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Interventions of Assistive Technology and Devices to Aid Physically, Cognitively and Speech-Impaired Patients

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ABSTRACT

Biomedical engineers have been revolutionizing the industry of assistive technologies to govern the lives of many pain points related to physical trajectories, cognitive impairments or disabilities. This research publication will provide a comprehensive analysis on how assistive technology and devices assist various patients of different diagnosis. Specifically, components and functionalities like AI, bioengineering medical tools, and artificial tools that assist people throughout their daily lives will be addressed throughout this research publication. This research publication will also dive into the specifics of electronically-powered wheelchairs, wireless networks, eye-tracking devices and brain-computer interfaces to deduce how effective and optimal these technologies are. Additionally, this research publication will also explore the ethical limitations that have risen from the study of assistive technologies, such as financial issues, accessibility, and lack of humanitarian interaction.

Introduction

Since the development of first-powered wheelchairs introduced to the market in 1920s as well as the development of hearing aids in 1948, and the novel introduction of braille typewriters and new forms of everyday technology like wheelchairs, computers and vehicles, researchers are beginning to understand the practicality of assistive technologies that could facilitate the day-to-day functions of patients bearing with mental impairments, cognitive disabilities or physical impediments. As researchers continue to make such scientific paradigms and advancements, more legislative action, R&D and public policies will be initiated and developed, to ensure that AI, machine learning and robotics could be implemented into assistive devices for years to come. For instance, laws such as the Americans with Disabilities Act (ADA) and the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) have paved the way for creating accessibility standards that must abide by the terms of new biomedical applications and tech products that have been released to the market. With the current societal focuses on diversity, equity and inclusion, as well as in adhering to the global standards of DEI committees, it is crucial for researchers to ensure that new forms of assistive technology and wearable devices are accessible, optimized for efficacy, and provide guidance in the most equitable form for both industrial and clinical tests.

Assistive Technology and Wearable Devices to Aid Physically-Disabled Patients

Researchers have been analyzing the efficacy of novel forms of assistive technology that could be used to bridge the challenges that patients that are bedridden or have difficulties with muscle strength regain their strength to ensure proper quality of life. Specifically, a group of researchers utilized a keypad device using the software

tools of Arduino and other embedded tools for disabled patients who cannot speak or talk. (Veekshita et al., 2018) Veekshita and other researchers proposed that a voice recognition system could be introduced for speech-impaired people to receive proper rehabilitation programs through the refinements in a computer interface to bypass the traditional keyboard and active voice control. (Veekshita et al., 2018)

Another group of researchers looked into disabilities – except, looking into the technological interventions of powered wheelchairs that could be used to improve mobility. Specifically, researchers analyzed the comparative study of assistive technologies by analyzing the efficiency of wheelchairs that can be improved upon with a "joystick, brain-computer interface, voice recognition, eye tracer, and tongue drive systems". (Rwegoshora et al., 2022)

Researchers are exploring another form of assistive technology that utilizes a wireless network to help a person who might have physical impediments to drive wheelchairs. (Rwegoshora et al., 2022) This system includes a tracer that can be attached to patients' tongues if they are unable to use their arms and legs to drive a wheelchair by signaling UP, DOWN, LEFT, and RIGHT through particular commands. (Rwegoshora et al., 2022) An additional form of assistive technology that uses electrooculography and image processing, is Eye Tracing. (Rwegoshora et al., 2022) Patients who lack the ability, or are restricted in their mobility use the eye tracker to drive the wheelchair by just gazing in the direction they would like to go. (Rwegoshora et al., 2022) Straightforward commands like forward, backward, left rotation, right rotation, and stop movement are accessible to the patient. The only downside is that to use this you must be knowledgeable about technology. Many patients who need access to this are older and are not familiar with the futuristic technology advancements that have been enacted up until this point.

Another group of researchers looked into other forms of human assistive technology that could have critical applications for patients with physical impairments in the form of cost-effective healthcare solutions. Specifically, they witnessed recent advancements in utilizing electronics, as well as short-range and ultra-low power radio technologies that rely upon Intra-WBAN communications for further data processing and analysis. (Alam et al., 2014) They identified that WBAN coordinators that rely upon Wireless Body-to-Body Network (WBBN) can help enhance the smart and self-powered sensor devices.

