Autonomous Fault-Tolerant Operation of Redundant Robotic Arms

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The objective of this project is to develop a comprehensive solution to realize autonomous fault-tolerant and fail-active operation for redundant robots experiencing joint failures.

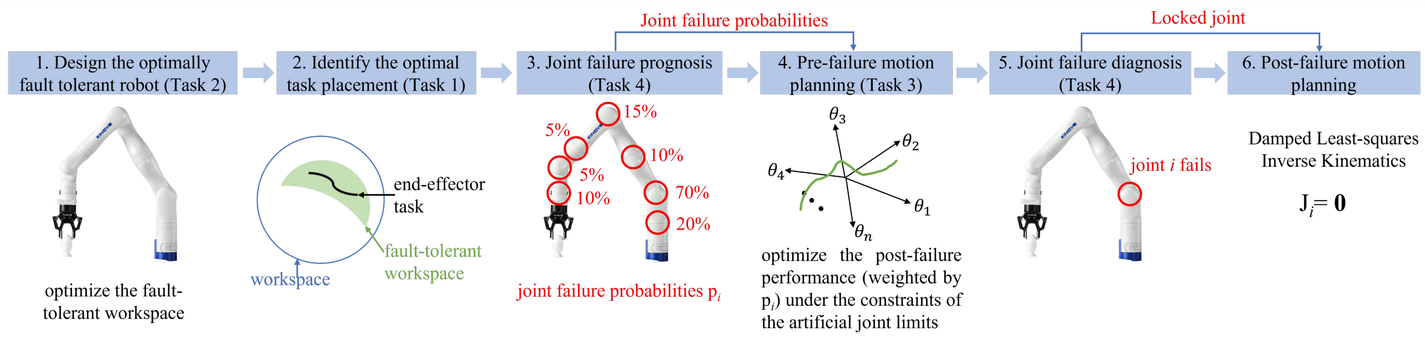
Key Problems

- Compute six-dimensional fault-tolerant workspace efficiently including both the volume and shape information to guarantee task completion.
- Design optimal fault-tolerant robots based on the volume and shape information of the fault-tolerant workspace.
- Optimize the robot post-failure performance through pre-failure motion planning based on predicted joint failure probabilities.
- Fault prognostics and diagnostics of robot joints, including the joint motor faults and the faults with the drive electronics.

Scientific Impact

We propose a fundamental scientific contribution for developing autonomous fault-tolerant and fail-active strategies for redundant robotic arms based on predicted and identified joint faults. Most of the conventional fault-tolerant control methods focus only on failure recovery, and unfortunately, it is usually too late to mitigate damages after failures occur. The proposed kinematic design of optimally fault-tolerant robots and fault-tolerant motion planning methods in anticipation of all potential failures can guarantee task completion and optimal post-failure performance.

Technical Approach:



Key Innovations:

- A novel efficient method is proposed to compute the six-dimensional fault-tolerant workspace.
- The optimally fault-tolerant robots will be designed to optimize the fault-tolerant workspace.
- The proposed joint fault prognostic and diagnostic algorithms do not require any additional sensors or hardware.

Impact on Society

- Recruit female and underrepresented minority students in STEM fields to participate in this project.
- The research outcome derived from this project will be integrated into the investigators' teaching courses.
- The undergraduate and graduate students on this project will receive dedicated training through the project execution, which will directly contribute to the local and regional workforce development.
- Disseminate the findings to the national robotics and motor-drive communities through publications and presentations in flagship international conferences and journals.

Education and Outreach

- Support the University of Kentucky ECE Undergraduate Research Fellowship
- Demonstration on the University of Kentucky College of Engineering's annual open house, E-Day (3000 attendees)
- Lecture and demonstration for Lafayette High School Pre-Engineering Program

2023 FRR & NRI Principal Investigators' Meeting
May 2-3, 2023

Award ID#: 2205292