UNIVERSITI PUTRA MALAYSIA

MULTIPLE CASE-BASED RETRIEVAL FOR UNIVERSITY COURSE TIMETABLING PROBLEM

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By

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Abstract of thesis presented to the Senate of University Putra Malaysia in fulfilment of the requirements for degree of Master of Science

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January 2016

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This thesis presents research for Case-based reasoning (CBR), a knowledge-based reasoning technique to solve university timetabling problem such as resource allocation for student's course timetabling. CBR model's was reviewed on Case-based Retrieval for timetabling discloses improvement that can be done to excel in accuracy and time consuming. From the review of past case-based retrieval techniques, a few concern is being investigate for the cases retrieval process such as the effectiveness of retrieval and time required to generate a comprehensive timetable. This research is aim to optimize the effectiveness of retrieval as well as generate a timetable in the shortest time possible with minimize violation. The case-based retrieval technique is further enhanced and improvised into a new algorithm known as Multiple Case-based Retrieval. The algorithm is combining separated distinct processes, with the combination of different functionalities: Prioritized Attributes, Frequency Grouping, and Value Difference Measurement. The algorithm was running on timetabling tests, comparing to classic Case-based retrieval and Genetic Algorithm for a wider comparison. Graphs are plot according to the readings from timetabling tests to show the result comparisons. Results from the experiments show the effectiveness and elapsed time to generate a timetable. Multiple Case-based Retrieval shows promising results in improving the effectiveness of case-based retrieval and also reduced the time required to generate a new timetable. This research summarize that the algorithm in retrieval is playing a very important role for an effective timetabling generator. Future research may concern to improve of the process of retaining cases, focus on case-based handling storage for generated cases for future review.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PELBAGAI KES-DAPATAN SEMULA BAGI MASALAH JADUAL WAKTU KURSUS UNIVERSITI

Oleh

HONG SIAW THENG

Januari 2016

Pengerusi: Abu Bakar Md Sultan, PhD
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Tesis ini membentangkan penyelidikan untuk penaakulan berasaskan kes (CBR), satu teknik penaakulan berasaskan pengetahuan untuk menyelesaikan masalah jadual waktu universiti seperti peruntukan sumber bagi kursus jadual waktu pelajar. CBR model ini telah dikaji semula pada langkah "*Capaian*" berasaskan kes jadual waktu untuk mendedahkan penambahbaikan yang boleh dilakukan untuk mencapai peningkatan dalam ketepatan dan masa yang diperlukan. Dari kajian teknik semula berasaskan kes yang lalu, beberapa kebimbangan sedang disiasat untuk proses kes-kes seperti keberkesanan mendapatkan kes dan masa yang diperlukan untuk menghasilkan jadual waktu yang menyeluruh. Kajian ini adalah bertujuan untuk mengoptimumkan keberkesanan semula serta menjana jadual waktu dalam masa yang sesingkat mungkin dengan mengurangkan pelanggaran. Teknik kes-dapatan semula telah dipertingkatkan dan diubahsuai kepada algoritma baharu. Algoritma ini menggabungkan beberapa teknik yang berbeza yang dikenali sebagai: Sifat-sifat Keutamaan, Pengumpulan Kekerapan, dan Pengukuran Perbezaan Nilai. Algorithm ini telah dilarikan pada jadual waktu, membanding dengan teknik kes-dapatan semula yang asli dan Algoritma Genetik untuk perbandingan yang lebih luas. Graf telah diplotkan mengikut bacaan dari ujian jadual waktu untuk menunjukkan perbandingan hasil. Keputusan daripada eksperimen menunjukkan keberkesanan dan pengambilan masa untuk menjana jadual waktu. Pelbagai Kes-dapatan Semula menunjukkan hasil yang memberangsangkan dalam meningkatkan keberkesanan berdasarkan kes-dapatan semula dan juga mengurangkan masa yang diperlukan untuk menghasilkan satu jadual baru. Kajian ini merumuskan bahawa algoritma dalam mendapatkan kes semula memainkan peranan yang amat penting bagi sebuah penjana jadual waktu yang berkesan. Kajian masa depan penting untuk meningkatkan proses penyimpanan kes, memberi tumpuan kepada pengendalian penyimpanan kes bagi kes-kes yang dijana untuk kajian masa depan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science.

