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Fuzzy Euler Approximation and its Local Convergence

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Abstract

Fuzzy differential equation driven by Liu process is an important tool to deal with dynamic system in fuzzy environment. In many cases, however, it is difficult to find analytic solution of fuzzy differential equation driven by Liu process. Based on credibility theory, the Taylor series of fuzzy differential driven by Liu process is given and Euler approximation that use Taylor expansion as the recursion formula is obtained in this paper. Then the local convergence of Euler approximation is deduced.

Keywords: Liu process; fuzzy differential equation; convergence; Euler approximation

1 Introduction

There are various types of fuzzy phenomena in the world. In order to address fuzzy event, fuzzy sets was initiated by Zadeh [27] in 1965 and possibility measure was proposed by Zadeh [28] in 1978. Although these theories provide a basis for describing fuzzy events and have been well developed, the self-dual property was not satisfied for possibility measure. A concept of credibility measure which satisfy self-dual property was presented by Liu and Liu [10] in 2002, this measure made up for the imperfections of possibility measure. Later, Li and Liu [9] presented a sufficient and necessary condition for credibility measure. In 2004, credibility theory was founded by Liu [11] and was refined by Liu [12] in 2007. Within the framework of credibility theory, the concept of fuzzy variable was defined by Liu [11], it is a function from a credibility space to the set of real numbers. Fuzzy process was proposed by Liu [11] to describe dynamic fuzzy phenomena. As a fuzzy counterpart of Brownian motion, Liu process was defined mathematically by Liu [14], which has stationary and independent increments, furthermore the increment is still a fuzzy variable. Later, Lipschiz continuity of Liu process is proved by Dai [4] and the reflection principle of Liu process was given by Dai [5]. Besides, complex Liu process was studied by Qin and Wen [16]. Geometric Liu process was proposed by Liu [12]. In order to deal with the problems with several fuzzy dynamic factors, You, Huo and Wang [20] extended Liu process to the case of multi-dimensional. Furthermore, Liu process has been applied to real life. On the one hand, Liu process was applied to financial market, for example, a basic stock model that assume stock price follows geometric Liu process was proposed by Liu [14], which was called Liu's stock model. On the basis of this model, the European option pricing formulas were considered by Qin and Li [17]. After a discussion of new fuzzy stock model, an application to option pricing was given by Gao and Gao [7]. On the other hand, Liu process was also