BUSINESS INTELLIGENCE FRAMEWORK USING ANT COLONY OPTIMIZATION FOR FEATURE SELECTION IN HIGHER EDUCATION INSTITUTION

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ABSTRACT

Recently, business intelligence (BI) has become an important tool for effective decision-making. BI is a mathematical framework to gain information and knowledge through the process of extracting, transforming, managing, and analyzing data. The demand for accurate knowledge in higher education sector needs a correct technique to extract the exact information for decision-making. However, current BI frameworks and systems lack the ability to transform data into information, and these caused users not to able to fully utilize the BI outcome. This research developed a BI framework for the higher education that is able to explore, analyse and visualize the relevant data into information for use by the top management. This framework identifies the best set of attributes and evaluates the performance of the model with the help of 27 input features. In this case study, the framework used Ant Colony Optimization (ACO) technique mainly to identify the best set of attributes, and the performance was validated using Support Vector Machine (SVM). The framework consists of four layers which are data source, data integration, analytic, and access. Each layer contributes to decision making in terms of processing data, selection of significant features and data visualization. In this study, 46,658 input data were processed for identification of Graduate on Time (GOT) decision in the context of higher education referred as Masters and Doctor of Philosophy (PhD) postgraduates who completed their study within a specified period. The performance evaluation of the data achieved accuracies of 86.44% for PhD and 96.2% for Master's. Based on the findings, the results showed that the BI dashboard as an output from the framework is capable of providing a good decision-making tool for education management.

ABSTRAK

Dewasa ini, kecerdasan perniagaan (BI) telah menjadi alat yang penting untuk membuat keputusan yang berkesan. BI ialah rangka kerja matematik untuk mendapatkan maklumat dan pengetahuan melalui proses pengekstrakan, transformasi, pengurusan, dan penganalisisan data. Permintaan terhadap pengetahuan yang sebenar dalam sektor pendidikan tinggi memerlukan teknik yang betul bagi mengekstrak maklumat yang tepat untuk membuat keputusan. Walau bagaimanapun, rangka kerja dan sistem BI semasa kurang kemampuan untuk mentransformasikan data kepada maklumat, dan ini menyebabkan pengguna tidak dapat menggunakan sepenuhnya dapatan BI. Kajian ini telah membangunkan rangka kerja BI untuk sektor pendidikan tinggi yang mampu menjelajah, menganalisis, dan menggambarkan data yang relevan kepada maklumat untuk kegunaan pengurusan atasan. Rangka kerja ini telah mengenal pasti set atribut terbaik dan menilai prestasi model dengan bantuan 27 atribut. Dalam kajian kes ini, rangka kerja BI ini menggunakan teknik Pengoptimuman Koloni Semut (ACO) bertujuan untuk mengenal pasti set atribut terbaik, dan prestasinya disahkan menggunakan Mesin Vektor Sokongan (SVM). Rangka kerja ini terdiri daripada empat lapisan iaitu sumber data, integrasi data, analisis dan akses. Setiap lapisan menyumbang kepada proses membuat keputusan dari segi pemprosesan data, pemilihan ciri-ciri penting dan visualisasi data. Dalam kajian ini, 46,658 data input telah diproses untuk mengenal pasti keputusan graduan dalam tempoh yang ditetapkan (GOT). Dalam konteks pendidikan tinggi, GOT merujuk kepada pelajar Sarjana dan Doktor Falsafah (PhD) yang berjaya menamatkan pengajiannya dalam tempoh yang ditetapkan. Penilaian prestasi bagi data menunjukkan ketepatan yang dicapai ialah 86.44% untuk PhD dan 96.2% bagi Sarjana. Berdasarkan dapatan ini, keputusan menunjukkan bahawa papan pemuka BI merupakan output daripada rangka kerja yang mampu menyediakan alat membuat keputusan yang baik untuk pengurusan pendidikan.

