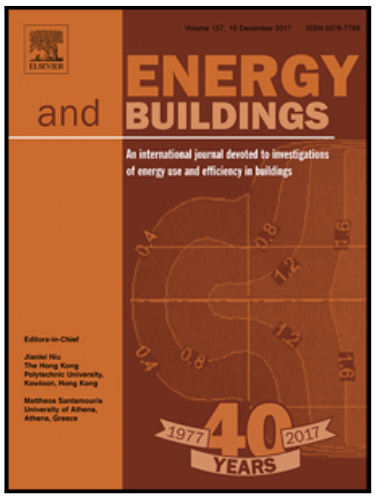

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A distributed approach to model-predictive control of radiant comfort delivery systems in office spaces with localized thermal environments

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Abstract

This paper introduces a new multi-agent system approach to optimal control of high performance buildings and presents algorithms for both distributed system identification and distributed model predictive control (DMPC). For the system identification, each thermal zone is divided into sub-systems, and a parameter set for each sub-system is first estimated individually, and then integrated into an inverse model for the whole thermal zone using the dual decomposition algorithm. For the DMPC, a distributed optimization algorithm inspired by the Proximal Jacobian Alternating Direction Method of Multipliers (PJ-ADMM) is deployed and multiple MPCs run iteratively while exchanging control input information until they converge. The developed algorithms are tested using field data from an occupied open-plan office space with a radiant floor system with distributed sensing, control, and data communication capabilities for localized comfort delivery. With this tractable approach, agents solve individual optimization problems in parallel, through information exchange and broadcasting, with a smaller scale of the input and constraints, facilitating optimal solutions with improved efficiency that are scalable to different building applications. Using a data-driven model and weather forecast, the DMPC controller is implemented to optimize the operation of an air-cooled chiller while providing different operative temperature bounds for each radiant floor loop. The radiant comfort delivery system with predictive control is capable of providing localized thermal environments while achieving significant energy savings. For the system and climate under consideration, results from the building operation during the cooling season, show 27% reduction in electricity consumption compared to baseline feedback control.

Keywords: Radiant floor cooling system, Distributed optimization, MPC implementation, Thermal environment control