HYBRIDIZATION OF MODIFIED SINE COSINE ALGORITHM WITH TABU SEARCH FOR SOLVING QUADRATIC ASSIGNMENT PROBLEM

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Abstrak

Algoritma Sinus Kosinus (SCA) ialah kaedah berasaskan populasi yang telah digunakan secara meluas untuk menyelesaikan pelbagai masalah pengoptimuman disebabkan oleh keupayaannya menstabilkan antara penerokaan dan eksploitasi. Walau bagaimanapun, SCA jarang digunakan dalam permasalahan pengoptimuman diskret seperti Masalah Umpukan Kuadratik (QAP) kerana ia menghasilkan penyelesaian nilai selanjar dan menjadikannya mencabar untuk menyelesaikan masalah pengoptimuman diskret. SCA juga didapati terperangkap dalam lokal optima memandangkan ia mempunyai kelemahan mengingati pergerakan. Selain itu, strategi carian lokal diperlukan dalam mencapai penyelesaian terbaik dan kebiasaannya ia direka berdasarkan permasalahan yang dikaji. Oleh itu, kajian ini bertujuan untuk membangunkan satu model hibrid SCA terubah suai dengan Carian Tabu (MSCA-TS) untuk menyelesaikan QAP. Dalam QAP, satu set fasiliti diumpukkan ke satu set lokasi untuk membentuk satu padanan satu-ke-satu dengan kos umpukan yang minimum. Pertamanya, model SCA terubah suai (MSCA) dengan strategi carian lokal berasaskan kos dibina. Kemudian, MSCA dihibridkan dengan TS untuk menghalang ulangan lawatan terhadap solusi yang lalu. Akhirnya, kedua-dua jenis model (MSCA dan MSCA-TS) diuji ke atas 60 data QAP dari QAPLIB. Analisis sensitiviti dilaksanakan untuk mengenalpasti tetapan parameter yang sesuai untuk kedua-dua model. Perbandingan keputusan menunjukkan MSCA-TS memiliki prestasi yang lebih baik berbanding MSCA. Peratus ralat dan sisihan piawaian untuk MSCA-TS adalah lebih rendah berbanding MSCA iaitu masing-masing 2.4574 dan 0.2968. Keputusan pengiraan juga menunjukkan yang MSCA-TS adalah kaedah yang berkesan dan terbaik dalam menyelesaikan QAP apabila dibandingkan dengan solusi yang dibentangkan dalam kajian terdahulu. Model yang telah dibangunkan boleh membantu pembuat keputusan dalam mencari umpukan yang paling sesuai untuk fasiliti dan lokasi dengan kos yang minimum.

Kata Kunci: Masalah umpukan kuadratik, Algoritma sinus kosinus, Metaheuristik berasas populasi, Carian lokal, Penerokaan dan eksploitasi.

Abstract

Sine Cosine Algorithm (SCA) is a population-based metaheuristic method that widely used to solve various optimization problem due to its ability in stabilizing between exploration and exploitation. However, SCA is rarely used to solve discrete optimization problem such as Quadratic Assignment Problem (QAP) due to the nature of its solution which produce continuous values and makes it challenging in solving discrete optimization problem. The SCA is also found to be trapped in local optima since its lacking in memorizing the moves. Besides, local search strategy is required in attaining superior results and it is usually designed based on the problem under study. Hence, this study aims to develop a hybrid modified SCA with Tabu Search (MSCA-TS) model to solve QAP. In QAP, a set of facilities is assigned to a set of locations to form a one-to-one assignment with minimum assignment cost. Firstly, the modified SCA (MSCA) model with cost-based local search strategy is developed. Then, the MSCA is hybridized with TS to prohibit revisiting the previous solutions. Finally, both designated models (MSCA and MSCA-TS) were tested on 60 QAP instances from QAPLIB. A sensitivity analysis is also performed to identify suitable parameter settings for both models. Comparison of results shows that MSCA-TS performs better than MSCA. The percentage of error and standard deviation for MSCA-TS are lower than the MSCA which are 2.4574 and 0.2968 respectively. The computational results also shows that the MSCA-TS is an effective and superior method in solving QAP when compared to the best-known solutions presented in the literature. The developed models may assist decision makers in searching the most suitable assignment for facilities and locations while minimizing cost.

Keywords: Quadratic Assignment Problem, Sine Cosine Algorithm, Population-based metaheuristics, Local search, Exploration and exploitation.

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List of Abbreviations

AA	Ant Algorithm
ACO	Ant Colony Optimization
AG	Average gap
ALO	Antlion Optimizer
BA	Bat Algorithm
BeA	Bees Algorithm
BBOTS	Biogeography-Based Optimization hybridized with Tabu Search
BBBC	Big Bang-Big Crunch
BFS	Best-found solution
BKS	Best-known solution
BiQAP	Biquadratic Assignment Problem
BOA	Base Optimization Algorithm
C	Combination of both random and cost-based local search strategies
CB	Cost-based local search strategy
CBO	Colliding Bodies Optimization
CEED	Combined economic and emission dispatch
CMOS	Complementary metal-oxide semiconductor
COA	Cuckoo Optimization Algorithm
CSA	Cuckoo Search Algorithm
CSO	Cat Swarm Optimization
CUDA	Compute Unified Device Architecture
D	Difference
DA	Dragonfly Algorithm
DCSO	Discrete Chicken Swarm Optimization
DyCSO	Dynamics Cat Swarm Optimization
DDE	Discrete Differential Evolution
DE	Differential Evolution
DERs	Distributed energy resources
DPB	Dynamic-programming bound
DPSO	Modified Discrete Particle Swarm Optimization

