



Title: Symbolic Regression by Grammatical evolution. Solving real world problems.

Short CV of the advisors

José Manuel Colmenar is a Computer Science Engineer since 2001 and PhD from the Complutense University of Madrid since 2008. His main research interests are related to the application of metaheuristics to combinatorial optimization problems as well as the application of evolutionary and bio-inspired algorithms to the optimization of real problems, with special emphasis on obtaining models for time series. Throughout his research career he has co-authored 38 publications indexed in JCR (19 Q1, 14 Q2, 2 Q3 and 3 Q4). According to the Web of Science database, he is co-author of 55 publications and accounts for more than 230 cites, reaching a h-index of 9. Among these publications, he is co-author of contributions to national and international conferences, related to the research lines in which he has worked. It is worth noticing that he has not only contributed to the design and development of new algorithms, but he has also worked in two areas that are very important for society. On the one hand, he has worked on the modeling of energy demand, a problem which is closely related to the global concern of the reduction of energy consumption. On the other hand, he has collaborated on the research about the artificial pancreas, co-authoring works about software applications for patients, as well as for glucose modeling, aiming to improve the quality of life of persons with this disease. Besides, he is co-inventor of a national patent related to the glucose modeling. Since 2001 he has participated as a researcher in national competitive projects uninterruptedly, being the PI on a competitive national project since January 2019. He has active collaborations with researchers from abroad. In particular, it is worth mentioning his collaborations with researchers from the University of Upper Austria or the University of Coimbra, among others. In addition, he is an active reviewer in relevant journals, as accredited in his Publons profile, and has collaborated with the industry by means of different Art. 83 contracts. He is co-advisor of a PhD thesis, finished in January 2017 and, in addition, he is currently advising two PhD students from the GRAFO research group, co-authoring 2 JCR indexed publications with them. He belongs to the steering committee of the GRAFO research group and, since 2018, he organizes an annual research meeting for the PhD students called "Workshop GRAFO". He is **Professor at Universidad Rey Juan Carlos (URJC)** since December 2019, and has served as Chair of the Degree in Software Engineering at URJC from January 2018 to January 2020. Since February 2020, he has been the Deputy Director of Academic Planning of the School of Computer Engineering of the URJC. In the teaching field, he has taught subjects of careers related to Computer Engineering from the academic year 2001-2002 to the present. In addition, he has participated in conferences about teaching innovation.

J. Ignacio Hidalgo is Full Professor at Complutense University of Madrid since 6-june-2019. 26 years of teaching and research experience. Computer Architecture Department, Computer Science Faculty, UCM. Degree in Physics (1994), Electronics and PhD in Physics (2001), Computer Science and Automation with thesis on partitioning and placement methods in Multi-FPGA systems based on GAs. From 2013 I am Principal Investigator of the Adaptive and Bioinspired Systems (ABSYS) group. Since 1995 I have been working in the development and implementation of evolutionary algorithms (EAs) applied to optimization problems and RWA. Since 2008 these tasks are joined in national projects and we apply AE techniques to the thermal improvement of MPSoC architectures in 3D and to logistics problems using the same algorithms in a project of the National Plan of i+D+I of which I was principal investigator. I have also been PI of another project of the Plan Nacional de i+D+I, within the INNPACTO program that has resulted in 3 doctoral theses, completed in April-2014. I was advisor of a doctoral thesis in 2013, in which the application of EA for the optimization of the call management system of the Telefónica Call Center, currently in use, was collected. Since 2010 I have collaborated with the Hospital V. de la Salud Toledo and Hospital Univ. Príncipe Asturias (Madrid) for the application of evolutionary techniques in the improvement of diabetes control: Result are publications in 1st third (J Of Biomedical Informatics and Applied Soft Computing) in which I appear as first author and other 14 publications in journal and several CORE A congress. I collaborate with other organizations (CSIC, UPV, DFA) in the application of AEs to different optimization problems from which JCR publications have been derived. I belong to the Program Committee of 3 most important conferences in the area; Evo*-Evo Apps (Co-Chair), IEEE CEC and ACM Gecco. I have conducted research and teaching stays at University of Applied Sciences of Upper Austria- Heuristic-Lab (2016,14 weeks) MIT (2012, 6), EPFL (2010, 5), U. P. Mozambique (2014,3), CNR-Pisa-Italy (2000, 25) and collaborations with Univ. of Nottingham, University of Coimbra and CSIC-CNIM leading to JCR publications such as Acta Materialia. In total I have supervised 9 PhD theses, I am co-directing another 5, to be defended in a gradual way in the next 3 years. In total, I have published 58 articles in IF-JCR journals, 18 of them in Q1. In relation to the project, the group I lead is internationally recognized, being referenced in most publications on glucose prediction with GE, and I have been invited to be part of the program committee of several workshops on the subject. 4 six-year research periods (1995-2000)(2001-2006)(2007-2012) (2012-2018), Google Scholar data No. of publications 118/94, Citations 1639/694, index h 19/ 14 ; Google Scholar: U0-TP94AAAAAAJ, Scopus: 7101787656 ; 17 competitive projects (7 as PI), 6 non-competitive projects (4 of them article 83, 1 as PI). Inventor of two patents and one utility model.



