



**MENU PLANNING MODEL FOR MALAYSIAN  
BOARDING SCHOOL USING SELF-ADAPTIVE HYBRID  
GENETIC ALGORITHMS**

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**SITI NOOR ASYIKIN BT MOHD RAZALI**

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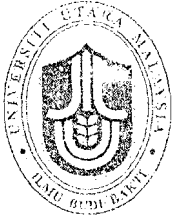
A Thesis submitted to the College of Arts and Sciences in full fulfillment of the  
requirements for the degree of Doctor of Philosophy

Universiti Utara Malaysia

by

Siti Noor Asyikin Bt Mohd Razali

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## ABSTRAK

Masalah malnutrisi menjadi satu ancaman yang hebat terhadap tahap kesihatan masyarakat dunia hari ini. Statistik menunjukkan bilangan kanak-kanak dan remaja yang mengalami kekurangan nutrisi dan lebihan nutrisi meningkat hari demi hari. Oleh itu, proses perancangan makanan yang betul dalam kalangan ahli perancang makanan dan pengendali kantin sangat penting untuk mengelakkan timbulnya masalah kesihatan yang berkaitan dengan pemakanan pada masa hadapan. Pengiraan perancangan makanan secara tradisional tidak dapat mengambil kira makronutrien dan mikronutrien pada masa yang sama kerana melibatkan data yang kompleks dan masa pengiraan yang panjang. Dalam kajian ini, teknik Hibrid Penyesuaian Algoritma Al-Kawarizmi (SHGA) telah diperkenalkan untuk menyelesaikan masalah perancangan makanan kepada pelajar Malaysia yang menuntut di sekolah berasrama penuh yang berumur antara 13 hingga 18 tahun. Objektif model perancangan makanan penyelidik adalah untuk menggunakan sepenuhnya peruntukan yang disediakan kepada setiap pelajar, meningkatkan kepelbagaian dalam makanan harian, mengambil kira kebolehan pengendali kantin, dan memenuhi saranan pengambilan nutrisi yang ditetapkan (RNI). Kaedah pencarian setempat baru diperkenalkan dalam kajian ini, '*insertion search with delete-and-create*' (ISDC), yang menggabungkan kaedah '*insertion search*' (IS) dan kaedah '*delete-and-create*' (DC). Perlaksanaan IS sahaja tidak dapat menjamin untuk menghasilkan penyelesaian yang boleh diterima memandangkan ia hanya menerokai kawasan jiran yang kecil sahaja. Oleh itu, kaedah ISDC disarankan untuk mengembangkan carian kepada kawasan jiran yang lebih luas dan keputusan menunjukkan kaedah yang diperkenalkan dapat menghasilkan 100% penyelesaian yang boleh diterima dengan nilai yang baik. Selain itu, perlaksanaan kaedah penyesuaian kebarangkalian untuk mutasi ialah secara signifikan mengurangkan masa pengiraan yang diambil untuk menghasilkan keputusan yang baik dalam beberapa minit sahaja. Teknik hibrid dengan kaedah pencarian setempat dan strategi penyesuaian telah meningkatkan prestasi kaedah tradisi algoritma Al-Kawarizmi melalui skema penerokaan dan eksplotasi yang seimbang. Pada akhir kajian, satu prototaip perancangan makanan dibangunkan untuk pengendali kantin supaya dapat menyediakan makanan harian yang sihat dan bernutrisi secara lebih efisien menggunakan antaramuka pengguna yang mudah dan mesra.

