Country Code 21.

SIMPLE GESTURE RECOGNITION TO ASSIST IN CONTROLLING A POWERED WHEELCHAIR

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Abstract

This short paper describes some initial work to create a simple hand gesture recognition system for a powered wheelchair. It is employed to assist people with mobility issues to drive a powered wheelchair. It replaces a standard joystick with hand gestures. Infrared sensors detect simple gestures and they are categorized in order to assist in driving a powered wheelchair. Some initial technical testing and results are described.

Key words: Wheelchair, Assist, Driving, Sensor, Infrared, Gesture.

Introduction

This short paper describes some initial work to create a simple hand gesture recognition system for a powered wheelchair. It replaces a standard joystick with hand gestures. Some initial technical testing and results are described.

Almost all powered wheelchairs are provided with a standard joystick controller but users often need a bespoke interface. Joysticks can only be used by someone able to apply enough force to move it in a controlled way in any direction.. An alternative is gesture based detection. Gesture based detection and classification has been successfully used for human computer interaction in various applications such as robot control, computer gaming, editing text and controlling vehicles.

There are a few papers about camera based hand gesture recognition [Zhang *et al*, 2011; Garg *et al*, 2009]. Those systems needed an expensive and complex system for image processing.

In this paper a new simple concept for a low cost approach is presented. Discussion with wheelchair users, clinicians and carers in the NHS suggested that the main factors considered when deliberating on whether to provide a powered wheelchair or not were functional ability and potential for return to normal life and work.

Wheelchairs controlled by a joystick are not suitable for some stroke patients and some spinal cord injury patients. Patients with acute quadriplegia take time to recover motor control in their hands. The simple system described here can be used by patients who are only able to move their hands a little.

Because powered wheelchairs with joysticks are not always appropriate, clinicians tend to suggest the use of manual wheelchairs. It is unusual to suggest modifications to a powered wheelchair to create a bespoke solution, especially as that can make a powered wheelchair more expensive.

Background

Many gesture recognition systems have been reported in the literature [Ahmad *et al*, 2011; Kaustubh & Bhiksha 2009; Perrin *et al*, 2004; Wang *et al*, 2010]. Several algorithms and methods have been proposed to interpret gestures [Igorevich *et al*, 2010; Hanning *et al*, 2004; Miners *et al*, Mu-Chun, 2000; Songmin *et al*, 2012; Ghosh & Ari, 2011; Tuan *et al*, 2011; Wang *et al*, 2010; Yamato & Ohya, 1992; Yamato & Ohya, 1992].

According to the stroke Association, roughly 15 million people worldwide are affected by stroke and 80% of them have mobility issues. In addition, 250,000 to 500,000 people suffer a spinal cord injury every year.

A lack of basic mobility is a factor resulting in the exclusion of people with a spinal cord injury from participating fully in society. The World Health Organisation suggests the use of suitable assistive devices to help them with basic everyday activities. There are about 400,000 spinal cord injury patients in the USA, with about 15,000 new injuries every year [Hasan Al-Nashash, 2009].

Assistive devices tend to be either generic or bespoke. There are systems based on movement of the tongue [Lund *et al*, 2010; Xueliang & Maysam, 2009], head [Ahmad *et al*, 2011; Zhang-fang *et al*, 2010; [Montesano *et al,* 2010], brain [Ituratte *et al*, 2009; Kyuwan *et al,* 2006], electrooculography and eyes [Chern-Sheng et al, 2006; as well as joysticks. Research presented here could create a low cost infrared sensor based assistive device that would fit between these two extremes.

The prototype system described in this paper can detect the movement of any part of the body, for example head, fingers, hands, arms etc. If movement can be detected then a powered wheelchair can be controlled by it.

The infrared sensors needed to interpret four simple gestures to control a wheelchair: forward, reverse, right and left.

Sensors

Infrared sensor technology is used in wide range of applications [Garcia *et al*, 2004; Singh *et al*, 2010; Rakshit & Chatterjee, 2010]. In this work, the motor drives were controlled from an infrared sensor array based on the principle of reflection from an incident surface.

