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A self-generating memetic algorithm for examination timetabling

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1 Introduction

Timetabling problems encompasses educational timetabling, nurse rostering, transportation timetabling and so on. The educational timetabling is one of the most widely studied timetabling problems including high school timetabling, university course and examination timetabling. In this study, we focus on the examination timetabling problem, which is one of the most important and repetitive administrative activities that occur in the educational institutions. In the last ten years or so, many methodologies have been developed to solve the examination timetabling problem. An examination timetabling problem consists of the designation of a set of exams to a given set of timeslots subject to various practical constraints. The generated timetable must satisfy all the hard constraints of a problem is called a feasible timetable. The hard constraints can not be violated. Soft constraints represent preferences that can be violated, but in many cases solution approaches attempt to reduce the number of such violations as much as they can to improve the quality of a generated timetable further. More on examination timetabling can be found in Qu et al. 2009 [13]. This study presents a self-generating multimeme algorithm for solving an examination timetabling problem at Suleyman Demirel University (SDU). Unlike previous multimeme algorithms, each meme in the proposed algorithm encodes a score as a performance indicator of the associated operator. Those scores are then used in the process of choosing operators to create/modify

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new candidate solutions, self-adaptively. The results obtained on some SDU and ITC2007 problem instances indicate that the proposed approach performs reasonably well.

2 Problem Definition

Suleyman Demirel University (SDU), located in Turkey also deals with the examination timetabling issue a couple of times in a year. This problem is not that different than the examination timetabling problems faced by the other educational institutions across the world. Recently, the second International Timetabling Competition (ITC 2007) was organised [8] with the goal of providing a set of real world problem instances and determining the state-of-the-art for educational timetabling. One of the competition tracks was on examination timetabling and the instances used at the competition turned into a benchmark. SDU examination timetabling problem is formulated in the same way as in the ITC2007. The SDU problems instances used in this study will be publicly provided extending the ITC2007 benchmark instances. The properties of each SDU instance is summarised in Table 1. SDU instances do not have any room hard constraints.

Table 1 The characteristics of the SDU examination timetabling problem instances, where HC indicates the number of hard constraints and Density is the conflict density in percentage.

Problem	Density	Students	Exams	Rooms	Periods	Period HC
SDU01	3.24	10953	212	17	50	142
SDU02	5.08	11012	236	26	61	123
SDU03	1.37	24867	430	29	80	317
SDU04	12.60	8028	166	18	59	61
SDU05	3.59	12091	269	33	46	173

3 Proposed Approach

A generic *Memetic Algorithm* is an evolutionary algorithm which makes heavy use of hill climbing as introduced by Moscato in [9]. The main components of an MA are mutation, crossover and hill climbing. In this study, we describe a novel "Self-Generating Multimeme Algorithm" (SGMA) that manages 6 mutation, 2 crossover and 2 hill climbing operators. The initial population is formed using multiple constructive heuristics with the goal of generating feasible initial solutions. The main feature of the proposed algorithm is that each meme encodes a score as a performance indicator of the associated operator. During the evolutionary process, when it is time to apply an operator of certain type, e.g., mutation, one of the operators is selected and employed randomly using roulette wheel selection based on the scores of operators of that type.

Table 2 Best result obtained from SGMA for each SDU instance.

Problem	SDU01	SDU02	SDU03	SDU04	SDU05
Score	760	5880	210	20000	30

4 Experimental Results

The performance of a self-generating multimeme algorithm for the examination timetabling problem is investigated on a subset of ITC2007 and SDU instances. Each experiment is repeated 10 times and a run is terminated after 325 seconds complying with the ITC2007 competition rules. We have used a 2 Core Duo 3.16 GHz (2 GB RAM) machine during our experiments. Feasible solutions are obtained for all problem instances used during the experiments. Table 2 provides the best results obtained by SGMA over 10 runs for the SDU instances. Similarly, Table 3 presents a comparison between our approach and some selected previously proposed approaches on six ITC2007 benchmark instances based on the best result that each approach achieves. SGMA performs reasonably well in the overall. It is not the best approach, but it performs potentially better than some other memetic approaches [11]. We will be implementing different types of memetic algorithms and testing them on all ITC2007 and SDU instances as future work.

