



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Interactive Demo of the SOPHIA Project: Combining Soft Robotics and Brain-Machine Interfaces for Stroke Rehabilitation

Citation for published version:

Mcconnell, A, Stokes, A, Muioli, RC, Brasil, FL, Corne, DW, Vallejo, M & Vargas, PA 2016, 'Interactive Demo of the SOPHIA Project: Combining Soft Robotics and Brain-Machine Interfaces for Stroke Rehabilitation', IEEE Human-Robot Interactive Communication, IEEE RO-MAN 2016, New York, United Kingdom, 25/08/16 - 31/08/16.

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



Interactive Demo of the SOPHIA Project: Combining Soft Robotics and Brain-Machine Interfaces for Stroke Rehabilitation*

Alistair C McConnell, *Member, IEEE*, Adam A Stokes, *Member, IEEE*, Renan C Moiola, Fabricio L Brasil, David W Corne, Marta Vallejo and Patricia A Vargas, *Member, IEEE*

Abstract— This is an interactive demo of the first prototype of the Soft Orthotic Physiotherapy Interactive Aid project (SOPHIA). SOPHIA combines a soft exoskeleton with a brain machine interface (BMI) to create a robotic device for stroke rehabilitation, more specifically for hand motor impairment recovery. The ultimate goal of SOPHIA is to create a system that is of a lightweight design, low cost and aesthetically friendly. Moreover, it will aid physiotherapists in tracking the patient’s rehabilitation progress. This demo aims at contributing to a greater understanding and knowledge of how people interact with assistive robotic devices and their opinions on this style of rehabilitation.

I. PROJECT PARTNERS

- Alistair C McConnell (acm9@hw.ac.uk). He has a MEng in Robotics and Cybertronics, MSc in Robotics, Autonomous and Interactive Systems and is a PhD candidate in Computer Sciences at Heriot-Watt University. Has experience in rehabilitation robotics, soft robotics and control systems.
- Patricia A Vargas (P.A.Vargas@hw.ac.uk) is the Founder Director of the Robotics Laboratory at Heriot-Watt University. She has a PhD in computer Engineering. She is an expert on Social Robotics and she is currently developing work in the field of Rehabilitation Robotics.
- David W Corne (dwcorne@gmail.com) is the Director of Enterprise, Impact and Innovation and leads the Intelligent System Lab at Heriot-Watt University. He researches into optimisation, machine learning and data mining in different application areas like environment, climate, energy and health.
- Marta Vallejo (mv59@hw.ac.uk) is a Research Associate at Heriot-Watt University and a PhD candidate in Computer Sciences. She has experience in machine learning, evolutionary

computation, clustering, local search optimizers and computational sustainability.

- Adam A Stokes (a.a.stokes@ed.ac.uk) is the Director of the Stokes Research Group at Edinburgh University. He is an expert in robotics, physical chemistry, electrical engineering, materials science and soft robotics.
- Fabricio L Brasil (brasil@isd.org.br) Ph.D. in Neuroscience. Has experience in the field of brain machine interface (BMI), rehabilitation, EEG plasticity and brain stimulation techniques.
- Renan C Moiola (moiola@isd.org.br) Ph. D in Computational Neuroscience and Robotics. Has experience in computational neuroscience, signal processing, information theory, autonomous robotics and neurorobotics.

II. DEMO PRESENTATION

We are available to present the demo during the allocated slot session open to the audience.

III. DEMO DETAILS

We will demonstrate SOPHIA (Fig. 1,2), a soft exoskeleton in combination with a real time neural signal processing BMI system in which the activity shown on the screen from the BMI data will be reflected in the motion of the exoskeleton.

Specifically we will use a soft robotic exoskeleton to provide the motion of the hand, the subject’s neural signals will be captured using a wireless electroencephalogram (EEG) device.

The task will consist of a two stages:

1. The subject will initially go through a training scenario in which they will actively imagine their own movements of the hand, for example opening the hand and then relaxing.
2. They will then be put into an online mode where the subject will observe different instructions and either imagine opening their hand which will then be reflected in the action of the exoskeleton opening their hand or they will imagine relaxing in which case the exoskeleton will remain still. At the end of the session, they will be able to see their progress and accuracy.

*Research supported by Royal Society/Newton Fund: Ref NI140250.

Alistair C McConnell, Patricia A Vargas, David W Corne and Marta Vallejo are with Robotics Lab, School of Mathematical & Computer Sciences, Heriot-Watt University, EH14 4AS Edinburgh, UK (+44(0)1316675490; e-mail: acm9@hw.ac.uk, P.A.Vargas@hw.ac.uk, dwcorne@gmail.com and mv59@hw.ac.uk).

Adam A Stokes is with Stokes Research Group at Edinburgh University, The King’s Buildings, W Mains Rd, EH9 3FF Edinburgh, UK. (e-mail: a.a.stokes@ed.ac.uk).

Fabricio L Brasil and Renan C Moiola are with the Edmond and Lily Safra International Institute of Neuroscience, Santos Dumont Institute, Rod. RN 160, Km 03, number 3003, 59280-000 Macaiba, Brazil, (e-mail: brasil@isd.org.br and moiola@isd.org.br).

The results of these demos would contribute to the greater knowledge of how people interact with assistive robots and their opinions on this type of rehabilitation.

