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STEM

Command Shaping for Minimizing Residual Vibration in a Flexible-Joint Robot

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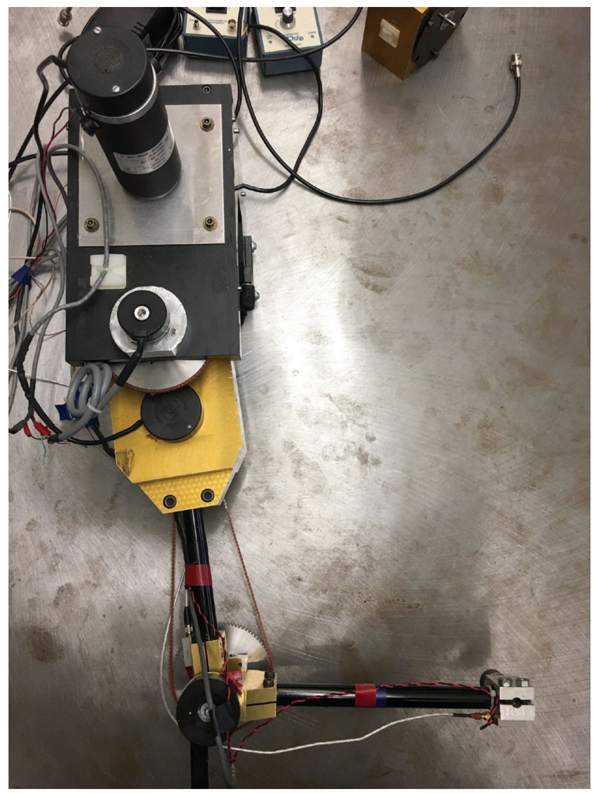
The performance of mechanical systems is limited by residual oscillations caused by joint flexibility. Command shaping reduces the residual oscillations at resonance frequencies of the system while achieving fast motions by carefully constructing torque commands to the motors. Two different cost functions are utilized to find the optimal input that minimizes residual oscillations at natural frequencies. One can be solved analytically with a closed-form solution, while the other requires a numerical solution. Two different input profiles are tested for both methods on a two-link flexible-joint robot. One profile uses a versine basis function and the other uses a ramped sinusoid basis function.

The objective of this research project is to study the effect of the peak motor torque on command shaping. The simulations were performed in MATLAB, and the experimental results were obtained from the two-link robot. The trajectory of the two-link flexible-joint robot is controlled using a computing platform that includes an FPGA and uses LabVIEW software. The motion is recorded through optical encoders mounted at the motors and the robot joints and accelerometers mounted on the robot links. Peak residual acceleration, settling time, and spectral magnitude are used as parameters to measure the performance of the system.

From the simulation and experimental results, it can be concluded that, for a certain value of peak motor torque, the numerical solution is more efficient than the closed-form solution by better utilizing available motor torque. An increase in the value of the peak motor torque up to a certain value, for all cases, reduces the values of settling time and peak-to-peak residual acceleration. The data from the research project will help in establishing the relationship between the peak motor torque and the efficiency of any mechanical system with resonance, and will help individuals and companies in buying the best motor for the mechanical system.

Research advisor Peter Meckl writes: "When Rishab started this project, he had to learn someone else's software code and modify it so as to allow easy comparison of different command-shaped profiles for given peak motor torque. He did a good job, successfully providing working code for future students. In addition, he learned how to describe the project in terms that anyone not involved with the project could understand. This is an important skill in today's business world."



The two-link flexible-joint robot in the Ruth and Joel Spira Laboratory.

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