Center of Technology and Systems

NEWSLETTER

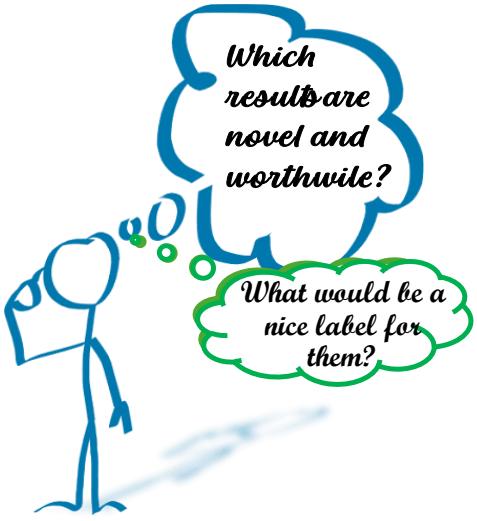
April 2025

Repeating, repeating, repeating

Pursuing excellence demands persistence, clear focus, and effective communication of our achievements.

CTS consistently produces high-quality research, as evidenced by outstanding PhD theses, numerous keynote invitations, and a wide range of international awards and recognitions. However, these accomplishments are not always fully leveraged.

Amid our demanding schedules — balancing academic responsibilities with the acquisition and management of research projects — it is essential to make time for reflection. We must ask ourselves: *What new knowledge have we generated?* More importantly, we need to refine ("clean up") this knowledge, so that it becomes generalizable, clearly identifiable (by giving it a distinct and meaningful name), and reusable by the broader research community.



Is there a clearly labeled piece of knowledge that other researchers immediately associate with you?

Writing project proposals and deliverables is a must, but not sufficient to build a "lasting legacy". Too often, valuable results remain buried in reports or conference papers with limited visibility and impact — simply because we haven't taken the time to reflect, synthesize, and promote them.

Remember: The language and style used in proposal writing ('bid language') strongly differs from the language and style used to communicate results to the scientific community.

Each year, CTS members supervise numerous high-quality PhD theses and produce an impressive number of publications. Yet we sometimes struggle to clearly articulate and communicate the novelty and significance of our contributions.


Which communication venue?

Additionally, some members continue to publish in questionable venues (e.g., MDPI, IARIA). We should ask ourselves: *Why persist with these choices?* Our collective goal should be to prioritize high-quality publication channels that truly reflect the value of our work.

Let us make a clear effort to identify the true "pearls" of our research and communicate them more effectively — to ensure that our work is not only excellent, but also visible, impactful, and lasting.

Luis Camarinha-Matos, Director of CTS

Editorial

Welcome to the latest edition of the CTS Newsletter, the first of 2025. As we move further into this new year, the Centre of Technology and Systems (CTS) is teeming with activity, innovation and a strong commitment to collaboration.
The year began with the Fundação para a Ciência e Tecnologia Evaluation Panel Visit. During this visit it was possible to present the importance of CTS's research and development activities and a valuable opportunity to showcase the ongoing work in our labs. For the past four years, CTS has executed a strategy aligned with a pivotal phase of global development in Cyber-Physical Systems (CPS), whose ambitious strategy encompasses numerous facets of CPS. Despite the complex challenges inherent in its comprehensive approach to CPS, CTS's research and development achievements between 2018 and 2022 demonstrate a strong capacity for interdisciplinary work, spanning diverse application domains, holding the potential to translate into practical applications, innovative services and products with tangible social impact.

The launch of the POEMS project, focusing on semiconductors, is a major step forward. This initiative, under the Chips for Europe Initiative, positions Portugal at the forefront of semiconductor innovation and production.

In this Newsletter we also celebrate the completion of several doctoral theses, highlighting the diverse research areas within CTS. These theses contribute to advancements in areas such as ultra-low-power CMOS electronic systems, energy community resilience, renewable energy flexibility, automated circuit design, smart manufacturing, and digital transition in agriculture.

CTS is actively involved in upcoming conferences like DoCEIS, YEF-ECE and PRO-VE. These events are already in a mature state and provide excellent platforms for sharing research, networking and fostering collaboration with the broader scientific community.

A recurring theme throughout this newsletter is the emphasis on collaboration – whether it's through the POEMS consortium, the interdisciplinary nature of the doctoral research, or the partnerships involved in the various conferences. This collaborative spirit is essential for driving innovation and addressing the complex challenges of today.

As we look ahead, CTS remains committed to pushing the boundaries of knowledge, fostering collaboration and making a meaningful impact on society. We encourage everyone to stay engaged, participate in upcoming events and contribute to the vibrant research community at CTS.

