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The Chebyshev Integral Formulation for Performing High Spatial Resolution Collocation Simulations

B.K. Muite[1,2,3]

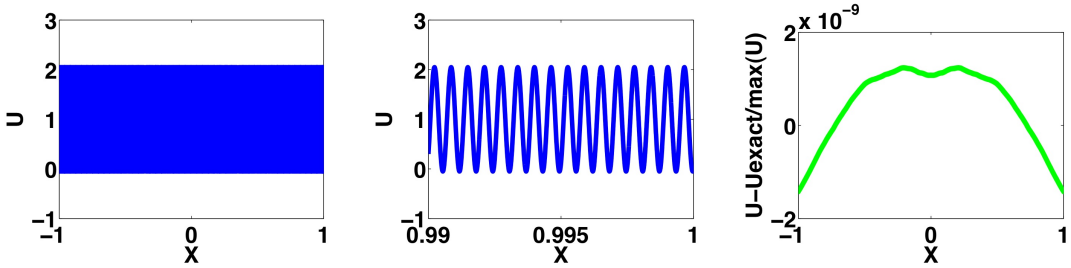
[1] *Mathematical Institute, University of Oxford, United Kingdom, muite@maths.ox.ac.uk*
[2] *Numerical Algorithms Group, Oxford, United Kingdom, benson@nag.co.uk*
[3] *Now at: Department of Mathematics, University of Michigan, USA, muite@umich.edu*

We describe an efficient implementation of the Chebyshev integration formulation. The implementation allows for spatially accurate simulations with $O(n \log n)$ computational costs and for the accurate recovery of derivatives [1,2]. High spatial resolution simulations using the implementation will be demonstrated. As a simple example we consider a numerical solution of the boundary value problem

$$10^{-6} u_{xx} + u = 1, \tag{1}$$

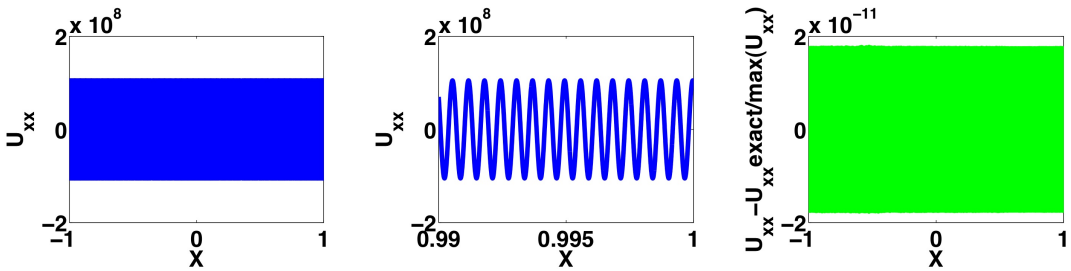
with $u(-1) = u(1) = 0$ and with 65,536 discretisation points. The exact solution is

$$1 - \frac{\cos(1000x)}{\cos(1000)}. \tag{2}$$



(a) The numerical solution u (b) Closeup of u. (c) Error in approximation.

Figure 1: The numerical solution and the error in the numerical solution of the singularly perturbed problem.



(a) The second derivative of the numerical solution. (b) Closeup of the second derivative of the numerical solution. (c) Error in approximation.

Figure 2: The second derivative of the numerical solution and the error in the second derivative of the numerical solution of the singularly perturbed problem.

References

[1] *A numerical comparison of Chebyshev methods for solving fourth-order semilinear initial boundary value problems*, B.K. Muite, Forthcoming Journal of Applied and Computational Mathematics (doi:10.1016/j.cam.2009.12.029).