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Nonlinear regression models under skew scale mixtures of normal distributions

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Abstract

Normal nonlinear regression models are applied in some areas of the sciences and engineering to explain or describe the phenomena under study. However, it is well known that several phenomena are not always represented by the normal model due to lack of symmetry or the presence of heavy-and-lightly tailed distributions related to the normal law in the data. This paper proposes an extension of nonlinear regression models using the skew-scale mixtures of normal (SSMN) distributions proposed by Ferreira et al. (2011). This class of models provides a useful generalization of the symmetrical nonlinear regression models since the random term distributions cover both asymmetric and heavy-tailed distributions, such as the skew-normal, skew-slash and skew-contaminated normal, among others. An expectation-maximization (EM) algorithm for maximum likelihood (ML) estimates is presented and the observed information matrix is derived analytically. Some simulation studies are presented to examine the performance of the proposed methods, with relation to robustness and asymptotic properties of the ML estimates. Finally, an illustration of the method is presented considering a dataset previously analyzed under normal and skew-normal (SN) nonlinear regression models. The main conclusion is that the ML estimates from the heavy tails SSMN nonlinear models are more robust against outlying observations compared to the corresponding SN estimates.

Keywords: EM algorithm, Nonlinear regression models, Skew-normal distribution, Skew scale mixtures of normal distributions.

2010 MSC: 62J02, 62F10, 62F12

1. Introduction

Normal nonlinear regression models (N-NLM) are applied in some areas of the sciences and engineering to model symmetrical data for which nonlinear functions of unknown parameters are used to explain or describe the phenomena under study. However, it is well known that several phenomena are not always represented by the normal model due to lack of symmetry in the distribution or the presence of heavy-and-lightly tailed distributions related to the normal law in the data. Particularly, it is known that the parameter estimates of the normal model based on maximum likelihood (ML) methods are often sensitive to atypical observations. To deal with this problem, some proposals have been made in the literature to replace the normal distribution with more flexible classes of distributions. For instance, in a heavy tailed context, Cysneiros and Vanegas (2008) studied the symmetrical nonlinear regression model and performed a standardized residual analysis following the method proposed by Cox and Snell (1968). Vanegas and Cysneiros (2010) proposed diagnostic procedures based on case-deletion for symmetrical nonlinear regression models.

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