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Computer based electronic system smart wheelchair

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ABSTRACT

This paper describes the design of a smart wheelchair with computer control systems. A short overview about wheelchair technology is explained with main parts of the system. This project also includes some evaluations and discussions of the smart wheelchair technology in the following pages. Some important considerations such as anthropometric, control, cognitive and environmental in wheelchair design are described in more detail. Furthermore, this project provides that the computer control system allows the chair user a safe, easy ride, and creates cognitive relation between user commands and actual trajectories.

KEYWORDS

Smart wheelchair;
Computer based wheelchair;
Motion control;
Wheelchair design.

INTRODUCTION

Due to the accidents, drugs or some chemical process, humankind can have physical injuries and limited control of their movement and this situation causes a significant mobility problem. As a result of this kind of situation, such people need equipment or an attendant to do their some daily activities such as movement, walking. Wheelchairs can be considered as a kind of medical devices which immobilized people use to improve their accessibility. Even though, to our knowledge, it is unknown exactly about the origin of the earliest design of wheelchairs and its main purpose. Depending on some pictures, the first three wheels of wheelchairwas designed by Chinese (6th century) and developed by Europe (16th century)[11]. According to McFarland and Wilson (1986), the first real wheelchair was appeared in the United States with two large wheels and a wooden bulky chair therebythe first wheelchair patent was delivered in the United States in around 1869s. Following these developments, in the beginning of 1900s, an electrical-driven wheelchair operating was launched to design and it was commonly fitted with electric drives in 1960s[11].

In 1990s, most wheelchairs were commercially ready on the market with still some technical problems such as heavy, bulky and infeasibility for transportation[8]. In this century, it is simply possible to have very well designed wheelchairs which is called 'smart wheelchair'. This type of wheelchair intended to decrease user's mission of driving motor-pow-

ered wheelchair. Although there is considerable number of types of wheelchairs such as manual wheelchair, standing wheelchair, bariatric wheelchair and pediatric wheelchair, smart wheelchair that havea significant place among others due to the utility, feasibility, controllability and suitability for the extremely disabled people[5]. The purpose of this essay is to explainthe technical features of the smart wheelchairs and focus on anthropometric, visual, control, cognitive, environmental considerations of the wheelchair in order to refer to common human factors in this technology. There will be also a comparison between smart wheelchair with others to observe weak and strong points of those wheelchairs.

SMART WHEELCHAIRS

Wheelchair technology crucially needs to be developed compared with the any other technologies because disabled people have opportunity to participate in the society, they can do some daily activities such as sport and exercise by themselves due to the provided technology. Therefore, the smart or intelligent wheelchair technology plays vital role in providing new life style for disabled people in order to reduce their tasks and decrease unexpected accidents. These devices enhance personal mobility in order to enjoy human rights and be a productive member of communities by applying artificial computer control systems as well[1].

Design of the smart wheelchair

Similar structural modelsfor the most of the wheelchair types are usually used with small differences in quality. First of all, these main parts of a wheelchair will be explained then different parts of smart wheelchairs will be given as follows:

(a) Frame

The frame is considered to be durable and employable for all terrain. The frame can be rigid or folding, both have advantages and disadvantages such as folding may be better for transporting but worse in terms of durability.

(b) Brake

Brake requires stopping wheelchairs in all required conditions such as descending when sloping and should not release while in use. It is also needed to be highly mounted to provide better pull and push action.

Figure 1 : Frame of a smart wheelchair

(c) Wheels

Wheels shows differences in terms of sizes due to the their user's needs. Additionally, the usage terrain and the weight of the wheels are other important parameters for wheel design such as light wheels requires less maintenance compared to heavier wheels.

(d) Armrest, backrest and footrest

Armrest and backrest length and high of wheelchair are important to access desk or other places. Therefore, armrest length should be removable and backrest should fold down. On the other hand, footrest should not break and bend easily and it needs to fold with reasonable power.

As mentioned above, these tools can be considered main technical feature for mainly all types of wheelchairs, apart from this smart wheelchair technology includes some electronic materials which

Figure 2 : Brake system of a smart wheelchair

Figure 3 : Wheel design of a smart wheelchair

provide easy control and more penetration to life.

(e) Hardware module

This module leads the wheelchair to act as a person, it can notice some important actions its surrounding such as environmental changes, some sense, user's command and planning next actions[2] (Braga et al., 2009). These all electronic parts work in a well combination and perfect realtion with users.

Traditional joystick
USB joystick
Head gesture
Keyboard and touch screen
Facial expression Figure 5

(f) Control module

This module can calculate the path condition and shape of the path and gives opportunity to ride on the safe area by depending on a basic control[4].

(g) Navigation module

This module works cooperatively with a very sentive sensor; it provides localization and planning information to the sensor to find needed location or any parts in the living area.

How does it work

In this technique, it is mainly aimed that to break down complex problems into several modules (hardware, simulation, control, navigation, planning and communication) by applying achieved advance control system in order to make driving easy for disabilities[5]. There are three leading control layers (basic, tactical, strategic) which are divided into two agents (control, intelligent). Control agent works with tactical layer, which includes information from basic layer, and the linear and angular speed are calculated by the control agent. The interaction between users and other systems are arranged by the intelligence agent that works with strategic layer.

