INPUT – H2020 EU project to advance hand prosthetic control

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***Abstract*— INPUT is a European H2020 project (02/2016-02/2020) that focuses on advancing upper limb prosthetics by tackling the most significant aspects of successfully fitting such a device to a user: Improved socket for more comfortable fit and wearing; Improved training to maximize the outcome with the patient; Improved recognition algorithms for better and more robust control; Improved evaluations to make sure that the devices are tested in clinically relevant scenarios.**

We will achieve this by increasing our theoretical knowledge on the control generating mechanisms, by ample end user testing (2 of the 4 project years are dedicated to user testing) and by implementing the project as an Innovation Action, meaning an increased focus on high market readiness.

I. Introduction

WOLF Schweitzer, transradial amputee since August 2008, writes on his Technical Right Below Elbow Amputee Issues blog: "Academic research is interesting, but for the most part has failed to deliver any improvements to upper arm prosthetics in the last 50 years. By and large people tend to be a bit shocked when I show them real stuff, when I tell them what really is going on. Reality of academic prosthetic research has it that they never end up actually helping amputees".
(http://www.swisswuff.ch/tech/?page_id=2, 2014)

» Prosthetic users are frustrated with the technology available on the market today [1]. The main objective of INPUT is to translate clinically relevant research results on advanced upper limb prosthetic control made in the past from the laboratory to an everyday usable solution for end-users – straight after donning of the prosthesis, under the motto "don and play".

To reach this objective, INPUT will build upon long experience in this field by the involved institutions and results achieved within two preceding EU projects working on advanced arm prosthetics – the EU FP7 IAPP projects AMYO (Grant No. 251555, 2011-2014) and MYOSENS (Grant No. 286208, 2012-2015).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 687795, project Acronym INPUT. The content of this article does not reflect the official opinion of the European Union. Responsibility for the information and views expressed therein lies entirely with the authors.

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II. Project Overview

A. Motivation

As also noted in the introductory quote by an end-user, despite many decades of research on improvement of upper limb prosthetic control, the most advanced commercially available technologies are still disappointing. Compared to natural arms, they significantly lack functionality required by amputees. Daily use of complex, highly dexterous wearable robotic arms is still not clinical reality. The vast majority of high-end myoelectric arm prostheses rely on a very simple, almost half a century old, electromyographic (EMG) interface with two electrodes. The acquired EMG signals are commonly used to drive "hand open" and "hand close" functions of the robotic device. More functions (shoulder, elbow, wrist, individual fingers) are not directly controllable, so that (if at all available) unintuitive switch- and sequential menu based schemes have to be applied. The movements lack naturalness, dexterity and somehow do not fit in today's picture of modern technology – with self-driving cars, intelligent robots and smart phones, which fit in our pockets and whose processors and memory capacities are ~1000 times more powerful than that of the computer used for the moon landing of Apollo 11 in 1969. Compared to these advancements in electronics of the last 40-50 years, the advancements of upper limb prosthetics have virtually stalled. No wonder that this reflects in user dissatisfaction: The acceptance of myoelectric prosthesis was reported to be only 61% in amputation levels of elbow or above and 33% of myoelectric users reported unsatisfying function [2], which was the most prominent problem found in that study, ranking above issues with cosmesis, fit and maintenance. Several other studies show similar results on arm prosthesis rejection.

B. Main project goals

In INPUT, a multi-functional arm prosthesis is being developed that enables users to control their devices in a natural, easy and – most importantly [3]-[6] – reliable way. INPUT channels research efforts of the past decades into one, finally clinically viable system: ready for market introduction by the project coordinator and prosthetics world market leader, Ottobock.

The efforts of INPUT do not just focus on new technology, but INPUT also aims to develop new tools to help the end-user achieve a higher level of functional use of the prosthesis. Therefore, a substantial part of the project is devoted to develop a proper rehabilitation training that can be used with the new device. Training is important because even with a prosthetic device, which has natural and intuitive control, patients need guidance to restore consistent muscle signals. The developed rehabilitation exercises will use a serious game, because in a fun training environment patients can be motivated to exercise longer due to the aspect of play involved, while being educational. Furthermore, such a training environment allows individualizing feedback that enlarges the chances of optimal performance improvement. The level of improvement with the new device and of the training developed is tested in functional tasks and daily life situations, to assess improvement in the behavioural domains most important for the end-users.

INPUT aims to significantly advance the state of the art in machine learning based upper limb prosthesis control. The particular focus lies on natural control, robustness, user training and frequent end-user tests. INPUT will advance the involved technologies from a technology readiness level (TRL) of 4/5 to one which will allow testing a qualified and complete prototype in its operational environment (TRL 8). The main focus of the project will thus be to provide natural, dexterous control of complex arm prostheses, while minimizing the efforts users have to make for mastering and maintaining this high functionality.

In particular, the following goals will be reached in INPUT:

- Simultaneous control of at least 4 DOF of a modern arm prosthesis (hand, wrist, elbow functions)
- Proportional control of each DOF
- Intuitive, natural control as exemplified by increased functional use of the prosthesis
- High robustness as assessed by experiments with end-users in real life situations
- Self-calibration and automatic parameter tuning for ease of use, especially after donning of the prosthesis ("don and play")
- A wearable prototype with high TRL of 8 ("system complete and qualified")
- A motivating and effective user training environment employing specific guided training
- Extensive tests and validations with end-users in real life settings and during activities of the daily living, including suitable biomechanical analysis to verify the advantages of the devised system
- A marketing strategy and exploitation plan for the obtained solution
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Fig. 1. Prosthetic wearer using several degrees of freedom at once to grasp a cup handle efficiently.

C. *First results*

In the first year of the project, the first prototypes of multi-electrode liners have been developed and tested for signal quality and comfortable fit.

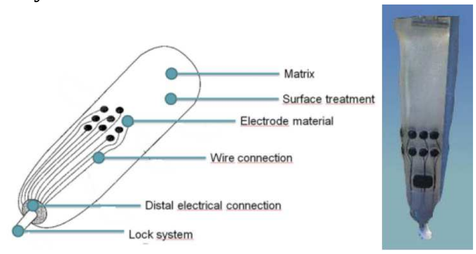

Fig. 2. First prototype of improved electrode liner for multi-channel EMG recording in transradial amputees.

Furthermore the first training concepts have been devised which specifically target improved muscle control of amputees for machine learning driven controls.

We have implemented a deep learning approach with advanced post-processing, which allows for precise control and simultaneous control over 3 degrees of freedom.

In the next year, the prototypes will be miniaturized, ported to portable hardware and be prepared for user testing.

ACKNOWLEDGMENT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 687795, project Acronym INPUT

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