





## Preface

---

The [1st Conference on Transfer between Mathematics & Industry \[CTMI 2019\]](#) aims at the promotion and dissemination of the mathematical tools of Statistics & Big Data and MSO (Modelling, Simulation and Optimization) and its industrial applications, the promotion of new research lines oriented to the needs of the industry and in the society in general, the renewal of curricula in this field and at all educational levels and the industry-academia collaboration internationalization. ([See our goals](#)).

This 1st edition of CTMI 2019 holds in Santiago de Compostela on 22nd-24th July 2019; in collaboration between the [Technological Institute for Industrial Mathematics \(ITMATI\)](#) and the [Spanish Network for Mathematics & Industry \(math-in\)](#). The [European Service Network of Mathematics for Industry and Innovation \(EU-MATHS-IN\)](#) is a collaborator of this international event and supports this initiative.

It is the first edition of this congress of mathematical transfer in Spain, promoted by the Spanish Network for Mathematics & Industry (math-in) and which foresees to have biannual editions. This Conference is a [satellite meeting of ICIAM 2019](#) that will be held the previous week at Valencia, Spain.

CTMI 2019 coincides with the much appraised local 2-week long fiesta in honour of St. James, the city's and Spain's patron saint ([FESTIVITIES IN HONOUR OF SANTIAGO APÓSTOL](#)), celebrated in Santiago de Compostela between the days 18th -31st July 2019.

The CTMI 2019 is also co-funded by the Ministry of Economy, Industry and Competitiveness – State Research Agency through the Thematic Network RTMath-in, granted within the call “Networks of Excellence” 2016, through the Strategic Network in Mathematics (REM) and by the Galician Innovation Agency (GAIN) and Consellería de Educación both of Xunta de Galicia (Galician government).

The matchmaking event from 23-24<sup>th</sup> of July is co-organized by the [Enterprise Europe Network](#) – the biggest European Network that provides internationalization and innovation support to European businesses.



## Acknowledgments

---

### SPONSORS



**Technological Institute for Industrial Mathematics [ITMATI]**



**Spanish Network for Mathematics & Industry [Red math-in]**



**Ministerio de Economía y Competitividad**



**Xunta de Galicia**



**Axencia Galega de Innovación [GAIN]**



**Agencia Estatal de Investigación**



**Universidade da Coruña [UDC]**



**Consellería de Educación, Universidade e Formación**

**Profesional**



**Universidade de Santiago de Compostela [USC]**

Universidade de Vigo

**Universidade de Vigo [UVigo]**



**Enterprise Europe Network**



**Red Estratégica en Matemáticas**



**Excellence Network [RT math-in]**



**Facultad de Matemáticas [USC]**



**REPSOL**



**1ST CONFERENCE ON TRANSFER BETWEEN  
MATHEMATICS & INDUSTRY  
[CTMI 2019]**

22nd-24th July 2019, Santiago de Compostela, Galicia, Spain

**[Book of Abstracts]**

**EDITED BY**

**Organizing Committee**

2019 ITMATI & math-in

## Scientific Committee

---

The members of the Scientific Committee are:

- [Alfredo Bermúdez](#), Chair. Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de Santiago de Compostela (USC).
- [Ricardo Cao Abad](#). Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de A Coruña (UDC).
- [Luca Gerardo-Giorda](#). Red Española Matemática – Industria (math-in) and Basque Center for Applied Mathematics (BCAM).
- [Patrice Hauret](#). Michelin, France.
- Elena Núñez. Centro de Tecnología de Repsol (CTR).
- [Antonino Sgalambro](#). European Service Network of Mathematics for Industry and Innovation (EU-MATHS-IN), Sportello Matematico per l'industria italiana and Sheffield University.

## Organizing Committee

---

The members of the Organizing Committee are:

- [Peregrina Quintela](#), Chair. Red Española Matemática – Industria (math-in), Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de Santiago de Compostela (USC).
- [Alba Márquez Sánchez](#). Red Española Matemática – Industria (math-in).
- [Adriana Castro Novo](#). Instituto Tecnológico de Matemática Industrial (ITMATI).
- [Bartomeu Coll Vicens](#). Red Española Matemática – Industria (math-in) and Universitat de les Illes Balears (UIB).
- [Rosa Crujeiras](#). Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de Santiago de Compostela (USC).
- [José Durany Castrillo](#). Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de Vigo (UVigo).
- Laureano Escudero Bueno. Red Española Matemática – Industria (math-in) and Universidad Rey Juan Carlos (URJC).



## BOOK OF ABSTRACTS (CONTENTS)

### INVITED SPEAKERS.....10

Recent Advances in Computational Models for the Discrete and Continuous Optimization Models of Industrial Process Systems ..... 10

*Ignacio Grossmann*

Stability of dynamical systems with applications to brake squeal. A port-Hamiltonian approach..... 11

*Volker Mehrmann*

Health Care Logistics ..... 12

*Stefan Nickel*

Data and mathematics. The promoters of the data driven companies..... 13

*Antonio Pita Lozano*

### MINISYMPOSIA (MS) .....14

**MS1: Mathematics of Logistics: emerging trends in Optimization and Simulation modelling** ..... 14

Coordinator: *Dr. Anna Melchiori*

Reliable estimations of a function and its derivatives. Application to certified positioning of trains, vehicles or drones..... 14

*Jean-François Abadie*

Making an impact in Logistics Management through optimization-based Decision Support Systems ..... 15

*Anna Melchiori, Antonino Sgalambro*

Sportello Matematico: success stories and initiatives for making an impact through Mathematical Technologies..... 15

*Anna Melchiori, Antonino Sgalambro*

**MS2: Successful examples of industry-academia collaboration in the energy sector** ..... 16

Coordinator: *Elena Núñez Domingo*

The creation of a stable network of academic collaborators at the industry.....	16
<i>Elena Núñez</i>	
Fracture propagation under stress using a phase field approach .....	16
<i>David Casanovas, Ángel Rivero</i>	
Application of NNs to solve PDE based physical systems.....	17
<i>Jaime López, Ángel Rivero</i>	
Mathematical modeling and numerical simulation of lithium-ion batteries for real time applications .....	17
<i>David Aller, Javier Arechalde, Alfredo Bermúdez, David Casanovas, Pedro Fontán, Marta Piñeiro, Alfredo Ríos, Pedro Rodríguez, Jerónimo Rodríguez</i>	
<b>MS3: Industrial Mathematics in Action .....</b>	<b>17</b>
Coordinators: <i>Edie Miglio, Luca Formaggia, Nicola Parolini</i>	
Enhanced numeric models to improve well loads estimation in oil and gas applications .....	18
<i>Raffaello Zambetti</i>	
How to crowdsource Industrial Mathematics and Data Science.....	18
<i>Maria Francesca Corrado</i>	
Model reduction applied to packaging systems.....	19
<i>Nicola Parolini</i>	
<b>MS4: Math-in awards &amp; math-in   Repsol award for outstanding Phd and Msc thesis in Industrial Mathematics .....</b>	<b>19</b>
Single particle models for the numerical simulation of lithium-ion cells.....	20
<i>Alfredo Ríos, Jerónimo Rodríguez</i>	
Modelling and numerical simulation of the quenching heat treatment. Application to the industrial quenching of automotive spindles.....	21
<i>Carlos Coroas, Elena Martín</i>	
<b>MS5: Mathematics and Data Analytics .....</b>	<b>22</b>
Coordinator: <i>Ricardo Cao Abad</i>	



Impact of intelligent telemanagement based on the OTEA platform for installations..... 22

*Gonzalo Ferro Costas, Nerea Vilela Barreira*

Data Science for big bank data ..... 23

*Jorge Martín Arevalillo*

Models and Big Data Analytics in the Modern Industry..... 24

*Abelardo Monsalve Cobis*

## COMMUNICATIONS (CO) .....25

Numerical computation of the diffuse field absorption coefficient of porous materials by using alpha cabins..... 25

*Juan Manuel Ávila, Alfredo Bermúdez, Laura del Río, Andrés Prieto, José Rodríguez*

Simulation of the seismic wave propagation in porous media described by three elastic parameters..... 27

*Dana Bliyeva, Kholmatzhon Imomnazarov, Abdumauvlen Suleimanovich\_Toc14263317*

Finding your audience in social networks: How to predict robot-user interaction response thanks to our robot..... 29

*Dobroslav Egorov, Alexander Komarov, Oleg Kravchenko*

Non-dimensional equations and toy models – Tools to improve the basic process understanding..... 30

*Mads Fromreide, Svenn Anton Halvorsen, Manuel Spart*

A transient thermal problem with non-local radiation arising in steelmaking industry .. 32

*Patricia Barral Rodiño, Luis Javier Pérez, Peregrina Quintela Estévez*

Prediction of wire rod temperatures under different industrial process conditions: Application of reduced order modelling for a fast prediction ..... 34

