iMEDiTEC 2017

ORIGINAL PAPER

Electric Standing Wheelchair Controller to Provide User Safety and Comfortness

Ahmad G. W. Rahman [a,*], Renaldo H. Putra [b], Didik S. Purnomo [c], Endah S. Ningrum [d]

[a,b,c,d] *Mechatronics Engineering Division, Energy and Mechanical Engineering Department, Politeknik Elektronika Negeri Surabaya, Sukolilo 60111, Surabaya, Indonesia*

* *Corresponding author: aghifari35@gmail.com*

ABSTRACT

There are several products electric wheelchair wherever issued, but their range is limited with physically challenged when they would reach or take higher position objects. Based on these problems, then at this paper discusses the control of electric wheelchair is able to support user into a standing posture. According to the wheelchair control particularity for requirements, this paper proposes an adaptive-PID control strategy in accordance with wheelchair speed deviation and changes in the rate of deviation which is applied to DC motor speed control system to achieve optimal speed and acceleration for the wheelchair.

INTRODUCTION

The number of physically challenged sizeable course will be a problem, especially in terms of participation in the construction sector which became a human right regardless of socioeconomic status is concerned. Indonesian Ministry of Health in collaboration with WHO, which began in 1975 has found that as many as 3317 or not less than 9.2 % has various limitations and physical disabilities, and increased to 12 % (Irwanto, 2009). Although it has been widely available aids such as wheelchairs, obtained either personally or given freely by the public or the government, does not reduce the limitations of people with disabilities in the activity. The problems increase participation rates in terms of everyday life in the community.

A wheelchair cannot only bring people with disabilities from one place to another easily, but also can support their daily activity. For example, a wheelchair that can help them to reach something that require them to stand up in order to reach it. Based on these following problem, a wheelchair that has an ability to make its user can stand up is being made. However, this paper focused on the control system. The main objective of this paper is to make a control system that can make the user feel comfortable.

The control system of electric wheelchairs is different from the general industrial DC motor control systems. The control system of electric wheelchair have many requirements so the wheelchair become comfortable and safe. the concrete requirements are the following (Tian *et al.*, 2009):

1. DC motor used in wheelchair is required to have a certain startup time and smooth process to remove the discomfort caused by inertia compared with the general DC motor. According to the results of psychological research, the start-up time should not be less than 5 seconds.
2. The overshoot is not permitted in the electric wheelchair when reaching the high speed compared with the general DC motor control system.
3. The process of adjusting speed should have certain time and is smooth enough without oscillation, which can supplies a comfortable feelings.
4. The control system should have a strong ability of anti-load disturbance.
5. The braking process time as same as the startup must be less than 2-6 seconds.

To obtain the desired motor response which fulfils the requirements, firstly the simulation should be done. In order to make a valid simulation, parameters of the electric standing wheelchair system needed to be included. First order model system was used to obtain the parameters. First order models are used in a large number of different applications, where the main dynamic is reasonably damped. First order models are also the basic for a number of controller methods. There exists a number of methods for estimation of the parameters in a first order system. One of the most used methods for estimation of parameters in first order systems is to apply a step response (Niemann, 2014).

MATERIALS AND METHOD

Method

To provide user comfort and safety, the electric standing wheelchair should be installed a control system that can fill the requirement of electric wheelchair control system. Because of that, adaptive-PID control has been chosen to become the control system method. Its robustness through some loads and stability in desired speed are some of the advantages of this method (Takeshi, 2012). And to make sure that the system works as are desired, so a standing wheelchair has been made. The wheelchair that has been made is shown in Fig. 1.

OPEN ACCESS Freely available online
eISBN 978-967-0194-93-6 FBME

.

Fig. 1 the appearances of the electric standing wheelchair in (a) sit-form and (b) standing-form

The sit-form of the electric standing wheelchair can be seen in Fig. 1(a). And in the Fig. 1(b) is the appearance of the electric standing wheelchair while in standing-form. Electric standing wheelchair is using a total of three motors. There are two DC motors to drive the wheelchair to start, brake, stepless speed regulating, go forward, go backward, 360 ° turning with a certain radius or not controlled by these two motors. And one DC linear motor to make the wheelchair can be transformed Controller Dual Motor differential control algorithm, wheelchair controller system will limit the single-phase plane coordinate Push Button through a series of coordinate transformation, and finally get to meet the maximum speed coordinates of the differential control, forward, backward, and turning. This coordinate is directly used to the dual-motors' motion control, with a very good controllability.

