

## A New Technique Based on the Algorithm of Particle Swarm to Solve Prediction Problem in Stock Market and Portfolio Selection

A thesis

submitted to Department of mathematics faculty of science Ain Shams University for the degree of the Doctor of philosophy (PH.D) in mathematics

# Presented By: Razan Adnan Jamous Supervised By:

### Prof. Bayoumi I. Bayoumi

Department of Mathematics- Faculty of Science - Ain Shams University

### Prof. Assem A. Tharwat

Department of Operations Research and Decision Support - Faculty of Computer and Information - Cairo University

### Prof. Essam Ahmed Solayman El.Seidy

Department of Mathematics - Faculty of Science - Ain Shams University

Ain Shams University Cairo Egypt 2016



**Faculty of Science** 

**Mathematics Department** 

### **Approval**

**Degree**: Doctor of Philosophy Degree in Appli ed mathematics

**Title:** A New Technique Based on the Algorithm of Particle Swarm to Solve Prediction Problem in Stock Market and Portfolio Selection

Candidate: Razan Adnan Jamous

M.Sc. in Applied mathematics and Programming, Aleppo University (2011)

Approved by the Advisors

### Prof. Bayoumi I. Bayoumi

Department of Mathematics- Faculty of Science - Ain Shams University

### Prof. Assem A. Tharwat

Department of Operations Research and Decision Support - Faculty of Computer and Information - Cairo University

### **Prof. Essam Ahmed Solayman El.Seidy**

Department of Mathematics - Faculty of Science - Ain Shams University

# **ACKNOWLEDGMENT**

### **ACKNOWLEDGMENT**

First of all I would like to thank Allah, the Creator, for giving me the ability to complete this thesis, and for guiding me while doing it.

I would like to take the opportunity to thank people who guided and supported me during this process. Without their contributions, this research would not have been possible.

Firstly, I would like to express special thanks to my supervisors **Prof. Dr. Bayoumi Ibrahim Bayoum**, Professor of Pure Mathematics Department, Faculty of Science, Ain Shams University, for his continuous guidance, faithful care, and valuable advices, which were always there when I needed. Without his encouragement and guidance this thesis would not have materialized.

Additionally, special thanks go to **Prof. Dr. Assem A. Tharwat**, Professor of Operations Research and Decision Support

Department, Faculty of Computer and Information, Cairo

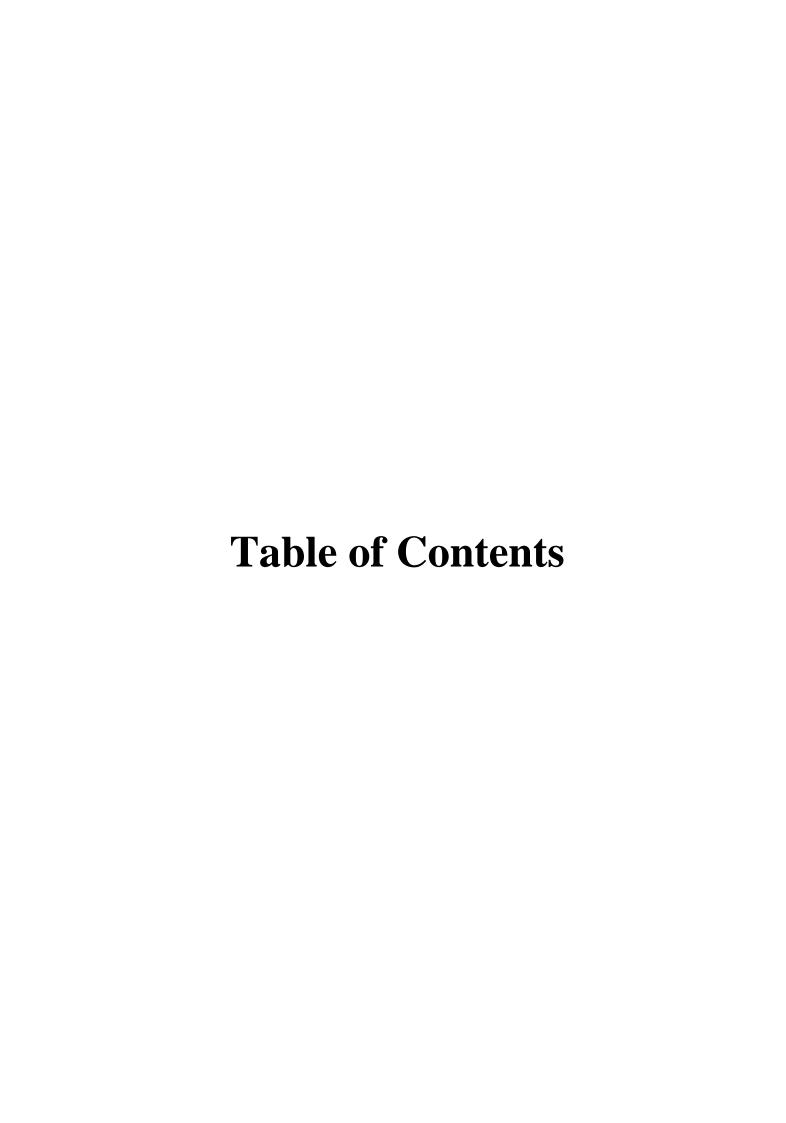
University for his kind advices, encouragements and for his

valuable revising of my thesis to be in the best form.