*Elena Martín, Fernando Varas, Iván Vieitez*

Numerical analysis with FEM to improve the planning of Transcatheter Aortic Valve Replacement ..... 36

*Marcos Loureiro-Ga, Cesar Veiga, Generosa Fdez-Manín, Pablo Juan Salvadores, Victor A. Jimenez, Jose A. Baz, Andres Iñiguez*



**SUCCESS STORIES POSTERS (SSPS) .....38**

Optimal design of a railway bypass at Parga, north-west of Spain ..... 38  
*Gerardo Casal, Alberte Castro, Duarte Santamarina, Miguel E. Vázquez-Méndez*

Copula-based anomaly scoring and localization of high-dimensional data with application in telecommunication networks ..... 40  
*Gábor Horváth, Edith Kovács, Roland Molontay, Szabolcs Nováczki*

Algorithms to Fight Wildfires ..... 42  
*Ana Belén Buide, M<sup>a</sup> José Ginzo, Manuel Antonio Novo*

Towards segmentation of hashtags for Instagram post analysis ..... 44  
*Dobroslav Egorov, Alexander Komarov, Oleg Kravchenko*

Machine learning algorithms for predicting academic performance and identifying the contributing factors ..... 45  
*Roland Molontay, Marcell Nagy*

**B2B MATCHMAKING EVENT .....47**

**LINKS OF INTEREST .....47**



## Invited Speakers

---

Monday 22, 17:15-18:15, Videoconference, Aula Magna

### Recent Advances in Computational Models for the Discrete and Continuous Optimization Models of Industrial Process Systems

**Ignacio Grossmann<sup>1</sup>**

<sup>1</sup>*Carnegie Mellon, Pittsburgh, Pensilvania.*

In this talk we give an overview of recent models and algorithms for the discrete and continuous optimization of a variety of challenging applications in Process Systems Engineering, and that have been largely the result of collaborations with industry. We first provide a brief overview of deterministic models based on mixed-integer linear/nonlinear programming (MILP/MINLP) to highlight the progress that has been made. Next, we provide a brief review of global optimization for which the progress is illustrated with the synthesis of integrated water networks, with the design of centralized and distributed manufacturing for biomass, and with the design and planning of infrastructures for shale gas production that involve large scale nonconvex MINLP models. In order to improve the prediction of lower bounds for convex and nonconvex MINLP problems, we describe theoretical procedures based on generalized disjunctive programming for strengthening the corresponding continuous relaxations, and for which effective cutting plane methods have been developed as will be shown with numerical results on test problems. Finally, we address the handling of uncertainty in discrete/continuous models through approaches that are based on robust optimization and stochastic programming. For the former, we consider affine-adjustable recourse to avoid overly conservative results, and which is illustrated in cryogenic storage in air separation plants that participate in the electricity and operating reserve markets. For the case of stochastic programming, we consider first the development of strategies based on decomposition and that can handle a very large number of scenario; this we illustrate with optimal design of supply chains that are subjected to disruptions in their distribution centers. Finally, we consider multistage stochastic programming models that involve exogenous and endogenous parameters for which effective theoretical and solution methods are proposed. These are applied to the design and planning of offshore facilities with uncertain crude oil prices and reservoir sizes.

*Chairman: Ricardo Cao, University of A Coruña and ITMATI*



Monday 22, 10:00-11:00, Aula Magna

## **Stability of dynamical systems with applications to brake squeal. A port-Hamiltonian approach**

**Volker Mehrmann<sup>1</sup>**

*<sup>1</sup>Institut f. Mathematik, TU Berlin, Germany.*

Brake squeal is an annoying phenomenon in almost all technical brake systems. It is a resonance phenomenon associated with a flutter instability.

To remove brake squeal it is necessary to carry out a stability analysis for extremely large finite element models of brakes and

to optimize damping material properties. A new approach of energy based modeling for brake systems is presented that allows to check

instability/stability of the systems using the structure of the models. This port-Hamiltonian system description directly shows the origins for the squeal and leads to very efficient methods to compute stability radii and to robustly optimize the oscillation properties of brake systems.

*Chairman: Alfredo Bermúdez, University of Santiago de Compostela and ITMATI*



Tuesday 23, 11:30-12:30, Aula Magna

## Health Care Logistics

**Stefan Nickel<sup>1</sup>**

<sup>1</sup>*Institute of Operations Research, Karlsruhe Institute of Technology (KIT), Germany.*

Healthcare logistics addresses the efficient planning, realization and control of patient-, material- and information-flow within the healthcare sector. Therefore, the use of Operations Research (OR) methods plays a crucial role. It is important to not only put emphasis upon the economic efficiency but also to take the quality of care and patient satisfaction into account. On the other hand, healthcare logistics should not get involved in (core) medical decisions. Healthcare logistics addresses healthcare facilities and service providers at all levels, for example general practitioners (GP) providing primary care or emergency departments (ED) treating patients with pressing health issues. Care pathways containing several different providers as well as the interaction of providers and services, e.g. when patients are transferred to a hospital by their GP, are also targeted. Usually, processes in healthcare grew historically (“We have always done it this way.”). Consequently, processes have not been analyzed critically until reforms of the health system have put increasing pressure on the providers. Nowadays, especially hospitals are looking for possibilities to improve their processes. The success of logistics concepts in healthcare lies in resource conservation for non-value-adding activities (not directly relevant for the healing process, e.g., administrative work) and high resource utilization for value-adding activities (e.g., surgery) while the personnel shall not be over-utilized (i.e., no overtime). Moreover, the interaction of appropriate logistics concepts with modern OR models allow a patient centered treatment, by respecting the needs of a patient and allowing a smoother process. The digitalization of the healthcare sector offers additional opportunities.

In this talk, we give an overview on how OR methods can be used in order to support process optimization in healthcare organizations. For a subset of healthcare logistics applications arising in different healthcare sectors OR models and numerical results mainly from real world projects will be presented. Examples include: location planning for ambulances and GPs, appointment planning, emergency department simulation, layout planning for hospitals and many more. We will also give some information on how healthcare logistics research is organized in Karlsruhe.

*Chairman: Antonino Sgalambro. European Service Network of Mathematics for Industry and Innovation (EU-MATHS-IN), Sportello Matematico per l'industria italiana and Sheffield University.*



Tuesday 23, 20:00-21:00, Auditorio Abanca (External Auditorium)

## Data and mathematics. The promoters of the data driven companies

**Antonio Pita Lozano<sup>1</sup>**

*<sup>1</sup>LUCA, Telefonica Data Unit, Spain*

It is a hardly questionable fact that data is an invaluable, strategic asset for companies carrying out their own digital transformation processes. The current challenge is the extraction of all of data's value. With this goal in mind, statistical and AI mathematical models are being used with the aims of increasing companies' income, reducing costs through efficiency models and mitigating risks targeted at improving business management.

*Event Moderator: Isabel Pichel, "A tarde" - Radio Galega*



## Minisymposia (MS)

---

### **MS1: Mathematics of Logistics: emerging trends in Optimization and Simulation modelling**

Monday 22, 15:30-17:00, Aula Magna

This Minisymposium aims at exploring relevant scientific contributions in the field of Optimization and Simulation, designed in support of practical challenges faced in the Logistics sector by companies and organizations.

**Coordinator and Chairman:** Dr. Anna Melchiori PhD, Researcher in Optimization and Operational Research, Institute for Application of Calculus “Mauro Picone”, National Research Council of Italy.

Monday 22, 15:30-16:00, Aula Magna

### **Reliable estimations of a function and its derivatives. Application to certified positioning of trains, vehicles or drones**

**Jean-François Abadie**<sup>1</sup>

<sup>1</sup>Laboratoire Jacques-Louis LIONS (LJLL), Sorbonne Université, Paris, France

Various models and algorithms that enable to provide accurate and certified tubular neighborhoods for a class of functions  $f: \mathbf{R} \rightarrow \mathbf{R}^n$  and its derivatives derived from data and certified intervals that contains  $f$  at some discrete points from  $\mathbf{R}$  are presented. Produced for the needs of Alstom and the RATP, they can be used to obtain in real time reliable estimations of the positions, speeds or accelerations of vehicles like trains, cars or drones.

Monday 22, 16:00-16:30, Aula Magna

## **Making an impact in Logistics Management through optimization-based Decision Support Systems**

**Anna Melchiori<sup>1</sup>, Antonino Sgalambro<sup>2,3</sup>**

<sup>1</sup>Institute for Application of Calculus “Mauro Picone”, National Research Council of Italy.

