UNIVERSITI TEKNOLOGI MARA

ENHANCED GRAVITATIONAL SEARCH ALGORITHM FOR NANO-PROCESS PARAMETER OPTIMIZATION PROBLEM

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Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Information Technology and Quantitative Sciences)

Faculty of Computer and Mathematical Sciences

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Metaheuristic algorithms have been adapted in various engineering applications due to their efficiencies in solving complex and larger real-life optimization problems. Based on the capabilities of the metaheuristic algorithms, this research is proposing the enhanced Gravitational Search Algorithm (eGSA) to solve the nano-process parameter optimization problem. The specific nano-process in this research is the Radio Frequency (RF) magnetron sputtering process. The current method in optimizing the RF magnetron sputtering process parameters is done through the trial and error which is based on guesswork, luck, experience, intuition and requires large resources. This trial and error method is often inefficient, unreliable, time consuming and might produce false optimum result in the process. In this research, the empirical experiments have been conducted for the five selected algorithms in the engineering optimization discipline, namely Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Gravitational Search Algorithm (GSA), Ant Colony Optimization (ACO) and Artificial Immune System (AIS). Their performances are measured based on the fitness values and the processing times. The datasets have been collected from the NANO-Electronic Centre (NET), UiTM and are divided into the higher and lower setting categories of parameters. The higher setting category contains three groups of datasets, while the lower setting contains five groups of datasets. Based on the theoretical studies and the empirical results, GSA has been selected as the best algorithm, despite having slow processimg times. Due to the weakness, two enhancements have been designed for GSA in order to overcome the problem in its computation time. The first enhancement is the implementation of the mass ratio parameter as the *Kbest* agents. The second enhancement is the implementation of the distance ratio parameter to select only the nearest agents for the accumulation of forces among the *Kbest* agents. The mass ratio parameter has been designed to improve on the exploration, while the distance ratio has been designed to improve on the exploitation capability of eGSA. The capabilities of eGSA has been tested with 7 benchmark functions for minimization and compared with 2 other enhanced GSA algorithms. The performance of eGSA in the testing has proven to be acceptable. In this research, eGSA has also been tested with the real datasets that have been used in the empirical experiments. Based on the analyses of results, eGSA has been able to achieve the highest mean fitness values in the experiment variations from the higher and lower setting categories. The analysis on the processing times has also shown that eGSA has been able to reduce its processing time compared to GSA and most of other algorithms. The results of the fitness values and processing times are supported by the paired t-test analyses, which have shown that the results generated by eGSA are mostly significant compared with the other algorithms. The overall results have shown that eGSA is a reliable algorithm in solving this RF magnetron sputtering parameter optimization problem. Future work could extend the research by focusing on the prediction of the thin film's electrical and optical properties. Another possible work is to explore the images of the nanostructures and develop the predictions on the morphology and topology of the structure. Enhancements could also be done to eGSA by exploring the possibility to hybrid the algorithm with other well-known metaheuristic algorithms.

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