Study and Analysis of Need for Accessible Design using HCI for Specially Abled Users

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Abstract **- Specially abled users face various challenges whilst interacting and communicating with technology-enabled devices as they possess their own limitations such as specific target user group, specialized user interface (UI) and interdependence problem and it is not always possible to design interfaces for people with cognitive disabilities, since the usability of these applications are also impacted by some factors such as time, cost, veracity, availability and efficiency.**

With the advent of booming technologies, many specially abled users in today's generations are empowered by computers to perform tasks such as facial recognition login, text-to-speech and speech-to-text conversion, spoken reminders, monitoring the doorbells, flexible keyboard, increased font size, which would have been difficult with the earlier systems such as requirement of a minder or the traditional technology.

This paper concentrates on the literature review, work and observations done to design technology-enabled devices and designing User Interface that emphasize on easing needs of not only specially abled users, but for normal users as well.

Index Terms **- Diffable, Technologies, User Interface Design, Text-to-Speech Conversion, Cognitive users, Accessibility.**

INTRODUCTION

Perception, Interaction and Accessibility are the core issues which are required for Human Computer Interaction for specially abled people [1].

Using Human Computer Interaction principles whilst designing with accessibility in mind facilitates us with a wide scope of both abilities and disabilities to comprehend, conclude, steer, collaborate, commit to and from the world wide web.

Despite the folks being born diffable either by birth or developed it during a stage of life, they possess unique talents which helps them grow depending on how the same is utilized. The hearing impaired possess a good eye power which makes up for their loss, which helps them in lip-reading and good observational skills, similarly the visually impaired or blind possess good hearing skills which in turn helps them to communicate and understand the things happening around.

However exceptional cases like in Hellen Keller's wherein she was born both deaf and blind, she had good resources that helped her to both gain knowledge and feel the happenings around. She communicated using braille, manual sign language and learnt the art of tadoma- using her sense of touch to read lips by bringing her hands near the speaker's face. The resources that we get our hands on and use them, also play an important role in determining how exquisite the diffable person grows up to be. Another special case was Kim Peek who possessed a neurological disability related to the brain wherein he was a human savant, possessed the difficulty to self-maintain himself, understand and evaluate the meanings of the words and lacked comprehension, despite that he owned brilliant qualities of being learned, had the ability to perform mathematical calculations, have a good memory, sensory abilities, mechanical skills, hyperlexia and art.

The recent pandemic situation has increased the rapid use of technology in all facets of life. While normal users too face challenges in accessing the technology, similar problems are posed by the specially abled people.

LITERATURE SURVEY

This research paper surveys the existing literature for designing technology enabled devices and designing User Interface which are assisting and supporting the Cognitive disabilities which comprise of functional difficulties such as perception, learning, orientation,

visual and verbal thinking, etc. Throughout this audit, the existing literature is studied for visually impaired users, deaf users, paraplegic users, and other diffability users. Data was collected and surmised using the existing academic databases, which included peer-reviewed articles along with reading reviews from diffable users over Quora.

Out of 285 million people living across the globe, 90% of the population living in developed countries, possess a disability inherently by birth or can develop it at a certain stage of life. To cater towards the need of these users who have truncated sound sense, visual sense or any other non-functional operability, there is a need for research and development in building interactive technologies [2], document resizing tools [3], sensory tools [4], accessible emoji [5], building prototypes [6], social media websites [7][8] as such many users cannot be ignored. These audiences face many psychological, social, biological, and physical factors [9]. Different interfaces have been built since 1990. Many applications such as Sonic Finder [10], Mercator exist which currently cater towards the needs of such users, however a more general problem occurring whilst using audio is - there are no standards or defined ways to use the simplest modifications in volume, pitch, timbre, or spectral content of an auditory event.

