# Timetabling using a Steady State Genetic Algorithm

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**Abstract.** In this paper, we present a steady state genetic algorithm (SSGA) for solving a multi-constraint university course-timetabling problem. A configurable tool has been developed, named TEDI (Timetabling Tool for Educational Institutions) for the Faculty of Engineering and Architecture (FEA) at Yeditepe University (YU) using SSGA. TEDI includes a powerful and interactive graphical user interface (GUI) for entering input data and viewing the output. 18 different constraints are identified for university timetabling. No distinction is made between hard and soft constraints. Several new crossover and mutation operators are tested. A new successful mutation operator, named Ranking Mutation Operator (RMO), has been introduced. Initial experimental results are promising.

## 1 Introduction

Timetabling problems involve in feasible assignment of users to time-slots that are distributed over a period of time, based on a set of constraints. The timetabling problem is an NP complete problem [3], studied by numerous researchers ([1], [2], [4]).

## 2 Timetabling Problem

In YU, each semester, a regular undergraduate student must complete 5-8 courses depending on the curriculum. Each course requires 1-4 class hours, excluding labs. Each lab requires 1-4 class hours. There are 6 departments in FEA. Curriculum of each department consists of 8 curriculum terms (semesters). Students can start the Faculty any semester. Thus, all the courses in the curriculum are opened every semester. There are full-time and part-time instructors in the university. Most of the part time instructors are full-time instructors in other universities. Therefore, there are strict time/day constraints.

Lectures are held in 9 hours per day and 5 days a week (45 time slots). Every day, the middle slot is assumed to be the lunch break. Timetabling problem involves in finding an optimal assignment of time slots as class hours for all Faculty courses offered in a semester based on some constraints.

It is obvious that schedule of the courses in the same curriculum term and the time slots assigned for an instructor must not overlap. Class hours of a course can be grouped into meetings, forcing each meeting to be scheduled in different days. Time slots assigned for the class hours of a course in different terms of the same department may overlap. Lunch breaks are allowed to be used as a time slot for a course. An instructor can lecture in different faculties during the same semester. The courses that an instructor offers are subject to change. Furthermore, part-time instructors work on semester basis, which makes it almost impossible to produce a long term schedule.

## 3 TEDI

All SSGA parameters and constraints are entered into TEDI using the corresponding GUI. Then TEDI is invoked for finding the optimum timetable with the given input using our SSGA. After the execution completes, by selecting a department's term or an instructor, related timetable can be visualized as an output. TEDI is designed to interact with the academic database, named STARS, currently in use in the FEA, by setting the offered course schedule.

### 3.1 SSGA

Genetic Algorithms were introduced by J. Holland [5], and have been used to solve many difficult problems.

A population of individuals is created randomly. An individual maps class hours of all faculty courses to time slots. Individuals are evaluated using a fitness function, penalizing any mapping that does not satisfy a constraint. During each generation, two parents are selected using well known ranking strategy. Traditional one point crossover (1PTX) is applied, resulting with two offspring. Then Ranking Mutation Operator (RMO) is applied on each offspring. Considering the fitness contributions of genes, RMO selects a gene to be mutated using ranking strategy. Applying crossover and mutation can yield an infeasible representation. A filtering algorithm, named Intersection Filter (IFO), is used for repair, *if possible*. Elitist survival scheme selects two best individuals among parents and their offspring, than replaces the worst two individuals in the population with them. Evolutionary process continues in the same manner, until the best fitness is achieved or the number of generations exceeds 200,000. The same individuals are not allowed in the system.

## 4 Results and Conclusions

Initial experiments were done for fine-tuning SSGA parameters and testing different genetic operators. The initial experimental data consisted of 66 offered courses, summing up to 205 class hours to be assigned to a timetable slot with a total of 115 course meetings. SSGA with 1PTX, RMO and IFO performed the best (see Sect. 3.1). Each run was repeated 20 times.

TEDI, successfully, generated the course schedule of FEA for 2001/2002-2$^{nd}$ semester. This data consisted of 163 offered courses in 33 curriculum terms, having 246 course meetings, summing up to 481 class hours, 86 instructors and their 276 requests.

Disallowing clones provided diversity among individuals, increasing the performance. Entering the requests as constraints into the system took one day. Finding the optimal timetable for both experimental data took less than half an hour on average. Before TEDI, timetables were generated manually in 2-4 days. Note that FEA was enlarged by two new departments in 2001/2002-1, increasing the complexity of the problem.

As a future work, a fitness function that adaptively adjusts the penalties associated with the constraints will be tested. TEDI will be modified to handle classroom assignments and high school timetabling.

## References


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