A study on fairness objectives for nurse rostering

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Abstract

The nurse rostering problem is a combinatorial optimisation problem in which shifts should be assigned to nurses, subject to a large number of administrative, legal and other workforce related constraints. This problem has received ample attention in the last decades, however, the fairness of the constructed rosters is an often neglected aspect in the literature. The quality of the solution is often evaluated by means of an objective function which does not explicitly account for the fair distribution of individual high quality rosters. We present novel approaches to incorporate fairness measures in existing solution methods for the nurse rostering problem.

Keywords: nurse rostering, fairness

1 Introduction

Due to the ageing population and an increased cost of treatments, the health care sector is under severe pressure to maintain a certain degree of quality of service, while still controlling the overall costs. A major contributor in guaranteeing this quality of service is the nursing staff, hence it are the nurses who experience a lot of stress on a daily basis. Job dissatisfaction plays a key role in the nurses' high resignation rates. It is clear that satisfying the nurses' requests for high quality rosters is necessary to ensure a qualitative health care infrastructure. Even though this thus appears to be of vital importance, fairness in nurse rostering has only received limited attention in research. We present a methodology for better taking into account the fairness in constructing rosters for nurses, resulting in an overall higher satisfaction for all nurses.

2 Fairness measures

Automatically generated rosters are commonly evaluated using a weighted sum objective function, in which, summed over all soft constraints, the number of violations is multiplied

by the weight of the constraint. However, this approach far from guarantees a fair solution. There can still exist large differences in roster quality between nurses. We propose to incorporate fairness measures in an existing model by means of new objective functions.

Real world nurse rostering problems can be represented as constraint optimisation problems using 5-tuples (N, D, S, K, C) with N the set of nurses, D the set of days in the planning period and all relevant days in the previous and next planning periods, S the set of shift types, K the set of skill types and C the set of constraints. A common objective function is the weighted sum objective function WO (Equation (1)) which should be minimised. In Equation (1), $C_s \subseteq C$ refers to the set of all soft constraints.

$$WO = \sum_{n \in N} \sum_{c \in C_s} \#violations_{n,c} \times weight_c \tag{1}$$

Rosters with a low value of WO will not necessarily be perceived as fair by each nurse. This is an obvious result as no real distinction is made between individual nurses. Therefore one nurse can have a very bad roster which is then compensated in the overall objective value by another nurses' high quality roster.

The fairness of individual rosters is better respected by the objective function FO in which the quality of the worst individual roster determines the overall solution quality (Equation (2)). Both WO and FO can be used in a centralised approach (e.g. meta-heuristics). When modelling objectives for a decentralised approach, it is possible to specify an objective for each individual nurse. This is modelled in objective function IO_n (Equation (3)), in which nurse n's roster should be optimised. Ouelhadj et al. [1] apply this decentralised approach in an agent-based framework [2].

$$FO = max_{n \in N} \sum_{c \in C_s} \#violations_{n,c} \times weight_c \tag{2}$$

$$IO_n = \sum_{c \in C_s} \#violations_{n,c} \times weight_c \tag{3}$$

Experiments on benchmark datasets taken from Bilgin et al. [3] indicate the effect of the different fairness measures. The results will be presented at the conference.

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References

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