Neuro-inspired complex systems for Biorobotics

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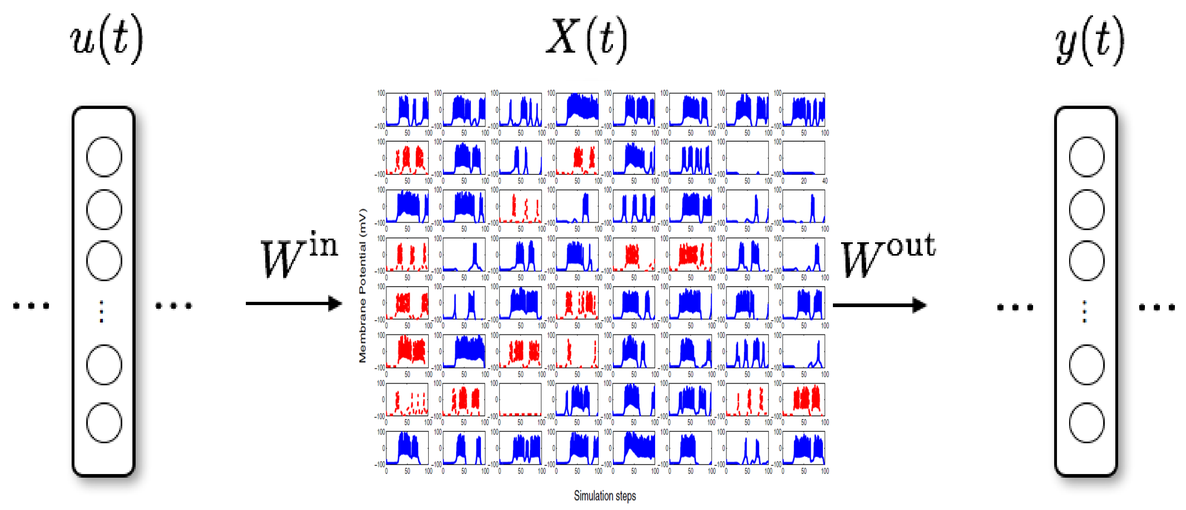
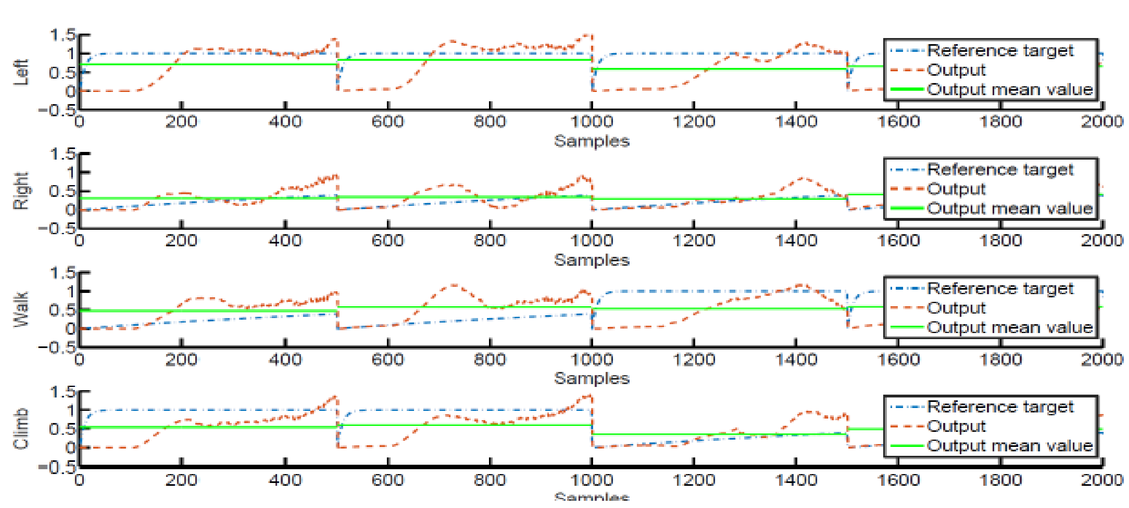
Reservoir Computing

In reservoir-based networks, usually consisting of three layers, only reservoir-to-output weights undergo training, either online or offline. Many applications have been considered, ranging from supervised classification, to internal model definition in locomotion issues, to more theoretical aspects like hyperparameters optimisation or dimensionality reduction.