<sup>2</sup>Sportello Matematico, Roma, Italy

<sup>3</sup>Sheffield University Management School, Sheffield, England

Recalling the essential role of carefully co-designed optimization-based Decision Support Systems as a tool to provide the final users in the Industry with an actionable transfer of research findings from mathematical optimization science is the main purpose. To this aim, selected examples from the literature on real-world applications of optimization-based analytics across a range of different fields in Supply Chain Management are discussed, including Waste Management Services, Humanitarian Logistics and Industrial Manufacturing.

Monday 22, 16:30-17:00, Aula Magna

## **Sportello Matematico: success stories and initiatives for making an impact through Mathematical Technologies**

**Anna Melchiori<sup>1</sup>, Antonino Sgalambro<sup>2,3</sup>**

<sup>1</sup>Institute for Application of Calculus “Mauro Picone”, National Research Council of Italy.

<sup>2</sup>Sportello Matematico, Roma, Italy

<sup>3</sup>Sheffield University Management School, Sheffield, England

An institutional network for Industrial Mathematics, coordinated by the National Research Council of Italy (IAC) to promote an increasing range of collaborations between Companies and Research Centres. This is Sportello Matematico, operating since 2012 as a highly qualified solver brokerage service in the field of Mathematical Modeling, Simulation and Optimization (MSO) for Industry and Innovation. In this talk we present some success stories, together with novel initiatives aimed at releasing the huge potential of Mathematical Technologies.



## **MS2: Successful examples of industry-academia collaboration in the energy sector**

Tuesday 23, 9:00-11:00, Aula Magna

This Minisymposium objective is to show the results of establishing a robust collaboration between academia and the energy sector, through the development of simulation models to solve some challenges this industries face.

**Coordinator and Chairman:** Elena Núñez Domingo, Senior Scientific in Advanced Mathematics Division at Repsol Technology Lab.

Tuesday 23, 9:00-10:30, Aula Magna

### **The creation of a stable network of academic collaborators at the industry**

**Elena Núñez**<sup>1</sup>

<sup>1</sup>Repsol Technology Lab, Móstoles, Spain.

The energy industry faces several problems that can be addressed through mathematics. To do this, we establish a network of academic collaborators in which we all win. It allows the industry to incorporate know-how and to explore new alternatives to solve problems, while providing use cases for the theoretical developments carried out in the Academy.

Tuesday 23, 9:30-10:00, Aula Magna

### **Fracture propagation under stress using a phase field approach**

**David Casasnovas**<sup>1</sup>, **Ángel Rivero**<sup>1</sup>

<sup>1</sup>Repsol Technology Lab, Móstoles, Spain.

An application of phase field models coupled to solid mechanics to study fracture propagation due to fluid flow in porous media is shown. The results can provide an alternative approach to solve problems with discontinuities and singularities in multiphysics systems.

Tuesday 23, 10:00-10:30, Aula Magna

## Application of NNs to solve PDE based physical systems

**Jaime López<sup>1</sup>, Ángel Rivero<sup>1</sup>**

<sup>1</sup>Repsol Technology Lab, Móstoles, Spain

Lately, it has sprouted an interest of bringing deep learning success to the computation of dynamic systems and PDEs solutions, having in mind their capacity to implement non local and nonlinear order reduction as well as performing transfer learning. The exploration of this possibility brings some light in the mathematical foundations of neural networks. Along this path, the recent perspective of neural networks as dynamic systems has been remarked, and the potential to integrate mathematical knowledge with learning models has been solidly established.

Tuesday 23, 10:30-11:00, Aula Magna

## Mathematical modeling and numerical simulation of lithium-ion batteries for real time applications

**David Aller<sup>1</sup>, Javier Arechalde<sup>1</sup>, Alfredo Bermúdez<sup>2,3,4</sup>, David Casanovas<sup>1</sup>, Pedro Fontán<sup>1</sup>, Marta Piñeiro<sup>2</sup>, Alfredo Ríos<sup>2</sup>, Pedro Rodríguez<sup>2</sup>, Jerónimo Rodríguez<sup>2,3,4</sup>**

<sup>1</sup>Repsol Technology Lab, Móstoles, Spain

<sup>2</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

<sup>3</sup>Departamento de Matemática Aplicada, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

<sup>4</sup>IMAT, Universidade de Santiago de Compostela,

Santiago de Compostela, Spain

Lithium-ion batteries are of great importance in many applications nowadays. Their performance and safety rely heavily on proper real time management. Real time management of Lithium-ion batteries needs to combine mathematical modelling, numerical simulation, model order reduction and observer techniques to accurately predict the internal behaviour of the battery. During the talk we will discuss some of these techniques.



## **MS3: Industrial Mathematics in Action**

**Tuesday 23, 12:30-14:00, Aula Magna**

The aim of the mini-symposium is to describe different success models of collaboration between industry and applied mathematicians.

**Coordinators:** Edie Miglio, Luca Formaggia, Nicola Parolini, all the organizers are from MOX, Department of Mathematics, Politecnico di Milano.

**Chairman:** Edie Miglio, MOX, Department of Mathematics, Politecnico di Milano.

**Tuesday 23, 12:30-13:00, Aula Magna**

### **Enhanced numeric models to improve well loads estimation in oil and gas applications**

**Raffaello Zambetti**<sup>1</sup>

<sup>1</sup>Tenaris Dalmine, Dalmine ,Italy

Some challenges, that are typical to the Oil & Gas industry and the changes that are available by increasing computational power in standard laptops, are presented. Some examples related to loads induced by temperature on tubular and how numerical models are improving well design. Higher computational power is silently changing the industry from simplified spreadsheet models and rules of thumb to state of the art numerical models.

**Tuesday 23, 13:00-13:30, Aula Magna**

### **How to crowdsource Industrial Mathematics and Data Science**

**Maria Francesca Corrado**<sup>1</sup>

<sup>1</sup>Research and business development, Mathesia, Milano, Italia

Mathesia is the crowdsourcing platform that connects organizations to thousands of leading mathematicians, data scientists and engineers to find results-focused and innovative solutions to business challenges. A crowdsourcing model and some of our projects are



presented: Safety Pre-Sense (ENI), CFD Optimization of Cooling towers (MITA), Resource Allocation Optimization.

Tuesday 23, 13:30-14:00, Aula Magna

## **Model reduction applied to packaging systems**

**Nicola Parolini**<sup>1</sup>

<sup>1</sup>MOX, Department of Mathematics, Politecnico di Milano, Milano, Italy

The results presented are from a collaboration with the company MOXOFF s.p.a. and Tetra Pak, world leader in food processing and packaging solutions, where different model reduction strategies have been adopted to improve the efficiency of the simulation pipeline for the analysis of fluid-structure interaction problems in the filling and forming processes. The successful implementation of a set of model reduction techniques, including geometrical multi-scale models, reduced basis method, transpiration and absorbing boundary conditions is considered.

## **MS4: Math-in awards & math-in | Repsol award for outstanding Phd and Msc thesis in Industrial Mathematics**

Monday 22, 16:15-17:15, Aula Magna

In this minisymposia the math-in awards will be awarded and presented.

These awards, for MSc theses, will recognize the contributions of the candidates attending to the novelty of the project, the technology generated in their work, the development and use of new mathematical tools, as well as the benefits obtained by the company.

**Chairman:** Ángel Rivero, Repsol Technology



Monday 22, 16:15-16:45, Aula Magna

## Single particle models for the numerical simulation of lithium-ion cells

**Author: Alfredo Ríos Alborés**

**Supervisor: Jerónimo Rodríguez García<sup>1,2,3</sup>**

<sup>1</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

<sup>2</sup>Departamento de Matemática Aplicada, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

<sup>3</sup>IMAT, Universidade de Santiago de Compostela,  
Santiago de Compostela, Spain

In the last decade there has been an increasing interest in the development and improvement of electrical energy storage devices in the automotive industry, to use them in electrical vehicles. Electrochemical lithium-ion batteries have good properties such as high energy and power density, a long life expectancy, low self-discharge rate, non-memory effect, among others; that's why this technology is one of the preferred candidates to be used by this industry.

However, for safety reasons, due to the batteries sensitivity to inappropriate use parameters and to improve their performance, it is necessary to design and implement battery control algorithms in which a mathematical model is used to estimate the cells internal behavior. The so-called pseudo-2D (P2D) is the most popular validated model for lithium-ion batteries in the literature, but due to its high computational cost of resolution this model is not suitable for its implementation in real-time applications.

In this master's thesis, the family of the simple single-particle models (SPM) were deduced, studied and implemented. These models present a reduced computational cost, compared to the P2D model, so that they could be suitable for their use in real-time battery control software.

