PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

UNIVERSITY OF M 'SI L A
FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

COMPUTER SCIENCE DEPARTMENT

Dissertation Submitted in partial fulfillment of the requirements for the Degree of MASTER

Domain: Mathematics and Computer Science

Branch: Computer Science

Specialty: Networks

By: Benamara Mohamed Sifeddine

TOPIC

A hybrid GRASP algorithm for the minimum weight vertex cover problem

Publicly defended: 01 / 06 /2016 before a Jury composed of :

Dr. S. Bouamama	University of M'sila	Supervisor
Dr. A. Gasmi	University of M'sila	Chair
Mr. A.Guerna	University of M'sila	Examiner

Academic Year: 2015 /2016

Contents

Figures list 4

Algorithm table 4

Introduction 5

The objective 5

CHAPTER 1 GRAPH THEORY

Introduction 7

What's a graph? 7

Types of graphs 8

Undirected graphs 8

Directed graphs 8

Terminologies 9

Representations of graphs 10

Adjacency list 11

Adjacency matrix 11

Some graph algorithms 12

Minimum Spanning Trees 12

The shortest path problem 13

Dijkstra's algorithm 14

CHAPTER 2 COMBINATORIAL OPTIMIZATION

Introduction 16

Motivation 17

Combinatorial Optimization Problems 18

Complexity of algorithms 19

The class P 19

The class NP 19

NP-complete 19

Optimization Methods 19

Exact Methods 20

Approximate Algorithms 20

Metaheuristics 21

Classifications of metaheuristics 22

Contents

Population-based vs. single point search 23
Dynamic vs. static objective function 23
One vs. various neighborhood structures 23
Memory usage vs. memory-less methods 23
Exact vs. approximate 24
With continuous variables vs. with discrete variables 24
Local search 25
Running time 26
The Traveling Salesman Problem 28
Introduction 28
Definition 28
Methods to solve the traveling salesman problem 29
CHAPTER 3 MINIMUM WEIGHT VERTEX COVER PROBLEM
Introduction 31
The vertex-cover problem 31
Approximation Algorithms 32
Minimum weighted vertex cover problem 33
Complexity 36
Related works 37
Chapter 4 GRASP
1 Introduction 40
2 Principles and Building Blocks 40
2.1 Greedy Algorithms 40
2.2 Randomization and Greedy Randomized Algorithms 41
2.3 Neighborhoods 42
2.4 Local Search 43
3 A Template for GRASP 43
4 Some Promising Areas for Future Application 44
4.1 Continuous GRASP 44
4.2 Probabilistic-Based Stopping Rules 45
Chapter 5 EXPERIMENTAL RESULTS

Contents

Introduction 47

Benchmark instances and experimental protocols 47

Comparison with the best performing reference algorithms 47

Comparison with other greedy algorithms 48

Experimental results on SPI type instances 48

Experimental results on MPI type instances 49

Experimental results on LPI type instances 50

General conclusion 54

References 55

INTRODUCTION

The Minimum Weight Vertex Cover problem (MWVC) is a classical combinatorial optimization which can be stated as follows. Given a vertex-weighted undirected (with positive values) graph, the goal of the MWVC problem is to find a subset of the given vertices with minimum total weight with the property that at least one of the endpoints of each edge of the graph is contained in the subset. MWVC problem is a fundamental graph problem with many important real-life applications such as, for example, in wireless communication, circuit design and network flows [Bouamama 2012].

In theory of complexity, the Minimum Weight Vertex Cover Problem is an NP-complete problem [Garey 1979] where is unlikely to find a polynomial-time algorithm for solving it to optimality.

Therefore, most existing methods for dealing with this problem are based on heuristics for providing approximate solutions in a reasonable computation time.

In this work we firstly provide a comparison between different variations of a greedy heuristic for the MWVC problem. Besides, the greedy heuristics that have been used for the minimum weight dominating set problems [Potluri 2013][Bouamama 2016] have been also adopted for the MWVC problems. Secondly, the two best greedy heuristics obtained from the previous experiments have been investigated in the developments of a hybrid GRASP algorithm. The performance of our approach has been tested on well known dataset.

The thesis is organized as follows. In the first chapter we discuss graph theory basics, we give examples and some widely used algorithms. In the second chapter we talk about combinatorial optimization, its classes and we explain the Traveling Salesman Problem (TSP). The third chapter contains the interested problem (the minimum weight vertex cover or MWVC). The last two chapters discuss the proposed algorithms before and our algorithm, we compare between them in term of running-time and the minimum cost to see if our proposed algorithm is better than the previous.

The objective:

We aim in our work to solve the MWVC problem with lower complexity (running-time) and lower cost than the previous proposed approaches.

GENERAL CONCLUSION:

The minimum weight vertex cover problem (MWVCP) is a well known optimization problem with a wide range of practical applications such as in wireless communication, circuit design, and network flows.

GRASP, which stands for greedy randomized adaptive search procedures is a multistart, or iterative, metaheuristic. GRASP was proposed before to tackle The capacitated clustering problem (CCP), and we modified it to tackle the minimum weight vertex cover problem (MWVCP).

The platform of our experiments was a personal computer with an Intel(R) Core(TM) i3-3110M CPU with 2.40GHz and 4 GB RAM. We used CodeBlocks as our IDE with g++ compiler and C++ as our programming language. The codes are available under CC license.

The obstacles that faced us was the difficulty of the good understanding of the problem at hand, how to select the proper language to code the algorithm, how to code it to obtain minimum running-time and results as possible as we could.

ملخص:

في مشروعنا هذا حاولنا برمجة برنامج يحل مشكل MWVC بأقل تكلفة ممكنة واستعملنا لهذا الغرض لغة البرمجة سي++ وبرنامج codeblocks كبيئة برمجية

الكلمات المفتاحية:

MWVCP ، سي++، codeblocks

Abstract :

In this project we tried to implement a program to solve MWVCP with minimum cost, to do that we used C++ language and codeblocks IDE.

Key words:

MWVCP, C++, codeblocks

Resume:

Dans ce projet, nous avons essayé de mettre en œuvre un programme pour résoudre MWVCP avec un coût minimum, pour le faire, nous avons utilisé le langage C ++ et le codeblocs IDE.

Mots clés :

MWVCP , C++, codeblocks