Jain et. al [9] and others in their paper proposed the guidelines to design and develop a website considering Screen Readers and Visual Audio Devices to serve the specially abled users having visual impairment. Their paper also covered the diverse operations done so far in the field of screen readers, text to speech converters and the usability analysis of blinds and visually impaired from their day-to-day activities to their work activities. The analysis of surveys and interviews was conducted for the visually impaired users to draw minimum requirements for any computing application for them. Based upon the persona drawn, our understanding of HCIU was utilized, and through thorough research of existing paradigms in the TTS and screen readers, the drawbacks of such efforts were identified. Thus, subsequently combining these three analyses, HCI guidelines for web design for blinds were proposed and to achieve maximum flexibility in website navigation for blinds and developing a bridge of language conversion and auditory interaction to implement usability of these guidelines and to also make it efficient for existing or previously developed website, an analysis of required resources and the possible algorithm for the implementation was done as a part of this research. If you implement required resources in browsers and proposed guidelines in websites, you might achieve hands free navigation of all the future websites in any language for blinds.[38] The challenges proposed are as below:

- To enable resources in various languages for blinds without a brain.
- To develop an interface / a medium to interact with blinds and visually impaired which is easily adaptable by blinds even for those with limited technical exposure.
- Voice interaction is the best sense for blinds.
- Processing power of such systems should be faster.
- Any hardware used should be durable.
- Customization as per the regional preferences should be there.
- Controlling of applications should be handy and flexible.
- Feedback system should be highly adaptive and handling all the exceptions should be effective.

Visually impaired users cannot read and take advantage of all the literature available for them until and unless it is in braille. Also, the lack of interactive technology and limited resources demotivates the users, thus affecting the willingness to learn and share. The author Park et. al [11]and others carried out a two phased study to develop mobile applications accessibility guidelines for people with visual impairment. The first phase investigated how these users use the mobile phones. The usage pattern was collected and analyzed and problems in VoiceOver and typing were found out. A set of 10 heuristics for developing mobile applications is designed which include Substitutive text, Focus Object, Logical Focus Flow, OS accessibility support, Press Action support, Simple Structure, Substitutive action, Notice Function, Consistent User Interface, and efficient use of System Sound. However, the authors did not differentiate the degree of importance across heuristics items. An investigation of weighted heuristics for more accurate evaluation and standards. The fragmentation of developing techniques would make the standardization of mobile accessibility issues even more complex. The authors suggest that there is a critical need for developing internationally- agreed

guidelines and standards to improve the current mobile environment for people with disabilities.

Ilvio Bruder et. al. [12] in their research paper focus on HCI and access to graphics. For Computer Interaction, graphical interface is the important part for information and communication due to its fast, flexible and comprehensive usage. The recent pandemic situation has increased the importance of e-learning and is being widely accepted. There is also a need for a Learning Support System which assists the disabled in taking notes, has increased font size and a good audio system. Braille documents [13] also need a special environment for conversion. There is a need for Optical Braille Recognition. A dot detection of Optical Braille Images for Braille Cells recognition has already been made. A. Pandian et al. [14] and others [28] separately worked on the conversion of Braille text image to regional language conversion which uses Segmentation, Character Extraction, Character Recognition and Text Conversion techniques. Various tools such as Braille Embossers, Braille Copier, Braille Translator, Braille Blaster exist which helps the visually impaired users [37-44].

The book chapter surveys the principles of haptics and the perceptual capabilities, assistive design technologies of touch achievable with the human hand.[15]

W3C Consortium has provided guidelines on how to make the content usable with cognitive and learning disabilities. [16]

The authors [17][18][19] in their research paper independently designed Smart Stick which acts as an aid to help the visually impaired to be safe by identifying the obstacles lying ahead of the user in a range of four meters, detecting stairs and water pits. They designed a low-cost, reliable, portable, low-power consumption and robust solution for navigation [4] with obvious short response time. It's a hardwired system having light weight sensors and parts. The authors proposed that the range of the sensors can be increased, and the system can operate via the network. However, it can be modified for shape detection as everything that it detects is considered an obstacle.

The author Lorna et al. [20] has stressed upon the use of Assistive Technologies. Considering the vast usage of mobile in every field, there is a need for evidence-based solutions, audio-tactile Maps [21], Assistive technologies which argument, or supplement tasks, can be used to support users with learning difficulties at any stage of education.

The authors Edram in [22] reviews assistive technologies and models at the first stage. Assistive technologies [23][7] can support equal learning opportunities for users with special needs that include physical, visual, hearing incompetency etc.

The author K. Mahawariya et al. [24] discusses the necessity and requirements of educational resources to cater to the needs of specially abled users. They have studied the opportunities provided by the Equal Opportunities Cell (EOC) established at University of Delhi, India. The EOC is constantly striving to perform the responsibilities and serving the Differently Abled users, studying the utilization of resources, and analyzing the need and requirement of resources.

