Summarized CV of Francisco Chicano

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Scientific production

Francisco Chicano has 36 publications in journals indexed by Clarivate JCR, 6 publications in other journals, 10 book chapters, 39 publications in conferences listed in the CORE ranking (1 in A*, 25 in CORE A, 11 in CORE B and 2 in CORE C), 27 publications in other international conferences and 27 publications in national ones. He has been awarded with 6 best paper awards in international conferences (GECCO 2008, ISDA 2011, EvoCOP 2012, twice in GECCO 2018 and EvoCOP 2019) and got 6 best paper nominations (GECCO 2007, GECCO 2011, GECCO 2012, GECCO 2015, GECCO 2017, EvoApps 2021). He has been proceedings editor in 10 conferences (4 national and 6 international). He has h-index of 33 according to Google Scholar.

Research activities

Dr. Chicano is (or has been) involved in 8 national research projects, (one as co-PI), 1 European project, 1 regional project (Junta de Andalucía), 4 local projects (Universidad de Málaga), in two as PI, and 12 transference contracts with companies and institutions. He has been awarded with a "José Castillejo" 10.500€ grant to do a research stay in the Computer Science Department of Colorado State University and a Fulbright grant (only 5 in Spain in 2013). It was also awarded in 2022 with a mobility grant (more than 8.000€) to do a research stay at the Université de Lille and INRIA in summer 2022.

Research management and organization

Francisco Chicano is in the **editorial board** of Journal of Systems and Software, Evolutionary Computation Journal, Mathematical Problems in Engineering, Engineering Applications of Artificial Intelligence, Electronics and is **Area Editor** in ACM Transactions on Evolutionary Learning and Optimization. He has been guest editor in IEEE Transactions on Evolutionary Computation (special issue on Theoretical Foundations of Evolutionary Computation), Algorithmica (special issue on selected papers of Theory @ GECCO 2015) and Journal of Heuristics (special issue on Metaheuristics for COP). He has been **editor-in-Chief** in GECCO 2021 and has been **Track Chair** in GECCO 2013, GECCO 2015, GECCO 2019 and GECCO 2020, **Program Chair** in EvoCOP 2015 and EvoCOP 2016. He has also been **Workshop Organizer of the QuantOpt Workshop** in GECCO 2022 and 2023 (focused on Quantum Computing and Optimization), **Track Chair** in the SBSE Track of JISBD since 2015 to 2017, 2021 and 2022, General Session Chair of CAEPIA 20/21, Late-Breaking Abstract Chair in GECCO 2016, Proceedings Chair in GECCO 2017, Electronic Media Chair in GECCO 2018 and Publication Chair in Smart-CT 2016 and 2017.

Mentoring experience

Francisco Chicano is or has been co-advisor of 8 PhD students (4 of them completed), 5 master students (plus currently advising 5) and advised the undergraduate thesis of more than 40 students.

Description of the Research Group

The NEO Research Group (https://neo.lcc.uma.es) is part of the Institute of Software Engineering and Technology (https://itis.uma.es) and the Department of Languages and Computer Science of the University of Malaga (Spain). NEO is composed of both young and experienced researchers with **multidisciplinary research abilities** in the field of applied artificial intelligence and optimization. Application domains include Software Engineering, Smart Cities, Transport and Logistics, Telecommunications and Bioinformatics. The group also has experience **producing software prototypes and open-source code** (see our GitHub site at https://github.com/NEO-Research-Group). NEO has many international collaborators and is visited by international researchers (around 5 or 6 every year, except during COVID-19 pandemics).

The group is currently composed of 11 members (9 doctors and 1 PhD student, 1 Master student). **Dr. Enrique Alba**, head of the group (now in Brussels, as seconded national expert of ERC), **Dr. Francisco Chicano** (quantum computing, search-based software engineering, combinatorial optimization), **Dr. Zakaria Dahi** (quantum computing and evolutionary computation); **Dr. Gabriel Luque** (metaheuristics, high-performance computing, dynamic problems, software development); **Dr. Javier Ferrer** (automatic test case generation using AI, logistics); **Dr. Rubén Saborido** (automatic refactoring to improve software quality and non-functional requirements); **Dr. Jamal Toutouh** (smart cities, machine learning and generative models); **Dr. Christian Cintrano** (smart cities and software development); **Dr. José Ángel Morell** (ubiquitous computing and federated learning); **Mg. Diego Pedroza** (AI applied to smart mobility), **Ms. Irene Suárez** (AI applied to smart mobility).

The selected candidate student will integrate fully with the NEO group, participating in seminars, scientific meetings, social activities, etc. We will provide office space, as well as access to all the facilities of the university (library access and computational resources). We can also provide a desktop computer if the student is not bringing his/her own laptop. We have a cluster of computers specially for the NEO group to run the experiments. The group participates in several international collaborations and projects, including the TAILOR network (Trustworthy AI - Integrating Learning, Optimisation and Reasoning, https://tailor- network.eu/).

