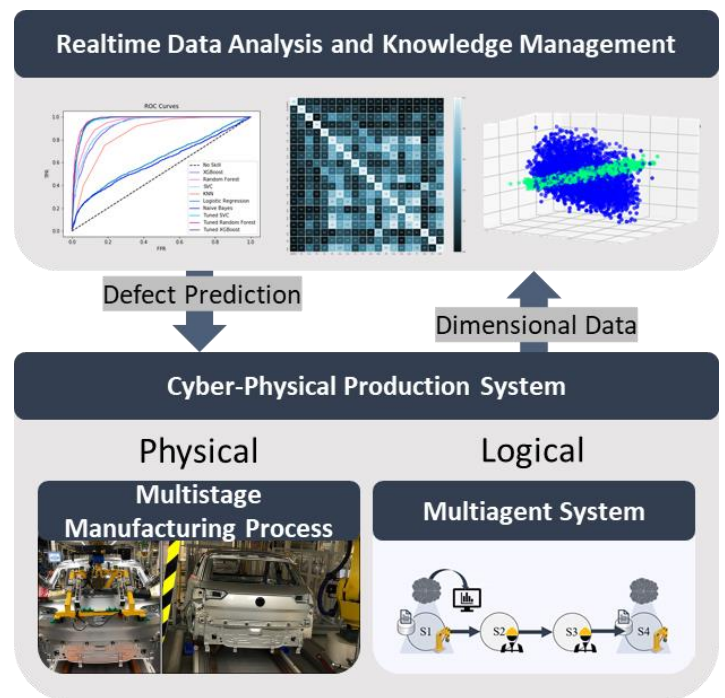# CPPS and ML: Predictive Quality Control in an Automotive Multistage Process

Product dimensional variability is a crucial factor in the quality control of complex multistage manufacturing processes in the automotive industry, where undetected defects can easily be propagated downstream. Furthermore, this inherent complexity and the random nature of uncertainties and disturbances in manufacturing processes make it considerably difficult to guarantee the desired quality of the product. Therefore, an effective method to enable the automated and early detection of potential defects during production using online data would be highly advantageous to manufacturers. The recent advances in information technologies and consequently the increased volume of data that has become readily available provide an excellent opportunity for the development of automated defect detection approaches that are capable of extracting the implicit complex relationships in these multivariate data-rich environments.

In this light, the Predictive Manufacturing System (PMS) paradigm has been gaining traction as an approach to develop solutions ready to answer this need. Due to recent technological developments renewing the interest in Machine Learning (ML) applications, along with a growing adoption of Industry 4.0 concepts and approaches such as Cyber-Physical Production Systems (CPPS), the foundation for the realization of such systems is being laid down. Hence, the conditions are being created for the utilization of advanced predictive tools capable of systematically processing these data into information that can explain the aforementioned uncertainties and thus assist manufacturing personnel in making more informed decisions.

For this purpose, UNINOVA-CTS and Volkswagen AutoEuropa developed a predictive solution combining multiagent-based CPPS and Machine Learning (ML) to enable an early detection of potential dimensional defects based on framing measurements taken prior to the part assembly stages in the body shop. The case study encompassed two automated inspection stations with several human-operated assembly and pre-alignment stages in between, for which dimensional data in the first inspection stage was used to predict gap and flush defects during the inspection at the end of this assembly line.

The results suggest that non-linear models like XGBoost and Random Forests are capable of modelling the complexity of such an environment, achieving a high true positive rate and showing promise for the improvement of existing quality control approaches, enabling defects and deviations to be addressed earlier and thus assisting in the reduction of scrap and repair costs.

