The long-term goal of this research project is to develop methods and techniques to make large-scale manufacturing systems safer, more secure, and more productive, enabling them to produce high-quality products for consumers at modest cost.

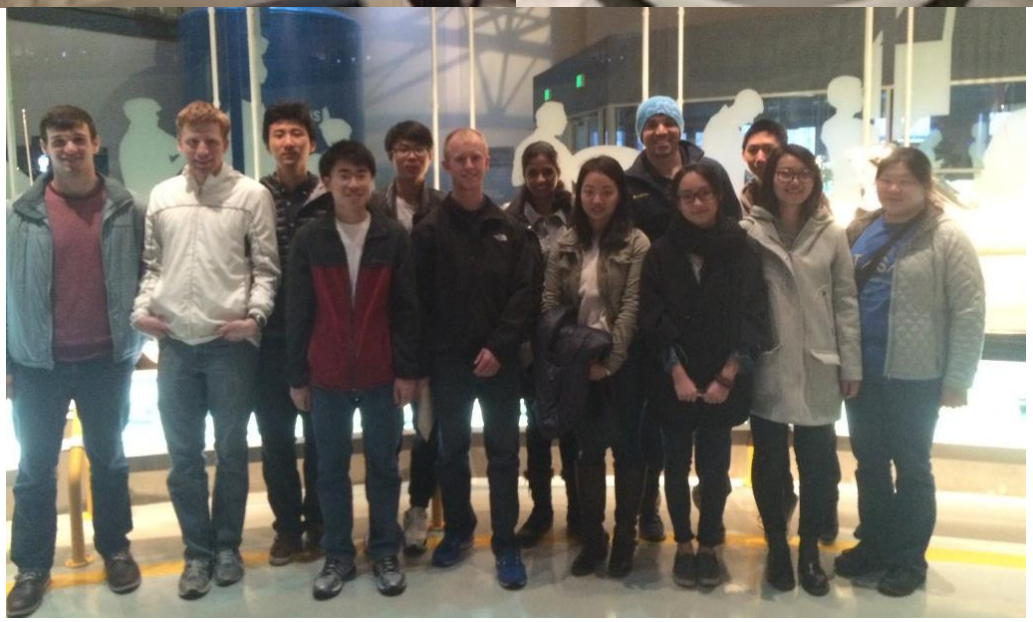
Project Description

This project utilizes a small manufacturing system that consists of three industrial robots, four machine tools, and two conveyors, with an integrated industrial control system (Rockwell Automation) connected by Ethernet/IP. The testbed is instrumented with presence sensors, inspection cameras, an interactive HMI display, and a computer for synchronization of real-time and historical data to a cloud platform. The research goals around the testbed include: control development and validation, learning control, agent-based control, optimizing scheduling, reconfigurable control, cloud-based manufacturing, security of cyber-physical systems, etc. One key enabler for the research program is to have simulation models of the different system components that can be validated off-line, or in a hardware-in-the-loop framework. Another key enabler is the hosting of testbed-generated data in a deployed cloud environment to enable real-time cloud analytics, predictive maintenance, and remote system monitoring.

Specific tasks to be done by the MDP student team may include:

1. Build simulation models of the components in the system (conveyor, robots, machine tools) at different levels of fidelity, and connecting these different simulations to each other, to the control system, etc.
2. Use simulation to recognize and/or predict failures and detect attacks in real time
3. Use simulation models to reconfigure the control system in response to a cyber-attack
4. Robot and CNC programming including autonomous integration with system level PLC
5. Integrate new sensors to the system control, e.g. computer vision, energy usage (current/voltage) of machines and conveyor, tracking of people in the system and build simulation models that incorporate these new sensors
6. Develop new parts to be made in the system, including new pallets, grippers, G-code for machines, etc. and write the associated logic control code for automated operation
7. HMI graphic display design and integration for increased operator efficiency
8. Computer vision part and anomaly detection programming
9. Deploy cloud analytic schemes, dashboards, and data management on the Microsoft Azure platform for predictive maintenance and remote monitoring
10. Incorporate new machines e.g. the laser cutter
11. Develop new system-wide control strategies for the system
12. Characterize the attack surface for external attackers to break in or tamper any network-based access/control to the testbed
13. Develop methods to authenticate access, and redundancy mechanisms for fault tolerance and attack resilience

