

Bridging AI, Teleoperation, and Workforce Development: An Industry 5.0 Approach to Experiential Robotics Education

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Abstract:

The rapid adoption of artificial intelligence (AI), advanced robotics, and smart manufacturing technologies is transforming workforce requirements across modern industry. Educational institutions face increasing pressure to provide learners with practical experience using advanced automation systems while overcoming challenges associated with equipment cost, laboratory access, and geographical barriers. This paper presents an innovative approach developed at Michigan Technological University through the National Science Foundation Experiential Learning for Emerging and Novel Technologies (ExLENT) program that combines AI education, industrial robotics training, and remote teleoperation technologies into a scalable experiential learning ecosystem.

Central to this effort is the development of a Teleoperated Robotic Workcell (TRW), an Internet-accessible industrial robotic platform that enables students to remotely interact with, program, monitor, and operate industrial robots in real time. The TRW integrates multiple camera systems, remote visualization tools, virtual teach-pendant interfaces, and AI-enabled monitoring capabilities to provide authentic hands-on experiences regardless of learner location. The system serves as an extension of the Mechatronics Education Portal and complements in-person laboratory activities by providing continuous access to industrial equipment and digital learning resources.

The paper describes the architecture of the teleoperated system, its integration into experiential learning activities, and its role in supporting workforce preparation in robotics, artificial intelligence, cybersecurity, and advanced manufacturing. Assessment data from the first two years of the ExLENT program demonstrate significant gains in student engagement, technical competency, and industry awareness. The incorporation of teleoperated robotics expands access to advanced manufacturing education while supporting Industry 5.0 principles that emphasize collaboration between humans and intelligent systems.

The presented framework demonstrates how AI-enabled teleoperation can serve as a scalable model for developing the future workforce, reducing barriers to experiential learning, and supporting broader adoption of advanced manufacturing technologies across educational institutions and industry partners.

Keywords:

Robot Teleoperation, Advanced manufacturing, robotic AI systems.