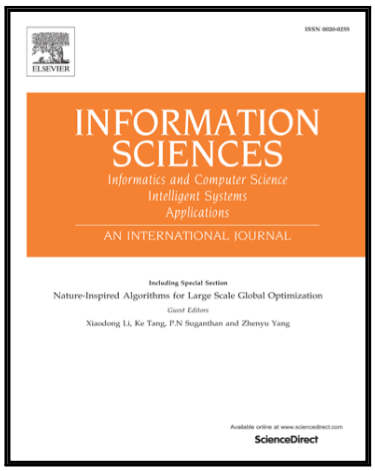

From fuzzy regression to gradual regression: Interval-based analysis and extensions

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From fuzzy regression to gradual regression: Interval-based analysis and extensions

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Abstract

This paper proposes an analysis of parametric interval-based regression methodologies according to ontic and epistemic visions of intervals. When assuming an epistemic point of view, a new interpretation of fuzzy regression through the notion of gradual intervals is developed, which leads to gradual regression. Gradual regression is viewed as an extension of the imprecise interval-based regression, which is obtained by integrating an uncertain dimension. Gradual intervals can yield improved specificity compared to conventional intervals and jointly consider the concepts of imprecision and uncertainty through a single and coherent formalism. The formulation of the gradual regression problem, its resolution and the propagation of the information through the obtained regressive models are carried out via gradual interval arithmetic. The proposed method allows not only the extension of the interval vision to the gradual case but also interesting interpretations according to non-additive confidence measure theories (possibility and belief functions).

Keywords: Possibilistic and Least-Squares Regressions, Ontic and Epistemic visions, Intervals and Gradual Intervals, Gradual Regression, Imprecision and Uncertainty, Possibility and Belief Function Theories.

I. INTRODUCTION

Traditionally, the purpose of a regression analysis is to find a crisp relationship between dependent and independent variables. Most statistical regression methodologies assume that the involved random elements can be formalized as real-valued random variables (the observation data are random with some measurement errors or noise). Moreover, verification of statistical assumptions requires many observations. However, in many practical situations, the observations are insufficient in quantity and/or quality, since costs and delays make obtaining rich and sufficient data impossible. Moreover, available data are often tainted by measurement errors and/or imperfections. In some cases, subjective observations in the form of confidence intervals and/or possibility distributions can be provided on the manipulated variables. In this context, interval regression and fuzzy regression can be interesting alternatives, in which the involved attributes do not take precise real values, but intervals [12][26][27][28][41] or fuzzy intervals [4][23][27][30][34][37][38][46][47][48]. In this framework, standard statistical methods for single-valued data are unable to properly consider this interval data [27].

Two main families of parametric fuzzy regression methodologies [25] are considered in the literature:

- The possibilistic methods, which were introduced by Tanaka [46][47] and developed in [35][30][34][48]. This denomination, although questionable, is due to the representation of the parameters and/or variables by membership functions, which can be considered as distributions of possibility;

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