A heuristic repair algorithm for the maximum stable marriage problem with ties and incomplete lists

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Abstract

This paper proposes a heuristic repair algorithm to find a maximum weakly stable matching for the stable marriage problem with ties and incomplete lists. Our algorithm is designed including a well-known Gale-Shapley algorithm to find a stable matching for the stable marriage problem with ties and incomplete lists and a heuristic repair function to improve the found stable matching in terms of maximum size. Experimental results for large randomly generated instances of the problem showed that our algorithm is efficient in terms of both execution time and solution quality for solving the problem

Introduction

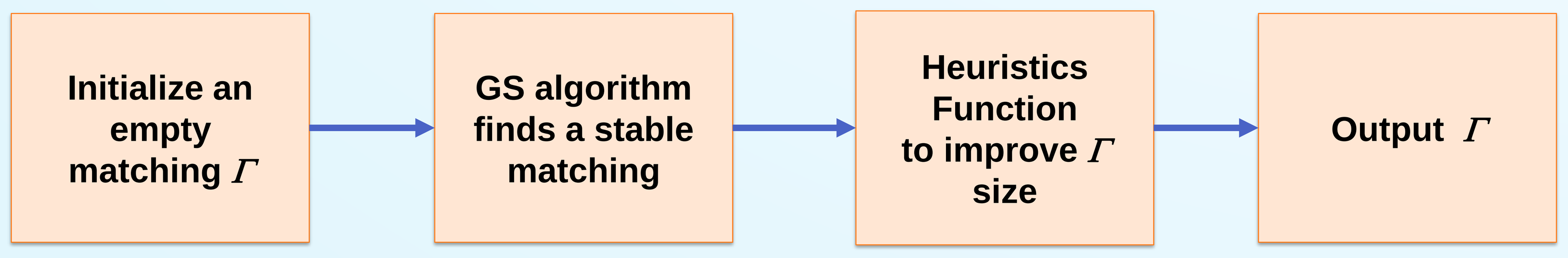
The stable marriage problem with ties and incomplete lists (SMTI) is an extension of the stable marriage (SM) problem. The SMTI problem is a well-known matching problem and recently, it has been attracting much attention from the research community due to its important role in a wide range of applications such as the Hospitals/Residents with Ties (HRT) problem, the Student-Project Allocation (SPA) problem or the Stable Marriage and Roommates (SMR) problem.

Irving et al. showed that weakly stable matchings of an SMTI instance have different sizes. In order for every person paired, we need to find a matching that is not only weakly stable but also of maximum size. This problem is known as MAX-SMTI and NP-hard and therefore, finding an efficient algorithm to solve the problem of large sizes is a challenge for researchers.

In this paper, we call a weakly stable matching a stable matching. Accordingly, we propose an approximation algorithm to solve MAX-SMTI. Our idea is to apply the Gale-Shapley algorithm (GS) for SMTI to find a stable matching. If the found matching is non-perfect, we propose a heuristic repair function to improve the matching by swapping the partners of men for single men in the matching, and then apply GS again. Our algorithm terminates when it finds a perfect matching or reaches a maximum number of iterations. Experiments show that our algorithm is efficient in terms of execution time and solution quality for solving MAX-SMTI of large sizes.

Methodology

Based on the well-known Gale-Shapley algorithm, we proposed a heuristic repair algorithm to find a maximum weakly stable matching for the stable marriage problem with ties and incomplete lists. Our algorithm idea is as follows.



Experimental Results

We have presented our experimental results in comparing the percentage of perfect matchings found by HR with that found by GSA2 (5/3–approximation algorithm) and GS as well as the execution time for finding perfect matchings.

