European success stories in industrial mathematics

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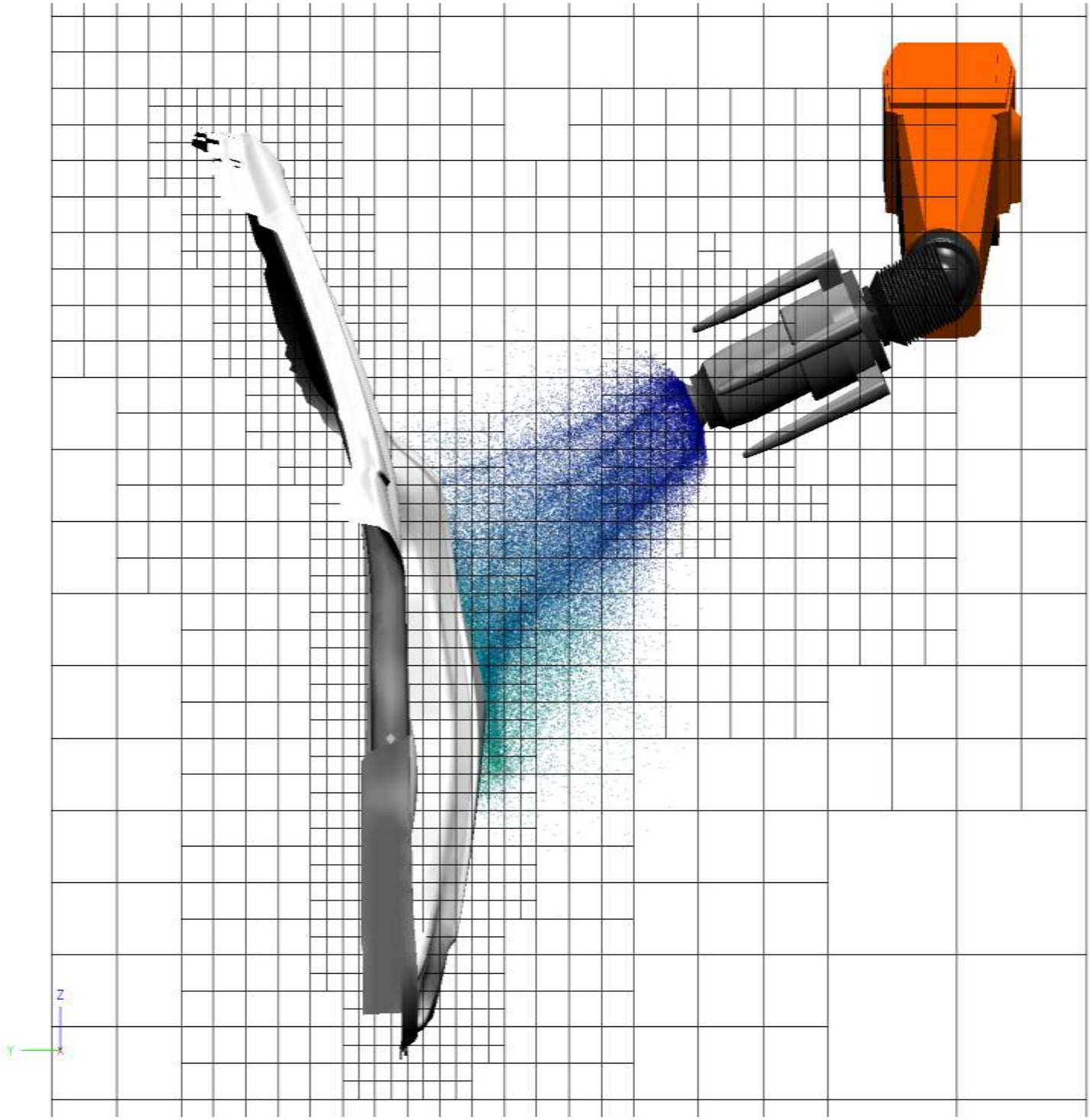

European Mathematical Society

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Since its establishment in 1974, ESF, which has its headquarters in Strasbourg with offices in Brussels and Ostend, has assembled a host of organisations that span all disciplines of science, to create a common platform for cross-border cooperation in Europe.

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Foreword

This brochure shows via several success stories the crucial contribution of mathematics to the industrial creation of value and the key position of mathematics in the handling of complex systems, amplifying innovation.

Each story describes the challenge that led to the industrial cooperation, how the challenge was approached and how the solutions were achieved and implemented, and when brought together, they illustrate the versatile European landscape of projects in almost all areas of applied mathematics and across all business sectors.

