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Guest editors' introduction: special issue on Inductive Logic Programming (ILP 2019)

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This special issue contains six articles selected from submissions to the journal track of the 29th International Conference on Inductive Logic Programming (ILP 2019). ILP is a type of symbolic machine learning in which logic of first or higher order is used to represent both the data, and the models (theories) learnt. The main conference was held in Plovdiv, Bulgaria over three days, 3–5 Sep 2019, and was followed by two tutorials on 6 Sep 2019. The articles here reflect some of the salient topics of current interest to the community.

In particular, learning in higher-order logics has recently demonstrated some important advantages over the traditional first-order setting, providing facilities for predicate invention and more flexibility in the representation of background knowledge. There are two articles in this issue concerned with the topic. *Learning higher-order logic programs* by A. Cropper, R. Morel, and S. Muggleton introduces inductive techniques for the said goal by extending the recent framework of meta-interpretive learning. The authors show that compared to learning first-order programs, learning higher-order programs can significantly improve predictive accuracy and reduce learning times.

The second article, entitled *Logical reduction of metarules* by A. Cropper and S. Tourret considers metarules, which are second-order Horn clauses, as a way to define the structure of learnable programs and thus the hypothesis space. The authors study whether fragments of metarules can be logically reduced to minimal finite subsets and propose a new reduction technique called derivation reduction, which is based on SLD-resolution. The technique is shown to outperform alternative methods using subsumption and entailment on the task of reducing metarule sets. This article also received the ILP 2019 conference *Best Paper Award*, which was chosen among the long conference track papers and the papers accepted in the journal track. This award was kindly sponsored by Springer.

The next two articles demonstrate innovative applications of ILP in other fields of artificial intelligence. In particular, in the study *Constructing Generative Logical Models for Optimisation Problems using Domain Knowledge*, A. Srinivasan, L. Vig and G. Shroff

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investigate how ILP can be used to learn models that generate solution candidates in large-scale optimization problems exploiting domain knowledge such as constraints or rules of thumb. Their results suggest that generative modelling using ILP can indeed be very effective for optimisation problems with a restricted number of training instances when domain knowledge is available.

The article entitled *Inductive general game playing* by A. Cropper, R. Evans and M. Law uses ILP in the domain of game playing traditionally associated with reinforcement learning. Rather than the more usual goal of learning a game strategy, the authors consider a different yet also important problem in the domain: a learner is given game traces and the task is to learn the game rules that could produce those traces. The results show that the best performing system solves perfectly only 40% of the experimental learning tasks, which suggests that inductive general game playing poses a challenge to existing ILP methods. To motivate further research, the authors contribute a substantial evaluation data set, which is intended to continue to expand.

Transfer learning by mapping and revising boosted relational dependency networks by R. Azevedo Santos, A. Paes and G. Zaverucha describes the use of transfer learning in the context of Statistical Relational Learning from scarce data. The approach is tested on several distinct domains where it performs comparably or better than learning from scratch methods in terms of accuracy, and outperforms a transfer learning approach in terms of accuracy and runtime.

N. Lavrač, B. Škrlj and M. Robnik-Šikonja's *Propositionalization and Embeddings: Two Sides of the Same Coin* brings together two popular and successful data transformation techniques, propositionalization and embedding. The article provides a unifying framework for their understanding, and a unifying methodology that allows the user to benefit from the advantages of both approaches. Two implementations of this methodology are presented, and evaluated on several relational tasks, showing positive results.

The above six articles were selected from eight submissions, and were reviewed by a total of 15 reviewers (2.5 reviewers on average), who were recruited both from the ILP 2019 PC and beyond. Three articles were accepted after one revision, two underwent two revisions, and one required three revisions.

In conclusion, we want to express our gratitude to the authors, the reviewers, and the publisher Springer for giving us the opportunity to compile this reflection of current research in inductive logic programming. In so doing, Filip Železný was supported by the Czech Science Foundation project 20-29260S.