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Combination of the variational iteration method and numerical algorithms for nonlinear problems. (English) [Zbl 07190971]

Summary: A very simple and efficient local variational iteration method (LVIM), or variational iteration method with local property, for solving problems of nonlinear science is proposed in this paper. The analytical iteration formula of this method is derived first using a general form of first order nonlinear differential equations, followed by straightforward discretization using Chebyshev polynomials and collocation method. The resulting numerical algorithm is very concise and easy to use, only involving highly sparse matrix operations of addition and multiplication, and no inversion of the Jacobian in nonlinear problems. Apart from the simple yet efficient iteration formula, another extraordinary feature of LVIM is that in each local domain, all the collocation nodes participate in the calculation simultaneously, thus each local domain can be regarded as one “node” in calculation through GPU acceleration and parallel processing. For illustration, the proposed algorithm of LVIM is applied to various nonlinear problems including Blasius equations in fluid mechanics, buckled bar equations in solid mechanics, the Chandrasekhar equation in astrophysics, the low-Earth-orbit equation in orbital mechanics, etc. Using the built-in highly optimized ode45 function of MATLAB as a comparison, it is found that the LVIM is not only very accurate, but also much faster by an order of magnitude than ode45 in all the numerical examples, especially when the nonlinear terms are very complicated and difficult to evaluate.

MSC:
65-XX Numerical analysis
74-XX Mechanics of deformable solids

Keywords:
Chebyshev polynomial; collocation method; local variational iteration method; nonlinear differential equation

Software:
Matlab

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