Nonlinear Factor Analysis as a Statistical Method

by

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ABSTRACT

Factor analysis and its extensions are widely used in social and behavioral sciences, and can be considered useful tools for exploration and model fitting in multivariate analysis. Despite the popularity in applications, factor analysis has attracted rather limited attention from statisticians. Three issues, identification ambiguity, heavy reliance on normality, and limitation to linearity, may have contributed to statisticians' lack of interest in factor analysis. In this paper, the statistical contributions to the first two issues are reviewed, and the third issue is addressed in detail. Linear models can be unrealistic even as an approximation in many applications, and often do not fit the data well without increasing the number of factors beyond the level explainable by the subject-matter theory. As an exploratory model, the conventional factor analysis model fails to address nonlinear structure underlying multivariate data. It is argued here that factor analysis does not need to be restricted to the linearity and that nonlinear factor analysis can be formulated and carried out as a useful statistical method. In particular, for a general parametric nonlinear factor analysis model, the errors-in-variables parameterization is suggested as a sensible way to formulate the model, and two procedures for model fitting are introduced and described. Tests for the goodness of fit of the model are also proposed. The procedures are studied through a simulation study. An example from personality testing is used to illustrate the issues and the methods.