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English Abstracts

Interfaces and Systems of Rehabilitation and Functional Compensation for Personal Autonomy and Clinical Therapy

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Abstract: Bioengineering is a field of interdisciplinary research between engineering and medicine resulting from a growing human, social and economic interest. Automatica in particular, with its aspects of perception, modeling, control, monitoring, action and interaction, among others, provides important insights and tools to overcome problems related to diagnosis and monitoring of diseases, to special functional needs and also with different applied treatments. This tutorial presents aspects related to the state of the art and recent advances in the following areas: Interfaces for interaction and communication of people with disabilities, rehabilitation robotics and functional compensation, and systems to improve clinical therapy. Copyright © 2011 CEA.

Keywords: Electroencephalography, electromyography, human-machine interface, rehabilitation, mechanical ventilation, supporting technologies, clinical therapy.

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Multi-Robot Teleoperation System based on a Brain-Computer Interface

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Abstract: This paper reports multi-robot teleoperation system based on a brain-computer interface, which allows the user to control simultaneously a non-predefined number of robots via internet, only by brain activity. These devices are oriented to people with severe neuromuscular disabilities, providing them telepresence with a interaction mode based on their thoughts. This work is an extension of a teleoperation system which has been improved to support the teleoperation of N robots, and that uses small and portable robots (of two orders of dimension below the original). The brain-computer interface is based on EEG with a P300-based protocol of control, and the robots are able to navigate, interact by sending alarms, and visually perceive the environments. The system has been validated with two healthy users and the main result is that all of them were able to successfully solve the proposed tasks with no failures, which demonstrates the validity and high robustness of the prototype. Copyright © 2011 CEA.

Keywords: brain-computer interface, BCI, robotics, teleoperation, rehabilitation.

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Multimodal Interface for a Surgical Robotic Assistant: Surgical Maneuvers Recognition Approach

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Abstract: This paper proposes a methodology for the recognition of surgical maneuvers in laparoscopic surgical interventions. The aim is to create an interface between the surgeon and a surgical robotic assistant for two arms of minimally invasive surgery procedures. The proposed interface receives information about the positioning of surgical tools of the surgeon using 3D sensors and the recognition system facilitates the current maneuver is completed. Therefore, the recognition system maneuvers that supports this interface requires a library of models of maneuvers to work. The models chosen to represent the surgical maneuvers are Hidden Markov Models. To validate the proposed methodology, we have developed a series of in-vitro experiments.

Keywords: human machine inferface, Markov Hidden Models, surgical robotics.

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Evaluation of Neuromuscular Function on the forearm during isometric contractions by Multichannel Surface Electromyography

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Abstract: An experimental protocol has been designed with specific exercises and the study of forearm muscles which are related with repetitive effort disorders (RED) and myalgia . The analysis and results obtained in a control group by multichannel surface electromyography (EMG) have validated this technique in order to be applied in patients such as diagnosis help or assessment of muscles changes during rehabilitation processes. Variables of interest from EMG signals have been defined and calculated during the protocol resulting repetitive. Multichannel surface EMG has permitted to obtain activation pattern of three extensor muscles and one flexor during fingers isometric flexion and to obtain the dependence on the pressure developed by different fingers which will be very interesting in the monitoring of myalgia in pianist musicians. Thanks to the electrodes matrices, muscle fatigue of the flexor and one extensor have been detected along endurance exercises. Finally, this non-invasive technique has been validated in exercises associates with RED and forearm muscles by detecting propagating action potentials with a good estimation of conduction velocity and, thus, permitting to obtain reliable data and information of muscle patterns.

Keywords: bioengineering, electromyogarphy, muscle disorder, signal processing, rehabilitation.

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GA based synthesis of Mechanisms for Lower Limb Prosthetic Applications

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Abstract: The synthesis of planar mechanism represents an attractive problem to be solved using evolutionary techniques as it involves an underdetermined nonlinear set of equations that grow in number as more precision points are defined to describe the desired trajectory of the coupler. This paper presents a Genetic Algorithm (GA) based approach for optimisation of the kinematical synthesis of a 6-bar Watt type mechanism for prosthetic knee applications. The desired trajectory to be described by the coupler corresponds to the trajectory of the knee during a normal gait cycle. The generated trajectory illustrates how it naturally evolves from an erratic solution to a smooth fitted curve.

Keywords: Genetic algorithm, mechanism synthesis, prosthetic, Lower Limb.

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HIS: Hearing Impairment Simulator

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Abstract: The audio compression standard for high-quality MPEG is a standard developed to compress signals without losing relevant information. In particular, the MPEG-1 Audio Layer III is based on Psychoacoustic Model I. Throughout this paper a system that exploits the characteristics of the perceptual model to simulate different types of hearing impairment based on the curves representing the threshold of hearing of the ear as a function of frequency. Subjective and objective experiments are made in order to analyze the performance of the simulator with some types of hearing impairment.

Keywords: Hearing Impairments; Digital Signal Processing; MPEG-1 Audio Layer III, Psychoacoustic Model I; Audiometry.