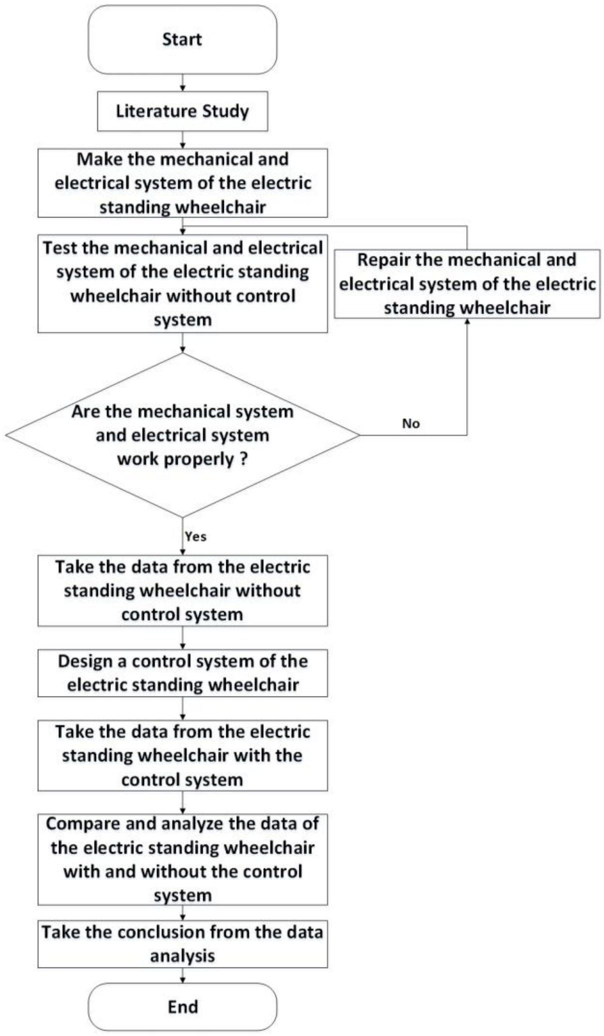


Fig. 2 The flowchart of this research

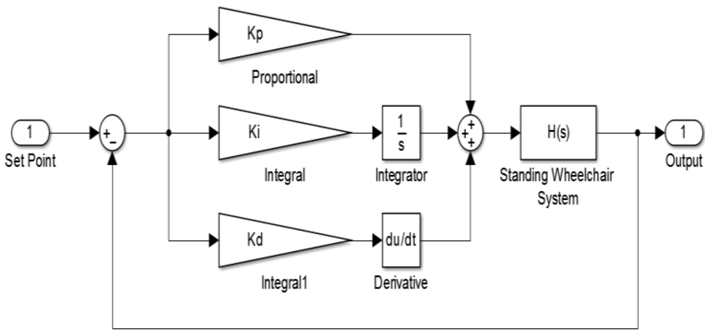


Fig. 3 The PID Control System Diagram

Fig. 2 is the flowchart of the research. The research method used in this research is experimental method. By applying the method on standing wheelchairs that have been made, it will increase the level of validity of this research. The system can also be applied to the actual electric standing wheelchair. In addition to the experimental method, the literature study was also conducted to find out about previous studies. In order to obtain the comfortness and the safety of the standing wheelchair, control system are needed to embed on it. Fig. 3 shows the PID control used on the standing wheelchair.

Modelling the standing wheelchair system

OPEN ACCESS Freely available online
eISBN 978-967-0194-93-6 FBME

In order to obtain the best controller, simulations are needed. Simulations are done in software MATLAB™. In simulations, the model of the system that would be controlled is needed to be included in simulations. In modelling, first order model was used to estimating the parameter of the electric standing wheelchair. To get the parameters for simulations, the electric standing wheelchair's motor is given an step input voltage without feedback control. The motor speed data is taken using a rotary encoder sensor placed on the motor shaft. Eq. (1) shows the general equation of first order system G(s).

$$G(s) = \frac{k}{Ts+1} \quad (1)$$

$$C(s) = G(s) \times D(s) \quad (2)$$

$$C(t) = kD(1 - e^{-\frac{1}{T}t}) \quad (3)$$

Where k is the gain and T is the time constant. k is obtained by dividing the constant speed of the motor with the step input. In Eq. (2), $C(s)$ is an output of the system and $D(s)$ is an input to the system. Eq. 3 shows time-domain equation of the output of the system.

