

SPECIES Scholarships – Advisor/Host Institution Application

1. Short CV of the advisor

PERSONAL INFORMATION

Family name/surname: Giovanni Iacca

Date/place of birth: 27/04/1982, Taranto (Italy)

Personal web site: <https://sites.google.com/site/giovanniacca/>

EDUCATION

2017: Habilitation as Associate Professor in Computer Science, Italian Ministry of Universities

2011: PhD in Mathematical Information Technology, University of Jyväskylä, Finland

2006: Master in Computer Engineering, Technical University of Bari, Italy

WORK EXPERIENCE

2018-present: Tenure-track assistant professor, University of Trento, Italy

2017-2018: Postdoctoral Researcher, RWTH Aachen University, Germany

2013-2016: Postdoctoral Researcher, University of Lausanne and EPFL, Switzerland

2012-2016: Postdoctoral Researcher, INCAS³, The Netherlands

2006-2009: Software Engineer (1 FTE), Sintesi, Bari, Italy

TEACHING ACTIVITIES

2019 – present: Lecturer, "Computer Architectures", University of Trento, Italy

2018 – present: Lecturer, "Bio-Inspired Artificial Intelligence", University of Trento, Italy

2014 – 2016: Teaching assistant, "Bio-Inspired Artificial Intelligence", EPFL, Switzerland

2014 – 2016: Teaching assistant, "Mobile Robots", EPFL, Switzerland

2009 – 2010: Lecturer, "Protocols & fieldbus", CNR Master in Industrial Research, Italy

AWARDS (SELECTED)

2017: Evostar 2017 Best Paper Award

2012: UKCI AWARENESS Best Paper Award

GRANTS (SELECTED)

2015-2019: Co-applicant and work package leader of FET-Open project "PHOENIX"

ORGANIZATION OF SCIENTIFIC MEETINGS (SELECTED)

2017-present: Co-organizer of various Evostar tracks/special sessions

2017-2018: Co-organizer of EIEHSCoEvo (workshop, part of GECCO)

REVIEWING ACTIVITIES (SELECTED)

- Panel member for scientific conferences, such as: CEC, SSCI, MSC, WICT, ICCSII, ICA, Robionetics, TIME-E, GECCO, PPSN, Evostar, NaBIC, SEMCCO, SCIS-ISIS, ISDA, SoCPaR
- Reviewer for scientific journals, such as: Scientific Reports, IEEE Trans. on Evolutionary Computation, IEEE Trans. on Cybernetics, Engineering Optimization, Information Sciences, Expert Systems with Applications, Applied Soft Computing, Soft Computing, PLOS ONE

MEMBERSHIPS OF SCIENTIFIC SOCIETIES (SELECTED)

SPECIES, COST Action ImAppNIO, CINI AIIS, various EURO working groups

2. Description of the research group

The visiting PhD student will be hosted in the Distributed Intelligence and Optimization Lab (DIOL) at the Department of Information Engineering and Computer Science (DISI) of the University of Trento (UNITN), Italy. The group is led by Dr. Giovanni Iacca, currently affiliated at DISI as tenure-track assistant professor, and its main research focus is on **bio-inspired computational methods applied to optimization and distributed systems**. The group is also actively involved in dissemination and teaching activities in the field of Bio-Inspired computational methods. In particular, every year Dr. Iacca gives an elective Master course on “Bio-Inspired Artificial Intelligence” (6 ECTS), which is attended on average by 30 students (of which approximately one third are international) from different backgrounds, i.e. Computer Science, Data Science, TLC Engineering, Quantitative & Computational Biology, Mathematics, Physics. The course is considered by the students one of the most successful and interesting Master courses given at DISI.

The DIOL currently hosts three PhD candidates, one visiting PhD student, and an average of ten research interns and master/bachelor students¹. More specifically:

- The three ongoing PhD projects, which started in November 2019, are focused, respectively, on neuro-evolution for distributed, cooperative tasks (PhD candidate: Leonardo Lucio Custode); estimation distribution algorithms for quantum annealers (PhD candidate: Le Hoa Nghiem); online machine learning & optimization techniques for predictive maintenance (PhD candidate: Hyunho Mo).
- In the period February-July 2020, the DIOL will host a visiting PhD student (Ahmed Djilali) from the University of Tlemcen, Algeria, as part of an ERASMUS+ agreement. During this period, the visiting PhD student will investigate the use of multi-objective evolutionary algorithms applied to the optimization of automated storage/retrieval systems (AS/RS).
- Most of the interns/students (of which some are international) have previously attended the course “Bio-Inspired Artificial Intelligence” and later only joined the DIOL. These students are currently working (or have worked) on various topics related to evolutionary computation and machine learning, such as neuro-evolution and adversarial training, evolution of communication and network protocols, influence maximization in social networks, evolutionary robotics and swarm intelligence, quality diversity mechanisms, constrained optimization, very large-scale optimization, agent-based simulations, and their applications.

Overall, the DIOL research group is very dynamic and international. It has been growing quite rapidly (the group leader started his affiliation at DISI two years ago), as it managed to attract the interest of several students fascinated by bio-inspired computing. One of the main strengths of the group is that it leverages complementary expertise, maintaining a strong focus both on algorithmic and applied research.

Dr. Iacca is now engaged in attracting additional funding for students and PhD/postdoc fellowships.

¹ See <https://sites.google.com/site/giovanniacca/team> for the updated lists of the DIOL group members.