Ricardo Silva Peres

CONTENTS

R&D projects

Storage4Grid: CTS at the Portugal Smart Cities Summit

João Martins

On 21-23 May, CTS researchers were present at the Portugal Smart Cities Summit held at FIL's premises. This participation results from a partnership with WeMob, Almada's municipal company for mobility. The Interreg Smart Heritage City and H2020 Storage4Grid projects were presented. The Smart Heritage City project addresses the innovative challenge of creating a single open source tool for managing historic urban centres and facilitating the work of competent authorities in decision-making. The SHCITY (http://shcity.eu/) solution integrates data collected by sensor networks implemented in the urban area in order to monitor and respond to risk factors affecting buildings and their surrounding area, energy consumption management and the control and management of visitor flow. The Storage4Grid project provides utilities and end-users with new tools for optimal grid planning, use and evaluation of storage technologies. Storage4Grid (http://www.storage4grid.eu/pages/index.html) considers new storage control models and interfaces built upon existing standards and suitable to support scalable and cost-efficient coordination of heterogeneous SS.

foRESTER

Luis Oliveira

In the last 20 years, Portugal has been severely affected by large wildfires with dramatic consequences. The recent 2017 year was the worst on record, with the largest burnt area extent and the largest number of casualties. It is urgent that the scientific community provides sound and efficient tools capable of improving decision making during wildfires crisis to minimize its negative consequences. A key issue is the lack of decision support mechanisms for operational interventions. Due to the complexity of large wildfires, their effective suppression requires suitable and well-coordinated resources, up-to-date knowledge of the landscape, and accurate prediction of fire behavior. A Decision Support System (DSS) that can integrate the panoply of required information in a simple and efficient platform is the main scientific challenge of foRESTER. The main goal is to provide fire managers with useful and sound information to improve fire suppression strategy and decisions. To accomplish this, foRESTER proposes a fast, reliable and informative DSS based on advanced computational intelligence and visualization techniques, that integrates innovative technologies from multi-sensor systems, cutting edge satellite image processing, and near real-time (NRT) fire spread predictions (FSP). The project aims to provide a low-cost framework based on a WSN and new information system tools to produce a pilot demonstrator of the effectiveness of DSS for supporting decision-making in fire suppression context. It will be built on past experience from MacFIRE, together with new layers of information, providing a more informative DSS for the fire managers. Moreover, we will extend the pilot to the Médio-Tejo region and demonstrated it as a scalable platform for the entire national territory.

Funder by the National Foundation for Science and Technology (FCT), the project is coordinated by CTS and started last March, with duration of 3 years.
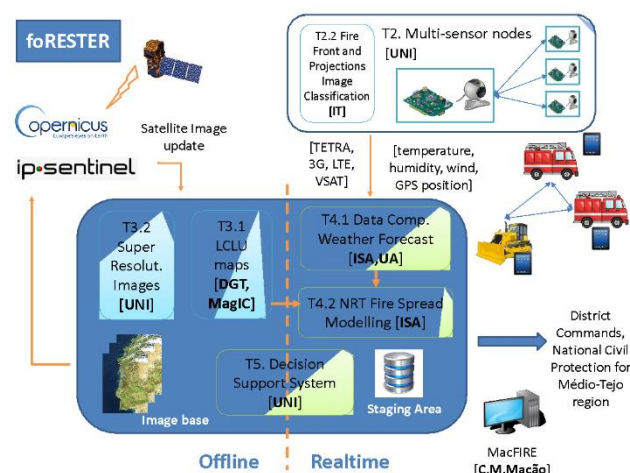
A Positive Energy CITY Transformation Framework

João Martins

A new H2020 Smart Cities project, involving CTS, will start next October having Portuguese City Évora as Lighthouse. POCITYF supports the Lighthouse cities of Evora (PT) and Alkmaar (NL) and their Fellow cities Granada (ES), Bari (IT), Celje (SI), Ujpest (HU), Ioannina (GR) and Hvidovre (DK) to address their urgent need to deliver positive energy blocks and districts in their cities, towards rendering their mixed urban environment (also including the case of cultural protected buildings) into cheaper, better accessible, healthier and more reliable. By demonstrating in overall 10 integrated solutions (ISs), comprising 73 individual innovative elements (technologies, tools, methods), rooted under existing City Information Platforms (CIPs), POCITYF quantifies their value, and connects interests of many different stakeholders in innovative business models, allowing for upscale and replication of those solutions in a form of a validated roadmap for sustainable cities across Europe and world-wide.

