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Development of Residual Power Series Methods for Efficient Solutions of Stiff Differential Equations

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Abstract : This paper presents the development of residual power series methods aimed at efficiently solving stiff differential equations, which pose significant challenges in numerical analysis due to their rapid changes in solution behavior. The RPSM is a numerical approach that generates polynomial-based approximate solutions without the need for linearization, discretization, or perturbation techniques, making it straightforward to implement and less prone to computational errors. We introduce an approach that utilizes power series expansions combined with residual minimization techniques to enhance convergence and stability. By analyzing the theoretical foundations of stiffness, we delve into the formulation of the residual power series method, detailing how it effectively captures the dynamics of stiff systems while maintaining computational efficiency. Numerical experiments demonstrate the method's superiority in terms of accuracy and computational cost when compared to traditional methods like implicit Runge-Kutta or multistep techniques. We also explore adaptive strategies within our framework to automatically adjust parameters based on the stiffness characteristics of the problem at hand. Ultimately, our findings contribute to the broader toolkit for tackling stiff differential equations, offering a robust alternative that promises to streamline computational workflows in various applied mathematics and engineering contexts.

Keywords : residual power series methods, stiff differential equoations, numerical approach, Runge Kutta methods
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