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Polynomial Chaos Expansion Combined with Exponential Spline for Singularly Perturbed Boundary Value Problems with Random Parameter

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Abstract : So many practical problems in science and technology developed over the past decays. For instance, the mathematical boundary layer theory or the approximation of solution for different problems described by differential equations. When such problems consider large or small parameters, they become increasingly complex and therefore require the use of asymptotic methods. In this work, we consider the singularly perturbed boundary value problems which contain very small parameters. Moreover, we will consider these perturbation parameters as random variables. We propose a numerical method to solve this kind of problems. The proposed method is based on an exponential spline, Shishkin mesh discretization, and polynomial chaos expansion. The polynomial chaos expansion is used to handle the randomness exist in the perturbation parameter. Furthermore, the Monte Carlo Simulations (MCS) are used to validate the solution and the accuracy of the proposed method. Numerical results are provided to show the applicability and efficiency of the proposed method, which maintains a very remarkable high accuracy and it is ε-uniform convergence of almost second order.

Keywords : singular perturbation problem, polynomial chaos expansion, Shishkin mesh, two small parameters, exponential spline
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