João Martins, CTS Communication Officer

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Recognition

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Luis M. Camarinha-Matos

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Amir Faghri
PRESIDENT AND CEO, ScholarGPS

CTS Labs visit by FCT Evaluation Panel

On 24 Jan 2025, CTS researchers welcomed the visit of the FCT Evaluation Panel. The Panel members had the opportunity to visit some of our labs and get a glimpse of ongoing R&D activities.

POEMS: PORTUGUESE COMPETENCE CENTRE IN SEMICONDUCTORS
(EU CHIPS JU Project)

Time-frame: 2025 - 2029 (4 years, starting March 1, 2025)
Total Funding: 8 M€ (Horizon Europe / CHIPS JU).

POEMS, as a cutting-edge initiative under the Chips for Europe Initiative, directly addresses the critical needs outlined in Axis 1 of the National Semiconductor Strategy, targeting capacity building (work package 3: Access to Training and Skills) and key technological advancements (work package 4: Support of semiconductor solutions). This strategic alignment aims to catapult Portugal to the forefront of semiconductor innovation and production, specifically focusing on microelectronics and semiconductors, pivotal for elevating the existing industrial and technological capacities to meet the key global challenges. Focusing on the strategic areas of chip design, advanced packaging, and emerging semiconductor technologies, POEMS leverages the diverse expertise of its 17 consortium partners, including leading research and academic institutions, that bring specialised training resources and cutting-edge capabilities.

Associação Portuguesa de Controlo Automático

Keynote:

L. Brito Palma, "Visão Sistémica do Ensino e da Aprendizagem de Controlo Automático", Workshop APCA 30 Anos – Ensino e Aprendizagem nas Áreas do Controlo Automático, Faculdade de Engenharia da Universidade do Porto (FEUP), 2024-Dez-02

https://apca.pt/workshop-apca-30-anos/.

Thesis: Neuro-Inspired Ultra-low-power CMOS Electronic System (µW range) for ECG and BMI
PhD Candidate: **Miguel de Lima Teixeira**
Supervisors: João Carlos Palma Goes + José Carlos Príncipe
FCT-NOVA, 13 Dec 2024

Brain-machine interfaces (BMIs) require major advances in electronics, so that constrains such as the need of low power, small size, lightweight, and high bandwidth wireless- communications with small data-rates can be solved, Sanchez et al. [1]. Continuous time (CT) asynchronous data converters namely, analog-to-digital converters (ADCs) and analog-to-time converters (ATCs), can be beneficial for certain types of applications, such as, processing of biological signals with sparse information. A particular case of these converters is the integrate-and-fire converter (IFC) that is inspired by the neural system. This dissertation presents and compares two CT asynchronous ATC that do not require an external clock signal. They are two low power IFC solutions, one analog and the other a fully digital dynamic IFC [2, 3]. The first is a closed-loop analog IFC with conventional blocks and on-chip capacitor, although not sacrificing either the chip area or power. The latter, is an open-loop standard cell-based (SCB) IFC, fully synthesizable (with the addition of two on-chip capacitors) and dynamic as each individual block can be powered o↵. Both can be used as an analog frontend (AFE) without requiring external blocks. Being fully-di↵erential - the analog solution is fully-di↵erential, the SCB one is pseudo-di↵erential, it also benefits its performance in AFE applications. As both systems are asynchronous, having a low power dissipation, and with pulse outputs with low data rates, they are a good solution for edge applications, such as low power sensors AFE in internet of things (IoT). Both have been designed and prototyped in a 130 nm CMOS standard process. The analog version has a power dissipation of 53 µW, an energy per pulse of 1060 pJ, and it can convert signals with a peak-to-peak amplitude of 0.6 mV to 2.4 mV and a frequency range of 10 Hz to 4 kHz, and the SCB version: 59 µW, 18 pJ - which is one of the lowest energy per pulse consumption reported for IFC circuits, and 1.6 mV to 32 mV and 2 Hz to 42 kHz, respectively. The maximum pulse density (average firing rate) for analog version is 50 kHz and SCB version 3300 kHz.
https://run.unl.pt/handle/10362/178365

Thesis: The Use of Cooperative Flexibility to Improve the Energy Communities' Resilience
PhD Candidate: **Adriana Mar Brazuna de Jesus**
Supervisors: João Francisco Alves Martins + Pedro Pereira
FCT-NOVA, 16 Dec 2024

The increasing integration of renewable energy sources into the power grid has prompted a paradigm shift towards sustainable and resilient energy systems. On the other hand, the energetic flexibility offered by shiftable loads or storage devices brings new win-win solutions for the grid, businesses, households, and the environment. This work explores the concept of Energy Communities (EnCs) cooperative flexibility as a strategic approach to bolstering EnCs resilience. EnCs can influence collaborative efforts among diverse energy stakeholders to optimize energy production, distribution, and consumption. This PhD dissertation reviews the key components of EnCs, such as decentralized energy generation, smart grid technologies, and energy flexibility, highlighting their potential to enhance the overall reliability and adaptability of the power grid.