IMproving Sustainable Development Policies and PrActices to assess, diversify and foster Cultural TOURism in European regions and areas (IMPACTOUR)

João Martins

CTS will coordinate the new H2020 IMPACTOUR project. The main ambition of IMPACTOUR project is to create an innovative and easy-to-use methodology and tool to measure and assess the impact of Cultural Tourism (CT) on European economic and social development and to improve Europe's policies and practices on CT, strengthening its role as a sustainable driving force in the growth and economic development of European regions. IMPACTOUR proposes to bring together CT-related stakeholders and researchers to achieve new approaches taking advantage of the large amounts of information that confront policy-makers. By identifying and comparing quantitative/qualitative pan-European information on CT forms and promotion, and by providing quantifiable evidence of CT strategies and their effect on European regions' development and Europeanisation, IMPACTOUR will deliver an innovative methodology and tool (combining data analytics algorithms with artificial intelligence and machine learning strategies) providing CT stakeholders with strategic guidance so that policies and practices on CT can be improved. IMPACTOUR Methodology will be completed and tested with data coming from 15 Data Information Pilots and the IMPACTOUR tool will be validated in 5 Validation Pilots, with distinct characteristics spread around Europe.

Coordinating energy research for a low-carbon Europe

João Murta Pina

The **European Energy Research Alliance** (EERA)[1] is the largest energy research community in Europe. It was founded in 2008 by the top European R&D centres, aiming to coordinate the research efforts in this field across Europe.
Currently, more than 250 European organisations, from 30 countries in the EU and in associated member countries, integrate EERA, involving an estimated number of 50,000 researchers. These work together in 17 Joint Programmes, which are aligned with the priorities of the Strategic Energy Technology Plan (SET-Plan)[2], the research and innovation pillar of the EU's energy and climate policy for more than a decade. CTS, through FCT NOVA, actively participates in the **Joint Programme on Energy Storage** [3] (JPES), launched in 2011 and coordinated by the Karlsruhe Institute of Technology (KIT). The JPES is the first pan-European programme to bring together all major fields and players of energy storage research and is a privileged opportunity to coordinate R&D efforts and influence EU policy in this field. The JPES strongly fosters the efficient development of new and improved energy storage technologies. It supports the SET-Plan goals and priorities by "pooling and integrating activities and resources including international partners" on all levels of the value chain. The JPES is a forum for collaboration among members and with other Joint Programmes, **promoting synergies through joint EU projects**, bridging the gap to industry, supporting technology transfer, and establishing a strategic European leadership in Energy Storage.

Joint Programmes are organised in Sub-Programmes, where Work Packages related to their specific field are defined and implemented. The JPES is built around five Sub-Programmes related to specific energy storage technological families (SP1 to SP5) and one cross-sectorial Sub-Programme concerning technical and econ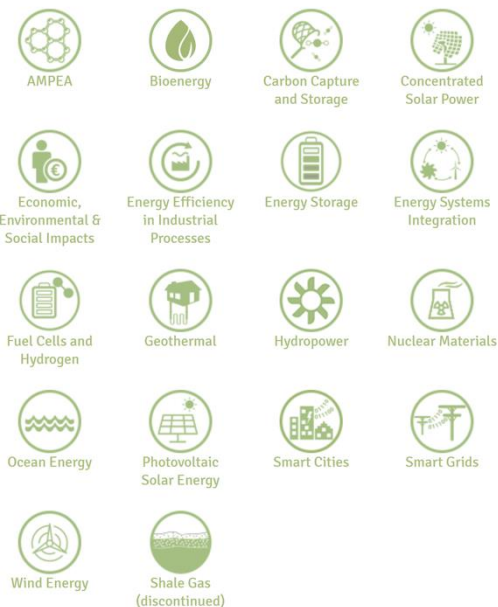omic aspects of those families, namely: *Electro-chemical Storage* (SP1); *Chemical Storage* (SP2); *Thermal Storage* (SP3); *Mechanical Storage* (SP4); *Superconducting Magnetic Energy Storage* (SP5); and *Techno-Economics* (SP6).

