Conference Paper

The Non-traditional Methods of Robotic Wheelchair Multi-channel Control

T. I. Voznenko, A. A. Gridvev, and E. V. Chepin

National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe shosse, 31, Moscow, 115409, Russia

Abstract

The most common way to control a wheelchair is the joystick. However, for some people the joystick control is difficult or impossible for one reason or another. For such people, other (non-traditional) control methods are being developed using methods of robotics. In this article, we consider possible non-traditional control methods that can be used to allow patients control a robotic wheelchair by themselves.

Keywords: robotic wheelchair, multi-channel control, non-traditional control methods, robotics

Corresponding Author:
T. I. Voznenko

Received: 22 July 2018
Accepted: 9 September 2018
Published: 8 October 2018

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the Breakthrough Directions of Scientific Research at MEPhI Conference Committee.

1. Introduction

The main (most traditional) way to control a motorized wheelchair is the joystick [1]. In most cases, it is the simplest and most convenient way to control, but for some people (patients) the joystick control is difficult or impossible for one reason or another. For such people, other (non-traditional) control methods based on robotic control methods are begin developed. Non-traditional control methods are based on the usage of special device that can receive various information from the patient [2]. These data can be interpreted into commands for controlling the robotic wheelchair. The general scheme of traditional and non-traditional control methods is shown in Figure 1.

2. Related Works

Let's consider known non-traditional control methods.

One such method is voice control. This control method is based on the processing of the audio signal from the microphone. After the audio signal processing, the obtained data is compared with the reference data obtained during the patient training, or with

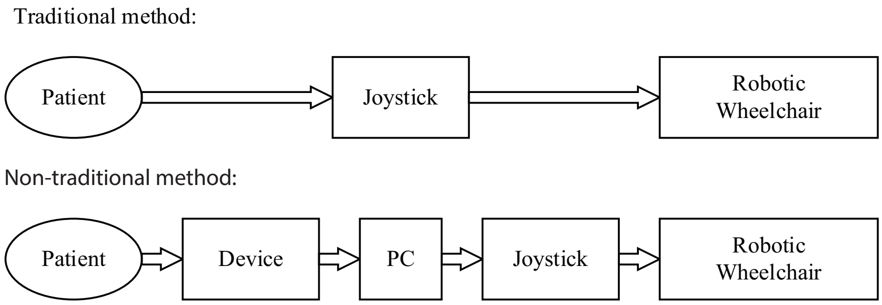

Figure 1: The general scheme of traditional and non-traditional control methods.

known phonemes and grammars. An example of this voice recognition technology is shown in [3].

Another method is control via gestures. This method is based on the recognition and interpretation of the gesture in a particular command. Gestures made by hands are divided into two types: static and dynamic. By static gestures, we mean a fixed position of the operator's palm. A dynamic gesture is a gesture that takes place over a period of time. To recognize gestures based on the various body parts movement, special 3D-cameras are used. For example, in [4], we described the implementation of the wheeled robot control based on the gesture recognition using a Kinect sensor. Another example of 3D camera application for gesture recognition is the system [5], developed in the 'Robotics' laboratory in NRNU MEPhI. The gesture is executed when the hand passes two areas – the gesture beginning area and the area that determines the movement direction.

One of the most actual control methods is the brain-computer interface (BCI). This control method is based on the EEG pattern recognition system. However, since the brain is a complex organ consisting of a large number of neurons, the recognition accuracy on the basis of the images is insufficient for the reliable wheelchair control. This complexity is also caused by the work specificity of the brain, which can react to surrounding factors (both external and internal). The image recognition accuracy improvement is achieved via prolonged patient training. Also, there are many studies aimed at the recognition accuracy improvement, for example, considering the emotional state of the operator [6, 7].

Another non-traditional robotic wheelchair control method is the 'Extended BCI interface' concept [2]. This concept is based on the simultaneous usage of several non-traditional data channels (BCI, voice, gestures) to improve the control reliability. In practice, there may be situations when controlling via some particular data channel (control method) is preferable at this moment. Extended BCI considers the characteristics of each patient when deciding which command and from which data channel to perform at that moment.

3. Theory

According to [2], the 'Extended BCI interface' is a robotic control system based on a set of independently operating non-traditional control methods. When the operator uses more than one control method, it is necessary to decide which command to execute at this moment. To solve this problem, the decision system described in [8] was developed. Wherein, for each channel parameters are defined, on the basis of which the decision is made. This system allows to work with multiple data channels such as voice, gestures and BCI. However, other non-traditional control methods can be used. Let's consider the possible non-traditional control methods that can be used to control a robotic wheelchair.

3.1. Eye tracking

Eye tracking can be implemented using a camera aimed at the patient's face, as well as special software that tracks the direction of sight. Using a relatively simple system of gestures (several specific consecutive directions of view) it is possible to implement control. For example, look down is to stop; look down-up-down-straight is to move forward; look down-left-down-straight is to turn left. Several definite sequential actions are necessary for usability: that is, in a normal situation (when the patient looks to the left or to the right) there is no false positives.