Comparison with others

It obviously too hard to compare the smart wheelchair with other wheelchair technologies because other technologies such as manual wheelchairs may have some technical advantages or can be affordable[18] while the smart wheelchair offers more mobility and penetration to the society and communities as well as it makes disabled people more productive which is very important for disabled people to feel valuable person of this life for them. In the smart wheelchair technology, it is proposed that to

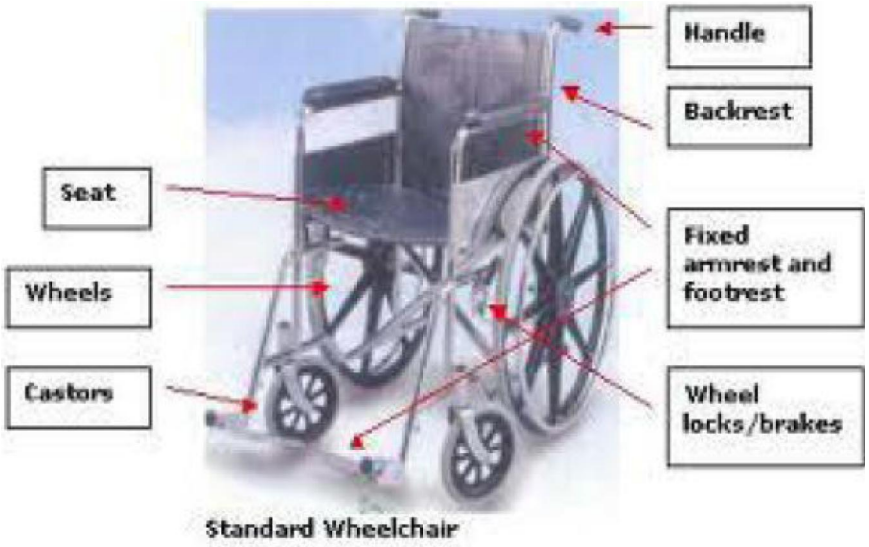

Figure 4 : Armrest, backrest and footrest of a smart wheelchair

Figure 5 : Smart wheelchair prototype

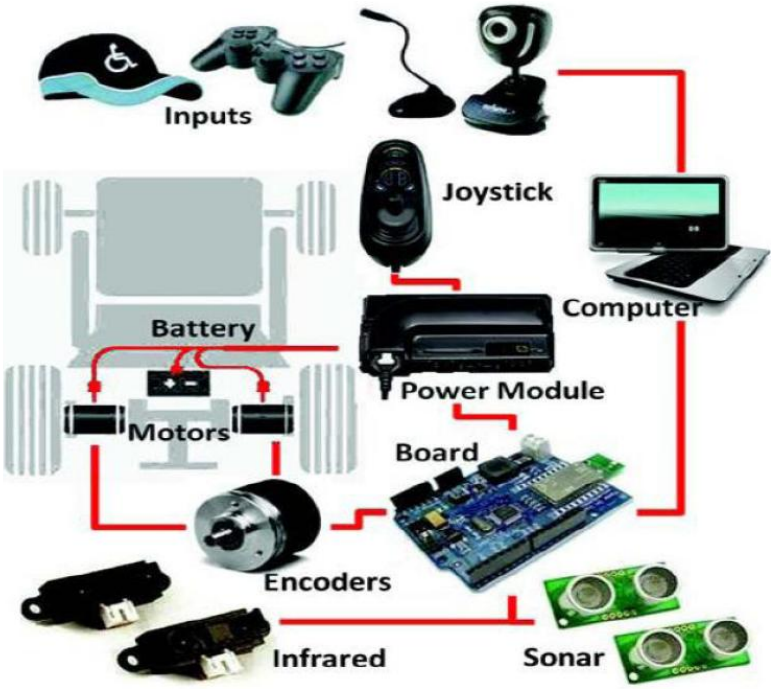

Figure 6 : Architecture of Smart Wheels hardware framework

form a strong interaction between users and computer based system to overcome all the difficulties which disabled people can face in their daily action. In this context, not only all tests have been carried out yet but some of them tested and implemented and significantly positive result obtained from these tests[3]. Due to the smart wheelchair technology, disabled people can drive alone and feel independent which the most important right is for human kinds are.

