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Identification and feedback control in deep brain stimulation: a simulation study

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## **ABSTRACT OF THE TALK**

Deep brain stimulation (DBS) is an effective electric therapy introduced to treat movement disorders associated with chronic neural degenerative diseases like essential tremor, dystonia and Parkinson's disease. In spite of a long clinical experience and detailed studies, the cellular effects of the DBS are still partially unknown because of the lack of information about the target sites. Recent studies, however, have proposed the local field potentials (LFPs) generated by the simultaneous electric activity of several neurons in the target sites as a useful tool to investigate the behavior before and after stimulation.

Our work, conducted in association with Prof. Warren Grill, Duke University, Durham (USA), investigates the relationship occurring between DBS settings (i.e., frequency and amplitude of the stimulus) and LFPs in a 3D simulation environment reproducing the activity of the Vim (a thalamic nucleus, one of the main surgical targets) in tremor conditions. A least-square identification approach is adopted to define a functional, input-output autoregressive model of the Vim and evaluate the effects of the stimulation on its electric patterns. Starting from that model, a minimum variance control scheme is then proposed to restore the auto-spectrum of the Vim LFPs to reference values,

derived from subjects not affected by movement disorders. The control law works by updating the amplitude of the stimulus while the frequency is fixed at an aliasing-free value. Results indicate good performances in tracking the healthy spectral features through selective changes in the low (2-7 Hz), alpha (7-13 Hz) and beta (13-35 Hz) ranges.

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**Luigi Glielmo** received the Laurea degree in Electronic Engineering and the PhD degree in Automatic Control from the University of Napoli Federico II. There he joined the Faculty of Engineering first as an assistant professor and then as an associate professor of System Theory. In 2000 he joined the Faculty of Engineering of the University of Sannio in Benevento where he is professor of Automatic Control (SSD: ING/INF04) and heads GRACE, the Group for Research on Automatic Control Engineering. From November 2001 to October 2007 he was Head of the Department of Engineering. In 1989 and 1990 he was *visiting scholar* in the *School of Aeronautics and Astronautics, Purdue University, (USA)* and in 1990, *visiting scientist* in *NET Team, Max-Planck-Institut für Plasmaphysik (Germany)*. In 2002 he was *visiting professor* at the *Johannes Kepler Universität of Linz (Austria)*. His research interests include the modeling

and the control for “automotive” applications, the study of system dynamics with singular perturbation techniques, the analysis and the control of uncertain systems, the simulation of manufacturing systems.

He is co-author of about 80 publications and co-editor of an international book on “Variable Structure and Lyapunov Techniques” (Springer-Verlag, 1996). He is *senior member* of IEEE, Institute of Electrical and Electronic Engineers. He was member of Editorial Board of the scientific journals *Dynamics and Control (Kluwer)* and *IEEE Transactions on Automatic Control* and member of Program Committee of several international conferences. He was promoter and chairman of *IEEE Control Systems Society Technical Committee on Automotive Controls*. He was Principal Investigator for research contracts with several companies and for Italian and EC research projects in the automotive and automatic control fields.

**Giovanni Fiengo** obtained the Laurea degree cum laude in Computer Science Engineering in 1998, and the Ph.D degree in “Ingegneria dell’Informazione” at the Università di Napoli Federico II, in 2001. He actively collaborates with several universities and research centres. In particular, he collaborates with Ford Research Laboratory in Dearborn (MI, USA) and l’University of Michigan in Ann Arbor (MI, USA), Istitut Francais du Petrol in Lione (France) and, recently, with The Duke University in Durham (NC, USA).

Since 1st November 2002 he is an assistant professor at Engineering Department of Università del Sannio in Benevento. His main research activity deals with the modelling and control of Spark Ignition Internal Combustion Engines, the Three-Way Catalytic Converters, and hybrid vehicles. Recently, he showed interest in bioengineering field, with particular interest to the Deep Brain Stimulation.

**Sabatino Santaniello** received the Laurea degree in Control Engineering from Università degli Studi di Napoli “Federico II”, Naples (Italy), in 2004, and the Ph.D. degree in Information Engineering from Università degli Studi del Sannio, Benevento (Italy), in 2007. From April 2006 to May 2007 he was a Visiting Researcher with the Department of Biomedical Engineering, Duke University, Durham, NC (USA). He is currently a post-doc with the Department of Engineering, Università degli Studi del Sannio. His research interests include central nervous system modelling and simulation, and neural prostheses control, with particular regards to the deep brain stimulation techniques for the treatment of the motor symptoms of the Parkinson’s disease.

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