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Safety Critical Applications for RISC-V Platforms

ELECOMP Capstone Design Project 2024-2025

Sponsoring Company:

The Charles Stark Draper Laboratory, Inc.
555 Technology Square
Cambridge, Massachusetts 02139
<https://www.draper.com/>

Company Overview:

As a nonprofit engineering innovation company, Draper serves our nation's interests and security needs; advances technologies at the intersection of government, academia, and industry; cultivates the next generation of innovators; and solves the most complex challenges. Multidisciplinary teams drawn from a broad and deep talent pool of 1,300 engineers and scientists collaborate to develop first-of-a-kind solutions. Our unbiased approach enables us to focus on our customers' needs and to deliver new capabilities to them.



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Technical Director:

Steve Lawrence (URI '10)

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Project Motivation:

The race for space is real and happening now, and Draper is on a mission to lead. Safety critical applications and computer platforms are a part of Draper's DNA that go back to the Apollo era guidance computer. Developing the next generation of this technology is critical to our national defense. We are looking for a motivated student team to support development of a safety critical application using the Rust programming language on a RISC-V platform.



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Anticipated Best Outcome:

The goal is to create a Rust application on a RISC-V platform and identify security features of Rust used to increase robustness of the application.

The student team is expected to deliver:

1. Detailed system level design document including system ICD
2. Detailed hardware design of system
3. Detailed software design document
4. Software test plan
5. Integration test plan
6. Source code
7. Compiled binaries
8. A working prototype system
9. Technology assessment report including
 - a. Security assessment of Rust
 - b. Benchmark of RISC-V architecture performance
 - c. Benchmark of GPU performance

Draper will provide system level requirement and provide hardware resources needed to create the prototype system. The student team will have weekly correspondence (i.e., email, phone calls) with the Sponsor's Project POCs at a time that is mutually agreed upon. In addition to the technical director, student will have access to additional subject matter experts from Draper as needed.

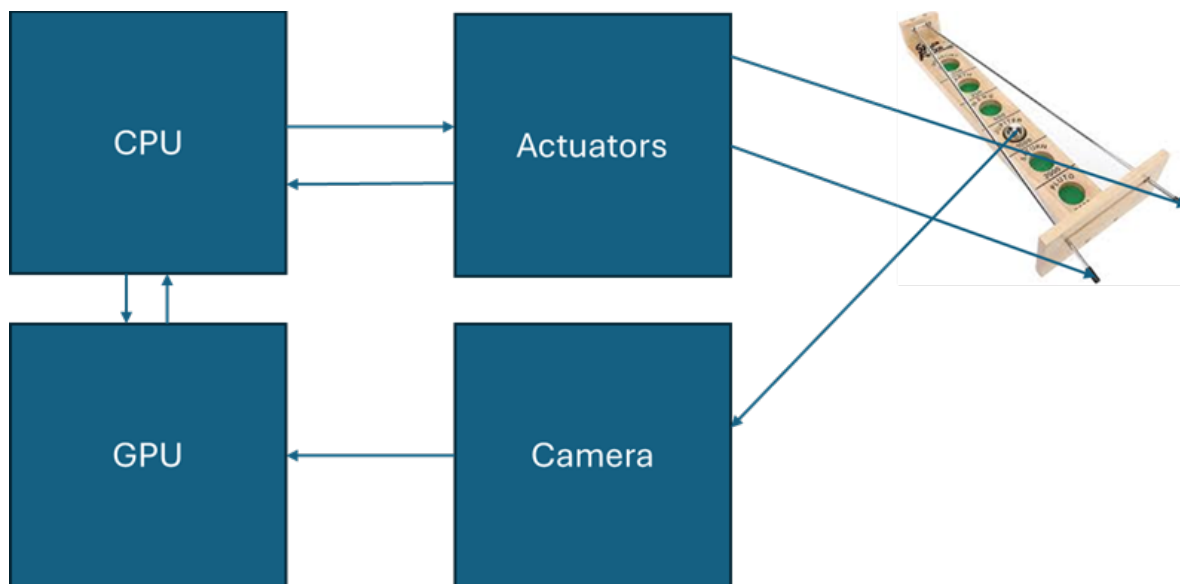


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Project Details:

The objective of this project is to use a camera to detect position/velocity of the ball for the “Shoot the moon” game and control the actuators to win the game. This will help determine the feasibility of using a Rust on a RISC-V platform for safety critical platforms.

To achieve this objective, the RISC-V CPU must process data from the GPU and control the actuators to place the ball in the desired slot by applying dynamics and control theory. The software application for the CPU will be done in Rust.





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Hardware/Electrical Tasks:

- Create schematics of components
- Create assembly to attach servos to the “Shoot the moon” rails
- Create assembly to hold camera and observe ball position/velocity and position of rails
- Create the control loop needed for solution

Firmware/Software/Computer Tasks:

- Create drivers for hardware interfaces
- Create Rust application on CPU
- Create GPU application to process image data

Composition of Team:

1 Electrical Engineer & 2 Computer Engineers

US Citizenship Required

Skills Required:

Electrical Engineering Skills Required:

- Dynamics and control theory
- Electronics
- Matlab/Simulink

Computer Engineering Skills Required:

- Embedded software
- Familiarity with instruction set architectures (ISAs); preferably RISC-V
- Rust or familiarity with other programming such as C++
- OpenCV



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Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

RISC-V is an instruction set architecture (ISA) that is being used on modern platforms in industry and is open source. This has the opportunity to reduce overall cost and increase support for vendors of potential platforms. With the addition of implementing an application using the safety features of Rust, the potential of a next generation flight computer starts to emerge that can be used in human and safety critical applications. This is critical to stay competitive in the emerging space race. Draper will continue pursuing developing software in Rust as well as creating new RISC-V platforms for space systems.

Broader Implications of the Best Outcome on the Company's Industry:

The White House delivered a press release February 26, 2024 titled "Future Software Should Be Memory Safe" (<https://www.whitehouse.gov/oncd/briefing-room/2024/02/26/press-release-technical-report/>). Overall, there is a push to use memory safe languages to reduce the attack surface of and prevent entire classes of bugs from entering software applications. This is especially important for reducing vulnerabilities of software and decreasing cost for both commercial and military space systems. A successful outcome will enable Draper and the rest of industry to normalize memory safe languages.

There has recently been a push from NASA and other government agencies to start pursuing RISC-V architectures. Given Draper's position as a nonprofit organization, we typically consult with different agencies and provide recommendations based on our collaboration with academic institutions and commercial partners. Draper's mastery of RISC-V will result in further adoption of RISC-V in different government agencies.