

MASTER'S THESIS

A matrix free method for unconstrained optimization problems

Xie, Xiaohui

Date of Award:
2011

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

A Matrix Free Method for Unconstrained Optimization Problems

XIE Xiaohui

A thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Philosophy

Principal Supervisor: Dr. TAM Hon Wah

Hong Kong Baptist University

July 2011

Abstract

These years people pay more and more attention to solve optimization problems which will help to handle a large number of application problems in different areas. The analysis of the minimum or maximum problem has become an active research topic in mathematics, computer science and economics.

In this thesis, we focus on methods for unconstrained optimization problems (UP). We apply an existing EPS method for nonlinear equations to UP via the dynamical system approach. By varying some method parameters, the stability region of the method can be tuned to get a balance between numerical stability and the order of accuracy.

One of the main contributions of this thesis is to increase the problem dimension to a high order of magnitude, which has not been achieved for a lot of problems. For many optimization problems, $n = 10^4$ is already considered large. Beyond this problem size the computer will run out of memory. Our experiments have succeeded in solving problem sizes of $n = 10^5$ and $n = 10^6$.

Large problems can be solved because the method used is matrix-free. This is done by computing only the first order derivative and diagonal elements of the Hessian of the given objective function. The performance of our method is shown by testing 27 well-known problems.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgements	iii
Contents	iv
List of Tables	vi
List of Figures	vii
1 Introduction	1
1.1 Background	1
1.2 Conventional Methods for Optimization Problems	2
1.2.1 Steepest Descent Method	3
1.2.2 Newton's Method	4
1.2.3 Quasi-Newton Method	6
1.2.3.1 Background and Update Formula	6
1.2.3.2 The DFP Formula	7
1.2.3.3 The BFGS Formula	8
1.3 Thesis Outline	10
2 The Dynamical System Approach	12
2.1 Introduction	12
2.2 Basic Definitions and Theorems	13
2.3 Dynamical System Approach for Optimization Problems	14

3	A Matrix Free Method for Large Scale Optimization	16
3.1	The EPS Method for Nonlinear Equations	16
3.2	EPS Method for Optimization	20
3.3	Matrix-Free Algorithm Based on the EPS Method	21
3.4	Parameter Discussion	24
3.5	Benefits of Solving Large Scale Optimization Problems	25
4	Experimental Results	26
4.1	Performance on Large Scale Optimization Problems	26
4.1.1	Evaluation on CPU Time	26
4.1.2	Trajectory of Objective Function	31
4.2	Parameter Selection	54
5	Conclusions	56
	A Test Problems	58
	Curriculum Vitae	69