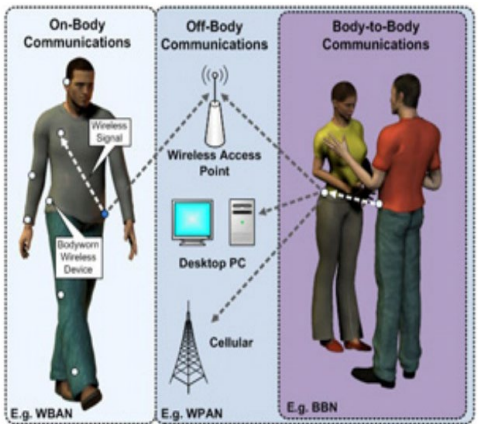

Figure 1. Representation of Wireless Body-to-Body Assistive Technologies

Brain-Computer, AI and Stimulation Devices to Aid Cognitive Disabilities

Researchers have been looking into different forms of technology to help patients who have cognitive disabilities such as limitations in memory, communication, and social skills. Particularly, researchers are looking into assistive technologies that can promote independence in a patient's quality of life. Amidst various cognitive

disabilities and impairments, researchers have found that those living with such disabilities constitute about 7% of the population in the United States of 20 million citizens. (Scherer et al., 2005) Researchers have been exploring technological findings to help people with cognitive and neurobehavioral changes, such as organizational deficits and memory.

Patients suffering from cognitive impairments greatly benefited from the usage of these portable devices. Researchers discovered that even when patients are not exposed to these forms of "high-tech" ATC devices, positive implications on the memory were still secured. Also portable devices, like pagers, and hand-held computers are sized in a convenient way, so users can easily travel with their devices in hand. (Scherer et al., 2005)

Despite these innovative interventions, researchers have also identified some weaknesses with applying these electronic devices for all patients suffering from a form of cognitive impairment. When it comes to using technology for your cognitive disabilities, there could be some mishaps like battery failure and crashes. Patients using these kinds of devices need to be knowledgeable of the technology, but the problem is that many patients who would benefit from these electronic devices, might not know how to maintain them in the long run, and may not have someone to assist them at all times. Additionally, when diversifying these sets of results, the weakness lies in the fact that these data points and findings were derived from 2005, when there was limited technology, innovation compared to the modern course of era, when Artificial Intelligence and novel forms of bioelectronics have revolutionized this industry.

Novel Interventions for Neurodegenerative Diseases (Parkinson's, Alzheimer's Diseases)

Amidst the field of regenerative medicine, researchers have been looking into the development of new frontiers including 3D printing and laser-based techniques that engineers have devised to help treat multiple neurodegenerative diseases. One group of researchers looked into the efficacy of tissue engineering, by analyzing the complex 3D structures that could be formulated to improve "cell homing, and to facilitate the flow of culture medium or blood through construction in order to ensure the supply of nutrients and oxygenation." (Rey et al., 2022) Specifically, researchers looked into the usage of biomaterials like synthetic palmers, natural polymers and ceramics that have flexible adaptations with mechanical properties — due to their adaptive design, researchers have witnessed how they could promote minimal inflammatory and immune responses. (Rey et al., 2022) Thus, through combining this with the ECM-based scaffolds, researchers witnessed how it could further promote and bolster cell adhesion and growth, which would mimic the growth of native tissues. As these 3-D cell culture systems can mimic the living tissue, these effective treatments could help formulate solutions for diseases like Alzheimer's disease, Parkinson's disease, and ALS — which are all relevant in their impact on the Central Nervous System. In terms of the efficacy on the brain, the use of scaffolds have been argued to mimic the "brain's morphology" and functions, that could further improve cellular growth for transportation purposes, and help facilitate the drug delivery process to be transplanted into the lesion site.

