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Fractional discrete–time diffusion equation with uncertainty: – Applications of fuzzy discrete fractional calculus

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Abstract

This study provides some basics of fuzzy discrete fractional calculus as well as applications to fuzzy fractional discrete–time equations. With theories of r–cut set, fuzzy Caputo and Riemann–Liouville fractional differences are defined on a isolated time scale. Discrete Leibniz integral law is given by use of w–monotonicity conditions. Furthermore, equivalent fractional sum equations are established. Fuzzy discrete Mittag–Leffler functions are obtained by the Picard approximation. Finally, fractional discrete–time diffusion equations with uncertainty is investigated and exact solutions are expressed in form of two kinds of fuzzy discrete Mittag–Leffler functions. This paper suggests a discrete time tool for modeling discrete fractional systems with uncertainty.

Keywords: Fractional difference equations; Fuzzy–valued functions; Time scale

1 Introduction

Discrete natural phenomena like time series, image and population hold discrete–time features often require discrete–time mathematical tools for modeling. Difference equations are performing a crucial role. There are excellent monographs on this topic [1, 2].

Long memory models have attracted much attention in finance [3] since around 1980. Then fractional calculus [4] became one of the methods because fractional integral can rather well depict the rate of decay. The tool was also paid much attention in possibility of climate changes and population characteristics [5]. Up to now, it has played as an efficient tool in various real world applications,

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