References

1. Abdul-Rahman, S., Bargiela, A., Burke, E.K., Özcan, E., McCollum, B.: Linear Combination of Heuristic Orderings in Constructing Examination Timetables. European Journal of Operational Research, **232**(2), 287–297 (2014)
2. Atsuta, M., Nonobe, K., Ibaraki, T.: Itc2007 track 1: An approach using general csp solver. http://www.cs.qub.ac.uk/itc2007
3. De Smet, G.: Itc2007 - examination track. In: Practice and Theory of Automated Timetabling (PATAT 2008), Montreal, 19-22, August (2008)
4. Demeester, P., Bilgin, B., De Causmaecker, P., Vanden Berghe, G.: A hyperheuristic approach to examination timetabling problems:benchmarks and a new problem from practice. Journal of Scheduling, **15**(1), 83–103 (2012)
5. Gogos, C., Alefragis, P., Housos, E.: A multi-staged algorithmic process for the solution of the examination timetabling problem. In: Practice and Theory of Automated Timetabling (PATAT 2008), Montreal, pp. 19–22, August (2008)
6. Gogos, C., Alefragis, P., Housos, E.: An improved multi-staged algorithmic process for the solution of the examination timetabling problem. Annals of Operation Research **3**, 1–3, (2010)
7. McCollum, B., McMullan, P., Parkes, A.J., Burke, E.K., Abdullah, S.: An extended great deluge approach to the examination timetabling problem. In: The 4th Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA09), Dublin, (2009)
8. McCollum, B., McMullan, P., Parkes, A.J., Burke, E.K., Qu, R.: A new model for automated examination timetabling. Annals of Operations Research **194**(1), 291–315 (2012)
9. Moscato, P.: On evolution, search, optimization, genetic algorithms and martial arts: Towards memetic algorithms, *Caltech Concurrent Computation Program Report* 826, California Institute of Technology (1989)
10. Müller, T.: Itc2007 solver description: A hybrid approach. Annals of Operations Research **172**(1), 429–446 (2009)

Table 3 Performance comparison of our approach to the previously proposed approaches based on the best results (scores) obtained in 10 runs over the ITC2007 benchmark instances.

	Exam 1		Exam 2		Exam 3	
Ranking	Approach	Score	Approach	Score	Approach	Score
1^{st}	Müller[10]	4370	Gogos[6]	385	Gogos[6]	8996
2^{nd}	McCollum[7]	4633	Müller[10]	400	McCollum[7]	9064
3^{rd}	Gogos[6]	4775	McCollum[7]	405	Müller[10]	10049
4^{th}	**SGMA**	**5626**	Demeester[4]	515	Gogos[5]	13771
5^{th}	Gogos[5]	5905	**SGMA**	**616**	Pillay[12]	15917
6^{th}	Demeester[4]	6060	De Smet[3]	623	Atsuta[2]	17669
7^{th}	De Smet[3]	6670	Gogos[5]	1008	Rahman[1]	19098
8^{th}	Atsuta[2]	8006	Pillay[12]	2886	**SGMA**	**19617**
9^{th}	Rahman[1]	11060	Rahman[1]	3133	Demeester[4]	23580
10^{th}	Pillay[12]	12035	Atsuta[2]	3470	De Smet[3]	x
	Exam 4		Exam 5		Exam 6	
Ranking	Approach	Score	Approach	Score	Approach	Score
1^{st}	McCollum[7]	15663	Gogos[6]	2929	Gogos[6]	25740
2^{nd}	Gogos[6]	16204	Müller[10]	2988	McCollum[7]	25880
3^{rd}	Müller[10]	18141	McCollum[7]	3042	Müller[10]	26585
4^{th}	Gogos[5]	18674	De Smet[3]	3847	Demeester[4]	27605
5^{th}	Rahman[1]	20830	Gogos[5]	4139	Gogos[5]	27640
6^{th}	Atsuta[2]	22559	Atsuta[2]	4638	De Smet[3]	27815
7^{th}	Pillay[12]	23582	Demeester[4]	4855	Rahman[1]	28330
8^{th}	**SGMA**	**30010**	**SGMA**	**5002**	Atsuta[2]	29155
9^{th}	Demeester[4]	x	Pillay[12]	6860	Pillay[12]	32250
10^{th}	De Smet[3]	x	Rahman[1]	7975	**SGMA**	**33085**

11. Özcan, E., Asta, S. and Altintas, C.: Memetic algorithms for cross-domain heuristic search. In: The 13th Annual Workshop on Computational Intelligence (UKCI), pp. 175–182 (2013).
12. Pillay, N.: A developmental approach to the examination timetabling problem. In: Practice and Theory of Automated Timetabling (PATAT 2008), Montreal, pp. 19–22, August (2008)
13. Qu, R., Burke, E.K., McCollum, B., Merlot, L., Lee, S.: A survey of search methodologies and automated system development for examination timetabling. Journal of Scheduling **12**(1), 55–89 (2009)