Monday 22, 16:45-17:15, Aula Magna

## **Modelling and numerical simulation of the quenching heat treatment. Application to the industrial quenching of automotive spindles.**

**Author: C.Coroas<sup>1</sup>**

**Supervisor: E.Martín<sup>2,3</sup>**

<sup>1</sup>Departamento de Matemática Aplicada II, E. de Ing. de Telecomunicación, Universidad de Vigo, Campus Marcosende, E-36310 Vigo

<sup>2</sup>Departamento de Ingeniería Mecánica, Máquinas y Motores Térmicos y Fluidos, E. de Ing. Industrial, Universidad de Vigo, Campus Marcosende

<sup>3</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

The quenching heat treatment consists in the immersion of a steel piece, previously heated above the austenization temperature. The fast cooling underwent by the pieces induces microstructure transformations (from austenite to martensite) that provides the piece with specific mechanical properties (high hardness) at the end of the process.

The numerical simulation to solve the cooling process and the final crystallographic structure involves several problems associated with the strong interaction between a fluid-dynamic model on a two-phase fluid (due to the presence of liquid and vapor because of the high temperatures), a thermal model and a metallurgical model.

To solve these problems, the heat flow on the surface of the spindle is characterized using correlations adapted to the curve of Nukiyama's experiments (based on the literature). It allows to describe (up to a certain degree of accuracy) the cooling process without solving a complex fluid-dynamic multiphase model. The objective of this study is to obtain conclusive results about the cooling process and the final crystallographic structure, in order to optimize the industrial process of steel quenched spindles used on the automotive industry.

**Keywords:** Numerical simulation, heat treatment, quenching, microstructure prediction.



## MS5: Mathematics and Data Analytics

Wednesday 23, 09:00-11:00, Aula Magna

Statistical and artificial intelligence data analysis methods are fundamental tools for business intelligence in many industrial sectors, like energy, finance and environment, among many others. The Industry 4.0 paradigm needs modern mathematical and statistical tools for smart data analysis. Functional data analysis, censored data analysis, high dimensional data analysis, complex data analysis and big data statistical analysis are some of the relevant methods for data analysis in complex industrial environments

**Coordinator:** Ricardo Cao Abad. Instituto Tecnológico de Matemática Industrial (ITMATI) and Universidade de A Coruña (UDC).

**Chairman:** Wenceslao Rodríguez Manteiga, Universidade de Santiago de Compostela (USC) and Instituto Tecnológico de Matemática Industrial (ITMATI)

Wednesday 23, 09:00-09:30, Aula Magna

### Impact of intelligent telemanagement based on the OTEA platform for installations

**Gonzalo Ferro Costas<sup>1</sup>, Nerea Vilela Barreira<sup>1</sup>**

<sup>1</sup>Ecomanagement Technology, A Coruña, Spain

The objective is to present the OTEA energy efficiency platform and its new functionalities, based on Machine Learning methods. These new tools are aimed at improving sustainability, focusing on productivity and creating a more comfortable environment.

They will present and analyze examples applied in real installations directed to different sectors, such as retail or industry. The algorithms cover the needs of clients to obtain reliable estimates in real time useful to optimize decision making.

Wednesday 23, 9:30-10:00, Aula Magna

## Data Science for big bank data

Jorge Martín Arevalillo<sup>1</sup>

<sup>1</sup>Departamento de Estadística, Investigación Operativa y Cálculo Numérico,  
Universidad Nacional de Educación a Distancia (U.N.E.D)

Statistical and Machine Learning algorithms appear as part of our ongoing research practice as statisticians and mathematicians, having become powerful tools to address different challenges arising from Big Data scenarios in the banking sector. The research advances in the data science field can complement information database storage and business know-how in the construction of mathematical and statistical models that help to guide the management of commercial campaigns and also highlight business insights for data-driven decision making. Some ideas about how scientific research from academia can be put into action to generate business value are shown as well as several projects carried out for the banking sector and show that the journey from mathematical research to business value is achievable. All these initiatives have arisen as a result of pursuing research in the development of Statistical and Machine Learning algorithms and their applications to solve problems in different fields [1-5]. They all belong to the contracting framework of the Knowledge and Research Transfer Office at University Nacional de Educación a Distancia (U.N.E.D).

**Keywords:** Big Data. Banking. Machine Learning. Statistical Learning. Business value

### REFERENCES

- [1] Jorge M Arevalillo (2019). A machine learning approach to assess price sensitivity with application to automobile loan segmentation. *Applied Soft Computing*. 76.390-399.
- [2] Jorge M Arevalillo, Marcelo B Sztejn, Karen L Kotloff, Myron M Levine, Jakub K Simon (2017). Identification of immune correlates of protection in Shigella infection by application of machine learning. *Journal of Biomedical Informatics*. 74. 1-9.
- [3] Jorge M Arevalillo, Hilario Navarro (2013). Exploring correlations in gene expression microarray data for maximum predictive – minimum redundancy biomarker selection and classification. *Computers in Biology and Medicine*. 43 (10). 1437-1443.
- [4] Sara Jurdao, Emilio Chuvieco, Jorge M Arevalillo (2012). Modelling forest fire ignition probability from satellite estimations of life fuel moisture content. *Fire Ecology*. 8 (1). 77-97.
- [5] Jorge M Arevalillo, Hilario Navarro (2011). Uncovering bivariate interactions in high dimensional data using Random Forests with data augmentation. *Fundamenta Informaticae*. 113 (2). 97-115.



Monday 23, 10:00-10:30, Aula Magna

## **Models and Big Data Analytics in the Modern Industry**

**Abelardo Monsalve Cobis<sup>1</sup>**

<sup>1</sup> ITMATI, Campus Vida, Santiago de Compostela and University of Vigo, Spain

The main goal of the manufacturing industry is to produce more efficiently by reducing costs. This new paradigm is addressed under the framework of Industry 4.0 that develops new technologies and methods such as embedded sensors and wireless connectivity that need to be analyzed in a Big Data environment. Someone of these methods, such as Condition monitoring (CM) and Big Data Analytics (BDA) offers an unprecedented opportunity to track machine-tool performance and health condition.

The objective is to present some experiences about the trends of the manufacturing industry in a big data environment, as well as the readiness of smart predictive tools, thereby achieving efficiency and improve productivity.

## Communications (CO)

---

### Communications (CO1)

Monday 22, 11:30-13:30, Aula Magna

Chairman: Andrés Prieto, Associate Professor at University of A Coruña and ITMATI

Monday 22, 11:30-12:00, Aula Magna

### **Numerical computation of the diffuse field absorption coefficient of porous materials by using alpha cabins**

**Juan Manuel Ávila<sup>1</sup>, Alfredo Bermúdez<sup>2,3</sup>, Laura del Río<sup>4</sup>, Andrés Prieto<sup>3,4</sup>, José Rodríguez<sup>1</sup>**

<sup>1</sup>Adhex Tech Tapes, Porriño, Spain

<sup>2</sup>Departamento de Matemática Aplicada, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

<sup>3</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

<sup>4</sup>Departamento de Matemáticas, Universidad de A Coruña, A Coruña, Spain

The Alpha Cabin (or small reverberation room) is widely used in the automotive industry [1,2,3] inasmuch as the frequency range and sample size is adapted to the requirements of automotive acoustics. The main goal of this work consists of a detailed description of the numerical procedures to determine the diffuse field absorption coefficient associated with a porous material by using the reverberation time technique [4,5].

Firstly, a numerical methodology based on the computation of the decay modes of the cabin is described. Following [4,5], to quantify the absorption of a sample firstly is necessary to compute the reverberation time associated with the empty room and the reverberation time in the cabin with an absorbing sample. In order to compute the Sound Pressure Level at several points inside the cabin, it is necessary to solve an eigenvalue problem inside the alpha cabin. Thus, reverberation times are measured without and with the tested sample and the absorption coefficient is computed by using the Sabine expression. Since this numerical approach does not allow us to obtain accurate results, a new numerical methodology is used. The modal expansion is replaced by a full time-dependent discretization [6] and the American standard ASTM C423-09 [7] is used to compute the decay rates. Then, the

reverberation times are based on the local average of the pressure values in different time windows.

Finally, some numerical results of the reverberation times and the absorption values associated with different samples of porous materials are compared with measured data showing a significant agreement.

**Keywords:** Diffuse field, reverberation time, numerical simulation

#### REFERENCES

- [1] Bertolini, C. and Guj, L. "Numerical simulation of the measurement of the diffuse field absorption coefficient in small reverberation rooms" SAE International Journal of Passenger Cars-Mechanical Systems. 4. 1168-1194. 10.4271/2011-01-1641. 2011.
- [2] Saha, P., Pan, J. and Veen, J.R. "Thoughts behind Developing SAE Standard J2883 – Random Incidence Sound Absorption Tests Using a Small Reverberation Room" No. 2009-01-2141. SAE Technical Paper. 2009.
- [3] Duval, A. et al. "Diffuse field absorption coefficient simulation of porous materials in small reverberant rooms: finite size and diffusivity issues" 10ème Congrès Français d'Acoustique, 2010.
- [4] ISO 354 "Acoustics - Measurement of sound absorption in a reverberation room", International Standard Organisation (2003).
- [5] ASTM C423-02, "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method", American Society for Testing and Materials (2002).
- [6] Noh, G. and Bathe, K.J. "An explicit time integration scheme for the analysis of wave propagations". Computers and Structures. 129 (2013) 178 - 193.
- [7] ASTM C423-09a, "Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method", American Society for Testing and Materials (2009).

