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A Controlled Randomization Method to Schedule Doctors in Al-Ramadi Hospital

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Abstract

This paper aims to improve the scheduling solutions by creating fair schedule to solve some of the problems that can be found during the preparation of schedules. This paper uses a controlled randomization method in order to schedule the doctors in Al-Ramadi General Hospital in a fair way. Three hard constraints as well as three soft constraints are selected to distribute 41 doctors over a period of one month, at which each day is divided into four periods. The obtained results are promising, as the controlled randomization method is able to outperform the current manual schedule that is produced by the hospital. This will open future research directions.

Introduction

The applications of scheduling are very much intervention in all areas such as (management) there are timetables for factories and service companies, as well as educational institutions (universities) that have many schedules in order to organize exams, classes and halls as well as organizing lectures [1]. The aim of this paper is to schedule the doctors' shifts in Al-Ramadi General Hospital for the period of one month. There were about 40 doctors to be scheduled.

Background

Hospital staffing involves determining the number of personnel of the required skills in order to meet predicted requirements. It is also called workforce scheduling in other personnel planning environments such as production scheduling and cargo forwarding. The doctor rostering problem represents an important administration activity in modern hospitals.

The problem consists of generating a configuration of individual schedules for all available doctors satisfying a set of constraints including working regulations and doctors' preferences. Solving the problem properly has a positive impact on doctor' working conditions and contributes to a higher quality of healthcare [2][3]. Doctor scheduling problems belong to the personnel scheduling problem, which is one of the combinatorial optimization problems. Solving complex doctor scheduling problems, which is NP-hard [4], presents a challenge to both practitioners in practice and researchers in Operations Research (OR) and Artificial Intelligence (AI) communities.

Due to their strengths in optimality reasoning and relaxation, OR techniques such as linear programming [5], integer programming [6] and mixed-integer programming [7] have been applied to doctor scheduling problems. The core problem of doctor scheduling problems can be modeled as the set partitioning or set covering problem. These well structured models, although are often rather simplified, can help to reveal important problem properties and define efficient (and often polynomial) algorithms [8]. In personnel scheduling, researchers have investigated column generation and branch-and-price approaches [9]-[12].

However, real-world large scale doctor scheduling problems are usually highly constrained and difficult to solve efficiently by using pure OR techniques. Constraint Programming (CP) offers a rich modeling paradigm to handle complex and heterogeneous constraints in combinatorial problems. Its strength of feasibility reasoning has been widely recognized in the literature, where doctor scheduling problems are modeled as constraint satisfaction problems and solved subject to a set of complex constraints [13][14].

Experimental Setup

The goal of any timetable is to be familiar with each work so in this paper we try to find a fair schedule to distribute the 41 doctors over the period of one month (30 days) for 24 hours per day. The day hours is divided into four periods (according to the hospital rules):

1. The first period starts from 8 AM to 2 PM.
2. The second period from 2 PM to 7 PM.
3. The third period starts from 7 PM to 12 AM.
4- The fourth period starts from 12 AM to 8 AM.

The 41 doctors will be distributed over the four periods in a way that there will be three doctors in each one of the first three periods and two doctors in the fourth period.
So the hard constraints for this schedule are:

A. The doctor cannot attend more than one period per a day.
B. The doctor who attends the fourth period must not have a first period of the next day.
C. All the doctors must have as much as possible equal periods especially in the overnight shifts (4^{th} period).

While the soft constraints are:

A. Minimize the gap between the working days for the doctors (<=3 days is preferable).
B. Minimize the number of overnight shifts for the doctors (<=3 is preferable).
C. No overnight shifts for the female doctors.

The quality of the solution will be determined by satisfying all the hard constraints and as much as possible from the soft constraints.

