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The Control System Based on Extended BCI for a Robotic Wheelchair

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Abstract

In most cases, the movement of wheelchairs is controlled by disabled people using a joystick or by an accompanying person. Significantly disabled patients need alternative control methods without using the wheelchair joystick because it is undesirable or impossible for these patients. In this article, we present the implementation of a robotic wheelchair based on a powered wheelchair that is controlled not by the joystick but by the onboard computer that receives and processes data from the extended brain-computer interface (extended BCI). Under this term we understand the robotic complex control system with simultaneous independent alternative control channels. In this robotic wheelchair version the BCI works with voice and gesture control channels.

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Keywords: extended brain-computer interface, robotic wheelchair, control channel, robotics

1 Introduction

Technical projects on the development of robotic wheelchairs have been carried out since the last century. Modern mobile robotic complexes (MR) which include robotic wheelchairs are complex heterogeneous hardware and software systems and they should provide a certain level of comfort and reliability of control answering the fields of their application. Under the term MR we understand the robotic system having an onboard powerful, versatile, and inexpensive miniature computer with a modern CPU providing the ability to connect the modern peripherals to the system without any restrictions, unlike the microcontroller capabilities. Because of this, it is possible to use the maximum possible set of software, more memory and parallel programming techniques to achieve the real-time mode (RTM).

The robotic wheelchair (hereinafter the "chair") is designed for patients with severe disorders of the musculoskeletal system and other functions of the body (hands, speech, hearing, etc.). The patient is the operator of the chair sitting in it and controlling it via the control system. For

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clarity we will call them the "patient". Along with it, the chair is controlled by the specialist-operator who can remotely monitor the chair. This is possible because of a parallel chair-control channel provided by the Wi-Fi connection of the onboard computer with a remote Tracking and Control Station (TCS). TCS is a remote computer through which the specialist-operator can control the chair "intercepting", if necessary, the control from the patient-operator.

2 Related Works

The patients who use the wheelchairs in most cases are quite satisfied with them, if the chair is equipped with an electric drive and control system via the joystick. An example of such a robotic wheelchair called Wheelesley is described by Yanco [1]. This chair provides additional opportunities for the patient during the driving by the provision of the information "with a lower level of navigation".

One of the modern trends in the development of the robotic wheelchairs is the projects such as the Chinese project Chiba (Robotic wheelchair) described by Morales et al. [2] and Szondy [3]. The main objective of these projects is the control system of the mechatronics of the chair which effectively overcomes the obstacles in the way such as stairs and border stones. However, some patients are unable to control the chair with such functions. Therefore, for these patients the way to improve the quality of their lives is the development of the control systems for the robotic wheelchairs that would allow them to control their own wheelchair using their modest possibilities: weak hands, voice, etc.

There is a great variety of the ways to control the MR. The most common is to control directly by the joystick as described by Jawawi et al. [4]. However, the directly connected to the servomotor of the joystick Arduino opens the opportunity of controlling the chair using such methods as the brain-computer interface (BCI), voice or gesture control. Each MR has onboard a powerful general-purpose computer. It interacts during the operation with the external computing unit — Tracking and Control Station (TCS). The TCS allows to carry out the remote control of the MR's work by the operator. Also, it is possible to send to the TCS the data to gather the statistics on the basis of which it is possible to make the changes in the values of the parameters to improve the quality of the MR's control.

The global problem of increasing the intelligence of such complex systems is extremely relevant nowadays, especially in the transition to the control of the teams of robots, for example proposed by Bereznyak et al. [5]. For some applications of the MRs their control circuit includes a human-operator. For example, in medicine it is extremely important to implement the control system based on the traditional paradigm of "control commands", but on the basis of non-traditional methods of controlling the complex systems.

There are several works describing BCI-controlled wheelchairs but the control accuracy is not high enough for reliable control, for example, 50% and above described by Ng et al. [6] and 79.38% presented by Achic et al. [7].

In order to increase the control accuracy of BCI-controlled robotic wheelchair we propose using of other control channels like voice commands or gestures. In this project, we proposed the new non-traditional control method we called "extended BCI", which involves the operation of three control channels in parallel: voice commands, gestures and the BCI. The urgency and necessity of this control method is determined by the field of its application: medical robotics.