RANDOM WEIGHT-BASED ANT COLONY OPTIMIZATION ALGORITHM FOR THE MULTI-OBJECTIVE OPTIMIZATION PROBLEMS

By

ILANDARI DEWAGE

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Certification of the Supervisor

I certify that the candidate has incorporate all corrections, additions, and amendments recommended by the examiners to the final version of the M. Phil. thesis.

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Declaration

The work described in this thesis was carried out by me under the supervision of Dr. T.G.I. Fernando and a report on this has not been submitted in whole or in part to any university or any other institution for another Degree/Diploma.

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I certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the university for the purpose of evaluation.

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ABBREVIATIONS

ACO	**A**nt **C**olony **O**ptimization
ACOMOFS	Efficient **A**nt **C**olony **O**ptimization for **M**ulti **O**bjective **F**low **S**hop Scheduling
ACS	**A**nt **C**olony **S**ystem
ARPD	**A**verage **R**elative **P**ercentage **D**eviation
AS	**A**nt **S**ystem
CO	**C**ombinatorial **O**ptimization
CPACO	**C**rowding **P**opulation-based **A**nt **C**olony **O**ptimization
ER	**E**rror **R**atio
GA	**G**enetic **A**lgorithm
HAMC	**H**ybrid **A**lgorithms for **M**ulti **C**riterion
HVR	**H**yper **V**olume **R**atio
JSSP	**J**ob **S**hop **S**cheduling **P**roblem
MACS	**M**ultiple **A**nt **C**olony **S**ystem
MCAA	**M**ulti **C**olony **A**nt **A**lgorithm
MOACO	**M**ulti **O**bjective **A**nt **C**olony **O**ptimization
MOACSA	**M**ulti **O**bjective **A**nt **C**olony **S**ystem **A**lgorithm
MOOP	**M**ulti **O**bjective **O**ptimization **P**roblem
MOTSP	**M**ulti **O**bjective **T**raveling **S**alesman **P**roblem
mQAP	**M**ulti-objective **Q**uadratic **A**ssignment **P**roblem
NP	**N**on-deterministic **P**olynomial Time
ONVG	**O**verall **N**on-dominated **V**ector **G**eneration
OTNVG	**O**verall **T**rue **N**on-dominated **V**ector **G**eneration
OTNVGR	**O**verall **T**rue **N**on-dominated **V**ector **G**eneration **R**atio
P	**P**olynomial Time

PSACO	**P**areto **S**trength **A**nt **C**olony **O**ptimization
QAP	**Q**uadratic **A**ssignment **P**roblem
RPD	**R**elative **P**ercentage **D**eviation
RWACO	**R**andom **W**eight-based **A**nt **C**olony **O**ptimization
SA	**S**imulated **A**nnealing
TS	**T**abu **S**earch
TSP	**T**raveling **S**alesman **P**roblem
VRPTW	**V**ehicle **R**outing **P**roblem with **T**ime **W**indows

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RANDOM WEIGHT-BASED ANT COLONY OPTIMIZATION ALGORITHM FOR THE MULTI-OBJECTIVE OPTIMIZATION PROBLEMS

I.D.I.D. Ariyasingha

ABSTRACT

This thesis concentrates on analysing, improving and developing ant colony optimization algorithms for solving multiple objectives. Initially, the thesis reviews the recently proposed ant colony optimization algorithms which have been introduced for optimizing multiple objectives simultaneously. Then, it analyses the performances of these multi-objective ant colony optimization (MOACO) algorithms when applied to some combinatorial optimization problems.

Therefore, the performances of the MOACO algorithms are analysed by applying them to several benchmark instances of the traveling salesman problem (TSP). It considers various objectives, such as two, three and four objectives, and changes the number of ants and number of iterations for understanding their effects on the performances of MOACO algorithms. The results of the detailed analysis have shown that some MOACO algorithms achieve better performances. Also, their performance slightly depends on the number of ants, the number of objectives and the number of iterations used in the colony.

Then, the thesis analyses the performance of some recent multi-objective ant colony optimization algorithms by applying them to sixteen benchmark problem instances of the job shop scheduling problem (JSSP) on up to 20 jobs $\times$ 5 machines. Also, it considers two, three, and four objectives and it optimizes four criteria – makespan, mean flow time, mean tardiness, and mean machine idle time – simultaneously. Furthermore, different numbers of ants are used in a colony, to see their effects on the performance of the algorithms. The results obtained have shown that the performance of some multi-objective ant colony optimization algorithms depend on the number of objectives and the number of ants.

This thesis proposes a new ant colony optimization (ACO) algorithm named the random weight-based ant colony optimization algorithm (RWACO) to solve multiple objectives simultaneously. The RWACO algorithm is based on the ant colony system (ACS) algorithm and uses randomly generated weights for each objective associated with heuristic information which is called the random weight-based method. Each weight finds solutions in the specific part of the Pareto front. RWACO algorithm uses different weights for each objective in each iteration. Finally, the randomly generated weights defined for heuristic information, obtain solutions by covering the whole Pareto-optimal front.

The performance of the newly proposed algorithm, RWACO, is evaluated by comparing it with more recent MOACO algorithms when applied to the three combinatorial optimization problems: the traveling salesman problem (TSP), the job shop scheduling problem (JSSP) and the quadratic assignment problem (QAP). According to the results obtained with these studies, it has been shown that the RWACO algorithm achieves better performances than all the other MOACO algorithms considered in these studies. Furthermore, the RWACO algorithm obtains well-distributed Pareto front than all the other MOACO algorithms considered in this thesis.

According to the results obtained in this thesis, the Pareto strength ant colony optimization (PSACO) algorithm obtains better performance for the TSP and the JSSP. However, it obtains the third best performance for the TSP and the JSSP and returns the solutions only in the central part of the Pareto front. Therefore, the random weight-based method, which has been introduced for the RWACO algorithm, is applied to the PSACO algorithm to examine its effects on the performance of the PSACO algorithm. The performance is evaluated by applying it to the traveling salesman problem. The experimental results have shown that the PSACO algorithm performs better when the random weight-based method is applied. Also, the new PSACO algorithm obtains the well-distributed Pareto front and the distributed solutions than the original PSACO algorithm.

Keywords: ant colony system, ant system, heuristic information, job shop scheduling problem, multi-objective ant colony optimization algorithm, multi-objective problem, non-dominated solution, pareto front, pheromone trail, quadratic assignment problem, random weight-based ant colony optimization algorithm, traveling salesman problem.