AN ALTERNATIVE SCALING FACTOR IN QUASI-NEWTON METHODS FOR UNCONSTRAINED OPTIMIZATION

MUHAMMAD FAUZI BIN EMBONG

MASTER OF SCIENCE

UNIVERSITI MALAYSIA TERENGGANU

2011

7966

1100084329

Perpustakaan Sultanah Nur Zahirah
Universiti Malaysia Terengganu (UMT)

tesis
QA 402.5 .M8 2011

1100084329
An alternative scaling factor in quasi-newton methods for uncostrained optimization / Muhammad Fauzi Embong.

PERPUSTAKAAN SULTANAH NUR ZAHIRAH
UNIVERSITI MALAYSIA TERENGGANU (UMT)
21030 KUALA TERENGGANU.

1100084329

Lihat sebelah

HAK MILIK
PERPUSTAKAAN SULTANAH NUR ZAHIRAH UMT

AN ALTERNATIVE SCALING FACTOR IN QUASI-NEWTON METHODS FOR UNCONSTRAINED OPTIMIZATION

MUHAMMAD FAUZI BIN EMBONG

Thesis Submitted in Fulfillment of the Requirement
for the Degree of Master of Science in the
Faculty of Science and Technology
Universiti Malaysia Terengganu

July 2011

TABLE OF CONTENTS

	Page
ABSTRACT	ii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APPROVAL	vii
DECLARATION	x
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS AND SYMBOLS	xiv
LIST OF ALGORITHMS	xvi

CHAPTER

1. INTRODUCTION

1.1	Introduction	1
1.2	Research Background	1
1.3	Objective of Research	4
1.4	Scope of Research	4
1.5	Importance of Research	5
1.6	Organization of Thesis	5

2. FUNDAMENTALS OF UNCONSTRAINED OPTIMIZATION

2.1	Introduction	8
2.2	Local and Global Optimization	11

2.3 Line Searches 16

2.4 Eigenvalues and Eigenvectors 18

2.5 Stopping Criterion 19

2.6 Convergence Rate 20

2.7 Conclusion 21

3. UNCONSTRAINED OPTIMIZATION METHODS

3.1 Introduction 23

3.2 Steepest Descent Method 24

3.3 Newton Method 26

3.4 Conjugate Gradient Methods 28

3.5 Quasi-Newton Methods 29

3.6 Performance Comparison 40

3.7 Conclusion 45

4. SELF SCALING VARIABLE METRIC METHODS

4.1 Introduction 46

4.2 Self-scaling Variable Metric (SSVM) Methods 46

4.3 Choices of The Scaling Factor 47

4.4 An Alternative Scaling Factor 50

4.5 Standard Optimization Test Problems 52

4.6 Conclusion 57

5. NUMERICAL RESULTS AND DISCUSSION

5.1 Introduction 58

5.2 Numerical Results 58

5.3 Discussion 62

5.4 Conclusion 63

6. CONCLUSION AND SUGGESTIONS

6.1 Introduction 64

6.2 Conclusion 64

6.3 Suggestions 67

REFERENCES 68

APPENDICES 71

LIST OF PUBLICATION BY THE AUTHOR 99

ABOUT THE AUTHOR 101

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirement for the degree of Master of Science.

AN ALTERNATIVE SCALING FACTOR IN QUASI-NEWTON METHODS FOR UNCONSTRAINED OPTIMIZATION

MUHAMMAD FAUZI BIN EMBONG

JULY 2011

Chairman : **Associate Professor Hj. Mustafa Bin Mamat, Ph.D.**

Members : **Professor Hj. Ismail Bin Mohd, Ph.D.**
Yosza Bin Dasril, Ph.D.

Faculty : **Science and Technology**

Quasi-Newton methods play a vital role in theoretical and computational mathematics. The first quasi-Newton algorithm was developed by Davidon in mid 1950s, and later demonstrated by Fletcher and Powell that the new algorithm was more reliable and faster than the existing methods.