The randomization algorithm is used to implement the required hard and soft constraints in order to obtain the schedule:

1- Construct an empty schedule with 31 days and four periods (time slots) for each day.
2- Distribute the 41 doctors over the time slots such that three doctors will be distributed for each time slot (for the first three periods), and two doctors for the overnight shifts (4^{th} period).
3- While the hard constraints is not satisfied do:
    - For each doctor in the schedule, if the doctor is found in two or more time slots in the same day, then keep the first time slot and replace the remaining time slot(s) with another doctor(s). The replacement can be done by searching for the best time slot that can satisfy the constraint, if no such times slot can be found then do a random replacement.
    - For each doctor in the schedule, if the doctor is found in the last time slot of the day and in the first time slot of the first day then replace the last time shift with another time slot in another day.
    - For each doctor, calculate the number of shifts, and the number of overnight shifts, then try to make each doctor have the same number of shifts and overnight shifts by replacing the shifts between the doctor with the highest number of shifts and the doctor with the lowest number of shifts.
4- Try to achieve the soft constraints by doing random substitute and if there is any substitute done then go to 3, else exit and output the obtained schedule.

Results

The randomization algorithm is applied to find the required schedule for the doctors; the obtained results were promising as the hard constraints is all satisfied, which reflects a success for our proposed approach, the results are shown in table 1, while table 2 shows the results of satisfying the soft constraints, which reflects another success to our approach.

Table1: Hard Constraints Results.

Hard Constraints	Manual Approach's Number of Violations	Our Proposed Approach's Number of Violations
The doctor cannot attend more than one period per a day.	7	0
The doctor who attends the fourth period must not have a first period of the next day.	0	0
All the doctors must have as much as possible equal periods especially in the overnight shifts (4^{th} period).	22	0

The results in table 1 clearly show that our proposed approach is better than the hospital manual approach, especially in satisfying the third hard constraint.

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Soft Constraints	Manual Approach's Number of Violations	Our Proposed Approach's Number of Violations
Minimize the gap between the working days for the doctors (<=3 days is preferable).	4	0
Minimize the number of overnight shifts for the doctors (<=3 is preferable).	5	3
No overnight shifts for the female doctors.	0	20

Table2: Soft Constraints Results.

The results in table2 show that our approach outperforms the hospital's manual approach in two out of three soft constraints, and the results in the third soft constraint is expected as there is a confliction between this soft constraint and the third hard constraint. It is clear that the priority is for the hard constraint, so this is why our approach is outperformed in the third soft constraint.

Conclusions and Future Works

This paper presents an attempt to produce a fair schedule for doctors in Al-Ramadi general hospital. The obtained results are promising and clearly indicate a success for our proposed method. The results in table1show that our method outperformed the hospital manual method in two out of three of the required hard constraints and they are equal in the third one. Also the results in table2 show that our approach is better than the hospital approach in two out of three soft constraints, and is not of comparable performance in the third one. The reason behind this is that the third soft constraint contradicts with the third hard constraints and its obvious that the hard constraints have all the priority over the soft constraints.
Although the obtained results showed that the randomization method is better than the manual method, but we need to investigate another algorithms including AI algorithms in order to improve the quality of the solutions in the term of satisfying the soft constraints. should be referenced like Equation (1). Unless it is absolutely necessary, equation numbers should not have parts to them. E.g., instead of using Equation 1(a) and Equation 1(b), please number them as Equation (1) and Equation (2).

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Biographies

Belal Al-Khateeb received the B.Sc. (honors) (first class) degree in computer science from Al-Nahrain University, Baghdad, IRAQ, in 2000, and the M.Sc. degree in computer science from Al-Nahrain University, Baghdad, IRAQ, in 2003, and the Ph.D. degree from the School of Computer Science, University of Nottingham, Nottingham, U.K., in 2011. He is currently a lecturer at the College of Computer, Al-Anbar University. He has published over 15 refereed journal and conference papers. His current research interests include evolutionary and adaptive learning particularly in computer games, expert systems, and heuristics and meta/hyper-heuristics. He has a particular interest in computer games programming. Dr. Al-Khateeb is a reviewer of two international journals (including one IEEE Transaction) and four conferences.