Job Title: Internal Research Fellow (post-doc) in Dependable Machine Learning on FPGA

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EUROPEAN SPACE AGENCY

Research Fellowship Opportunity in the Directorate of Technology, Engineering and Quality.

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Post
Internal Research Fellow (post-doc) in Dependable Machine Learning on FPGA
This post is classified F2.

Location
ESTEC, Noordwijk, The Netherlands

Description
Research into Artificial Intelligence (AI) has been revitalised over the last years, driven by the recent advancements of Machine Learning (ML) and the advent of large Artificial Neural Networks (ANNs). Given the intrinsic parallelism between neurons and layers, the ANNs can be efficiently accelerated by hardware.

The state-of-the-art static RAM (SRAM) FPGAs deliver significant advantages in the implementation of ANNs in terms of throughput, reduced cost and higher fault-tolerance (due to possibility of implementing redundant synapses and neurons). These large ANNs introduce demanding computing requirements in terms of processing power and data storage, increasing system Size, Weight and Power (SWaP). The SRAM FPGAs are also vulnerable to radiation-induced Single Event Effects (SEEs). Low-power and radiation-hardening design techniques therefore need to be developed for the FPGA ANNs to enable their integration into onboard computing modules for Dependable applications.

This project aims to propose design techniques that will improve the performance/energy/reliability trade-off of SRAM FPGA ANNs, targeting both space-grade (NanoXplore BRAVE) and commercial off-the-shelf (COTS) FPGA.

Approximate Computing (AC) is a promising design paradigm that improves the system performance in error-resilient applications (e.g. ML-based object classification) by relaxing the requirement for precise computations.

Here the error-resiliency property will be exploited from two different perspectives:

1. using AC design techniques, such as low-precision quantisation and weight-reduction, in FPGA ANNs to improve energy efficiency;
2. using AC techniques to reduce the area and delay overheads imposed by fault-tolerance (FT) schemes in FPGA ANNs (e.g. redundant replicas and voters of a TMR approach can be designed with AC techniques).

The main research objectives of the project are:

- radiation-induced SEE characterisation and error-resilience analysis of SRAM FPGA ANNs (using both fault injection and radiation testing experiments);
- design of an AC-aware SRAM FPGA ANN;
- design of an FT-aware SRAM FPGA ANN with AC techniques.

Field(s) of activities/research
Working in the Onboard Computer & Data Handling Section of the Data Systems & Microelectronics Division, you will be expected to propose design techniques based on the Approximate Computing (AC) paradigm that provides solutions to the

following two challenging design problems of integrating ANN hardware (FPGA) accelerators on onboard processing systems:

- ANNs typically elaborate and produce an ever-increasing amount of data, while their computing requirements grow proportionally with the ANN size and training data volume. Consequently the power consumption of these systems maybe extremely high. To eliminate the energy budget constraint from integrating an FPGA ANN accelerator into an onboard data processing system, low-power design techniques should be proposed.
- SRAM FPGAs are vulnerable to radiation-induced Single Event Effects (SEEs) imposing significant design-for-reliability challenges. Effective hardening techniques against SEEs must therefore be developed for FPGA-based ANNs in order to satisfy the strict reliability and availability requirements of onboard payload computers.

The main research questions/challenges to be addressed in this project are:

- Can the inherent error resilience of ANNs be used to relax the Dependability requirements of onboard SRAM FPGA ANN accelerators?
- How much energy consumption (SWaT) improvement can be achieved by AC design techniques in SRAM FPGA ANNs without compromising system performance and data precision?
- How can the AC and FT design techniques be combined in SRAM FPGA ANNs in order to improve energy consumption (SWaT) while also satisfying system Dependability requirements?
- How can validation of FT FPGA inference design be performed in an experimental and formal way?

Technical competencies

Ability to conduct research autonomously
Breadth of exposure coming from past and/or current research/activities
Research/publication record
Knowledge relevant to the field of research
General interest in space and space research
Ability to gather and share relevant information

Behavioural competencies

Innovation & Creativity
Continuous Learning
Relationship Management
Self Motivation
Communication
Problem Solving
Cross-Cultural Sensitivity

Education

You should have recently completed, or be close to completing, a PhD in a relevant field. Preference will be given to candidates awarded their doctorate within the past five years.

Additional requirements

FPGA programming
Tensorflow
Radiation testing of complex digital devices
The working languages of the Agency are English and French. A good knowledge of one of these is required. Knowledge of another Member State language would be an asset.

Other information

For behavioural competencies expected from ESA staff in general, please refer to the ESA Competency Framework.

The Agency may require applicants to undergo selection tests.

The closing date for applications is 08 June 2020.

In addition to your CV and your motivation letter, please add your proposal of no more than 5 pages outlining your proposed research in the "additional documents" field of the "application information" section.

If you require support with your application due to a disability, please email contact.human.resources@esa.int.

Please note that applications are only considered from nationals of one of the following States: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom. Nationals from Slovenia, as an Associate Member, or Canada as a Cooperating State, can apply as well as those from Bulgaria, Cyprus, Latvia, Lithuania and Slovakia as European Cooperating States (ECS).
Priority will first be given to candidates from under-represented Member States.

In accordance with the European Space Agency's security procedures and as part of the selection process, successful candidates will be required to undergo basic screening before appointment