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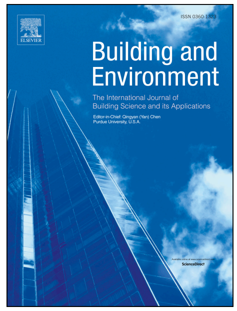

Bi-objective Optimization of Building Enclosure Design for Thermal and Lighting Performance

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Abstract
We address the challenging problem of optimizing early building design for daylighting and thermal performance with the objectives of passively satisfying occupant thermal and luminous needs, to the greatest degree possible, therefore minimizing energy demand for heating, cooling, and lighting. A bi-objective optimization method using GenOpt and its implementation of a Hooke Jeeves and Particle Swarm Optimization algorithm is demonstrated that investigates how building enclosure design influences the above objectives. Thermal performance was evaluated by how heat transfer across enclosure elements impacts hourly heating and cooling loads. Lighting performance was evaluated based on the frequency and magnitude at which daylight levels, during occupied hours, deviate from a desired target illuminance range. A single-zone classroom design in Charlotte, NC was optimized for north, south, east, and west orientations. For each orientation, a Pareto front was approximated to help evaluate trade-offs between thermal and daylighting objectives. Results show that for the south orientation, thermal and daylighting objectives are not in strong conflict, however, for other orientations there is a more marked conflict between these objectives, particularly for the north orientation.

Keywords
building energy simulation, building energy performance optimization, daylighting, multi-objective optimization, simulation optimization.

1 Introduction
The most basic purpose of buildings is to create comfortable environments. Typically, thermal and lighting comfort conditions are sustained primarily by energy-intensive equipment. In 2012, the commercial building sector accounted for 19% of total energy consumption in the United States [1]. Nationwide, lighting alone accounts for 20.5% of major fuel consumption in commercial buildings [2]. Major determining factors of heating, cooling, and lighting loads that must be met by HVAC and electrical light systems are climate, internal equipment, building use type, and occupancy profile and schedule, and the design of the building enclosure. Of these factors, building enclosure design is perhaps the most freely controlled by the design team. Building enclosure design includes building orientation, floor plan/footprint shape, window placement and size, material selection, etc. The building