ELITIST HYBRID MIGRATING BIRDS OPTIMIZATION AND GENETIC ALGORITHM BASED STRATEGY FOR T-WAY TEST SUITE GENERATION

HASNEEZA LIZA BINTI ZAKARIA

DOCTOR OF PHILOSOPHY

UNIVERSITI MALAYSIA PAHANG

MAKLUMAT PANEL PEMERIKSA PEPERIKSAAN LISAN

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Tesis ini telah diperiksa dan diakui oleh
This thesis has been checked and verified by

Nama dan Alamat Pemeriksa Dalam *Name and Address Internal Examiner*	: Assoc. Prof. Dr. Mohd Nizam bin Mohammad Kahar *Faculty of Computing,* Universiti Malaysia Pahang
Nama dan Alamat Pemeriksa Luar *Name and Address External Examiner*	: Prof. Dr. Rosni Abdullah *School of Computer Science,* Universiti Sains Malaysia
Nama dan Alamat Pemeriksa Luar *Name and Address External Examiner*	: Assoc. Prof. Dr. Siti Zaiton Mohd Hashim *School of Computing, Faculty of Engineering,* Universiti Teknologi Malaysia,

Disahkan oleh Penolong Pendaftar di IPS
Verified by Assistant Registrar IPS

Tandatangan : Tarikh:
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Name

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____

(Supervisor's Signature)

Full Name : PROF. TS. DR. KAMAL ZUHAIRI BIN ZAMLI

Position : PROFESSOR

Date :

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(Student's Signature)

Full Name : HASNEEZA LIZA BINTI ZAKARIA

ID Number : PCS14003

Date :

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HASNEEZA LIZA BINTI ZAKARIA

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ABSTRAK

Perisian adalah penting dalam gaya hidup pelbagai rupa kita hari ini, daripada penggunaan harian ke penerokaan angkasa lepas. Peningkatan baris kod menjadikannya mustahil untuk diuji secara keseluruhan. Kaedah ujian tradisional seperti pembahagian kesetaraan, analisis nilai sempadan dan jadual keputusan adalah kaedah yang terkenal untuk mengurangkan ukuran ujian. Pembahagian kesetaraan mengandaikan bahawa semua data dalam kelas dibahagi sama rata. Selanjutnya, pembahagi kesetaraan mesti dilengkapi dengan analisis nilai sempadan untuk memastikan pengujian yang mencukupi di semua sempadan input. Jadual keputusan merangkumi pengujian aliran program. Walaupun semua kaedah pengujian tradisional ini berguna, mereka tidak menangani ujian input interaksi. Untuk menangani ujian interaksi. penggunaan ujian t-hala, di mana t menunjukkan kekuatan interaksi,didapati berkesan sebagai cara persampelan ujian secara sistematik. Berasal dari objek matematik yang dipanggil litupan tatasususnan, pelbagai strategi *t*-hala telah dibangunkan menggunakan pendekatan yang berbeza seperti algebra, komputasi umum serta meta-heuristik. Baru-baru ini, penggunaan meta-heuristik sebagai tulang belakang strategi t-hala menjadi popular kerana keberkesanannya dari segi menjana saiz sut ujian paling minimum. Walaupun berguna, kebanyakkan strategi berdasarkan meta-heuristik tidak meneroka secara berkesan pengadaptasian lebih daripada satu meta-heuristik untuk melaksanakan pencarian (dipanggil penghibridan). Secara khusus, penerokaan dan eksploitasi strategi-strategi yang sedia ada telah dihadkan berdasarkan pengendali carian (tempatan dan global) yang diperolehi daripada algoritma meta-heuristik tunggal. Di dalam kes ini, memilih kombinasi pengendali carian yang betul boleh menjadi kunci untuk mecapai prestasi yang baik (sebagai penghibridan boleh mengambil kesempatan ke atas kekuatan dan menangani kekurangan setiap algoritma individu secara kolektif dan bersinergi). Menangani isu-isu yang dinyatakan di atas, kajian ini mencadangkan pembangunan dan pelaksanaan satu hibrid strategi *t*-hala berdasarkan Algoritma Penghijrahan Burung (MBO) dan Algoritma Genetik (GA) dengan elitisma, dipanggil *Elitist Hybrid* MBO-GA. Ini adalah bagi menyelesaikan masalah penumpuan awal MBO dengan kebolehan GA untuk mempelbagaikan penyelesaian. *Elitist Hybrid* MBO-GA kemudiannya dibandingkan dengan strategi MBO asli dan juga beberapa strategi penanda aras lain. Strategi yang dicadangkan menjadi wadah penyelidikan kami untuk menyiasat keberkesanan hibrid meta-heuristik untuk generasi ujian *t*-hala. *Elitist Hybrid* MBO-GA berjaya memperoleh hasil terbaik yang serupa dengan strategi penanda aras lain dalam 17 eksperimen. *Elitist Hybrid* MBO-GA juga mengatasi strategi lain dalam 8 eksperimen. Oleh itu, *Elitist Hybrid* MBO-GA mendapat keputusan yang baik untuk 25 daripada 33 eksperimen iaitu 75% daripada eksperimen. Tambahan pula, analisis statistik menunjukkan 87.5% kepentingan statistik berdasarkan perbandingan pasangan Wilcoxon bertanda-peringkat. Oleh itu, kajian ini menyimpulkan bahawa *Elitist Hybrid* MBO-GA adalah strategi yang berguna untuk menjana suite ujian t-hala.