CURRENTLY, 17 EERA JOINT PROGRAMMES ARE ACTIVE:

AMPEA · Bioenergy · Carbon Capture and Storage · Concentrated Solar Power · Economic, Environmental & Social Impacts · Energy Efficiency in Industrial Processes · Energy Storage · Energy Systems Integration · Fuel Cells and Hydrogen · Geothermal · Hydropower · Nuclear Materials · Ocean Energy · Photovoltaic Solar Energy · Smart Cities · Smart Grids · Wind Energy · Shale Gas (discontinued)

EERA JP ES Meeting on May 2018 at DIFFER (Eindhoven, Netherlands)

Besides producing policy reports on energy storage for the EU, or organising regular Steering Committee and Management Board Meetings, where participants personally discuss strategic and operational aspects (CTS has voting right on these boards), the JPES organises **Workshops on Hybrid Storage and Energy Storage Systems** typically once a year, where challenges, innovative storage schemes, and advanced knowledge in the field is exchanged, with a strong industry participation. This year's Workshop will be in November, in Rome. *We strongly encourage you to participate in a leading European network on energy and energy storage.*

[1] https://www.eera---set.eu/
[2] http://ec.europa.eu/research/energy/index.cfm?pg=policy&policyname=set
[3] https://eera---es.eu/

Recent PhD thesis:

Evolutionary Service Composition and Personalization Ecosystem for Elderly Care
PhD student: **Thais Baldissera**

Supervisor: Prof. Luis M. Camarinha-Matos

Defense date: 2 Oct 2019
Faculty of Sciences and Technology, NOVA University of Lisbon

Books

Handbook of Fractional Calculus with Applications

Manuel D. Ortigueira

The Fractional Calculus (FC) has attracted increasing number of scientists and engineers. This gave rise to a great evolution and increase in the application fields. Although, the number of publications grew up exponentially, many people felt the need for a high-quality publication making an upgrade of the actual status of FC. The 8 books series under title "Handbook of Fractional Calculus with Applications" (De Gruyter) tried to respond to such need. It was organized by Prof. J. Tenreiro Machado, from ISEP, Porto, Portugal and covers all the theoretical and practical aspects of FC, mainly, differential equations, numerical methods, applications in Physics, Control, Engineering, Social Life, etc.

1 - Continuous-time fractional linear systems: transient responses, Volume 6, pages 119-148. Authors: Manuel D. Ortigueira, Duarte Valério, and António M. Lopes
Highlights: Introduction to fractional continuous-time linear systems based on suitable fractional derivatives. Definition and computation of the usual tools: impulse response, transfer function, and frequency responses for both, commensurate and non-commensurate cases. Properties of the systems, like causality, periodicity, and stability are also studied. The MIMO systems are studied from the state-space point of view.

2 - Continuous-Time Fractional Linear Systems: steady-state responses, Volume 6, pages 149-174. Authors: Duarte Valério, Manuel D. Ortigueira, J. A. Tenreiro Machado, and António M. Lopes
Highlights: Presentation of the frequency responses for several single-input, single-output fractional-order systems – commensurate, non-commensurate, and implicit. Both analytical expressions, and Bode, Nyquist and Nichols diagrams are shown for several typical transfer functions. Addressing of: a) the Levy identification method for fractional orders, b) integer-order approximations of fractional-order systems (Crone, Carlson, Matsuda), and c) the Nyquist stability criterion for closed loop commensurate systems.

3 - Recursive–operational method for fractional systems - System theory without Laplace transform, Volume 8, pages 119-147. Authors: Gabriel Bengochea, Manuel Ortigueira, Luis Verde–Star, and António Lopes
Highlights: Presentation of a recursive-operational method for studying fractional continuous–time linear systems based on the convolution product. The method is recursive in the sense that we can add or remove (pseudo-) poles or zeros in an individual form. The procedure can be used also in nonlinear systems.

4 - Discrete-Time Fractional Signals and Systems, Volume 8, pages 149 -178; Authors: Manuel D. Ortigueira, José T. Machado, Fernando J. V. Coito, and Gabriel Bengochea
Highlights: Formulation of a coherent theory for fractional discrete-time signals and systems taking two derivatives, namely the nabla (forward) and delta (backward), as basis. Two discrete-time Laplace transforms are introduced, and their properties deduced. Study of fractional discrete-time linear systems defined by differential equations with the introduction of the notions of impulse response, transfer function and frequency response. The framework is compatible with classic discrete-time signals and systems and allow a uniform approximation of continuous systems when the sampling interval reduces to zero.

