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JUDUL: CONSTRAINT OPTIMIZATION FOR NURSE ROSTERING USING PARTICLE SWARM OPTIMIZATION WITH GLOBAL OPTIMUM TEST FUNCTION

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CONSTRAINT OPTIMIZATION FOR NURSE ROSTERING USING PARTICLE SWARM OPTIMIZATION WITH GLOBAL OPTIMUM TEST FUNCTION

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This report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science (Artificial Intelligence)

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2012

DECLARATION

I hereby declare that this project report entitled

CONSTRAINT OPTIMIZATION FOR NURSE ROSTERING USING PARTICLE SWARM OPTIMIZATION WITH GLOBAL OPTIMUM TEST FUNCTION

is written by me and is my own effort and that no part has been plagiarized without citations.

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DEDICATION

To my beloved parents, A Jalil Bin Aman and Normah Binti Salleh, for their expression of love and fully support.

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I owe my deepest gratitude to my friends, for making this study a wonderful experience. Besides, I would like to thanks them for their valuable and sincere comments for my work. Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of this research.

ABSTRACT

The decision making in assigning all nursing staffs to shift duties in a hospital unit must be done appropriately because it is a difficult task due to various requirements and constraints that need to be fulfilled. The shift assignment or also known as roster has a great impact on the nurses' operational circumstances which are strongly related to the intensity of quality of health care. The head nurse usually spends a substantial amount of time developing manual rosters, especially when there are many staff requests. Yet, sometimes she could not ensure that all constraints are met. Therefore, this research identified the relevant constraints being imposed in optimizing the nurse rostering problem and examined the efficient method to generate the nurse roster based on constraints involved. Subsequently, as part of this research, we use a Particle Swarm Optimization (PSO) to solve this problem. The proposed PSO technique is evaluated for its efficiency, where 50 samples of rosters generated were taken for analysis. The feasible solutions were evaluated based on their minimum penalty values. The penalty values were given based on different violations of soft constraints. The PSO technique is able to optimize the soft constraints as much as possible.

ABSTRAK

Tugas dalam menentukan pembahagian kerja bagi setiap jururawat dihospital hendaklah dilaksanakan dengan sebaiknya kerana ianya perlu mengikut pelbagai kehendak dan kekangan yang telah ditetapkan oleh pihak pentadbiran hospital. Jadual pembahagian kerja yang memenuhi kehendak pihak pentadbiran dan jururawat amat penting dalam melahirkan suasana kerja yang produktif untuk setiap staf. Pada kebiasaannya, ketua jururawat terpaksa mengambil masa yang lama untuk menyiapkan sesebuah jadual kerja berikutan terpaksa menyesuaikan kehendak setiap jururawat dan kekangan yang perlu dipatuhi oleh pihak hospital. Walau bagaimanapun, tidak kesemua kehendak jururawat dapat dipatuhi dan ini mampu melahirkan perasaan tidak senang dikalangan staf. Oleh itu, kajian ini sangat bersesuaian untuk mengenalpasti kekangan-kekangan yang boleh digunakan dalam membina sesebuah jadual kerja. Maka, dalam kajian ini, penggunaaan teknik Particle Swarm Optimization (PSO) telah digunakan untuk menyelesaikan masalah. Teknik ini dinilai melalui keupayaannya dengan menggunakan 50 contoh jadual kerja dan pelbagai jenis kekangan digunakan untuk dianalisa. Teknik PSO dilihat mampu untuk mengoptimakan kekangan yang ada sebanyak yang mungkin.

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Co-PSO -	Constraint Optimization for Nurse Rostering using Particle Swarm Optimization with Global Optimum Test Function
PSO -	Particle swarm optimization
AI -	Artificial Intelligent
GA -	Genetic Algorithms
LP -	Linear Programming
IP -	Integer Programming
NLP -	Nonlinear Programming
GP -	Goal Programming
SI -	Swarm Intelligence
GCPSO -	Guaranteed Convergence Particle Swarm Optimizer
DCPSO -	Dynamic Particle Swarm Optimization Algorithm
RAD -	Rapid Application Development
OOAD -	Object-Oriented Analysis and Design
HOnN -	Hours On Number
DOnN -	Shift Type
DOff -	Day Off
DOnWd -	Days On Most for Weekday
DOnWe -	Days On at Most for Weekend
BA -	Bees Algorithm
RAD -	Rapid Application Development

CHAPTER 1

INTRODUCTION

1.1 Project Background

Nurse rostering is a complex scheduling problem that affects hospital personnel on a daily basis all over the world. Solving properly the nurse scheduling problem has a great impact on nurses' working conditions which are strongly related to nursing quality and working moral. The need to take into account individual preferences further complicates the process. Thus, to improve nurses' level of satisfaction, schedules are generated individually for each hospital unit by the nurse chiefs.

