Emerging Accessibility Solutions for Physical & Mobility Impairments

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1. Introduction

Innovation has played a substantial role in the field of Accessibility to the Information Communication Technology (ICT) throughout the past decade. The impact of these groundbreaking achievements has been reflected throughout all industries including Accessibility and Inclusive Technologies. The technological breakthroughs in areas like miniaturized computer hardware (e.g. wearables, smartphones, etc.), Artificial Intelligence (AI), Deep Neural Network, Machine Learning, Robotics, and Internet of Things (IoT) have paved the way for innovative solutions to meet a wide range of needs for people with disabilities (Al-Thani et al., 2019).

Since the past few years, Assistive Technologies and ICT Accessibility Solutions have demonstrated a trend of being incorporated into mainstream technological solutions through built-in accessibility features available within products. Trends of emerging assistive technologies currently being explored are converging towards being a hybrid of mainstream and medical technologies including technologies like implants and exoskeletons. These emerging solutions tends to compliment conventional assistive products rather than replacing them.

2. Background

According to World Intellectual Patent Organization (WIPO), currently there are over 1 billion potential users of assistive technology and accessibility solutions. It is estimated that this population would grow to 2 billion by 2050 as human life expectancy increases over this period along with the convergence of mainstream products and assistive technology features. The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) recognizes access to assistive technology as a human right, bearing responsibilities and obligations towards the accessibility industry and market

influence. UNCRPD identifies legislations and policies play a crucial role in attracting market sector investments along with related demographics and consumer demand. Significant work is being done to develop assistive technology solutions for individuals with mobility impairment to augment or recover human functional limitations. Emerging assistive technologies leverage on a combination of groundbreaking technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Brain Computer Interface (BCI), and advance sensors (Lahiri et al., 2020).

3. Cutting-edge Technologies

Primary cutting-edge products in this sector are evolving from conventional assistive products such as advanced walking aids (balancing aids and smart canes), advanced prosthetics (neuroprosthetics, smart and 3D printed prosthetics), advanced wheelchairs (including self-driving wheelchairs and wheelchair control) and exoskeletons (full-body exosuits, lower and upper body exoskeletons). An example of such trend is indicated by the fact that there has been a 34% growth rate in the patent filings for advanced wheelchairs last year (Source: WIPO). The present article will highlight the advanced prosthetics, Brain Computer Interface, Exoskeletons and Advanced walking aids.

Table 1: Comparison of Conventional Vs. Emerging Assistive Technology

Conventional Assistive Technology	Emerging Assistive Technology
Walking aids	**Advanced prosthetics**
Accessories for walking aids	**Exoskeletons**
Wheelchairs	**Advanced walking aids**
Accessories for wheelchairs	Advanced wheelchairs
Other mobility and mobility accessories	**Brain–computer interface (BCI)**
Accessories for changing body position or lifting persons	Smart assistants
Orthoses	Smart homes
Prostheses	
Standing frames and supports for standing	

3.1. Advanced Prosthetics

An example of innovative emerging assistive technology is advanced prosthetics which

compared to conventional prosthetics and orthoses offer features well beyond mechanical and cosmetic support. The utilization of sophisticated technologies such as cameras & pressure, temperature or strain sensors combined with machine learning algorithms, enables the device to understand the user's prosthetic control behavior and harness neural signals to be controlled by the nervous system and signals from the skeletal muscles.

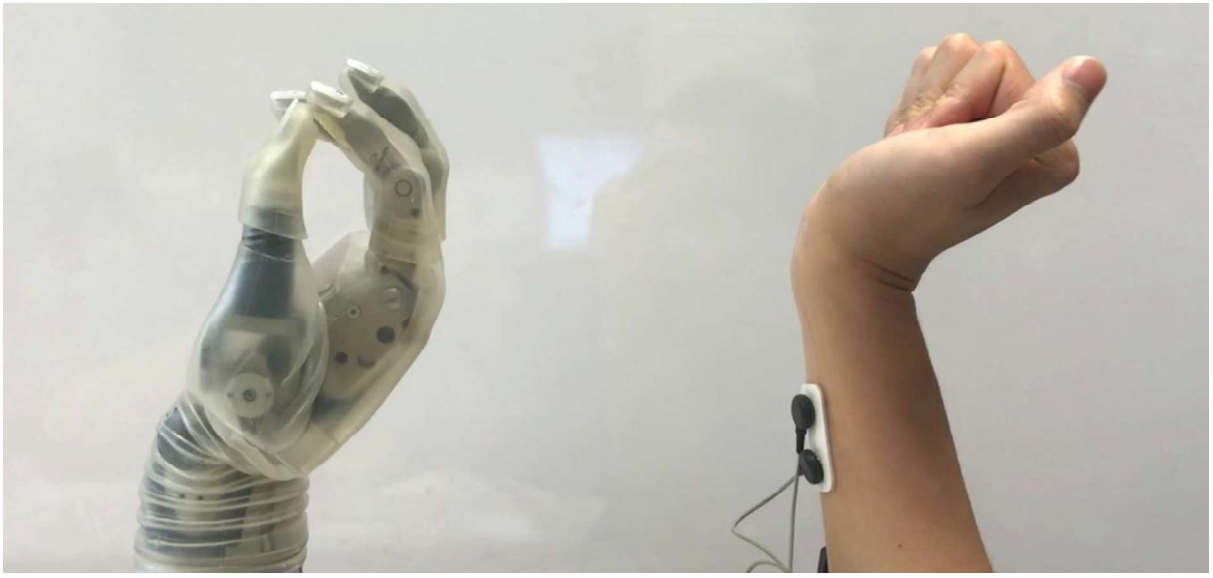

Figure 1. New Tech May Make Prosthetic Hands Easier for Patients to Use (Source: NC State University news.ncsu.edu)

Current state-of-the-art prosthetics rely on machine learning to create a "pattern recognition" approach to prosthesis control. This approach requires users to "teach" the device to recognize specific patterns of muscle activity and translate them into commands – such as opening or closing a prosthetic hand.