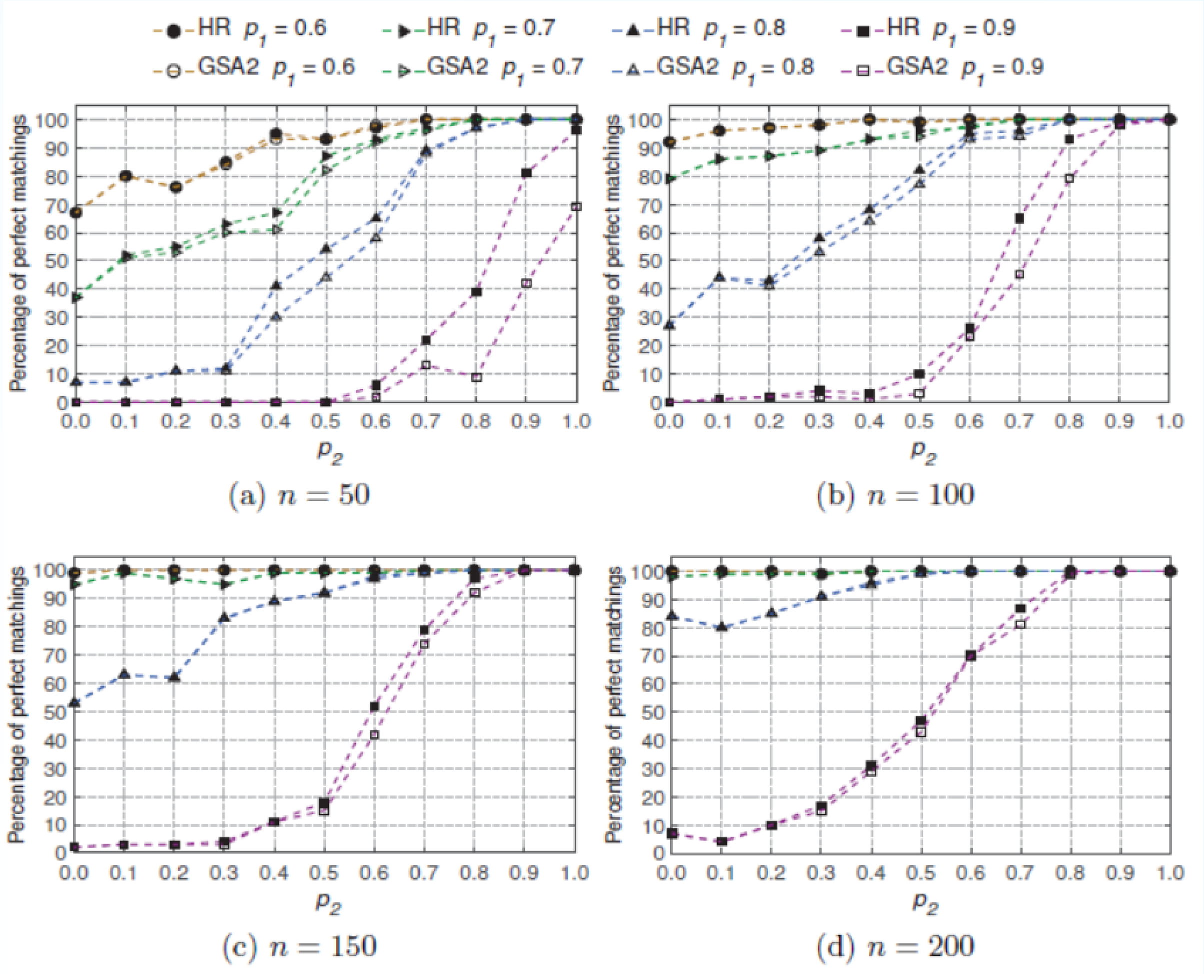


Fig. 1. Percentage of perfect matchings found for $n \in \{50, 100, 150, 200\}$

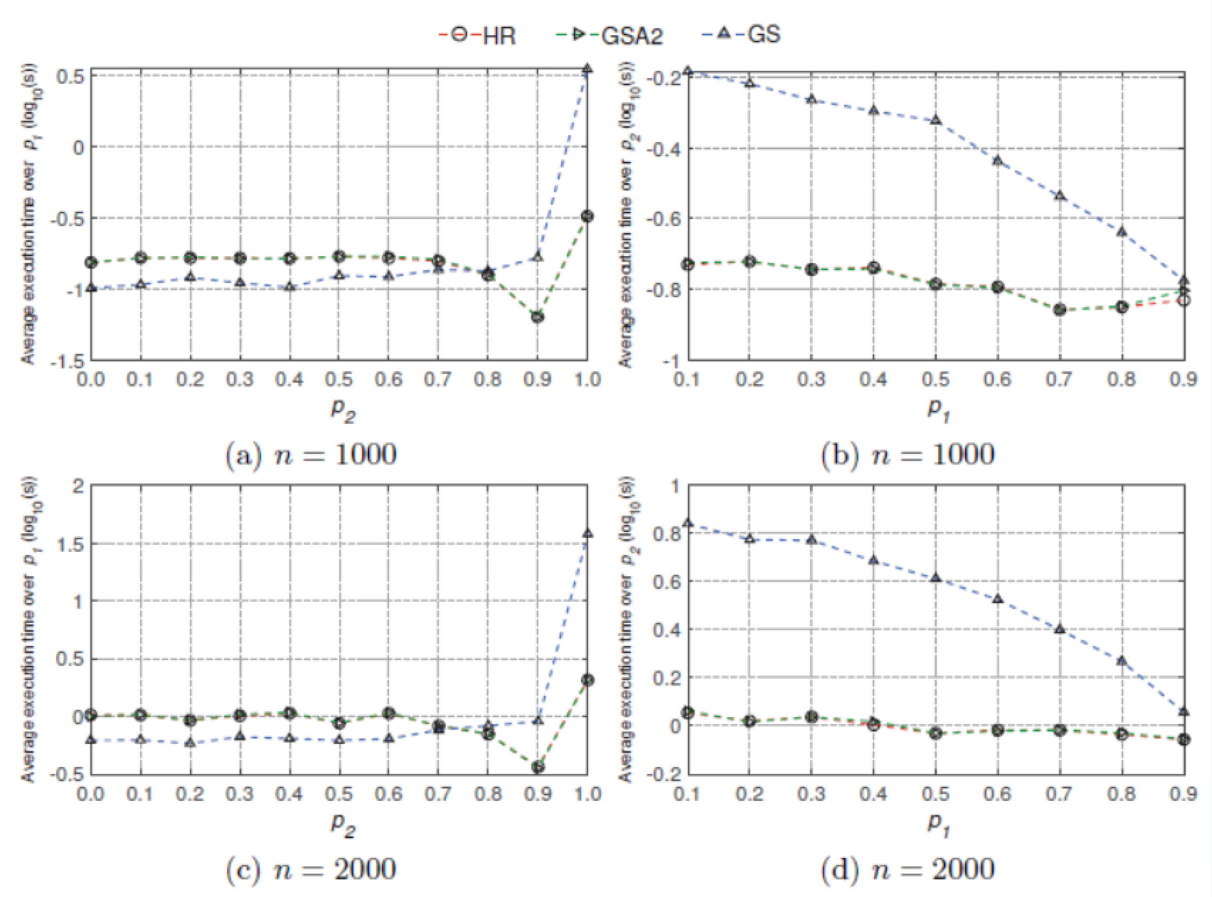


Fig. 3. Execution time for finding perfect matchings, where $p_1 \in [0.1, 0.2, \cdots, 0.9]$

Conclusions

This paper proposed a heuristic repair algorithm, namely HR, to solve the MAX-SMTI problem. HR is designed including a well-known GS algorithm to find a stable matching for the SMTI problem and a heuristic repair function to improve the quality of the found stable matching in terms of maximum size. The experimental results for large randomly generated instances of SMTI showed that HR outperforms GSA2 in terms of solution quality for finding perfect matchings of SMTI problem. In the future, we plan to extend the proposed approach to the Hospitals/Residents with Ties problem and the Student-Project Allocation problem.

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