Although the quasi-Newton methods are sophisticated and reliable, these methods are more sensitive to calculation errors. The common errors are round-off errors and inaccurate line searches. To overcome the weakness, the self-scaling variable matrices (SSVM) method was introduced by Oren in 1973. The method introduces a scaling factor to quasi-Newton method. The choice of a suitable scaling factor is always of

interest of researchers. A few scaling factors that are commonly used are those introduced by Oren and Luenberger in 1974. But the use of the scaling factors does destroy the property of Hessian matrix in quadratic case. To overcome this problem, a much simpler initial scaling method was introduced by Shanno and Phua in 1978. The initial scaling method does not require additional information about the objective function that routinely required by variable metric algorithm as the scaling factor is the already available step size.

In this thesis, an alternative scaling factor was introduced to quasi-Newton methods. The alternative scaling factor had been tried and numerically tested on common standard optimization problems using Maple software. The numerical results show that the alternative scaling factor reduces the number of iteration of the standard quasi-Newton methods. The positive definiteness of Hessian matrix and global convergence property are also retained.

Abstrak tesis yang dikemukakan kapada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk Ijazah Sarjana Sains.

FAKTOR PENGSKALAAN ALTERNATIF DALAM KAEDAH QUASI-NEWTON BAGI PENGOPTIMUMAN TAK BERKEKANGAN

MUHAMMAD FAUZI BIN EMBONG

JULAI 2011

Pengerusi : **Profesor Madya Hj. Mustafa Bin Mamat, Ph.D.**

Ahli : **Profesor Hj. Ismail Bin Mohd, Ph.D.**
Yosza Bin Dasril, Ph.D.

Fakulti : **Sains dan Teknologi**

Kaedah quasi-Newton memainkan peranan yang penting dalam matematik teori dan komputasi. Kaedah quasi-Newton diperkenalkan oleh Davidon pada pertengahan 1950-an, telah ditunjukkan oleh Fletcher dan Powell bahawa kaedah baru tersebut adalah lebih tekal dan pantas daripada kaedah sedia ada pada masa itu.

Walaupun kaedah quasi-Newton lebih canggih dan tekal, kaedah ini adalah lebih sensitif kepada ralat pengiraan. Ralat yang lazim adalah ralat bundaran dan panjang langkah yang tidak tepat. Untuk mengatasi masalah ini, kaedah pengskalaan sendiri matriks (SSVM) telah diperkenalkan oleh Oren dalam tahun 1973. Kaedah ini menambahkan faktor pengskalaan kepada kedah quasi-Newton. Pemilihan faktor pengskalaan yang sesuai sentiasa menarik minat para pengkaji. Faktor pengskalaan yang lazim digunakan ialah faktor pengskalaan yang diperkenalkan oleh Oren dan

Perpustakaan Sultanah Nur Zahirah
Universiti Malaysia Terengganu (UMT)

Luenberger dalam tahun 1974. Tetapi penggunaan faktor pengskalaan tersebut boleh merosakkan sifat matrik Hessian dalam kes quadratik. Untuk mengatasi kekurangan ini, kaedah pengskalaan awal yang lebih ringkas telah diperkenalkan oleh Sahno dan Phua dalam tahun 1978. Kaedah pengskalaan awal tidak memerlukan maklumat tambahan memandangkan faktor pengskalaan yang digunakan merupakan panjang langkah yang memang telah tersedia ada.

Dalam tesis ini, satu faktor pengskalaan alternatif diperkenalkan ke dalam kaedah quasi-Newton. Faktor pengskalaan ini telah dicuba dan diuji secara berangka ke atas masalah pengoptimuman piawai yang lazim, menggunakan perisian Maple. Keputusan berangka menunjukkan faktor pengskalaan alternatif tersebut telah mengurangkan bilangan lelaran kaedah quasi-Newton asal. Sifat positif tentu bagi matrik Hessian dan penumpuan global juga dikekalkan.