aids, such as electronic or electrical assistive devices, and high-performance mobile devices that enable people with disabilities to participate in sports and be physically active are some of the examples. They can also help avoid impairments and secondary health problems by encouraging independence and autonomy in the person and those around them.

Scope of the Assistive Technology

Assistive technology offers opportunities for every individual with a disability by providing the most appropriate technologies and removing environmental barriers to functioning. Computers are the entities most widely associated with Assistive Technology. However, a broad spectrum of Assistive Technology ranges from mainstream gadgets to exoskeletons and robotics, sophisticated automated systems, intelligent houses, *etc.* The technology support includes ergonomics and telerehabilitation with the aid of environmental accommodations and service delivery systems.

People with learning difficulties are increasingly turning to assistive technologies for help. Nevertheless, general computer use is a relatively widespread phenomenon, as seen by the availability of computers for a wide range of applications. The potential advancement in the computer environment has changed the nature of technology support. First, in the last decade, technology has emerged as a platform where powerful yet cheaper modern equipment can be afforded. Second, a lot of new technologies have developed. Third, the sophistication of technology has improved significantly, especially in the realm of computer software. Traditional technology has little in common with modern technology, which features realistic sound, spectacular images, and on-screen videos. According to the current consensus, computer technology and other innovations have a great deal of potential for improving the capacities of children, teens, and adults with learning difficulties.

Smart Self-management as a Means to Empower with Assistive Technology

Equal opportunities are everyone's rights, but people with disabilities are often ostracised, marginalized, and driven into poverty, which intensifies the impact of psychological distress on a person's social environment and makes it critical to provide helpful services to individuals with a diverse range of impairments. Self-management skills refer to the capabilities to govern one's beliefs and actions. A self-motivated, physically challenged individual can strengthen confidence to manage potential tasks with significant and precise technology-driven assistance. An assistive device-based task accomplishment paradigm can enhance an individual's self-management ability by solving ongoing issues and assignments. There are two main goals of assistive technology. First, it can enhance an individual's strengths so that personal abilities can compensate for any impairments. Second, technologies can provide an alternative means of executing a task, allowing for compensation or eliminating limitations.

Who Adopts Assistive Technology?

The typical assistive technology user has an impairment that necessitates using a compensatory solution in an attempt to gain more independence. The user's ability or disability can vary. It might range from someone who has a spinal cord injury and can only move their head to someone who suffers from carpal tunnel syndrome and has pain when opening their mouth. Technology can be beneficial to both adults and children. Individuals with a short illness, a long-standing impairment, or a neurologic condition in which the individual's functional abilities will continue to deteriorate are almost all illustrations of AT users.

CHAPTER 2

Accessibility of Software/Hardware

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Abstract: The phenomenal growth in Information and Communication Technology (ICT) is rapid and is responsible for changing disruptively the way various day-to-day tasks were being performed earlier. A plethora of user categories has benefitted immensely from this upward growth. It is also providing society with a multitude of entertainment options. The support of user-friendly software platforms for various ICT applications and tools is crucial in all these activities. Unfortunately, in the past, the designers of many software and hardware systems have not appropriately considered the Persons with Disability (PwD) as the active co-fellows of this journey and are being left behind in most of such applications of ICT. Thus, this significant part of the world population often seems to be neglected. Accessibility to every user with specific reference here to the ICT has always been a very important issue. What may be easily accessible to a set of persons may not be completely or partially accessible to another set of persons with disabilities. In this chapter, we discuss various types of disabilities along with the accessibility of hardware and software. Further, we highlight the concept of web accessibility and ICT accessibility for PwDs.

Keywords: Accessibility, Accessible technology, Accessible Website, Adaptive technology, Assistive technology, Causes of impairment, Cognitive impairment, Communication difficulties, Handicap, Hardware accessibility, Hearing impairment, ICT, Persons with Disability, Physical impairment, Reading disabilities, Sensory impairment, Software accessibility, Visual impairment, Voice dictation system, Web accessibility.

BACKGROUND

Information and Communication Technology has seen a mammoth growth from the era of Industry 3.0 to 4.0 and still continuing into Industry 5.0. The developments in hardware, software and communication technologies, including the disruptive ones, continue to touch every part of the daily life of even a common man. As per the Internet Live Stats website, which is part of the

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Real-Time Statistics Project (Worldometers and 7 Billion World), on 1st November 2021 at 3:00 pm IST, there was approximately a) five billion internet users, b) 2 billion websites, c) 175 billion emails sent, d) 5 billion google searches, e) 5 billion videos viewed on YouTube, f) 2 billion active Facebook users, g) 380 million active Twitter users, h) 400 million active Pinterest users, i) 421 thousand computers sold, j) 2 million smartphones sold, k) 243 thousand tablets sold, l) 7 billion GB of Internet traffic, m) 2.9 million MWh of electricity consumed. Not only this, in one second, there were a) 9717 Tweets, b) 1112 Instagram photos upload, c) 1980 Tumblr posts, d) 6180 Skype calls, e) 97 thousand Google searches, f) 92 thousand YouTube videos viewed, g) 3 million emails sent and h) 132 thousand GB of Internet traffic on the net [1]. This portrays the latest snapshot of the length and breadth of penetration of the technology for normal human beings.

But on the other side, some segments of the population, such as the elderly or those with disabilities, may have trouble accessing the new technology and services that society provides to the masses in general. Most of the software programmes overlook this disadvantaged set of users, and may be unintentional while presuming that all computer users can accomplish the following activities with ease and without any discomfort [2]:

1. Reading and responding to the text and visuals displayed on the screen.

2. Using the standard keyboard while keying in text/instructions.

3. Using the standard mouse to perform various operations on text, images and other data.

4. Paying attention to various audio signals and responding to them appropriately.

There are several sections of individuals who face difficulties in performing one or more of the aforementioned activities and hence seem unable to access many prominent computer applications [3]. To operate a computing device, a user who is print impaired (*e.g.,* blind, dyslexic, cognitively disabled, or illiterate), physically disabled with restricted mobility, or hearing impaired requires the support of some specific assistive technology.

