Reliability of Computing Systems and Components Facing Cosmic Ray Radiation Effects

Abstract:

In the era of autonomous things, artificial intelligence (AI) computing solutions are being developed also for the edge of applications (close to sensors) in order to minimize data transfer to/from the cloud and reduce related risks in case of unavailable connections. On the other hand, edge computing is normally resource-constrained in terms of latency, power, and memory, demanding the development of tiny and also reliable machine learning (ML) systems that naturally face cosmic ray radiations effects even at ground levels.

This talk will present experimental results of three prominent ML algorithms for tiny ML computing systems in tolerating neutron-induced soft errors. Radiation test-based results suggest that the case-study ML algorithms retain a certain intrinsic level of effectiveness in tolerating neutron effects even thought without any mitigation technique. Notably, random forest algorithm has performed no misclassification during different radiation testing campaigns carried out with 14-MeV and thermal neutron beams.

Furthermore, this talk will also discuss neutron radiation effects on the attitude estimation (AE) processing typically embedded in inertial navigation systems (INS) and modern autonomous things. Findings highlight the importance of radiation-induced critical failures that are able to upset INS embedding AE processing modules. Radiation tests have been conducted running three strategies for computing different advanced AE algorithms on a case-study processing module exposed to 14-MeV neutron and thermal neutron radiation. Results and analysis suggest that the contribution of radiation-induced soft errors to be mitigated on the AE processing modules is essentially related to single event functional interrupts that can lead the inertial navigation to critical failures.

Finally, the talk will present experimental results of radiation effects in an UGA/TIMA's computing system embedded in an AFRL/NASA/GSFC satellite in orbit since June 2019.

Short bio:

Dr Rodrigo POSSAMAI BASTOS is an associate professor since 2012 at the UGA/TIMA. His research interests include reliability aspects of computing systems and integrated circuits, from hardware/software design to test, considering effects of environmental radiation particles. He is/was the supervisor/co-supervisor of 8 PhD students from 2014 to 2023. Dr BASTOS has obtained his HDR in January 2018, having a sabbatical year for research ("Délégation CNRS") in 2019/2020. He is qualified for the full-professor functions since 2019, and he has been awarded twice with the research and PhD supervision gratification PEDR since 2016, being classified among the best 20% in CNU-61 for 2020-2024. Springer Nature has published his first book in 2020, and he is also an author/co-author of more than 120 related scientific articles/communications (27 in international journals). Dr BASTOS is currently the general coordinator of the international exchange project BRAFITEC/BRAFISAT (2019-2023) and the international research project MultiRad (France, UK, Spain, Brazil), granted by Auvergne-Rhône-Alpes region (2020-2023). In addition, he is/was the coordinator of 15 other international/national research projects funding PhD/master students/researchers (2014-2023), including the project COTS-2 phase 2 (2019-2023) in which a UGA/TIMA-designed electronic board was on medium-Earth orbit (between 6000 km and 12000 km) in a satellite AFRL/NASA/GSFC. Dr BASTOS is also responsable for the math-computer-science international course UGA/DLST/L2/MIN-Int (university's second semester) and the coordinator of a training in which 5 information-technology engineers teach >1200 students (university's first semester) computer and Internet basics.