14. 2.

Doctoral Thesis Report

Algorithms for Personnel Scheduling Enhanced by Machine Learning Techniques

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The Results of the Work

The thesis consists of three journal papers published in the impact factor journals. All three papers propose some machine learning (ML) method related to solution quality in scheduling problems. Nurse rostering problems (NRP) were mostly examined, the generality of the approach for scheduling was also discussed.

The first paper published in the Journal of Heuristics (IF 1.129) prepared Roman together with his supervisors only. He proposed classifiers which can identify promising neighbors during the search to be further examined precisely. Classifiers were shown to be the best in contrast to other ML methods. Also, the tabu search was shown to be the most important among other search methods. Altogether significant speedup for the benchmark as well as real-life instances was demonstrated while maintaining comparable quality.

The second paper was published in the European Journal of Operational Research (IF 3.428) and prepared together with supervisors and one more doctoral student Antonín Novák which role was the proposal of the initial branch and price algorithm for NRP. This thesis concentrated on the pricing component of the problem in correspondence with the completed analysis, applies the regression model to predict its upper bound using online learning from previous iterations and accelerates the search. Importantly the method preserves exactness of the underlying branch and price. The study was validated on benchmarks from NPR and time-division multiplexing to demonstrate generality.

The last paper was published in the journal Computers & Operations Research (IF 2.962) together with supervisors and other three authors. The contribution of this paper to the thesis is limited to the proposal of the regression model which can estimate processing time function related to the quality of the solution. This estimation is computed using the earlier execution of similar tasks (Section 5). The estimator was further evaluated (Section 6) in various settings of the scheduling system (including the exact knowledge about the instance difficulty) for nurse rostering tasks.

To summarize: Initially, the thesis seemed to be more or less spread into three distinct works. Now I see it as a nice study specialized in learning of complex cost functions in nurse rostering and generally scheduling problems. Machine learning allows to (1) find better solutions, (2) predict a tight upper bound for the pricing problem, and (3) estimate and relate the processing time to the quality of solution.

Thesis Structure

The initial part of the thesis introduces motivation for the work, describes NRP as the main problem studied in the thesis and discusses the algorithm design where the author argues that data-driven approach can be further investigated to take advantages from existing results. Related work is shortly addressed with the following relation to particular journal

papers. The initial part is concluded with the summary of contributions in particular papers. It is very important that contributions are summarized along with particular papers. Otherwise, it would be tough to distinguish the contributions of the thesis from the contributions of other authors. I know, it is hard, but it would be better to be more precise about the contributions of other authors. Now we need to confirm the main ideas from Section 1.5 using Acknowledgement. Still, it is not clear whether the author of this thesis has any contribution in additional improvements of the branch and price in NRP which have a significant effect on final results as it is demonstrated in Table 3 (given that I expect it is not the contribution of the thesis).

Next three chapters of the thesis discuss the main content of the thesis with the work and contributions as summarized above. Further questions to some parts of the work are provided below.

The final part of the work concludes the thesis while discussing the particular goals of the thesis and their accomplishment. Finally, we learn that author co-authored a book chapter with six other co-authors and presented his work at five conferences (all of them are short papers as far as I can understand).

Defense Questions

1. In the paper published in the Journal of Heuristics, offline learning was applied to each benchmark instance separately. Table 5 studied the impact of the changes in the problem solution of one instance. We can see that the addition of the constraints or changes in employees caused difficulties because classifier was weaker in terms of the evaluation. Can you discuss what is the role of such learning? Should we start a new offline learning process any time a new instance appear? It would be very interesting to see how the approach works on problems coming from the same (part of the) hospital and different periods of times. For example, what would be the results on February instance when learning on January instance?

2. In the paper published in the European Journal of Operational Research, we can see standard benchmark instances for NRP. In Journal of Heuristics, real-life instances were studied. What would be the results of the branch and price on these more complex problems?

Conclusions

The author of this dissertation thesis has demonstrated the ability to work independently and creatively in the specified field. The thesis includes original results published by the author of the thesis. The thesis meets the standard requirements imposed on the dissertation thesis in the field. I clearly **recommend its acceptance**.

In Brno, February 8, 2019

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