Monday 22, 12:00-12:30, Aula Magna

## Simulation of the seismic wave propagation in porous media described by three elastic parameters

Dana Bliyeva<sup>1</sup>, Kholmatzhon Imomnazarov<sup>2</sup>, Abdumauvlen Suleimanovich<sup>3</sup>

<sup>1</sup>Al-Farabi Kazakh National University, Almaty, Kazakhstan

<sup>2</sup>Institute of Computational Mathematics and Mathematical Geophysics, Novosibirsk, Russia

<sup>3</sup>Institute of mathematics, physics and computer science, Abai Kazakh National Pedagogical University, Almaty, Kazajistán

An algorithm based on the spectral-difference method for numerical solution of the dynamic problem for porous media is proposed, using a linear two-dimensional problem in the form of dynamic equations in terms of displacement components described by three elastic parameters. The governing equations are based on conservation laws and consistent with the thermodynamics conditions. The medium is assumed to be isotropic and two-dimensional-inhomogeneous with respect to the spatial coordinates. The problem is numerically solved applying a method based on the joint use of the Laguerre integral transformation with respect to time and the finite difference approximation with respect to spatial coordinates. A description of the numerical implementation of the proposed method is given and its features are analyzed in the calculations. The efficiency of applying the Laguerre transformation and its difference from the Fourier transform for solving the direct dynamic seismic problems is discussed. Numerical results of the simulation of the seismic wave propagation fields for the test medium model are presented.

**Keywords:** Laguerre transform, porous media, wave field, numerical modeling, difference scheme.

### REFERENCES

- [1] Berdyshev A.S., Imomnazarov Kh.Kh., Jian-Gang Tang, Tuchieva S. The symmetric form of poroelasticity dynamic equations in terms of velocities, stresses, and pressure. //Open Engineering formerly Central European Journal of Engineering. Volume 6(2016), Issue 1. –P322-325.(Scopus)
- [2] Blokhin A. M., Dorovsky V. N. Mathematical Modelling in the Theory of Multivelocity Continuum //Nova Sci., New York, -1995, MathSciNet
- [3] Dorovsky V. N. Imomnazarov Kh. Kh. A Mathematical model for the movement of a conducting liquid through a conducting porous medium //Mathl. Comput. Modelling, Printed in Great Britain, - 1994, Vol. 20, No. 7, pp. 91-97.
- [4] Imomnazarov Kh.Kh., Imomnazarov Sh.Kh., Mamatqulov M.M., Chernykh E.G. The fundamental solution of the stationary two-velocity hydrodynamics equation with one pressure. Bull. Of the

Novosibirsk Computing Center, series: Mathematical Modeling in Geophysics, Novosibirsk, 2014, № 17, pp.5-12.

[5] Бердышев А.С., Блиева Д.Н. Применение преобразования Лапласа для сведения уравнений пороупругости к эллиптической системе уравнений //Материалы науч.конф ИИВТ МОН РК «Современные проблемы информатики и вычислительных технологий», 2-5 июля 2018г, г.Алматы, Казахстан, С80-81

[6] Френкель Я.И. К теории сейсмических и сейсмоэлектрических явлений во влажной почве // Изв.АН СССР. Сер.геогр. и геофиз. – 1944.-т.8, No.4 –С133-150

[7] Biot M.A. Theory of propagation of elastic waves in a fluid-saturated porous solids // J. Acoustic. Soc. Amer., - 1956, V. 28. P. 168 – 186.

[8] Abdumauvlen Berdyshev, Kholmatzhon Imomnazarov, Jian-Gang Tang, A. Mikhailov //The Laguerre spectral method as applied to numerical solution of a two-dimensional linear dynamic seismic problem for porous media. //Open Comput.Sci. – 2016, 6, p208-212



Monday 22, 12:30-13:00, Aula Magna

## **Finding your audience in social networks: How to predict robot-user interaction response thanks to our robot**

**Dobroslav Egorov<sup>1</sup>, Alexander Komarov<sup>1</sup>, Oleg Kravchenko<sup>1</sup>**

<sup>1</sup>Bauman Moscow State Technical University, Moscow, Russia

Nowadays many products in digital market provide automated solutions for communication with potential customer in Instagram. Different techniques as mass following/unfollowing are applied. However, the methods of picking up the potential audience are dubious. In addition, there is no any sort of analysis that would inspect the potential customer's profile and make a right corresponding action on the right time. In tactics of following/unfollowing the robot follows a user for few days usually and then unfollows. This time is enough for user to notice the account and follow it back in case of being interested in that profile.

In this work as the first step, data of Instagram robot-user interactions and analyze user responses in the scope of machine learning techniques has been recollected. Ideally, the goal is to maximize the following back rate for the users we follow. Using publicly available user's data to generate the features and to train the model. The final goal is to achieve high accuracy model that can predict how a user is likely to respond to the interaction. With such understanding, it makes possible focus on most potential users and easily build an account with the big audience. As the second step, learn how to retain these users for a long time. Unfollowing a user might trigger that user to unfollow your profile too. However, applying different sort of interactions with the user at particular moment before unfollowing might help a user to not notice the fact that he was unfollowed. Here we need to model which sort of interactions, how many and in which moment during our lifetime of following him we need to apply to the user in order to retain him as our follower. Being able to model these two important facts gives a huge leverage to a business to correctly target right audience in Instagram and retain these users for as long as possible.

Different approaches to handle the dataset of users have been made and model their interaction with a simulated robot. An explanation of how the feature engineering and validation on our dataset to prepare it for training is given.



## Communications (CO2)

Wednesday 24, 11:00-13:00, Aula Magna

Chairman: José Durany, Professor at University of Vigo and ITMATI

Wednesday 24, 11:00-11:30, Aula Magna

### Non-dimensional equations and toy models – Tools to improve the basic process understanding

**Mads Fromreide<sup>1</sup>, Svern Anton Halvorsen<sup>1</sup>, Manuel Sparta<sup>1</sup>**

<sup>1</sup>NORCE Norwegian Research Centre AS, Norway

Fundamental insight can be acquired by studying very simple mathematical models, called toy models. Such models should include some fundamental properties but will often be simplified to a degree that precludes direct, realistic, predictions. We recommend that the models are non-dimensionalized as part of a model study. The non-dimensional equations will reveal which non-dimensional groups can be relevant, and how these groups will identify various model regimes.

The methodology will be demonstrated for a 2D electric model for a smelting furnace running on alternating current (AC). The model includes electrodes, non-conductive lining and charge, slag or coke bed, and a metal layer. Assuming constant material properties, each region can be characterized by its electromagnetic penetration depth.

Three different types of non-dimensional groups can be defined:

- The squared ratio between two geometric lengths
- The squared ratio between two penetration depths
- The squared ratio between a geometric length and a penetration depth

Some of these groups define interesting model regimes, classified by whether the relevant non-dimensional group is very small, of order 1, or very large. Some examples will be discussed. Among others, the study has revealed conditions for when a direct current (DC) model can be appropriately applied to compute the furnace power distribution.

**Keywords:** Toy model, Non-dimensional equation, Model regimes, Process understanding, Metallurgy, Alternating Current, AC

## REFERENCES

- [1] J. C. Maxwell: “A dynamical theory of the electromagnetic field”, Philosophical Transactions of the Royal Society of London, Vol. 155, pp. 459-512, 1865
- [2] Alonso Rodriguez and A. Valli: “Eddy Current Approximation of Maxwell Equations”, Springer-Verlag Italia, 2010.
- [3] Bermúdez, D. Gómez and P. Salgado: “Mathematical Models and Numerical Simulation in Electromagnetism”, Springer International Publishing, Switzerland, 2014.
- [4] S.A. Halvorsen, H.A.H. Olsen, and M. Fromreide, “An Efficient Simulation Method for Current and Power distribution in 3-Phase Electrical Smelting Furnaces”, IFAC-PapersOnLine, Vol. 49, Issue 20, pp. 167–172. 2016
- [5] R. Schlanbusch, S.A. Halvorsen, S. Shinkevich, D. Gómez: “Electrical scale-up of metallurgical processes”, COMSOL Conference, Cambridge, UK, 2014. <https://www.comsol.com/paper/electrical-scale-up-of-metallurgical-processes-18321>. Accessed 15 May 2019
- [6] M. Fromreide, S.A. Halvorsen, E. Herland, D. Gómez, P. Salgado: “Simplified Models of the Electromagnetic Field Distribution in Metallurgical Smelting Furnaces”, poster presented at 11th International Symposium on Electric and Magnetic Fields, Darmstadt, 10-12 April 2018.
- [7] Harald Hanche-Olsen, “Buckingham  $\pi$  theorem”, Version 2004–08–16, 2004. <https://folk.ntnu.no/hanche/notes/buckingham/buckingham-a4.pdf>. Accessed 15 Feb 2019
- [8] Wikipedia: “Buckingham  $\pi$  theorem”, [https://en.wikipedia.org/wiki/Buckingham\\_%CF%80\\_theorem](https://en.wikipedia.org/wiki/Buckingham_%CF%80_theorem). Accessed 15 Feb 2019
- [9] COMSOL Inc.: COMSOL Multiphysics Reference Manual, ver. 5.3, 2018, <https://www.comsol.com>. Accessed 27 Dec 2018.
- [10] COMSOL Inc.: AC/DC Module User’s Guide, COMSOL Multiphysics 5.3, 2018, <https://www.comsol.com>. Accessed 27 Dec 2018.



