Proposer

Institution / Initiative	ANR (NB: This topic proposal builds on past years' topic suggestions in the domains of unconventional computing and of green ICT)
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Topic definition

Topic title *(2-10 words)*	Analog computing for Artificial Intelligence
Short description *(max ½ page)*	Analog computing, which was initially the mainstream approach in computing, has seen its progress outpaced by the huge investments in digital computing following Moore's law during almost five decades. However, with the end of Moore's law, there is room again for more varied computer architectures including analog ones. These can enable fast, energy-efficient computing for specific applications and thus become attractive again. Furthermore, the field of Artificial Intelligence, which is progressing fast, addresses signals which are intrinsically analog (image, sound, speech, proprioception, etc…) and increasingly relies on neural networks which naturally lend themselves to analog computing. In this context, analog computing becomes appealing for running Artificial Intelligence applications locally on personal devices, and more generally in an energy-efficient way.
Application sectors	All application sectors of Artificial Intelligence, especially in portable or autonomous devices
Keywords	Analog computing, Artificial Intelligence, neural networks, neuromorphic, low-power ICT, resource-efficient ICT

Scientific interest and innovation potential of topic

Describe the state-of-the-art, missing science, and expected outcomes (max 1/2 page).

Comment on all items below:

- *Describe how the topic can support the exploration of bold ideas for radically new technologies based on high-risk / high gain cutting-edge science*

Analog computing (AC) is receiving renewed interest in the context of the end of Moore's law. After a move towards parallel architectures, analog ones can be expected to be a new frontier for fast, energy-efficient computing. For example, analog VLSI chips have been launched on market for differential equation applications. AI applications are good candidates for exploiting the possibilities offered by AC. They can easily tolerate approximate computations, neural networks are suitable for analog implementations, and there is a strong need for low-power AI systems. The topic is thus highly novel and plausible. The topic is also highly ambitious. Analog neuromorphic hardware is still in its infancy and has not yet reached the point where it outperforms GPUs for AI applications. Missing science includes how to design AC and in particular neural network architectures which offer the same capabilities as the highly optimised GPUs while being more energy-efficient for some real AI tasks.

- *Describe how knowledge and communities from different disciplines can be brought together*

A challenge is to combine research on AI systems, which are currently implemented on general-purpose hardware, with research on analog computing. Analog computing, being non-Turing, can open the way to completely new techniques for AI systems. Conversely, the AI field, which is expanding quickly, can offer many prospects for analog computing.

- *Describe how scientific and technological performance can be objectively measured in the area (measurement methods, metrics, tools, infrastructures, …)*

The topic can be clearly defined as expanding the capabilities of AI systems by exploiting the possibilities offered by analog computing. Measurability can be developed from existing AI system performance benchmarks, energy consumption metrics and computation time.

- *Describe how research results can be transformed into innovations with societal or economic impact*

With the need for AI for many applications and the end of Moore's law, the topic is timely. Energy consumption becomes a bottleneck and radically new low-power implementations are needed to make AI applications sustainable especially in the context of edge computing. Fast and energy-efficient implementations of AI applications can make them much more successful in many environments, especially on mobile devices. By binding information with the hardware, analog architectures also make systems less prone to cloning and to information security attacks.

Suitability of topic for a CHIST-ERA call

Describe the need for transnational cooperation, complementarity with existing calls, and suitability of topic size (max 1/2 page).

Comment on all items below:

- *Describe how transnational cooperation in the framework of a joint call can bring added value (complementary national scientific strengths, need for critical mass, need for joint infrastructures, …)*

There is a need for transnational cooperation to leverage critical mass at the European level, and to take advantage of complementarities.

- *Describe closest calls (EIC Pathfinder, Horizon Europe, H2020, ERA-NETs, …) and how the topic complements and/or leverages them (the topic should not be redundant with other calls)*

The closest call in the H2020 WP2018-2020 is the one on "Unconventional Nanoelectronics" (ICT-06-2019, 30 M€, expected project size of 2-4 M€, deadline 29.03.2019). It covers energy-efficient computation devices and circuit architectures but has a much wider scope. It is also hardware-oriented and does not focus on any application domain. If a project selected in that framework is selected, it could be invited to the CHIST-ERA Projects Seminars.

Besides, the FET programme includes a call for a CSA on "Community building in Neuromorphic Computing Technologies" (FETPROACT-02-2018, 0.5 M€, deadline 22.03.2018). Synergies can also be expected with this potential CSA.

- *Describe how a significant contribution in the area can be obtained with a call of a few M€, possibly giving indications about the size of the main events, initiatives or structures in the area (conferences, programmes, teams, centres, professional associations, …)*

Combining AI with analog computing is highly novel. A few projects can thus make a significant difference for the topic.