The authors K.S. Ali et al [25] concluded that Libraries and information centers should satisfy and cater to the needs of all kinds of users. In this modern era where innovation is the key, advances in science and technologies particularly the information and communication technologies and newer scientific gadgets of recording and disseminating information that are being adopted in every field.

Library professionals need to adopt and provide the services to the differently abled persons so as to keep them up to date with all the developments in society. Hence there is a need to undertake necessary steps to mobilize and upgrade the existing library and information systems and services to ensure a barrier free environment for differently abled Users. Use of Information Technology, Assistive technology and personalized services is imperative and can prove beneficial both for Libraries and Users with disabilities.

Emeline et.al [26] proposed the need for a design of adequate quantitative empirical evaluation. They also raised concern regarding the sample of participants. The main concerns are heterogeneity, access to education, and assistive technology. Use of single subject experiments is also encouraged. There is a lack of systematic surveys that provide detailed overview of reported difficulties.

Banking sector has also started considering and being sensitive to the requirements of such persons. Explicit mechanisms need to be devised so that these users do not feel marginalized. There is a need to note down the complaints and provide better facilities at the banks.

[27] Constant Efforts are being taken by the Government to provide differently abled people with aids and appliances at minimum costs. The Scheme of Assistance to Differently Abled Persons for Purchase/Fitting of Aids/Appliances is launched and clearly highlighted the constraints while implementing the scheme [28]

The study of existing devices is also being carried out. The major devices and aids which assist the specially abled users are: Sonar systems such as 3D space preceptor provides information about the obstacle but does not provide precise information about the shape, hence travel direction judgements cannot be made. Tyflos assists the users to select a travel path. ClaroSpeak US, Dragon Dictation, Dragon NaturallySpeaking Home, JAWS, Scan and Read Pro, Voice Dream Reader - Text to Speech, Screen Readers such as:Non-Visual Desktop Access, Serotek System Access (Windows), Apple VoiceOver, ORCA, BRLTTY, Emacspeak, WebAnywhere, Spoken-Web, Google ChromeVox, Google ChromeVis are some of the tools available [29-35]. However, these systems have a relatively high cost. [37]

FINDINGS OF THE LITERATURE

A broad range of publications covering academic literature and government schemes was considered for this survey. It is observed that much work is carried on for the use of technology for specially abled users. With the current pandemic situation, these categories of users are now being focused.

Depending upon the literature studied it is observed that the following are the needs of the specially abled users.

Table 1: Findings of the Literature

Sr. No	Technology Area	Needs Analysis for specific Domain
	Conversation and Communication Technology	● Talking ATM, Skip Ability feature. ● Device giving information about the public transport system. ● Speech generating device with dynamic display. ● Text-based device with speech synthesis. ● Simple speech generating device. ● Picture Exchange Communication System PECS. ● Speech generating device with levels. ● Smart phones. ● Speech generating device with icon sequencing.
	Reading	● Audio Captcha at all major websites. ● Adapted books for access e.g., page separators. ● Talking electronic dictionaries. ● Modified text: size, color, spacing. ● Digital e-Readers. ● Word scanners. ● Braille printed materials. ● Digital books with text highlighted as read. ● Audio books, MP3 player. ● Text-to-Speech. ● Tape recorder. ● Digital books with adapted text. ● Picture symbol supported the text. ● Closed circuit television-CCTVs. ● Tracking aids, e.g., Reading windows. ● Screen reader. ● Optical Character Recognition (OCR). ● Electronic magnifier.
	Writing	● Word processing with spell checker. ● Voice recognition software. ● Adapted pen/pencil. ● Computer with voice recognition software. ● Pencil or pen with adaptive grip. ● Word prediction software. ● Adapted paper, e.g., raised line, highlighted lines. ● Word processing with digital support. ● Slant Board to create slanted writing surface. ● Talking word processing. ● Speech-to-text interface. ● Writing templates. ● Tools for citations and formats. ● Picture Supports to write from/about. ● Typing with audio support. ● Word cards/Word banks/Word wall. ● Tape or digital recording device. ● Pocket dictionary/Thesaurus. ● Braillewriter. ● High contrast pen. ● Slate and stylus. ● Portable, talking spell checker/dictionary/thesaurus. ● Typing with Braille support. ● Portable word processing device. ● Computer-based recording software. ● Alternative keyboards. ● Braille keyboard. ● Computer with scanner. ● Electronic Braille note taker. ● Proofreading.
	Mathematics	● Abacus. ● Enlarged math worksheets. ● Talking calculator. ● Tactile/audio graphics and Maps. ● Models, 2D, 3D geometric shapes. ● Voice recognition software. ● Tactile measuring devices. ● Calculator. ● Braille Monitor. ● On-screen/scanning calculator. ● Alternative keyboard. ● Money calculator. ● Electronic Mathematics Worksheets.
	Vision	● Eyeglasses. ● Screen magnification software. ● Screen color contrast.