## Ultra-Low Input Power Conversion Circuits based on Tunnel-FETs

Stanimir Valtchev
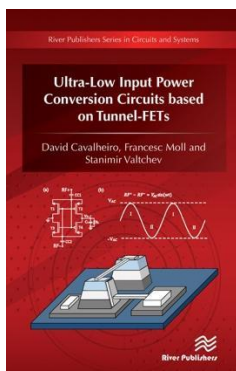
The increasing demand in electronic portability imposes low power consumption as a key metric to analog and digital circuit design. Tunnel FET (*TFET*) devices have been explored mostly in digital circuits, showing promising results for ultra-low power and energy efficient circuit applications. The *TFET* presents a low inverse sub-threshold slope (*SS*) that allows a low leakage energy consumption, desirable in many digital circuits, especially memories. In this book, the *TFET* is explored as an alternative technology also for ultra-low power and voltage conversion and management circuits, suitable for weak energy harvesting (*EH*) sources. The *TFET* distinct electrical characteristics under reverse bias conditions require changes in conventional circuit topologies. In this book, ultra-low input power conversion circuits based on *TFETs* are designed and analyzed, evaluating their performance as rectifiers, charge pumps and power management circuits (*PMC*) for *RF* and *DC EH* sources.

CTS at CIÊNCIA 2019

CTS had 3 presentations at the annual Meeting of the Portuguese scientific community, Lisbon, 8-10 Jul 2019.
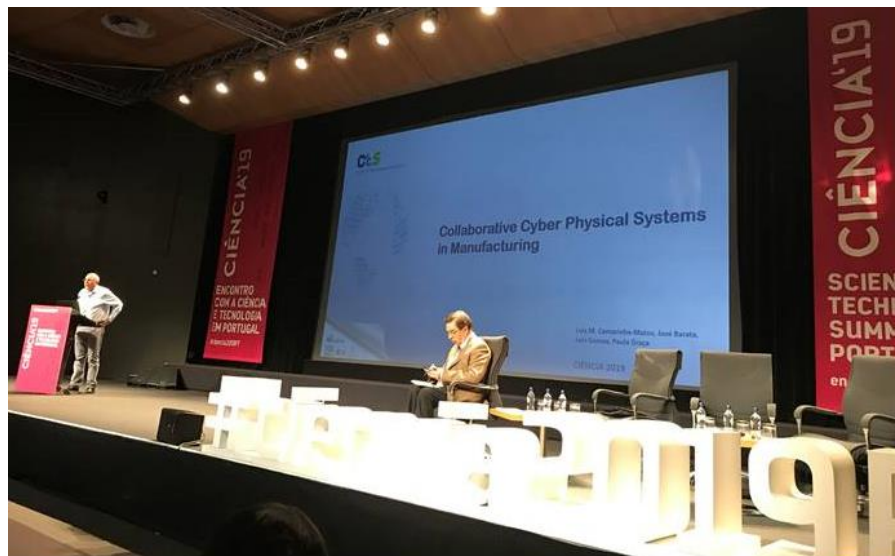
Collaborative Cyber Physical Systems in Manufacturing

Luis M. Camarinha-Matos, José Barata, Luis Gomes, Paula Graça

Challenge 9 – Industry, Innovation and Infrastructure

Collaborative Cyber Physical Systems for Disaster Management in Smart Communities

Javad Jassbi, Luis M. Camarinha-Matos, Pedro Pereira, Daniel Alienei, Ana Inês Oliveira, Anikó Costa, Javaneh Ramezani

Challenge 11 – Sustainable cities and communities

Evolving the IoT into a Cyber-Physical System for Sustainable Development

João P. Oliveira, João Murta Pina, João Martins, Luis M. Camarinha-Matos, Kankam Adu-Kankam

Challenge 7 – Affordable and Clean Energy

CTS also participated in a presentation of the InnovPlantProtect colab:

InnovPlantProtect - Innovative bio-based solutions for crop protection

M. Margarida Oliveira, Pedro Fevereiro, J. Ferreira Machado, Isabel Abreu, Nelson Saibo, Carlota V. Patto, Carlos Damásio, João Moura Pires, Mathias Knorr, João Rosas, Luis Camarinha-Matos, Rita Ribeiro, José Manuel Fonseca, Miguel Castro Neto, Benvindo Maçãs, Edmundo Sousa, Fátima Duarte, Liliana Marum, Ana Barradas (for the Consortium: InnovPlantProtect-Associação), Soluções inovadoras de base biológica para protecção de culturas

11th Advanced Doctoral Conference On Computing, Electrical And Industrial Systems

May 6-8 2020
Caparica, Portugal 🇵🇹

The Advanced Doctoral Conference on Computing, Electrical and Industrial Systems is celebrating its 11th edition (DoCEIS 2020) with a focus on Technological Innovation for Life Improvement.