RESULTS AND DISCUSSION

The electric standing wheelchair is using a total of three motors. There are two DC motors to drive the wheelchair to start, brake, stepless speed regulating, go forward, go backward, 360 ° turning with a certain radius or not controlled by these two motors. And one DC linear motor to make the wheelchair can be transformed Controller Dual Motor differential control algorithm, electric standing wheelchair controller system will limit the single-phase plane coordinate Push Button through a series of coordinate transformation, and finally get to meet the maximum speed coordinates of the differential control, forward, backward, and turning. This coordinate is directly used to the dual-motors' motion control, with a very good controllability.

To find out whether the wheelchair stand that has been made requires a control system or not, then experiments are performed. The experiment is done by measuring the speed of a DC motor. The measured DC motor is a DC motor used to drive the wheels. DC motor is measured with no-load. From the experiments performed on a DC motor, we get a graph of DC motor response with constant speed of different motor. Here in Fig. 3 is a graph of the results of the experiments that have been done.

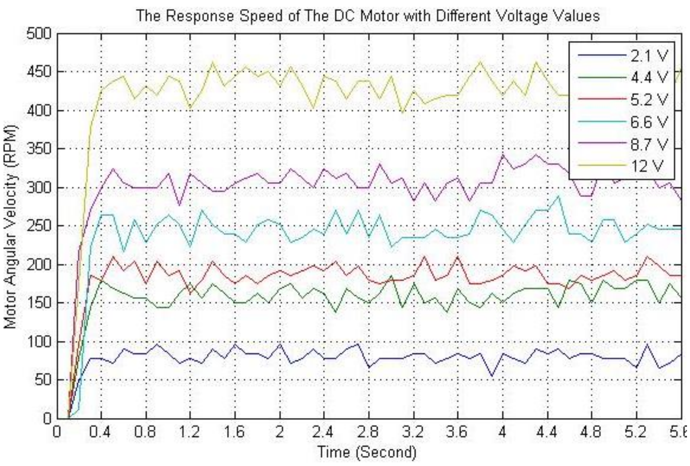


Fig. 3 Graph of motor speed response with steady-state speed varies according to given input voltage.

The purpose of showing the steady-state speed of different motors is for comparison. From the above graph note that with different speeds, the motor still produces steady-state speed at almost the same time, which is between 0.4 seconds to 0.6 seconds. This indicates that the larger the speed, the greater the acceleration generated by the DC motor.The next experiment is measuring the speed response of the motor with human load on the standing wheelchair. This experiment is done to know the speed response of the motor when the standing wheelchair is being ridden by the user. This experiments is done with open-loop system, so the characteristics of the motor when being given certain human load are known. This experiment also determine the equations of the system so the motor of the standing wheelchair can be controlled.

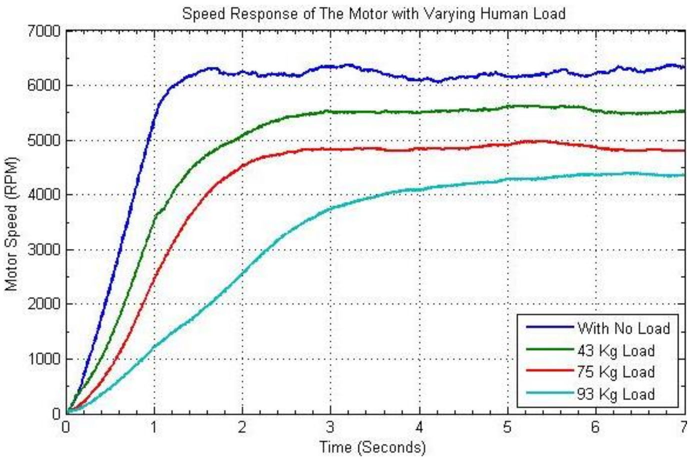
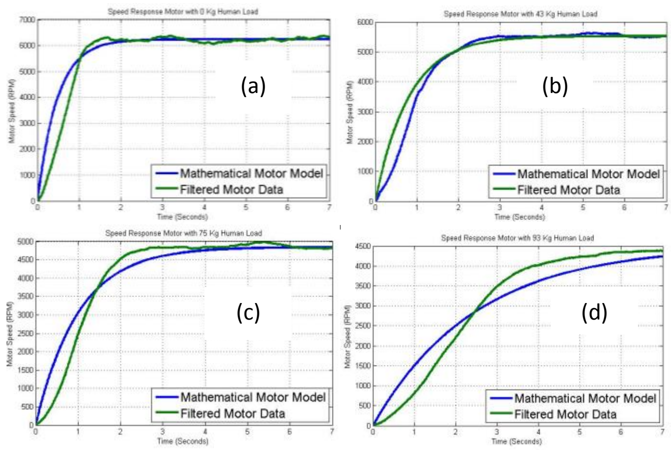


Fig. 4 Graph of motor speed response with human load varies and 12 V input

Fig. 4 shows that the greater the human load is, the slower the motor speed would be. So, the control system not only controlling the speed response of the motor but also the constant speed of the motor. To control the motor, simulations are needed to determine the best parameter of the controller. Table 1 shows the parameters obtained from Fig. 4. From the parameters in table 2, the graph model can be made.