3. Description of the work to be carried out by the student

A family of EAs that are particularly interesting from both theoretical and practical viewpoints is called "compact" Evolutionary Algorithms² (cEAs), which is a class of Estimation of Distribution Algorithms (EDAs) that instead of evolving a population of solutions build a probabilistic model (one for each variable), sampled at each step of the algorithm to generate new solutions and updated according to their fitness. An important advantage of cEAs is their limited memory footprint: differently from population-based EAs, where at least p n -dimensional arrays need to be stored in memory (being p the population size and n the problem dimension, with p generally being in the order of tens), cEAs need to store only the probabilistic representation of the distribution (typically, 2-4 n -dimensional arrays). This feature makes cEAs especially suited for embedded systems, although recently they have also been used for solving very large-scale optimization problems, i.e. problems ranging in the order of millions of variables, as shown by Deb and Myburgh³, who used a GPU-based compact Genetic Algorithm to solve problems scaled up to $2e30$ dimensions. It is therefore of great interest to study ways to make cEAs scalable and efficient at solving very-large scale problems, as those that might be found for instance in deep learning training.

The perspective visiting PhD student will focus his/her research on the scalability of cEAs, especially in comparison with modern (linear complexity and/or matrix-free) variants of CMA-ES^{4,5}, the state-of-the-art in continuous black-box optimization. Scalability might be attained for instance by considering hybridization with other single-solution optimization algorithms, decomposition techniques, and possibly quantum-inspired principles (this last aspect might be investigated with the help the PhD student who is currently working on quantum annealing, as discussed in the previous section). GPU-enabled implementations of cEAs will also be considered as a way to speed up the computation and scale the experiments up to problems in the order millions of variables: for this, it will be possible to use existing code that has recently been developed by one of the interns at the DIOL.

A tentative outline of the activities that will be carried out by visiting PhD student will be:

1. Initially, the student will get familiar with the existing code and computing environment. The first experiments will replicate results from the literature.
2. One or more alternative mechanisms to improve algorithmic scalability will be tested on scalable benchmark functions (such as those used in CEC and BBOB competitions) in the order of hundreds/thousands of variables. Results will be compared with state-of-the-art algorithms for large-scale-optimization and CMA-ES variants.
3. The most promising mechanisms will be tested further on scalable benchmark problems in the order of hundred thousands/millions of variables.
4. Finally, one or two practical applications will be considered for evaluation, such as the scheduling problem discussed by Deb and Myburgh³, or the training of a deep network with millions of parameters (compared with gradient-based approaches).
5. Finally, a paper will be prepared, to be submitted to Evostar 2021.

² F. Neri, et al., "Compact Optimization", Handbook of Optimization, Springer 2013

³ K. Deb, C. Myburgh, "Breaking the billion-variable barrier in real-world optimization using a customized evolutionary algorithm", Proceedings of GECCO, ACM 2016

⁴ J. Arabas, D. Jagodzinski, "Towards a Matrix-free Covariance Matrix Adaptation Evolution Strategy", IEEE TEVC 2020

⁵ I. Loshchilov, et al, "Large scale black-box optimization by limited-memory matrix adaptation," IEEE TEVC 2018

4. Other information

As for the Host Institution, UNITN is a medium-sized university (with more than 16000 students and almost 700 faculty members), constantly ranked among the best Italian Universities, according to national and international rankings. Notably, UNITN is part of the European Consortium of Innovative Universities (ECIU), which is the leading international consortium of research-intensive universities, with collective emphasis on innovation, creativity and societal impact, driving the development of a knowledge-based economy.

Within UNITN, in particular the Department of Information Engineering and Computer Science (DISI) is an international working environment whose research is especially focused on systems and networks, artificial intelligence, signal processing, embedded systems, remote and distributed sensing, cybersecurity and computer vision. DISI has a strong success record on several European competitive funding schemes (such as ERC and FET projects), as well as regional/national funds. DISI has also important existing facilities that will be available to the visiting PhD student, among which an HPC with more than 4000 CPU cores and 37000 GPU CUDA cores⁶, an IoT/WSN testbed including more than 100 nodes, and a laboratory of robotics.

The accommodation and bureaucracy necessary to welcome the visiting PhD student will be handled by the Mobility Office of DISI⁷, which has a longstanding experience in handling the needed paperwork for both EU and non-EU countries and is always available for facilitating the arrival of new researchers and students. If needed, additional funding (to extend the visiting period of up to three additional months, but also for travelling) might be provided to the visiting PhD student, for instance by local funds or by means of the ERASMUS+ program or other international mobility funds. Nevertheless, the SPECIES fellowship allowance would be enough to cover all accommodation and living expenses for three months, considering that the cost of living in Trento is relatively cheap compared to much bigger cities.

Last but not least, the city of Trento is a fascinating old town -with a typical Northern Italy medieval style- surrounded by an amazing mountain landscape. It is constantly ranked among the first three Italian cities for its quality of life. The city is relatively small, with a population of almost 120.000 people, but its center is vibrant and full of restaurants, bars and opportunities for social life. The city also hosts the famous Science Museum (MUSE), which has hosted almost 3 million visitors since 2013. Trento is also well-known for its passion for sports (especially basket, volley, winter sports), and its many sport facilities. Public transportation is extremely efficient and well-organized (and it's basically free for Bachelor, Master and PhD students). For instance, some of the most beautiful Dolomites locations (which are part of the UNESCO world heritage) can be reached within just one hour by local bus and trains.

⁶ <https://sites.google.com/unitn.it/hpc/home>

⁷ <https://www.disi.unitn.it/education/international-mobility>