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LIST OF ABBREVIATIONS

BI   -   Business intelligence

SPS   -   School of Graduate Studies

UTM   -   Universiti Teknologi Malaysia

ACO   -   Ant colony optimization

SVM   -   Support Vector Machine

IT   -   Information technology

PSO   -   Particle swarm optimization

GA   -   Genetic algorithm

RBF   -   Radial basis function

DT   -   Decision trees

NV   -   Naïve bayes

NB   -   Network bayesian

NN   -   Neural network

CGPA   -   Cumulative grade point average

LIST OF SYMBOLS

C	-	Cost
γ	-	Gamma
p	-	Evaporation rate
N	-	Number of ants
TN	-	True negative
TP	-	True positive
FP	-	False positive
FN	-	False negative

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CHAPTER 1

INTRODUCTION

1.1   Introduction

Business intelligence (BI) is a process of extracting, transforming, managing, and analyzing data by making a mathematical framework gain information and knowledge (Fitriana and Djatna, 2011). BI allows the incorporation of various ideas, methods, and components to accommodate users in any sector with actionable information. In order to be competitive among higher education sectors, the emphasis of BI lies in making ad hoc decisions to guarantee the quality of education that is being provided.

Corresponding with today's quality of education, academic institutions are being forced to gather, evaluate and harness their data to make effective decisions (Baepler and Murdoch, 2010). Most education sectors are facing challenges in processing and analyzing the data as the data are scattered at various departments (Xu *et al.*, 2007). As a result, this research proposes a BI framework using with Ant Colony Optimization (ACO) based feature selection and Support Vector Machine (SVM).

The current BI frameworks and systems lack in terms of transforming data into information, and this causes users not able to fully utilize the BI outcome (Zulkefli *et al.*, 2015). It is an undeniable factor that the demand for accurate knowledge requires a good technique to extract the exact information for accurate decision-making. Hence, using ACO in BI is very recent among the research and it is believed that this algorithm is diversified to solve a wider perspective of problems

and can be reduced to search for good paths (Krishnaraj and Vinothkumar, 2014). Feature selection is applied to the BI framework, in order to identify the best set of attributes and evaluates the performance of the model with the help of input features. Support Vector Machine (SVM) has been chosen as the classifier to validate the algorithm in BI framework. These methods are integrated into the BI framework, in order, to explore, analysis and visualize the relevant data into information. The upcoming section gives the description of the existing problems that cause the emerging of this research.

1.2   Problem Background

The market growth toward the application of business intelligence (BI) has seen a positive impact in organizations and provide deeper insights of data (Gartner, 2016). The forecast of BI spending which is recently released showed an increase to 5.2% from 2015 to 2016 hitting $16.9 billion (Gartner, 2016). According to IDG Enterprise (2016), a recent survey of Chief Information Officer (CIO), 231 respondents who indicated they are the Information Technology (IT) executives revealed that 50% increase in usage of BI and analytics compared to last 12 months. Therefore, it can be seen that BI adoption is common in developed countries, in contrast, the reports of deployment of BI in developing countries such as in Malaysia has been scarce (Ong *et al.*, 2011).

In Malaysia, there is a lack of evidence of deployment of BI, especially in higher education sector. In order to globalize the higher education market in Malaysia, Malaysia higher education system must attentive in opening new markets and utilize intelligence systems (Grapragasem *et al.*, 2014). Malaysian higher education system should reap full benefits from the BI to be competitive and lead to effective decision-making. This is to ensure Malaysian higher education institutions present high accuracy of decision-making.

Accordance to Malaysia Education Blueprint, Higher Education 2015-2025 (2015), universities in Malaysia is experiencing a dramatic change over which is triggered by the disruptive emerging trend of technologies. The bodies in universities

such as faculties, schools, libraries and student bodies are under maximised pressure to increase the level of effectiveness and productivity on decision-making. This research proposes the improvement of decision-making in the case study of Graduate On Time (GOT). This case study entails on Graduate On Time (GOT) under the context of higher education refers to students who completed their study within specified duration as stated by one of the interviewees under this research.

This case study under this research will unlock the improvement of decision-making around the abilities of postgraduates who completed their study within the duration allocated. This directly impacts the decision-making, by making the information are more easily accessible to all levels of managements. The ability to understand the features that contribute a postgraduate to attain the GOT status and availability of the data based on the significant features allow the university to direct the right information to right people at a correct time.

Generally, higher education institutions operate in a rapidly changing business environment requires a decision-making framework as a kick-start for the institution. Focusing on academic institutions, a number of higher education institutions are failing to be effective in terms of students' success rate, graduate on time rates, enrolment targets, and staff retentions (Piedade and Santos, 2010). Nevertheless, universities are obliged to play the main role to monitor and understand the performances and elicit the factors that react in postgraduate enrolment and tuition, finance, scholarship, staffing, and asset management (Beckett and Mccomb, 2012; Mutanga, 2015). Therefore, higher education institutions have defects that initially affect the quality of decision-making and its academic analytical processes. As stated by Prem and Karnan (2014), there are no consistent enterprise-wide BI methodologies as such it proves that there is analyst using Microsoft Excel and Spreadsheets functions. This inconsistency allows the inability of users to gain decisions from data.