I would like to acknowledge my indebtedness and render my warmest thanks to **Prof. Dr. Essam El-Seidy** for the patient guidance, encouragement and advice he has provided throughout my time as his student. He has the great merit in determining the research point of my thesis and his friendly guidance and expert advices have been invaluable throughout all stages of the work. Who cared so much about my work, and who responded to my questions and queries so promptly.

I am forever indebted to my parents, my husband, my Childs, my brothers, my sisters and my friends for their understanding, endless patience and encouragement when it was most required. This work would not have been possible without their support and encouragement.

With great respect I would like to say thanks to every member in Mathematics department, I really feel a proud to achive my thesis in this department, college and university.



### **Table of Contents**

Acknowledgment	1
A List of the Published Papers	III
Summary	IV
Table of Contents	VI
List of Figures	IX
List of Tables	XII
List of Abbreviations	XIII
CHAPTER .1 COMPUTATOINAL INTELLIGENCE	1
1.1 Introduction	1
1.2 Computational Intelligence Paradigms	1
1.2.1 Artificial Neural Networks	2
1.2.2 Evolutionary Computation	5
1.2.3 Swarm Intelligence	7
1.2.4 Artificial Immune Systems	9
1.2.5 Fuzzy Systems	10
1.2.6 Bacterial foraging optimization	11
1.2.7 Adaptive Bacterial Foraging optimization	12
1.2.8 Genetic Algorithms	12
1.3 Summary	13
CHAPTER. 2 PARTICLE SWARM OPTIMIZATION	14
2.1 Introduction	14
2.2 Historical Background	14
2.3 Basic Particle Swarm Optimization	16
2.3.1 Global Best PSO	17
2.3.2 Local Best PSO	17
2.3.3 Velocity Components	17
2.4 Limitations of Particle Swarm Optimization	18
2.5 Modifications of Particle Swarm Optimization	19
2.5.1 External Modification Techniques	19
2.5.1.1 Dynamic multi-swarm particle swarm optimizer	19
2.5.1.2 Multi-swarm and multi-best particle swarm optimization algorithm	20
2.5.1.3 Dynamic multi-swarm particle swarm optimizer with	20
sub-regional harmony	_0
2.5.1.4 Multi-swarm Particle Swarm Optimization	21

2.5.1.5 Master-slave swarm evolutionary	20
2.5.1.6 Heterogeneous particle swarm Optimization	21
2.5.1.7 Back-Propagation algorithm	21
2.5.2 Internal Modification Techniques	22
2.5.2.1 Velocity Clamping	22
2.5.2.1.1 Particle Swarm Optimization with passive	23
congregation	
2.5.2.1.2 Stochastic Particle Swarm Optimization	23
2.5.2.1.3 Cooperative Particle Swarm Optimization	24
2.5.2.1.4 Particle Swarm Optimization with disturbance term	24
2.5.2.1.5 Center Particle Swarm Optimization	24
2.5.2.1.6 Mean Particle Swarm Optimization	25
2.5.2.1.7 Field-Effect Transistor (FET):	26
2.5.2.1.8 Fuzzy particle swarm optimization (FPSO)	26
2.5.2.1.9 A Modified particle swarm optimization (MPSO)	27
2.5.2.2 Inertia Weight	27
2.5.2.2.1 Linear Decreasing Weight Particle Swarm	28
Optimization	
2.4.2.2.2 Exponential Particle Swarm Optimization	28
2.5.2.2.3 C-Catfish PSO	29
2.5.2.2.4 PSO with Nonlinear Decreasing inertia Weight	29
2.5.2.3 Acceleration Coefficients	29
2.5.2.3.1 Constrained Particle Swarm Optimization CPS	30
2.6 Particle Swarm Optimization Applications	32
CHAPTER. 3 STOCK MARKET	34
3.1 Portfolio Optimization Problem	34
3.2 Portfolio Optimization Techniques	35
3.3 The Stock Market	37
3.4 Investment Theories	38
3.4.1 Data Related to the Market	39
3.5 Prediction of the Stock Market	40
3.5.1 Defining the prediction task	40
3.5.2 Is the Market predictable?	41
3.5.3 Prediction Methods	42
3.5.3.1 Technical Analysis	42
3.5.3.2 Fundamental Analysis	43
3.5.3.3 Machine Learning Methods	44
3.5.4 Prediction Techniques	44
3.5.5 Technical Indicators and Portfolio Optimization	45

3.5.5.1 Simple Moving Average (SMA)	45
3.5.5.2 Exponential Moving Average (EMA)	46
3.5.5.3 Relative Strength Index (RSI)	47
3.5.5.4 Rate of Change (ROC)	47
Chapter. 4 Computational INTELLIGENCE'S	49
PROPOSED TECHNIQE	
4.1 Center of Mass Particle Swarm Optimization Technique	49
4.2 Definitions	50
4.3 Assumptions	50
4.4 Velocity Update Function	51
4.5 The Philosophy of Center of Mass PSO .	53
4.6 Pseudo Code of the Center of Mass PSO	54
4.7 Evaluation of PSOCoM Technique	54
4.7.1 Benchmark Test Functions	54
4.7.2 Parameter Settings	58
4.7.3 Results and Discussion	59
4.8 Comparison of PSOCoM to LDWPSO and CenterPSO	59
CHAPTER .5 STOCK MARKET'S PROPOSED MODEL	66
5.1 Introduction	66
5.2 Stock Market Prediction Model	66
5.3 Center of Mass Selection Model	68
5.4 Evaluation of the Proposed Techniques	70
5.4.1 Historical Data	71
5.4.2 Parameter Settings	71
5.4.3 Results and Discussion	72
REFERENCE	84
Appendix A	94

# LIST OF FIGURES