A Review of Smart Urban Designs and Technologies for the Disabled

Ali Aljowair

Email: a_j0@hotmail.com

Abstract

This study aimed to review the studies carried out on smart urban designs and technology being used for disabled people worldwide. Various databases were searched for keywords 'smart urban design & disabled' and 'smart technology & disabled'. These studies were then shortlisted based on their relevance to the topic and how current they were. The review found that during recent years, health care has evolved to an extent where patients and medical resources can be directly connected through Smart Health Care and Smart City Architecture. Studies show that people with physical disabilities may need devices to assist them with their mobility. According to the reviewed research, a smart wheelchair is developed based on a conventional wheelchair and is equipped with sensors, cameras and a computer-based system as its main processing unit. This unit can perform specific algorithms for the wheelchair's intelligent capabilities. There have also been proposals for developing a smart wheelchair system which facilitates obstacle detection and human tracking using computer vision. Other authors have talked about Smart Walking Stick and other Smart Home applications – medical and assistive. One of the practical implications of this research is that there is a shortage of research on the interaction between smart technologies and smart city infrastructure for the disabled.

Keywords: Smart urban design, smart technologies, disabled, review

Introduction

Disability is part of humanity and the social reality. According to Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), disability is a part of the human condition and hence, must be comprehended as “a complex social reality that should be addressed from multiple perspectives and disciplines. We also face unprecedented demographic changes due to the general ageing of the world population. Therefore, it is urgent that we rethink and humanize environments so that they are readily accessible and can respond to the social needs of the 21st century” (Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor, 2015). Constant demographic changes across the world are leading to a greater number of elderly people, which may also have various levels of disabilities.

Despite the proportion of the elderly and the disabled in the population, the environment constructed around us has largely failed to take their needs into account. According to Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), a significant portion of the public-built environment is not accessible enough as its design does not take into account the necessities of the disabled population.

According to Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), in the late 1960s, a new way of understanding disabilities was proposed by the associations of persons with disabilities in some countries. This new concept highlighted "the close connection between the limitations experienced by persons with disabilities and their environment". This social model highlighted that the focus would not just be on the individual disabled person —as the medical or

assistance models proposed— but also on the obstacles to participation (Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor, 2015). According to Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), the inadequacies and absences of systems for the disabled are apparent.

In this paper, we will review studies which talk about smart urban designs and technologies which try to lessen the difficulties faced by the disabled when they access the environment around them.

Methodology

In this paper, we will review some of the research studies which have been carried out on the subject of Smart Urban Designs and Technologies for the disabled or the specially-abled. Towards this end, specific search terms were used in the Google Scholar search engine, such as 'smart urban design & disabled', and 'smart technology & disabled'. The results of these searches were shortlisted as per their relevance to the topic and how current they were. For the purpose of this study, only studies published after 2010 were used in order to review the studies on smart technologies for the disabled.

Results and Discussion

According to Ojasalo, Seppälä, Suomalainen & Moonen (2010), new technologies and services of smart homes have the potential to increase the effectiveness and efficiency of caring disabled. The authors are of the opinion that there is a great potential to improve the quality of life of disabled people if the right solutions are used. The need for the development of such technologies and services increases due to the disabled individuals' desire to remain independent in their own homes, the increasing costs of health care, and the ageing of the population (Ojasalo, Seppälä, Suomalainen & Moonen, 2010).

Many times, assisted technology is abandoned due to various reasons. In a survey featured in the study by Galbraith & Hegde (n.d.), a third of all devices were abandoned completely due to reasons such as:

1. User involvement in device selection
2. Ease of procuring the device
3. Device performance
4. Change in ability.

Smart Home Applications

Smart homes are no longer design concepts for the future. Such a concept is also required by disabled people in order to make their life easier as they encounter a lot of problems in their everyday life, especially when they are at home. The study by Isilak (2010) is based on the wireless sensor network, which can be described as a collection of low-power sensor nodes which are connected wirelessly and where the system allows these sensor nodes to communicate with each other. In the study by Isilak (2010), the following systems, based on the integration of the wireless sensor network (WSN) in smart homes and its applications, have been described:

1. Automatic Door Control System
   According to Isilak (2010), this automatic door control system actuation has been developed for disabled people who had no hands or arms and hence, could not use the key to open and lock the door. Here, the system recognizes the person who approaches

the door and then decides whether to open or not to open the door, according to the identity of the person.

2. Gas Detection System
   Isilak (2010) says that this gas detection system actuation is for deaf people. He says that at home, deaf people may not be aware of sounds such as the doorbell or the gas leaking warning alarm. The author says that this system empowers deaf people by making them aware of a gas leak through a vibrating device carried by the person.
3. Warning System
   According to Isilak (2010), the warning system actuation is for people suffering from Alzheimer's disease. In this case, if there is a gas leak, the smart home system detects it and warns the person with sound, warning message as well as vibration.