Description of Adaptive and Bioinspired systems (ABSYS) research group and GRAFO groups

The **Adaptive and Bioinspired Research Group (ABSYS)** research group is coordinated by **J. Ignacio Hidalgo** (Full Professor) and **Oscar Garnica** (Associate Professor) at **Universidad Complutense de Madrid (UCM)**. The group has been economically funded under different grants during the last 10 years and has been successfully applying Evolutionary Algorithms, Neural Networks (both software and hardware implementations) and other IA solutions to real-world problems, which has led to significant knowledge transfer results in patents (2), software applications and hardware prototypes. Apart from 4 National research grants and two additional grants of highly competitive programs (Madrid Synergy grant and Biomedical project grants) of the regional research agency of Madrid, Absys received in 2021 the Roche Foundation's research award on personalized precision medicine and a Grant from Eugenio-Rodriguez-Pascual Foundation for biomedical research. **Hidalgo** is currently PI of 4 competitive projects, has supervised 9 PhD theses, 7 of them related to parallel evolutionary computing and AI applications and 2 in energy consumption reduction and asynchronous systems. He has published 58 articles in IF-JCR journals. **Garnica** has broad experience in computer architecture and ASIC design both in academia and industry. He has been an ASIC design engineer in Lucent Bell Labs Innovations and LSI, Inc. and IP of several projects with Indra and Crisa (Airbus group) to develop and verify FPGAs. He holds two awards and two mentions (Roche 2020, DATE 2001, SiPS 2001, and CACSD 2001), and 97 publications in journals and conferences in topics of hardware design, low-power circuits, asynchronous processors, and more recently, the application of AI to bioengineering. He has supervised 3 PhD theses.

The objectives of ABSYS research group is the design and implementation of Adaptive and Bioinspired Systems to solve optimization and modeling problems. In the past we worked in the application of ideas taken from parallel, cluster and grid computing to algorithms inspired by nature and the application of Bioinspired Algorithm for solving optimization problems with special emphasis on parallel architectures and embedded systems optimization problems. Since 2011 we have been developing our research around real world applications with special emphasis on medical problems. Our group has published several publications on Glucose time Series Prediction, Diabetes Management, hypoglycemia prognosis and Obesity..

GRAFO research group¹ belongs to the **Rey Juan Carlos University (URJC)**, a public university in Madrid with more than 40K students. GRAFO conducts research into relevant problems in both science and engineering. GRAFO mainly focuses on optimization problems such as: ordering problems (with applications in VLSI design or in the efficient resolution of systems of equations); location problems (with interest in telecommunication applications such as distribution of signal regenerators or network design); graph-based problems (with applications in the distribution of electronic devices in electronic boards or in image segmentation), routing problems (by focusing on multi-objective problems with applications in the transport of hazardous materials or in recommendation systems), or selection problems (with applications in the construction of diverse groups or clustering of documents). We provide solutions to those problems for which general and specifically tailored solutions or existing procedures have failed to provide satisfactory results. To this end, we employ the most advanced optimization technologies from computer science, artificial intelligence and operations research.

Description of the work to be carried out by the student

GRAFO and ABSYS have been developing during the last years a tool for symbolic regression based on Evolutionary Computation with special interest in Grammatical Evolution². The main objective of the project to be developed during the stay is to improve the current Grammatical Evolution library developed by former members of the research group and to include other algorithms in both the Web³ and the Desktop applications^{4,5}. To this aim, the new proposals will be studied from the theoretical point of view, and tested on different target problems. The student will be involved both in research and development tasks. In particular, several development tasks related to Grammatical Evolution will be needed, in order to implement the proposals of the advisors. For the development tasks, Java and Python programming skills are required. In the application area the granted person will tackle problems related to bioengineering and other topics. We will also study different configurations of the algorithms comparing several evolutionary computation algorithms vs other machine learning approaches and classical regression techniques.

¹ <https://grafo.etsii.urjc.es/>

² <https://github.com/ABSysGroup/jeco>

³ https://link.springer.com/chapter/10.1007/978-3-031-02462-7_18

⁴ <https://link.springer.com/article/10.1007/s00500-020-05062-9>

⁵ https://link.springer.com/chapter/10.1007/978-3-319-78717-6_15



Other relevant information

The student will work at the [Faculty of Computer Science](#) (Facultad de Informática) of the Complutense University of Madrid (UCM). The Faculty of Computer Science building was inaugurated in March 2003 and holds approximately 2,000 students. The building is located in the Moncloa campus of the UCM. A wonderful environment in the center of Madrid, with more than 70.000 students and 6000 Professors. The campus is well connected by Metro and several buses. UCM was a pioneer in Spain in the area of Computer Science when it introduced it as a research and teaching field more than half a century ago.

Already in the 50's there was a research group at UCM in close relationship with other groups at Cambridge and Harvard, universities where what we know today as Computer Science was being developed. In the 60's, doctoral courses were taught in these topics, as well as international courses in the field of UNESCO. In the early 70's, before the creation of the first Faculties of Computer Science in the country, the UCM established Computer Science specialties in the Bachelor's Degrees of Physics and Mathematics.

In October 1991, the School of Computer Science was created at UCM, which later, in April 2000, changed its name to the Faculty of Computer Science. It has been teaching the three official university level degrees: Computer Engineering, Technical Engineering in Computer Management and Technical Engineering in Computer Systems. Our Faculty has been the most demanded university center in the Community of Madrid for the three degrees offered. Of the eight Spanish Nobel Prize winners, seven studied or were professors at the UCM. Among them, the Nobel Prize winners in Medicine Severo Ochoa and Santiago Ramón y Cajal and the Nobel Prize winners in Literature José Echegaray, Camilo José Cela, Vicente Aleixandre, Jacinto Benavente and Mario Vargas Llosa.

Additional funding for accommodation can be provided depending on the progress of the work. Accommodation is available in the Campus in Several Houses of Residence and offers single rooms at a reasonable price. UCM will provide a place in the Lab with a monitor and other computing resources if requested.

Ideally the intention is to start working on the project at least a month before the arrival of the student.