The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
CBR	Case-based Reasoning
UCTP	University Course Timetabling Problem
GA	Genetic Algorithm
NP-hard	Non-deterministic Polynomial-time hard
TS	Tabu Search
PSO	Partial Swarm Optimization
MA	Memetic Algorithm
ACO	Ant Colony Optimization
NN	Nearest Neighbour Algorithm
HPARA	Human Preference Adaptable Retrieval Approach
FDW	Financial Working Distress
ANN	Artificial Neural Network
DBMS	Database Management System
ERD	Entity Relational Diagram
SV	Similarity Value
CASV	Component Average Similarity Value
TTAV	Timetable Average Similarity Value
CKB	Construction Knowledge Base

CHAPTER 1

INTRODUCTION

1.1 Background

Many real world problem solving methods are related to recalling previous experience in solving similar problems, reusing the experiences by minor modification according to the current problems needs and situations. Reasoning is based on the assumption that 'similar problems may have similar solutions' and 'the types of problems an agent encounters tend to recur' (Leake D.B., 1996).

To solve a real-world problem, people often review past experience for a successful and similar attempt. In Artificial Intelligence (AI), knowledge-based using the technique of mimic and storing past experience people had used before. Those experiences will then reuse to solve new problems. In Case-based Reasoning (CBR), experiences and solutions will be stored as cases. New solutions for problems will be generating by refining cases retrieved from knowledge base (case-base). Therefore, CBR problem solving focus on reusing, revise and retain previous solutions, avoiding reasoning to start from scratch.

These 4 phases know as 4 REs, with each phase playing an individual role to determine the effectiveness of CBR solution. In first phase, given a regarding problem, certain similar cases is retrieve from case-base stored based on CBR system. Then particular case selected is modified to propose suggested solution case. The next phase, suggested solution case is retrieved to validate the feasibility. Selected case is check to confirm the solution is optimized for the problem. The last phase will stored the solution case in the case-base of the system for future revise.

According to (Ramon L. D. M. et. al., 2006), the efficient case retrieval is a major factor of determining the performance of CBR system. This phase of this approach involves the process of finding similar case from stored case in the case base. The concept of similarity measure is used for finding similar case among stored cases.

In this thesis, research is focus on case retrieval phase, which is a crucial factor for CBR system performance.

1.2 Motivation

University timetabling is a major administrative activity for a wide variety of institutions. Every new semester means a new timetabling need to be prepared for both course timetabling and exam timetabling. From the observation of academic timetabling in every semester, the changes are not always a major transformation. Instead, most of the time, time table plotting only required some minor alteration or transition of certain components within timetables. Thus, as a practice for constructing a timetable, it is normally start from 'last year's' timetable and make changes as less as possible. This is only appropriate if there is little change in the problem from one year to another. From the behaviour of revise previous cases to generate new case, it provided the motivation for investigating a CBR approach to timetabling problems.

1.3 Case-based retrieval

Case retrieval in CBR is one of the key phases in CBR cycle. Retrieved time is a major concern when a CBR system is performing on a problem solution. Case retrieval may be defined as the process of probing the case which is contiguous to the present case contained by a case base (Surjeet Dalal et al., 2011). The main role in the process is to discover the relevant case. In order to achieve the objective, case selection mechanism is used to control how a case is searched from case-base, and determine how close current case is compare to the existing case stored in case based.

How appropriate a case is being searched out form case based depends on how accurate a case is selected. A few major factors need to take into consideration for the retrieval method. The efficiency of case retrieval depending to the number of cases stored in the case base. A large case base basically will provide more accurate case; however, retrieved time may be longer depending on search mechanism. The availability of domain specific knowledge is the second factor in retrieval method. Following next factor is simplicity of determining weightings on particular case for certain specific requirements. Case indexing, which is the last factor may shorten the time required on searching with stored cases in certain indexed or particular labels. Similarity measurement will be performing between similar cases from a retrieval output to finalize solution case. The most appropriate case will be reused to solve the problem.

