ArcelorMittal & ArcelorMittal Global R&D

ArcelorMittal is the world's leading steel and mining company, with a presence in 60 countries and primary steelmaking facilities in 16 countries. In 2021, ArcelorMittal had revenues of $76.6 billion and crude steel production of 69.1 million metric tonnes, while iron ore production reached 50.9 million metric tonnes. Our goal is to help build a better world with smarter steels. Steels made using innovative processes which use less energy, emit significantly less carbon and reduce costs. Steels that are cleaner, stronger and reusable. Steels for electric vehicles and renewable energy infrastructure that will support societies as they transform through this century. With steel at our core, our inventive people and an entrepreneurial culture at heart, we will support the world in making that change. This is what we believe it takes to be the steel company of the future. ArcelorMittal is listed on the stock exchanges of New York (MT), Amsterdam (MT), Paris (MT), Luxembourg (MT) and on the Spanish stock exchanges of Barcelona, Bilbao, Madrid and Valencia (MTS).

ArcelorMittal Global R&D employs 1,500 full-time researchers at 11 geographical sites and 12 research centers strategically placed in Europe, North and South America and close to key operations and customers. These centers are where new steel products, processes and solutions are envisioned, tested, improved and deployed. ArcelorMittal invests in R&D activities that keep us at the forefront of innovation and put us ahead of the competition as the material and steel manufacturer of choice for our customers. More info: https://corporate.arcelormittal.com/

ArcelorMittal Global R&D SAB and KiN

Global R&D SAB is one of the centers in ArcelorMittal Global R&D network. An R&D Campus of almost 20000m^2 in 3 Locations (2 in Asturias: Avilés and Gijón and 1 in the Basque Country: Sestao) employs a wide team of young talented people coached by seniors working globally for all Arcelormittal. The activity develop in the center is divided in 4 different technical directions aligned with the group strategical priorities

- Digitalization
- Decarbonization & Sustainability
- Process & Product Technologies
- Additive Manufacturing

The research team where the student would develop its activity is the Business and Technoeconomic Team (KiN Area), that is part of the Digitalization Direction in ArcelorMittal Global R&D SAB in Spain (Asturias location). The objective of the team is to offer a global service to the company developing decision support systems, based on AI (Machine Learning, Optimization, Evolutionary Computation, etc) to help transversal teams to make better decisions. Our research is totally applied, and we are in constant and direct contact with the business part of our company.

Although our research is applied, we actively participate in scientific communities as part of our research mission, attending research conferences and organizing/participating in events as for example the IAM workshop at GECCO (Industrial Application of Metaheuristics) that we organize every edition together with Iridia, the Artificial Intelligence Laboratory at ULB (free University of Brussels).

Some examples of publications of our team:

- Fernandez, Silvino; Alvarez, Segundo; Díaz, Diego; Iglesias, Miguel; Ena, Borja. *Scheduling a galvanizing line by ant colony optimization*, International Conference on Swarm Intelligence, 146-157,2014, Springer.
- Fernández Alzueta, Silvino; Díaz Fidalgo, Diego; Manso Nuño, Tatiana; Suárez Rodríguez, Montserrat; *Optimization Techniques to Improve the Management of a Distribution Fleet in the Steel Industry*, Third International Conference on Multidisciplinary Design Optimization and Applications, 2010
- Fernández, S.; Álvarez, S.; Malatsetxebarria, E.; Valledor, P.; Díaz, D. *Performance Comparison of Ant Colony Algorithms for the Scheduling of Steel Production Lines*, Genetic and Evolutionary Computation Conference,1387-1388, 2015, ACM
- Fernández, Silvino; Valledor, Pablo; Diaz, Diego; Malatsetxebarria, Eneko; Iglesias, Miguel; *Criticality of Response Time in the usage of Metaheuristics in Industry*, Proceedings of the 2016 on Genetic and Evolutionary Computation Conference Companion, 937-940,2016.
- Pellicer, Pablo Valledor; Escudero, Miguel Iglesias; Alzueta, Silvino Fernández; Deb, Kalyanmoy; *Gap finding and validation in evolutionary multi-and many-objective optimization*, Proceedings of the 2020 Genetic and Evolutionary Computation Conference, 578-586, 2020.

Asturias

The Principality of Asturias is located in the North of Spain occupying a territory of 10,603 km2 and is home of 1M people. It is bordered on the West by Galicia, in the North by the Cantabrian Sea, on the East by Cantabria and to the South by the province of León. The capital of the Principality of Asturias is Oviedo, with the city of Gijón being the largest one. Other significant towns in the region are: Avilés, Langreo, Mieres, Pola de Siero, Cangas de Onis and Llanes.

