We are looking for a strongly motivated young scholar for a two-year Post-doctoral position at the Physics Department, University of Padova. The post-doc will work with Dr. Michele Allegra, but also in close contact with Prof. Dal Maschio's Lab (Department of Biomedical Sciences, Unipd) and in collaboration with Dr. Pietro Rotondo (Department of Mathematical, Physical and Information Sciences, University of Parma). The post-doc will combine data analysis and modeling to investigate low-dimensional manifolds in neural activity, comparing real data from zebrafish and computational models based on artificial neural networks (a more detailed description of the project is provided below). The position will be fully funded by the National Interest Research Project (PRIN) "Unveiling the role of low dimensional activity manifolds in biological and artificial neural networks", which also includes funding for traveling.

Candidates should have a PhD in Physics, Computational Neuroscience or a related subject. Advanced computational skills (including solid experience with Matlab or Python programming) and data analysis experience are mandatory. Previous experience with neural data is highly welcome.

Contact:

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Project summary. Recent evidence in neuroscience suggests that computations during a task occur through collective dynamics unfolding over a low-dimensional neural manifold in the phase space defined by the activity of all neurons. However, a solid theoretical framework to understand why this low-dimensional organization occurs - what determines it, and what is its functional advantage - is still lacking. A possible strategy to fill this gap is to look at bio-inspired artificial neural networks (ANNs), which typically display a low-dimensional activity structure when trained to mimic biological networks in simple tasks. In our project, we will investigate in parallel a simple animal model (zebrafish) performing an active visuomotor integration task, and an artificial neural network trained to perform the same task. By simultaneously investigating the biological and the artificial network, we will test the ANN model's power to explain the features of the low-dimensional manifold observed in the biological network, and its response to perturbations. Our project will be carried out by two research units, one located in Padova (led by Dr. Michele Allegra) and the other in Parma (led by Dr. Pietro Rotondo). Collaborating with Prof. Dal Maschio's Lab (Department of Biomedical Sciences, Unipd), the Padova unit will develop a dimensionality-reduction-based analysis pipeline to identify the low-dimensional structure of a zebrafish's neural activity in association with the task. The Parma Unit will in parallel develop a maximally explainable model of the biological neural network, based on an ANN trained to perform the same task, and analyze its collective dynamics. This will enable us to better clarify dynamical and computational principles leading to the emergence of a stable low-dimensional activity manifold. Finally, the two units will join efforts and use the ANN model to formulate falsifiable predictions on the response of the biological network and its collective dynamics to novel stimuli or neuromodulation. Combining an advanced imaging setup and the team's expertise in dimensionality reduction, dynamical systems and artificial neural networks, we will enjoy a unique opportunity to fill a gap in the understanding of biological neural networks, and advance the integration between neuroscience and machine learning.