According to Ojasalo, Seppälä, Suomalainen & Moonen (2010), Smart Homes contribute to caring for disabled people living alone at home, the elderly, and people with chronic illnesses. This approach to health assessment can better the quality and variety of information transmitted to the clinician. "Measures of physiological signs and behavioural patterns can be translated into accurate predictors of health risk. This can happen already at an early stage and can be combined with alarm-triggering systems as a technical platform to initiate appropriate action"(Ojasalo, Seppälä, Suomalainen & Moonen, 2010).

According to Ojasalo, Seppälä, Suomalainen & Moonen (2010), Smart Homes and Telecare can "provide the infrastructure for coordinating multidisciplinary care outside the hospital. This can include, for example scheduling visits with health staff and community health workers, automating the collection of clinical findings and test results". As the needs of people vary, therefore, the assistance provided to people should be customized.

Smart Elderly Home Monitoring System (SEHMS)

According to Pande & Sen (2014), the smart elderly home monitoring system (SEHMS) is divided into three different modules - safety monitoring system, telehealth system and telecare system. "The smartphone is connected to the monitoring system by using the TCP/IP networking method via Wi-Fi. A graphical user interface (GUI) is developed as the monitoring system which exhibits the information gathered from the system. The GUI opens an option for the user to examine the fall as well as make the confirmation or cancellation. A remote panic button has also been tested and implemented in the same android based smartphone. In addition, the monitoring system can also answer the call automatically after the emergency alarm has started" (Pande & Sen, 2014).

SNS Smartphone Application for the Disabled

According to Jeong, Lim, Hyun, & An (2013), both smartphone usage and data consumption have been drastically increasing. This trend is also visible amongst the disabled, and the number of smartphone users among the disabled has increased exponentially in recent years. Out of the five billion mobile phones in the world, 1.08 billion are smartphones. The study says that since the use of smartphones is increasing, people's lifestyles, as well as trends in the future of information technology, are being changed.

According to Jeong, Lim, Hyun, & An (2013), many applications which have a variety of different functions for easy access by the disabled (except the visually impaired or those disabled who are unable to use smartphones) have been released, and telecommunication companies also

provide their products at an affordable price. In their study, Jeong, Lim, Hyun, & An (2013) propose a new location-based Social Networking Service (SNS) application for the disabled population (except for those who are visually impaired or the disabled who are not able to use a smartphone) with three major characteristics of this application to be considered as follows:

(i) "the person uses a Social Networking Service (SNS) by constructing a friend matching system such as Facebook or Twitter, which are the most widely used SNS in the world;
(ii) the general population registers real-time information for a specific location on the map for the disabled population using SNS. This information with photos and messages is given and evaluated by users, and
(iii) this system makes it easier to see that the menu in the GUI was implemented" (Jeong, Lim, Hyun, & An, 2013).

Smart Walking Stick

According to the World Health Organization (WHO), there are 285 million people visually impaired people worldwide, out of whom 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired live in developing countries (Mahmud, Saha & Islam, 2013). The study by Mahmud, Saha & Islam (2013) is based on lessening the disabilities faced by the blind by "constructing a microcontroller based automated hardware that can corroborate a blind to detect obstacles in front of him/her instantly. The hardware consists of a microcontroller incorporated with ping sonar sensor, proximity sensor, wet detector, a micro pager motor and additional equipment". According to Mahmud, Saha & Islam (2013),

> "It is a walking stick, normally used by the blinds. But it is fully automated, easy to maintain, cheap, and it is very comfortable to use. The power consumption is low and can be operated easily. Above all the stick is very economic over the conventional one. The walking stick mentioned above is a stick that consists of a circuit board that contains a PIC microcontroller, a LED for indication, input from a micro-pager motor, and inputs from sensors that are installed at the proper position of the stick. The positioning of the sensors is predefined by real-life applications. The entire project is designed using a microcontroller based on its reliability. The micro-controller is code protected, so its security bridge cannot be overridden by the vendor or owner. Here one microcontroller is used, PIC16F690. All sensors' data are taken by the micro-controller, and it produces different Pulse Width Modulation (PWM) based on the output of the sensor to operate pager motor".

Low-Cost Self-assistive Voice Controlled Technology

According to Puviarasi, Ramalingam, & Chinnavan (2013), at times, low-technology devices are the most suitable and even preferred for their simplicity, ease of use, maintenance, and low cost. "Naturally, a wheelchair voice control system should operate reliably for a large number of users, reduce the physical requirements; and if avoiding the need to move on one or more road extremities, should assist a user in maintaining well the chair position" (Puviarasi, Ramalingam, & Chinnavan, 2013). However, the limited bandwidth of the voice makes it difficult to adjust frequently with the wheelchair's velocity, and also, a voice input system may fail to identify a speaker. Thus, voice interface has yet to become commercially viable for wheelchair control (Puviarasi, Ramalingam, & Chinnavan, 2013).

