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On an asymptotic-numerical hybrid method for solving singularly perturbed nonlinear delay differential equations

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Abstract

Modelling automatic systems often involves the idea of control because feedback is necessary in order to maintain a stable state. But much of this feedback require a finite time to sense information and react to it. A general way for describing this process is to formulate a delay differential equation (difference-differential equation). Delay differential equations (DDE) are widely used for modelling problems in population dynamics, nonlinear optics, fluid mechanics, mechanical engineering, evolutionary biology and even in modelling of (HIV) infection and human pupil-light reflex.

Almost all physical phenomena in nature are modelled using differential equations, and singularly perturbed problems are vital class of these kind of problems. In general, a singular perturbation problem defined as a differential equation that is controlled by a positive small parameter $0<\varepsilon\ll 1$ that exists as multiplier to the highest derivative term in the differential equation. As ε tends to zero, the solution of problem exhibits interesting behaviours since the order of the equation reduces. The region where these rapid changes occur is called *inner region* and the region in which the solution changes mildly is called *outer region*.

In this work, approximate solutions to singularly perturbed two-point nonlinear delay differential equations will be considered. An asymptotic-numerical hybrid method will be proposed to achieve this. This hybrid method consists of an efficient asymptotic method so-called Successive Complementary Expansion Method and an easy-applicable numerical procedure based on finite difference approximations. Numerical results show that the present method is well-suited for solving singularly perturbed nonlinear delay differential equations.

Keywords: **Asymptotic approximation, Delay differential equations, Singular perturbation, Successive complementary expansion method**

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