Based on the interviews conducted in this research, the task force team has highlighted that "The analysis of a large amount of data consumes a lot of time, subsequently delaying the decision-making process of the department. The delay in the decision-making leads to the delay of decision-making and forces the use of

intuition and experience of staff." It is common for higher education staffs to deal with huge amounts of students' data with numerous features detail. The problem here is, how to handle huge amounts of students' data using BI with numerous features detail which affect the performance of management in terms of accuracy in decisions. Liu *et al.* (2011) have stated by performing the pre-processing process with all dataset features are less encouraging with a total accuracy of 75.9%, while, using proposed feature selection technique, 80.2% accuracy will be improved.

Nevertheless, the other problems highlighted by the scope and case study of this research is the decision makers use manual data visualization using Microsoft Excel and PDF file. Figure 1.1 illustrates the problem are that emerge this research that causes the time of consumption in the decision-making process.
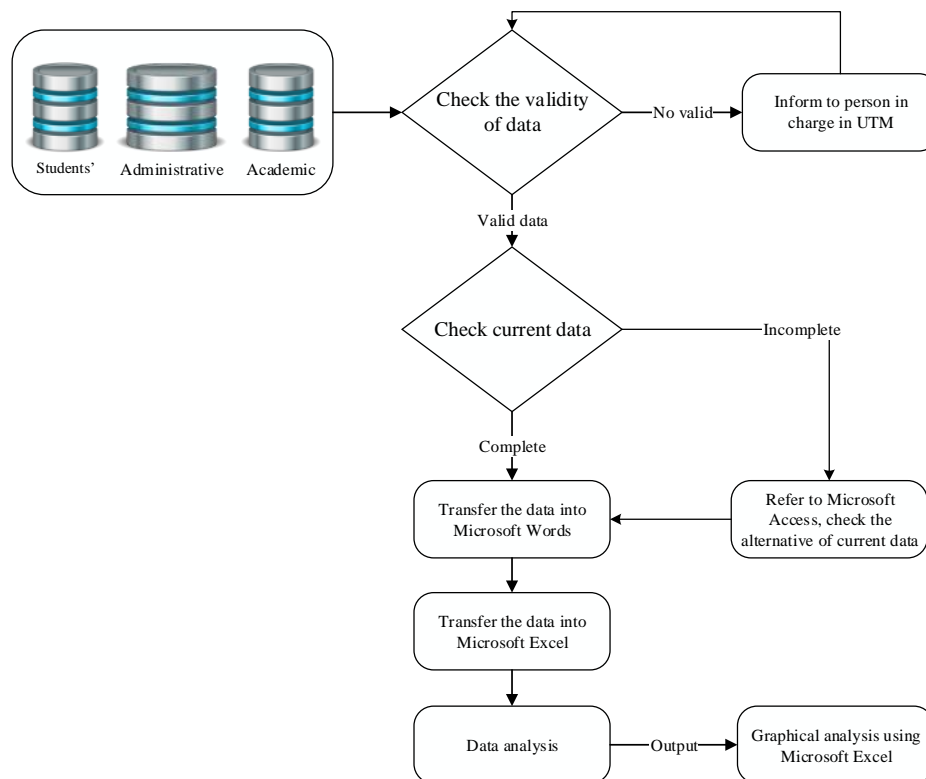
Figure 1.1   Problematic area in decision-making in higher education department

The problematic area leads to the data lack analytical and failed to facilitate all level of administration in the departments as stated by the BI task force during the interview on 7th January 2016. The real scenario of manual data visualization is the staff in-charge will extract the data from the databases and will pass it to the research officer in Excel format. This research officer will use extracted data and conduct manual visualization using Microsoft Excel without the knowledge of specific user requirement and give PDF file with to the top management who requires it for decision-making.

Hence, this research addresses these shortcomings by incorporating meta-heuristic algorithm and data mining for decision-making purposes so that BI system for higher education can be robust towards the shifting needs of the academic sector. Thus, this research proposed to develop a BI framework in order to assist the decision makers to full use of their information, in the sense, the transformation of data into decisions.