Wednesday 24, 11:30-12:00, Aula Magna

## A transient thermal problem with non-local radiation arising in steelmaking industry

**Patricia Barral Rodiño<sup>1,2</sup>, Luis Javier Pérez<sup>1</sup>, Peregrina Quintela Estévez<sup>1,2</sup>**

<sup>1</sup>Departamento de Matemática Aplicada, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

<sup>2</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

This work aims to assess the time-dependent thermal response of the Blast Furnace runner or main trough, a refractory concrete structure used in the basic oxygen steelmaking process. It is specifically designed to separate and transport the slag and pig iron produced at the Blast Furnace. During its life, it has to sustain harsh operation conditions, which include extremely high temperatures, reaching 1500°C. The high degree of wear suffered by the main trough motivates the industrial interest on its assessment and minimization.

The wear suffered by the trough is due to various factors, such as erosion, corrosion and thermal stresses. It is believed to be strongly related to the position of the critical isotherms, which indicate the onset of chemical composition changes in the refractory lining. The casting process is not continuous, as it is done in cycles. Typically, each cast lasts for 90 minutes, followed by short stops. However, depending on the conditions at the casthouse, these stops frequently have a longer duration, reaching up to several days. During these longer stops, the trough has enough time to cool down. Consequently, the temperature field in the trough does not fully reach a steady state and follows patterns that match these cycles. Nonetheless, given the time scales of the temperature variations are very long, in the literature it is usual to assume steady thermal problems (see e.g. [1]). Also, in the previous work [3], a steady thermo-hydrodynamic 3d problem was studied.

Here, we focus on a simplified problem defined on a 2d cross-section of one of the runners that ArcelorMittal Spain operates in Veriña, Asturias. The main objective is to assess the transient thermal behaviour of this section during the two-month campaign life of the runner and to find the position of the critical isotherms. With this purpose, we use time-dependent boundary conditions which emulate the effect of the casting process stops. In addition, we model the non-local radiation at the boundary as an integral equation, which accounts for the effects of thermal radiation emitted by the slag free surface and reflected by the walls of the trough. The spatial discretization and numerical solution of the non-linear problem is done with a finite element method, using the FEniCS library.

The proposed methodology has shown promising results and proved useful in order to predict the transient position of the critical isotherms. The computed temperatures are validated using experimental measures supplied by ArcelorMittal.

#### Acknowledgements

This work was partially supported by FEDER and Xunta de Galicia funds under the ED431C 2017/60 grant, by the Ministerio de Ciencia, Innovación y Universidades through the Plan Nacional de I+D+i (MTM2015-68275-R) and the grant BES-2016-077228

**Keywords:** steelmaking, transient heat transfer, non-local radiation

#### REFERENCES

- [1] S. Vázquez-Fernández, A. G.-L. Pieiga, C. Lausín-González, and P. Quintela, "Mathematical modelling and numerical simulation of the heat transfer in a trough of a blast furnace", *International Journal of Thermal Sciences*, vol. 137, pp. 364-374, 2019.
- [2] M. Geerdes, R. Chaigneau, and I. Kurunov, *Modern blast furnace ironmaking: An introduction*. IOS Press, 2015.
- [3] P. Barral, B. Nicolás, L. J. Pérez-Pérez, and P. Quintela, "Numerical simulation of wear-related problems in a blast furnace runner", in *Recent Advances in Differential Equations and Applications* pp. 229-244, Springer, 2019.



Wednesday 24, 12:00-12:30, Aula Magna

## Prediction of wire rod temperatures under different industrial process conditions: Application of reduced order modelling for a fast prediction

Elena Martín<sup>1,3</sup>, Fernando Varas<sup>2</sup>, Iván Vieitez<sup>1,4</sup>

<sup>1</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

<sup>2</sup>Departamento de matemática Aplicada a la ingeniería aeroespacial, E.T.S.I. Aeronáutica y del Espacio, Universidad Politécnica de Madrid, Madrid, Spain

<sup>3</sup>Escola de Enxeñaría Industrial, Universidade de Vigo, Vigo, Spain

<sup>4</sup>Escola de enxeñaría de telecomunicación, Universidade de Vigo, Vigo, Spain

The number of operational variables that determines the cooling process of steel wire, given by the conveyor velocity and the different fan sections powers (controlled independently), lead to a dependency of the cooling on a high multidimensional parameter space whose potential combinations are impossible to be analyzed, either experimentally or by numerical simulation of a thermal-metallurgical model. To tackle this problem, an efficient strategy, based on the use of Higher Order Singular Value Decomposition (HOSVD), is presented. The approach presented permits to predict quite accurately the cooling curve for any combination of the process parameters. Fast on-line predictions of the cooling rates allow incorporating accurate modelling results in many Engineering tools, such as model predictive control algorithms or planting simulation software.

**Keywords:** Numerical simulation, Heat treatment, Wire rod cooling, Reduced order models, Higher order singular value decomposition

### REFERENCES

- [1] E. Anelli, Application of mathematical modelling to hot rolling and controlled cooling of wire rods and bars, *ISIJ Int.* 32 (3) (1992) 440–449.
- [2] I. Vieitez, F. Varas, E. Martín, An efficient computational technique for the prediction of wire rod temperatures under different industrial process conditions, *Applied Thermal Engineering* 149 (2019) 287-297.
- [3] G. Berkooz, P. Holmes, J.L. Lumley, The proper orthogonal decomposition in the analysis of turbulent flows, *Annu. Rev. Fluid Mech.* 25 (1993) 539–575.
- [4] R. Everson, L. Sirovich, Karhunen-Loeve procedure for gappy data, *J. Opt. Soc. Am. A* 12 (8) (1995) 1657–1664.
- [5] L. De Lathauwer, B. de Moor, J. Vandewalle, A multilinear singular value decomposition, *SIAM J. Matrix Anal. Appl.* 21 (2000) 1253–1278.



[6] E. Martín, M. Meis, C. Mourenza, D. Rivas, F. Varas, Fast solution of direct and inverse design problems concerning furnace operation conditions in steel industry, Appl. Therm. Eng. 47 (2012) 41–53.



Wednesday 24, 12:30-13:00, Aula Magna

## Numerical analysis with FEM to improve the planning of Transcatheter Aortic Valve Replacement

Marcos Loureiro-Ga<sup>1,2</sup>, Cesar Veiga<sup>1</sup>, Generosa Fdez-Manín<sup>2</sup>, Pablo Juan Salvadores<sup>1</sup>,  
Victor A. Jimenez<sup>3</sup>, Jose A. Baz<sup>3</sup>, Andres Iñiguez<sup>3</sup>

<sup>1</sup>Instituto de Investigación Sanitaria Galicia Sur, Hospital Álvaro Cunqueiro Bloque técnico, Vigo, Spain

<sup>2</sup>Escola de Enxeñaría de Telecomunicación, Universidade de Vigo, Vigo, Spain

<sup>3</sup>Servizo de CardioloXía, Hospital Alvaro Cunqueiro, Vigo, Spain

This research arises from a collaboration between the Applied Mathematics II department (DMA-II) of the University of Vigo and the Health Research Institute Galicia Sur (IISGS) with the scope of contributing to the field of cardiology with advanced techniques of numerical simulation in a relatively new procedure called Transcatheter Aortic Valve Replacement (TAVR). The planning of this intervention faces several difficulties such as optimal device selection [1] where numerical simulation is playing an increasingly important role [2]. Consequently, several TAVR devices are designed and patient-specific 3D reconstruction is obtained by processing CT scan images. Those geometries are processed to create a finite element mesh valid for numerical simulation where a solid mechanics problem involving a contact problem is configured. The deployment process of different valves is simulated for the patient and insightful information such as haemodynamics of the left coronary artery [3] or induced tension after the procedure [4] can be computed. Therefore, the inclusion of numerical simulation in the clinical pipeline of TAVR is a powerful tool which can increase the amount of information considered when decision making. Further validations need to be done to apply this methodology in a great scale. A position paper from the ISO Working Group regarding this issue was recently published [5]. This research has lead also to the development of Marcos Loureiro-Ga doctoral thesis, funded by Xunta de Galicia.