Infrared LEDs emit continuous beams of infrared. When a reflecting surface is in front of the infrared receiver (a photodiode) then the infrared rays reflect back and are captured by the photodiode, which generates a current. The amount of current generated was proportional to the amount of infrared rays reflected. A part of a user's body serves as a reflecting surface.

When the user places a part of the body in front of the array, then software attempts to identify a gesture.

When a gesture is identified, the system responds with a movement of the wheelchair: forward , Right, Reverse or Left.

Testing and results

Response timings were compared in the laboratory with those of a joystick. The new system was slower but successfully steered the wheelchair.

A group of 13 volunteers were then asked to rate the use of the gesture system compared to using a joystick. All the volunteers preferred the use of the joystick but all were able to steer the wheelchair with both.

After using the prototype, volunteers rated the new system as very good, good, satisfactory, unsatisfactory and poor. The average rating was satisfactory.

The success rate of the prototype in identifying correct gestures was low. Overall success rate in recognizing gestures was 29.5%, although in some cases the percentage was a high as 70%.

For any gesture change, the response time was around one second. That was slower than all the joysticks considered.

Discussion

Although the new system was slower and all the volunteers preferred the use of the joystick, it did successfully steer the wheelchair and the average rating was satisfactory.

A main problem was that the success rate was low so that gestures needed to be repeated. That needs to be improved. Response times were slow compared to a joystick and that also needs to be improved.

Response time for gesture change was about one second and that was too slow so that the new systems will not be suitable for everybody with impaired mobility. That said, it could be another alternative to existing control methods.

Future work will concentrate on improving recognition and response times.

References

Ahmad Akl, Chen Feng, and Shahrokh Valaee, "A Novel Accelerometer-Based Gesture Recognition System", IEEE Transactions on signal processing 59 (12), 2011.

Chern-Sheng Lin; Chien-Wa Ho; Wen-Chen Chen, “Chuang-Chien Chiu; Mau-Shiun Yeh, Powered wheelchair controlled by eye-tracking system”, Optica Applicata, 01/2006, Vol. 36, pp. 401-412.

Garcia, J.J. ; Urena, J. ; Hernandez, A. ; Mazo, M. ; Garcia, , JC ; Alvarez, F. ; Jimenez, J.A. ; Donato, P. ; Perez, M.C., "IR sensor array configuration and signal processing for detecting obstacles in railways", Sensor Array and Multichannel Signal Processing Workshop Proceedings, 2004, pp: 216 -220.

Garg, R. ; Shriram, N. ; Gupta, V. ; Agrawal, V., "A smart mobility solution for physically challenged", 2009 IEEE International Conference on Vehicular Electronics and Safety (ICVES), pp: 168 – 173.

Ghosh, D.K. ; Ari, S., "A static hand gesture recognition algorithm using k-mean based radial basis function neural network", 8th International Conference on Information, Communications and Signal Processing (ICICS) 2011 pp: 1 - 5

Hasan Al-Nashash, Noreen A. Fatoo, Nabil N. Mirza, Rabi I. Ahmed, Gracee Agrawal, Nitish V. Thakor, Angelo H. All, "Spinal Cord Injury Detection and Monitoring Using Spectral Coherence", IEEE Transactions On Biomedical Engineering, 56(8), pp:1971-9. 2009.

Hong P, Turk M, and Huang TS, "Gesture modeling and recognition using finite state machines," in Proc. 4th IEEE Int. Conf. Autom. Face Gesture Recogn., Grenoble, France, Mar. 2000, pp. 410–415.

Igorevich, R.R., Pusik Park, Dugki Min, Yunjung Park, Jongchan Choi, Eunmi Choi, "Hand gesture recognition algorithm based on grayscale histogram of the image", 2010 4th International Conference on Application of Information & Communication Technologies (AICT), pp: 1 – 4.

Inake Ituratte, Javier M Antellis, Andrea Kubler and Javier Minguez, "A Noninvasive brain actuated wheelchair based on a P300 Neuropsychological protocol and Automated Navigation", IEEE Transactions on Robotics, Vol.25, No.3, pp: 614-626. June 2009.

Kaustubh Kalgaonkar, Bhiksha Raj, "One-Handed Gesture Recognition Using Ultrasonic Doppler Sonar", ICASSP 2009, 978-1-4244-2354-5/09. pp: 1889 – 1892.

