

COMPUTER AND CONTROL ENGINEERING

ADA University - Emerging Topics in Evolutionary Computation: Diversity Promotion and Graph-GP

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Supervisor	SQUILLERO GIOVANNI - giovanni.squillero@polito.it
Contact	Alberto Tonda (INRAE Université Paris-Saclay)
Context of the research activity	<p>Soft Computing, including evolutionary computation (EC), is currently experiencing a unique moment. While fewer scientific papers focus solely on EC, traditional EC techniques are frequently utilized in practical activities under different labels. The objective of this analysis is to examine both the new representations that scholars are currently exploring and the old, yet still pressing, problems that practitioners are facing.</p> <p>Politecnico di Torino will reserve this position to selected candidates from ADA University according to the Cooperation Agreement in the framework of IAU University.</p>
	<p>Although the classical approach to representing solutions in EC involves bit strings and expression trees, far more complex encodings have been recently proposed. More specifically, graph-based representations have led to novel applications of EC in circuit design, cryptography, image analysis, and other fields.</p> <p>At the same time, divergence of character, or, more precisely, the lack of it, is widely recognized as the most impairing single problem in the field of EC. While divergence of character is a cornerstone of natural evolution, in EC all candidate solutions eventually crowd the very same areas in the search space, such a "lack of speciation" has been pointed out in the seminal work of Holland back in 1975. It is usually labeled with the oxymoron "premature convergence" to stress the tendency of an algorithm to convergence toward a point where it was not supposed to converge to in the first place. The research activity would tackle "diversity promotion", that is either "increasing" or "preserving" diversity in an EC population, both from a practical and theoretical point of view. It will also include the related problems of defining and measuring diversity.</p> <p>The research project shall include an extensive experimental study of existing diversity preservation methods across various global optimization problems. Open-source, general-purpose EA toolkits, inspyred and DEAP, will also be used to study the influence of various methodologies and</p>

Objectives	<p>modifications on the population dynamics. Solutions that do not require the analysis of the internal structure of the individual (e.g., Cellular EAs, Deterministic Crowding, Hierarchical Fair Competition, Island Models, or Segregation) shall be considered. This study should allow the development of a, possibly new, effective methodology, able to generalize and coalesce most of the cited techniques.</p> <p>During the first year, the candidate will take a course in Artificial Intelligence, and all Ph.D. courses of the educational path on Data Science. Additionally, the candidate is required to improve the knowledge of Python.</p> <p>Starting from the second year, the research activity shall include Turing-complete program generation. The candidate will work on an open-source Python project, currently under active development. The candidate will try to replicate the work of the first year on much more difficult genotype-level methodologies, such as Clearing, Diversifiers, Fitness Sharing, Restricted Tournament Selection, Sequential Niching, Standard Crowding, Tarpeian Method, and Two-level Diversity Selection.</p> <p>At some point, probably toward the end of the second year, the new methodologies will be integrated into the Grammatical Evolution framework developed at the Machine Learning Lab of University of Trieste ? GE allows a sharp distinction between phenotype, genotype and fitness, creating an unprecedented test bench (the research group is already collaborating with a group in UniTS on these topics, see "Multi-level diversity promotion strategies for Grammar-guided Genetic Programming" Applied Soft Computing, 2019).</p> <p>A remarkable goal of this research would be to link phenotype-level methodologies to genotype measures.</p> <p>Target Publications</p> <p>Journals with impact factors</p> <ul style="list-style-type: none"> - ASOC - Applied Soft Computing - ECJ - Evolutionary Computation Journal - GPem - Genetic Programming and Evolvable Machines - Informatics and Computer Science Intelligent Systems Applications - IS - Information Sciences - NC - Natural Computing - TCIAIG - IEEE Transactions on Computational Intelligence and AI in Games - TEC - IEEE Transactions on Evolutionary Computation <p>Top conferences</p> <ul style="list-style-type: none"> - ACM GECCO - Genetic and Evolutionary Computation Conference - IEEE CEC/WCCI - World Congress on Computational Intelligence - PPSN - Parallel Problem Solving From Nature
Skills and competencies for the development of the activity	<p>Proficiency in Python (including deep understanding of object-oriented principles and design patterns, and handling of parallelism); Preferred: Experience with metaheuristics, Experience with optimization algorithms.</p>