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A Uniformly Convergent Numerical Scheme for a Singularly Perturbed Volterra Integrodifferential Equation

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Abstract : Singularly perturbed problems are parameter dependent problems, and they play major roles in the modelling of real-life situational problems in applied sciences. Thus, designing efficient numerical schemes to solve these problems is of much interest since the exact solutions of such problems may not even exist. Generally, singularly perturbed problems are identified by a small parameter multiplying at least the highest derivative in the equation. The presence of this parameter causes the solution of these problems to be characterized by rapid oscillations. This unique feature renders classical numerical schemes inefficient since they are unable to capture the behaviour of the exact solution in the part of the domain where the rapid oscillations are present. In this paper, a numerical scheme is proposed to solve a singularly perturbed Volterra Integro-differential equation. The scheme is based on the midpoint rule and employs the non-standard finite difference scheme to solve the differential part whilst the composite trapezoidal rule is used for the integral part. A fully fledged error estimate is performed, and Richardson extrapolation is applied to accelerate the convergence of the scheme. Numerical simulations are conducted to confirm the theoretical findings before and after extrapolation.

Keywords : midpoint rule, non-standard finite difference schemes, Richardson extrapolation, singularly perturbed problems, trapezoidal rule, uniform convergence
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