Different scientific areas, such as electronics, telecommunications, computing and energy, are innovating and changing their paradigm to promote a digital world with tools and concepts such as Virtual and Augmented Reality, Artificial Intelligence, Machine Learning, Big Data, Internet of Things, and Collaborative Networks, to provide a better and sustainable future with high quality of life. The impacts of these technological developments enhance health, environment, transportation and communication systems across the globe, through new products and services. Thus, the transition of these concepts to real-world solutions have a huge potential to face existing challenges, and increase knowledge, wellbeing, **quality of life** and collaboration among companies, organizations, people, and systems.

Prospective authors of research papers are invited to submit their manuscripts reporting original work, in any of the scientific areas of the conference. Papers describing advanced prototypes, systems, tools and techniques, and general survey papers indicating future directions are also encouraged. Nevertheless, each paper must make a clear link to the main theme of the conference, including a section describing that link.

For more information visit DoCEIS 2020 web page http://doceis.dee.fct.unl.pt/

Edition of 2019

The success of the preceding conference editions is demonstrated by the positive feedback received from the participants. As examples, the following statements were gathered during the edition of this year, 2019.

"*It was very great, especially the topics about Power Electronics and Energy. The subjects were trendy and useful for students, like me*", SONIA HOSSEINPOUR, FCT/NOVA - PORTUGAL
"*The organization was good, there was a good variety of themes and research lines of study.*", RAMY ALFA, BUDAPEST UNIVERSITY OF TECHNOLOGIES AND ECONOMICS - HUNGARY
"*The presentations were interesting and the topics addressed to Industry 4.0 contributed a lot to the quality of the event.*", BRUNO MIRANDA, UNICAMP – BRAZIL
"*The organizers made a very good job, I felt especially welcome. The papers in this conference were very practical and relevant for the innovative aspect of research.*", QASIM KHALID, UNIVERSIDAD REY JUAN CARLOS – SPAIN
"*The event was interesting because the working groups were organized by topic. Excellent opportunity to know related work and form networks of work cooperation.*", FELIPE CRISPIM, USP - BRAZIL

4th International Young Engineers Forum on Electrical and Computer Engineering

Following the success of the 2019 edition, we are proud to announce the organization of the 2020 International Young Engineers Forum on Electrical and Computer Engineering - YEF-ECE 2020.

The **International Young Engineers Forum** looks for the latest developments and innovative applications in electrical and computer engineering, dealing with systems' design and utilization, looking forward to efficient devices and systems with appropriate control algorithms to meet the needs of business and industry in a global economy. This event will be a unique opportunity for young engineers to connect with each other enabling experience's sharing and to become internationally active.

YEF-ECE 2020 will be co-located with the doctoral conference **DoCEIS 2020**, giving participants the opportunity to attend both events. The conference will be held in **Caparica (Lisbon region), PORTUGAL**.

For more information visit YEF-ECE 2020 web page http://sites.uninova.pt/yef-ece

Edition of 2019

The 3rd edition of the International Young Engineers Forum (YEF ---ECE 2019) was held last May. 22 papers were presented (out of 35 submissions) from 22 countries. The papers were published on IEEExplore and presented in four different sessions. This year the keynote lecture, entitled "Integration of Photovoltaic Electric Energy Generation to Smart Grids", was given by Prof. Enrique Romero-Cadaval (Universidad de Extremadura, Spain).

PRO-VE 2019 - **20th IFIP Working Conference on Virtual Enterprises**
Turin, Italy– 23-25 Sep 2019.

CTS was extensively represented at PRO-VE 2019 with **9 papers** from different groups accepted for the conference.

This year's edition of the conference was devoted to **Collaborative Networks and Digital Transformation.**