Kyuwan Choi; Sato, M.; Koike, Y, "A new, human-centered wheelchair system controlled by the EMG signal", International Joint Conference on Neural Networks, 2006. IJCNN '06,pp: 4664 – 4671.

Lund, M.E., Christiensen, H.V., Caltenco, H.A., Lontis, E.R., Bentsen, B., Struijk, J.J. "Inductive tongue control of powered wheelchairs", 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp: 3361 – 3364.

Megalingam, RK; Nair, Ramesh N; Prakhya, SM; Mohan M, "Gest-BOT' - A Highly Convenient Locomotive Solution for the Elderly and Physically Challenged", Global Humanitarian Technology Conference (GHTC), 21-24, October in Seattle, Washington, USA, IEEE Xplorer. pp: 350 – 355.

Miners BW, Basir OA, and Kamel MS, "Understanding Hand Gestures Using Approximate Graph Matching", IEEE Transactions On Systems, Man, And Cybernetics—Part A: Systems And Humans, Vol. 35, No. 2, March 2005, pp: 239 – 248.

Mu-Chun Su, 'A Fuzzy Rule-Based Approach to Spatio-Temporal Hand Gesture Recognition', IEEE Transactions On Systems, Man, And Cybernetics-VOL. 30, NO. 2, MAY 2000, pp: 276 – 281.

Perrin, S. ; Cassinelli, A. ; Ishikawa, M., " Gesture recognition using laser-based tracking system", Sixth IEEE International Conference on Automatic Face and Gesture Recognition, 2004. Proceedings. Pp: 541 – 546.

Ramamoorthy A, Vaswani N, Chaudhury S, and Banerjee S, "Recognition of dynamic hand gestures," Pattern Recogn., vol. 36, pp: 2069–2081, 2003.

Singh, S.K. ; Singh, D.K. ; Thapa, R. ; Khurana, R., "Design and implementation of navigation algorithm for intelligent racing car", 2010 International Conference on Emerging Trends in Robotics and Communication Technologies (INTERACT), pp: 303 – 306.

Songmin Jia ; Jun Yan ; Jinhui Fan ; Xiuzhi Li ; Liwen Gao, "Multimodal intelligent wheelchair control based on fuzzy algorithm", 2012 International Conference on Information and Automation (ICIA), pp: 582 – 587.

Tuan Nghia Nguyen, Steven W. Su, and Hung T. Nguyen, "Robust Neuro-sliding Mode Multivariable Control Strategy for Powered Wheelchairs", IEEE Transactions On Neural Systems And Rehabilitation Engineering, Vol. 19, No. 1, February 2011, pp: 105-111.

Wang Xinyu ; Sun Guan ; Han Dong ; Zhang Ting, "Data glove gesture recognition based on an improved neural network", 29th Chinese Control Conference (CCC), 2010 2010, pp: 2434 – 2437.

Xueliang Huo, Maysam Ghovanloo, "Using Unconstrained Tongue Motion as an Alternative Control Mechanism for Wheeled Mobility", IEEE Transactions On Biomedical Engineering, Vol. 56, No. 6, June 2009. pp:1719-1726.

Yamato, J. Ohya, J. Ishii, K "Recognizing human action in time sequential images using hidden Markov model," in Proc. IEEE Int. Conf. Comput. Vis. Pattern Recogn., Champaign, IL, 1992, pp. 379–385.

Yeasin M and Chaudhuri S, "Visual understanding of dynamic hand gestures," Pattern Recogn., vol. 33, pp: 1805–1817, 2000.

Yoon HS, Soh J, Bae YJ and Yang HS, "Hand gesture recognition using combined features of location, angle and velocity," Pattern Recogn, vol. 34, pp: 1491–1501, 2001.

Zhang-fang Hu ; Lin Li ; Yuan Luo ; Yi Zhang ; Xing Wei, "A novel intelligent wheelchair control approach based on head gesture recognition" Computer Application and System Modeling (ICCASM), 2010 International Conference on Volume: 6. Pp: V6 159-163.

Zhang Y; Zhang J; Luo Y, "A novel intelligent wheelchair control system based on hand gesture recognition", 2011 IEEE/ICME International Conference on Complex Medical Engineering (CME), pp: 334 – 339.