There is a kind of social barrier that at least restricts, if not prevents, a Person with Disabilities (PwD) from participating in particular activities or interacting with the environment around them. Disability is defined as a reduction in one or more of the following faculties of a human being: physical, cognitive, mental, sensory, emotional, developmental, or any combination of these. This reduction in the faculties may be by birth or may develop over a period of time [4].

The medical fraternity categorises the causes of impairment as follows [3]:

a. Through inheritance (genetically transmitted)
b. Because of a congenital problem, infection or other diseases in the mother during pregnancy, an immature or deadly developmental abnormality, or an accident during or shortly after delivery
c. Through the acquisition, such as problems brought on by an unidentified disease or accident after birth, anytime later

This paper is an attempt to explore the role of accessibility of the Information and Communication Technology tools and infrastructure and the difficulties being encountered by various categories of PwDs while interacting with them.

INTRODUCTION

According to the Global Report on Disability, disability affects almost 15% of the total global population, which is approximately one billion people [3]. In nature, a handicap or a disability of a human being may either be clearly evident or invisible. Physically impaired members of society are unable to fully coordinate their physical motor abilities, resulting in restricted body motions, lack of body coordination, and/or decreased strength in various muscular structures. Visual impairment is the inability to perceive items as clearly as a healthy individual can. Near or far, vision impairment affects probably at least 2.2 billion people globally, which includes around 1 billion with vision impairment that might have been barred or rectified [5]. Visually Impaired (VI) persons have to strive harder, even in their own environments, to navigate from one location to the other and/or to locate objects around them. According to the World Health Organization (WHO), 253 million people are suffering from disabling vision impairment, out of which 36 million people are completely blind and 217 million are suffering from mild to moderate vision impairment [6]. Hearing impairment refers to a person's inability to hear words or sounds clearly and/or precisely. In such persons, any portion of the ear of a human being might be affected by inappropriate development, injuries, or infection(s). Hearing is a critical condition of appropriate speech and language development. Communication difficulties also prevent deaf individuals from socialising and working in the same manner that normal people do. Due to their limited communication access and engagement, deaf people frequently suffer damage and dissatisfaction in their personal and professional life [7].

The rest of the paper has been organized as follows. After covering the brief background and necessary introduction to the topic concerned, different categories

CHAPTER 3

Computer Vision-Based Assistive Technology for Blind and Visually Impaired People: A Deep Learning Approach

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Abstract: According to the World Health Organization (WHO), a minimum of 2.2 billion individuals worldwide have impaired vision or are blind. In contrast to hereditary blindness, gained visual impairment is frequently identified as a result of aging, lifestyle habits, or hereditary influences. Aging-related presbyopia has the largest influence on visual impairment and is the second most prevalent cause of blindness globally, and the rate of acquired blindness is predicted to rise dramatically as life expectancy rises. When performing most of the everyday tasks that non-disabled individuals do, visually and blind people face several problems. Thus, assistive gadgets have been utilized to help the blind and visually impaired overcome physical, social, infrastructural, and accessibility hurdles to independence, allowing them to live engaged, creative, and fruitful life as equal members of society. The usage of assistance equipment has increased, and numerous electronic help devices have been produced in recent years, which have been superseded by traditional aid gear, such as white canes. Currently, ATs are created by integrating various types of sensors, cameras, or feedback channels that combine with various implementation methodologies to increase movement for the visually handicapped. Assistive systems based on computer vision or machine learning approaches have emerged, and as technology has advanced, so has assistive technology. Assistive technology is a priority in the field of education and rehabilitation for individuals with blindness or low vision because it “equalizes the ability to access, store, and retrieve information between sighted people and those with visual impairments”. Nowadays, technological advances are making a difference in their ability to overcome difficulties to some extent. Every day, they encounter a slew of challenges, the most significant of which are establishing one's position, determining one's heading and movement directions, and comprehending the placements of things. The goal of assistive technology is to boost impaired people's faith, comfort, security, independence, and quality of life by enhancing their mobility and decreasing their impairment.

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Keywords: Assistive Technologies, COCO-Dataset, Computer Vision, Object Recognition, OCR, TESSERACT, Visually Impaired, YOLO-v3.

INTRODUCTION

The globe is transforming from machinery-employed or industrial economies to intelligence and information economizing in the twenty-first century. The goal of knowledge economy development is to address conventional societal hurdles, such as spatial variability of citizens, linguistic or knowledge barriers, handicaps caused by impairments or environmental circumstances, social position, and global influence. This might imply that the "digital divide" among developed/developing nations is diminishing. Will individuals with disabilities be included in the digital age resulting in considerable development and improvement in living circumstances in developing nations? The answer to the query will be "yes" when adequate attention is paid. The entry to the knowledge-based economy is Information and Communication Technology (ICTs), which consists of systems, conventional and smart cell devices, and laptops. Internet access is very important for disabled persons than the common public since they have fewer options for retrieving data or participating [1]. Currently, there are several methods in which ICTs are accessible and employed as assistive technology (ATs).

On the other side, a critical element is the fast evolution of technology that acts as a tool and has a significant impact on how we acquire, play, and operate. This reliance on technology may be discretionary for most of us, but it is far less for individuals with disabilities, who frequently rely on technology to access jobs, complete everyday chores, and fully engage in the community; ICTs transforming the technology alternatives available to persons with impairments.

Advanced materials also improve comfort and prevent skin deterioration in seating systems [2]. Wheelchairs and other mobility goods are becoming simpler to use and move in vehicles as materials get lighter. Changes in conventional home products (food preparation, self-care) are being created to suit elderly people who have arthritis, hearing problems, or vision loss. Notably, huge items, ranging from vehicles to household equipment with features, improve accessibility and usefulness for people with disabilities. As a result of such reasons, there are many more technological alternatives accessible to suit the requirements of disabled people. Some of them are popular items, while others are developed specifically for individuals with impairments.