		● Large print. ● Screen reader, text reader. ● Embossed pictures. ● Braille translation software. ● Embossed maps. ● Closed circuit television, CCTV.
	Hearing	● Pen and paper Computer/portable word processor. ● Signaling device e.g., flashing light or vibrating pager. ● Closed Captioning Real-time captioning. ● Flash for alert signals on computer. ● Phone amplifier Personal amplification system/Hearing aid/cochlear implant. ● FM or loop system. ● Infrared One to One Communicators. ● Computer-aided note taking. ● Sign Language(ASL/ISL) communicator/translator.
	Mobility	● Standard seat/workstation at correct height and depth. ● Tactile and Textured Floor Guidance. ● Powered wheelchair joystick or other control. ● Adapted/alternate chair, sidelyer, stander. ● Custom fitted wheelchair Walking devices/walker. ● Smart Cane.
	Social Skills and Leisure	● Adapted toys. ● Adapted sporting equipment. ● Modified rubber stamp, rollers, brushes. ● Arm support for drawing/ Painting. ● Software to complete art activities. ● Games on the computer. ● Another computer software. ● Electronic aid to control/ operate TV, CD player.
	Daily Living	● Universal cuff/strap to hold items in hand. ● Color coded items for easier locating and identifying. ● Adaptive eating devices. ● Adaptive drinking devices. ● Light switch extension. ● Radio/ultrasound to remotely control appliances. ● Adaptive equipment for cooking. ● Adaptive driving equipment. ● Adapted toothbrushes, raised toilet seat. ● Adaptive dressing devices. ● Adaptive sewing devices. ● Interface and switch to turn on electric appliances using. ● Internet of Things Technology.
	Information Management	● Sticky notes, index cards. ● Study guide. ● Task analysis. ● Digital highlighters. ● Handheld scanners. ● Electronic organization. ● Online search tools, Web Trackers. ● Online sorting file tools. ● Digital graphic organizers. ● Online manipulatives, interactive, tutorials, animations.
		● Recorded material such as lectures, audio books. ● Prewriting organizers.
	Time Management	● Checklists Schedules- visual Portable, adapted timekeepers. ● Electronic reminders Digital planners (PDAs), cell phones. ● Web-based planning tools.
	Self-Management	● Sensory regulation tools, e.g., Sunglasses Movement and deep pressure tools. ● Fidgets' Auditory reminders. ● Visual reminders electronic reminders. ● Electronic filing and storage.
	Computer Access	● Easy Navigation Tools. ● Speech Recognition. ● Standard keyboard/mouse with accessibility/access features built into the operating system. ● Standard keyboard/mouse with adaptations. ● Alternate keyboards/ mouse. ● Onscreen keyboard. ● Voice recognition software. ● Eye Gaze. ● Morse Code. ● Large icons. ● Built-in fully featured magnification screen reader. ● Screen reader Screen reader with Braille device. ● Keyguard Enlarged or Braille/tactile labels for keyboard. ● Alternate keyboard with enlarged keys. ● Braille keyboard.

RESEARCH CHALLENGES

Spreading of knowledge and educating the normal folks about specially abled folks in school/college or through short advertisements/videos as a social education chapter to spread inclusivity, diversity and also enable the normal users to understand and manage them in a better way.