The international airport of the Principality of Asturias is located in the locality of Santiago del Monte in Castrillon, which is at the center of the province and is only 10 minutes drive from Aviles and 40 from Oviedo and Gijón.

There is an extensive rail network managed by FEVE at regional and local level and RENFE providing national services. Currently an AVE high-speed train line in under construction which will reduce travel time between Asturias and Madrid significantly.
There are two main national motorways crossing the province and a wide and well-maintained network of roads. This makes possible to cross Asturias from one extreme to another in a maximum of three hours. Source and more info: https://whereisasturias.com/so-where-is-asturias/.

Avilés

Avilés is a commercial town of medieval origin and long-standing maritime tradition, it boasts an old quarter dotted with mansions, gardens, fountains, churches, arcaded houses, and more... all of which lend it a unique atmosphere. The size and proportions of its estuary, and the fact that it passes right through the heart of the city, make Avilés the only city in Asturias with a major river flowing at the foot of the old town, one of the best preserved in all of Northern Spain.

The city has an artistic calling besides being open to innovation. What's more contemporary Avilés also experienced a major industrial revolution in the form of the steel industry, which has lent it the post-industrial 'appearance' that inspired the genius of architecture Oscar Niemeyer to design the last of his major international projects, a cultural center that bears his name and is a symbol of the urban and sociological renewal the city has undergone.

Main things to see in Avilés:

1. The old quarter of Avilés is one of the best preserved in Asturias and constitutes an example of civil and religious architecture ranging from the Middle Ages right up to the present day.
2. Avilés Estuary is one of the most beautiful natural estuaries in Asturias. Restored environmentally, it has a pathway with views of the marina and its related activities, the Niemeyer Centre, etc.
3. The Niemeyer Centre, the last and most important work in Europe by Brazilian architect Oscar Niemeyer, is a facility that adds both an innovative touch and a new skyline to the city.
4. Shopping in Avilés. The city constitutes an ideal place to shop, especially the old part of the town - Calle de la Cámara and surrounding streets -, home to the old food market, which has recently undergone a successful 'restyling'.

Source and more info: https://whereisasturias.com/so-where-is-asturias/.

Supervisor from Industry: Silvino Fernandez Alzueta

Silvino Fernández Alzueta is a R&D Engineer at the Global R&D Division of ArcelorMittal for more than 15 years. He develops his activity in the ArcelorMittal R&D Centre of Asturias in Spain, in the framework of the Business and TechnoEconomic project Department (KiN). He has a Master Science degree in Computer Science, obtained at University of Oviedo in Spain, and also a Ph.D. in Engineering Project Management obtained in 2015. His main research interests are analytics, metaheuristics and swarm intelligence, and he has broad experience using these techniques in industrial environment to optimize production processes. His research is 100% applied. His paper "Scheduling a Galvanizing Line by Ant Colony Optimization" obtained the best paper award in the ANTS conference in 2014.

CV: https://www.linkedin.com/in/silvinofernandezalzueta/

Publications: https://scholar.google.es/citations?user=rn-lkyUAAAAJ

Supervisor from Academia: Manuel López-Ibáñez

Senior Lecturer (Associate Professor) 2018 – Present
at Alliance Manchester Business School, University of Manchester, UK.

The University of Manchester
Alliance Manchester Business School

Academic Qualifications
PhD from Edinburgh Napier University, United Kingdom, 2009
Ingeniero en Informática (Spanish equivalent of MS degree in Computer Science), University of Granada, Spain, 2004

Research Interests
I am interested in improving the understanding of **optimization algorithms** by empirical means, and I am particularly interested in **multi-objective multidisciplinary problems** arising from logistics, manufacturing, bioinformatics, etc. These interests include **evolutionary algorithms**, **matheuristics**, **metaheuristics** and **stochastic local search methods**, their **automatic selection, configuration (hyper-parameter optimization)** and design, and **expensive black-box optimization**, including **Bayesian optimization.**

Publication Track-Record and Citations
32 journal papers (26 in journals indexed ISI-JCR, 21 in Q1), 9 book chapters and 55 papers in peer-reviewed proceedings of international conferences, and edited 6 books.
According to the Google Scholar database (or SCOPUS and excluding self-citations):

- H-index: 35 (SCOPUS : 27)
- Total number of citations: More than 5739 (SCOPUS: 3147)

Selection of Software Published **(complete list:** http://lopez-ibanez.eu/research **)**

