

Assessment of Machine Learning Algorithms for Near-Sensor Computing Under Radiation Soft Errors

Matheus Garay Trindade, Rafael Garibotti, Luciano Ost, M. Letiche, J. Beaucour, Rodrigo Possamai Bastos

► To cite this version:

Matheus Garay Trindade, Rafael Garibotti, Luciano Ost, M. Letiche, J. Beaucour, et al.. Assessment of Machine Learning Algorithms for Near-Sensor Computing Under Radiation Soft Errors. 16th International School on the Effects of Radiation on Embedded Systems for Space Applications (SERESSA 2020), Dec 2020, Porto Alegre (Virtual edition), Brazil. hal-03100531

HAL Id: hal-03100531 https://hal.science/hal-03100531

Submitted on 3 Feb 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License





La Région

Auvergne-Rhône-Alpes

CNRS - Grenoble INP - UGA

(1) Motivation

Machine

Learning

- Machine Learning (ML) is more and more • ubiquitous;
- Can we use them for Safety **Critical Applications?**
 - Radiation induced faults. Neutrons.
 - Heavy lons.

(4) Implementation

Iris Flower Dataset

Offline training (Matlab for SVM, Keras for NN)

Classifier moder extracted





(7) Radiation Campaign

Methodology

ANN was tested Continuously executed. Score output from the board monitored.

 TOMOH9 neutron accelerator 1-2 MeV neutrons. Irradiation time: 4h 30min.

Assessment of Machine Learning Algorithms for Near-Sensor Computing **under Radiation Soft Errors** M. G. Trindade¹, R. Garibotti², L.Ost³, M. Letiche⁴,

J. Beaucour⁴, and R. Possamai Bastos¹ Corresponding authors: {matheus.trindade, rodrigo.bastos}@univ-grenoble-alpes.fr 1 Univ. Grenoble Alpes, Grenoble INP, CNRS, TIMA, F-38031 Grenoble, France

2 School of Technology, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre 90619-900, Brazil 3 Loughborough University, Loughborough LE11 3TU, U.K. 4 Institut Laue-Langevin, 38042, Grenoble, France.

(2) Radiation effects in ML



Sample to infer class

- **Board outputs** score given by the algorithms
- Score

KNN [Libano, 2020] Neural [Draghetti, 2019] Networks [dos Santos, 2019] [Libano, 2019] [Libano, 2018] [Coelho, 2017] [Trindade, 2019] [Velazco, 1997]

(5) Metrics

No Failure: No difference from golden

reference;

Tolerable Failure:

Mismatch but classification still correct;

Critical Failure:

- Misclassification; • Computing Crash:
 - Board stops executing.

- (Institut Laue-Languevin ILL)
- **Cross-section:** $8.23 \times 10^{-9} \text{ cm}^2$.

Results

- •24 faults identified.
 - 19 Computing Crashes.
 - •2 Tolerable Failures.
 - 3 Critical Failures.
- Results match those of the fault injection campaigns.



for z in [set of processor registers] do for w in [set of processor register bits] do FaultInjectionProfile(x, y, z, w)

(7) Final Remarks

Both our ANN and SVM implementations presented an intrinsic fault tolerance.

- detectable.

+ Further experimental fault-injection campaigns • SVM presented a marginal advantage over ANN. More execution points. • Crashes are proeminent, but they are Different datasets. Further comparisons between both Mostly caused faults on control registers, e.g. ML algorithms. PC, LR.

Machine learning (ML) algorithms have been regaining momentum thanks to their ability to analyze substantial and complex data, supporting artificial intelligence decisions in cloud computing but also in near-sensor computing in endpoint devices. Both cloud and near-sensor computing are liable to radiationinduced soft errors, especially in automotive and aerospace safety-critical applications. In this regard, this paper contributes by comparing the accuracy of two prominent machine learning algorithms running on a lowpower processor upset by radiation-induced soft errors. Both ML algorithms have been assessed with the help of a fault injectionbased method able to natively emulate soft errors directly in a development board. In addition, neutron radiation test results suggest the most critical situations in which mitigation solutions should address.

(3) Machine Learning Algorithms

No Failures Tolerable Failures Computing Crashes Critical Failures Majority of faults do not incur failure. High percentage of crahses. • 2% or less of critical failures without • Differently than critical failures, they can be identified. any protection.

•Ongoing works:

+ Radiation campaigns.