American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-4, pp-90-94
www.ajer.org
Research Paper Open Access

Smart Navigation and Control System for Electric Wheelchair

Bader Dakhilallah Samran Alrashdi, K. Prahlad Rao[1] and Naif D. Alotaibi
Department of Electrical and Computer Engineering, Faculty of Engineering, King Abdulaziz University, Jeddah, Saudi Arabia
[1]Corresponding Author: prahladk@gmail.com

ABSTRACT: *When a keyword for wheelchair is searched on internet browser, the search engine returns with more than 1.8 billion. Such a big number is an indicator of a large group of people interested in the wheelchair. Meaning that, the larger interest corresponds to greater demand. Recent statistics shows that 1 in 4 of Americans have a disability that impacts major life activities and number could slightly differ in other countries. The people with disability are trying to move independently for schools, work places, markets and other places of their interest. Therefore, they are needed by a mobility aid which is safe, comfortable and less expensive. In this paper, the development of navigation and control system for an electrically powered wheelchair is reported. The system requires popularly used Smartphone Arduino UNO board, motor driver, joystick and proximity sensor. For navigation and tracking the destination, mobile application software is developed on Android platform. Arduino platform was used as microcontroller for interfacing the sensors and electric motor driver board. The system was tested for the speed, operational skill and safety issues. From the tests it is found that the navigation and control of the wheelchair is efficient, cost-effective and reliable.*
KEYWORDS: *Wheelchair, Disability, Arduino, Android, Microcontroller, DC Motor*

Date of Submission:28-03-2019 Date of acceptance: 08-04-2019

I. INTRODUCTION

Personal mobility devices are designed to assist walking the people with mobility impairment. There are many walking aids which can improve with impaired ability to walk and wheelchairs for more severe disability or longer distance journeys which would otherwise be struggling on foot. The wheelchair basically substitutes for walking by providing a wheeled devise on which the user sits. Wheelchairs may be either manually propelled or electrically powered. But the demand for electric powered two-wheeled wheelchair is growing rapidly because of the fact that they do not require any assistance from others or physical strength to go around. Wide range of wheelchair models is entering the market to meet its user's requirements. But, there is a big challenge to the designers and manufacturers to produce a comfortable, convenient, and greater efficient with cost effective technology. Therefore, the objective of this research is to design an electrically energized wheelchair with sophisticated technology to control the movements without straining its user. We use popular Smartphone with newly developed application software to navigate the wheelchair and evaluated the performance.

II. LITERATURE REVIEW

Wheelchairs are considered as medical devices. Patients with impairment in mobility are prescribed by the clinicians to use the wheelchair for assisting in their movement independently. In the present competitive world, every individual wish to engage themselves either in jobs or educational activities irrespective of their disability. People with disability often are at risk of health problems which could have great impact on physical, mental, emotional and social activities. Therefore, they look for an improved ride in wheelchairs to become independent from family members and care-takers promoting self-reliance. Traditional wheelchairs which need to be propelled manually for mobility are difficult to maneuver by individuals in confined spaces [1]. Due to the fact that manual wheelchairs are more physically demanding, powered wheelchairs were emerged in the market since early 1970 [2]. Since then, a considerable research and development activities are being focused in the improvisation of electric wheelchairs. Several methods have been reported for the navigation and control of electric wheelchair such as joystick [3], voice controlled [4][5], vision based [6][7][8] and gesture controlled

[9][10][11]. Several researchers have developed smart wheelchairs utilizing the trending IoT technologies [12][13]. Traditional input methods such as joystick, pneumatic switches have also been incorporated in smart wheelchairs. It has been reported that the wheelchairs can be controlled from mind. The principle in the technique is based on acquisition of brain waves through electroencephalography electrodes positioned over the wheelchair user's head and then the processed signal is made to actuate the controllers of the wheelchair. The technique is also known as brain-computer interfacing (BCI) method of wheelchair control. [14][15]. All these methods have been made possible because of advancement of sensors and control interfaces which has significantly increased during previous years.

Now-a-days, Smartphones are ubiquitous in human life because of their ever-increasing technology and affordability. Multifunctional mobile phones with superior display quality and internet accessing capabilities are being boosting them to play a vital role in human life. Emerged primarily as communicative device, the mobile smart phones are extending their uses to medical applications too. Several application software (App) on Android platform are being developed for performing daily tasks [16][17]. We tapped the merits of the smart phone for navigating the wheelchair and an Arduino microcontroller is employed to control the sensors and motors in the wheelchair. In this project, we developed the wheelchair control and navigation system from the new trend of technology making it as economically viable, less complexity and easy operation in comparison with previously reported methods.

