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Multi-axial Real-time Hybrid Simulation Framework

Billie F. Spencer Jr.
Nathan M. And Anne M. Newmark Endowed Chair in Civil Engineering
University of Illinois at Urbana-Champaign
bfs@illinois.edu

Abstract

Real-time hybrid simulation is an efficient and cost-effective cyber-physical dynamic testing technique for performance evaluation of structural systems subjected to earthquake loading with rate-dependent behavior. To assess the response of structural components subjected to multi-axial loading, a parallel manipulator with multiple actuators connected to a rigid moving platform is considered. The use of this platform makes it possible to impose realistic boundary conditions on physical components, which has not been studied previously in detail. However, this testing system is expected to exhibit significant dynamic coupling between actuators and suffer from potential time delays that are intrinsic in servo-hydraulic systems due to control-structure interaction (CSI). This paper presents a framework for multi-axial real-time hybrid simulation. The methodology consists in designing a model-based compensators for time lag reduction, and developing kinematic transformations to run the experiments in real-time through control of task variables. The compensators and kinematic transformations are implemented over an embedded system with a micro-controller and digital signal processor for real-time applications. The approach is demonstrated using a 1/5th-scale Load and Boundary Condition Box (LBCB) located at the University of Illinois at Urbana-Champaign. Experimental results are compared to analytical simulations for validation purposes.