The function constellation of ICTs like mobile devices is similar to those necessary for various ATs related to mainstream techniques or custom-built devices. All that remains is to ensure that this occurs with new technology. One of the most precise technologies that can aid the blind incorrectly exploring their environment is the object detection system for the visually impaired [3]. This assists in recognizing the barrier and traveling from one location to another. Finally, it generates audio data about the item. Consequently, it would be easier to operate and portable for the visually handicapped. It also helps the blind understand their surroundings without the help of another person.

In its broadest sense, the term "Assistive Technologies" (AT) relates to any grouping of technological advances (items, environmental modifications, facilities, and procedures) that may be utilized to address deficiencies and/or improve human function. AT, in particular, strives to assist persons with impairments or learning difficulties in coping with their daily surroundings and obtaining a greater quality of life. In general, AT is utilized in two major application scenarios: 1) health care, which attempts to alleviate (remediate) cognitive and behavioral deficits, and 2) social, which works on the surrounding community and focuses on social barriers and injustices.

In the past few decades, there seems to be a tremendous increase in demand for novel technology that would enhance the quality of life, for example, for elderly people or individuals with different talents, as well as for those who have various disorders but wish to improve their comfort. Researchers from many areas have used their knowledge to build new technologies to satisfy the demands of various assistive device application settings.

To summarize, at least one innovation is created every day throughout the world, and progress in the field of automated systems is quick and constant. Without this, the world would not have envisaged visually challenged individuals wearing a digital helmet integrated with a portable monitor, audio sensors, and stereo headphones to assist them in navigating. Thus, the breakthrough in wireless technology uses a sensor to take photos and process the acquired images to recognize things and give an audio message *via* stereo headphones. This may be useful in any indoor/outdoor setting.

In this chapter, we examine the broad range of developing technical capacity as well as the particular significance of such technologies for persons with impairments. Few studies have noted that "although an advancement of technology and consumerism which is so concerning in other ways, many individuals remain excluded and handicapped by design which does not recognize their talents." Inscribing this problem by gaining access to specialized and mainstream technology will allow persons with disabilities to engage fully in all society sections. Furthermore, a camera, a machine, and an audio output device comprise the main component based on computer vision for locating and

CHAPTER 4

Assistive Technology for Home Comfort and Care

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Abstract: Every second, individuals with physical and cognitive disabilities struggle so much to do some actions that normal people easily do within seconds. Assistive Technologies (AT) are those modules or sets of arrangements that aim to make life easy for disabled people, by stopping blockage and improving their mental and physical power. They improve their working capability, confidence, standard of living, and optimism. In modern times, Artificial Intelligence (AI) and technologies are developing rapidly, and new machines, motors, and mostly electronic devices powered by powerful batteries are being built every second. These are making it possible for disabled people to become self-dependent. Today, Assistive technology devices are efficient and suitable for disabled people. This chapter aims to provide in-depth knowledge about various types of disabilities, how disabled people face different problems and challenges, and how they can select and use assistive devices and mobile apps to live independently and comfortably.

Keywords: Ability, Activities, Aids, Assistive Technology, Comfort, Communication, Devices, Disability, Disabled People, Disease, Difficulty, Guardian, Help, Independence, Home, Individual, Mobility, Obstacles, Product, Person, Services.

INTRODUCTION

Assistive technologies are devices used to support the health and every activity of a disabled person [1]. It promotes the ability of a disabled person to perform activities of daily living (ADLs) independently. ADLs are self-care activities, such as eating, bathing, dressing, toileting, mobility, and personal device care. Assistive Technologies help to perform major and daily life activities that are otherwise impossible for the individual to carry out. The great principle of promoting ability includes a higher level of independence, reduction of spending

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time in daily living activities, and greater satisfaction in participating in daily activities. For example, wheelchairs provide great help in independent mobility for those who cannot walk, assistive eating devices can enable people who cannot eat food themselves, and hearing aids are useful for hearing-disabled people to hear more clearly, *etc* [2]. By using assistive technology, a disabled person has an opportunity for a positive and independent lifestyle and increased participation in social activities. This technology has proved a boon for disabled people by providing entertainment, security, a comfort zone, independent life, *etc.* Today, a lot of disabled people have gained high fame and name in the world by using AT. Several companies, such as Apple, Facebook, Flipkart, Google, Tata Group of Industries, and IBM Corporation, have increasingly focused on making their services more accessible for disabled people and building adaptive devices to improve their user's quality of life. By current estimations, more than 4,000 assistive technology devices have been invented for elders and disabled people. This equipment includes everything from wheelchairs to a wide collection of high-technology devices, and many firms today are turning their focus and research to assistive technologies. There is an urgent requirement to consult a health care provider, such as a doctor, pharmacy technician, psychologist, or physical therapist to find out what is best available to fit the requirements. Various public and privates sources, such as UCP Bellow Funds, American Council of Blinds, Muscular Dystrophy Association, US Department of Veterans Affairs, National Multiple Sclerosis Society, *etc.* provide funds for AT devices.

The organized structure of the chapter is as follows: Sect. 2 presents the disability and types of disabilities, Sect. 3 presents the common barriers faced by people with disabilities, Sect. 4 presents the principles for providing assistive devices, Sect. 5 presents various types of assistive technologies, Sect. 6 presents different types of mobile apps for disabled people, Sect. 7 presents the benefits of assistive devices in individual life and Sect. 8 includes a conclusion.

DISABILITY

More than one billion (1,000,000,000) people worldwide, making up approximately 15% of the total population, live with some kind of disability [3]. According to the WHO disability report, the population of disabled people is increasing daily because of the global rise in severe health conditions related to disability, such as hypertension, diabetes, respiratory illnesses, heart diseases, and mental disorder. Other environmental elements, *e.g.,* floods, volcanoes, earthquakes, inaccessible transportation, road accidents and quarrels, are also responsible for increased disabilities.

Disabled people often face discrimination in recruitment, salary, promotion, work, healthcare services, and educational institutions [4]. Usually, organizations and governments often overlook the needs of disabled people, even though people with disabilities are among the weakest, with lower educational success, lower job opportunities, and the poorest people. Poverty can be reduced if we include and take disabled people together.

Types of Disabilities

According to the RPWD (Rights of Persons with Disabilities) Act 2016, the list of disabilities has included a total of 21 disabilities, and all the disabilities are explained below.

