Journal of the Applied Mathematics, Statistics and Informatics (JAMSI), **4** (2008), No. **2**

Optimizing highly constrained examination time tabling problems

EKTA SINGH, VISHWAS DEEP JOSHI AND NILAMA GUPTA

Abstract

In this paper an improvement of hybrid genetic algorithm has been described. The algorithm has been enhanced with local search operators which are based around heuristic timetabling framework. The population is seeded to produce a solution which cannot be outperformed by the heuristic method alone. A hybridization of ($\mu+\lambda$) evolution strategies algorithm with local search operators is proposed to solve the problem.

Mathematics Subject Classification 2000: 90C70, 90C99
General Terms: Genetic algorithm, local search, time tabling.

INTRODUCTION:

Timetabling is defined as the allocation subject to constraints, of given resources to objects being placed in space-time, in such a way to satisfy as much as possible desirable objectives. Time tabling is the problem of scheduling a set of events (for eg. exams, lectures and tutorials) to specific timeslots such that no person or resource is expected to be in more than one location at the same time and that there is enough space available in each location for the no. of people expected to be there. These two main fundamental constraints and many others, combine to make timetabling a classical hard problem to solve.

The algorithm we present here uses heuristic timetabling framework used in Graph coloring heuristics

EXAMINATION TIMETABLING:

The timetabling constraints have been divided into hard and soft categories based on a distinction between feasible and (near) optimal timetable.

Hard constraints are those that must be fulfilled. A timetable, which breaks a hard constraint, is not a feasible solution.

Examples of such constraints are

1. No students are allowed to seat for more than one exam in one period.
2. For each period there should be sufficient resources i.e. seats, available for all the exams that have been scheduled for that period.

   Soft constraints are those that are desirable or requested but not absolutely essential and it is impossible avoid breaking at least one of them. The soft constraints vary from one institution to another. Some soft constraints for university timetabling are as follows.

(1) Time assignment: A course / exam may need to be schedule in a particular time period.

(2) Time constraints between events: One course / exam may need to be scheduled before / after the other.

(3) Spreading events out in time: Students should not have exam in consecutive periods or two exams one the same day.

The genetic algorithm evolves new timetables, possibly reducing the length if required. This approach guarantees a feasible timetable while not potentially creating search space in which no solution exists.

HYBRID EVOLUTIONARY ALGORITHM :

1. Creation of an initial population.

2. For each population member: Generate a random ordering of exam.

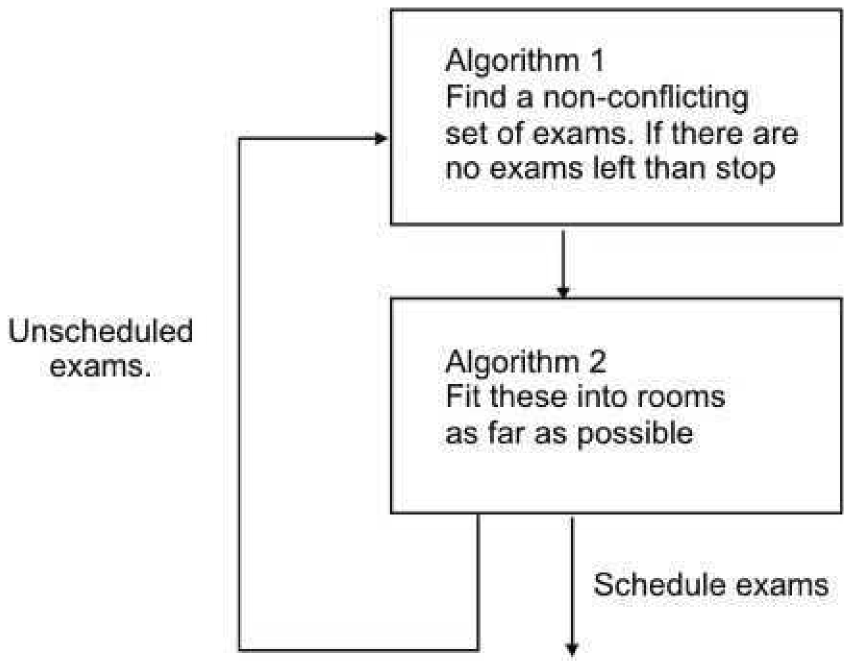
Taking each exam in turn according to that ordering.

(a) Find the first period in which the exam may not be placed without conflict, so that the no. of students does not go above a set of maximum.

(b) Place the exam in that period.

This algorithm can quickly produce large populations of random feasible timetables.

Clearly, it will not produce extremely long drawn out timetables containing unused or little used periods. The assumption is that the amount of time and space available is limited.



Time tabling framework

WORKING STRATEGY OF LOCAL SEARCH OPERATORS :

Local search operators are used. The operators work on the given solution or timetable as follows:

(i) List and mark exams should be moved to another period in such a way that a better timetable is obtained.

(ii) Move the marked exams.

