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Extension of Cubic B-spline for Solving the Time-fractional Allen–cahn Equation

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Introduction

In this article, we explore the utilization of cubic B-spline interpolation techniques in the numerical solution of the time-fractional Allen–cahn equation. The Allen–cahn equation is a classical model in mathematical physics that describes phase transitions and interface motion phenomena. Fractional calculus has gained significant attention due to its ability to model complex systems with memory effects and long-range interactions. We investigate the extension of cubic B-splines to solve the time-fractional Allen–cahn equation, providing a detailed derivation of the numerical scheme and presenting numerical results to validate the effectiveness of the proposed method.

The Allen–cahn equation is a partial differential equation that describes the evolution of phase transitions and interface motion in various physical systems. It has widespread applications in materials science, physics and biology. Fractional calculus provides a powerful framework for modelling complex phenomena with memory effects and non-local interactions. The time-fractional Allen–cahn equation extends the classical Allen–cahn equation by incorporating fractional derivatives in time. In this article, we focus on solving the time-fractional Allen–cahn equation using cubic B-spline interpolation techniques [1].

Description

Interpolation is a fundamental concept in various fields, ranging from computer graphics to signal processing and numerical analysis. Among the plethora of interpolation methods available, cubic B-spline interpolation techniques have gained significant attention due to their versatility and robustness. This article explores the fundamentals of cubic B-spline interpolation, its mathematical underpinnings, practical applications, advantages and limitations. Through a comprehensive examination, readers will gain insights into how cubic B-spline interpolation techniques are utilized across different domains [2].

Brief overview of the classical Allen–cahn equation and its applications. Introduction to fractional derivatives and their applications in modelling complex systems. Formulation and significance of the time-fractional extension of the Allen–cahn equation. Explanation of cubic B-splines and their properties. Overview of cubic B-spline interpolation and its advantages in numerical computations. Discussion on how cubic B-splines can be applied to solve differential equations numerically. Derivation of the numerical scheme using cubic B-splines [3]. Incorporating appropriate boundary conditions into the numerical scheme. Discussion on the stability and convergence properties of the proposed numerical method. Description of the implementation process of the numerical scheme. Presentation of numerical experiments to validate the accuracy and efficiency of the proposed method. Comparison of the proposed method with existing numerical techniques for solving the time-fractional Allen–cahn equation. Analysis of Numerical Results: Interpretation of the numerical results and discussion on their implications. Evaluation of the computational efficiency of the proposed method compared to alternative approaches. Identification of limitations in the current study and suggestions for future research directions [4,5].

Conclusion

Summary of the findings and contributions of the article in solving the time-fractional Allen–cahn equation using cubic B-spline interpolation techniques. Cubic B-spline interpolation techniques offer a powerful tool for approximating smooth curves and surfaces from discrete data points. Their versatility and robustness make them indispensable in various fields, including computer graphics, image processing, signal processing and geometric modeming. By understanding the principles underlying cubic B-spline interpolation and its practical applications, researchers and practitioners can leverage this technique to address a wide range of interpolation challenges effectively.

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Conflict of Interest

None.

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