A HYBRID FRAMEWORK FOR HEURISTIC RESEARCH: THE TRAVELLING SALESPERSON PROBLEM

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By

Stanley Murairwa

DEDICATION

..... to my wife

Sharon Kwaramba,

son

Samuel Tinashe

and parents

Mr Maraini & Mrs Jetina (Nee Tarume) Murairwa

Kolej Sastera dan Sains
(UUM College of Arts and Sciences)
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ABSTRACT

The research community is confusing research and development: with competitive experiment suited only for the latter. This realisation led to the call for the revision of the current TSP heuristic investigation framework which researchers believe is biased towards development frameworks. However, despite the wide spread debate on the subject, minimum attempts to correct the situation have been done may be due to lack of necessary information required to implement heuristic research frameworks.

This thesis, therefore, develops and implements a hybrid TSP heuristic research framework which amalgamates the two frameworks. The implementation process involves conducting heuristic experiments and classification, developing a novel data analysis tool and hybrid metaheuristic and statistically comparing heuristic performances to determine the best heuristic and its features. Surveys on the TSP implemented heuristics and variants and investigation frameworks applied are conducted. The heuristic classification develops a standard scheme and its classifying templates.

A thorough statistical comparison of heuristic performances produces results that prompt debatable remarks. One of them is that heuristics tend to reach an absorption stage during the search for the global optimum solution and thus require a mechanism to drag them out of the trapping search space. The other remark is that the ANOVA assumptions are irrelevant. The reliability analysis reveals that heuristic performances are unpredictable. The Simulated Annealing is the best heuristic. However, other metaheuristics can not be dismissed because they performed statistically the same in

many cases. The work designs a Hybrid Erosion And Deposition (HEAD) metaheuristic. The new discovery employs the Tabu Search, Simulated Annealing, Ant Colony, constructive heuristic, central management and erosion and deposition dynamics. These features are amalgamated into a three phased loop (Evaluation, Development and Improvement) which improves the initial solution developed by the constructive heuristic.

This thesis develops a hybrid heuristic research framework. It also contributes towards clarification of the misconception between research and development frameworks, thus, making available the vital information hindering the implementation of research frameworks. This study suggests that more scientific researches should be conducted in statistical data analysis, violation of ANOVA assumptions and application of matrix instances.

ABSTRAK (BAHASA MALAYSIA)

Komuniti penyelidik mengelirukan penyelidikan dan pembangunan: ujikaji kempetitif hanyalah sesuai untuk pembangunan. Kesedaran ini menjurus kepada panggilan untuk melihat semula rangka kerja kajian heuristik semasa yang mana penyelidik-penyelidik percaya bias terhadap pembangunan rangka kerja. Namun begitu, di sebalik debat yang meluas terhadap perkara ini, cubaan untuk memperbaiki keadaan ini berada ditahap minimum berkemungkinan kerana maklumat yang diperlukan untuk mengimplimentasi rangka kerja kajian heuristik ini amat kurang.

Tesis ini dengan itu membentuk dan mengimplimentasi satu rangka kerja kajian heuristik berhibrid yang menyatukan penyelidikan dan pembangunan. Proses implimentasi melibatkan pengendalian uji kaji dan pengkelasan heuristik, pembentukan instrumen analisis data yang baru, pembentukan satu heuristik meta berhibrid, dan perbandingan prestasi heuristik bagi menentukan heuristik terbaik berserta ciri-ciri yang dimiliki oleh heuristik terbaik itu. Kajian terhadap heuristik-heuristik untuk masalah jurujual kembara dan penelitian ke atas rangka kerja yang digunakan telah dilakukan. Pengkelasan heuristic membentuk satu skema piawai dan satu templat pengkelasan.

Ujian perbandingan menyeluruh secara berstatistik terhadap prestasi heuristik menghasilkan keputusan yang mencetus perdebatan. Satu daripadanya adalah heuristik berkemungkinan menjangkau tahap penyerapan semasa pencarian penyelesaian optimum global dan memerlukan satu mekanisma untuk mengeluarkan heuristik itu dari terperangkap di dalam ruang pencarian. Satu lagi kenyataan merupakan andaian-andaian ANOVA adalah tidak relevan. Analisis kebolehpercayaan menunjukkan

bahawa prestasi heuristik sukar untuk diramalkan. Simulated Annealing merupakan heuristik terbaik. Namun, heuristik-heuristik meta yang lain tidak boleh diketepikan kerana dalam banyak keadaan, keupayaan mereka tidak dapat dibezakan secara berstatistik. Kajian ini menghasilkan satu heuristik meta yang dinamakan Hybrid Erosion And Deposition (HEAD). Penemuan baru ini menggabungkan ciri-ciri terbaik yang terdapat di dalam Tabu Search, Simulated Annealing, Ant Colony, heuristik pembinaan, pengurusan berpusat serta penghakisan dan pendepositan. Ciri-ciri ini digabungkan ke dalam tiga fasa pusingan (Penilaian, Pembangunan dan Penambahbaikan) yang berupaya memperbaiki penyelesaian yang dihasilkan oleh heuristik pembinaan.

Tesis ini juga telah menghasilkan satu rangka kerja penyelidikan heuristik berhibrid. Rangka kerja ini boleh menjelaskan kekeliruan di antara rangka kerja penyelidikan dan rangka kerja pembangunan, lantas memberikan maklumat penting yang membantutkan pengimplimentasian rangka kerja penyelidikan. Kajian ini mencadangkan agar lebih banyak kajian bersaintifik dilakukan terhadap analisis data berstatistik, ketidakpatuhan andaian-andaian ANOVA dan aplikasi kes matriks.