III. PROPOSED METHODOLOGY

(a) The Wheelchair:

The core of this project is the wheelchair. Due to several advantages of electric wheelchair over the traditional manual type, an used electric powered wheelchair is considered in this work. The wheelchair is assembled with two D.C. motors; each of 24 Volts, 250 Watts, an electrically chargeable battery, and two driving wheels coupled to the motor shaft through a 28:1 gear system and two balancing freewheels. This wheelchair did not have any efficient peripheral devices such as motor control system, sensors and controlling mechanism. We designed all these peripherals and then assembled on the wheelchair. The assembled wheelchair is shown in Fig. (1). The battery, control circuit boards and separate d.c. power supply source for the circuits are fixed in a custom-made wooden box that is placed under the seat of the wheelchair.

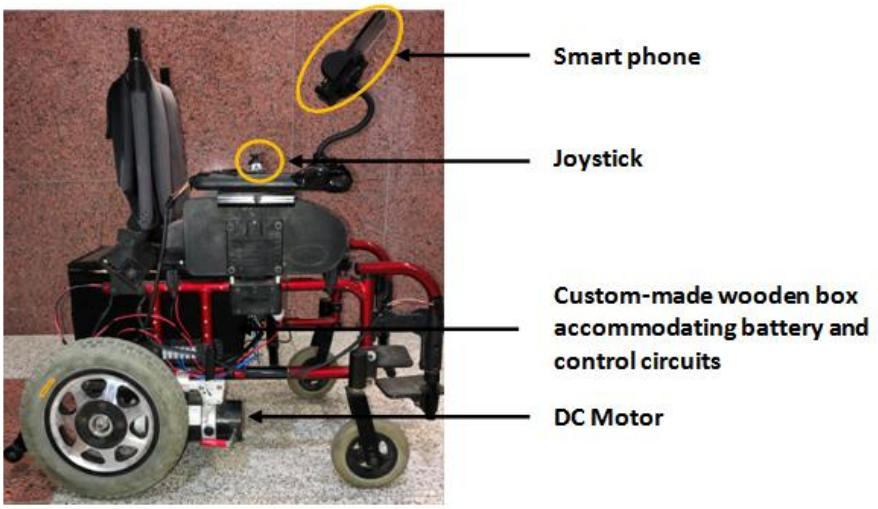

Fig. 1. Electric Wheelchair with assemblies

(b) Architecture of the Proposed Wheelchair Navigation and Control System:

Fig. (2) shows the block diagram of the proposed scheme to implement on electric power wheelchair. The scheme is designed to minimize the physical and cognitive load needed to be applied in steering the wheelchair. The hardware part in the system consists of an embedded system which is based on Arduino Uno board as microcontroller, user interface module, Android based smart phone and motor driver. For navigation of the wheelchair, dual methods using traditional joystick and popular Smartphone, are employed. The joystick is used as standby to the phone when the wheelchair goes beyond internet connectivity area. Smartphone is basically a mobile phone based on mobile OS (operating system) such as Android, iOS or Windows. It has more advanced features than an ordinary mobile phone. Android OS is emerging as a popular operating system in mobile phones, tablets and computers. This platform is based on Linux kernel with user interface and regarded

as high level language and the code is written in Java programming language. Many application software (App) have been developed on Android platform [18] since it offers open source programming [19].

For the flow of commands between hardwares, Arduino platform was used as microcontroller. Arduino UNO (Arduino, Ivrea, Italy) has an ATmega 328P microcontroller with 16 MHZ clock, 32 KB flash memory, 2 KB SRAM and 1KB EEPROM memory. It is used in many stand-alone project building circuits which has 6 analogic input and 14 digital I/O works with 5 V DC supply. Among 14 digital doors, I/O pins 3,5,6,9, 10 and 11, PWM (pulse width modulation) output is available. Arduino platform is selected in our project because its programming environment is easy to use and much flexible unlike other Window based microcontrollers.

The two d.c. motors are controlled by the microcontroller through a driver board. The motor driver (DROK 16A Dual Channel) is a dual channel, H-Bridge, DC brush motor controller that can be used for DC 5V-36V, 12V, 24V and 30V high power, PMW speed regulation.

To protect against un-noticed obstacles while motion, an ultrasonic sensor is installed on the wheelchair. The sensor recognizes any obstructions on the way far from 0.5 m distance and it is programmed to send the flag by the microcontroller and stops the vehicle when it approaches a set value of distance in the code.