3.2. Virtual joystick

Virtual joystick is an imaginary joystick in space or on a plane. Moving an arm or a finger in the air or on the touch panel can be much easier than moving the joystick handle if, for example, the patient has weak hands.

3.3. Finger tracking

Tracking of small (barely noticeable) finger movements can be done with a specially directed camera. This is especially used if the usage of a virtual joystick or hand gestures is difficult or impossible.

3.4. Facial expressions

If the person (patient) only has facial expressions, then it can be used to control the robotic wheelchair. The facial expression can be recorded with a camera, or via muscles of facial expressions.

4. Practice

The aforementioned robotic wheelchair is implemented without additional non-traditional control channels (only gestures, voice control, BCI) [2] at the moment. As the first tests results in our laboratory and in the Scientific and Practical Center for Medical and Social Rehabilitation of Disabled Persons named after L. I. Shvetsova show that the data channels used although have false positives and are not 100% accurate, they are sufficiently reliable for further use in a robotic wheelchair. To improve the accuracy of the work, the developed decision-making system [8] is used, which allows to control with several control channels, including the arrival of conflicting commands. Testing of the decision-making system showed a significant increase in control accuracy without significant latency increase [8, 9]. This wheelchair has received quite a wide coverage on Russian television and in foreign mass-media, for example, in [10, 11]. The new control channels that will make the chair control more convenient to use are being developed. Our experience allows us to make the following conclusion: it is necessary to have a large number of non-traditional control channels in the control system so that during the training and initial exploitation of the robotic wheelchair each individual patient has the opportunity to choose the preferred set of these channels for himself.

5. Conclusion

In this article, various non-traditional ways of robotic wheelchair control were considered. Adding these methods to the implementation of the extended BCI interface concept will increase the functionality of the wheelchair control system. The choice of the channels used will be made in accordance with the preferences of the patient, also considering his features.

References

[1] Yanco, H. A. (1998). Wheelesley: A robotic wheelchair system: Indoor navigation and user interface, in *Assistive Technology and Artificial Intelligence*, pp. 256–268. Springer.

[2] Voznenko, T., Chepin, E., and Urvanov, G. (2017). The control system based on extended bci for a robotic wheelchair. *2017 Annual International Conference on Biologically Inspired Cognitive Architectures: Eighth Annual Meeting of the BICA Society* [unpublished].

[3] Lamere, P., Kwok, P., Gouvea, E., et al. (2003). The cmu sphinx-4 speech recognition system, in *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2003)*, vol. 1, pp. 2–5. Hong Kong.

[4] Wang, Y., Song, G., Qiao, G., et al. (2013). Wheeled robot control based on gesture recognition using the Kinect sensor. *2013 IEEE International Conference on Robotics and Biomimetics (ROBIO)*.

[5] Chistjakov, I. S., Urvanov, G. A., Bajkov. D. V., et al. (2016). Sistema upravlenija robotizirovannym kreslom pri pomoshhi zhestov [The system of control robotic wheelchair using gestures]. *Vestnik natsional'nogo issledovatel'skogo yadernogo universiteta 'MIFI'*, vol. 5, no. 4, pp. 381–388.

[6] Voznenko, T., Urvanov, G., Dyumin, A., et al. (2016). The research of emotional state influence on quality of a brain-computer interface usage. *Procedia Computer Science*, vol. 88, pp. 391–396.

[7] Chepin, E., Dyumin, A., Urvanov, G., et al. (2016). The improved method for robotic devices control with operator's emotions detection. *2016 IEEE NW Russia Young Researchers in Electrical and Electronic Engineering Conference (EIConRusNW)*, pp. 173–176.

[8] Gridnev, A., Voznenko, T., and Chepin, E. (2017). The decision-making system for a multi-channel robotic device control. *2017 Annual International Conference on Biologically Inspired Cognitive Architectures: Eighth Annual Meeting of the BICA Society* [unpublished].

[9] Chepin, E., Gridnev, A., Voznenko, T., et al. (2017). Testing a mobile robotic wheelchair controlled with several channels. *Proceedings of the 19th international*

workshop on computer science and information technologies CSIT'2017. Germany, Baden-Baden [unpublished].

[10] 'La silla de ruedas del futuro será guiada por el pensamiento' ['The wheelchair of the future will be guided by thought']. (2016). Retrieved from http://www.eluniversal.com/noticias/estilo-vida/silla-ruedas-del-futuro-sera-guiada-por-pensamiento_305388

[11] 'Invalidnoe kreslo, upravljaemoe siloj mysli' ['Wheelchair controlled by thought']. (2016). Retrieved from http://inosmi.ru/science/20160617/236896139.html