The existing literature exhibits a notable gap concerning the EnC resilience. Thus, this research endeavors not only to enhance the resilience of EnCs during faults or power deviations but also to discuss the concept of EnC resilience, incorporating energy flexibility as a pivotal component within the proposed methodology.
A community made up of 30 households is considered to conduct experiments, where energy storage system as well as photovoltaic systems are installed. The EnC's resilience is quantified by key metrics, proposed for this thesis, that allow analyzing the community's behavior regarding the user's needs in different situations. The conducted experiments show that the proposed Energy Community framework improves the resilience of the community, benefiting not only the community's users as well as the Distribution System Operator (DSO).

https://run.unl.pt/handle/10362/178591

Thesis: Exploring Energy Flexibility in Renewable Energy Communities
PhD Candidate: **Humberto Almeida de Queiroz**
Supervisors: João Francisco Alves Martins + Rui Amaral Lopes
FCT-NOVA, 17 Dec 2024

To avoid the worst effects of climate change, there must be a paradigm shift in the way energy is produced, transported, distributed, and consumed. More specifically, there should be a change from the current state, where supply always follows demand, to a new state, where demand is also adjusted instantly to the supply level. In this context, energy flexibility represents an important tool to adapt consumption to the different generation conditions, assuming particular interest in the integration of distributed energy generation systems, based on renewable sources, in an energy transition towards sustainability. In addition, energy flexibility will be fundamental in solving the challenges imposed by the increasing electrification of society's processes (e.g., introduction of electric vehicles), which highlights the additional burden imposed on energy systems, and the joint effort of society to mitigate changes with the limitation of greenhouse gas emissions.
In this context, the contribution of this Doctoral thesis is threefold: firstly, based on a literature review on demand energy flexibility, a novel characterization of the energy flexibility potential of event-based devices is proposed, considering the Portuguese legislation on the operation of renewable energy communities. The second contribution of this study is to propose a new framework to support the management of renewable energy communities, namely the energy sharing process. Lastly, the energy flexibility potential of selected event-based devices is explored in a case study to increase the benefits of energy consumers and prosumers and to assess the impact of energy flexibility on energy sharing strategies in renewable energy communities.

