CONTENTS
Chapter 1
INTRODUCTION1
1.1 Networks and shortest paths ..... 1
1.2 Algorithms ..... 2
1.3 How to evaluate an algorithm ..... 3
1.4 The organization of the monograph ..... 3
Chapter 2
FINDING THE SHORTEST DISTANCES FROM A FIXED NODE TO ALL OTHER NODES IN N-NODE NON-NEGATIVE DISTANCE NETWORKS ..... 6
2.1 Introduction ..... 6
2.2 Notation ..... 8
2.3 Algorithm 2.3 ..... 9
2.4 Justification of Algorithm 2.3 ..... 11
2.5. The efficiency of Algorithm 2.3 ..... 11
2.6 An empirical stuay on the efficiency of Algorithm 2.3 on a computer ..... 15
2.7 Applications of Algorithm 2.3 ..... 16
2.1A Appendix 2.1 A "matrix" algorithm for finding all shortest paths from a fixed node in a non-negative distance network ..... 17
2.2A Appendix 2.2 FORTRAN IV computer programs for Algorithm 2.3 and Dijkstra's algorithm as suggested by Dreyfus ..... 20
Chapter 3
FINDING THE SHORTEST DISTANCES BETWEEN ALL PAIRS OF NODES IN NON-NEGATIVE DISTANCE NETWORKS ..... 23
3.1 Introduction ..... 23
3.2 Algorithm 3.2 ..... 24
3.3 Floyd's and Hoffman and Winograd's algorithms ..... 26
3.4 Dantzig's algorithm and its improvement by Tabourier ..... 33
3.5 Algorithm 3.5 ..... 37
3.6 Algorithm 3.6 ..... 41
3.7 Algorithm 3.7 ..... 43
3.1A Appendix 3.1 FORTRAN IV computer programs for Algorithm 3.2 Algorithm 3.3.1 (Floyd), and Algorithm 3.3.2 ..... 49
Chapter 4
FINDING ALL SHORTEST DISTANCES FROM A FIXED NODE IN GENERAL NETWORKS ..... 52
4.1 Introduction ..... 52
4.2 Algorithm 4.2 ..... 53
4.2.1 Notation ..... 53
4.2.2 Algorithm 4.2 ..... 54
4.2.3 Proof of Algorithm 4.2 ..... 55
4.2.4 The efficiency of Algorithm 4.2 ..... 56
4.2.5 A "matrix" algorithm of Algorithm 4.2 ..... 57
4.3 Algorithm 4.3 ..... 61
4.3.1 Notation ..... 61
4.3.2 Algorithm 4.3 ..... 62
4.3.3 Proof of Algorithrn 4.3 ..... 63
4.3.4 A five node example ..... 66
4.3.5 Efficiency of Algorithm 4.3 ..... 67
4.3.6 Comparison of Algorithms ..... 68
Chapter 5
FINDING THE SHORTEST DISTANCES BETWEEN ALL PAIRS OF NODES IN GENERAL NETWORKS ..... 72
5.1 Introduction ..... 72
5.2 Algorithm 5.2 ..... 73
5.3 Algorithm 5.3 ..... 76
5.4 Comparison of the efficiencies of different algorithms for finding all shortest distances in general networks ..... 80

## Chapter 6

EFFICIENCIES OF ALGORITHMS FOR DETECTING THE EXISTENCE OF NEGATIVE CYCLES IN GENERAL NETWORKS ..... 82
6.1 Introduction ..... 82
6.2 The computational bounds of different algorithms for detecting the existence of negative cycles in general networks ..... 82
6.3 An empirical study ..... 85
6.4 Conclusions based on the empirical study ..... 88
Chapter 7
FINDING THE SHORTEST DISTANCES BETWEEN ALL PAIRS OF NODES IN NON-CIRCULAR SPARSE NETWORKS BY DECOMPOSITION ALGORITHMS ..... 90
7.1 Introduction ..... 90
7.2 Decomposition algorithms for finding all shortest distances in the first type of linearly overlapping network ..... 92
7.2.1 Algorithm 7.2.1 for finding all key shortest distance submatrices in the first type of linearly overlapping sparse network. ..... 93
7.2.2 Algorithm 7.2.2 for finding all non-key shortest distance submatrices in the first type of linearly overlapping sparse network ..... 97
7.3 Decomposition algorithm for finding all shortest distances in the second type of linearly overlapping sparse network ..... 99
7.3.1 Algorithm 7.3.1 for finding all key shortest distance submatrices in the second type of linearly overlapping sparse network ..... 100
7.3.2 Algorithm 7.3.2 for finding all non-key shortest distance submatrices in the second type of linearly overlapping sparse network ..... 104
7.4 Algorithm 7.4 for finding all shortest distances in star-shaped sparse networks. ..... 106
7.5 Decomposition algorithms for finding all shortest distances in non-circular sparse networks ..... 109
7.5.1 Algorithm 7.5.1 for finding all key shortest distance submatrices in non-circular sparse networks ..... 110
7.5.2 Algorithm 7.5.2 for finding all non-key distance submatrices in non-circular sparse networks. ..... 113
7.5.3 The efficiency of Algorithms 7.5.1 and 7.5.2 ..... 114
7.6 Extension ..... 115
Chapter 8
FINDING THE SHORTEST DISTANCES BETWEEN ALL PAIRS OF NODES IN CIRCULAR SPARSE NETWORKS BY DECOMPOSITION ALGORITHMS ..... 117
8.1 Introduction ..... 117
8.2 Decomposition algorithms for finding all shortest distances in donut-shaped sparse networks. ..... 118
8.2.1 Algorithm 8.2.1 (a node-elimination approach) ..... 120
8.2.2 Algorithm 8.2.2 (an arc-elimination approach) ..... 123
8.3 Algorithm 8.3 for finding all shortest distances in a first-degree circular sparse network. ..... 126
8.4 Decomposition algorithm for finding all shortest distances in a wheel-shaped sparse network ..... 127
8.4.1 Algorithm 8.4.1 (a node-elimination approach) ..... 129
8.4.2 Algorithm 8.4.2 (an arc-elimination approach) ..... 131
8.4.3 Algorithm 8.4.3 (an arc-node-elimination approach) ..... 133
8.5 Algorithm 8.5 for finding all shortest distances in second-degree circular sparse networks ..... 135
8.6 Decomposition algorithms for finding all shortest distances in an n-degree circular sparse network ..... 137
Chapter 9
FINDING THE K SHORTEST LOOPLESS PATHS BETWEEN A PAIR OF NODES IN A NETWORK ..... 141
9.1 Algorithm 9.1 for finding the $K$ shortest loopless paths between a pair of nodes in general networks ..... 141
9.2 Algorithm 9.2 for finding the K shortest loopless paths between a pair of nodes in non-negative distance networks ..... 146
BIBLIOGRAPHY ..... 149

