Faculty of Information and Communication Technology

AN IMPROVED FAIR NURSE SCHEDULING OPTIMISATION USING PARTICLE SWARM INTELLIGENT TECHNIQUE

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NURSE SCHEDULING OPTIMISE FROM ADAPTING PARTICLE SWARM INTELLIGENT TECHNIQUE

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2015

DECLARATION

I declare that this thesis entitle “Nurse Scheduling Optimise from Adapting Particle Swarm Intelligent Technique” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Mohamad Raziff Bin Ramli

Date :

APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.

Signature :

Name : Associate Professor Dr Burairah Bin Hussin

Date :

DEDICATION

Ya Allah, hanya kerana keizinan dan kehendak-Mu sahaja
terhasilnya semua ini.
Khas buat ayahbonda;
Ramli bin Long dan **Rokiah binti Shafie**,
Penasihat-penasihat;
PM Dr. Burairah bin Hussin dan **Nuzulha Khilwani binti Ibrahim**,
yang banyak memberi tunjuk ajar dan
sentiasa sabar melayan kerenah seorang pelajar
Seterusnya adik-beradik, saudara-mara,
sahabat-sahabat dan sifu-sifu - dulu, kini dan selamanya.
Sesungguhnya, kejayaan ini adalah milik kita bersama.

Semoga kejayaan ini memberikan kebaikan
dan menjadi pemangkin untuk kita agar terus berjaya
dan cemerlang di dunia, lebih-lebih lagi di akhirat.

"Ya Allah, kami memohon kecintaan kepada-Mu dan
kecintaan kepada mereka yang mencintai-Mu.
Rajinkan kami mengerjakan amalan-amalan yang
membawa kepada kecintaan kepada-Mu.
Dan jadikanlah kecintaan kepada-Mu itu lebih kami cintai
daripada diri kami sendiri dan daripada air yang sejuk.
Ya Tuhan kami, kekalkan kami dalam kecintaan-Mu
dan kumpulkan kami bersama para kekasih-Mu
di syurga-Mu kelak.
Sesungguhnya kecintaan-Mu itu jauh lebih besar daripada
kejayaan sekecil ini. Amin Ya Rabb."

ABSTRACT

Nurse schedule is a list showing the arrangement such as dates and times of each employee must work at a particular period of time. Nurse scheduling is one of the important and complex tasks which influence the hospital productivity. Common issues in nurse scheduling problem are the unfair of the working shifts between nurses and the shortages of nursing staffs combined with the uncertain nature of patient workloads. Assigning each available nurse to the right place at the right time is therefore a major concern among many modern hospitals. A well-designed schedule algorithm shall be able to generate an efficient task that can precede the restriction and variability. Nevertheless, the fairness of the task been assigned to the nurses should also considered nurses perspectives. Therefore, this research aims to propose practical and effective nurse scheduling approach that takes into consideration both preferences by hospital and nurse. The suggested approach provides better solution not only with respect to efficiency but also the quality of the nurse scheduling to the hospital and the nurse themselves. Particle Swarm Optimisation (PSO) has many successful applications in continuous optimisation problems, thus, the capability of PSO is used to provide a high performance predictive nurse schedule. The nurse schedule produced by PSO then will investigate and compared with real schedule while the data successfully tested on benchmark and verified base on fairness measures. The experimental results have positively shown that the nurse schedule generated by PSO much better and effective in providing reasonably high quality solutions with respect to the desired hospital.

ABSTRAK

Penjadualan jururawat adalah satu senarai yang menunjukkan susunan seperti tarikh dan masa setiap jururawat perlu bekerja dalam tempoh tertentu. Penjadualan jururawat adalah salah satu tugas penting dan kompleks yang perlu dibimbangkan dimana mempengaruhi productiviti sesebuah hospital. Isu-isu biasa dalam sistem kesihatan di seluruh dunia khususnya dalam penjadualan jururawat adalah ketidakadilan di dalam perubahan kerja antara jururawat dan kekurangan kakitangan kejururawatan ditambahkan lagi dengan bebanan penjagaan pesakit yang tidak menentu. Menetapkan setiap jururawat berada di tempat yang betul pada masa yang tepat memberi kebimbangan utama di kalangan banyak hospital. Satu algoritma jadual yang direka dengan baik akan dapat menghasilkan satu tugas kerja yang cekap disamping mampu mendahului sekatan dan kebolehubahan. Walaubagaimanapun, keadilan tugas yang diberikan kepada jururawat juga perlu dipertimbangkan mengikut perspektif jururawat. Kajian ini bertujuan untuk merialisasikan penjadualan jururawat menggunakan pendekatan yang praktikal dan berkesan disamping mengambil kira kedua-dua keutamaan hospital dan kepuasan jururawat. Pendekatan yang dicadangkan menyediakan penyelesaian yang lebih baik bukan sahaja berkenaan dengan kecekapan tetapi juga kualiti penjadualan jururawat mengikut kehendak hospital dan jururawat itu sendiri. Particle Swarm Optmisation (PSO) mempunyai banyak aplikasi yang berjaya dalam menyelesaikan masalah pengoptimuman secara berterusan, dengan itu, keupayaan PSO digunakan untuk mengeluarkan jadual jururawat berkualiti tinggi ini. Jadual jururawat yang dihasilkan oleh PSO akan dianalisa dan dibanding dengan jadual sebenar selain data diuji pada penanda aras dan diukur berdasarkan keadilan jadual dihasilkan. Keputusan eksperimen telah menunjukkan secara positif bahawa jadual jururawat yang dihasilkan oleh PSO jauh lebih baik dan berkesan dalam menyediakan penyelesaian yang berkualiti tinggi seperti dikehendaki oleh pihak hospital.