The nurse rostering can be defined as the problem of placing resources or nurses, subject to constraints, into slot in a pattern, where the pattern denotes a set of legal shifts defined in terms of work that needs to be done. Rostering process of nurses is actually the allocating of nurses to execute their nursing services per shift per day in a department. The nurse rostering is a set of work and rest days assigned to each nurse in the planning horizon and must satisfy the entire problem rules and regulations that apply to the complete roster entity. Through this rostering process, the nursing services or operation times can be worked out as expected. Rosters are cyclic prototypes of days off and days on (or shifts-off and shifts-on) that are allocated as a whole to nurses.

The importance of a systematic approach to create good timetables is very high, especially in healthcare, where it is unacceptable not to fully support patient care needs and staff requirements. Periodically, for example daily, pool nurses have

to be assigned for the following days while considering a variety of soft and hard constraints regarding working date and time, working patterns, nurses' qualifications, nurses' and hospital preferences, as well as costs. Thus, optimizing the nurse scheduling is important to efficiently utilize time and effort, to evenly balance the workload among people and to attempt to satisfy personnel preferences.

The constraint conditions for nurse scheduling is broad, and may differ from case to case. Some of the constraint conditions even conflict with each other. For example, the shift preferences of nursing staff may violate the requirement for shift fairness. In practice, the nurse chiefs arrange the schedule based on their subjective experience. In fact, the nurse scheduling issue remains challenging, and the developments of more sophisticated approach to solve the problem deserve further exploration.

Particle swarm optimization (PSO) is an evolutionary computation method. It is a population based random search strategy and an adaptive optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. Because of the unique search mechanism, excellent convergence performance and easy realization, the algorithm has obtained rapid development and has been widely used in many fields since it was proposed.

PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions or a set of software agents, called particles, fly through the problem space and search for a good solutions by following the current optimum particles.

Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. PSO has been applied to many different problems and is another example of successful artificial/engineering swarm intelligence system. Thus, for this project, the application of PSO in introduced in the

nurse scheduling to predict the minimum total penalty that will satisfy as many as possible of a set of soft constraints.

1.2 Problems Statement(s)

Nurse scheduling can be considered as a partial constraint satisfaction problem. The task is to find a consistent allocation of shift values, for a group of nurses, over a fixed period of time, that satisfy as many as possible of a set of rostering constraints. There are two basic type of constraint: (i) schedule constraints defining acceptable shift combinations and (ii) staff constraints defining acceptable overall staffing levels. Some constraints are hard (must be satisfied) while others are soft (may be violated). Thus, the best schedule would be the one that minimizes total penalty for nurse scheduling optimization and produced the best combination of constraints.

1.3 Objective

Design and development of robust and reliable scheduling algorithms has been an active research area in Computer Science and Artificial Intelligence. Given that the general problem is computationally intractable, many heuristic-based techniques have been developed, while other approaches have used optimizing techniques for specific and limited problem domains. Therefore, the objectives of presenting Particle Swarm Optimization technique in nurse scheduling are:

1. To investigate the total penalty optimization associated for nurse scheduling optimization.
2. To model the nurse scheduling optimization using Six Hump Camelback, Branins' and Goldstein Price test functions.

1.4 Scope

The data collection will only cover the combination of soft constraint and the penalty assigned for each soft constraint. There will be no suggestion schedule assigned, but it will concentrate on analyzing the graph produced from the data collection.

1.5 Project Significance

This project will bring benefits to the hospital management and nurses where it helps optimize the schedule of nurses' by fulfilling the nurse satisfaction with optimizing soft constraints while minimizing the penalty that had been assigned. The roster must be optimize especially to the healthcare organization that consist of many type of nurses and requirements in their environment to make sure that all the operation that has been scheduled can work precisely.

By optimizing the nurse scheduling will give enormous impact upon the working environment. The nurses for sure will give their best performance if they can work with comfortable environment as much as they want.