Blindness

Blindness refers to a person with a blindness disability who is altogether unable to see by both eyes or sightless at all [5, 6].

Low Vision

Low vision refers to the vision loss caused by a disease of the eyes, which cannot be improved or corrected *via* regular glasses, surgery, pharmaceuticals, or contact lenses.

Hearing Disability

This disability includes those people who are partially or completely deaf. They often use hearing aids and sign language for interaction with normal people. Hearing aids assist the hard of hearing people to hear sound clearly. Sign Language is a visual gesture language used by deaf people to convey what they want to say.

Dwarfism

Dwarfism or short stature, is a growth disorder characterized by a smaller height than usual.

Intellectual Disability

Intellectual disability, also called Mental Retardation (MR) or learning disability, is characterized by below-average brain functioning (decision-making, learning, thinking, and reasoning) and a lack of skills required for everyday life activities [7]. A person with an intellectual disability can learn new activities, but he/she learns slowly compared to normal people [8].

CHAPTER 5

Technologies for Hearing Impaired People Using Indian Sign Language Synthetic Animations

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Abstract: This chapter discusses various technologies developed for deaf people using Indian sign language synthetic animations. An automatic translation system for English Text to Indian Sign Language synthetic animations in the real domain has been developed, which consists of a parsing module that parses the input English sentence-to-phrase structure grammar representation on which Indian sign language grammar rules are applied to reorder the words of the English sentence. The elimination module eliminates the unwanted words from the reordered sentence. Lemmatization is applied to convert the words into the root form. The words (or their synonym in case the word is not available in the database) in the sentence are replaced by their HamNoSys code. In case the word or its synonym is not present in the lexicon, the HamNoSys code will be taken for each alphabet of the word. The HamNoSys code is converted into SiGML tags, which are sent to the animation module, which converts the SiGML tags into synthetic Animation using an avatar.

Prototypes for announcement systems for deaf people at railway stations, airports and bus stands have been developed. The announcements are categorized and sent to the system in written form. These announcements are dynamically converted to ISL sentences and then animated using HamNoSys and SiGML tags.

These translation and announcements systems are the only systems in the country that use continuous synthetic animations of the words in the sentence. Existing systems are limited to the conversion of words and predefined sentences into Indian sign language, whereas our conversion system converts English sentences into Indian sign language in the real domain.

Keywords: Cued Speech, HamNoSys, Hearing impaired people, Indian Sign Language, Lemmatization, Parsing, SiGML, SiGML Stanford Parser, Stemming, Synthetic Animation, Translation System, Visual special Language.

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INTRODUCTION

There are almost 7117 living languages in the world, which are organized into 153 language families. One of the 153 families of languages used by deaf people to communicate is sign language. This language family includes 144 different sign languages from all around the world, depending on the locality (SIL International 2021). Almost 72 million individuals worldwide are deaf or hearing impaired, out of a total population of nearly 7.5 billion. Only about 4.3 million individuals use Sign language out of such a large number. The remaining almost 67 million deaf and hard of hearing persons do not communicate using correct sign language. As a result, approximately 90% of deaf people have limited or no access to schooling and other informational needs [1].

Deaf people communicate using different hand shapes, facial expressions, finger formations, mouth gestures, and movement of other body parts [1]. The signer uses the 3D space around the body to convey an event, making it a visual-spatial language [2]. Prior to Stokoe's pioneering study, it was thought those sign languages lacked a well-defined structure and syntax. The grammatical rules employed by ISL were discovered by Stokoe's research study, however they are not full-fledged. These signs are only accepted in the small world of deaf people rather than there acceptability in the outside world also. Until the 1960s, sign languages were thought to be nothing more than a collection of gestures and mimes. Dr. Stokoe's research on American Sign Language established that it is a complete language with its own grammar, syntax, and other linguistic characteristics. Other sign languages, such as Indian Sign Languages, are being studied to see if they contain linguistic structure [3].

A sign in Sign language can be made up of both manual and non-manual parts, or both. Hand formations, hand orientation, hand location, and hand movements are the primary components in the manual element of the sign (straight, circular or curved). Facial expressions, eye gazing, body postures and head movements are primary components in the non-manual element of the sign [4].

Some signs, on the other hand, may comprise solely manual or non-manual components. The sign “Yes,” for instance, is made with a vertical head nod and lacks any manual sign. One-handed, two-handed, and non-manual signs are three categories of Sign Language signs. The- Indian- sign- hierarchy- is depicted in Fig. (**1**).

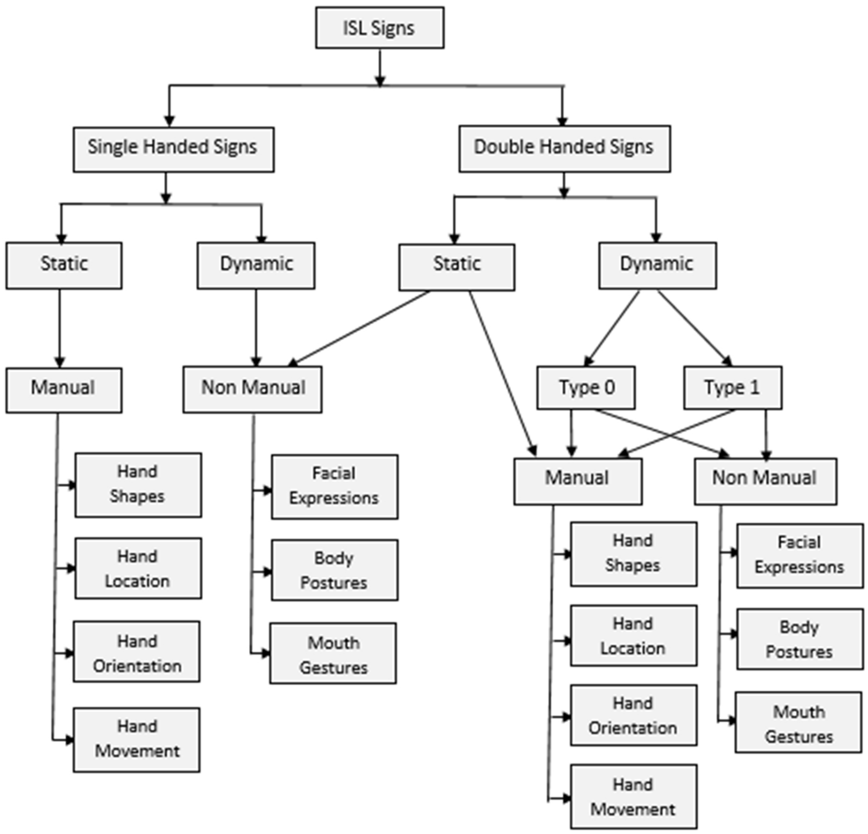

Fig. (1). Hierarchy of Indian Sign Language Signs.