SOME IMPORTANT CONSIDERATIONS IN WHEELCHAIR DESIGN

Anthropometric consideration of the wheelchairs

Because of the crucial importance of the wheelchair in disabled people and deviously attendant people life, there are many studiesthat have been carrying out by many scientists and designers who try to develop wheelchair technically by applying

Figure7 : Cycling Wheelchair Brake system[7]

different type of methods for instance, using computational control system. Technical features are obviously considered to be a significant part for all system and there is no disagreement about the importance of it. On the other hand, for the wheelchair technology the interaction and compatibility of the human body to the wheelchair system has an inarguable importance for feeling comfortable when in use[14]. This is mainly due to the anthropometric structure of human body. Due to the considerable differences within disabilities, anthropometric data is needed to achieve maximum usefulness and to design a convenient wheelchair for all disabled people[8]. In this context, Paquat and Feathers (2004) also mentioned that there are anthropometric differences mainly from gender, wheelchair type and age therefore three dimensional methods, which capture body and wheelchairs landmarks to use it in the calculation of standard anthropometric dimensional values, are applied to obtain more reliable average anthropometric value. Furthermore, because of the high developed technology (3D light-based body scanner); it is considerably easy to obtain more reliable and wide rage anthropometric data with high degree accuracy in relatively short time[17].

Control consideration of the wheelchairs

There is a significant increase in the number and types of wheelchair with very high quality and more functionality. Having an advance in technology allows designer and engineer to design better wheelchairs as well as any kinds of machine to provide easy use and make life easy for people. Controlling a device by a driver is the first main step to have safe travel in any kinds of machine. For disabled people, controlling has a vital importance thereby it is tried to use computer based control system in the wheelchair system (smart or intelligent wheelchair). For example, Autonomous robotic wheelchair, which is a kind of smart wheelchair, technology uses an embedded control system[9]. In this system some kinds of information are collected from the environment by sensor or other electronic tools and evaluated in computer based control sys-

Figure 8 : Embedded control system[9]

tem to promote autonomous driving. In addition, it is aimed to strengthen walking abilities for disable people to avoid them leg weakness by travelling themselves incycling wheelchair system. Moreover, there is a handlebar controlling bottom to manage navigation system which allows finding desired location and also a servo motor brake system is also built up to control speed to prevent unexpected collision Figure 6s[7].

Cognitive consideration of the wheelchairs

Smart wheelchair can be considered to be a perfect example to make strong relation between wheelchair design and its users. As it was mentioned in section 2 above, there is a computer based control system mounted to the wheelchair. These controls system can detect some environmental changes surrounding and can create actions according to these stimulation. All those studies mainly focus on physiological or technical sides of the wheelchairs but cognitive and motor abilities of wheelchair users are also other significant parts of achieving goals of everyday life for the severely disabled people. In this context, there were some valuable studies to teach how to control a powered smart wheelchair for high level spinal cord injured and serious brain injured patients in a more than one month process[10]. As a result of this observation, intention estimation method is developed which makes relation between users gaze and wheelchairs. In this method, wheelchair is controlled by gaze movement via electro-oculographic potential[15]. At the same time, there is a cognitive burden for users that they are needed to know their natural gaze behavior[10]. On the other hand, visual consideration can be considered an important need for a successful design of any devices regardless of its aim in the field of engineering. The appearance of the wheelchair can show differences according to types of the wheelchair or due to any special needs.

Environmental consideration of the wheelchairs

In terms of environmental concerns of wheelchair users, rehabilitation centers are significantly important since it can be provided safety area for individual using which encourages disabled people to participate to real life in spite of having a limited training time. On the other hand, there is a virtual reality training method which applies more interactive and practicable training activities to be more realistic and adaptable to environment effectively[13]. Due to the driving difficulties of wheelchair in real environment or in society, it is needed to be trained more practically to reduce collision or ineffective use. Smart wheelchair technology clearly contributes to disable people environmental adaptation process due to its computational based electronic system[12]. It is widely believed that wheelchairs users will face really challenging difficulties in the society for instance, inconvenient infrastructure of the paths crowded people population. It is needed to develop the wheelchair technology to overcome these mainly environmental issues.

With the developing of the technology in wheelchair as well as all other devices, the health, performance and comfort of people are intensely considered as a main target which are significantly important and the essential purpose of the implementation of human factor in engineering. As a recommendation, the wheelchair technology could be designed with a computer based control system which increases the mobility of disabled people by giving opportunity to control individually as has mentioned above. However, inter- subject and intra-subject variability, which interested in the relationship between people and different environmental conditions to raise the performance, comfort and health should be taken into account during design of the wheelchair mechanical and electronic process. For instance, when disabled people expose difficult weather conditions such as heavy rains during their daily activities, they could protect themselves using the technological features of the wheelchair. In this regard, an automatically coverable wheelchair could be designed for rainy days and it could be opened a sunny day which prevents disabled people from the unexpected weather conditions.

CONCLUSION

All technological developments aim to provide higher living standard for humankinds even

though some environmental damages are caused by the technology such as CO_2 emission released by burning fuels in combustion engine. Apart from this, wheelchair technology has significantly different position among other technologies because there are great number of disabled people (around 10% of the world population equal 650 million disabled people) in the world and 10% of disabled people need wheelchair[6]. This proportion confirms that why there is a strong demand for the wheelchair technology. As it was mentioned above, on the one hand wheelchair technology makes contribution to mobility of disabled people. On the other hand, it is also possible to create cognitive relation between users and wheelchair computer based electronic system that gives opportunity disabled people to control wheelchair when in use. In other words, disabled people can be a more productive member of the society.

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