A Mathematical Programming Approach for solving Nonmetric Multidimensional Scaling Problems

Afaf El-Dash [1] Ali El-Hefnawy [2] Nada Hafez [3]

ABSTRACT: Multidimensional scaling is a data visualization method for identifying structure or clusters of objects depending on proximity measures between pairs of objects. In this paper, nonmetric multidimensional scaling problem is considered, which is prone to local minimum solution when minimizing the stress function. For this reason, the mathematical programming approach will be used in this paper for solving nonmetric multidimensional scaling problems, while most classical techniques do not depend on mathematical programming. Two mathematical programming models are proposed to solve nonmetric multidimensional scaling problems. The first proposed model is mixed integer programming model; it minimizes stress function based on city block metric, which is transformed to a linear form, so that it guarantees obtaining the global optimum, and it was solved using Branch and Bound method. The second proposed model is nonlinear programming model; it minimizes stress function based on Euclidean distance using the Generalized Reduced Gradient method, it comes out with at least local minimum solution. The problem of corruption is considered, and the corruption perceptions index 2010 for 19 Middle East countries was applied on the two proposed mathematical programming models to create a map according to level of corruption. The results obtained from the nonlinear programming model were compared with results of classical approach; which shows the superiority of nonlinear programming model, especially for stress and structure of configuration. As for the mixed integer programming model, it is a linear model and it guarantees obtaining the global optimum for stress.

Keywords: Nonmetric Multidimensional Scaling; Nonlinear Programming; Mixed Integer programming, Generalized Reduced Gradient method, Branch and Bound method, Corruption Perceptions Index.