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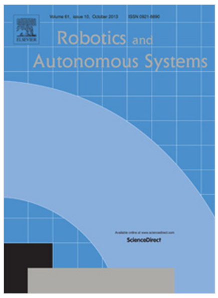

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I. Batzianoulis, S. El-Khoury, E. Pirondini, M. Coscia, S. Micera, A. Billard

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EMG-Based Decoding of Grasp Gestures in Reaching-to-Grasping Motions

I. Batzianoulis[a], S. El-Khoury[a], E. Pirondini[b], M. Coscia[b], S. Micera[b,c], A. Billard[a]

[a]*Learning Algorithms and Systems Laboratory (LASA), School of Engineering, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
[b]*Bertarelli Foundation Chair in Translational Neuroengineering, Center for Neuroprosthetics and Institute of Bioengineering, School of Engineering, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland*
[c]*The Biorobotics Institute, Scuola Superiore SantAnna, Pisa, Italy*

Abstract

Predicting the grasping function during reach-to-grasp motions is essential for controlling a prosthetic hand or a robotic assistive device. An early accurate prediction increases the usability and the comfort of a prosthetic device. This work proposes an electromyographic-based learning approach that decodes the grasping intention at an early stage of reach-to-grasp motion, i.e. before the final grasp/hand pre-shape takes place. Superficial electrodes and a Cyberglove were used to record the arm muscle activity and the finger joints during reach-to-grasp motions. Our results showed a 90% accuracy for the detection of the final grasp about 0.5 sec after motion onset. This paper also examines the effect of different objects' distances and different motion speeds on the detection time and accuracy of the classifier. The use of our learning approach to control a 16-degrees of freedom robotic hand confirmed the usability of our approach for the real-time control of robotic devices.

Keywords:
Reach-to-grasp, grasp planning, machine learning, electromyographic (EMG) signals, prosthesis

1. Introduction

Nowadays, robotic devices are frequently used to restore motor abilities lost after pathologies or trauma, such as exoskeletons and operative devices adopted for the patients assistance during rehabilitation, and the prostheses for amputees [1]. Studies on amputees and stroke patients [2, 3] have reported that comfort is one of the priorities for the acceptability of a wearable robotic device, and that inconvenient and time ineffective systems may avert individuals from using a prosthetic device [2]. To increase the level of comfort and effectiveness, these devices should detect the human intention early enough in order to ensure the smooth and prompt behavior of the system.
It has been extensively demonstrated that users motion intention can be accurately detected by surface electromyographic recordings (sEMG) [4]. Different sEMG-based systems were proposed for the estimation of hand and wrist movements, and consequently used as noninvasive interfaces for controlling exoskeletons [5, 6], prosthetic devices [7, 8, 9], computer-animated hands in a virtual environment [10], or for teleoperating robotic arms [9, 11]. The previous studies focused on the investigation of discrete classifications of wrist abduction/adduction [9, 11], flexion/extension [7, 10, 12, 13] as well as of a different combination of finger motions [9, 11, 14]. Such strategies are useful for accomplishing power grasps that require simultaneous closure of all fingers on the object. However, this is insufficient to generate differentiated control of all fingers in the variety of pinch grasps used in dexterous objects manipulation, as required by the grasping of a larger variety of objects.

The differentiated control of all fingers is complex to achieve due to the high dimensionality of the hand's degrees of freedom. Indeed, the human hand is characterized by 21 degrees of freedom (DOFs) controlled by 29 muscles [15]. It has been hypothesized that humans are capable to control this large number of DOFs

Email addresses: iason.batzianoulis@epfl.ch (I. Batzianoulis[a]), sahar.elkhoury@epfl.ch (S. El-Khoury[a]), elvira.pirondini@epfl.ch (E. Pirondini[b]), martina.coscia@epfl.ch (M. Coscia[b]), silvestro.micera@epfl.ch (S. Micera[b,c]), aude.billard@epfl.ch (A. Billard[a])