Hyper-heuristics and Fairness in Examination Timetabling Problems

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Outline

Background and Motivation

- Examination timetabling problem (ETP) is Well-known as challenging real world optimisation problems (NP-Hard).
- Gap between ETP formulation in scientific literature and the real-world structure, especially our suspicion that fairness among students were overlooked.

Main Contributions

Generally, the main contribution of this research is that it is the first study on investigating fairness in ETP.

Main Contributions

Survey on investigating the gap between ETP formulation in scientific literature and real-world structure (Chapter 3):

- Better understanding on students preferences over their exam timetable.
- Confirm that students concern about fairness among students, especially within their cohort.
- The different level of difficulty of exams that should be taken into account.

Main Contributions

New examination timetabling problem formulation, which is an extension of ITC 2007 formulation (Chapter 4):

- Formulation different notions of fairness in ETP.
- Formulation to take into account different level of difficulty of exams.
- Explicit Multi-objective ETP (MOETP) with different notions of fairness as well as multiple stakeholders perspective.
- New public repository for MOETP with fairness (especially cohort fairness) data set, in order to allow the problem further studied by the community.

Main Contributions

New results over ETP benchmark data sets, i.e. Carter, ITC 2007, Yeditepe, Nottingham (Chapter 5):

- Extension to HyFlex, a hyper-heuristic (HH) framework, with new problem instance, i.e. ETP with four different data sets.
- Propose a new HH strategy, i.e. hybridisation of Self-adaptive and Great Deluge algorithm to solve benchmark problem.
- New results which are very competitive with the results recently reported in the scientific literature.

Main Contributions

Propose single objective approaches within HH to enforce fairness in addition to the standard objective function:

- 'Sum of Powers' (Chapter 6).
- Multi-Stage approach (Chapter 7).

Main Contributions

Propose multi-objective objective approaches within HH over MOETP with fairness (5 variants) and MOETP with multiple stakeholders perspective:

- Pareto - Scalarisation techniques based approaches, i.e. weighted sum and weighted Tchebycheff (Chapter 8).
- Population-based Algorithms: Non-dominated sorting memetic algorithm - II (NSMA-II) and Artificial Bee Colony - Strength Pareto Evolutionary Algorithm 2 (ABC-SPEA2) in Chapter 9.
- Extension to Hyflex to cope with multi-objective problems.
- The first comprehensive study with MO approach over ITC 2007 ETP.
- The first comprehensive study over MOETP with multiple stakeholders perspective over ITC 2007.

Main Findings

- Solutions could be made fairer, in which over most problem instances, compensates on worsening the standard objective functions. The trade-off between standard objective function and fairness objective function varies among different problem instance.
- Fairness within a cohort could be enforced much more significantly than fairness among all the entire students / global fairness.
- The proposed MO approach could improve the standard objective function even better, i.e. result in best-known solution for some benchmark problem instances.
- Generally, the classical scalarisation based MOHH outperforms the population-based MOHH.

List of Publications

List of Publications:

1. Muklason A., Parkes A.J., McCollum B. and Özcan E. Cohort Fairness in Examination Timetabling Problems, PATAT 2016, 11th International Conference on The Practice and Theory of Automated Timetabling (PATAT 2016), 23-27 August 2016, Udine, Italy, 2016.
2. Muklason A., Parkes A.J., McCollum B. and Özcan E. Hyper-heuristic Approaches for Multi-Objective Examination Timetabling Problems With Fairness, to be submitted.
3. Muklason A., Parkes A.J., McCollum B. and Özcan E. Hyper-heuristics for Solving Multi-objective ITC 2007 Examination Timetabling Problem with multiple stakeholders perspective, to be submitted.
4. Muklason A., Parkes A.J., McCollum B. and Özcan E. Fairness in Examination Timetabling Problems, submitted to Journal of Applied Soft Computing, 2016 (in second review after revision).
5. Muklason A., Parkes A.J., McCollum B. and Özcan E. Fairness in Examination Timetabling Problems: A Survey and the New Problem Formulation, PATAT 2014, 10th International Conference on The Practice and Theory of Automated Timetabling (PATAT 2014), 26-29 August 2014, York, UK.
6. Muklason A., Parkes A.J., McCollum B. and Özcan E. Hyper-Heuristics for Examination Timetabling with Fairness, SCOR 2014, the 4th Student Conference on Operational Research (SCOR 2014), 2-4 May 2014, Nottingham, UK.
7. Muklason, A., Parkes, A. J., McCollum, B., & Özcan, E. (2013). Initial Results on Fairness in Examination Timetabling. Multidisciplinary International Scheduling Conference: Theory and Application 2013 (MISTA 2013), 27-29 August 2013,Ghent, Belgium.

Future Works

- More complex MOETP: multiple objectives with multiple stakeholders perspective in the first level and fairness among the same stakeholder in the second level.
- More flexible cohort notions, i.e. 'soft cohort' or 'fuzzy cohort' could be defined as follows:

$$\sum_{s_i \neq s_j, s_i \in N, s_j \in N} S(s_i, s_j) \left| P_{s_i} - P_{s_j} \right| \tag{1}$$

- MOETP with multiple fairness.
- Investigation on interaction between fairness and different difficulty level of exams.
- Further investigation on the algorithm, e.g. hybridisation weighted sum and weighted Tchebycheff, improvement on NSMA-II and ABC-SPEA2.
- Fairness in other different problems.
- Experimentation of our proposed HH over cross multi-objective problem domains instead of ETP only.