According to Puviarasi, Ramalingam, & Chinnavan (2013), the design of a state-of-the-art and low-cost self-assistive technology is used to simplify the control of a wheelchair and home appliances by using advanced voice commands of disabled people. This proposed system will provide an alternative to physically challenged people (such as quadriplegics who cannot move their limbs but can speak and hear) as well as to the elderly in controlling the motion of the wheelchair and home appliances by using their voices. In their study, Puviarasi, Ramalingam, & Chinnavan (2013) propose a system which enables physically challenged persons, like paralytic patients or physically disabled patients or patients having acute diseases like Parkinson's disease, to facilitate the control of a wheelchair. This is especially useful for people who can move their wheelchairs in their own direction without any third party's help or support. "Wheelchairs provide unique mobility for the disabled and elderly with motor impairments. The designed system is based on grouping a microcontroller with a new voice recognition processor" (Puviarasi, Ramalingam, & Chinnavan, 2013). This is likely to empower them to lead an independent, confident and enjoyable life.

Computer Vision Based Obstacle Detection and Human Tracking on Smart Wheelchair

According to Utaminingrum, Kurniawan, Fauzi et al. (2017), people with a physical disabilities such as quadriplegics may need a device which assists in their mobility. Hence, a smart wheelchair is developed based on a conventional wheelchair but is also "equipped with sensors, cameras and the computer-based system as a main processing unit to be able to perform specific algorithm for the intelligent capabilities" (Utaminingrum, Kurniawan, Fauzi et al., 2017). In their study, the authors describe the development of a smart wheelchair system which simplifies obstacle detection and human tracking based on computer vision.

Medical Technology in Smart Homes

The study by Ziefle, Röcker & Holzinger (2011) explored the attitude of users towards video-based monitoring systems for long-term care of elderly or disabled people in smart home environments. The focus of this study was on examining the readiness of users to accept medical technology in their homes and the specific conditions under which continuous monitoring would be acceptable.

According to Ziefle, Röcker & Holzinger (2011), decreasing both the costs of healthcare services and a load of doctors and nurses requires a dramatic change in the way future healthcare services will be provided. Various medical experts argue that “institutionalization in senior homes is unnecessary (and even counterproductive) and promote homecare as a fundamental component of a future network of long-term care facilities” (Ziefle, Röcker & Holzinger, 2011).

According to Ziefle, Röcker & Holzinger (2011), recent developments in information and communication technology have laid the foundation for new patient-centred homecare solutions. “While the majority of computer-supported healthcare tools designed in the last decades focused mainly on medical caregivers, this trend recently changed with the introduction of assistive technology for providing supportive and adaptive services to ill or disabled individuals” (Ziefle, Röcker & Holzinger, 2011). Several authors covered in the study even expect the next generation of healthcare systems to be primarily based on the homecare idea. This concept extends healthcare from the traditional hospital setting to the patient's home. The authors are of the opinion that since the availability of broadband network connections has expanded dramatically and the costs for networked cameras and large-scale displays have decreased, video-based homecare solutions are becoming an interesting alternative for a wide group of

patients. "Even low-cost systems provide high-resolution video images with low latency and offer a reliable infrastructure for medical monitoring and remote consultation" (Ziefle, Röcker & Holzinger, 2011).

RFID Technology

In the study by Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), the foremost scientific contribution of the study comprises uniting several new technologies to devise a method for the accessibility analysis of places in an urban environment. "The method is based on the deployment of RFID technology along the studied places of the city—both indoor and outdoor—to check which route citizens with and without a disability follow around these locations. This infrastructure performs a local analysis and allows continuous supervision over time" (Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor, 2015). RFID is extensively used to obtain location information for objects and people tracking. Additionally, more communication and processing capabilities are included on new devices embedded anywhere. According to Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor (2015), based on the authors' previous experience with these technologies and other previous research works, "the working hypothesis of this research is that this type of solution can be used to trace users with and without movement disabilities when they move around the city and to check whether they are accessible" (Gilart-Iglesias, Mora, Pérez-delHoyo & García-Mayor, 2015).

Conclusion

In this paper, we have reviewed studies which have been carried out on the subject of smart urban designs and technologies for the disabled or the specially-abled. It was found that due to the pervasiveness of wireless technologies and the Internet, there are a lot of technologies which have been coming up for the disabled and the elderly. Smart home applications, some of them dealing with healthcare, smart wheelchairs, smart walking sticks etc., are some of the examples of proposals that authors have talked about. One of the practical implications of this research is that there is a shortage of research on the interaction between smart technologies and smart city infrastructure for the disabled.

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