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LIST OF ABBREVIATIONS

PSO	-	Particle Swarm Optimisation
NSP	-	Nurse Scheduling Problem
GA	-	Genetic Algorithm
ILP	-	Integer Linear Programming
TS	-	Tabu Search
ACO	-	Ant Colony Optimisation
ANSP	-	Anaesthesiology Nurse Scheduling
OR	-	Operation Research
O	-	Day Off
M	-	Shift Morning
E	-	Shift Evening
N	-	Shift Night

LIST OF RELATED PUBLICATIONS

No.	Publications	Related Chapter
	Journal (1)	
1.	Ramli, M. R., Hussin, B., and Ibrahim, N. K. (2013). Utilizing particle swarm optimisation techniques in solving unfair nurse scheduling problem. International Review on Computers and Software, 8(9), 2205-2212.	3 and 4

CHAPTER 1

INTRODUCTION

1.1 Problem Background

In many organisations, obtaining efficient schedules in their daily operations is necessary for management. Due to its importance, the planning and scheduling issue has become a popular topic among researchers. The research on staff planning and scheduling in the literature commonly relates to the determination of the number of staff with particular skills and allocation of staff according to a contain demand (Jaumard et al., 1998).

Others aims are minimising costs, meeting customers' demands, satisfying employee preferences or distributing work equally. This issue has been successfully resolved in many areas such as in manufacturing schedules (Kamble and Kadam, 2012), timetables for examination scheduling (Hussin et al., 2011) containership schedules (Go et al., 2012) and many others. Examples of application include nurse scheduling (Cheng et. al, 2003), bus driver scheduling (Lourenço et al., 2001), airline crew scheduling (Klabjan et al., 2001; Yin and Chiang, 2013) and call centre scheduling (Aksin et al., 2008).

Although there are many success stories about scheduling, researchers still focus their efforts on scheduling problems because each problem is unique and computational advantages give more opportunity for researchers to enhance their solutions.

Unlike other organisations, healthcare institutions are required to be operational around the clock. This will be reflected in the number of nurses available to support the working conditions in healthcare delivery. The main nurse duties include maintaining patient care and records with good behaviour and sense of responsibility. Without good quality of nurse duties' management, the nurses' tasks may be increased due to overloaded working hours. This will result in demotivated nurses and can lead to low standards of patient care.

To manage nurse duties, it is important to have a good nurse schedule system. Generally, a nurse schedule is a planned schedule that represents daily duties for nurses in the hospital's departments or units. The schedule may consist of a daily, weekly or monthly time schedule based on the requirements of a specific unit. Failure to properly schedule or adhere to the planned schedule will result in the escalation of work overload and the possibility that replacement nurses will be needed to fill up the pre-arranged schedule.

The need for quality schedule solutions is significant nowadays, for a number of reasons, particularly in balancing the workload among nurses as well as attempting to reasonably satisfy the nurses' preferences. In this study, a quality measure that might be used is a fair schedule system as discussed in many areas (Burke et al., 2004). With the fair schedule, the more quality schedule will be produced (Abobaker et al., 2011).

1.2 Problem Statement

In general, public hospitals utilise a duty roster to schedule their daily nursing operations. It is recognised that they already have a system to efficiently generate the schedule for each nurse. However, from a human perspective, efficient schedules usually are generated without factoring in the fairness of workload distribution between each nurse.

Therefore, the main research questions of this study are:

1. How can the task for each nurse be scheduled following their preferences and the needs of the hospitals?
2. How is a fairness criterion inserted into the designed method?
3. How can the proposed nurse schedule be developed using heuristic techniques?
4. How can the proposed nurse schedule system be verified?

1.3 Objectives

The goal of this research is to propose fair nurse scheduling based on constraints. The hard and soft constrains will be listed practically through consideration of real-world preferences by hospital and nurses' requirements as well as desired hospital objectives in order to provide an acceptable solution.

1. To design a fair/balanced module for nurse scheduling.
2. To develop a module optimising fairness for nurse schedules using Particle Swarm Optimisation (PSO).
3. To validate the improvements to the nurse schedules by PSO.