Today models are used everywhere to describe real world processes in the language of mathematics. The art of modelling is to focus on the important relationships to make the model as useful as possible to the user, and modelling therefore needs support from domain specialists. Indeed, close collaboration between industry experts and academia is both highly valued by all parties and highly valuable to successful projects.

The next step after creating the mathematical model is the analysis or numerical simulation, to validate the model in comparison with experimental data and to investigate the robustness and sensitivity of the model. Once a mathematical model has been validated, then this model can be used to improve, optimize or control the process described. Model based control and optimization is a crucial element of automation in all areas of industry, often reducing the cost and time of product, process and service development and innovation.

> "In view of concrete economic and social challenges, Mathematics plays a central role. Mathematics enables innovations in the industrial and service sectors that lead to more jobs and an increasing competitiveness."
>
> Dr. Annette Schavan
> German Federal Minister
> of Education and Research

All of this is unthinkable without the existence of modern computers and information technology. However, the progress in computer technology is not alone sufficient for the future development of high technology innovation. Many of the success also rely to a large extent on the progress in the development of mathematical algorithms and tools.

Although this brochure only describes a snapshot of all the European activities in industrial mathematics, it demonstrates that the level of cooperation between academia and industry is not equally well established throughout Europe and that there exists great opportunity for more industrial challenges to be addressed with the powerful ideas and tools at the disposal of mathematicians. The impact achieved in industrial mathematics is through a wide variety of timescales and engagement mechanisms, from PhD studentships and post-doctoral research contracts to shorter-term Internships, Study Groups and consultancy contracts.

SmartGrid.gc: Intelligent agent based modeling and simulation of electrical grids

Executive summary

This project deals with the development of a framework that allows simulation of island power systems at market and operational levels. Complex situations that occur in the management of electricity networks are modelled based on the interaction of multiple decision making units, with bounded rationality and self-interest. For system behaviour studies is used the paradigm of Agent Based Modeling and Simulation (ABMS). It is conceived as a tool for modeling and simulating scenarios, that is configurations and situations in electrical grids. Special emphasis is focused on the study and simulation of the effects of technological trends regarding generation, storage and processing in order to evolve towards future smart grids. This project has received financial support from by the Canary Islands Agency for Research, Innovation and Information Society (ACIISI) of the Canary Islands Government and with the participation of the important utilities sector, UNELCO-ENDESA (Canary Islands electrical generation company) and *Red Eléctrica de España* (Spanish electrical transportation company).

Challenge overview

The results of this project are:

- The study of solutions to future scenarios for restructuring and management of island power systems (like Gran Canaria island electrical grid) can simulate situations in order to maximize renewable energy sources (RES) integration into the grid, ensuring the service quality and reducing dependence on fossil fuels and environmental contamination.
- Studies towards the definition of smart power grid management solutions, like the ones related to the maximization, the RES integration and use of electrified vehicle fleet as storage element.

Implementation of the initiative

The initiative has been developed by the Artificial Intelligence and System Division with Prof. Mario Hernández (fhernandez@siani.es) as scientific director. The research group is composed by a multi-disciplinary team of engineers, computer science graduates and scientists working together in research and innovation for industry and government departments.

The problem

Electrical systems are facing major challenges due to:

- The new environmental needs related to climate change control.
- The introduction of market structure at different levels of electrical business.
- The economic and geostrategic problems related to the electrical energy production from fossil fuels.
- The massive introduction of unmanaged RES in the electrical grid.
- The revolutionary changes that are occurring in the automotive industry due to the planned production of plug in electrical vehicles (PHEV).
- The technological changes that are necessary to grid management with the introduction of the Smart Grid concept.

Lessons learned and replicability

Over 97% of domestic energy demand of Gran Canaria is covered with refined oil (more than 10 million barrels per year), with an annual consumption of oil of 1.4 million Tm of which 0.8 million Tm are dedicated to produce electricity and 0.6 million Tm. to transport and others. This situation occurs in the island of Gran Canaria with the best wind resources in Europe. The integration of a substantial amount of RES in an isolated electrical system of medium size like the island of Gran Canaria grid (3800 GWh of annual production), demand intelligent management systems to guarantee their effectiveness and stability. Both of them can be increased if it is done with storage systems, acting in a buffering mode, as can be PHEV. The case of Gran Canaria electrical grid is similar to many other medium size grids around the world and is a good laboratory exemplar to evaluate different technological approaches and market solutions for future grid studies.

Contact

INSTITUTO UNIVERSITARIO SIANI INGENIERIA COMPUTACIONAL

Edificio Central del Parque Científico y Tecnológico,
Universidad de Las Palmas de Gran Canaria
Islas Canarias, España
Web : http://www.siani.es/
Prof. Rafael Montenegro Armas rafa@dma.ulpgc.es