"Pattern recognition control requires patients to go through a lengthy process of training their prosthesis," according to the research conducted by (Pal et al., 2018) and this process can be both tedious and time-consuming.

3.2. Brain Computer Interface (BCI)

An innovative area of technology being actively explored to develop emerging assistive technology is Brain Computer Interface (BCI). BCI is a branch of computing technology that seeks to detect brain activity patterns and map them to specific output commands

to be processed by a computer application or device. BCI technology can be used as an alternative input method where the user is unable to use conventional input devices (e.g. mouse, keyboard, etc.). BCI can be in invasive and non-invasive forms. Invasive BCI consists of connecting hardware computing device(s) directly to sensors implanted in the brain while non-invasive BCI comprise of external sensors that detect brainwave patterns while in contact with specific areas of the head (Pandarinath et al., 2017).

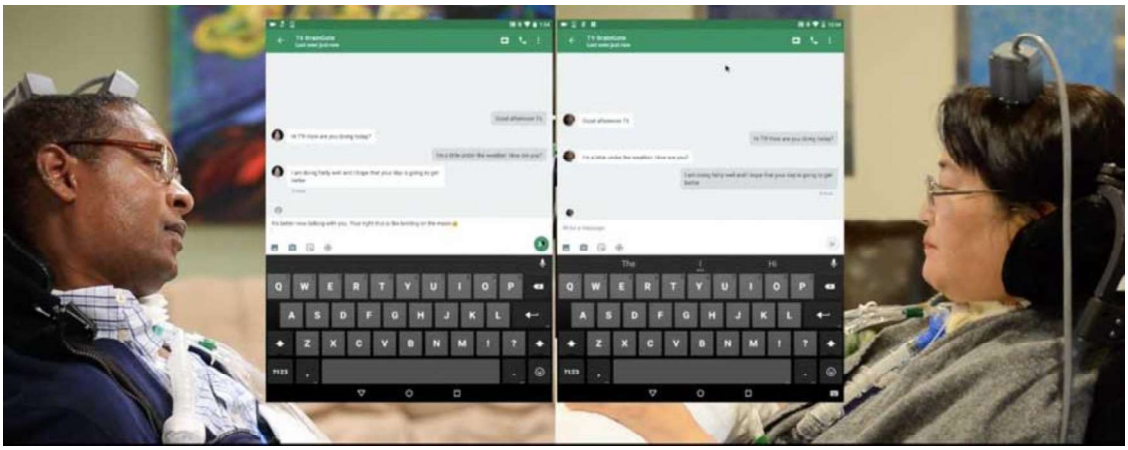

Figure 2. Brain-Computer Interface turns thoughts into a mouse for tablet control (Source: Slash Gear slashgear.com)

BCI applications can be helpful for individuals with various types of disabilities as it can be operated through a direct pathway of communication between the user's brain and the external device being controlled without the need for the user to perform a physical task like pressing a switch or even initiating voice commands. AlterEgo is a non-invasive BCI wearable that allows users to communicate with machines through the medium of neural language without the use of any voice or gesture commands. The solution uses AI and machine learning to interpret commands by processing them internally and provides feedback to the user through bone conduction headset retaining complete privacy for the user. Currently under research and conceptualization in Massachusetts Institute of Technology (MIT), this technology can have significant impact for individuals with physical and communication impairments by reducing the functional barriers to carry out various daily living tasks.

3.3. Exoskeletons and advanced walking aids

Exoskeletons are innovative mechanical structures that humans can wear to increase their strength and endurance. It can be an additional option for the supply of aids if the

structural and functional properties of the neuromuscular and skeletal system are too limited to be able to achieve mobilization with an orthosis. In patients with complete paraplegia (ASIA A), exoskeletons are interesting as an alternative to an orthosis under this criterion for lesion heights above the thoracic vertebra (T12). In patients with incomplete paraplegia (ASIA B-D), orthotics are even suitable for lesion heights above T12 in order to promote the patient's own activity to such an extent that the therapeutical mobilization can be successful. In contrast to an orthosis, an exoskeleton takes on a large part of the active muscle work. In addition powered exoskeletons can improve the quality of life of individuals who have lost the use of their legs by enabling system-assisted walking. Exoskeletons—that may be called "step rehabilitation robots"—may also help with the rehabilitation from stroke, spinal cord injury or during aging. Several prototype exoskeletons are under development. The Ekso GT, made by Ekso Bionics, is the first exoskeleton to be approved by the US Food and Drug Administration (FDA) for stroke patients.

Figure 3. Example of Exoskeletons Technology used by a person with physical disability (Source: International Business Time www.ibtimes.co.uk)

4. Conclusion

Emerging accessibility solutions for users with physical and mobility impairment primarily involve the introduction of advanced innovative features to existing conventional technologies by allowing these solutions to perform far more functions for the user in an automated manner while also enabling the technologies to self-learn about the user's requirements, and behavior to function accordingly. The ultimate goal of all these technologies is to maintain the overall safety of the user and allow him/her to function to the fullest extent possible.

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