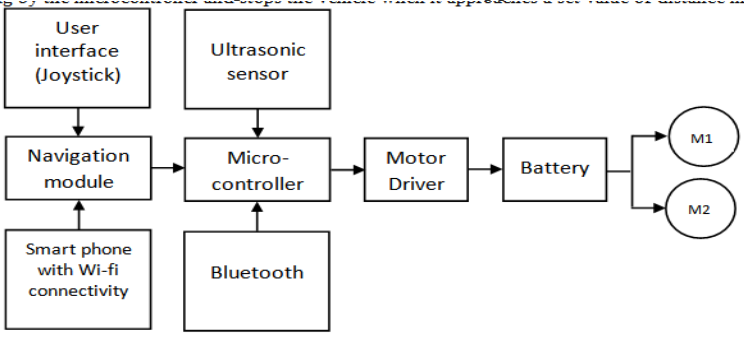

Fig. 2. Block diagram of Wheelchair Navigation and Control system

IV. RESULTS AND DISCUSSION

A user-friendly Android based mobile application software was developed and tested by comparing with another mobile phone. The screenshot of the App is shown in fig. (3). The mobile App is GPS based and can browse the Google Map in which the destination to travel can be selected. Below the map, two press buttons are created from the software programming. One button is indicated as "CONNECT" and another as "DISCONNECT". When the wheelchair user is seated comfortably then the CONNECT button can be activated making the microcontroller initiate the motor driver for electrical supply from the battery to both motors. The wheelchair can be stopped by using the button DISCONNECT. These are included in the App itself avoiding use of mechanical ON/OFF switch which may be inconvenient to the disabled. Four arrow marked buttons are also created on the front of the app through the programming. These are used to navigate the wheelchair along the track shown in the map window to reach the desired location. It has been tested ten times for different locations to confirm consistency from repeatability. All the test are performed in our university campus. These tests have been performed by operating the app remotely without any person seated on the wheelchair.

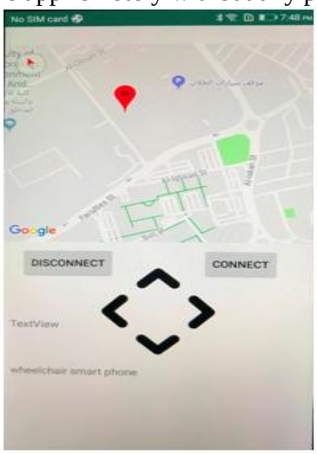

Fig. 3. Screenshot of Android Mobile App for wheelchair navigation

Then the wheelchair was operated realistically by a volunteer of 17 year old male boy without any disabilities weighing 45 Kgs. His psychological feelings and movement of the wheelchair along the selected track was observed from a distance of 1 m. It was noticed that there was no any discomfort to the user while operating it.

Speed of the wheelchair can be set in the programming to the desired value. We have tested the wheelchair at 100, 80 and 60 digital values in the Arduino code. It is found from many trials that the speed at 80 digital values is comfortable, moderate and safe value. While moving in a corridor of the building measuring 3 m., an obstacle was simulated by placing a small desk close to the movement track at one point. It has been observed that the proximity sensor started beep siren prompting the hindrance on its track. When it moved close to 10 cm away from the desk, the wheelchair stopped due to the action of ultrasonic sensor.

From all these tests and observations, it has been experimentally verified that the designed navigation and control system for powered wheelchair is efficient, safe and easy to operate. The rider feels stress-free in driving the wheelchair and enjoys the ride as if a favorite video game is being played. This characteristic is more appealing and attractive because any person feeling physically and emotionally distressed disabilities should not be burdened of driving.

V. CONCLUSION

An efficient, safe and simple navigation and control system for driving an electric wheelchair has been developed and evaluated. Arduino platform was used as microcontroller for interfacing the sensors and electric motor driver board. For execution of commands, the microcontroller was programmed by using Arduino IDE software. For the navigation of wheelchair, Android application software was developed and tested. The App can browse the map to locate the destination and create a track from initial position. Safe drive was ensured from ultrasonic sensors controlled by the microcontroller for the presence of any obstacles on the track. The system of operation is simple, easy and enjoyable without requirement of any rigorous training in its operation. It is also cost effective, comfortable and easy to build with the components which are readily available.

REFERENCES

[1]. Cooper, R.A. Wheelchairs and related technology for the millennium. Journal of Rehabilitation Research and Development, v.37, (3), 2000.

[2]. Nash MS, Koppens D, van Haaren M, Sherman AL, Lippiatt JP, Lewis JE. Power-assisted wheels ease energy costs and perceptual responses to wheelchair propulsion in persons with shoulder pain and spinal cord injury. Arch Phys Med Rehabil. 2008 Nov;89(11):2080-5.

