Evolutionary Computation for the Design of General Purpose Artificial Intelligent Systems (GPAIS)

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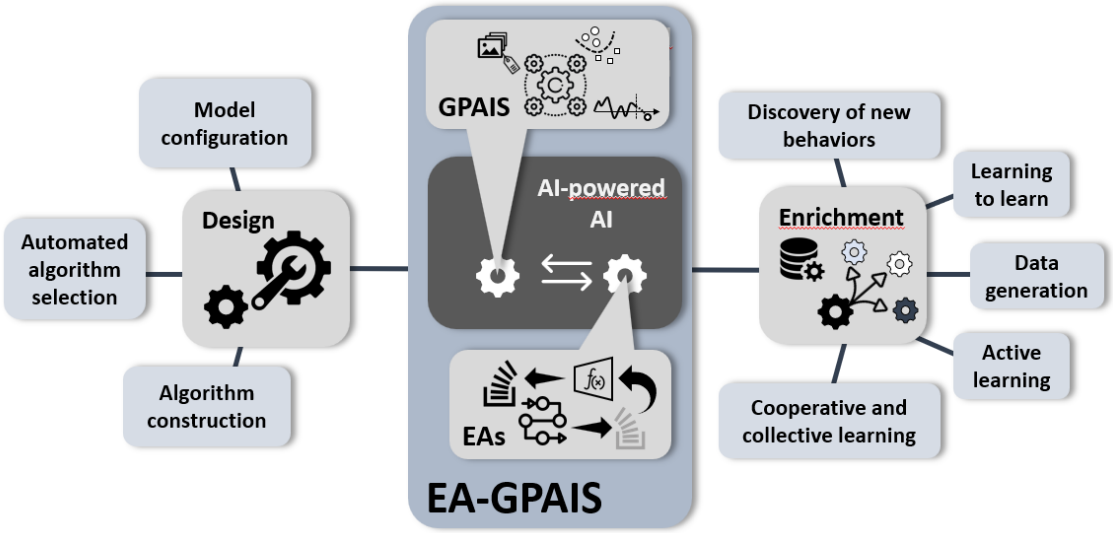
Abstract:

In Artificial Intelligence, there is an increasing demand for adaptive models capable of dealing with a diverse spectrum of learning tasks, surpassing the limitations of systems devised to cope with a single task. The recent emergence of General-Purpose Artificial Intelligence Systems (GPAIS) poses model configuration and adaptability challenges at far greater complexity scales than the optimal design of traditional Machine Learning models. Evolutionary Computation – and in general, bio-inspired optimization – has been a useful tool for both the design and optimization of Machine Learning models, endowing them with the capability to configure and/or adapt themselves to the task under consideration. Therefore, their application to GPAIS is a natural choice.



In this tutorial, we will first provide a discussion around the definition of GPAIS, articulating a definition that allows for a gradual differentiation among types of GPAIS according to their properties and limitations. We will present a taxonomy of approaches to realize GPAIS, describing research trends such as the use of AI techniques to improve another AI (commonly referred to as AI-powered AI) or (single) foundation models. We will then analyze the important role of Evolutionary Computation in the design of GPAIS under the AI-powered AI paradigm. We will examine various case studies in which Evolutionary Algorithms can either help design these systems or enhance them towards improving their performance in close-world or open-world scenarios. We also present different strategies followed to this end, discussing on tangential areas, recent contributions, identifying research niches, and outlining potential research directions.

This emerging field holds the promise of revolutionizing AI, unfolding a new and exciting landscape of new research directions and practical applications leveraging the synergy between Evolutionary Computation and GPAIS. Towards the end of the tutorial and with the goal of providing a holistic view of GPAIS, we discuss the current state of GPAIS, its prospects, implications for our society, and the need for regulation and governance of GPAIS to ensure their responsible and trustworthy development.

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- Introduction and motivation
- Definition and taxonomy for GPAIS
- Evolutionary Computation for the Design of GPAIS
    - Motivation for EC-powered GPAIS
    - Strategies to realize EC-powered GPAIS
    - Research advances and case studies
    - Research niches and challenges

- Prospects and implications of the need for regulation and governance of GPAIS in the context of safe and responsible AI

Intended audience and expected enrollment:

Expected Length: 2 hours

Level: Introductory

This 2-hour introductory tutorial is aimed at all those researchers involved in the development of data science solutions based on computational intelligence, with an emphasis on evolutionary computation. The audience will also be able to understand the impact of the use of such kind of approaches in the most advanced AI systems.

Isaac Triguero's Bio:

Isaac Triguero received his M.Sc. and Ph.D. degrees in Computer Science from the University of Granada, Granada, Spain, in 2009 and 2014, respectively. He is a currently enjoying a Distinguished Senior Research Fellowship at the University of Granada. His work is mostly concerned with the research of novel methodologies for big data analytics. Dr Triguero has published more than 90 international publications in the fields of Big Data, Machine Learning and Optimisation (H-index=35 and more than 5700 citations on Google Scholar). He is a Section Editor-in-Chief of the Machine Learning and Knowledge Extraction journal, and an associate editor of the Big Data and Cognitive Computing journal and the IEEE Access journal. He has acted as Program Co-Chair of the IEEE Conference on Smart Data (2016), the IEEE Conference on Big Data Science and Engineering (2017), and the IEEE International Congress on Big Data (2018). Dr Triguero is currently co-leading two projects on General Purpose Artificial Intelligence: a €1.6M University-Industry Research Grant funded by the European Union-Next Generation EU as well as a €120K Knowledge Generation Project, funded by the Ministry of Science, Innovation and Universities of Spain.

Daniel Molina's Bio:

Daniel Molina received his M.Sc. and Ph.D. degrees in Computer Science from the University of Granada, Granada, Spain, in 2000 and 2007, respectively. He is currently an Assistant Professor at the University of Granada. Since his Ph.D., he has been extensively working on Memetic Algorithms, particularly in Large-Scale Global Optimization and Neuroevolution. Dr. Daniel Molina has published 40 papers in international journals, 30 of them in Q1 journals, with over 13,000 citations (source: scopus.com), positioning him among the top 2% most influential researchers in Stanford. Dr. D. Molina is currently co-leading a General Purpose Artificial Intelligence project, a €120K Knowledge Generation Project, funded by the Ministry of Science, Innovation and Universities of Spain. He is an Associate Editor in Swarm and Evolutionary Computation. In Large-Scale Global Optimization, he has obtained two international awards, and within this line, he has driven several initiatives, such as organizing numerous competitions and special journal

issues on this topic, and serving as the Chair of the IEEE Task-Force on Large-Scale Global Optimization (2015-2019). Regarding Neuroevolution, he has published various articles in prestigious journals and supervised a thesis.

Bing Xue Bio:

Bing Xue is a Fellow of IEEE and Fellow of Engineering New Zealand. She is currently Professor of Artificial Intelligence, Deputy Head of School for Engineering and Computer Science, Deputy Director of Centre for Data Science and Artificial Intelligence, at Victoria University of Wellington (VUW). Her research focuses mainly on machine learning and evolutionary computation, such as evolutionary deep learning, feature selection, and image analysis, and their real-world applications in aquaculture, marine science, biology, healthcare, forest, and others. She has over 400 fully refereed publications and leading several prestigious research grants. She has been organising many international conferences, such as General/Conference Chair of PRICAI 2025, IVCNZ 2025 and EuroGP 2025, Conference Chair of IEEE CEC 2024 and EuroGP 2024. She has also served as an Associate Editor of several international journals, such as IEEE TEVC, IEEE TAI, IEEE CIM, and ACM TELO.