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ABBREVIATIONS AND ACRONYMS

This section presents the general abbreviations, heuristics and their abbreviations or acronyms for quick referencing since the rest of this thesis is in abbreviations or acronyms. This approach reduces confusion when dealing with a large pool of acronyms.

GENERAL ABBREVIATIONS

ASR	Average Scaled Rate
BBF	Best of Best Fits
BF	Best Fit
BFS	Best of Feasible Solutions
CIT	Central Processing Unit Idle Time
COP	Combinatorial Optimisation Problem
CT	Computation Time
Dev	Deviation
DL	Development Loop
EDT	Experimental Data Table
EEE	Experiments Execution Environment

EJOR	European Journal of Operational Research
EL	Evaluation Loop
FS	Feasible Solution
GOS	Global Optimum Solution
HEAD	Hybrid Erosion And Deposition
HESDAM	Heuristic Experimentation and Statistical Data Analysis Manual
ICR	Internal Consistency Reliability
IL	Improvement Loop
INFORMS	Institute for Operations Research and the Management Sciences
IRR	Inter Rater Reliability
JORS	Journal of the Operational Research Society
JSTOR	Journal Storage
KS	Kolmogorov-Smirnov
LOS	Local Optimum Solution
MRRA	Multivariate Row Rank Accumulation
NS	Neighbourhood Structure
OR	Operations Research

ORSA	Operations Research Society of America
PD	Percentage Deviation
Q-Q	Quartile-Quartile
RCL	Restricted Candidate List
RT	Run Time
SHR	Split Half Reliability
SPSS	Statistical Package for Social Scientists
TRR	Test-Retest Reliability
TSP	Travelling Salesperson (Salesman) Problem
TSP	Travelling Salesperson Problem
UM	Update Manager
USLE	Universal Soil Loss Equation
VRP	Vehicle Routing Problem
WBF	Worst Best Fit

VARIOUS HEURISTICS AND THEIR ACRONYMS

ANN	Artificial Neural Networks
EA	Evolutionary Algorithms such as the Genetic Algorithms (GA e.g. Estimation of Distribution Algorithm (EDA) sometimes called Probabilistic Model-Building Genetic Algorithms (PMBGA)), Evolutionary Strategies (ES e.g. Differential Evolution (DE)), Evolutionary Programming (EP) and Genetic Programming (GP e.g. Grammar Guided GP (GGGP), Linear GP (LGP) and Standard GP (SGP)). The known EDAs include the Compact Genetic Algorithm (CGA), Population-based Incremental Learning (PIL), the Univariate Marginal Distribution Algorithm (UMDA), and the Estimation of Multivariate Normal Algorithm (EMNA)
EC	Evolutionary Computing
EFDRA	Enhanced Fast Descent-Random Ascent Algorithm
FITS	Fast Iterated Tabu Search
GH	Greedy Algorithm such as Pure Greedy Algorithms (PGAs), Orthogonal Greedy Algorithms (OGAs) and Relaxed Greedy Algorithms (RGAs)
GLS	Guided Local Search
HS	Harmony Search also known as soft computing algorithm (CA) or evolutionary algorithm (EA)
IH	Insertion Heuristic
IILS	Iterated Improvement Local Search
ILS	Iterated Local Search

LKH	Lin-Kernighan Heuristic
LS	Local Search
MA	Memetic Algorithm also named Baldwinian EAs (BEAs), Lamarckian EAs (LEAs), Cultural Algorithms (CAs) or Genetic Local Search (GLSe). The heuristic denote a family of metaheuristics that tried to blend several concepts from those tightly separated at that time – families such as the EAs and SA
MSM	Multi-Start Method such as the Greedy Randomized Adaptive Search Procedure (GRASP)
MST	Minimum Spanning Tree
NNA	Nearest Neighbour Algorithm
SA	Simulated Annealing
SI	Swarm Intelligence such as the Ant Colony Optimisation (AC) {e.g. Ant System (AS), Elitist AS, Ant-Q, Ant Colony System (ACS), MAX-MIN AS (MMS), Rank based AS, ANTS, Hyper Cube AS, Best worm Ant System (BWAS), Hybrid Ant System (HAS), Fast Ant System (FANT)}, particle swarm (PS) optimizations, Stochastic Diffusion Search (SDS), Honey Bee Algorithm (HBA), Firefly Algorithm (FA) and Artificial Bee Colony Algorithm (ABCA)
SS	Scatter Search
TS	Tabu Search other versions of the TS include the Probabilistic Tabu Search (PTS) and Iterated Tabu Search (ITS)
VND	Variable Neighbourhood Descent
VNS	Variable Neighbourhood Search

CHAPTER 1

INTRODUCTION

The research in heuristics developed much interest in the early 1980s after the discovery of metaheuristics as a remedy to traditional search strategies' failure to escape from being trapped in the local optimum solutions (LOS) of poor quality. The current favourite heuristic research framework, development framework, should be credited for discovering metaheuristics although the framework's weaknesses overshadow its strengths. According to Shah and Oppenheimer (2008), there are three main problems with the current heuristic research framework: there is a significant amount of redundancy in the field (and researchers have failed to recognise the similarities between various research strategies), tendency to over extend and misapply existing theoretical methodologies and failure by the current study framework to describe heuristics that are highly domain-specific.

However, as has been discovered by many heuristic researchers including Hooker (1994) and Johnson (2002), there are many ways to carry out a study of heuristics. Hooker (1994) wrote that heuristic research can be theoretical (deductive mathematics) or empirical (computational experiments). The latter can be either a simulated experiment or a practical experiment, depending on the configuration of the problem instance being used. On the other hand, Johnson (2002) stated that any implementation of a heuristic algorithm results in any of the four different studies: experimental mathematics, horse race, experimental analysis and experimental average-case studies. The horse race is what Hooker (1996) referred to as

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