**Embedded system for real time determination of brain connectivity**

T.S. Silva1, L. A. Baccalá1

1,Telecommunications and Control Dept, Escola Politécnica, University of São Paulo

**Introduction**: Since the 90s considerable effort has gone into approaches to study the dynamical interrelations between brain regions [1]. Through EEG (electroencephalogram) one may identify immediate relations between multivariate signal structures via a technique termed '*partial directed coherence'* (PDC) [2] which portrays brain connectivity in the frequency domain and is intimately related to Granger "causality" [3] whereby the mutual influence between observed time series can be quantified. Most current PDC applications (as for other techniques) are mainly carried out off-line, bringing little experience about their practical feasibility in real time processing. The main goal of this work was to develop a system that computes PDC continuously and in real time on an embedded device (henceforth referred as RTMcarns).

**Materials and Methods**: RTMcarns was developed as a multithreading application in C that facilitates its portability to other platforms. The development board used for this work was the Wand Board Quad, which has an ARM cortex-A59 processor and whose accuracy was checked against an existing program written in MATLAB.

**Results**: RTMcarns allows PDC calculation for signals ranging from 2 to 32 channels, with calculation times varying from a few milliseconds to a few seconds, depending on the number of channels. The signals are received through a TCP/IP interface and the computed results are stored in local disk and later sent via TCP/IP to LAN/WAN connected devices. A maximum error of 10-15 was attained when compared to offline MATLAB algorithm implementation.

**Discussion**: Most connectivity inference implementations, including PDC’s are carried out off-line. Data are first collected and stored for later processing. Hence RTMcarns is a first step towards a real time computational infrastructure for connectivity which should facilitate pathophysiological evaluation by the clinical staffs that usually perform data interpretation and diagnostic decisions in parallel with patient observation.

**Conclusion**: The current project has met the expectations related to creating an implementation of a real time application, respecting certain time limits that depend on the signal characteristics. The desired numerical accuracy was reached. More importantly, its development has opened a new research venue for a practical diagnostic tool.

References: [1] Kaminski MJ and Blinowska, K., Biol. Cybern. 65(1): 203--210, 1991; [2] Baccala LA and Sameshima S, Biol. Cybern. 84(6): 546-553, 2001; [3] Granger CWJ, Econometrica 37(1): 424-438, 1969.