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GUEST EDITORIAL

Special issue on highlights of genetic programming 2019 events

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This special issue highlights particularly promising work presented at Genetic Programming events in 2019, including EuroGP'19 and GECCO'19 GP track. The European Conference on Genetic Programming (EuroGP) is the world's only conference devoted to Genetic Programming (GP). The EuroGP'19 conference was held in Leipzig, Germany, in April 2019. The conference proceedings published 18 papers (12 presented through talks and 6 through posters) from 36 total submissions. The Genetic and Evolutionary Computation Conference (GECCO) is the largest conference in the field of Evolutionary Computation, and the flagship conference of the Association for Computing Machinery (ACM) Special Interest Group on Genetic and Evolutionary Computation (SIGEVO). GECCO-GP is one of the thirteen tracks, which specifically focuses on GP. The GECCO'19 conference took place in Prague, Czech Republic, in July 2019. GECCO'19 GP track selected 15 papers from 39 submissions for full-length publications in its proceedings.

The goal of this special issue is to promote diverse and promising research being presented at the two major events in the field of GP. From each event, we selected three papers that were rated highest and considered the most inspiring as the result of our rigorous review process for both conferences. Their authors were invited to expand their original work and submit an extended version to this special issue. In the case of a conflict of interest between an editor and the authorship of a paper, the paper was handled by other editors. These submissions went through the journal's extensive review process, re-reviewed by their original conference program committee members, as well as additional external reviewers. This ensures the highlighted

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research and their extended versions meet the highest scholarly standards and helps the research reach a wider audience.

The article authored by Kocnova and Vasicek tackled a significant real-world application problem, optimizing digital circuits. They proposed a local evolutionary resynthesis method which used Cartesian GP to optimize sub-circuits from a complex circuit and then implanted them back to the original circuit. This strategy was shown to be very efficient at removing redundant gates. A significant performance improvement was also observed in comparison with the traditional method of globally optimizing entire large-scale circuits.

In the article authored by Atkinson et al., a new recombination method, called horizontal gene transfer (HGT) was proposed for a graph-based GP algorithm, evolving graphs by genetic programming (EGGP). The authors identified neutral and active components in the representation of an individual and used active components from one individual to replace neutral components in another. This recombination strategy was implemented with elitism and was shown to be able to achieve superior performance on benchmark symbolic regression problems, compared with other related GP algorithms.

In Helmuth et al.'s article, the authors examined lexicase selection on its characteristic of selecting specialist individuals. As a recently proposed parent selection mechanism for GP, lexicase selection filters the population by considering one random training case at a time, eliminating any individual with an error for the current case that is worse than the best error of any individual in the selection pool, until a single individual remains. It, therefore, favors specialist individuals that have low errors on some training cases but high errors on others. This differentiates lexicase selection from traditional selection mechanisms, e.g., tournament selection, where an individual is selected based on aggregating errors. The authors pointed out that such a specialist-selecting feature explains lexicase selection's improved performance compared with tournament selection.

The highly redundant genotype–phenotype mapping of a small linear GP system was analyzed by Hu et al. They applied the principles of complex network analysis to quantify the mutational connections among phenotypes. They revealed that some phenotypes are more difficult to find than others, not only because they are underrepresented in genotypic space, but also because the target phenotype is connected to only a few phenotypes that are distant from the rest of the phenotypes. These observations could be utilized to design more efficient search strategies in the future.

The paper written by Lensen et al. used multi-objective GP to address the manifold learning problem, i.e. an unsupervised learning problem based on the observation that most high-dimensional data can be represented in a much lower-dimensional space. The proposed method can automatically find a good trade-off between the dimensionality of the embedded manifold and manifold quality. In addition to obtaining state of the art results on common benchmarks, they showed that their system has the potential to evolve interpretable manifolds.

Finally, La Cava and Moore present an approach to regression, by using GP to learn sets of features. Their multidimensional GP approach is interesting in the sense that, instead of evolving single expression trees, each individual consists of a set of expressions. During evaluation, coefficients are evolved for each of those

expressions (using a Machine Learning method such as Ridge Regression), whereas the internal edges of each expression have associated weights optimised by gradient descent. Combined with a semantic crossover operator, they achieve state-of-the-art results in a set of regression benchmarks, when compared to other GP and machine learning approaches.

Such a collection of articles includes theoretical investigation of GP algorithms, proposal and analysis of new operators, and exploration of significant application problems. They collectively showcase the active and interesting research in the GP community and the great potential of GP.

We thank all the authors who submitted their outstanding research to this special issue and all the reviewers who dedicated their time and scientific expertise to ensure the quality of the published articles. We also thank Sarvagnan Subramanian for his editorial help and Springer for making this special issue a reality. Finally, we would like to thank the Editor-in-Chief, Lee Spector, for all his encouragement and guidance during the process and his constant support and dedication to the GP community.