University Timetabling with Fuzzy Constraints

Sanja Petrovic, Vijay Patel, Yong Yang

Automated Scheduling, Optimisation and Planning Research Group
School of Computer Science and Information Technology
University of Nottingham Jubilee Campus, Wollaton Road
Nottingham NG8 1BB UK
{ sxp,vxp01u,yxy@cs.nott.ac.uk }

Abstract

The aim of this paper is to consider flexible constraint satisfaction in timetabling problems. The research is carried out in the context of university examination timetabling. Examination timetabling is subject to two types of constraints: hard and soft. Hard constraints must not be violated under any conditions, while soft constraints are desirable to satisfy, but often they have to be violated to some extent. Usually, an objective function is introduced to measure the satisfaction of soft constraints in the solution by summing up the number of students involved in the violation of the constraint.

In existing timetabling models a binary logic strategy is employed to handle the satisfaction of the constraints, i.e. a constraint is either satisfied or not. A typical example is the constraint on the proximity of exams, which requires that students do not have exams in adjacent time periods. If the solution violates this constraint, the objective function takes into consideration the number of students for whom this constraint is not satisfied. However, there are some constraints that are difficult to evaluate using binary logic. In this research we consider two such constraints: the constraint that larger exams should be scheduled early in the timetable, and that students should have enough break between two consecutive exams. Fuzzy sets are employed to introduce gradualism in the constraint satisfaction. Namely, the degree of a constraint satisfaction is described by five fuzzy sets: *low*, *medium-low*, *medium*, *medium-high*, *high*.

Fuzzy IF-THEN rules are defined to derive the satisfaction degree of each of the constraint. The satisfaction degree of scheduling large exams is derived using the linguistic variables *Size of exam* and *Time period* that the exam is scheduled in. *Size of exam* is described by linguistic terms *small*, *medium*, and *large*, while *Time period* is assessed as *early*, *middle*, and *late* with respect to its position in the timetable. Similarly, the linguistic variables *Distance* between two exams and the *Number of students* that these two exams have in common are used to reason about the satisfaction degree of the proximity of exams. The linguistic terms *small*, *medium*, and *large* are used to evaluate both linguistic variables. Of course, these linguistic terms have different membership functions for each linguistic variable. The result of firing fuzzy IF-THEN rules defined for each constraint is a fuzzy set which represents a satisfaction degree of the constraint. In order to get a crisp number that can be used

in the evaluation of the quality of the timetable, the obtained fuzzy set is defuzzified using the centre of gravity of the obtained fuzzy set.

A genetic algorithm is developed whose fitness function aggregates the satisfaction degrees of both fuzzy constraints. The proposed approach is tested on real-world benchmark problems and the results are discussed.