## ABSTRACT

Malnutrition problem is the gravest single threat to the world's public health today. Statistics have showed that the number of under-nourished and over-nourished children and adolescents is increasing day by day. Thus, proper menu planning process among menu planners or caterers is important to avoid some diet-related diseases in the future. Manual calculation of menu planning is unable to consider macronutrients and micronutrients simultaneously due to complexities of data and length of time. In this study, self-adaptive hybrid genetic algorithm (SHGA) approach has been proposed to solve the menu planning problem for Malaysian boarding school students aged 13 to 18 years old. The objectives of our menu planning model are to optimize the budget allocation for each student, to take into consideration the caterer's ability, to fulfill the standard recommended nutrient intake (RNI) and maximize the variety of daily meals. New local search was adopted in this study, the insertion search with delete-and-create (ISDC) method, which combined the insertion search (IS) and delete-and-create (DC) local search method. The implementation of IS itself could not guarantee the production of feasible solutions as it only explores a small neighborhood area. Thus, the ISDC was utilized to enhance the search towards a large neighborhood area and the results indicated that the proposed algorithm is able to produce 100% feasible solutions with the best fitness value. Besides that, implementation of self-adaptive probability for mutation has significantly minimized computational time taken to generate the good solutions in just few minutes. Hybridization technique of local search method and self-adaptive strategy have improved the performance of traditional genetic algorithm through balanced exploitation and exploration scheme. Finally, the present study has developed a menu planning prototype for caterers to provide healthy and nutritious daily meals using simple and friendly user interface.

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## LIST OF ABBREVIATIONS

WHO	– World Health Organization
FAO	– Food and Agriculture Organization
MMWR	– Morbidity and Mortality Weekly Report
RNI	– Recommended Nutrient Intake
MS/OR	– Management Science or Operational Research
GA	– Genetic Algorithm
NSGA	– Non-dominated Sorting Genetic Algorithm
NSGA II	– Non-dominated Sorting Genetic Algorithm II
USDA	– U.S. Department of Agriculture
UL	– Upper Intake Level
RDA	– Recommended Daily Allowance
CAMP	– Computer-assisted Menu Planning System
MPCF	– Machine-part Cell Formation
JSP	– Job-shop Scheduling Problem
fJSP	– Flexible Job-shop Scheduling Problem
CMP	– Chip Multi-processor
DMS	– Distributed Manufacturing System
AGASA	– Self-adapted Hybrid Genetic Algorithm
AHP	– Analytic Hierarchy Process
IS	– Insertion Search
ISCR	– Insertion Search with Cut-and-Repair
ISDC	– Insertion Search with Delete-and-Crete
MDKP	– Multi-Dimensional Knapsack Problem
SHGA	– Self-adaptive Hybrid Genetic Algorithm
HGA	– Hybrid Genetic Algorithm
GA_IS_SMP	– Genetic algorithm + insertion search + self-adaptive mutation probability
GA_ISDC	– Genetic algorithm + insertion search with delete-and-create method
GA_ISDC_SMP	– Genetic algorithm + insertion search with delete-and-create method + self-adaptive mutation probability
SMS Muar	– Sekolah Menengah Sains Muar

## CHAPTER 1

### INTRODUCTION

A healthy body needs sufficient nutrients from food that we eat every day. Eating more or less than what our body needs will lead to malnutrition (under-nutrition and over-nutrition). Malnutrition is defined as inadequate, excessive or imbalanced consumption of nutrients that are necessary for growth and development of the human body (Ge and Chang, 2001). The World Health Organization (WHO) cites malnutrition as the gravest single threat to the world's public health today (Silva *et al.*, 2006). Although statistic from 1969 to 1995 showed a decreasing number of undernourished people around the world, the figure surprisingly increased sharply starting 1995 until 2009 (refer to Figure 1.1).

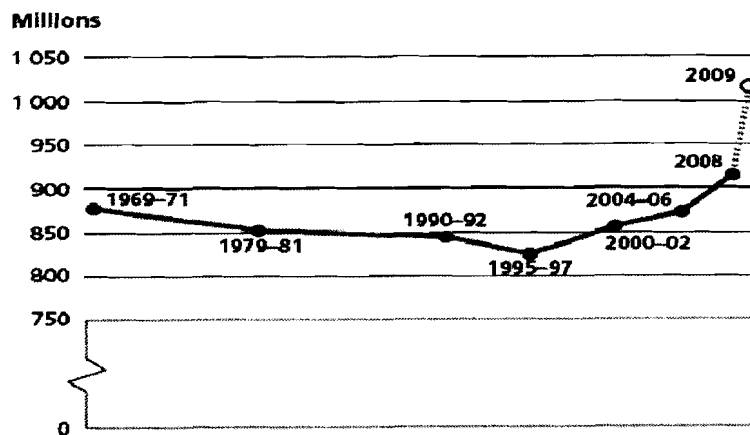


Figure 1.1: Undernourished people around the world (FAO, 2009)



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