14. Develop the software support to automatically move and replicate computation and network operations from local testbed servers to remote cloud



Faculty Sponsors

Dawn M. Tilbury

Dawn M. Tilbury is currently the Associate Dean for Research in the College of Engineering, University of Michigan. She received the B.S. degree in Electrical Engineering, summa cum laude, from the University of Minnesota in 1989, and the M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California, Berkeley, in 1992 and 1994, respectively. In 1995, she joined the Mechanical Engineering Department at the University of Michigan, Ann Arbor, where she is currently Professor, with a joint appointment as Professor of EECS. Her research interests include distributed control of mechanical systems with network communication, logic control of manufacturing systems, reliability of ground robotics, and dynamic systems modeling of physiological systems. She was elected Fellow of the IEEE in 2008 and Fellow of the ASME in 2012, and is a Life Member of SWE.

Kira Barton

Assistant Professor, Mechanical Engineering
2160 GGB (George G. Brown Laboratory)

Prof. Kira Barton (**bartonkl@umich.edu**) received her B.S. degree in Mechanical Engineering from the University of Colorado at Boulder in 2001. Barton continued her education in mechanical engineering at the University of Illinois at Urbana-Champaign and completed her M.S. and Ph.D. degrees in 2006 and 2010, respectively. She held a postdoctoral research position at the University of Illinois from Fall 2010 until Fall 2011, at which point she joined the Mechanical Engineering Department at the University of Michigan at Ann Arbor. Her primary research focus is on precision coordination and motion control for emerging applications, with a specialization in iterative learning control. Barton's work intersects controls and manufacturing and combines innovative manufacturing processes with enhanced engineering capabilities. The potential impact of this research ranges from building high-resolution DNA sensors for biological applications, to the integration of advanced sensing and control for rehabilitation robotics.

Z. Morley Mao

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Her current research focus encompasses software-defined networking, Internet security, next-generation Internet protocols, and mobile systems. She is a recipient

of the Sloan Fellowship, the NSF CAREER Award, the ARMY YIP Award, and an IBM Faculty Award. Her other honors include the Morris Wellman Faculty Development Professor and EECS Achievement Award at University of Michigan. She has participated and played leadership roles in several large joint research efforts with funding from government as well as industry, including those involving researchers at AT&T, IBM, and at other universities. Her group has successfully developed several important prototypes based on the research work. Many such prototypes have been converted into commercial products through close collaboration with researchers in industry such as AT&T, Google, and Docomo. In addition, software prototypes such as MobiPerf and Powertutor focused on mobile platform characterization have been open-sourced and widely used by researchers in academia and industry.

Student Responsibilities

VIP faculty research projects are both a professional and academic learning experience for students. By participating in this program, students are actively preparing for graduate school and a professional career. As part of the experience, MDP expects professional behavior. To best prepare you for future professional opportunities, your experiences on this MDP team will be very broad. In addition to key technical skills that you will bring to the team, you will engage deeply in the self-directed learning of new and important concepts, demonstrate flexibility, collaboration, and cooperation, and develop strong professional communication skills. This also means that you will need to be able to work outside of your traditional area of study in the true multidisciplinary nature of our projects. You won't always be able to anticipate how your skills and expertise will be used, so joining a VIP faculty research team will challenge you to grow and develop as a professional.

Internship

The Multidisciplinary Design Program offers summer research stipends to continue research over the summer. Applications for funding will open in February 2017. Research stipends will not exceed $3,000.

Legal

All students must sign a standard MDP Faculty Research IP Agreement.

The Fine Print

- Application for all projects is open from September 6th, 2016 until 11:59pm on Sunday, October 16th.
- Please schedule an appointment with your home department's academic advisor before November and make sure you will have time in your schedule to complete a project if offered a position.
- All projects will start in January 2017 and end in December 2017. Summer participation is not required unless otherwise specified in the project description. Project Teams labeled VIP (Faculty Research) will extend for multiple semesters, and long-term participation is highly encouraged.
- Increase your chances of matching to a project by applying for all of the teams that interest you and attend the Project Opportunity Fair on October 5th.
- Successful students will receive one offer to join one project only. Offers will be sent to students starting in November and will continue until all teams are filled (early December).