Electromyography for Hand Prosthetics Demo

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ABSTRACT
A hand amputation is one of the most impairing injuries and can dramatically affect the capabilities of a person. Scientific research is proceeding towards robotic prostheses that can act almost like real hands. This demo introduces to the functioning of surface electromyography electrodes, one of the main parts the acquisition setup of the SNSF financed projects NINAPRO and MEGANE PRO. The use of surface electromyography electrodes in the two projects improves the control of robotic prosthetic hands and the knowledge of the neurologic and neurocognitive effects of amputations.

Author Keywords
Electromyography, rehabilitation robotics, machine learning.

ACM Classification Keywords
I.2.9 Robotics - sensors

INTRODUCTION
Myoelectric hand prostheses with many degrees of freedom are commercially available and recent advances in rehabilitation robotics suggest that their natural control can be performed in real life. Nevertheless, the most common control systems are still usually unnatural and the path to naturally controlled prostheses requires several steps to increase robustness.

In the sEMG prosthetics market, a relatively wide choice of devices is available to restore the capabilities of hand amputees with sEMG robotic prostheses [1]. Few have the capability to reproduce many movements, but the control methods are still in most cases unnatural and cumbersome.

In scientific research, many papers have been written about the natural control of robotic hands by intact and transradial hand amputated subjects. Most of the methods rely on the use of sEMG and of pattern recognition or proportional control algorithms. Pattern recognition algorithms are used to classify the movement that the subject aims to perform according to a label [2]. Pattern recognition results provided in several cases classification accuracy over 90%-95% on less than 10 classes however average results are usually below 80-90% [3].

Our group has long experience in the field of sEMG prosthesis control. This is demonstrated also by the high number of peer reviewed international publications in high level journals (e.g. IEEE Transactions on Neural Systems and Rehabilitation Engineering, Nature Scientific Data) and conferences (e.g. ICORR, IEEE International Conference on Rehabilitation Robotics; Biorob, IEEE International Conference on Biorobotics and Mechatronics; EMBC, Annual International Conference of the IEEE Engineering in Medicine and Biology Society). Several novel results are described in these publications. First, we publicly released the biggest database in the field of sEMG signals for hand movements (which includes three databases containing the sEMG recordings of at least 50 movements repeated by respectively 67 intact subjects and 11 transradial amputated subjects). The data were made available publicly and can be downloaded by researchers all over the world to test and compare their movement classification performance. The number of subjects participating in the data collection is comparatively high, especially considering the difficulty of recruiting trans-radial amputees and the fact that intact subjects can only be used as an approximated measure for amputees [4]. Second, the analyses carried out by applying machine learning methods to the database revealed that the data are similar to data acquired in real-life conditions and that they allow recognition of hand movements by applying state-of-the-art signal features and machine-learning algorithms [5]. This also acts as a validation of the acquisition and of the experimental protocol, meaning that stability over more persons and movements is possible. Third, the availability of such a large amount of data allowed comparing several machine learning methods to recognize the movements performed by the subjects [6]. Fourth, the acquisition protocol allowed showing that it is possible to improve the movement classification accuracy both with spatial registration methods [7] and with multimodal data acquisition (including e.g. additional sensors, such as accelerometers) [8]. Fifth, the preliminary analysis on small sets of amputated subjects allowed obtaining very good results in the recognition of the movements by the remnants of the hand muscles [9]. With the project MEGANE PRO (started in February 2016) our group started to fuse sEMG analysis with computer vision and eye tracking techniques in order to make the prostheses more autonomous.

METHODS
This demo introduces to the functioning of surface electromyography electrodes, one of the main components of the NINAPRO and MEGANE PRO acquisition setup.

The demo will show how the electrodes work. A representation of the NINAPRO acquisition setup is reported in figure 1.

Up to 8 electrodes will be used in the demo. The persons attending the demo will have the opportunity to test the electrodes on themselves and to see the electrical signal emitted by their muscles on the screen of a laptop, experiencing the usefulness of this biometric technique. The analysis of surface electromyography electrodes to measure the muscular activity by amputated subjects in combination with artificial intelligence algorithms allows to recognize the movements that the persons would be doing with their missing hand.

CONCLUSIONS

A hand amputation can strongly affect the capabilities of a person.

Scientific research is proceeding towards robotic prostheses that try to imitate real hands. This demo introduces to this research field by showing how surface electromyography electrodes work.

The analysis of surface electromyography electrodes to record the muscular activity of amputated subjects in combination with artificial intelligence algorithms is a promising resource for the field, since it can allow to naturally control robotic hand prostheses.

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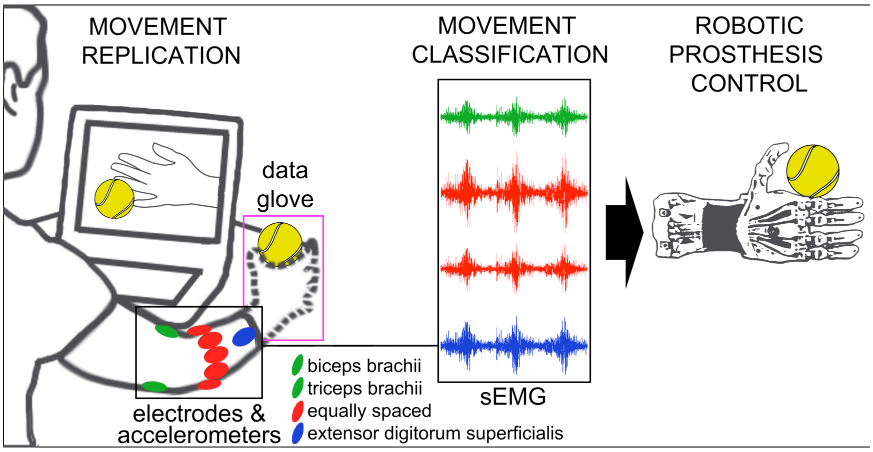

Figure 1. Ninapro acquisition setup.

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