Because of budget constraints, most university robotics labs can provide at best one type of basic robot. As a result, students have little hands-on experience in the design of robots and their control systems, and very limited access to robot manipulators commonly used in industry.

To address these limitations, the University of Toronto Institute for Aerospace Studies developed a reconfigurable robot manipulator and an Integrated Design and Simulation Environment (IDSE). Built using MATLAB® and Simulink®, the robot and IDSE enable students to design, simulate, optimize, and operate most configurations of robot manipulators used in industry today.

“With Simulink and Simulink 3D Animation, students can visualize a realistic simulation of the robot,” says Dr. Reza Emami, senior lecturer at the University of Toronto Institute for Aerospace Studies.

“Using the IDSE, the students can identify the best configuration of kinematic, dynamic, and control parameters for a given task before testing their design on an actual robot manipulator.”

The Challenge
When Dr. Emami began teaching the new robotics course at University of Toronto, the lab had no robots. The students used rudimentary simulations, until the course obtained access to a few tabletop robots. These were too simple to enable Dr. Emami to demonstrate all aspects of industrial robotics, but purchasing a variety of robots, and enough of each type for all the students in this popular course, would have been prohibitively expensive.

Dr. Emami’s primary goal was to develop a reconfigurable robot manipulator that would engage students in designing not only control systems but also the robots themselves. He also wanted to ensure that the design environment was easy to use and accessible remotely. “We needed students to be able to use the IDSE with minimal training to design robots, optimize control parameters, and see their designs working in the lab,” he explains.

The Solution
Dr. Emami and his team of students and engineers used MATLAB and Simulink to develop an integrated environment for simulating, visualizing, and optimizing designs using a reconfigurable robot.

The Results
- Students prepared for work in industry
- Complex optimizations automated
- Months of development time eliminated
IDSE user interface and additional modules that the students need to complete course assignments.

The optimization module, implemented with Simulink Control Design™ and Simulink Design Optimization™, enables students to configure the robot for a specific trajectory or task by identifying an optimal set of dynamic, kinematic, and control parameters.

For course assignments, students use MATLAB and Control System Toolbox™ to create plots and visualize system behavior in the time and frequency domains, as well as to calculate proportional, derivative, and integral gains for each joint in a selected configuration.

The students use the IDSE to complete their design, simulation, and optimization exercises and to visualize the 3D animation of the robot. Ultimately, once they have verified their design through simulations, the students will test them on the actual robot.

The Results

Students prepared for work in industry.

“Our students now have a reconfigurable platform that enables them to explore the various robot configurations they are likely to encounter in the industry,” says Dr. Emami. “They are learning to design optimized robots for a given task, which would be impossible if they were working with only one type of robot manipulator with a fixed configuration.”

Complex optimizations automated. “Our robot has 18 degrees of freedom in total, and I was initially skeptical about the ability of software optimization tools to handle such a complex problem,” says Dr. Emami. “We found that Simulink Control Design and Simulink Design Optimization work well with such complex, realistic systems, something I have not seen with other tools.”

Months of development time eliminated. “The ability to translate our CAD assemblies into a SimMechanics model saved us months of development time,” says Dr. Emami. “The resulting model provided the basis for the core simulation and visualization features in our design environment.”

Industry

- Education

Application Areas

- System design and simulation
- Physical modeling
- Control systems
- Mechatronics

Products Used

- MATLAB
- Simulink
- Control System Toolbox
- SimElectronics
- SimMechanics
- SimPowerSystems
- Simscape
- Simulink 3D Animation
- Simulink Control Design
- Simulink Design Optimization

Learn More About the University of Toronto Institute for Aerospace Studies

www.aerospace.utoronto.ca