

SOME MODIFICATIONS
OF CONJUGATE GRADIENT COEFFICIENT
FOR UNCONSTRAINED OPTIMIZATION

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MASTER OF SCIENCE
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March 2010

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Conjugate gradient methods have been widely used in unconstrained optimization. However, these methods are sensitive to the choice of the conjugate gradient coefficient. In this thesis, some new modifications of conjugate gradient coefficient (CG) are proposed. The performance of these methods has been compared.

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Conjugate gradient methods hold an important role in unconstrained optimization. Numerous studies and modifications have been done recently to improve this method. However, these new modifications tend to be complicated and difficult. In this research, three new simple modifications of conjugate gradient coefficient (β_k) for solving unconstrained optimization problems have been proposed.

In the first modification, motivated by Battaglia, this well known β_k is computed using the eigenvalues generated by exact Hessian matrix of $f(x)$. Whereas the second

and third modification are motivated by Hestenes and Steifel formula using two different denominators while retaining the original numerator.

These new β_k have been tested using ten standard optimization test problems and compared with the other six known conjugate gradient methods that are the Fletcher and Reeves, Polak and Ribiere, Hestenes and Steifel, Liu and Storey, Dai and Yuan and Conjugate Descent method. For every test problems, four different initial points have been used ranging from the one that is close to the solution point, to the one that is further away from the solution point.

Numerical results based on number of iterations have shown that this new formula perform better than the original conjugate gradient methods, retain its simplicity and still possesses global convergence properties.

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**PENGUBAHSUAIAN KOEFISIEN KECERUNAN KONJUGAT
BAGI PENGOPTIMUMAN TAK BERKEKANGAN**

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Kaedah kecerunan konjugat memainkan peranan yang penting di dalam permasalahan pengoptimuman tak berkekangan. Sehingga kini, banyak pengubahsuaian dan kajian dilakukan bagi meningkatkan kecekapan kaedah ini. Dalam kajian ini, dicadangkan tiga pengubahsuaian terhadap koefisien kecerunan konjugat (β_k) bagi menyelesaikan masalah pengoptimuman tak berkekangan.

Cadangan pengubahsuaian pertama telah dicetuskan hasil daripada kajian oleh Battaglia. Dalam pengubahsuaian ini, nilai β_k telah dihitung menggunakan salingan nilai-nilai eigen diperolehi daripada matrik Hessian. Manakala pengubahsuaian kedua dan ketiga telah dicetuskan oleh kajian Hestenes dan Steifel. Pengubahsuaian hanya

dilakukan pada bahagian pengangka manakala bahagian penyebut dikekalkan seperti rumus asal.

Rumus baru β_k ini telah diuji dengan sepuluh masalah piawai pengoptimuman dan perbandingan telah dilakukan dengan enam kaedah kecerunan konjugat iaitu kaedah Fletcher dan Reeves, Polak dan Ribiere, Hestenes dan Steifel, Liu dan Storey, Dai dan Yuan dan yang terakhir, kaedah Konjugat Penurunan. Bagi setiap masalah piawai pengoptimuman, empat titik awal berlainan telah digunakan bermula dari titik yang hampir ke titik yang jauh dari titik minimum sebenar.

Keputusan berangka telah menunjukkan bahawa rumus baru ini cukup efisien dari segi bilangan nilai lelaran berbanding kaedah kecerunan konjugat asal. Rumus baru ini juga adalah lebih mudah disamping mengekalkan sifat peminimuman sejagat.