(a) The process of marking the exam is presented as follows :

For each exam calculated how many students are seating for the exam in consecutive periods. The exam, index and results stored in a list are sorted. The result for each exam shows the no. of students taking the exams and also must seat for other exam before and after the period. If the result is zero that means that the exam is scheduled in a good period since there is no student seating for this exam who must also seat for other exam before and after the period. On the other hand, a non zero value means that there are some students seating for this exam who must also seat for other exams before and after the period. Therefore the exam should be schedule to another period to decrease no. of students that have exam in consecutive slots.

(b) After the marked exam, find the no of. available periods. Then a period that will give better timetable or decrease the value of objective function is selected.

(c) After all marked exams are processed, the new timetable will replace the old one if its objective function is decreased.

SELECTION OPERATORS :

The modified $(\mu+\lambda)$ selection operators are applied. The modified selection operators will maintain the diversity of individuals in a population.

In $(\mu+\lambda)$ selection, the best individuals are selected from the union of the μ parents and the λ offspring's.

Before each individual is stored in a population its similarities to others that have been in the population are measured as follows:

Given two individuals (timetables) in the population, one of them lets say A, will be stored in the population, while the other B, is already in the population.

For every exam, no. of exams that are scheduled in the same period in both timetables is calculated. The no. is divided by the no. of exam in the timetable to find the similarity index. The index will be used to determine whether the timetable above can be selected and stored in the population or not. If the similarity index is 100%, it means that both timetables are exactly the same; on the other hand if it is zero, the timetables are exactly different.

WHY LOCAL SEARCH AND MODIFIED $(\mu+\lambda)$ OPERATORS :

Modified selection operator will maintain the diversities of individuals in a population. Maintaining diversification can be used to avoid premature convergence of the algorithm towards local optimum. In this way new individuals may be systematically generated in new regions.

If local search and modified $(\mu+\lambda)$ operators are used altogether the penalty value is decreased gradually and is not trapped in local optimal.

FITNESS CALCULATION AND SELECTION :

The evaluation function can clearly be made up of any timetabling related factors. For instance, if it were hoped that larger exams appeared earlier on for marking purposes than it would be possible to include that in the function. For any problem we concentrate on two particular common requirements.

(1) The length of the timetable.

(2) The no. of conflicts between exams in adjacent periods.

Although many different alternatives are available for epitomizing a no. of semi-dependent criteria such as may be found in timetabling problem. Similar linear penalty - weighted sum is sufficient for the timetabling problem. If we wish to produce a system to be used, the working of the penalty function needs to be sufficiently clear for the use to be able to alter it usefully.

CONCLUSIONS :

An evolutionary algorithm shows great promises in the area of education timetabling, particularly in their ability to consider and optimize the wide variety of different constraints that may be found in universities. The modified selection operator maintains the diversity.

REFERENCES

'The Hitch-Hiker's Guide to Evolutionary Computation', ftp://rtfm.mit.edu/pub/usenet/news. answers/ai - fag/genetic/

ABRAMSON, ABELA, 1991 'A parallel genetic algorithm for solving the school time tabling problem', Technical Report, Division of IT., C.S.l.R.O

COLORNI A., M. DORIGO AND V. MANIEZZO, 1990 'Genetic algorithms and highly constrained problems: The Time-Table Case', Proceeding of The First International Workshop on Parallel Problem Solving from Nature, Dortmund, Germany, Lecture Note in Computer Science 496, Springer-Verlag, , pp. 55-59. Also available from http://iridia.ulb.ac.be/dorigo/ dorigo/conferences/le.O I-PSSN1.ps.gz

CORNE, D., FANG H.L., C. MELLISH, 1993 'Solving the modular exam scheduling problem with Genetic Algorithms', Proceeding of 6th International Conference on Industrial and Engineering Applications of Artificial Intelligence & Expert System.

CORNE D., PETER ROSS, H.L., FANG, 1994 'Fast practical evolutionary time-tabling', in T.C. Fogarty, 'Evolutionary Computing', AISB Workshop, Leed, UK, Selected Papers, Springer-Verlag, Berlin, , pp. 250-263

PAECHTER B., 1994 'Optimising a presentation time table using Evolutionary Algorithms, , in T.C. Fogarty, 'Evolutionary Computing', AISB Workshop, Leed, UK, Selected Papers, SpringerVerlag, Berlin, , pp. 264-275

BURKE E., D. ELLIMAN AND R. WEARE, 'Specialised recombinative operators for time-tabling problems, in , in T.C. Fogarty, 'Evolutionary Computing',

EKTA SINGH
Department of mathematics
Malaviya national institute of technology
Jaipur-302017
(Rajasthan) India
ektasingh001@yahoo.com

VISHWAS DEEP JOSHI
Department of mathematics
Malaviya national institute of technology
Jaipur-302017
(Rajasthan) India
vishijoshi@gmail.com

NILAMA GUPTA
Department of mathematics
Malaviya national institute of technology
Jaipur-302017
(Rajasthan) India
n1_gupt@yahoo.com

Received April 2008