1.4 Problems statement

CBR has been applied to scheduling problems since the year 1997 (Padraig C. et. al., 1997). Following the basic idea behind CBR, a number of previously solved timetabling problems are stored in a case base. These case bases are later used for constructing solutions for new timetabling problems. Since then, a number of researches had been done which applied CBR in educational timetabling problems. (Burke E. K. et al. 2000) apply structured cases in CBR which reusing and adapting cases for timetabling problems using attribute graph approach. The research is the further developed in the year 2001. Burke aimed to solve a wider range of problems with similarity measures (Burke E. K. et al. 2001). At the year of 2005, the author enhanced the approach again which is known as multiple retrieval CBR that partitions a large problem into small solvable sub-problems by recursively inputting the unsolved part of the graph into the decision tree for retrieval (Burke E. K. et al. 2005). In the year 2006, Burke release another approach known as Case-based heuristic selection for timetabling problems which aimed to increase the generality (Burke E. K. et al. 2006).

In CBR research path, many research had been done on case retrieval in order to improve CBR retrieval approach. A number of research works make a major improvement in case retrieval phase of CBR. However, most research works were mainly based on nearest neighbour (NN) algorithm. (Boris C.G. et al., 2013) improving CBR system on renal transplant waiting list. (Zhi-Ying Z. et al., 2008) introduced a case retrieval model based on artificial neural network (ANN) and NN to improve the efficiency and quality of case retrieval in CBR. (Enrico B. et. al., 1999) discussed probability based metrics for NN classification and CBR. (Lech P., 2012) presents the data-mining and knowledge discovery method with CBR and NN.

(Surjeet D. et. al. 2011) claims that NN algorithm advantages in less complicity. Nonetheless, NN is inefficient to deal with large case base which will be very time consuming. Surjeet improve case retrieval with the concept of knowledge intensive intend for faster case retrieval through knowledge-intensive similarity measures. Yet, this approach composes global similarity measure with set of local similarity measures with the drawback if local similarity measures is performed, then this approach is very time consuming.

Through the investigation of CBR retrieval approaches from above, it is found that existing CBR approaches mainly retrieve cases based on summation of weighted attributes without considering the inter-relation among the attributes of cases. However, as Burke claims, some complex problems (such as time-tabling problems) consist of events that are heavily inter-connected with each other (Burke et al. 2000).
Another problem with timetabling solutions is when target case information is incomplete. There are some algorithms which able to solve this problem such as Genetic Algorithm (GA) from the work of (Shengxiang Y., 2011) and Memetic Algorithm (MA) from the work of (Burke E. K., et. al., 1996) but these algorithms are very time consuming while populate for results.

1.5 Research objectives

The main objective of this research is to introduce Multiple Case-based Retrieval algorithm to solve University Course Timetabling Problem (UCTP). In order to achieve the main objective we outline the following two sub objectives:

i. retrieve cases by matching the inter-relation of attributes to improve the accuracy of CBR retrieval for timetabling problem
ii. improve capability to handle incomplete information with less computational time

A few techniques are proposed to answer the research objectives. The first technique is using Euclidian Distance similarity measurement for CBR retrieval to reduce time consuming. In the same time, linked prioritized attributes technique is applied to improve the accuracy of retrieving cases by matching the related attributes. The second technique which is known as frequency grouping is propose to allow CBR system to adapt the capability of handling incomplete information and improve computational time required.

1.6 Research scope and limitation

Figure 1.1 illustrates the research direction of timetabling problems. The category direction referring from the thesis work of Shahrzad on approaches of university examination timetabling problems (Shahrzad, 2009). Arrow lines indicates the research path of this thesis which focus on educational timetabling in University course timetabling. The technique in this research mainly concerned on case-based retrieval for timetabling solution for university course timetable.