ABSTRACT

Software is essential in our multifaceted lifestyle today, from everyday usage to space exploration. Testing is a crucial part of software development as it determines whether the developed software is met its requirements. The ever increasing line of codes makes it impossible to test the software exhaustively. Traditional testing methods such as equivalence partitioning, boundary value analysis and decision tables are well known methods to reduce test size. Equivalence partitioning assumes that all data in a class are equally partitioned. Furthermore, equivalence partitioning must be complemented with boundary value analysis to ensure enough testing at all the input boundaries. Decision table incorporates testing of the flow of the program. While all these traditional testing methods are useful, they do not deal with interaction testing of inputs. To deal with interaction testing. the adoption of *t*-way testing, where *t* indicates the interaction strength, is known to be effective as far as sampling of the tests in a systematic manner. Derived from mathematical object called covering arrays, many *t*-way strategies have been developed utilizing different approaches such as algebraic, general computational as well as meta-heuristics. Recently, the adoption of meta-heuristics as the backbone of *t*-way strategies is becoming popular owing to its effectiveness in terms of generating the most minimal test suite sizes. Although useful, much existing meta-heuristic based strategies have not sufficiently explored the adoption of more than one meta-heuristic to perform the search (termed *hybridization*). Specifically, the exploration and exploitation of existing strategies has been limited based on the (local and global) search operators derived from a single meta-heuristic algorithm. In this case, choosing a proper combination of search operators can be the key for achieving good performance (as hybridization can capitalize on the strengths and address the deficiencies of each individual algorithm in a collective and synergistic manner). Addressing the aforementioned issues, this research proposes the development and implementation of hybrid *t*-way strategy based Migrating Birds Optimization Algorithm (MBO) and Genetic Algorithm (GA) with elitism, termed Elitist Hybrid MBO-GA. This is to solve the MBO's early convergence problem with GA's ability to diversify solutions. The Elitist Hybrid MBO-GA is then compared with the original MBO strategy and several other benchmarked strategies. The proposed strategy serves as our research conduit to investigate the effectiveness of hybrid meta-heuristics for *t*-way test generation. The Elitist Hybrid MBO-GA manages to get the similar best result with other benchmarked strategies in 17 experiments. The Elitist Hybrid MBO-GA also outperforms other strategies in 8 experiments. Thus, the Elitist Hybrid MBO-GA gets a good result for 25 out of 33 experiments that is 75% of the experiments. Furthermore, the statistical analysis shows 87.5% statistical significance based on the pair comparison of Wilcoxon signed-rank. Therefore, this study concludes that that Elitist Hybrid MBO-GA is a useful strategy for generating t-way test suite generation.

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LIST OF ABBREVIATIONS

2SSA	2-Steps Simulated Annealing
A	Alpha
ABC	Artificial Bee Colony
ACA	Ant Colony Algorithm
ACO	Ant Colony Optimization
ACS	Ant Colony System
ACTS	Advanced Combinatorial Testing Suite
AETG	Automatic Efficient Test Generator
BA	Bat-inspired Algorithm
BA*	Bees Algorithm
CA	Covering Array
DF	Degree Of Freedom
DNA	Deoxyribonucleic Acid
DoEs	Design of Experiments
DPSO	Discrete Particle Swarm Optimization
e	Elitism
EA	Evolutionary Algorithm
eFPA	Hybrid Elitism Flower Pollination Algorithm
FPA	Flower Pollination Algorithm
FSAPSO	Fuzzy Logic Algorithm Particle Swarm Optimization
GA	Genetic Algorithm
GAPTS	Genetic Algorithm for Pairwise Test Sets
HHH	High Level Hyper-Heuristic
HS	Harmony Search
HSS	Harmony Search Strategy
HSTSG	Harmony Search Test Suite Generator
HIS	Improved Harmony Search
IPO	In Parameter Order
IPOG	In-Parameter-Order-General
IPOG-D	In-Parameter-Order-General Double
ISA	Improved SA

ILS	Iterated Local Search
k	number of neighbour solutions
m	number of tours
mAETG	Modified Automatic Efficient Test Generator
MBO	Migrating Birds Optimization Algorithm
MBO-GA	Migrating Birds Optimization Algorithm-Genetic Algorithm
MCA	Mixed Covering Array
MIPOG	Modified IPOG
n	number of initial solutions
NA	Not Available
NASA	National Aeronautics and Space Association
OA	Orthogonal Array
OTAT	One-Test-at-a-Time
OPAT	One-Parameter-at-a-Time
p	Parameter
PHSS	Pairwise Harmony Search Strategy
PICT	Pairwise Independent Combinatorial Testing
PPSTG	Pairwise Particle Swarm Test Generator
PSO	Particle Swarm Optimization
PSTG	Particle Swarm Test Generator
SA	Simulated Annealing
SBC	Simulated Bee Colony
SN	Signal-to-noise
SQA	Software Quality Assurance
SSO	Simplified Swarm Optimization
t	Interaction strength
TCG	Test Case Generator
TConfig	Test Configuration
TS	Tabu Search
TVG	Test Vector Generator
v	Value
VCA	Variable Strength Covering Array
VS-PSTG	Variable Strength Particle Swarm Test Generator

x	number of neighbour solutions to be shared with the next solution
X2	Chi Square

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