Table 2 Parameters for the first-order system

Human Load (Kg)	k	T
0	519.98	0.475
43	460.56	1.005
75	403.86	0.805
93	374.75	2.460



OPEN ACCESS Freely available online
eISBN 978-967-0194-93-6 FBME

Fig. 4 Graph of the motor speed response compared to the graph of the first order model system with (a) 0 Kg human load, (b) 43 Kg human load, (c) 75 Kg human load, (c) 93 Kg human load varies.

From the parameters in table 2, the graph model can be made. Fig. 5 shows the graph of the first order system compared to the graph of the speed of the motor data.

CONCLUSION

Adaptive-PID control will be implemented to the electric standing wheelchair to control the speed respond of the electric standing wheelchair. Controlling the speed respond of the electric standing wheelchair is used to prevent the electric standing wheelchair from falling. According to the experiment, the response of the DC motor from zero speed to steady-state speed is fast. Because of that, the control system is needed to slow down the respond of the DC motor.

ACKNOWLEDGEMENT

This work was financially supported by Ministry of Research, Technology and Higher Education of the Republic of Indonesia.

REFERENCES

Amanah, A.. 2010. Rancang bangun kursi roda dengan sistem navigasi tanjakan berbasis fuzzy logic dan turunan untuk meningkatkan kenyamanan pasien. Tugas Akhir D4 Teknik Elektronika, PENS-ITS, Surabaya.

Becker, D. G., Washington, B. V., Devlin, P. M., Edlich, R. F., Zook, J. E. 1991. Injury due to uncontrolled acceleration of an electric wheelchair. The Journal of emergency medicine, 9(3), 115-117.

Brown, K. E., Inigo, R. M., Johnson, B. W. 1990. Design, implementation, and testing of an adaptable optimal controller for an electric wheelchair. IEEE Transactions on Industry Applications, 26(6), 1144-1157.

Cooper, R. A., Jones, D. K., Fitzgerald, S., et al. 2000. Analysis of Position and Isometric Joysticks for Powered Wheelchair Driving. IEEE Transactions On Biomedical Engineering, 2000, 47(7): pp. 902-910.

Din, D., Cooper, R. A. 2005. Electric- powered Wheelchairs. IEEE Control System Magazine, 2005, 25(2): pp. 22 34.

Irwanto., Kasim, E.R., Fransiska, A., Lusli, M., Siradj, O.. 2010. Analisis situasi penyandang disabilitas di Indonesia. Pusat Kajian Disabilitas Fakultas Ilmu-ilmu Sosial dan Politik, Universitas Indonesia, Jakarta.

Korsane, D. T., Yadav, V., & Raut, K. H.. 2014. PID tuning rules for first order plus time delay system. Int. Journal of Innovative Research in Electrical, Instrumentation and Control Engineering, 2(1), 582-586.

Niemann, H., & Miklos, R.. 2014. A Simple Method for Estimation of Parameters in First order Systems. In Journal of Physics: Conference Series (Vol. 570, No. 1, p. 012001). IOP Publishing.

Takei, T., Suzuki, Y., Matsumoto, O., Adachi, Y., Sasaki, Y., Kamo, M. 2010. Development of assistive technologies for safe operation of electric wheelchairs on sloping sidewalks and grade height differences. In System Integration (SII), 2010 IEEE/SICE International Symposium on (pp. 43-48). IEEE.

Takeshi, T. 2012. Investigation about robustness of air fuel ratio control at transient state by fusing adaptive PID control and adaptive feedforward system. Transactions of Society of Automotive Engineers of Japan, 43(2).

Tian, Z., Xu, W. 2009. Electric wheelchair controller based on parameter self-adjusting fuzzy PID. Computational Intelligence and Natural Computing, 2009. CINC'09. International Conference on Vol. 1, pp. 358-361.

Widyotriatmo, A., Rauzanfiqr, S. K.. 2012. A modified PID algorithm for dynamic control of an automatic wheelchair. Control, Systems & Industrial Informatics (ICCSII), 2012 IEEE Conference on. IEEE, 2012.

OPEN ACCESS Freely available online
eISBN 978-967-0194-93-6 FBME