Automated Planning for Supporting Human Robot Collaboration in Assembly Cells

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Abstract

Human and robots have complementary strengths in performing assembly operations. Humans are very good at perception tasks in unstructured environments. For example, they are able to recognize and locate a part from a bin of miscellaneous parts. They are also very good at complex manipulation in tight spaces. In contrast, robots are very good at pick and place operations and highly repeatable. Robots can perform tasks at high speeds and still maintain precision. Robots can also operate for long periods of times with showing signs of fatigue. Typically, robots are used in mass production lines. Small batch and custom production operations predominantly use manual assembly lines.

The high labor cost is making it difficult for small and medium manufacturers to remain cost competitive in high wage markets. These manufactures are mainly involved in small batch and custom production. They need to find a way to reduce the labor cost in assembly operations. Purely robotic cells will not be able to provide them the necessary flexibility. Creating hybrid cells where humans and robots can collaborate in close physical proximities is a potential solution. The underlying idea behind such cells is to decompose assembly operations into tasks such that humans and robots can collaborate by performing subtasks that are suitable for them.

This presentation will describe the on-going assembly planning research at the Maryland Robotics Center to realize hybrid assembly cells to enable safe and efficient human and robot collaboration. The following three topics will be covered as a part of this presentation:

1. We need to be able to automatically generate plans to operate hybrid assembly cells to ensure efficient cell operation. This requires generating feasible assembly sequences and instructions for robots and human operators, respectively. Automated planning poses the following two challenges. First, generating operation plans for complex assemblies is challenging. The complexity can come due to the combinatorial explosion caused by the size of the assembly or the complex paths needed to perform the assembly. Second, generating feasible plans requires accounting for robot and human motion constraints. I will describe algorithms for automatically generating plans for the operation of hybrid cells. It will address both assembly complexity and motion constraints issues.
2. The collaboration between humans and robots in the assembly cell will only be practical if human safety can be ensured during the assembly tasks that require collaboration between humans and robots. I will describe different options for real-time monitoring of the state of human operator with respect to the robot and strategies for taking appropriate measures to ensure human safety when the planned move by the robot may compromise the safety of the human operator.
3. If the human operator makes an error in selecting the part or placing it correctly, the robot will be unable to correctly perform the task assigned to it. If the error goes undetected, it can lead to a defective product and inefficiencies in the cell operation. In order to ensure smooth and error-free operation of the cell, we will need to monitor the state of the assembly operations in the cell. I will present algorithms to identify and track parts in the cell and automatically generate instructions for taking corrective actions if a human operator deviates from the selected plan. Potential corrective actions include replanning if it is possible to continue the assembly operation from the current state and issuing warning and generating instructions to undo the current task.

Speaker Biography: Dr. Satyandra K. Gupta is a Professor in the Mechanical Engineering Department and the Institute for Systems Research at the University of Maryland, College Park. He was the founding director of the Maryland Robotics Center. Prior to joining the University of Maryland, he was a Research Scientist in the Robotics Institute at Carnegie Mellon University. Currently, he is on an IPA assignment at

National Science Foundation and serving as a program director in the Division of Information and Intelligent Systems. He manages National Robotics Initiative.

Dr. Gupta's interest is broadly in the area of automation. He is specifically interested in automation problems arising in Engineering Design, Manufacturing, and Robotics. He is a fellow of the American Society of Mechanical Engineers (ASME). He has served as an Associate Editor for IEEE Transactions on Automation Science and Engineering, ASME Journal of Computing and Information Science in Engineering, and SME Journal of Manufacturing Processes.

Dr. Gupta has received several honors and awards for his research contributions. Representative examples include: a Young Investigator Award from the Office of Naval Research in 2000, a Robert W. Galvin Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers in 2001, a CAREER Award from the National Science Foundation in 2001, a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2001, Invention of the Year Award in Physical Science category at the University of Maryland in 2007, Kos Ishii-Toshiba Award from ASME Design for Manufacturing and the Life Cycle Committee in 2011, and Excellence in Research Award from ASME Computers and Information in Engineering Division in 2013. He has also received six best paper awards at conferences and 2012 Most Cited Paper Award from Computer Aided Design Journal.