Proposal for the ICAR 2013 task: Dexterous Control of Prosthetic Hands

1. Title:
Dexterous Control of Prosthetic Hands

2. Format:
Half day; workshop

3. Main Organizer:
Dr. Manfredo Atzori
University of Applied Sciences Western Switzerland (HES-SO)
TechnoArk 3, 3960 Sierre, Switzerland
manfredo.atzori@hevs.ch, http://medgift.hevs.ch/silverstripe/index.php/team/manfredo-atzori/, tel. +41 27 6069023

4. Co-Organizers:
Dr. Barbara Caputo
Head of the Cognitive Visual Systems Group
Idiap Research Institute
Rue Marconi 19, 1920 Martigny, Switzerland
bcaputo@idiap.ch, http://www.idiap.ch/~bcaputo/, tel: +41 27 721 7737

Dr. Claudio Castellini
Robotics and Mechatronics Center
German Aerospace Research Center - DLR,
Münchenerstr. 20, d-82230 Oberpfaffenhofen, Germany
claudio.castellini@dlr.de, http://www.robotic.dlr.de/Claudio.Castellini, tel: +49 8153 28 1093

Dr. Arjan Gijsberts
Idiap Research Institute
Rue Marconi 19, 1920 Martigny, Switzerland
arjan.gijsberts@idiap.ch, http://www.idiap.ch/~agijsberts, tel: +41 27 720 5808

Prof. Dr. Henning Müller
Head of eHealth Unit
University of Applied Sciences Western Switzerland (HES-SO)
TechnoArk 3, 3960 Sierre, Switzerland
henning.mueller@hevs.ch, http://medgift.hevs.ch/silverstripe/index.php/team/henning-mueller, tel. +41276069036

5. Abstract *(less than 200 words)*
Upper-limb prostheses have been under development for several decades with the aim of restoring the hand's original functionality and appearance. These prostheses are commonly controlled by the electrical signal generated by the muscle remnants on the patients stump using Surface Electromyography (SEMG). Gradually, this technology has evolved from the control of a single-DoF prosthesis function (such as "open-close") to polyarticulate prostheses.
However, natural and dexterous control of non-invasive robotic prosthetic hands is still far from reality. This is in contrast with recent advances in mechatronics that lead to the natural control of robotic hands with high movement capability.
To improve the situation, we built the free NinaPro (Non-Invasive Adaptive Prosthetics) database, which includes sEMG signals, finger movements and force responses from 50 hand movements recorded from intact and amputated persons.
In this workshop we will present and explain how to use the database, we will describe the state of the art in sEMG controlled robotics and we invite the participants to compare performance on the sEMG control of a robotic hand in 50 different movements. The task includes datasets from 40 intact subjects, and will help the participants to work on the Ninapro database with 20 amputated subjects.

6. Motivation and Objectives *(less than 300 words)*

Despite the significant technological advancements that have been performed in the field of robotic hands and the commercial availability of dexterous prosthetic hands, their diffusion among amputees is lacking. This fact is due to several aspects. First, the control of the robotic hands is difficult and not natural: amputated subjects control the prosthesis with movements that are different from the ones that the prosthesis does. Second, the training procedure to learn controlling the prosthesis usually requires months. Third, the control of the robotic hands still shows an insufficient level of dexterity, even for common tasks.

Therefore, there is a user-driven need for signal processing and machine learning algorithms able to improve the control of prostheses by amputees.

During the workshop we will give to the participants all the information needed to get the best from the database that we are releasing, including practical examples of the acquisitions and of the related problems (both on intact and amputated subjects); experiences on the pre-processing of datasets; experiences on the analysis of the datasets.

During the associated robotic hand control task, the participants will be asked to evaluate their system to detect the 50 hand movements in 40 subjects. The signal is acquired at 2 KHz with 12 electrodes placed on the forearm as described in [1]. The database includes 6 repetitions of each movement: repetitions {1,3,4,6} will constitute the training set, while the remaining two movements will form the test set. With this task we aim to get the participants involved in the project, as well as (hopefully) to get important results.

We truly hope that the workshop will seed important advances in this field that could allow amputated subjects to recover a significant percentage of the dexterity and functionality of their missing limb and therefore of their daily autonomy.