Current BI frameworks in the higher education sector have neglected the modeling of some important underlying processes that may affect the data. This research has discussed on eight frameworks on higher education based BI frameworks in upcoming Chapter 2. Based on the eight frameworks, it is able to summarize that there is an existing gap between data and decisions. Nenortaite and Butleris (2009) has a perspective that existing business intelligence frameworks still have limitations and focused on three main constraints, namely, data collection, data transformation and visualization of knowledge. Figure 1.2 illustrates the summarization of the research gap between information and decisions in this research.
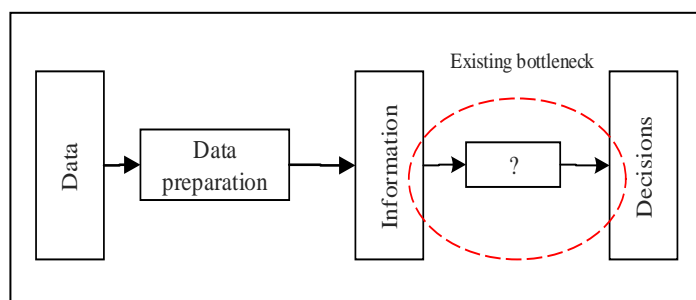
Figure 1.2   Bottleneck in the transition of knowledge to decisions

Although the importance of closing the gap linking information and decisions has been identified and steps have been proposed, the frameworks that have been produced to model the process flow for decision-making for higher education sector still has its gaps. As a result, management is still unable to possess a complete view of the information via dashboards for decision-making. As stated by Guster *et al.* (2014), toward gaining a good outcome of decision-making, the business intelligence shall invest in the transformation of data to decisions.

Thus, to extract decisions from the datasets before injected into data visualization for decision-making in business intelligence, an optimization technique which is meta-heuristic algorithm has to be incorporated for better decision-making. The important function of a BI framework is to give suitable decisions. The idea of carrying out optimization techniques will assist BI in achieving the single version truth of decisions. Hence, this depicts that proper meta-heuristic algorithm is required to produce accurate decisions to higher education.

In this research, ACO based feature selection is incorporated into the framework in order to provide accurate decision-making. As supported by Anusha and Nallaperumal (2015), ACO as a metaheuristic algorithm creates efficient and accurate decision-making as it assists in transforming raw data into actionable information. Feature selection plays a huge necessity of choosing significant and informative features in order to improve the quality of decision-making (Pudil and Somol, 2008). BI allows descriptive modelling approach whereby by incorporating ACO based feature selection in BI framework, it allows to evaluate the performance of the case study with the help of input attributes (Anusha and Nallaperumal, 2015). Hence, the problem background leads into next section, problem statement.

1.3 Problem Statement

To invest the knowledge into decisions, it fully depends on two main factors which are extracting the knowledge from the data and visualizing the knowledge into the dashboard. So, business intelligence (BI) has the capability to visualize data, however, the limitation is the users who unable to gain decision from the data.

Therefore, implementation of a meta-heuristic algorithm based feature selection in business intelligence framework is a way to select the informative and potential features for decision-making.

Nevertheless, the main problem that has been highlighted in problem background is anticipated to be solved via these research questions. The main research question is, "*How to develop a BI framework to handle decision-making problem for higher education?*"

From the main research, the following questions are addressed:

i) What are the existing BI frameworks aspects of meta-heuristic algorithm and feature selection that have been implemented in the higher education sector?

ii) How to develop a business intelligence framework for higher education integrating with a meta-heuristic algorithm for feature selection?

1.4 Research Objectives

The main aim of the research is, "*To develop a business intelligence (BI) framework using ACO algorithm with feature selection to handle decision-making in higher education sector*". To accomplish the aim, the research objectives are specified as follows:

i) To evaluate the existing BI frameworks to support decision-making in higher education.

ii) To develop a business intelligence framework for higher education using Ant Colony Optimization (ACO) based feature selection.

1.5   Scope

The scopes of research are as follows:

i)   The output of business intelligence in support management decision-making at School of Graduate Studies (SPS), Universiti Teknologi Malaysia (UTM).

ii) BI framework implemented on Postgraduate by Research Mode comprising PhD and Masters students from the enrolment year 2010 till the year 2013, with the total data of 46,658.

iii) Using ACO based feature selection to select significant features from the Graduate On Time (GOT) case study through the layers in BI framework.

iv) Apply SVM classifier to validate the data respective to the GOT case study BI framework.