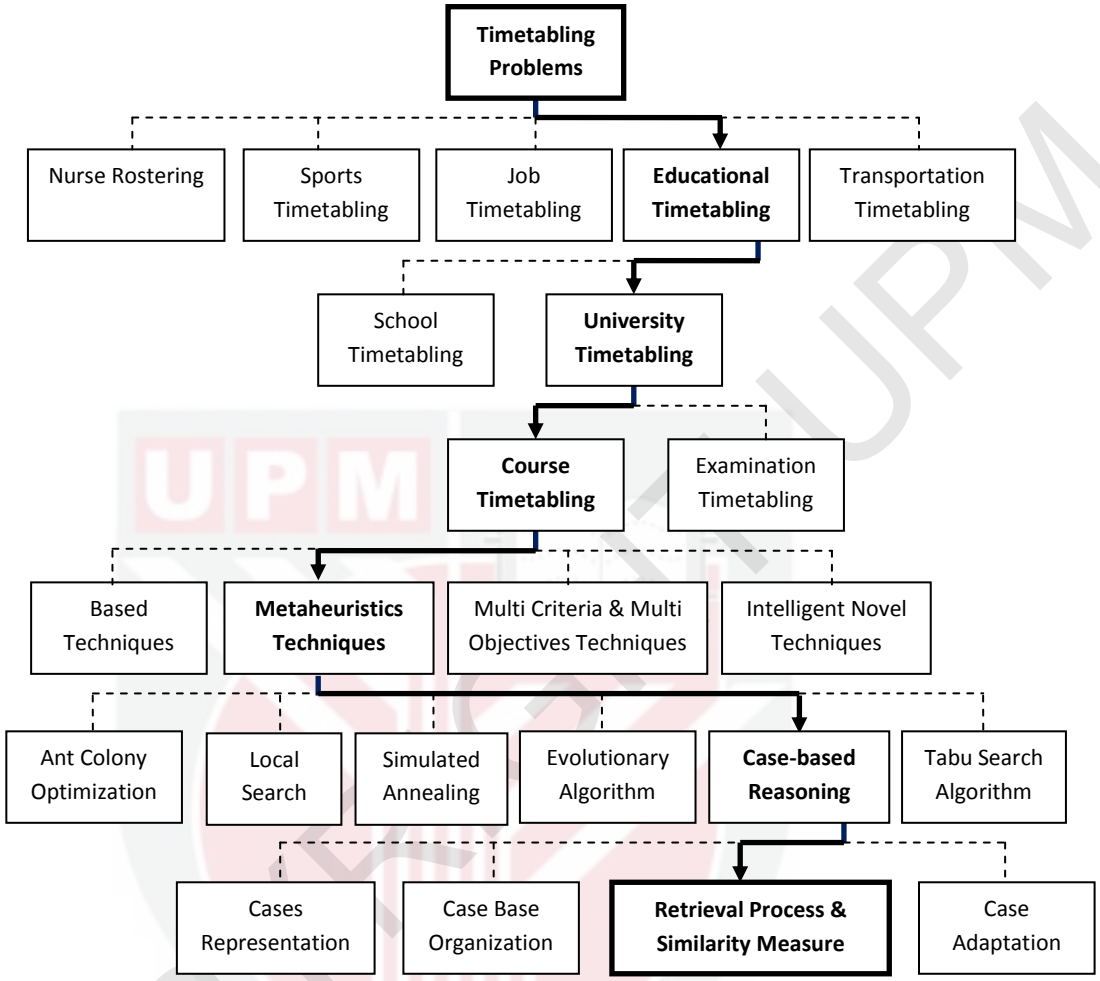

Figure 1.1 : Research study module (Shahrzad, 2009)

1.7 Research contribution

The Contribution of this research is a CBR algorithm known as Multiple Case-based Retrieval with the combination of three approaches namely linked prioritized attributes, frequency grouping and Euclidian Distance. The algorithm meant to reduce case retrieval elapsed time and amount of soft constraint violation.

These approaches provide higher accuracy while retrieving case pattern from the case base. Every finalize case will be hash into individual case and store in case base. Each case storing unique attributes such as subject, lecturer, day, time and classroom. Euclidian distance approach helps on case comparison for retrieval optimization.

1.8 Organization of the thesis

The first chapter presented the background of the research. Problems statement and objectives state the aim and issues of CBR. The rest of the chapters in this thesis are organized as follow:

Chapter 2 summarize literature review of CBR for time tabling, introduced the models of case-based framework, discussed CBR application in certain field and related work on CBR retrieval.

Chapter 3 explains the methodology of this research, discussed research progression in different phases. Experiment model was also introduced in this model as well as the details for performance metrics for the experiments.

Chapter 4 shows the Multiple Case-based Retrieval approach. The retrieval approach was briefly explained with the combination of different approaches.

Chapter 5 presents Research experiment with results table and plotted graph. Results and discussed based on the experiment outcome.

Chapter 6 finalize the conclusion of this research as well as future work discussion for possible improvement.

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