1.4 Research Scopes

Balanced nurse scheduling is a design which includes some complex requirements, assorted parameters, constraints and limitations that can cause the problem to become more complicated. The aim of this research scope is to confine the research study. As this study is supposed to elucidate the role of meta-heuristic approaches, therefore several techniques were used in order to conduct the experiment, such as PSO, mathematical programming and swap approach.

The scopes and limitations of this research are as follows:

1. This thesis will focus on how to improve personalised healthcare through optimising the nurse schedule where the nurse schedule influences the quality of patient care, with more precise diagnostics and better therapies.
2. The real nurse schedule data used in this study are provided by the Hospital Besar Melaka.

1.5 Significance of the study

This research is considered significant as it intends to solve the issue of providing a fair/balanced module for nurse schedules where until now there is still an unbalanced workload among nurses. The capability of the PSO approach aids in making decisions for producing a near optimal solution with reducing computational cost, while the mathematical approach that is adopted in PSO is used to simplify the PSO in defining that the best nurse schedule has been selected. In addition, the proposed swap process is used to balance shift assignments between nurses.

The performance measures considered in this research are concerned about the fair/balanced workload between each nurse, hospital preferences and nurse satisfaction, which is also one of the aims to enhance the quality of nurse schedules, and cut the creation period and cost. Therefore, the accomplishment of this scrutiny could support the improvement of the creation of nurse schedules. The improvement can be achieved through the minimum fitness value in PSO.

1.6 Structure of the Thesis

This thesis is organised into six chapters. Figure 1.1 shows the structure of this thesis. The content of each chapter is briefly described as follows:

1. Chapter 1 provides deliberations on some problem background, goal, objectives, scopes and significance of this research.
2. Chapter 2 reviews some related works in this area as well as related domains that would help in understanding the rest of this thesis.
3. Chapter 3 describes the research methodology employed in this research including the research framework, data sources (analyses the preliminary data collection), instrumentations, problem descriptions, performance measures, experiment and analysis used in the thesis.
4. Next, Chapter 4 where all the modules in PSO been implemented into case study in order to produce best nurse schedule.
5. Then, in chapter 5 the result produce by PSO been analysed. Through experiments, preference fair nurse schedule according to hospital and nurses could be verify.
6. Finally, Chapter 6 concludes with the findings, contributions and potential future research to be conducted as derived from this study.

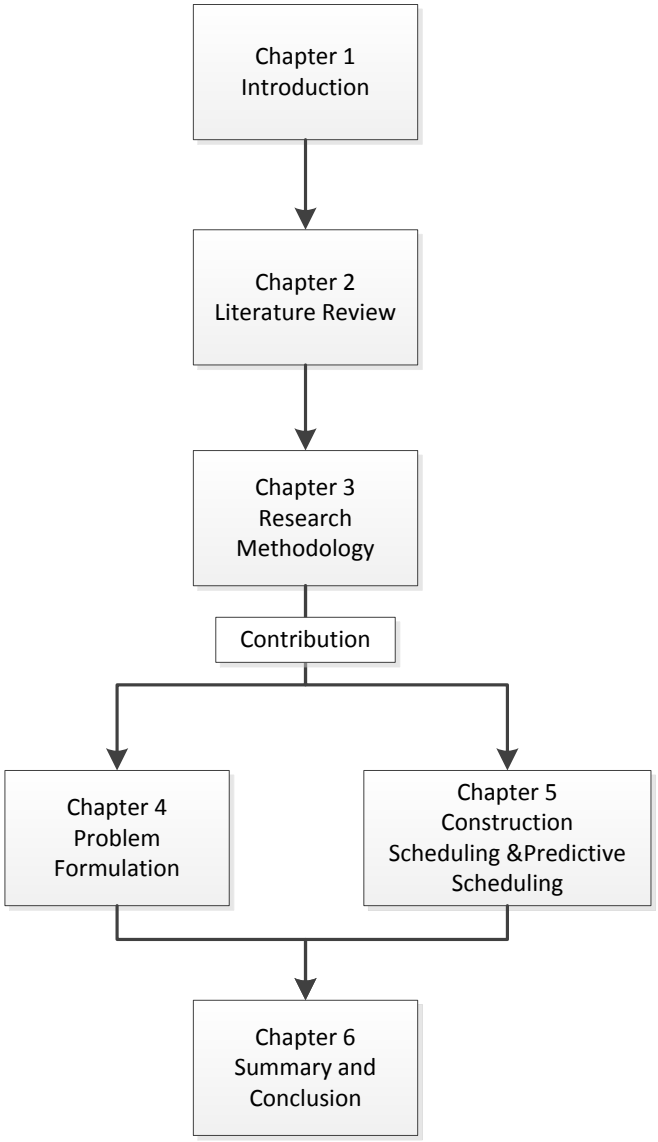

Figure 1.1 : Structure of the thesis