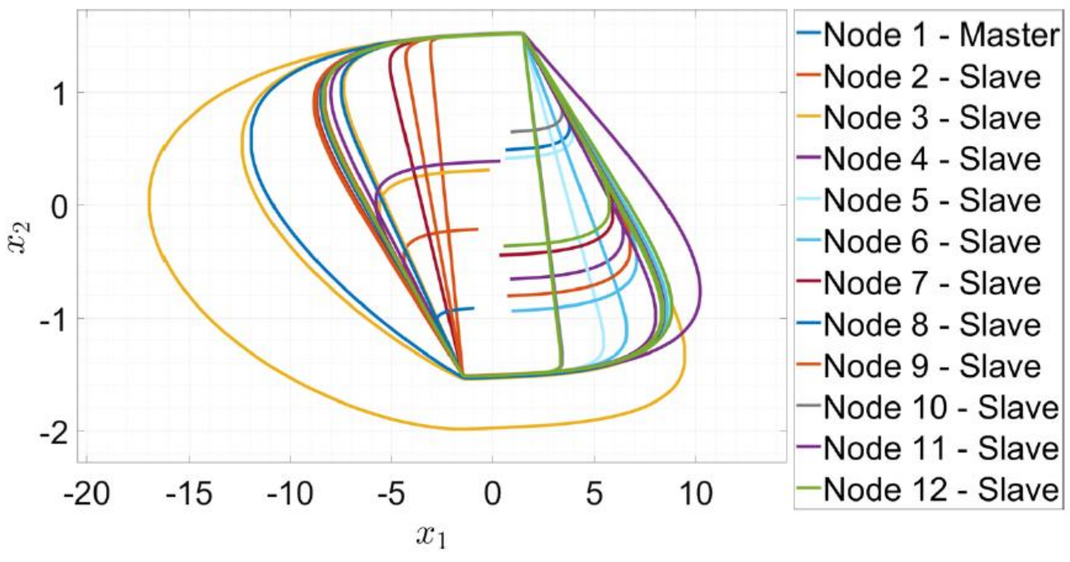
Example of Liquid State Machine with spiking reservoir neurons



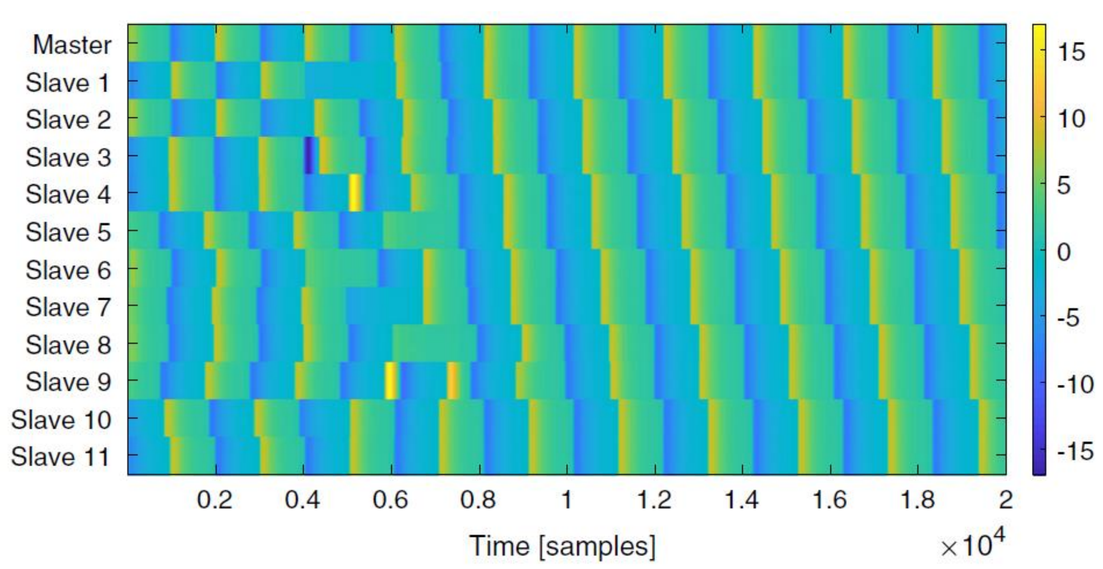
Application of the reservoir computing for WTA-like supervised classification

Modelling and control of nonlinear systems

A new method, named the nullcline-based algorithm, for modelling and controlling coupled nonlinear oscillators in master-slave topologies has been introduced. This technique aims to manipulate the whole dynamics according to predefined requirements, such as phase displacements or period of oscillation, relying on the piecewise linear approximation.



