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Smart Wheelchairs – An Opportunity to Maximize Human Potential

Deborah A George*

Department of Physical Therapy, University of Findlay, USA

Editorial

Approximately 25 million people in the United States (11.4 percent) have had an ambulatory disability, whereby 2.7 million reported using a wheelchair or similar device [1]. The needs of most users are met by traditional manual or power-driven wheelchairs. However, a portion of the users have found it difficult to use traditional wheelchairs independently [2]. For example, those users could be individuals with visual issues, upper body physical impairments (e.g., ataxia, tremors), or cognitive deficits [3]. Since 1980, researchers have been developing technologies for smart wheelchairs (SWs) and continue to do so today. Smart wheelchairs could maximize the human potential of users to live more independently than they could ever have imagined.

Simpson [2] has defined the SW as a standard power wheelchair with a computer and a collection of sensors or a mobile robot-base with an added seat. This integrated device allows independent mobility, as well as other functions, such as communication, telehealth monitoring or safety surveillance [4,5]. The degree of intelligence of the SW is based on its ability to perceive its environment through its sensors [6].

Simpson [2] conducted a literature review and listed a large number of SWs; Leaman and La [4] updated this listing in 2017. From this extensive list, he identified common components of each SW: (a) type of form, (b) input methods, (c) sensors, (d) control software, (e) operating modes, and (f) internal map [2] Early on, SWs utilized mobile robots with seats; however, the form typically used today is a power-driven wheelchair with advanced technology. There are also "add-on" units that may be attached to the underlying power systems. The biggest advantage to the add-on units is to invest in the system one time and use it with multiple chairs over a lifetime. Traditional input methods may be used, such as joysticks or pneumatic switches [2]. Other advanced methods include voice control, user sight activation through electrooculographic (EOG) activity, or the use of machine vision [2,4]. Sensors on SWs are important for avoidance of environmental objects and clearance through narrow pathways, such as doorways. The sensors may use ultrasonic acoustic range finder, infrared light range finder, laser range finder, laser striper, or computer vision system [2]. Although the ultrasonic and infrared finders are less expensive, they have difficulty with reading stairs, curbs, or potholes. The two laser types of sensors are more expensive and require more power. Greater control at a reasonable price is the computer vision system, which uses small video cameras for landmark detection [7]. The control software is dependent on the various functions supported by SWs and its sensors [2] The operating modes may be fully controlled by SWs, whereby the user gives the system a destination and it executes automatically to the target [2,4,6]. In order to be successful, these systems typically require an internal map of the environment. In contrast, operating modes may have collision avoidance, but allows the user to plan and navigate the system [2,4,6]. As mentioned some systems require an internal map and others have autonomous navigation, such as following floor tracks.

The advancements of technology have made it possible to integrate a variety of functions into the current smart wheelchair, including position changes; environmental navigation options; communication devices; environmental control units; and telehealth monitoring and surveillance systems. The wheelchair itself may change positions, such as into a reclined position of the backrest; a standing position of the user; tilt in space of the wheelchair itself; or lowered seat to the floor. Each of these position changes have specific purposes for users. For example, the reclining backrest and the tilt in space features would be helpful for maintenance of skin integrity for the user. Secondly, SWs may have various navigation options to allow safe collision-free mobility; to aid in specific tasks (e.g., passing through doorways), and to provide autonomous transport between locations [8]. A third option could involve the use of a communication device, allowing communication in the direct environment, through the phone system, or internet. A fourth possibility would be the inclusion of an environmental control unit, allowing control over household devices and objects, such as the television, lights, and doors. Finally, SWs could be equipped with telehealth monitoring and surveillance systems to monitor users' temperature, pulse, and/or blood oxygen levels [9] Interestingly, Madigan and Newman [5] found that users prefer the safety and telehealth functions of smart wheelchairs [5].

Along with the multiple benefits, smart wheelchairs have some challenges. These additional functions may be seen as intrusive or bothersome by some users [5]. The SW may be too complicated for some individuals to use and certainly would require training [2,4,5]. Not only the cost of the SW, but also the cost of training and long-term service could be a barrier to some users [2,4,5]. Madigan and Newman [5] conducted a pilot study involving five wheelchair users, who lived in an assisted living facility. Through a questionnaire and a focus group, the investigators found that the benefits outweighed any intrusiveness [5].