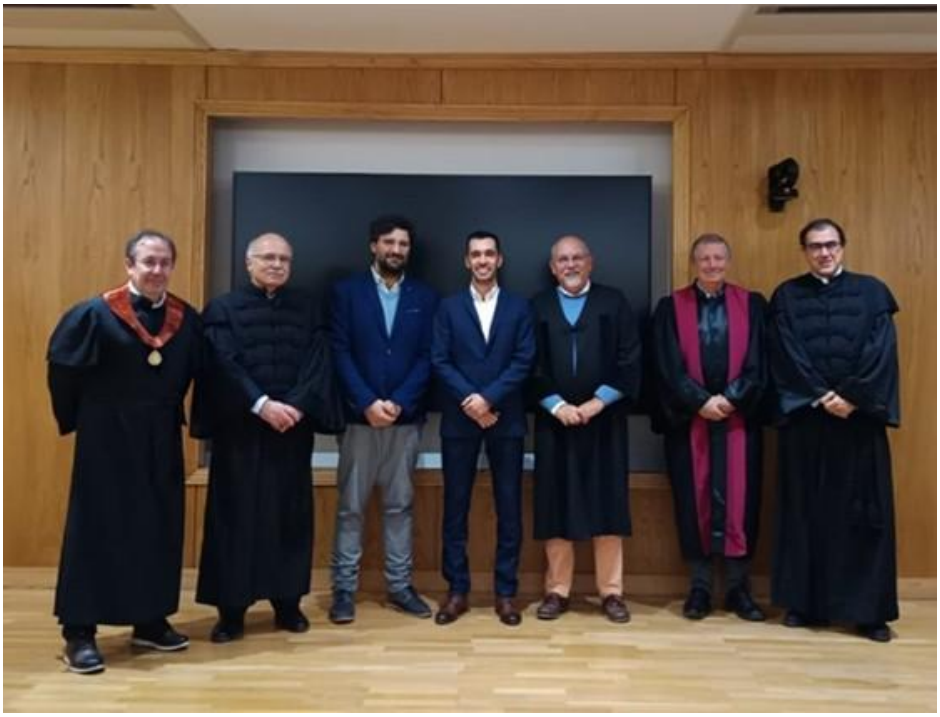
https://run.unl.pt/handle/10362/180128

Thesis: **Automated flat circuit-level topology generation**
PhD Candidate: **Miguel Pinto Campilho Gomes**
Supervisors: Rui Santos Tavares + João Goes
FCT-NOVA, 18 Dec 2024

Digital and analog circuit design for integrated circuits classically has three distinct stages: topology choice, component sizing and layout generation. In the Electronic Design Automation (EDA) field, the automatic topology synthesis stage is the least developed stage, particularly for analog circuits. Analog circuit design is still essentially based on human expert designers and is generally geared toward the reuse of well-known topologies in new circuit functions or to improve existing circuit topologies and, less often, to create new circuit topologies.
Generation of circuit topologies can be seen as a search and optimization problem and, therefore, it can be performed with Genetic Algorithms (GAs). What is presently unclear is to what extent this can be accomplished by a GA, particularly when handled at flat circuit level, and in concrete for the case of MOS integrated amplifiers. Boosted by the current submicron technologies used in today's integrated circuits, MOS integrated amplifiers have high efficiencies and very optimized specifications compared to the not-so-distant past. Eventually, an automatically generated topology could not only meet such specifications, but achieve it being a novelty, that is, potentially a GA can generate new topologies different from the traditional ones.
The work described in this thesis concerns the use of GAs in automatic circuit synthesis at flat circuit-level, and tries to understand its merits and its limitations, i.e., what are the capabilities of a GA in producing useful circuits and what is the relevance of additional enhancement techniques in its overall performance. In this work a GA kernel has been developed using parallelism in some stages of the algorithm, namely where it is most relevant which is in the fitness evaluation stage. In this stage, fitness evaluation is accomplished by a spice-like circuit simulator run using thread-level parallelism.
Part of the difficulty of obtaining good results with GAs is the choice of the codification scheme of the problem. Several coding schemes can be used for electric circuits and in v this work there was a first attempt to use a codification technique for circuits that applies the classic bit strings used by the canonic (or original) GA to represent a circuit. In this representation there is a fixed number of components available to the GA and the evolution takes place by changing the nodes to which each component terminal is connected to. In several experimental results obtained with this coding simple circuits were synthesized, such as NAND gates with MOS transistors. But scaling to more complex topologies was not possible. Hence, another codification technique was attempted, and variable-length chromosomes (VLCs) were tested.
Using VLCs and an encoding scheme in which a chromosome is a circuit descriptor and each gene is a component descriptor, circuits of higher complexity were synthesized by the GA, like other logic gates never successfully generated before (e.g., XOR gate and half-adder) and analog circuits (such as DC amplifiers of gain up to 38 dB). In addition, a few techniques have been developed and incorporated in the GA which contribute to its robustness, leading to better and faster results. Robustness is enhanced because the GA has less sensitivity to initial pseudo-random generator seed and to some parameters. Better results are obtained since circuits are produced with less redundant or useless components. https://run.unl.pt/handle/10362/178065

Thesis: **Modelling Smart Manufacturing Assets Targeting Scheduling Optimisation**
PhD Candidate: **Duarte José Marques Alemão**
Supervisors: José Barata de Oliveira + André Rocha
FCT-NOVA, 20 Dec 2024

The industry sector has evolved faster and faster over the past few decades, driven by increasingly complex market demands. Customers now hold greater decision power, and factories are pressured not only to deliver products fast but also to optimize production processes, reducing costs, inefficiencies, and delays. Companies must ensure they can meet customer expectations without compromising operational efficiency.



Thus, modern manufacturing systems must be robust and agile, capable of reacting smoothly to external events, and adaptable to unexpected changes. In this world that is becoming more and more connected, the rise of smart factories, characterized by interconnected and autonomous entities, is transforming how production systems operate. These entities are becoming able to adapt to real-time events but also share critical data between them to optimize workflow, minimize downtime, and ensure continuous production.

To maintain production efficiency, meet KPIs like makespan, reduce downtimes, and improve energy efficiency, or be more prepared for unexpected disturbances in the system, it is important that companies are equipped with robust and adaptable manufacturing scheduling systems. While numerous solutions have been proposed over the years to implement scheduling systems, in many cases, those approaches focus on specific cases and do not fulfill the necessary requirements to be applied in industry.