- **irace R package:** Automatic configuration (offline tuning) of optimization algorithms. More than 108,000 downloads (April, 2021) https://mlopez-ibanez.github.io/irace/
- **eaf R package:** Performance assessment of multi-objective optimizers. More than 78,000 downloads (April 2021) https://mlopez-ibanez.github.io/eaf/

Recent Publications **(complete list:** http://lopez-ibanez.eu/publications)

5. Juan Esteban Diaz and Manuel López-Ibáñez. **Incorporating Decision-Maker's Preferences into the Automatic Configuration of Bi-Objective Optimisation Algorithms**. *European Journal of Operational Research*, 289(3):1209–1222, 2021. Editor's Choice Award.
6. Leonardo C. T. Bezerra, Manuel López-Ibáñez, and Thomas Stützle. **Automatically Designing State-of-the-Art Multi- and Many-Objective Evolutionary Algorithms**. *Evolutionary Computation*, 28(2):195–226, 2020.
7. Javier Ferrer, Manuel López-Ibáñez, and Enrique Alba. **Reliable Simulation-Optimization of Traffic Lights in a Real-World City**. *Applied Soft Computing*, 78:697–711, 2019.
8. Manuel López-Ibáñez, Jérémie Dubois-Lacoste, Leslie Pérez Cáceres, Thomas Stützle, and Mauro Birattari. The ir**ace Package: Iterated Racing for Automatic Algorithm Configuration.** *Operations Research Perspectives*, 3:43–58, 2016.
(*1033 citations according to Google Scholar)*
9. Leonardo C. T. Bezerra, Manuel López-Ibáñez, and Thomas Stützle. **Automatic Component-Wise Design of Multi-Objective Evolutionary Algorithms.** *IEEE Transactions on Evolutionary Computation*, 20(3):403–417, 2016.

Mentoring Experience
Currently supervising 5 PhD students (2 as main supervisor), 5 other PhD students successfully completed their PhD. I have also supervised more than 20 MSc dissertations.

What you can expect from this experience

This scholarship has been thought to give an opportunity to work immersed in an industrial environment, working at the same time together with cutting edge scientific academic research teams. The candidate chosen will live the experience of applying academic research to real industrial problems, demonstrating their usability and potential benefits. At the end of the scholarship a paper will be published with the results and conclusions of the work, but more important, demonstrating how he/she has reduced the gap between academia and industry.

The scholarship will have an extra funding of 900 euros/month, doubling the regular assignment, that is, a total 1800 euros/month for 3 months.

Description of the work to be carried out by the student

The selected student will work in one of the two projects described below for 3 months at the **Business and Technoeconomic Team (KiN Area), that is part of the Digitalization Direction in ArcelorMittal Global R&D SAB in Asturias, Spain.** The student will be hosted by the team of Silvino Fernandez Alzueta (Industry Supervisor) and hold regular meetings with Dr. Manuel López-Ibáñez (Academic supervisor).

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Project #1: Feature Selection for Large-Scale Algorithm Selection

In (automatic) algorithm selection (AS) [1], an algorithm or algorithm configuration is automatically selected from a portfolio according to the features of the problem instance to be solved. While academic problems often have very few relevant features, many real-world scenarios provide hundreds of potentially relevant features. In particular, in a recent work (unpublished yet) on applying AS to an industrial solver used by Arcelor-Mittal for a real-world industrial production problem, the data available contained more than one-hundred static features. We already have a working algorithm selector and preliminary results with basic feature selection approaches such as Forward Sequential Selection [2].

The main goal of this project is to extend this work and examine other feature selection methods (possibly including if the student is interested, Deep Learning approaches [3]). Since the algorithm selector is already implemented and tested and the data is available, the project can start immediately by evaluating existing feature selection approaches (those provided by Scikit-learn). Nevertheless, devising original methods that go beyond the state-of-the-art would be welcome.

A secondary goal of this project is to compare the feature selection methods in terms of their *explainability*, that is, how understandable are the decisions made by the method when selecting/discarding features. An *a priori* analysis of the data available can identify correlations between features, however, it is an open question what other insights can be revealed. Researchers interested in Explainable ML/AI are welcome to apply, but it is not a prerequisite.

This project offers the candidate the opportunity to learn about a real-world application of algorithm selection and advanced techniques in feature selection, in addition to developing skills in experimental design and analysis. The candidate will be supervised by a joint team consisting of Dr Manuel López-Ibáñez and researchers from Arcelor-Mittal with expertise in optimization and machine learning. In addition to a conference paper in the next Evo*, the results of the research can potentially lead to a journal publication and serve as the starting point for a series of studies. There will be the possibility of creating an open-source package from work developed during the project after removing any data or heuristics of a commercially sensitive nature.