7. Intended Audience

This workshop is addressed to an audience of several research domains, including the robotics community, the rehabilitation robotics community, researchers from the brain-computer interface domains, from the machine learning domain and from the multimodal data analysis area.

As a further sign of the interest for this data task, hereby we add a list of the researchers not involved in the project that downloaded so far the NinaPro database in the version described in [1]. These researchers constitute a group of people that is likely to participate in the task.

Jianguo Liu, University of North Texas, Texas, USA
Mirjana Popovic, Belgrade University, Serbia
Ali Al-Timemy, Centre for Robotics and Neural Systems, United Kingdom
Javad Nazemi, Politecnico di Torino, Italy
Deng Xiaoming, National University of Singapore, Singapore
Ravi Aishwarya, Anna University (India), India
Renato Salinas, Universidad de Santiago, Chile
Paolo Ariano, Italian Institute of Technology Torino, Italy
Cheng-hung Chen, Idaho State University, Idaho, USA
Sasha Godfrey, Italian Institute of Technology Genova, Italy
Gene Shuman, George Mason University, USA
Miao Li, EPFL, Switzerland
Justin Bayer, Technical University of Munich, Germany
Hamid Reza Marateb, Politecnico di Torino, Italy
Rosa Jimenez, Universidade Federeal Rio Grande do Sul, Brasil
Minas Liarokapis, National Technical University of Athens, Athens, Greece
William Jacobs, University of Sheffield, Sheffield, UK
George Georgoulas, Technological Institute of Epirus, Arta, Greece
Juliana Fernandez, ITM Institucion Universitaria, Medellin, Colombia
V. Ramalingam, S.R.M University, Chennai, India
Ryan Smith, Johns Hopkins University, Baltimora, US
Ganesh Naik, University of Technlogy, Sidney, Australia
J.A. Oladosu, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
Wentao Wei, Zhejiang University, Hangzhou, China
Yang Dapeng, Harbin Institute of Technology, Heilongjiang, China
Qin Zhang, Huazhong University of Science and Technology, Wuhan, China
Wenbin Chen, Huazhong University of Science and Technology, Wuhan, China

8. List of potential Speakers

Prof. Roberto Merletti *(Invited Talk, confirmed)*
Laboratory of Engineering of the Neuromuscular System (LISiN)
Politecnico di Torino
Torino, Italy

Prof. Dario Farina *(Invited Talk, confirmed)*
Department of Neurorehabilitation Engineering
Georg-August University
Goettingen, Germany

Dr. Manfredo Atzori
University of Applied Sciences Western Switzerland (HES-SO)
Sierre, Switzerland

Dr. Barbara Caputo
Head of the Cognitive Visual Systems Group
Idiap Research Institute
Martigny, Switzerland

Dr. Claudio Castellini
Institute of Robotics and Mechatronics
German Aerospace Research Center - DLR,
Oberpfaffenhofen, Germany

Dr. Arjan Gijsberts
Idiap Research Institute
Martigny, Switzerland

Prof. Dr. Henning Müller
Head of eHealth Unit
University of Applied Sciences Western Switzerland (HES-SO)

For participants in the task we will propose an open call for papers, and the groups participating with the best results will be given the possibility to present their approaches.

9. List of Topics

1. The Ninapro database: introduction to the acquisition protocol and to the database facilities.
2. Pre-processing techniques in sEMG: introduction to the pre-processing techniques for the Ninapro database.
3. Hand movements similarity and hierarchy: evaluation of the 50 movements included in the acquisition protocol by computational methods
4. sEMG robotic hand control task: participants will be asked to simulate the control of a robotic hand in 50 different movements. The task includes datasets from 40 intact subjects using the signal from 12 SEMG electrodes placed on the forearm [1].
5. Invited Talk *(Prof. Roberto Merletti)*
6. Invited Talk *(Prof. Dario Farina)*

[1] *Building the NinaPro Database: a Resource for the Biorobotics Community* (2012). Atzori M., Gijsberts A., Heynen S., Mittaz Hager A.-G., Deriaz O., Van der Smagt P., Castellini C., Caputo B., and Müller H. 2012 IEEE International Conference on Biomedical Robotics and Biomechatronics.