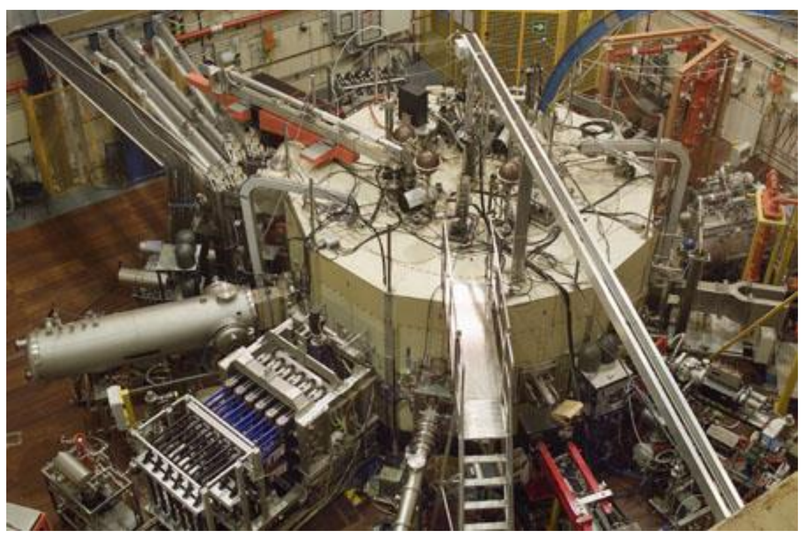
Nullcline-based algorithm in action: external slopes are changed dynamically...



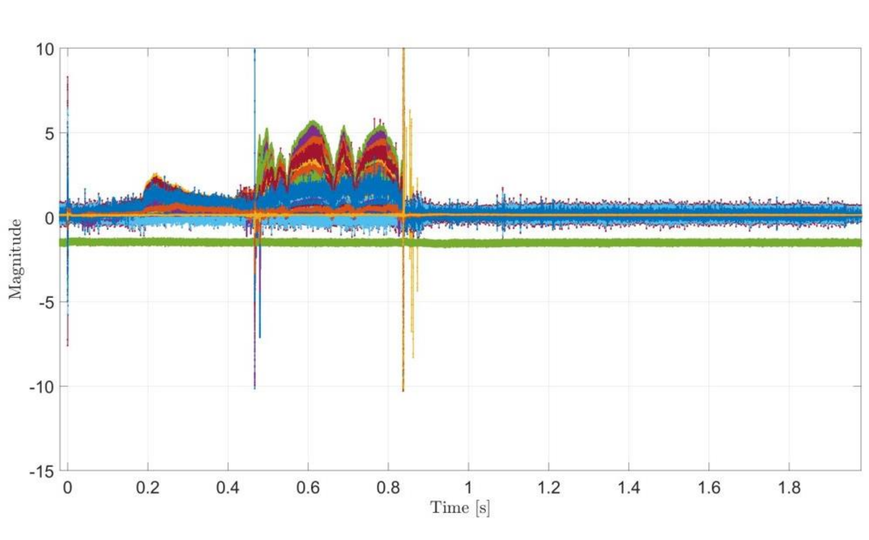
… to produce a stepping diagram compatible with predefined phase displacements

Time series analysis and processing for nuclear fusion

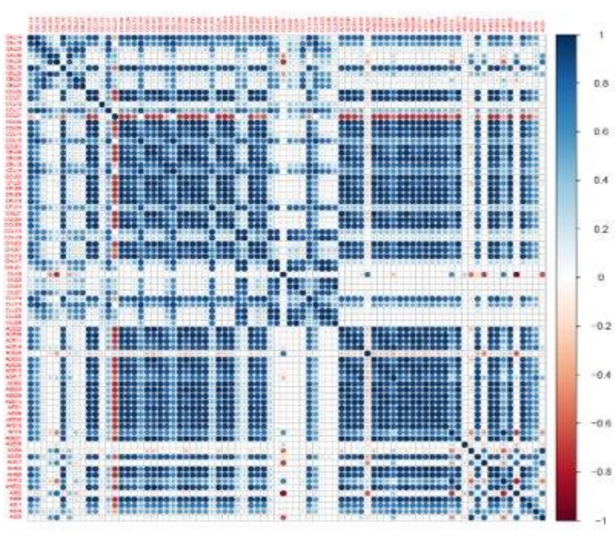
FTU (Frascati Tokamak Upgrade) is a Tokamak machine for hot plasma confinement and nuclear energy production that copes with a magnetic field of 80 Tesla. A required task, among others like statistical analysis or filtering, consists in performing Abel inversion of time-varying flux intensities to compute 2D plasma distribution in space.



FTU top view



Example of measured flux intensities



Example of correlation matrix amongst FTU channels

List of main publications

1. P. Arena, L. Patané, A. G. Spinosa, *Insect inspired spatial-temporal cellular processing for feature-action learning*, European Conference on Circuit Theory and Design (ECCTD), 2017
2. P. Arena, M. Calì, L. Patané, A. Portera, A. G. Spinosa, *A CNN-based neuromorphic model for classification and decision control*, Nonlinear Dynamics, Springer, 2018
3. P. Arena, L. Patané, A. G. Spinosa, *Data-based analysis of Laplacian Eigenmaps for manifold reduction in supervised Liquid State classifiers*, Information Sciences, Elsevier, 2018
4. P. Arena, L. Patané, A. G. Spinosa, *A nullcline-based control strategy for PWL-shaped oscillators*, Nonlinear Dynamics, Springer, 2019