The tasks of the student would be (with help from the host supervisor):

1. Research feature selection approaches for AS that are able to handle hundreds of features.
2. Select or devise 2 or 3 of such methods, implement them and evaluate them on the algorithm selector and data already available.
3. Evaluate the select methods according to their performance and computational cost (training and selection time).
4. (Optional) Evaluate the selected methods according to their explainability.

Pre-requisites:

- Knowledge about optimization, machine learning and feature selection.
- NO knowledge about the real-world problem is required.
- Basic programming skills in Python. The algorithm selector and feature selection methods available are implemented in Python. If you are willing to reimplement them in another language, such as R, this would also be an option.

References:

1. Pascal Kerschke, Holger H. Hoos, Frank Neumann, and Heike Trautmann. **Automated Algorithm Selection: Survey and Perspectives**. *Evolutionary Computation*, 27(1):3–45, March 2019.
2. F. J. Ferri, P. Pudil, M. Hatef, and J. Kittler. **Comparative study of techniques for large-scale feature selection**. In Pattern Recognition in Practice IV, 1994. doi: 10.1016/b978-0-444-81892-8.50040-7.
3. Mohamad Alissa, Kevin Sim, and Emma Hart. **Algorithm Selection Using Deep Learning without Feature Extraction**. In M. López-Ibáñez, A. Auger, and T. Stützle, editors, *Proceedings of GECCO 2019*, pages 198–206, New York, NY, 2019. ACM Press.

ArcelorMittal

Project #2: Simultaneous Algorithm Selection and Configuration

In (automatic) algorithm selection (AS) [1], an algorithm or algorithm configuration is automatically selected from a portfolio according to the features of the problem instance to be solved. In a recent work (unpublished yet) on applying AS to an industrial solver used by Arcelor-Mittal for a real-world industrial production problem, we build a selector that given a new instance chooses one out of 64 configurations. These configurations were generated based on human experts and latin hypercube sampling from a candidate space of millions of possible configurations, thus it is likely that better configurations exist.

The goal of this project is to work on methods that are able to automatically find good configurations to become part of the algorithm portfolio. Existing approaches [2] are based on iteratively adding configurations to the portfolio that complement the ones already present. The approach has several well-known drawbacks that result in a relatively slow process.

The goal of this project is to devise and implement new methods for configuring such a portfolio for algorithm selection using the state of the art configuration tool irace [3]. The host (ArcelorMittal) will provide access to real-world data from the above-mentioned industrial production problem, together with an existing implementation (in Python) of an algorithm selector. Moreover, the candidate will have access to the solver used by ArcelorMittal to generate additional data. Computational resources and technical support will be provided throughout the project by the supervisor at ArcelorMittal and its team engineers, while academic guidance will be provided by Dr Manuel López-Ibáñez.

This project offers the candidate the opportunity to learn about automatic configuration tools such as irace [1], work on a real-world problem with a professional team of optimization and machine learning engineers, and develop new methods for building algorithm selection portfolios that will have an impact beyond this particular project. Besides publishing a summary of the project in the next Evostar conference, the aim is to develop a general method, benchmark it in several public benchmarks, and publish the complete study in a high-quality journal.

The tasks of the student would be (with help from the supervisors):

1. Implement the strategy proposed in [2] using irace. A prototype implementation exists (in R).
2. Review or devise new strategies that take advantage of the prediction model to focus the search on the hardest instances or poorest configurations.
3. Compare and analyse the various methods on the real-world industrial production problem.

Pre-requisites:

- Excellent programming skills in Python or R (or both).
- Knowledge about automatic configuration and selection methods.
- Knowledge about irace is welcome but not required.

References:

1. Pascal Kerschke, Holger H. Hoos, Frank Neumann, and Heike Trautmann. **Automated Algorithm Selection: Survey and Perspectives**. *Evolutionary Computation*, 27(1):3–45, March 2019.
2. Lin Xu, Holger H. Hoos, and Kevin Leyton-Brown. **Hydra: Automatically Configuring Algorithms for Portfolio-Based Selection**. In M. Fox and D. Poole, editors, *Proceedings of the AAAI Conference on Artificial Intelligence*. AAAI Press, 2010.
3. M.López-Ibáñez, J.Dubois-Lacoste, L.Pérez Cáceres, T.Stützle, M.Birattari. **The irace Package: Iterated Racing for Automatic Algorithm Configuration**. *Operations Research Perspectives*, 3:43–58, 2016.