**Keywords:** finite element method, solid mechanics, contact problem, aortic stenosis, transcatheter aortic valve replacement

### REFERENCES

- [1] Neragi-Miandoab, S., & Michler, R. E. (2013). A review of most relevant complications of transcatheter aortic valve implantation. *ISRN cardiology*, 2013, 956252. <https://doi.org/10.1155/2013/956252>
- [2] Chandran, KB. Role of Computational Simulations in Heart Valve Dynamics and Design of Valvular Prostheses. *Cardiovasc Eng Tech* (2010) 1: 18. <https://doi.org/10.1007/s13239-010-0002-x>

- [3] Loureiro -Ga, M., Veiga, C., Fdez-Manin, G., Salvadores PJ., Jimenez VA., Baz, JA, Iñiguez, A. Hemodynamics of the left coronary artery after TAVI procedure: a numerical simulation analysis. European Heart Journal, Volume 39, Issue suppl\_1, August 2018, ehy566.P6224, <https://doi.org/10.1093/eurheartj/ehy566.P6224>
- [4] Loureiro-Ga, M., Veiga, C., Fdez-Manin, G., Salvadores PJ., Jimenez VA., Baz, JA, Iñiguez, A. SimulTAVI - Personalized Medicine: Predicting Device Behaviour and Possible Outcomes of a TAVI by Using Image Processing and Numerical Simulation Techniques. JACC: Cardiovascular Interventions Feb 2019, 12 (4 Supplement) S41; DOI: <https://doi.org/10.1016/j.jcin.2019.01.151>
- [5] Wei, Z.A., Sonntag, S.J., Toma, M. et al. Computational Fluid Dynamics Assessment Associated with Transcatheter Heart Valve Prostheses: A Position Paper of the ISO Working Group. Cardiovasc Eng Tech (2018) 9: 289. <https://doi.org/10.1007/s13239-018-0349-y>

## Success Stories Posters (SSPS)

---

Monday 22, 12:40-13:30, Salón de Graos.

Chairman: M<sup>a</sup> José Ginzo Departamento de Estadística, Análisis Matemático y Optimización, Universidade de Santiago de Compostela and ITMATI collaborator.

Monday 22, 12:40-12:50 Salón de Graos

### **Optimal design of a railway bypass at Parga, north-west of Spain**

**Gerardo Casal<sup>1</sup>, Alberte Castro<sup>2</sup>, Duarte Santamarina<sup>1</sup>, Miguel E. Vázquez-Méndez<sup>1</sup>**

<sup>1</sup>Departamento de Matemática Aplicada, Escola Politécnica Superior, Universidad de Santiago de Compostela, Campus de Lugo, Lugo, Spain

<sup>2</sup>Departamento de Ingeniería Agroforestal, Universidad de Santiago de Compostela, Campus de Lugo, Lugo, Spain

The railway line in the northwest of Spain was put into service at the end of the nineteenth century. It runs through multiple small towns and villages, which generates a high accident risk due to the existence of many level crossings with roads and secondary path. To alleviate this problem, inherited from the historical construction development of the railway, in recent years the Administrator of Railway Infrastructures in Spain (ADIF) is performing numerous actions. Usually, these actions consist of fencing the railway track area and removing level crossings, which are replaced by bridges or underpasses allowing the passage of vehicles and pedestrians. These actions may negatively affect some important aspects of the town (economical, environmental, social, etc.), and sometimes they are rejected by both neighbors and local institutions. This is the case of Parga, a village in the northwest of Spain, where the neighbors have established the #parganonsedivide association, to disagree with the project presented by ADIF and to require a railway bypass bordering the urban area. In this work, at the proposal of the aforementioned association, the feasibility of such bypass is studied. In order to do it, the problem of designing a bypass fulfilling with technical standards and being optimal from an economical point of view, is formulated and studied in the framework of non-linear and non-convex constrained optimization. As result of this work, a railway bypass at Parga is obtained. It satisfies all technical standards, is acceptable from an economical point of view, and verifies all requirements made by #parganonsedivide, promoter association of this Project.

**Keywords:** railway bypass; optimal design; non-convex optimization; differentiable optimization

#### REFERENCES

- [1] Vázquez-Méndez, M.E. and Casal, G. (2016). The clothoid computation: A simple and efficient numerical algorithm. *J. Surv. Eng.*, 142(3), 04016005.
- [2] Casal, G., Santamarina, D. and Vázquez-Méndez, M.E. (2017). Optimization of horizontal alignment geometry in road design and reconstruction. *Transp. Res. Pt. C-Emerg. Technol.*, 74, 261--274.
- [3] Vázquez-Méndez, M.E., Casal, G., Santamarina, D. and Castro, A. (2018). A 3D model for optimizing infrastructure costs in road design. *Comput.-Aided Civ. Infrastruct. Eng.*, 33, 423--439.
- [4] Vázquez-Méndez, M.E., Casal, G. and Ferreiro, J.B. (2019). Egg and double-egg curves with clothoids. Numerical computation. Preprint submitted to *J. Surv. Eng.*



Monday 22, 12:50 -13:00, Salón de Graos

## **Copula-based anomaly scoring and localization of high-dimensional data with application in telecommunication networks**

**Gábor Horváth<sup>1</sup>, Edith Kovács<sup>1,2</sup>, Roland Molontay<sup>1,2</sup>, Szabolcs Nováczki<sup>3</sup>**

<sup>1</sup>Budapest University of Technology and Economics, Budapest, Hungary

<sup>2</sup>University of Debrecen, Debrecen, Hungary

<sup>3</sup>Nokia Bell Labs, Budapest, Hungary

For decades, telecommunication operators have relied on network domain experts to report problems that affect the network performance and customer experience, with the aim of performance monitoring tools. The conventional approach of the tools is to pre-select a set of Key Performance Indicators (KPIs), based on human knowledge and experience of the domain experts. The trending of these KPIs are closely monitored, based on pre-defined single-value or multi-value thresholds, and/or pre-built single variate or multivariate time series profiles. If the KPI values exceed the thresholds/profiles, then alarms will be raised to trigger investigation, mitigation and on-site support. All the processes are manual or semi-auto with limited support of tools. The traditional tools are mainly based on human knowledge, and that the complex and hidden rules in the telecommunication network are not easy to fully detect, capture and utilize.

Thus there is a strong need to revolutionize network management with AI/machine learning technology. Automated solutions are needed that are capable to analyze the raw data and draw conclusions, generate actionable insights using AI technology. One important area in this field is the predictive detection of anomaly patterns that appear in the data.

Here we present an anomaly detection method that does not only indicate whether an observation is anomalous or not but also tells us what exactly makes an anomalous observation unusual. The proposed approach is model-based; it relies on the multivariate probability distribution associated with the observations. Since the rare events are present in the tails of the probability distributions, we use copula functions, that are able to model the fat-tailed distributions well. The presented procedure scales well; it can cope with a large number of high-dimensional samples.

We demonstrate the usability of the method through a case study, where we analyze a large data set consisting of the performance counters of a real mobile telecommunication network. Since such networks are complex systems, the signs of sub-optimal operation can remain hidden for a potentially long time. With the proposed procedure, many such hidden issues can be isolated and indicated to the network operator.

**Keywords:** anomaly detection, telecommunication network

## REFERENCES

- [1] C Chow and Cong Liu. 1968. Approximating discrete probability distributions with dependence trees. *IEEE Transactions on Information Theory* 14, 3 (1968), 462–467.
- [2] Rémi Domingues, Maurizio Filippone, Pietro Michiardi, and Jihane Zouaoui. 2018. A comparative evaluation of outlier detection algorithms: Experiments and analyses. *Pattern Recognition* 74 (2018), 406–421.
- [3] Maria Erdmann. 2018. Unsupervised Anomaly Detection in Sensor Data used for Predictive Maintenance. Ph.D. Dissertation.
- [4] Edith Kovács and Tamás Szántai. 2017. On the connection between cherry-tree copulas and truncated R-vine copulas. *Kybernetika* 53, 3 (2017), 437–460.
- [5] Hans-Peter Kriegel, Peer Kröger, and Arthur Zimek. 2009. Clustering high-dimensional data: A survey on subspace clustering, pattern-based clustering, and correlation clustering. *ACM Transactions on Knowledge Discovery from Data (TKDD)* 3, 1 (2009), 1.
- [6] Arthur Zimek, Erich Schubert, and Hans-Peter Kriegel. 2012. A survey on unsupervised outlier detection in high-dimensional numerical data. *Statistical Analysis and Data Mining: The ASA Data Science Journal* 5, 5 (2012), 363–387.



