

From Structural Dynamics to Operations: Human–Machine Integration for Civil Infrastructure

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Abstract:

New human–machine interfaces, sensing technologies, and automated systems are expanding the capabilities of structural engineers. Advances in structural dynamics, computational modeling, embedded sensing, and control now enable engineers to interact with robotic systems in near real time, creating new opportunities for infrastructure inspection, structural assessment, construction, and experimental testing. This seminar presents research integrating structural dynamics and engineering operations through the design, simulation, and experimental validation of human–robot interfaces. Applications include Augmented Reality (AR) systems for infrastructure inspection and automated defect detection, where image-based measurements are translated directly into engineering quantities and presented intuitively to the inspector. New tracking and sensing approaches are also introduced for low-latency identification of nonlinear structural and mechanical systems. Building on these capabilities, human–robot interfaces are developed to allow structural engineers to interact directly with robotic systems and modify their operation based on engineering judgment and observed structural response. Immersive AR environments provide intuitive access to robot motion, sensing information, and controller parameters, enabling bidirectional communication between engineers and machines without removing the engineer from the decision-making process. Applications spanning structural inspection, construction, and manufacturing demonstrate how these technologies can connect algorithms with engineering operations. More broadly, this work illustrates a pathway toward human–machine integration in which sensing, dynamics, automation, and engineering judgment work together to address emerging challenges in civil infrastructure.

Bio:

Fernando Moreu, PE, F. ASCE, is the Robert J. Stamm Professor of Advanced Design and Construction Practices and Dean's Excellence Lecturer in the Department of Civil, Construction, and Environmental Engineering at the University of New Mexico (UNM), where he is the founder and director of the Smart Management of Infrastructure Laboratory (www.SMILab.space). He received his MS and PhD degrees in Structural Engineering from the University of Illinois at Urbana-Champaign in 2005 and 2015, respectively. Professor Moreu's research advances structural engineering through structural dynamics and control, structural health monitoring, smart sensing, and human–machine integration. His work connects these foundations with cyber-physical systems, computer vision, augmented reality, and robotic and unmanned systems to develop new approaches for infrastructure inspection, experimental testing, and engineering operations. He also holds courtesy appointments in Electrical and Computer Engineering, Mechanical Engineering, and Computer Science at UNM. His research has been supported by DOE, NSF, ONR, the National Academies, U.S. DOT, TRB, FRA, and industry. He has been a registered Professional Engineer since 2010 and is a Fellow of the American Society of Civil Engineers (ASCE). He serves as Vice Chair of the ASCE Engineering Mechanics Institute Technical Committee on Structural Health Monitoring and Control (2026–2029), Chair of the ASCE EMI Education Committee (2024–2027), and Vice Chair of the Society for Experimental Mechanics Technical Division on Dynamics of Civil Structures (2025–2027). His recent recognitions include the 2025 UNM Research Ovation Award and the 2026 UNM Research and Creative Works Leadership Award, awarded to six faculty university wide.



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