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Biocooperative Robot with Haptic Modulation for Upper Limbs Neurorehabilitation Tasks

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Abstract: Biocooperative augmented robots can enhance rehabilitation therapies by giving the correct assistance to the patient at the correct time. Since different patients may benefit from different levels of assistance or resistance at a given time, predicting when a person enters in an undesired psychophysiological state can provide an intelligent system with important information about when to adpat interaction. This work presents a subject centered approach method that includes the human into the loop by using physiological feedback techniques. This gives the rehabilitation robot the ability to adapt to several different patients, and maintain the therapy as intensive as possible without compromising patient health, or letting the individual get stressed which would result in a decay of the overall performance.

We present here a novel subject centered approach method that includes the human into the loop by using novel biocooperation techniques, which let the rehabilitation robot changes its apparent dynamic parameters, by gathering, recording and processing several physiological data online at rehabilitation time, allowing for more intensive rehabilitation tasks, and possibly stimulate active participation by the patient..

Keywords: robot, biocontrol, rehabilitation.

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Adaptive Filtering of Involuntary Components in Walker Assisted Gait for the Detection of Intentions

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Abstract: The advances in technology have allowed the use of sensors, processors and actuators in the context of the mobility assistive devices for disabled people, improving their usability and safety. Considering walkers, the introduction of such technologies has created a group of devices called Smart Walkers. Among other devices, in the Bioengineering Group at CSIC, a smart walker was developed in the framework of the Simbiosis Project. This work presents a method of adaptive filtering designed for the suppression of involuntary force components from the interaction forces between user's upper limbs and walker. This process is based on the selective attenuation of components related to the user's trunk oscillations in assisted gait. For that purpose, gait cadence is estimated in real-time from a ultrasonic measurement system using the Weighted-Frequency Fourier Linear Combiner (WFLC). The cadence is, then, used to adjust a adaptive notch filter buld upon the Fourier Linear Combiner (FLC) algorithm, that filters in real-time the force data acquired by the sensors installed on the device's handles. The proposed methodology offered a real-time cancelation of about 80% of the forces components' energy at the desired frequencies. The output of the presented algorithm will be used as inputs for the controller that will be designed to command the motorized walker.

Keywords: Rehabilitation robotics, human-machine interfaces, adaptive filtering, intention detection, human gait.

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Autonomous SLAM-based Robotic Wheelchair's Assistive Navigation for Confined Spaces

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Abstract: In this work, an interface specially designed for a robotic wheelchair's navigation within confined spaces is presented. The interface performance is based on two modus: autonomous and non-autonomous. The non-autonomous execution of the robotic wheelchair interface is performed by means of a joystick. The joystick is adapted to the wheelchair's patient capabilities and it governs the motion of the vehicle within the environment. The autonomous modus of the robotic wheelchair is executed when the user has to turn a given angle within the environment. The turning strategy is performed by means of both: a maneuverability algorithm which is compatible with the wheelchair's kinematics and the SLAM (Simultaneous Localization and Mapping) algorithm. In addition, the autonomous modus is composed by two modules: a path planning module and a control module. The path planning module uses the map information provided by the SLAM algorithm to generate a safe path compatible with the robotic wheelchair. Such path will allow the vehicle to reach the orientation -angle of turning- given by the user. The control module governs the motion of the robotic wheelchair by means of a trajectory controller when following the path generated by the path planning algorithm. The controller references are updated by the SLAM estimation of the wheelchair's pose within the environment. Experimental results using a real robotic wheelchair are also shown in this work.

Keywords: Autonomous vehicles, biomedical systems, robot navigation.

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Methodology for Building Brain-Computer Interfaces Applied to Identify Voluntary Movement Intention

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Abstract: BCIs provide a channel for sending commands to the external environment by using electrophysiological measurements recording brain activity. The algorithm transforming the input signal into the output commands and the method used to extract the signal features for the algorithm are the key components for an optimum behaviour of the BCI. This paper presents a machine learning- based method to select these features and a classifier algorithm for building a predictive model from the EEg signal of patients with tremor. This model analyses and classifies the signal in a continous, asynchronous and adaptive way finding to identify the patient movement intention in order for a control system to cancel the tremor during the movement execution.

Keywords: asynchronous BCI, user modelling, adaption, data mining, ERD.

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Non-Invasive Brain-Computer Interface Based on Evoked Potentials for Controlling a Robotic Arm

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Abstract: This paper describes a Brain-Computer Interface (BCI) for controlling a robotic arm. The system uses electroencephalographic signals (EEG) recorded with 16 electrodes for controlling the robot with visual evoked potentials, using the P300 and N2pc paradigm. By this way, using visual stimuli, the user is able to control the robot movement focusing his attention in the different options shown in a screen. The system has been tested satisfactory by three healthy users. Each of them did several tasks of pick-and-place of objects, controlling a robot of 6 degrees of freedom. Copyright © 2011 CEA.

Keywords: brain-computer interface, human-robot interface, robotic arm, control, evoked potentials.

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Decoupled Predictive Control Algorithm with Disturbance Compensation for the Benchmark of 2009-2010

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Abstract: This paper presents the modelling and control methodologies used for the control problem of a industrial boiler, which was proposed by the benchmark supported by the control engineering group for the academic course 2009-2010. The resulting control strategy is based on a combination of several decoupled predictive control algorithms with external management of measurable disturbances. Furthermore, internal and external filters to the predictive control algorithm are used to increase the robustness strategy and to reduce the noise of the signals. Copyright © 2011 CEA.

Keywords: decoupled control, feedforward control, generalized predictive control, benchmark, industrial boiler.

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