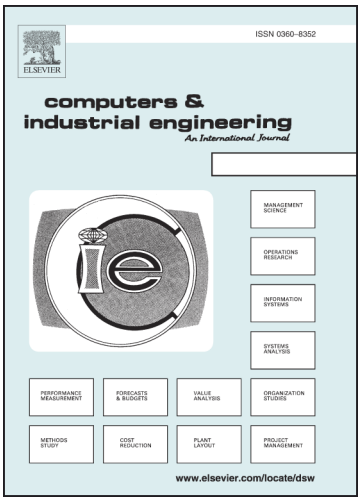

Optimizing Consistency Improvement of Positive Reciprocal Matrices with Implications for Monte Carlo Analytic Hierarchy Process

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Optimizing Consistency Improvement of Positive Reciprocal Matrices with Implications for Monte Carlo Analytic Hierarchy Process

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Abstract

Motivated by a situation encountered in a real-world application of the Analytic Hierarchy Process (AHP), this paper extends previous work on improving consistency of positive reciprocal judgment matrices by optimizing their transformation into near-consistent matrices. A sampling-optimization-adjustment approach is proposed and integrated into the Monte Carlo AHP framework, allowing it to deal with situations where no or insufficient distinct near-consistent matrices can be generated by directly sampling from the original pairwise comparison distributions – a situation that prohibits meaningful statistical analysis and effective decision-making using the traditional Monte Carlo AHP. Three mixed-integer nonlinear programing models are formulated for minimizing the sum of adjustments, maximum adjustment, and number of adjusted elements. Four heuristic algorithms are proposed to solve the models. The most appropriate heuristic(s) under each objective function and matrix size is determined through extensive statistical analysis of numerical experiments. The paper also presents an application of the proposed enhanced Monte Carlo AHP in a real-world industrial example of facility layout design selection, where the traditional Monte Carlo AHP fails to provide sufficient information to perform any statistical analysis on the final ranks and weights for the components in the hierarchy.

Keywords: Monte Carlo simulation, Analytic hierarchy process, Mixed-integer nonlinear programing, Consistency ratio, Facility layout

1. Introduction

The Analytic Hierarchy Process (AHP) is one of the fundamental decision analysis tools (Saaty, 1990) and has been widely applied in multi-criteria decision-making problems (Ho, 2008; Vaidya & Kumar, 2006). In AHP, the problem is structured as a hierarchy of criteria, subcriteria, and alternatives. Pairwise comparisons

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