One-Handed Signs: A single dominant hand is used to depict the one-handed signs. Static or dynamic (having movements) one-handed signals are both possible. Manual and non-manual signs are assigned to each of the static and moving signs. Examples of one-handed static signs with non-manual and manual components are shown in Fig. (**2**) below.

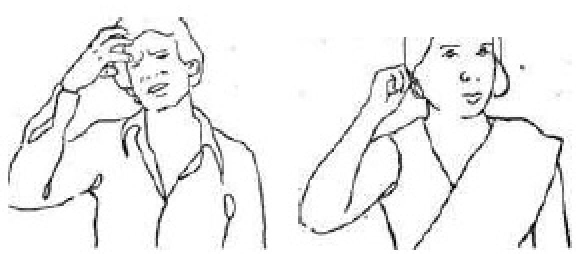

Fig. (2). One Handed Non-Manual Sign (Headache) and Static Manual Sign (Ear)

CHAPTER 6

Augmentative and Alternative Communication/ Hearing Impairments

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Abstract: Data-driven technologies aid in effective communication for deaf people. Research on sign language recognition, sign language generation and tools based on them is going at a fast pace. With the easy availability of depth sensors, specialized data sets, efficient machine learning algorithms, and computational capabilities provided by specialized hardware, the development of efficient data science-based solutions for deaf users and people with difficulty in hearing is possible now. This chapter focuses on recent research on Automatic Sign Language Recognition (ASLR), Sign Language Production (SLP) and tools based on them. A major focus of this chapter is research and tools using Sign Languages since they are the most commonly used communication medium by deaf people. Research on sign languages from different parts of the world as well as the effectiveness of Machine Learning techniques for ASLR and SLP, are discussed in detail.

Keywords: Augmentative and Alternative Communication (AAC), Automatic Sign Language Recognition (ASLR), Avatar, Corpus, Deaf, Depth Sensors, Generative Adversarial Network (GAN), Gesture, Indian Sign Language (ISL), Kinect, Leap Motion, Machine Learning, Neural Network, Pose, Recurrent Neural Network(RNN), Recognition, Sign Language, Sign Language generation, Sign Language Production (SLP), Vision, Variational AutoEncoder (VAE).

INTRODUCTION

Augmentative and Alternative Communication (**AAC**) refers to the communication methods used to aid or replace speech or writing for those with spoken or written language impairments. According to estimates, around 2 million people use AAC. AAC can be aided or unaided. In an unaided approach, no

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external tools are used. Sign Language is an example of unaided communication. Aided approaches make use of some devices for communication. This can range from simple ones like pen and paper to complex speech-generating devices. Sign language is one of the major communication mediums for deaf people. It involves gestures for communication. There are different sign languages around the world. Not only deaf people but parents of deaf people, researchers, social workers *etc*., also need to learn sign language. Since it consists of gestures, sign language is not easily represented in printed media. Two things are important for communication: translating gestures to text and vice versa. These two things are difficult because gestures are difficult to process using current techniques. Sign language gestures are made up of manual and non-manual components, making communication difficult. Though tools exist that help in a limited domain, full-fledged communication systems are an active area of research. Accuracy, ease of use and affordability are some important considerations in selecting sign language-based assistive tools.

Understanding the adoption of assistive technology tools is critical for its design and development. Studies have shown that adoption rates of assistive technology tools are very low. A major problem facing hardware-based assistive products developed is the high cost incurred. This bars people from using it. Even if these assistive tools reach their intended audience, most of them are abandoned over a short period of time. Studies show that the abandonment rate ranges from 8% to 75%. It has also been observed that, due to the lack of feedback from the users, most people are unhappy with the assistive tools they are using.

Data-driven technologies that aid effective communication for deaf people play an important role in developing assistive technologies for the Deaf. This includes techniques for sign language recognition, sign language generation and lip reading identification. With the availability of enough data, efficient applications based on these are possible. Each gesture in Sign Language comprises a number of building blocks, including articulation points (from joints such as the finger, arm, wrist, and elbow), hand configuration, action type, hand direction, and facial expression. Recognising sign language, which consists of finger spelling and varies across languages, is critical. Most sign languages use two-handed gestures, though some of the letters of the alphabet need one hand. Since it requires both hands, feature occlusion and computer vision techniques may fail to extract these features. Most data-enabled research for deaf people revolves around Automatic Sign Language Recognition (ASLR). Various depth-enabled sensors are used to efficiently recognize different sign language gestures. Due to the complexities involved in sign language grammar, current systems can only efficiently recognize isolated words.

Sign Language Production (SLP) is an emerging research area mainly based on using avatars. With the emergence of Machine Learning based techniques, the generation of natural-looking sign videos is possible. Research has shown that avatars that closely match human gestures are also possible using machine learning techniques. Text and video are the two input modalities for SLP. The linguistic complexity of sign languages makes it difficult to transform text to sign language gestures. Processing RGB videos is also a challenge. The huge amount of data involved makes it computationally intensive. This chapter is organized as follows. After discussing the background of sign languages, sign language recognition, generation techniques and data, science-based AAC solutions are discussed in detail.

BACKGROUND

Signs in sign language are analogous to morphemes, and the articulations of the hands and body can be described as phonemes. Chereme (in Greek, meaning hand) is used to represent the smallest meaning-bearing word. A sign is a sequential or parallel construction of these smallest meaning-bearing units. Unlike spoken languages, sign languages allow simultaneous signs. The lack of iconicity exhibited by sign language makes learning difficult for early-stage learners.