Due to the increasing number of stroke sufferers and also stroke survivors [1] the need for forms of rehabilitation outside of the clinical setting has increased dramatically. These rehabilitation systems have to be effective, simple to use and also provide a broad range of data to allow for greater knowledge of the rehabilitation process, such as length of time rehabilitation can be effective for [2], [3] and the intensity of the exercises [4].

Assistive orthotic systems aim to help restore functionality to patients who have impaired limbs, in this instance this impairment would occur as a result of a person suffering a stroke. It would be aiding the person to complete their rehabilitation in the most comprehensive manner, both encouraging them to perform the exercises more often, by fully moving the limb if the patient cannot move it by themselves and by guiding them in the correct range of motion.

Brain Machine Interface (BMI) systems aim to also compliment rehabilitation process by restoring the motor activity in subjects with motor impairment [5], [6]. This work is related to patients who have suffered motor impairment due to a stroke. A non-invasive BMI uses the electrical brain signal received through the patient's scalp which can be translated into actions. This in combination with other signal data such as Electromyography (EMG) can be used to control the motion of the prosthesis.

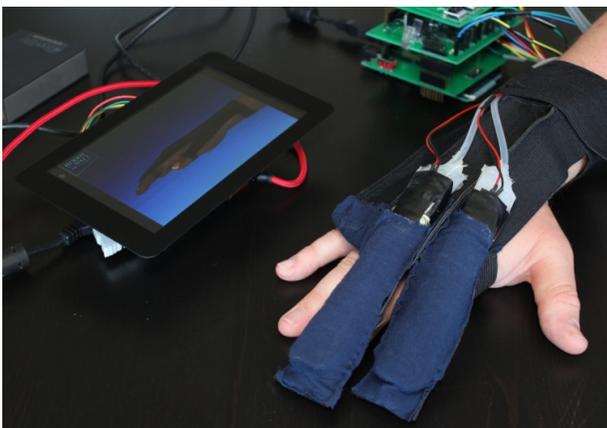


Figure 1: The full portable SOPHIA system showing the interactive display, mounted glove and the control unit.

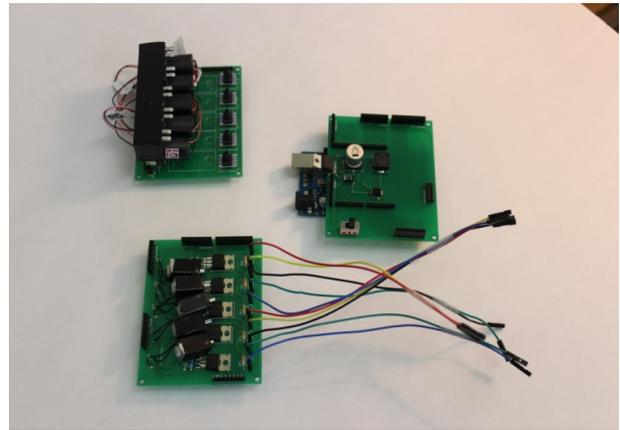


Figure 2: This is a breakdown of the modular control system that controls all of the actuation and sensors.

IV. DEMO EXPERIENCE

The participants will have the possibility to use the SOPHIA system (upon signing a disclaimer) to participate in the rehabilitation exercise and thus experience what it is like to use a BMI controlled hand orthosis.

V. DEMO TECHNICAL REQUIREMENTS

- HDMI compatible screen to connect to the laptop for the participant to see the instructions
- Three power outlets, a table and three chairs

ACKNOWLEDGMENT

The authors would like to thank the Royal Society for the Newton International Exchange award Ref NI140250. More information is available at <http://www.macs.hw.ac.uk/SophiaProject> or from emailing info.sophia.project@macs.hw.ac.uk.

REFERENCES

- [1] L. June, B. Smith, and B. Fretwell, "State of the Nation Stroke Statistics," no. 71, 2008.
- [2] G. Kwakkel, B. J. Kollen, J. van der Grond, and A. J. H. Prevo, "Probability of Regaining Dexterity in the Flaccid Upper Limb: Impact of Severity of Paresis and Time Since Onset in Acute Stroke," *Stroke*, vol. 34, no. 9, pp. 2181–2186, Sep. 2003.
- [3] G. Kwakkel, B. Kollen, and J. Twisk, "Impact of time on improvement of outcome after stroke.," *Stroke*, vol. 37, no. 9, pp. 2348–2353, Sep. 2006.
- [4] J. Sivenius, K. Pyorala, O. P. Heinonen, J. T. Salonen, and P. Riekkinen, "The significance of intensity of rehabilitation of stroke. A controlled trial," *Stroke*, vol. 16, no. 6, pp. 928–931, Nov. 1985.
- [5] B. H. Dobkin, "Brain-computer interface technology as a tool to augment plasticity and outcomes for neurological rehabilitation.," *J. Physiol.*, vol. 579, no. Pt 3, pp. 637–642, 2007.
- [6] S. R. Soekadar, N. Birbaumer, M. W. Slutzky, and L. G. Cohen, "Brain-machine interfaces in neurorehabilitation of stroke," *Neurobiol. Dis.*, vol. 83, pp. 172–179, Nov. 2014.