Multilingual development such ISL/ ASL/ any kind of sign language to English to another language, or English to another language or ISL/ ASL/ any kind of sign language or braille system or any other language to another language in a speech-to-text and text-to-speech interface over any device be it a mobile, laptop or pad, as many diffable users might not be well versed in English or a particular language.

There is an urgent need for text-to-speech and speech-to-text interface to be designed to an accuracy as follows –

- Increase and improvement in the dataset gathering and sampling for various kinds of users, as various kinds of folks have different accents, pitch, timbre, sound, pronunciation, etc.
- Development of the system such that it allows the diffable user to pick call, convert the speech to text, then the diffable user can type a response, wherein it gets converted into audio and gets transmitted as an audio reply to the normal user for more efficient means of communication and removes the challenge of requiring a minder in this case.
- Improvement of interface integration such that it separates air, noise and external factors and focuses on the human voice over our phones to enable socialism, improve peer-to-peer communication.

Development of a device catching horn sounds or sounds that come from behind/ anywhere using a sensor to detect and report that sound in order to secure the person from possible accidents.

Design of a system that uses facial recognition or the tip of any human body part to control the movement of the cursor over a device that shall enable the diffable folks to access technology-enabled devices like any other user and removes the drawback of requiring a minder.

Being interoperable along with or run as a background over any other website, software, games running which shall ease the challenges such as normal phone calls for hearing impaired users by using text to speech and speech to text, facial recognition for armless users or any other requirement that helps minimize the challenges faced by diffable users.

Design and development of portable hardware devices along with in-built features that cater to the needs of the diffable to ease the communication.

Development of human weight compatible robotic walking legs to help and hold the paraplegic individuals in a standing position and enable them to go about their daily activities and help them use the stairs in case lift or a slider is absent.

Usage and adoption of Augmented reality and Virtual Reality along with the interface to help normal users understand diffable folks.

Establishment of reachable, reliable, low-cost implementation and making specially abled users aware of the technology-enabled devices based on economic status in order to enable more access and bring up these users at par with the normal users.

RESEARCH PROBLEM STATEMENT

The learning gap and fluency in vocabulary for the hearing-impaired users has posed many hindrances and limitations such as education completion, pursuing higher education, technical job opportunities, despite the users showing potential, intellect and vivid interest in doing so. Quite often, there are various hearing-impaired users having different ranges of hearing loss (measured in decibels(dB), so not only depending on their range, but also factors like family background, resources accessed and utilized, support and efforts put in determine how the diffable user excels. Some users who have mild - moderate hearing loss can function with the help of hearing aids/cochlear implant, are also exposed to multiple languages, and have good speech, but sometimes a drawback of being exposed to multiple languages is they might not be fluent in at least one which could impact their communication whilst speaking. Whereas the users who have severe to profound hearing loss face speech problems along with not being able to hear clearly, however, they learn the art of lip-reading/ sign language or either remain mute or communicate by written notes/ spoken English but with poor/good speech clarity. Most of us to fit in with everyone jump at the prospect of speech therapy and to access more opportunities and fit in at a larger scale amidst the community. This works well for a few individuals as they grow up to be successful, however does not work well for some others. Not much importance is given to sign language and this in turn - limits the education and other opportunities, unavailability of trained instructors in sign language or to help the hearing-impaired individuals, no funding to help the diffable individual to receive translations and provide communication or any other necessary resources, wide divide among various types of hearing-impaired students- each all growing up based on their own experiences, lack of support and motivation. Similarly, in a way the visually impaired/blind also have restraints towards accessing information completely. Henceforth with the abundance of technology in today's realms to mitigate the gaps, there is a dire demand for multilingual development of a speech-to-text and text-to-speech interface development with an

accuracy to simultaneously open many doors, incite harmony and unity among all spheres of users and push the diffable individuals to aspire for a greater good.

CONCLUDING REMARKS

The main aim of this study was to briefly analyze the needs of users with cognitive disabilities. Different technology areas were analyzed, and the findings of the literature were tabulated. The research work carried out till date was studied along with the existing technology enabled devices. However, with the increased use of technology, this class of users cannot be left out from the mainstream. There is a need for talking websites, audio captcha, and captcha solver, facial recognition for automatic login in all the websites. Socially Interactive web interface [38][39] is required to increase the participation of such users. Technology aids need to be built up at a relatively cheaper cost.

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