The availability of a corpus plays a major role in the development of any language. Very few corpus projects exist for Sign Languages. RWTH-Phoeni--2014T [1] is one of the most popular datasets used in sign language translation. It consists of data from German public TV weather forecasts. Along with the corpus information, results suitable for translation and recognition tasks like hand tracking, sign recognition and sign language translation are provided by the dataset. Content4all [2] is a much larger dataset from an open domain. It consists of 190 hours of news footage annotated with sign language information. Content4all is a collection of six datasets. Swedish Sign Language Corpus Project, DGS-Corpus project, Corpus NGT project, BSL Corpus Project and How2Sign are some of the other major corpus projects around the world. Like corpus projects, dictionaries also play a major role in language development. Some of the corpus projects, like the DGS-Corpus project, have dictionaries also included with them. HandSpeak, ASL-LEX, LSE-Sign and ISLRTC ISL Signs are some of the sign language dictionary projects from around the world.

Different projects exist around the world to help deaf people. Most of these involve providing accessible facilities for deaf people. ViSiCAST(Virtual Signing: Capture, Animation, Storage, and Transmission) is a European Union-funded project focusing on its citizens. The virtual avatars Simon, Tessa and Visia, which form the basis of earlier projects, also form the foundation for

CHAPTER 7

Hardware and Software-based Accessibility Innovations to Help Physically Disabled User

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Abstract: Initially, text-based terminals were used as computers with DOS OS. The terminal had a cursor, and text was typed into the terminal. Accessibility for users was provided by using the text and events related to the user. The accessibility formats were voice and text in various font levels. The web has evolved, and accessibility support for the web is very important. HTML5 helps us to design websites for PDAs, Mobile, TV browsers, and other devices. Web browsers use the accessibility API for disabled users. Accessibility APIs used in the browsers are MSAA, UIA, and Microsoft UIA. This chapter in the book talks about accessibility software and hardware used in software design and development.

Keywords: Accessibility, Design, Hardware, Platform, Software.

INTRODUCTION

This book will highlight the accessibility of software and hardware implemented in software projects. Desktop, web, and mobile are designed using various tools to implement accessibility requirements. We will look at different elements of the accessibility design, development, and deployment platforms.

Accessibility is important for many users with disabilities, such as blindness, deaf, and others. They have problems like website content, color, images, and contrast. They use screen readers to change the content to voice for the disabled. Popular screen readers are listed below: Jaws, Window-Eye, NVDA, Seortek System Access, Apple VoiceOver, PRCA, BRLTTY, Emacspeak, WebAnywhere Spoken Web ChromeVox, ChromeVis.

Screen readers help the users for changing the content to a format that the user can understand and act upon it. Screen readers have features such as text-to-speech, braille display method, and piezo effect-based crystals. You can use other

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software and hardware assistive techniques for accessibility support Table **1**. There are devices like sip and puff switch and others for the disabled user for content typing and reading.

Table 1. Accessibility Matrix .

Context/Disability	Situation	Temporary	Permanent
Vision		Head concussion	Blind
Mobility	Object holding in the hand	arm injury	Repetitive Stain injury
Hearing	Noise		
Cognitive		Head concussion	

ACCESSIBILITY FOR DIFFERENT DISABILITIES

All operating systems have accessibility support, and users can handle content types like images, videos, and audio. OffScreen model for the content is created using API calls, such as retrieving text, images, events, formats, and actions. Screen readers, voice dictation software, and speaking word processors use this offscreen model. The offscreen model can have objects, context, user actions, and OS native calls. This model can be OS-independent, and it can have content-specific features, such as white spacing, content alignment, and formatting specifications.

Accessibility can be not only due to disability but also low bandwidth, low-speed internet, and mobile capabilities. Blind users and users with low-level vision and color blindness might be targeted for accessibility support. Some users might not have limbs or disabilities, which prevent them from typing properly. They can be provided hardware that has voice support for speech-to-text conversion. Audio content can be an issue for deaf users. Captions and voice/video alternatives are provided to deaf users. Accessibility support is provided for other groups of users who might have schizophrenia, dyslexia, depression, and ADHD.

Compliance standards have evolved in the accessibility area, such as WCAG, WCAG 2.0

WCAG 2.1, Section 508, and CVAA. ADA act stipulates the content design that needs to target disabled readers. WCAG compliance is used to certify the content for levels like A, AA, and AAA.

Accessibility software and tools have features for users who have issues in the following areas: Reading, Writing, Scanning Content.

Accessibility software needs to support industry standards and best practices [1]. It needs features to handle multiple operating systems, device types, and content types. This software needs to be audited and certified using checklists and best practices. Reports can be generated for accessibility compliance, violations, compliance rates, the severity of the issues, noticeability issues, tractability issues, and recommendations related to accessibility. Accessibility software needs to support the following: content types, controls, input indicators, signals, and alerts. It needs to provide features related to cognitive accessibility, which are: memory issues, processing speed issues, organization, problems coordination problems

Accessibility certification and verification is another project in the software lifecycle. It consists of the following phases: Planning, Analysis, Design [2] Development, Testing [3] and Maintenance.

This project involves the following areas: website design, structure outline, web page template development, template integration, content creation, and website publishing.

It would be best if you had a team for accessibility project execution. Accessibility architects, developers, and testers are needed for design and accessibility-certified website publishing. Testing tools [4] and software are required for verification and certification purposes. Different companies, like Microsoft, sell accessibility-specific tools to verify accessibility requirements. Project managers are needed on the team to manage the complex project related to accessibility.

The design of the accessible website will depend on the following key elements: charts, graphs, trees, outlines, page tabs, dialogs, calendar controls, animations, dynamic content, mobile, multi-media, control playback, typography, menus, navigation, page structure, color, contrast, forms, images, keyboard, links, language, typography, frames, data tables, dialogs, authoring tools and layout tables. Accessibility requirements related to text readability are listed below: sentence length, paragraph length, language complexity, content headings, content headers, content footers, content type, UI controls and usage, voice-over features, text hierarchy, bulleted lists, text font types, spelling issues, idiomatic English grammar-related issues. Addressing the text readability requirements helps in avoiding tiring and mental taxation for the users. Session management requirements are as follows: session time outs, expiry, communication channel support, action time for completion.

