Title: AI-oriented Design Methods for Intelligent Aerospace Computing Systems
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This dissertation explores methodologies and techniques to enable the development, evaluation, and optimization of radiation-hardened Field Programmable Gate Arrays (FPGAs) for high-performance computing in radiation-intense environments. A comprehensive suite of tools is introduced to enhance both reliability and computational efficiency, addressing the challenges posed by Single Event Upsets and other radiation-induced phenomena.

The research contributions span multiple levels of abstraction, from device-level characterization to system-level fault tolerance, employing fault injection, accelerated irradiation testing, and analytical modeling. Dedicated analysis frameworks have been developed to assess the sensitivity of FPGA designs to SEUs, with fault emulation platforms and irradiation campaigns targeting SRAM- and FinFET-based devices. These studies have revealed critical insights into the resilience and performance trade-offs inherent in FPGA-based systems, highlighting the limitations of traditional mitigation techniques such as redundancy and scrubbing.

Particular emphasis has been placed on soft-core processors, custom accelerators, and data-intensive applications, including artificial intelligence workloads, where fault propagation was shown to significantly impact both throughput and correctness. Interconnect reliability, especially in AXI-based data transfer modules, has also been rigorously evaluated, with results demonstrating that silent data corruption remains a major concern despite redundancy.

The outcomes of this work culminate in a framework dedicated to the analysis of European radiation-hardened FPGA platforms, laying the foundation for future research on placement and routing strategies tailored to these architectures.

This dissertation aims to advance the state of the art in radiation-tolerant reconfigurable computing, providing methodologies and insights that support the reliable deployment of FPGAs in aerospace and other high-reliability domains.