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Motor imaginary-based brain–machine interface design using programmable logic contro for the disabled

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Aiming at the implementation of brain–machine interfaces (BMI) for the aid of disabled people, this paper presents a system design for real-time communication between the BMI and programmable logic controllers (PLCs) to control an electrical actuator that could be used in devices to help the disabled. Motor imaginary signals extracted from the brain's motor cortex using an electroencephalogram (EEG) were used as a control signal. The EEG signals were pre-processed by means of adaptive recursive band-pass filtrations (ARBF) and classified using simplified fuzzy adaptive resonance theory mapping (ARTMAP) in which the classified signals are then translated into control signals used for machine control via the PLC. A real-time test system was designed using MATLAB for signal processing, KEP-Ware V4 OLE for process control (OPC), a wireless local area network router, an Omron Sysmac CPM1 PLC and a 5 V/0.3 A motor. This paper explains the signal processing techniques, the PLC's hardware configuration, OPC configuration and real-time data exchange between MATLAB and PLC using the MATLAB OPC toolbox. The test results indicate that the function of exchanging real-time data can be attained between the BMI and PLC through OPC server and proves that it is an effective and feasible method to be applied to devices such as wheelchairs or electronic equipment.

Keywords: BMI; PLC; OPC; motor imaginary; SFAM; adaptive filters

Introduction

Brain–machine interfaces (BMIs) are perceived as a communication channel which connects the human brain directly to an external device, while bypassing the peripheral nervous systems and muscular system. Thus, a BMI is often regarded as a new communication approach that provides assistance to people who are suffering from motor disorders or paralyses. Brain-controlled devices and systems of different types enable them to perform rehabilitation or to receive continuous assistance during their daily activities (e.g. home electronic equipment or wheel chairs), which represent two of the main goals of this discipline. Programmable logic controllers (PLCs) play an important role in industrial automation and control systems. The integration of BMIs with PLCs is introduced in this paper whereby this application could be implemented to aid the disabled by means of a non-invasive BMI.

The BMI design in this paper utilises an electroencephalogram (EEG) that captures the neuronal signals generated from the brain. This method is regarded as non-invasive because brain signals are obtained directly from electrodes placed on the scalp. An EEG signal consists of many electro-potentials. Among these potentials is the movement-related potential (MRP) which we are focusing on. The MRP can be recognised and associated in the EEG's mu rhythm (8–12 Hz) or beta frequency band (Jey et al. 2008a, 2008b, 2008c, 2008d), when a s performs or imagines a motor activity (Jeyabalan 2008a, 2008b). In this paper, we have used the MR result of the motor movement imagination capture the EEG's electrodes C3 and C4 (Jeyabalan et al. 2008b, 2008c, 2008d). These electrodes were placed scalp overlying the sensory-motor cortex where th signals are sensitive to movements. An efficient architecture consists of four main elements: th processing of signals, feature extraction, classificati translation into control instructions. In this paper, t motor imaginary signals were pre-processed by me band-pass filtration; features were extracted usi adaptive recursive band-pass filter (ARBF) (Jeyabala 2008a, 2008b, 2008c) and classified using a sim fuzzy ARTMAP (SFAM) artificial neural network (In this paper, we have used MATLAB for signal proc since this methodology has been successfully triallec in Jeyabalan et al. (2008a, 2008b, 2008c, 2008d).

The main aim of this paper is to design and demons BMI that utilises the classification output to cont electrical motor via the PLC. The OLE for process c (OPC) is used as a communication interface betwe BMI and PLC. The proposed BMI sends the electrical a 'switch on' instruction when a right-hand mov