Content-type related requirements are related to the following: user's interaction avoid confusion, distraction prevention, flashing effects, parallax effects, motion effects, screen size, Page-level settings and global-level settings.

CHAPTER 8

Elderly and Visually Impaired People Mobility in Home Environment Using Adhesive Tactile Walking Surface Indicators

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Abstract: Numerous health problems, particularly those involving the eyes, are associated with advancing age. It is difficult to live a normal life when you're blind. Visually impaired people face navigational difficulties both inside and outside of an environment, particularly those who are blind because of ageing. Numerous tools are available in the outdoor environment, such as pavement paths and kerbs. These, on the other hand, are ceramic, concrete, or metallic in nature, and once installed, their alignment cannot be altered. As a result, there is a need for adhesive-based tactile that is easily replaceable to meet the needs of the occupants of the house. The purpose of this paper is to design and develop various types of tactile using Thermoplastic Polyurethane (TPU) material and a 3D printer. These tiles include a Warning tile, a Straight tile, a Turning tile, and a Junction tile with surface indicators; elderly people can easily navigate their homes with the help of these tiles.

Keywords: 3D printer, Haptic Design, Junction Tile, Straight Tile, Surface Indicators, Tactile, Tactile surface indicators, Thermoplastic Polyurethane (TPU), Turning Tile, Visual impaired people, Warning Tile.

INTRODUCTION

According to the WHO [1, 2], there are 1.3 billion visually impaired people in the world, with 36 million of them being completely blind. Many blind people in the world reside in countries that are still developing [3]. This problem also affects the elderly, with the number of blind people over 65 growing at a rate of up to 2 million per decade, significantly faster than the overall population of blind people [3]. Individuals frequently rely on vision to determine their position and orientation in their environment, as well as to identify a variety of environmental components, as well as their distribution and relative placement.

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“Orientation” and “wayfinding” are common terms for these activities, while “mobility” refers to the ability to detect and avoid potential hazards in the immediate environment. Absent vision makes these activities more difficult, necessitating a determined effort to incorporate the experiences of other sense modalities, such as smells or sounds, into the activity.

When individuals reach a certain age, their health begins to deteriorate, resulting in a variety of tied to the user's age age-related conditions, such as limb numbness, diabetes, hypertension, and hypotension. Proliferative diabetic retinopathy (neovascularization), Retinitis pigmentosa (pigmentary retinopathy), and cataracts all affect vision [4]. Certain of these ocular disorders can be treated surgically. Certain ocular disorders, on the other hand, are incurable and cannot be treated surgically. Normal life can be extremely difficult for elderly people with incurable ophthalmic disorders [5]. A tool for safe travel within the home environment is required in this situation [6]. Pavement pathways and kerbs are examples of tools that can be found in the real world [6 - 8]. Nearly every railway station in major cities now has tactile surface indicators (TSIs) for visually impaired passengers. Numerous blind individuals claim to use these TSIs when walking alone across railway platforms [9].

Ceramics can be replaced with concrete or metal, but once it's in place, it can't be moved. However, the furniture and other equipment in the house can be rearranged to better suit the occupants' requirements. More than 60% of Indians, according to official Figures, rent their homes. Changing residences will cause changes to their internal organization. As a result, there's a market for tactile adhesive tiles that can be swapped out and reused for visually impaired users. To satisfy the requirements of those who are blind, there is a demand for adhesive tactile tiles that can be changed and reused. Many navigation systems are available, but each has its own set of limitations in terms of mobility [9, 10].

In this context, the current effort focuses on establishing a more effective and efficient navigation system for visually impaired senior persons. This technology employs an adhesive tactile with bumps, which individuals of all ages can easily comprehend and identify, allowing them to explore their environment.

The section that follows in the article is laid out as follows. The second section examines the most relevant works in the field. Within this section, we will talk about the system's architecture. Section 4 details the research conducted, while Section 5 offers some conclusions and suggestions for future endeavors.

RELATED WORK

For navigation in the outdoors, tactile walking surface indicators are frequently used. Many devices have been created to help and guide people with visual impairments through their daily activities, both indoors and outdoors. However, they did not meet all technical and user requirements. People with visual impairments face many challenges when it comes to spatial cognition and perception, and numerous research areas have emerged to address these issues [9]. First, this section will discuss related work on tactile standards. The second type of mobility for the visually impaired is sensory-based mobility, followed by tactile-based mobility.

A large part of early studies focused on how to design, install, and use detectable warning surfaces around the world. There are different types of standards evaluated for tactile. The specification and standards for tactile warnings on the entire curb ramp walking surface have been discussed in the study [11]. There are warning textures, later referred to as detectable warnings, that are specified in the standard [12]. In 1988, the Australian/New Zealand Standard [13] required the specification of truncated dome warning surfaces, but the Australian Building Code did not require them until 1999. The ADAG (Americans with Disabilities Act Accessibility Guidelines) mandated, starting in 1991 [14], that blind travelers use truncated dome detectable warnings. The Accessibility Standard includes requirements for ADAAG truncated dome detectable warnings [15]. As a bonus, the texture and visual contrast requirements were identical to those of ADAAG. Tactile surfaces have been standardized by the European Union since 2002 [16]. Tactile walking surface indicators, a new ISO standard for assistive products for people who are blind or have low vision, were first used in 2004 and were finalized in 2012 [17]. For this paper, the goal is for the users to identify and prioritize the features of TWSIs that comply with the standards for guiding building environment designers.