Simpson, LoPresti, and Cooper [3] have projected that the number of wheelchair users that could benefit from a SW would be 3.9 million individuals. Given this projection and the advancements of technology, clinicians need to consider the SW as a viable option for environmental independence. The rehabilitation team needs to consider the future direction of SWs through collaboration with all stakeholders such as rehabilitation engineers, scientists, physicians, and clinicians, but most importantly the users, themselves. The literature provides a glimpse into some future possibilities [3].

One advancement with an input device is the Emotiv EPOC headset for Brain computer interface (BCI). A BCI is a device that utilizes the user's brain signals (e.g., through an electroencephalograph) and a computer that analyzes the signals and maps them into a particular response of the wheelchair [4,8,10]. Not only would this device assist with the wheelchair mobility, it also could potentially assist with the control of robotic arms [4,8].

***Corresponding author:** Dr. Deborah George, Department of Physical Therapy, The University of Findlay, Findlay, OH, USA, Tel: 419-434-5531; E-mail: george@findlay.edu

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Another advancement used for localization and navigation within the environment is the global positioning systems [4]. These systems have been readily used with our vehicles, today. Unfortunately, they are not always reliable in tree covered environments. However, Leaman [4] reported that the fusion of the GPS system with wheel odometry information through a filter could allow the SW to achieve better localization.

Collision detectors have also been used with our vehicles and most certainly could be applied to SWs. This device would detect frontal collisions and could stop the wheelchair [4]. Not only could SWs have this simple feature of collision detection, technology has grown to the point of incorporating a prompter, which uses a Partially Observable Markov Decision Process to determine the optimal prompting strategy. In other words, the prompter would analyze users' past abilities to navigate and provide verbal prompts to assist with navigating safely to their destination [4].

Smart wheelchairs have continued to evolve, whereby future wheelchairs could utilize a multi-modal interface, which combines multiple inputs, such as computer vision, touch, voice, and brain control. This system will be able to create internal maps, using mobile sensors and to navigate the environment by analyzing data in real-time through computer applications. With these advancements, users will have improved quality of life by maximizing their abilities to function independently in their environment. The key to this evolvement of the SW is continued research and development with the entire team, including the user.

References

1. Steinmetz E (2006) Americans with Disabilities: 2002. US Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau.
2. Simpson RC (2005) Smart wheelchairs: A literature review. J Rehabil Res Dev 42: 423–436.
3. Simpson RC, LoPresti EF, Cooper RA (2008) How many people would benefit from a smart wheelchair? J Rehabil Res Dev 45: 53-71.
4. Leaman J, La HM (2017) A Comprehensive Review of Smart Wheelchairs: Past, Present and Future. IEEE Transactions on Human-Machine Systems 47: 486-499.
5. Madigan EA, Newman WS (2012) What do users want from "smart" wheelchairs? 11th International Congress on Nursing Informatics 263.
6. Bourhis G, Sahnoun M (2007) Assisted control mode for a smart wheelchair. Proceedings of the 2007 IEEE 10th International Conference on Rehabilitation Robotics.
7. Rao R, Conn K, Jung SH, Katupitiya J, Kientz T, et al. (2002) Human robot interaction: application to smart wheelchairs. Proceedings of the 2002 IEEE International Conference on Robotics and Automation.
8. Blatt R, Ceriani S, Dal Seno B, Fontana G, Matteucci M, et al. (2008) Brain control of a smart wheelchair. In Burgard W, Dillmann R, Plagemann C, Vahrencamp N, eds. Intelligent Autonomous Systems. Fairfax, VA, IOS Press, Netherlands: 221-228.
9. Dsouza DJ, Srivastava S, Prithika R, Rai S (2019) IoT based smart sensing wheelchair to assist in healthcare. International Journal of Recent Technology and Engineering 6: 7-13.
10. Pillette L, Jeunet C, Mansencal B, N'kambou R, N'Kaoua B, et al. (2020) A physical learning companion for mental-imagery BCI user training. Int J Hum Comput Stud 136: 1-22.