Project #1: Embedding in Quantum Annealers

Quantum Computing is a new computing paradigm that promises to yield a revolution in Computer Science, due to the quantum physics features that exploits to do computations. Entanglement, and, specially, superposition are quantum effects that allow to speed up computations compared to the performance in a classical machine and open the door to computations that are not practical in a classical computer, like quantum mechanics simulations.

Two main kinds of quantum computers exist: quantum-gate computers and quantum annealers. Quantum annealers solve optimization problems formulated as Quadratic Unconstrained Binary Optimization (QUBO). While QUBO is a well-known and old problem, the recent interest in quantum computing encouraged researchers to better understand QUBO and provide methodologies to transform optimization problems into QUBOs. Formally, an instance of QUBO is a function $f(x) = x^T Q x + a$, where Q is a $n \times n$ real matrix and a is a real constant.

Quantum annealers are composed of qubits with some links between them. A quantum annealer is characterized by an architecture, which is a graph $G(V, E)$ where V is the set of qubits and E is the set of interconnections between those qubits. Typically, not all the qubits are linked between them. Some examples of architectures are D-Wave's chimera and pegasus. To solve a QUBO in a quantum annealer, we need to map each variable to a set of physical qubits and assign a weight to the edges between qubits. The mapping must be in such a way that variables with a nonzero interaction in the QUBO are mapped to sets of qubits that are adjacent in the quantum annealer architecture. This is finding a minor embedding of the graph representing the VIG of the QUBO to the architecture. There can be many possible minor embeddings and not are equally good, according to the number of qubits used or the errors obtained after the computation.

The goal of this project is to apply evolutionary computation to find minor embeddings of graphs representing a QUBO problem into a quantum annealing architecture.

Tasks

1. Study the minor embedding problem and the embedding techniques used in practice in real quantum annealers
2. Propose a representation for the minor embedding problem and a metaheuristic algorithm to solve it
3. Run a set of experiments to check and improve the performance of the algorithm
4. Write the proposal and results in a paper to be submitted to Evostar 2024 or 2025.

References

1. Kochenberger, Gary; Hao, Jin-Kao (2014). "The unconstrained binary quadratic programming problem: a survey" (PDF). Journal of Combinatorial Optimization. 28: 58–81. doi:10.1007/s10878-014-9734-0. S2CID 16808394.
2. D-Wave. QPU architecture. https://docs.dwavesys.com/docs/latest/c_gs_4.html

Project #2: Efficient crossover operators for permutation problems

Partition crossover is a very efficient crossover operator that is able to find the best of an exponential number of potential offspring in linear time. The operator was originally defined for TSP (Whitley et al., 2008) and later defined for the binary representation, where it can be applied to any k-bounded pseudo-Boolean optimization problem (Tinós et al., 2015). It has been also recently extended to QAP (Abdelkafi et al., 2022).

The key ingredient of Partition Crossover is the decomposition of the objective function as a sum of non-interacting subfunctions. In the binary case, these non-interacting subfunctions can be computed from the so-called recombination graph, which is derived from the Variable Interacting Graph by removing the variables that take the same value in both parent solutions. In the case of permutation problems, like TSP, a graph is also used to define the non-interacting subfunctions.

This operator can also be extended to other permutation problems, like the Linear Ordering Problem (LOP) or the Single Machine Total Weighted Tardiness Problem (SMTWTP), but this possibility has not been explored yet (the algorithm is clear for the PI of the project, but not implemented). The goal of this project is to design, implement and check the performance of a version of Partition Crossover applied to permutation problems for which no Partition Crossover variant exists (e.g., LOP and SMTWTP).

Tasks

1. Study the state of the art in Partition Crossover
2. Implement a partition crossover variant that can be applied to Linear Ordering Problem and Single Machine Total Weighted Tardiness Problem
3. Run a set of experiments to check the performance of the proposed partition crossover in Evolutionary Algorithms and Iterated Local Search
4. Write a paper with the findings to Evostar 2024 or 2025.

References

1. Renato Tinós, L. Darrell Whitley, Francisco Chicano: Partition Crossover for Pseudo-Boolean Optimization. FOGA 2015: 137-149 https://doi.org/10.1145/2725494.2725497
2. L. Darrell Whitley, Doug Hains, Adele E. Howe: Tunneling between optima: partition crossover for the traveling salesman problem. GECCO 2009: 915-922 https://doi.org/10.1145/1569901.1570026
3. Omar Abdelkafi, Bilel Derbel, Arnaud Liefooghe, Darrell Whitley: On the Design of a Partition Crossover for the Quadratic Assignment Problem. PPSN (1) 2020: 303-316 https://doi.org/10.1007/978-3-030-58112-1_21

Other relevant information

About the city

Málaga is a vibrant and welcoming city in the south of Spain. Due to its international airport and the beauty of its coast, it receives international tourists for most of the year, making it easy to navigate for international students even without knowing Spanish. There is an active and outgoing expat community from many countries, including UK, France and Germany. If desired, there is the possibility of arranging single-room accommodation in student residences if requested well in advance. Living costs in Málaga are lower than in other parts of Spain, including Madrid, Valencia and Barcelona, and significantly lower than in most West European cities.

More information here: https://visita.malaga.eu/en/