Intersections of New Cognitive and Biomedical Engineering Tools for Speech Impairments

Outside of physical impairments and cognitive disabilities, researchers and pathologists are also looking into new forms of solutions for patients diagnosed with speech disorders (specifically, known as motor speech disorders). Speech-language pathologists, also known as SLPs have identified that from collecting speech modalities, tongue motion, lip gestures and voice, they can look into better-enhancing the articulation of speech, by looking into the

MSCS hardware and software components that could be reviewed with pattern-matching algorithms. (Sebkhi et al., 2017) Thus, in order to help with the recovery of such speed production skills, speech performance has been assessed by the SLP in listening to patients' "utterance, while watching the movement of the lips and jaw" to provide constructive feedback and encourage improvement in speech legibility. (Sebkhi et al., 2017) In assessing the biomedical components, researchers witnessed how tongue movements could be tracked using a wireless approach. The magnetic field fluctuations were generated by the tracer, captured by external 3-axial magnetometers and then converted into a 5D vector, of which the voice was finally developed by a pair of "bilateral microphones." (Sebkhi et al., 2017)

Prosthetic and Artificial Limbs to Provide Solutions for Lack of Mobility

Compared to previous years where patients with certain physical impairments and immobility were unable to discover a solution that could help them with their mobility, person-centered, and clinically-meaningful instruments have arisen over the last course of years in medical and biomedical advancements. Thus, researchers have been assessing the use of prosthetic limbs and how they could enable disabled communities. Researchers have identified that the biosensing properties of prosthetic limbs that consist of nanomaterials have enabled disabled members to better obtain greater movement — specifically, researchers identified that "carbon-based nanomaterials" have a strong transmission mechanism, that can enable these electrical, magnetic, thermal and mechanical properties to help with movement. (Tan et al., 2022)

Due to the bio-sensing nature of prosthetic limbs, researchers have witnessed how they can lead to resistance, affecting the useful life of prosthetic limbs. By achieving greater exogenous nerve sensor, combined with the electrospinning and 3D printing features, in the current focus of modern research, materials that consist of "man-machine interaction" are considered to be a pivotal focus for years to come. (Tan et al., 2022) By implementing nano materials that consist of fiber materials, metal synthetic materials as well as composite materials, the duality, hardness, weight and toughness could help dominate other materials and other intelligent forms of limbs.

(Tan et al., 2022)

Ethics, Discussion and Limitations

There are so many positive advancements due to assistive technology and devices that support physically, cognitively, and speech-impaired patients. Still, from an ethical perspective, there are some obstructive views on assistive technologies and devices. More sensitive individuals, who have depression-related weaknesses and cognitive disabilities, are recognized to increase the significance of ethical challenges. Mainly, when the devices require an understanding of modern technology, concerning machine intelligence, close vicinity to the body, and the gathering of thoughtful data, is when it would be acknowledged as an ethical challenge. (Wangmo at al., 2019)

Assistive technology can be very helpful for so many people, but many ethical considerations should be looked over as well. Especially, in low to middle-income places, it is harder to gain accessibility to assistive technologies because of different income levels. Also, when using assistive technologies, you can lose human interaction with the patients, which can cause them to lose their ability to socially interact. When humans have to interact with machines with "human characteristics", it can cause a false narrative that vulnerable patients will fall for. (Bennett at al., 2019) Additionally, many times, when testing these forms of assistive technology, ethical contradictions may arise as there could be limited informed consent and disclosure provided to patients. With many having indications of physical or mental impairments, it may be a challenge for researchers to receive proper consent prior to participating in laboratory and technical applications.

Conclusion

While biomedical researchers are continuing to test wearable devices, prosthetic limbs and artificial limbs to significantly shape the lives of physically and cognitively-impaired patients, new forms of technological advancements in Artificial Intelligence and Machine Learning have optimized the efficacy of such platforms.

Whether it's relying upon powered wheelchairs, wireless networks, eye-tracking devices or brain-computer interfaces, researchers have witnessed positive growth in positively bolstering the lives of disabled patients. In the years to come, researchers would be able to continue to adapt clinical trials and further R&D that can be invested into applying such technologies in many multifaceted industries.

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