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MAGAZINE

AI at the Edge and Sensors: technological opportunities for sustainable Artificial Intelligence

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A discussion among researchers and experts to explore challenges and opportunities of the integration between state-of-the-art microelectronic devices and AI algorithms.

The "**AI at the Edge and Sensors" workshop, an internal event dedicated to sharing cutting-edge and** prospective results of this new field of research, which sees knowledge on Artificial Intelligence strongly integrated with knowledge on **micro-nano electronic devices, was held at Fondazione Bruno Kessler on October 29.**

In fact, one of FBK's distinctive assets is to be able to rely not only on 30 years of experience in the AI field, but to combine these skills with the ability to develop and also mass-produce sensors and devices that underpin all the current application of artificial intelligence in society and business, spanning areas related to the environment, healthcare, agritech and many other innovative sectors.

Lorenza Ferrario and **Paolo Traverso**, organizers of the event and heads of the **MNF Micro Nano Facility** research **unit and FBK** Strategic Planning director, respectively, emphasized the importance of events like this for sharing and reflecting with relevant scientific communities. "Bringing AI to edge devices is not just a matter of efficiency, security and innovation, but requires an interdisciplinary approach," Ferrario noted, referring to the recent Nobel Prize in Physics awarded to scientists with interdisciplinary backgrounds and who have contributed specifically to AI. "This shows how the fusion of different kinds of expertise generates most innovative solutions," Lorenza Ferrario said.

Edge devices refers to a category of electronic devices with computing and processing capabilities that operate at the edge of the network, i.e. close to the data source. Unlike centralized servers or data centers, edge devices process data locally, reducing the need to transmit it to a remote cloud for processing, thus fostering less energy-intensive systems, faster responses, greater privacy control

“The intersection of AI and sensors is in the very roots of our research,” Paolo Traverso observed, recalling FBK’s origins and the figure of Luigi Stringa, the first director of the Center for S&D after whom the lecture hall where the event was held is named. “Understanding the results of integrating these two worlds is key to building the foundations for a truly useful and responsible AI.”

The event went on with a talk by Alessandro Cremonesi from STMicroelectronics, who addressed the impact of “**Edge AI” on future sustainability,** pointing out that this technology can improve energy efficiency and reduce the need to transfer large amounts of data to the cloud. Sabina Spiga from CNR IMM delved into the topic of memristive technologies – technologies that are based on memristors i.e., devices that can store and change their electrical resistance in response to the passage of current – illustrated as one of the possible ways to develop chips inspired by the functioning of the human brain; finally, Maurizio Patrick De Marchi from FBK discussed the possibilities of accelerating neural networks directly in image sensors, with practical applications ranging from security to privacy-by-design.

Elisabetta Farella, head of the Energy Efficient Embedded Digital Architectures E3DA unit at FBK’s Center for Digital Society, spoke about tinyAI (or TinyML) a strand of research at **the intersection of Artificial Intelligence and the Internet of Things**, in which approaches and technologies are being explored to bring Artificial Intelligence algorithms to embedded systems such as microcontrollers, i.e., systems with low power consumption and few computational resources. **TinyML techniques bring artificial intelligence close to the sensors, reducing** the need to transmit large volumes of data to the cloud. This technology enables rapid and local processing of collected information, facilitating real-time reactions and ensuring greater privacy protection by reducing the flow of data to external servers.

Farella illustrated several optimization techniques that make this approach possible, such as techniques to reduce the size **of** neural models (e.g., distillation and quantization of neural networks), integration between hardware and software that takes advantage of advanced devices (smart sensors, hardware accelerators, and neuromorphic architectures), and finally the exploration of architectural approaches, such as hardware-aware scaling, which is a neural network design technique that starts with hardware requirements and allows for the generation of efficient neural networks, quickly, and that exploit all available resources. Thanks to these innovations, AI can not only operate in decentralized, real-time contexts, but it can do so with drastically reduced resource usage, paving the way for new applications that are sustainable and accessible even on devices with limited capacity.

Farella outlined several optimization techniques that make this approach possible, such as distillation and quantization of neural networks to reduce the size and energy consumption of models. Among the most promising directions of this research, she mentioned the integration of hardware and software, which leverages advanced devices such as smart sensors, hardware accelerators and neuromorphic architectures to improve efficiency and accuracy. Thanks to these innovations, AI can not only operate in decentralized and real-time contexts, but it can do so with drastically reduced resource consumption, paving the way for new applications that are sustainable and accessible even on devices with limited capacity.

In the closing panel, Center for Sensors & Devices director **Richard** Hall-Wilton, Davide Marani from Sony, and Sabina Spiga from CNR IMM exchanged views, making the importance of interdisciplinarity emerge: the recent Nobel Prize awarded to two physicists for contributions to

artificial intelligence was cited as an example of the importance of not limiting oneself to one's own field. In this sense, the work of heterogeneous teams, composed of AI, hardware, and management specialists, is an effective model for addressing the complex and multidisciplinary challenges related to Artificial Intelligence.

The workshop is part of a series of meetings that FBK is devoting to topics crucial to the future of AI. After a first meeting on disruptive technologies in generative AI, this second workshop focused on AI and sensors, with a focus on sustainability, privacy and security of processed data. A third meeting is scheduled for February and will focus on **Artificial Intelligence and Energy, to** explore both challenges such as energy consumption for the development of AI technologies, and opportunities such as the application of AI in energy saving and energy management projects.

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