Closed-Loop Design Strategies for Neuroprosthetic Control

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ABSTRACT:

Brain-machine interfaces (BMIs) hold great potential to aid large numbers of people with sensory, motor and cognitive disabilities. BMIs provide also a framework for examining basic neuroscience questions, especially those related to the understanding of how neural plasticity relates to the acquisition and consolidation of neuroprosthetic skills, i.e., accurate, readily-recalled control of disembodied actuators irrespective of natural physical movement. In this talk I will postulate that achieving skillful, natural control of a multi-degree-of-freedom prosthetic device will entail synergizing two different types of adaptation processes: natural (brain plasticity) and artificial (decoder adaptation), as well as providing realistic sensory feedback from the prosthetic device. I will present recent work from our laboratory showing that 1) neuroplasticity facilitates consolidation of neuroprosthetic motor skill in a way that resembles that of natural motor learning; 2) corticostriatal plasticity is necessary for neuroprosthetic skill learning, and 3) closed-loop decoder adaptation (CLDA) techniques can expedite the learning process by adapting the decoder parameters during closed-loop BMI operation (i.e., while the subject is using the BMI). We believe that BMI systems capable of exploiting both neuroplasticity and CLDA will be able to boost learning, generalize well to novel movements and environments, and ultimately achieve a level of control and dexterity comparable to that of natural arm movements.

BIO:

Jose M. Carmena is an Associate Professor of Electrical Engineering and Neuroscience at the University of California-Berkeley, and Co-Director of the Center for Neural Engineering and Prostheses at UC Berkeley and UCSF. His research program in neural engineering and systems neuroscience is aimed at understanding the neural basis of sensorimotor learning and control, and at building the science and engineering base that will allow the creation of reliable neuroprosthetic systems for the severely disabled.

Dr. Carmena received the B.S. and M.S. degrees in electrical engineering from the Polytechnic University of Valencia (Spain) in 1995 and the University of Valencia (Spain) in 1997. Following those he received the M.S. degree in artificial intelligence and the Ph.D. degree in robotics both from the University of Edinburgh (Scotland, UK) in 1998 and 2002 respectively.

From 2002 to 2005 he was a Postdoctoral Fellow at the Department of Neurobiology and the Center for Neuroengineering at Duke University (Durham, NC).

He is senior member of the IEEE (RA, SMC and EMB societies), Society for Neuroscience, and the Neural Control of Movement Society. Dr. Carmena has been the recipient of the Bakar Fellowship (2012), the IEEE Engineering in Medicine and Biology Society Early Career Achievement Award (2011), the Aspen Brain Forum Prize in Neurotechnology (2010), the National Science Foundation CAREER Award (2010), the Alfred P. Sloan Research Fellowship (2009), the Okawa Foundation Research Grant Award (2007), the UC Berkeley Hellman Faculty Award (2007), and the Christopher Reeve Paralysis Foundation Postdoctoral Fellowship (2003).