A matrix-free quasi-Newton method for solving large-scale nonlinear systems.

ABSTRACT

One of the widely used methods for solving a nonlinear system of equations is the quasi-Newton method. The basic idea underlining this type of method is to approximate the solution of Newton's equation by means of approximating the Jacobian matrix via quasi-Newton update. Application of quasi-Newton methods for large scale problems requires, in principle, vast computational resource to form and store an approximation to the Jacobian matrix of the underlying problem. Hence, this paper proposes an approximation for Newton-step based on the update of approximation requiring a computational effort similar to that of matrix-free settings. It is made possible by approximating the Jacobian into a diagonal matrix using the least-change secant updating strategy, commonly employed in the development of quasi-Newton methods. Under suitable assumptions, local convergence of the proposed method is proved for nonsingular systems. Numerical experiments on popular test problems confirm the effectiveness of the approach in comparison with Newton's, Chord Newton's and Broyden's methods.

Keyword: Quasi-Newton method; Diagonal updating; Weak quasi-Newton equation; Jacobian approximation; Large-scale nonlinear system.