nanoSeminar Series 2022

Institute for Materials Science

Dr. Fabio Traversa

MemComputing Inc., San Diego, CA, US

An Introduction to Mem Computing

Thursday, March 10th 2022
16:00 – 17:00

Normal: Seminar Room 115, Hallwachsstr. 3 (HAL)
Pandemic version: https://tinyurl.com/nanoSeminar-GA

Memcomputing attempts to formalize the general concept of computing with and in memory (or computational memory), as opposed to conventional computing paradigms where the processing unit and memory are assumed physically separated entities exchanging information. To study this alternative computing paradigm, we have introduced the Universal Memcomputing Machine (UMM) as the abstract model describing the class of non-von Neumann architectures leveraging the computational memory as central building block. Proven to be equivalent to a non-deterministic Turing machine, the UMM leads to intriguing theoretical conclusions such as efficient solution of non-deterministic polynomial (NP) problems, with particular emphasis to combinatorial optimization.

The challenge is therefore finding a practical realization of a UMM possessing enough requirements to ultimately be able to efficiently solve problems that are combinatorial in nature. To this end, we have introduced the novel, unconventional, computational architecture based on Self-Organizing Gates (SOG), which we call Self-Organizing Circuits (SOCs). Each SOG is designed to reach an equilibrium iff a given relation among terminal states is satisfied. For example, if it is a boolean relation, we have a Self-Organizing Logic Gate. Unlike standard logic gates, they exploit the unique properties of being input/output terminal agnostic. Once assembled to form a Self-Organizing Logic Circuit, they take advantage of the collective state of the system to perform computation. This creates nonlocal long-range correlations that enable exceptionally fast convergence to solutions of hard combinatorial problems. To illustrate, I will discuss several results from using this approach to solve hard instances of MaxSAT problems and Integer linear Programming as well as accelerating the training of deep learning neural networks and challenging problems hoped to be solved one day by quantum computers.

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Dr. Traversa received the Laurea degree in Nuclear Engineering and the Ph.D. degree in Physics from Politecnico di Torino, Torino, Italy, in 2004 and 2008, respectively. He was a Researcher Fellow with the Electronics Department, Politecnico di Torino, in 2008. From 2009 to 2014, he was with the Departament d'Enginyeria Electrònica, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain first as a Post-Doctoral Researcher and then as a research fellow. During the same period, he was also a Visiting Researcher at the University of California-San Diego, San Diego, CA, USA, and at the New York University, New York, NY, USA. From 2015 to 2016 he was scientist at University of California San Diego and in 2016 visiting professor at Politecnico di Torino.

Internationally, he is well known for his invited talks on electronics, physics and unconventional computing. He has authored 80+ scientific papers published in top tier refereed journals. A near complete list can be found on Google Scholar, at https://scholar.google.com/citations?user=FJ8phpYAAAAJ&hl=en.

His research interests cover unconventional computing, memcomputing, high performance computing, numerical algorithms, computational complexity, circuit theory, circuit design, electronic transport in nano-devices, quantum transport, quantum computing, stability analysis of nonlinear circuits and systems, and noise analysis of nonlinear circuits.

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