DRD	Distance Reciprocal Distortion
EGATS	Hybrid method integrating an Elite Genetic Algorithm with Tabu Search
ELD	Economic Load Dispatch
Eq.	Equation
et al.	And others
FA	Firefly Algorithm
FIFO	First In First Out
FLP	Facility Layout Problem
FPA	Flower Pollination Algorithm
G	Gap
GA	Genetic Algorithm
GB	Golden Ball algorithm
GBSA	Golden Ball algorithm mixed with Simulated Annealing
GLB	Gilmore-Lawler Bound
Gold-SA	Golden Sine Algorithm
GPP	Grey pattern problem
GRASP	Greedy Randomized Adaptive Search Procedures
GROM	Golden Ratio Optimization Method
GSA	Gravitational Search Algorithm
HBMO	Honey Bee Mating Optimization
HDDETS	Hybrid method integrating a Discrete Differential Evolution Algorithm with Tabu Search
HGSCADE	Hybrid Greedy Sine Cosine Algorithm with Differential Evolution
HM	Harmony Memory
HS	Harmony Search
HSCA	Hybrid Sine Cosine Algorithm
HSS	Hyper-Spherical Search
HTS	Hydrothermal Scheduling Problem
ICA	Imperialist Competitive Algorithm
i.e	That is
IHS	Improved Harmony Search

IMO	Ion Motion Optimization
MBO	Migrating Birds Optimization
MCSA	Modified Cuckoo Search Algorithm
MDPSO	Modified Discrete Particle Swarm Optimization
MFO	Moth-Flame Optimizer
MI	Maximum iterations
MSAC	Modified Simulated Annealing by Connolly
MSAM	Modified Simulated Annealing by Misevicius
MSAR	Modified Simulated Annealing Restart
MPM	Misclassification Penalty Metric
mQAP	Multi objective Quadratic Assignment Problem
MSCA	Modified Sine Cosine Algorithm
MSCA-TS	Hybrid modified Sine Cosine Algorithm with Tabu Search
Np-hard	Non-deterministic Polynomial time hard
NRM	Negative Rate Metric
OIO	Optics Inspired Optimization
PBBO-TS	Parallel hybrid Bio-geography Based Optimization with Tabu Search
PCB	Printed circuit board
PHCSO	Parallel Hybrid Chicken Swarm Optimization
PMSA	Parallel Multistart Simulated Annealing
PS	Size of population
PSD	Percentage of standard deviation
PSNR	Peak Signal to Noise Ratio
PSO	Particle Swarm Optimization
QAP	Quadratic Assignment Problem
QAPFA	Quadratic Assignment Problem with Fixed Assignment
QAPLIB	A Quadratic Assignment Problem Library
QBAP	Quadratic Bottleneck Assignment Problem
QIEA	Quantum-Inspired Optimization Evolutionary Algorithm
QRIMO	Quasi Reflected Ion Motion Optimization
QSAP	Quadratic Semi-Assignment Problem

QSCA	Quasi-Opposition Sine Cosine Algorithm
Q3AP	Quadratic 3-Dimensional Assignment Problem
R	Random local search strategy
SA	Simulated Annealing
SAR	Simulated Annealing Restart
SCA	Sine Cosine Algorithm
SD	Standard deviation
SGQAP	Sub-Group Quadratic Assignment Problem
SKF	Simulated Kalman Filter
SQAP	Stochastic Quadratic Assignment Problem
TA	Threshold Accepting
TABUSA	Combined Tabu Search with Simulated Annealing
TIP	Tool Indexing Problem
TL	Tabu List
TLBO	Teaching-Learning -Based Optimization
TS	Tabu Search
TSL-SCA	Modified SCA with teacher supervision learning
VLSI	Very Large-Scale Integration
WA	Whale Algorithm
WAITS	Whale Algorithms Integrated with Tabu Search
WOA	Whale Optimization Algorithm

CHAPTER ONE

INTRODUCTION

This chapter briefly describes on the overall content of the thesis in general. The discussion in this chapter includes background of the study, problem statement, research questions, research objectives, scope of study, significance of study and thesis organization.

1.1 Background of Study

Quadratic Assignment Problem (QAP) is known as a popular problem in operation research field. It was initiated by Koopmans and Beckmann in 1957 (Koopmans & Beckmann, 1957). QAP is defined as a problem of assigning a set of facilities to a set of locations with a given distance and flow between locations and facilities while minimizing the assignment cost of each facility to each location (Syed-Abdullah, Abdul-Rahman, Benjamin, Wibowo & Ku-Mahamud, 2018). The product of flows between the facilities and the distance between the locations of the facilities is described as assignment cost occurred (Abdelkafi, Idoumghar & Lepagnot, 2016). The same perspective on QAP was also discussed by Gabrielsson (2008) where QAP is a set of facilities allocated to a set of locations where the distance between the locations and the flow between the facilities exists. QAP achieved optimum solution when the facilities allocate to locations respectively based on one-to-one assignment that minimize the total cost appointed as the grand total of the products of flows and distances.

Lim, Wibowo, Desa and Haron (2016) stated that QAP is an assignment model pertaining to allocate each facility to each location to attain goal of minimizing the

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