PRESS RELEASE

A NANODEVICE THAT SIMULATES HUMAN MEMORY

An article published on Nature Communications shows the discovery of researchers from INRiM and Politecnico di Torino in the field of artificial intelligence

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Since ancient times, **memory** has been considered as one of the three features of human mind, together with will and understanding. Indeed, differently from simple motor reflexes, all **cognitive functions** including thinking and carrying out a behavior, need the creation, consolidation and recalling of memories.

Since the last century, neurobiologists have postulated the existence of **specific neuronal microcircuits** acting as substrate and *trace* for memories. Thanks to advances in neuroimaging techniques during the last ten years, these microcircuit units – called ***engrams*** by the German biologist Richard Simon in 1921 – have been finally mapped *in vivo* in research laboratories like the one of the Nobel prize Susumu Tonegawa at MIT.

Now, the article "*Tomography of memory engrams in self-organizing nanowire connectomes*" published on the prestigious journal ***Nature Communications*** shows that the process of **consolidation from short-term to long-term memory** of engrams can be emulated also in **artificial substrates**. To obtain such a result, researchers from the Italian **National Metrology Institute of Italy** (INRiM) and **Politecnico di Torino** have exploited *connectomes* of memristive *nanowires* that are networks connected at the **nanometer scale** (the same scale of biological synapses) able to exhibit typical features of neuronal circuits, such as an emergent behavior as well as short-term and long-term plasticity. The main novelty of this work is to have experimentally unveiled the **hidden dynamics** of nanowire connectomes, where external spatiotemporal inputs have been demonstrated to induce both **local and reversible changes (the analogue of the working memory in our brain) and long-lasting physicochemical changes (the analogue of long-term memory storage)**. This measurement was enabled by a combined experimental and theoretical approach based on *electrical resistance tomography*, a technique developed in INRiM that enables a quantitative mapping of local and global electrical properties of nanonetworks.

«Besides emulating biological systems, the possibility of mapping the emerging behavior of the system opens new perspectives for in materia *implementation of novel computing paradigms able to process and store information on the same physical substrate, with high energy efficiency»*, says **Gianluca Milano**, researcher of the group **Advanced Materials & Devices** at INRiM and responsible of the **MEMQuD** project that partially financed the research.

«The next challenge will be to further enhance the complexity of the system, connecting different nanodevices and engrams – adds **Carlo Ricciardi**, professor at Politecnico di Torino and PI of the **NaMeS** group –*. In this way, we hope to address one of the main challenges of cognition, the so-called "*binding problem*": i.e, how features of the same item, which are associated to separated stimuli and experiences (e.g., shape, color, position, etc...), are combined in a unique mind representation, i.e. the intrinsic* idea *of the item».*

The link to the publication is available at this link:
https://www.nature.com/articles/s41467-023-40939-x

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