[3]. H.R. Singh, A Mobin, S Kumar, S Chauhan and S S Agarwal, "Design and Development of Voice/Joystick Operated Microcontroller Based Intelligent Motorised Wheelchair", Tencon 99. Proceedings Of The IEEE Region 10 Conference, Vol 2, pp. 1573 – 1576, Feb-1999.

[4]. M. Mazo, F. J. Rodr´ıguez, J. L. L´azaro, J. Ure˜na, J. C. Garc´ıa, E. Santiso, and P. A. Revenga, "Electronic control of a wheelchair guided by voice commands," Elsevier of Control Engineering Practice, Vol.3, pp. 665-674, 1995.

[5]. Rahul CM, NaliniC Iyer Voice and Accelemeter controlled Wheelchair, IJERECE ,vol:2 (11), Nov 2015.

[6]. P. Jia and H. Hu, "Head Gesture based control of an Intelligent Wheelchair," The 11th Annual Conf. of the Chinese Automation and Computing Society in the UK (CACSUK05), pp. 85-90, 2005.

[7]. D. Purwanto, R.Mardiyanto, and K. Arai, "Electric wheelchair control with gaze direction and eye blinking," Proc. of The Fourteenth Int. symposium on Artificial Life and Robotics, Vol.GS21, No.5, B-ConPlaza, Beppu, 2008.

[8]. K. Kawai, S. Hiramatu, Z. Luo, and A. Kato, "Construction of intellectual control system of autonomous, electric wheelchair," Bulletin of Aichi Institute of Technology, Part B, Vol.39, pp. 21-27, 2004.

[9]. Ericka Janet Rechy-Ramirez, Huosheng Hu and Klaus Mcdonald-Maier, "Head Movements Based Control of an Intelligent Wheelchair in an Indoor Environment", International Conference on Robotics and Biomemetics, pp. 1464-1469, June-2012.

[10]. Jeet K.Desai and Lifford Mclauchlan "Controlling A Wheelchair By Gesture And Wearable Movement", IEEE International Conference On Consumer Electronics (ICCE), Vol.3, no. 2, pp. 34-49, June-2017.

[11]. S. U. Khadilkar and N. Wagdarikar, "Android phone controlled voice, gesture and touch screen operated smart wheelchair," 2015 International Conference on Pervasive Computing (ICPC), Pune, 2015, pp. 1-4.

[12]. Simpson RC. Smart wheelchairs: A literature review. J Rehabil Res Dev. 2005;42(4):423–36.

[13]. Carmen Domingo, Mari. (2012). An overview of the Internet of Things for people with disabilities. J. Network and Computer Applications. 35. 584-596.

[14]. Craig D.A., Nguyen H.T. Adaptive EEG thought pattern classifier for advanced wheelchair control; Proceedings of the 29th Annual International Conference of the IEEE on Engineering in Medicine and Biology Society (EMBS); Lyon, France. 22–26 August 2007; pp. 2544–2547.

[15]. Herweg, Gutzeit J., Kleih S., Kübler A. Wheelchair control by elderly participants in a virtual environment with a brain-computer interface (BCI) and tactile stimulation. Biol. Psychol. 2016;121:117–124.

[16]. A. Garate, I. Lucas, N. Herrasti and A. Lopez, "Ambient intelligence as paradigm of a full automation process at home in a real application," 2005 International Symposium on Computational Intelligence in Robotics and Automation, Espoo, 2005, pp. 475-479.

[17]. H. D. J. Jeong, J. Lim, W. Hyun and W. Lee, "A Remote Lock System Using Bluetooth Communication," 2014 Eighth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing, Birmingham, 2014, pp. 441-446.

[18]. Ozdalga E, Ozdalga A, Ahuja N. The smartphone in medicine: a review of current and potential use among physicians and students. J Med Internet Res. 2012;14(5):e128. Published 2012 Sep 27. doi:10.2196/jmir.1994.

[19]. K. Prahlad Rao, Mohammed Ahmed Hanash, Gaafar Ahmed AL-Aidaros, "Development of Mobile Phone Medical Application Software for Clinical Diagnosis", International Journal of Innovative Science and Modern Engineering ISSN: 2319-6386, Volume-2 Issue-10, September 2014.
[20]. Pasha M.F., Supramanyam S., Liang K.K., Amran M.A., Chandra B.A. and Rajeswari M. (2012). An Android-based Mobile Medical Image Viewer and Collaborative Annotation: Development Issues and Challenges. Int. J of Digital Content Technology and its Applications. Vol. 6, No.1, 2012, pp. 208-217.

Bader Dakhilallah Samran Alrashdi" Smart Navigation and Control System for Electric Wheelchair" American Journal of Engineering Research (AJER), vol.8, no.04, 2019, pp.90-94