Description of Funded Research Projects
1st Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers

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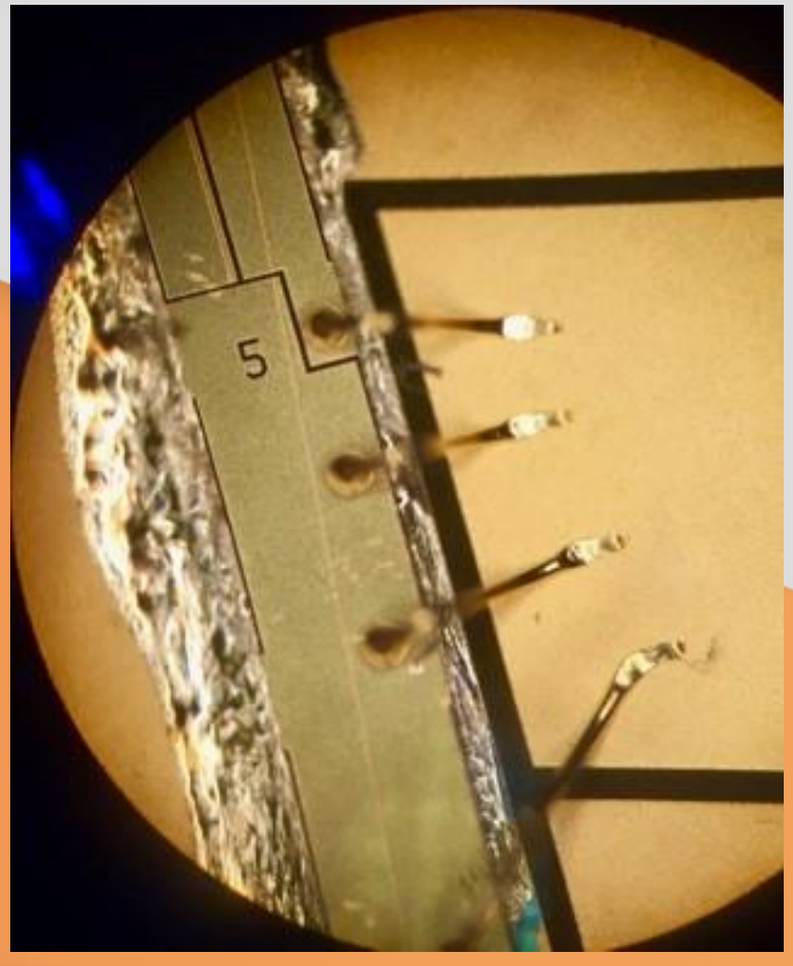
Research Project Title:

NEBULA - Neuromorphic Processors based on Quantum-Dot Lasers

Principal Investigator:
Charis Mesaritakis



Popular Title:
Processors based on artificial optical neurons

Scientific Field:
Natural Sciences, Photonics, Neuromorphic, lasers, Informatics

Host Institution:
National & Kapodistrian University, dep. Informatics & Telecommunications

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Research Project Summary

NEBULA project targets the investigation of cutting edge technologies in the emerging field of photonic neuromorphic engineering. This field, engulfs widespread computational paradigms like neural networks and photonic technology; aiming to merge the low power ultra-fast operation of photonics with the flexibility and computational efficiency of neural-like paradigms. In particular, our efforts will be focused on combining recent advantages in quantum-dot based ultra-fast photonic neurons and a subset of recursive neural networks with unparalleled merits called reservoir computing. Quantum dot photonic structures, due to the 3D spatial confinement of carriers allow an atom-in-a-box like behaviour, thus enabling thermal insensitivity, ultra-fast response time and more importantly multi-band emission capabilities. Especially, this last feature, can provide a fully isomorphic to neural circuits behaviour, by encoding inhibitory and excitatory neural signals as ultra-short pulses from different optical wavelengths. In a complementary direction, reservoir computing is an extremely powerful machine learning paradigm that bypasses the slow-convergence of training by employing nonlinear randomly interconnected recursive neural nodes driven to the edge-of-chaos. The dimensionality increase allows for high efficient prediction or classification of complex time-dependent signals.

These two technologies will be merged for the first time, allowing the envision of a clear roadmap towards the realization/simulation of a small-scale photonic neuromimetic processor able to process time-evolving digital/analogue data in the picosecond scale with minimum training requirements. These pivotal technological advantages will provide an alternative computational paradigm that will surpass conventional schemes in terms of efficiency and speed, in critical tasks like high speed pattern identification/prediction, multi-sensor data processing for imaging and security applications, cognitive RF/optical spectrum management.

Project Impact on Society

The impact of the NEBULA project is to introduce highly disruptive approaches in engineering, computing and natural sciences in general, allowing significant improvements in the processing speed and efficiency of neuromimetic systems. The NEBULA project aims at attracting new scholars, provide training for students, enable academic collaborations and enhance interaction with established industrial stakeholders. The long term goal of the project is to build an academic momentum that will allow the host-institution to become a key player in this field. The societal impact of the NEBULA project can be traced by examining the potential applications; a dedicated parallel photonic processor, operating at multi Gbps rate with low power consumption and low error rate could be employed in applications ranging from: Telecommunications: Automated channel capacity optimization. Real time optical/RF channel equalizer. Security: Automated analyzer of multiple sensors: data prognosis and risk evaluation, autonomous vehicles. Health: Autonomous multi-variant prognosis agent. Robotics: High speed sensorimotor processing, machine vision.

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To me, H.F.R.I. funding would mean...

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On a personal level H.F.R.I. provided the means to fund my personal research activity and pursuit significant academic goals, without been obliged to be re allocated to a research facility abroad. Furthermore, the ability to conduct fundamental research in high risk – high gain fields provided the basis for a successful academic carrier, while at the same time, by nourishing disruptive technological ideas, H.F.R.I. helps in minimizing the lab-to-market latency of upcoming start-ups. The academic independence alongside the experience in managing and disseminating a large-scale research project, is extremely valuable because it allows me to mature both scientifically and professionally. Finally, the generation of new clusters of people focusing on the same high-end scientific goals (Ph. D, Ms students etc.) is extremely important for the continuation of research in Greece and for supporting new highly promising technological areas.

The Principal Investigator,

Charis Mesaritakis

Funding

Amount: **199,272 €**

Duration: **36 months**

Foundation: **H.F.R.I.**

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Hellenic Foundation for Research & Innovation

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