1.6   Significance of the Study

This research indeed will be significant as it endeavors to build a BI framework with the meta-heuristic algorithm, as for this research, the implementation of ACO algorithm to be used by top management, staff and end users to assist them in decision-making. Accordance to this research, the outcome of this research will be significant and benefits higher education institutions. The first contribution of this thesis is the BI framework using the ACO algorithm based feature selection. This is to identify the best set of attributes and evaluates the performance of the model with the help of input attributes. The other significants are as follow:

i)   Theoretical

    a) Provides a clear understanding of business intelligence, data mining methods, meta-heuristic algorithms based on feature selection focuses on higher education within the context of research-based postgraduates.

    b) Provides a clear description flow of BI framework and the existence of bottleneck in transforming information to decisions.

    c) Provides a new BI framework using ACO based feature selection algorithm.

ii) Higher education top management, staff and BI end-user

Provide a clear BI framework using ACO algorithm based feature selection. This allows portraying sensible decision through selected features via the GOT case study. Users are able to monitor and elicit the factors that react among postgraduate students without the usage of intuition-feel.

iii) Researchers

There has been little research on business intelligence for higher education. Hence, this study contributes new knowledge for business intelligence by using ACO algorithm based feature selection and validate using SVM classifier in the BI framework for attribute selection before visualizing the decisions in the dashboard. This research can be beneficial for those researchers whom would like to expand the expertise in business intelligence field for any sector not specifically higher education.

1.7 Thesis Structure

This thesis is organized into six chapters where Chapter 1 for introduction, Chapter 2 is the section of literature review, Chapter 3 discusses the research design and methodology of this research and Chapter 4 is the detail explanation in developing the business intelligence (BI) framework integrating with ACO algorithm based feature selection for the purpose of attribute selection. While Chapter 5 is to measure and validate the implementation of ACO algorithm in integrating into BI framework based on the criteria of attribute selection. Chapter 6 is the conclusion, recommendation and future works under this research. The content of the chapters is briefly illustrated as the following:

i) Chapter 1

This chapter introduces the problem background of this research, research objectives, research questions, scope and limitations, the significance of the study and the structure of the thesis.

ii)   Chapter 2

Chapter 2 discusses the fundamental and theories of this research study which are derived from the previous work. The terms such as business intelligence, meta-heuristic algorithm, ACO algorithm, feature selection, existing BI frameworks under the context of higher education and the case study of previous work are discussed in this chapter.

iii)   Chapter 3

Chapter 3 is the chapter that is focused on the flow of research and it discusses the research design and methodology. Chapter 3 also devoted in giving the detailed mapping between the research problems, phases of the research, chapters involved, research activities and the objectives. This chapter also contributes toward the explanation on the development of the BI framework using ACO based feature selection for GOT case study. The strategic and systematic step of developing the BI framework for higher education is one of the contributions of this research.

iv)   Chapter 4

Chapter 4 under this research focuses on the case study of this research, implementing the feature selection using ACO to prove that ACO algorithm through performance analysis. The final outcome from the developed framework is discussed and also described the details of validation steps and method for attribute selection in BI framework using ACO algorithm. This chapter shows the analysis factors of layers proposed in the framework and incorporation of ACO algorithm based feature selection. This is to address the accuracy level and its contribution toward BI framework in producing a better decision-making in higher education. This chapter also discusses the verification process by the expertise in business intelligence for approving the importance selected features through the visualization in BI framework.

v)   Chapter 5

This chapter covers the conclusion, recommendations and future works of the conducted research. This chapter devoted giving a very clear understanding

about the goal of this research which has been successfully achieved in thesis and also the limitations. The future works is presented as well to give a wide opportunity in the field of business intelligence (BI).

1.8   Summary

This chapter has introduced the BI in general and its usage and importance in supporting the decision-making in sectors especially higher education sector. The following sections on the problem background, a case study has been explained the scenario and problems faced by management in the higher education sector that are related in achieving good decision-making. This led into research objectives and significance of the research study has also been provided to strengthen the research. This study attempted to propose a BI framework incorporated with Ant Colony Optimization (ACO) algorithm based feature selection to identify the best set of features and evaluates the performance using the dashboard with the help of input attributes for accurate decision-making.

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