CAREER: Data-Driven Control of High-Rate Dynamic Systems

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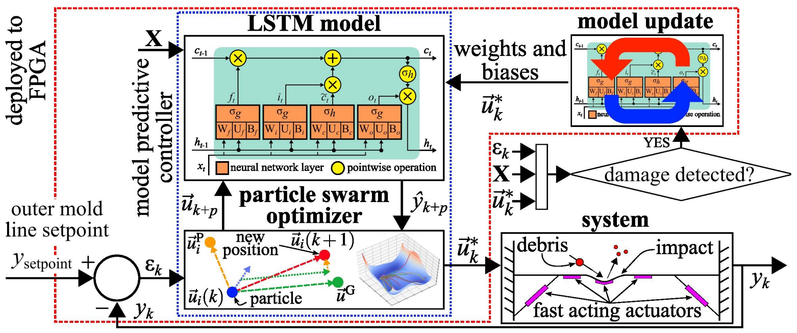
Objective: The project aims to enable real-time machine learning control and prediction at the microsecond scale for high-rate systems, through developing integrated frameworks, tools for IoT devices, hardware-in-the-loop validation, and open-source educational resources.

Challenges: Include deterministic knowledge transfer between models and controllers with strict latencies, maintaining control stability with fast actuators, shortage of educational resources on real-time control for high-rate systems, absence of tools for controller validation with FPGA deployment, and accurately validating low-latency control schemes that incorporate hardware co-design and real-world interactions.

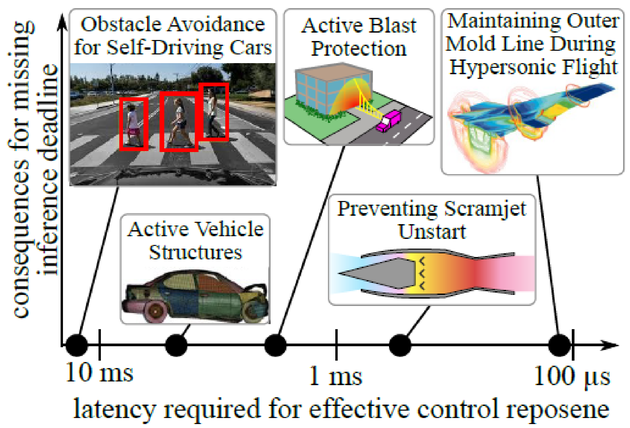


Real-time Model Predictive Controller formulated to maintain the outer mold line for the structure given a set of potential fast acting actuator inputs, where an LSTM is used to model the system.

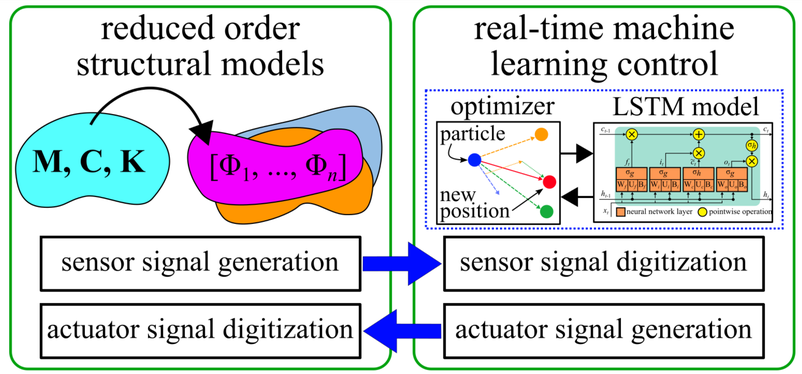
Solutions: Include automated tools for deploying machine learning algorithms on IoT devices with FPGAs, real-time validation of hardware/software solutions, and the creation of open-source educational materials on real-time machine learning controls.

Scientific Impact: Advancing co-design methodologies for hardware and software to meet latency and accuracy needs, developing novel real-time LSTM models for dynamic systems, innovating FPGA resource sharing for deterministic machine learning processes, and enhancing knowledge on the balance of accuracy, performance, and resources for microsecond-timescale control, alongside documenting latency and uncertainty impacts on controllability of advanced structures.

Broader Impact: Advancing control system design for complex applications, enhancing STEM education in under-represented regions, developing open-source tools for FPGA-based machine learning controls, and enabling innovations in critical areas such as automotive safety, cybersecurity, and energy.



Research Group Varies timing requirements for applications that could be impacted by this research that is focused on maintaining the outer mold line of hypersonic vehicles.



Hardware-in-the-Loop testbed for testing the developed real-time machine learning controllers against reduced order structural models.

Education and Outreach: Efforts are centered on creating and disseminating modular learning materials on real-time machine learning control, targeting audiences from high school students to professionals. These resources aim to bridge the gap between theoretical knowledge and practical application. Through participation in module development and implementation, students gain firsthand experience, fostering a collaborative learning environment that prepares them for future challenges in engineering.

Research Group Research group as of Spring 2023.

Project Dates: February 1, 2023 – January 31-2028
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