Monday 22, 13:00-13:10, Salón de Graos

## Algorithms to Fight Wildfires

**Ana Belén Buide<sup>1</sup>, M<sup>a</sup> José Ginzo<sup>2</sup>, Manuel Antonio Novo<sup>1</sup>**

<sup>1</sup>ITMATI, Campus Vida, Santiago de Compostela, Spain

<sup>2</sup>Departamento de Estadística, Análisis Matemático y Optimización, Universidade de Santiago de Compostela, Santiago de Compostela, Spain

For decades, telecommunication operators have relied on network domain experts to report problems that Spain is one of the countries with a large forest cover and also one of the most affected by wildfires. The northwest, region of Galicia in particular, has recorded the most number of fires and burnt surface in recent years.

“Emergency critical missions with manned and unmanned aerial resources in cooperative flight” (Project ENJAMBRE), of the CIEN programme (2014-2018), is one of the research and transfer projects aimed at tackling this problem of wildfires. It is co-financed by the Spanish Centre for the Development of Industrial Technology (CDTI).

Wildfires are included in the priority of protection in emergencies and disasters of the Spanish National Security Strategy, one of the priorities on which ENJAMBRE is focused; with the objective to develop technologies that allow manned aircraft to carry out intervention tasks and unmanned aircraft to undertake the observation tasks, to operate in the same airspace in a cooperative and secure way; to support the decision-making process during the observation tasks and to reduce costs.

The main algorithms in focus are the following: an algorithm for the estimation of wildfire perimeter by applying set estimation techniques to thermal images; an algorithm for collision prevention between the aircrafts that operate in a fire; an algorithm for the calculating escape routes for the brigades working on the extinction, taking into account the orography, vegetation and existing roads; an algorithm for calculating efficiency of water discharges from the aerial resources working in extinction operations; and, an algorithm for management of aerial resources, considering the current regulations for pilots and aircraft.

In the extinction of a forest fire, the use of brigades is an essential element for controlling the fire from the ground. Therefore, it is necessary to maintain good communication and organization between the brigades, so that they face it safely and prevent the fire from surrounding them. The Brigades’ Escape Routes Algorithm arises with the objective of calculating an escape route for the evacuation of the brigades working on the ground, in such a way that the brigade always has an exit even in extreme situations in which the probability of being trapped is elevated. For this, it is necessary to calculate a displacement

layer by the land for the brigades, based on the slope of the terrain, the existing vegetation, the available roads and the obstacles that the brigade must avoid. The maximum speed of displacement is calculated using the formula proposed by Tobler (1993) and takes into account the values proposed by Wood and Schmidlein (2011) that reduce the speed depending on the vegetation and the type of road. Once the displacement layer is calculated, the shortest path (the escape route) is computed to go from the brigades' position to the safe zone chosen beforehand, as shown by van Etten (2017).

Another important resource in the extinction of wildfires are aircrafts. The Aerial Resources' Optimization Algorithm's objective is to plan the aerial resources available on the level of investment resources and intervention needs, minimizing the periods without work and under consideration of the applicable legal regulations (Operational Circular 16-B). For this, an integer linear programming model is proposed based on Rodríguez-Veiga et al. (2018), which minimizes the unfulfillment of intervention needs and ensures fulfillment of legal regulations, expressed as the constraints in the problem.

**Keywords:** wildfire, escape routes, resources

#### REFERENCES

- [1] Etten, J. V. (2017). R package gdistance: distances and routes on geographical grids.
- [2] Rodríguez-Veiga J., Ginzo M. J., Casas-Méndez B (2018). An integer Linear Programming Model to select and Temporally Allocate Resources for Fighting Forest Fires. *Forests*, 9, 583.
- [3] Tobler, W. (1993). Three presentations on geographical analysis and modeling. *Speculations on the geometry of geography; and global spatial analysis*. UCSB.National Center for Geographic Information and Analysis Technical Report, 93, 583.
- [4] Wood, N. J., & Schmidlein, M. C. (2012). Anisotropic path modeling to assess pedestrian-evacuation potential from Cascadia-related tsunamis in the US Pacific Northwest. *Natural Hazards*, 62(2), 275-300.



Monday 22, 13:10-13:20, Salón de Graos

## **Towards segmentation of hashtags for Instagram post analysis**

**Dobroslav Egorov<sup>1</sup>, Alexander Komarov<sup>1</sup>, Oleg Kravchenko<sup>1</sup>**

<sup>1</sup>Bauman Moscow State Technical University, Moscow, Russia

Nowadays there are many solutions in digital market that provide automated massive interactions with the audience in Instagram. However the ways of picking up the audience are very general and the accuracy of targeting right people might be very low. Therefore it is important to clusterize the audience in Instagram and understand what the users you target write about and in which language. One of the ways to find it out is analyzing the hashtags for users' posts. However there are some pitfalls.

In general, there are two related problems. Disambiguation problem is the first one, and the second is about unknown words handling. The common way to solve the second problem is a hidden Markov model implementation. In present paper to solve the first problem a parallel corpora approach is considered.

Monday 22, 13:20-13:30, Salón de Graos

## Machine learning algorithms for predicting academic performance and identifying the contributing factors

Roland Molontay<sup>1</sup>, Marcell Nagy<sup>1</sup>

<sup>1</sup>Budapest University of Technology and Economics, Budapest, Hungary

Data-driven approaches have received a lot of attention recently from higher education researchers and policy-makers as well. At Budapest University of Technology and Economics in fruitful cooperation with an industrial partner who developed the unified educational administrative system, an extract insights from big data stored in the administrative system have been done. Among many other questions, there has been a study curriculum prerequisite networks with a student flow approach, the effect of mathematical remediation, the impact of living on-campus on academic achievement, the connection between grade inflation and student evaluation of teaching and efficient visualization of student flows. However, one of the most burning problems in higher STEM education all over the world is dropping out. A predictive analytical approach for early detection of students at risk of academic failure is shown. Relatively high accuracy has been achieved, compared to the results of related works. A web application that is able to identify at-risk students mainly based on their high school results and matura results using machine learning algorithms (neural networks and gradient boosting trees) has been developed. The application can also be used to recommend tutoring sessions and remedial courses for at-risk students. The application is also capable of making suggestions for students which skills to improve in order to succeed in their university studies.

**Keywords:** machine learning, predictive analytics, predicting dropout, educational data mining, leaning analytics

### REFERENCES

- [1] Aulck, L., Velagapudi, N., Blumenstock, J., & West, J. (2016). Predicting Student Dropout in Higher Education. *arXiv preprint arXiv:1606.06364*.
- [2] von Hippel, P., & Hofflinger, A. (2017). The Data Revolution Comes to Higher Education: Identifying Students at Risk of Dropout in Chile. *Available at SSRN 3073912*.
- [3] Vossensteyn, J. J., Kottmann, A., Jongbloed, B. W., Kaiser, F., Cremonini, L., Stensaker, B., Hovdhaugen, E., & Wollscheid, S. (2015). Dropout and Completion in Higher Education in Europe: Main report. European Union.
- [4] Lundberg, S. M., & Lee, S. I. (2017). A Unified Approach to Interpreting Model Predictions. In *Advances in Neural Information Processing Systems* (pp. 4765-4774).
- [5] Chen, T., & Guestrin, C. (2016). XGBoost: A Scalable Tree Boosting System. In *Proceedings of the*



*22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 785-794). ACM.

[6] Nagy, M., & Molontay, R. (2018). Predicting Dropout in Higher Education Based on Secondary School Performance. In *2018 IEEE 22nd International Conference on Intelligent Engineering Systems (INES)* (pp. 389-394). IEEE.

[7] Nagy, M., Molontay, R., & Szabó, M. (2019). A Web Application for Predicting Academic Performance and Identifying the Contributing Factors. In 47th SEFI Conference.

## B2B matchmaking event

---

The matchmaking event from 23-24 th of July is co-organised by the [Enterprise Europe Network](#) – the biggest European Network that provides internationalisation and innovation support to European businesses.

Matchmaking sessions allow you to use the full networking potential this conference offers. A brokerage event is a quick and easy way to meet potential cooperation partners.

Participants meet for pre-arranged bilateral face2face meetings. Each meeting will last around 15 minutes.

Take advantage of the opportunity and introduce your company/organisation by publishing a high quality profile.

### **AGENDA:**

#### **23rd July 2019 (Tuesday)**

**09:00 - 11:00** - Bilateral meetings - **Session 1**

*15min Meeting Duration*

**11:30 - 12:30** - Bilateral meetings - **Session 2**

*15min Meeting Duration*

## Links of interest

---

Main conference Agenda available [HERE](#)

Specific conference Agenda available : [HERE](#)