1.6 Expected Output

The system should be able to analyze nurse schedule data collection and plot the graph that corresponds to the data produced. Based on the generated graph, the analysis can be done to evaluate the corresponding combination of soft constraint and the optimization value (fitness value) with total penalty assigned.

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1.7 Conclusion

The nurses will get a moral burst to be more efficient in their work as they will feel treated nicely by the employer by getting the fairness roster. In real life situation, departmental rostering appear to become more appropriate and more effective for the high number of nurses with high difficulty of rostering problem. For the medium size number of nurses, the suitable rostering is team rostering, while the self-rostering is the less effective rostering to apply in the industries.

Cyclical scheduling is not suitable to be applied among nurse because there will be no rotation that will lead to the unfairness roster. Non-cyclical scheduling is the suitable schedule to be practice by the healthcare organization because they work around the clock.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature part of this research study will be presented and discussed. This includes the study on the nurse scheduling problem and the techniques used in the development of scheduling. Some of the optimization algorithms are discussed and compared in order to justify the choice of Particle Swarm Optimization (PSO) method. Furthermore, the project methodology will also be determined and justified its selection. Then followed by the requirement needed to build the proposed system will also be stated. Lastly, the project schedule and milestones are planned in order the system can finished in time by following them.

2.2 Fact and Finding

Before starting the analysis and design part of the system, some facts and findings have to be made so that suitable technique and methodology are chosen.

2.2.1 Existing System

While staff scheduling plays an important role in any company that relies on shift work, scheduling nurses has its own unique factors that make the problem both

interesting and complex. As with all businesses, costs must be kept to a minimum and contractual obligations adhered to. However, in nursing there are other important factors, for example fatigue. A poorly constructed nurse schedule can lead to fatigued nurses which can in turn lead to mistakes. Roger et al. (2004) reported a significant increase in mistakes made by nurses if shifts of more than 12 hours were worked, when more than 40 hours was worked in a one week period or, if extensive overtime was worked. The preferred rotating pattern has been shown to be morning, evening and then night shifts. The number of days a particular shift is worked before changing, the length of the break between changing shift and the distribution of days off have also been shown to have an impact on a person's health and productivity at work (Kostreva et al.; 2002).

Regular reports in the news about the shortage of qualified nurses all around the world has highlighted the importance for hospitals to retain their staff and good scheduling practices can help with this. Mc Vicar (2003) found that shift working is an increasing resource of distress for nurses. The UK's Royal College of Nursing has reported that "Nurses who are forces to work a rotating pattern of day and night shifts are more likely than other nurses to want to leave National Health Service" (Royal College of Nursing; 2004) supporting the idea of more flexible schedules.

Many ideas for improving nurse scheduling have been used in recent research with a tendency to focus on flexibility and giving nurses greater control over their own schedules. This has been introduced into schedules in a number of ways with preference scheduling being adopted to some degree by many researchers (warner; 1976; De Grano et al,; 2009).

2.2.2 Techniques

Optimization approach is a mathematical programming approach, which some objectives to minimized or maximized subject to a set of constraints on the possible solution sets (Sitompol & Randhawa, 1990). These include the linear programming (LP), the integer programming (IP), the nonlinear programming (NLP)

and the goal programming (GP). Several of these approaches had been employed in earlier works on the nurse rostering problem.

Swarm Intelligence (SI) is an innovative distributed intelligent paradigm for solving optimization problems that originally took its inspiration from the biological examples by swarming, flocking and herding phenomena in vertebrates. Ant Colony Optimization, Genetic Algorithm, Particle Swarm Optimization are various Evolutionary Algorithms proposed by researchers. Due to simplicity in Particle Swarm Optimization (PSO) equation and fast convergence, PSO is found to be best among these (Hemlata and Prof. Rahila Patel, 2012). After analyzing each parameter in PSO equation, Yuhui Shi and Russel Eberhart proposes new parameter "w" called inertia weight in the basic equation. It can be imagined that the search process for PSO without the first part is a process where the search space statically shrinks through the generations. It resembles a local search algorithm. Addition of this new parameter causes exploration and exploitation in the search space. Firstly, value of w was kept static. Later on it was kept linear from 0.9 to 0.4.

Figure 2.1: Bird flocking inspired the idea of Particle Swarm Optimization