Various nations around the world are currently working on tactile surface solutions. By 2001, the Japanese Industrial Standard [10] had standardized the form and height of tactile walking surface indicators. As a result of these findings, it is possible to efficiently achieve “ease of recognition,” “ease of walking on tiles,” and “ease of recognizing transitions from bar tiles to dome tiles”. For people who are visually impaired, TWSIs can be extremely helpful. However, TWSIs should not only be used by the blind or visually impaired; they should be used by everyone, including the elderly and those with mobility issues. Tactile paving surfaces, on the other hand, are difficult to maintain and implement properly, and practitioners have had to deal with numerous issues. Specific recommendations on how to design pavements to fit the surrounding environment,

CHAPTER 9

Assistive Technology Trends, Challenges and Future Directions

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Abstract: People with impairments frequently struggle to carry out daily activities alone or even with assistance. They encounter obstacles in the environment, movement, interaction, access to writings, personal health maintenance, handling medical issues and behavioral equality. One of the subjects that have received a lot of attention from researchers is computer-based Assistive Technology (AT). Disabled people utilize AT to tackle things previously practically impossible for them. Various forms of disabilities necessitate the use of AT, which can help people with disability to do their regular work. Therefore, these technological innovations have the power to play a substantial role in supporting huge segments of society to operate and lead a normal life. The fundamental goal of AT is to continually increase a person's ability to perform independently, hence improving their overall health. Individuals who use technological aids can lead healthy, dignified, independent and respectable lifestyles. On the whole, AT aims to enable disabled individuals to join nearly every facet of life, including at home, education and community, as well as to increase their opportunities for social interactions and meaningful employment. AT devices simply gives disabled individuals more freedom and control. The significance of AT and AT devices, current trends, approaches, limitations and some of the major challenges identified in previous assessments as well as recent research findings in the field of AT, are all effectively discussed in this chapter.

Keywords: Artificial intelligence, Assisted living, Assistive technology, Braille, Cognitive impairment, Daily living, Disability, Elderly care, Healthcare, Hearing impairment, Human activity recognition, Internet of things, Learning, Mobility challenges, Physically-challenged, Prosthesis, Research gaps for AT, Robotics, Sip and puff, Vision impairment.

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WHERE ARE WE NOW WITH ASSISTIVE TECHNOLOGY?

AT refers to assistive, adaptive and rehabilitative equipment for disabled and elderly individuals [1]. AT encourages greater autonomy by improving the AT device to complete activities that disabled people previously could not complete.

The Evolution of AT

The usage of AT devices and innovations has evolved over the years, as shown in Fig. (**1**). There have been key incidents in different historical periods that expanded the use of AT [2].

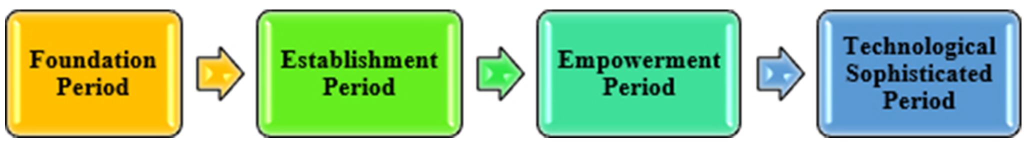

Fig. (1). Evolution of AT

Foundation Period (1800 – 1900)

The period preceding 1900 is considered the foundation period. During this time, people were capable of surviving with physical impairments. Education systems for blindness, dumb and some other impairments existed throughout the early 1900s [3]. AT inventions made during the foundation period are listed in Table **1**.

Table 1. Inventions during the foundation period

Year	Foundation Period Inventions
1829	**Braille** is a haptic communication system that consists of six raised dots and 64 combinations that can be read by visually impaired persons. It was officially published in 1929 and is still in use today.
1836	**Taylor** invented the **first practical math instrument** that could be utilized by people who were blind.
1869	The **besica model** for a **manual wheelchair** was originally patented and used in the United States during the War.
1877	The **phonograph** was invented by **Thomas Edison**.
1876	**Alexander Graham Bell's** invention is used to create the **first wearable cochlear implant**.
1892	The **Braille keypad** was developed by **Frank Hall**.
1898	**Akouphone** is the very **first electric implant** and compact enough to put in a pocket, are developed.

Establishment Period (1900-1972)

Impairment disciplines were developed during this establishment period [3]. People’s perceptions of disabled people had shifted in a good direction. As many people were suffering traumas, the number of disabled people grew. Some of the AT inventions made during the establishment period are listed in Table **2**.

Table 2. Inventions during the establishment period

Year	Establishment Period Inventions
1932	**Harry Jennings** created the first **steel frame foldable wheelchair**.
1935	The **phonograph** is deployed for both entertaining and learning in the form of talking books.
1936	The **Voder** is the first **electronic voice synthesizer**. It has a keypad and foot controls for controlling the machine and delivering sound.
1947	The **hoover cane** was created for soldiers who had been blind during the war.
1951	The **Perkins Brailler typewriter** was created to enable Braille typing. Writing Braille used to be a challenging task.
1952	**Tellatouch**, a deaf and blind communicating gadget, was introduced.
1960	To reduce their inferior complication, the first **Paralympic Games** were hosted in Rome. **Sip and Puff technology**, research by the University of Chicago, uses air pressure to regulate the device, similar to puffing through a straw. Paraplegics are the primary users of Sip and Puff systems nowadays.
1966	The **Lasercane** was invented, which produced light beams to detect and recognize, preventing clear movement.
1971	**Optacon** was promoted as a tool that would help blind individuals to read text.

Empowerment Period (1972-2010)

Individuals with disabilities were granted the right to achieve their life goals during the empowerment period [3]. Many legislations have been passed to improve the rights of people with disabilities. During this time, many AT devices were developed to help people with disabilities gain independence and achieve their goals. During this period of empowerment, disabled people understood their **"WILL TO SUCCEED"**. AT inventions made during the empowerment period are listed in Table **3**.

Table 3. Inventions during the empowerment period

Year	Empowerment Period Inventions
1976	The first **computer software** to detect printed letters was the **Kurzweil Reading Machine**. The first **wearable voice generator** was also developed in the same year.
1983	The augmented communication company is established and researchers chose to invent a technology, **DynaVox,** which allowed individuals to speak using only their eyes.
1992	**Text-to-speech** computer techniques are featured to assist people with disabilities in accessing printed texts.

SUBJECT INDEX

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