This research addresses these limitations by providing a more generic, comprehensive, and adaptable approach for smart manufacturing environments. The design and implementation of scheduling solutions in smart manufacturing systems is not standardized and there is not a reference model to develop scheduling solutions that reflect real industrial environments, leading to a gap between reference architectures and scheduling systems. Therefore, the proposed research intends to study the main challenges related to manufacturing scheduling and to model manufacturing components targeting the scheduling optimization based on one of the most prosperous reference architectures, RAMI 4.0.

Through an extensive literature review, both functional and non-functional requirements were identified and, after analyzing them, the design principles to develop a manufacturing scheduling system were established. Additionally, a methodology was proposed to serve as the foundation for designing scheduling solutions aligned with RAMI4.0, including the identification of the main assets and the development of their corresponding Asset Administration Shells, while addressing key design principles such as data uniformity, KPI harmonization, and automatic rescheduling. Finally, the proposed approach was applied to various use cases, including the KITT4SME and PERFoRM projects, to demonstrate its efficiency and adaptability.

This work aims to fill a critical gap in existing literature but also offers a practical roadmap for industry professionals aiming to fully integrate production scheduling into RAMI4.0, paving the way for smarter, more responsive manufacturing systems in the era of Industry 4.0. https://run.unl.pt/handle/10362/178793

Thesis: Methodology to Support the Digital Transition to Agriculture 4.0

PhD Candidate: **Sara Araújo**

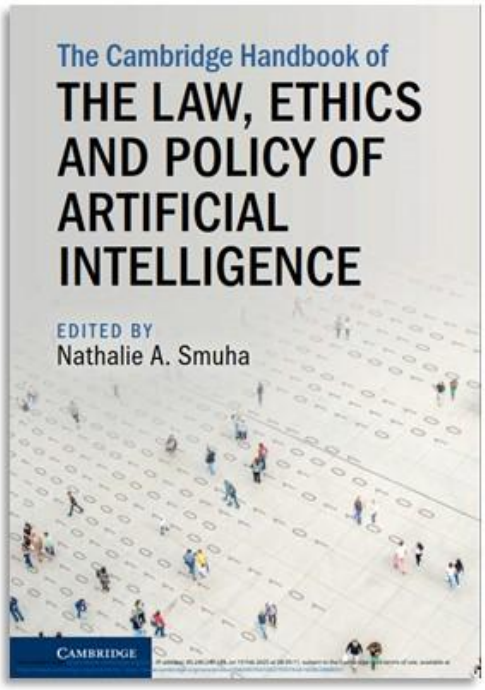
Supervisors: José Barata de Oliveira + Fernando Lidón + José Cochicho Ramalho

FCT-NOVA, 10 Jan 2025

The agricultural sector is an important area of research, facing multifaceted challenges on a global scale. These challenges stem not only from the rapid growth of the world population but also from factors such as water scarcity, unpredictable climate changes, and the decreasing availability of arable land. As a result, there is an urgent need to address these global trends and challenges that will shape the agricultural sector in the coming decades. Agriculture

4.0, characterised by the integration of advanced digital technologies, has emerged as a transformative solution to these challenges. Some key components of Agriculture 4.0 include wireless sensor and actuator networks for real-time monitoring and control, Artificial Intelligence (AI)-driven techniques for data analytics, predictive modeling, and decision support, robotics for precision farming, and cloud computing for scalable data management. Together, these technologies offer strategic solutions to increase agricultural productivity, optimise the use of resources (e.g., irrigation water, pesticides, fertilisers), and reduce environmental impact, thereby ensuring that the agricultural sector can sustainably meet the demands of a growing global population.
The present Ph.D. research introduces the formalisation of a methodology — Intelligent Data-Driven Decision Support System (ID3SAS) — designed for the development of smart agricultural systems within the context of Agriculture 4.0. ID3SAS combines sensing and actuating technologies, edge, fog and cloud computing, data analytics, and AI-based decision support with the aim of optimising agricultural practices. The implementation and validation of ID3SAS are explored through three case studies: (1) Case Study 1 - Proof of Concept: Conducted at UNINOVA/NOVA-SST with tomato plants in a controlled environment, this study verified the core functionalities of ID3SAS and its components; (2) Case Study 2 - Plant Growth Chamber: This study advanced the ID3SAS system's application in a walk-in growth chamber containing bean plants, preparing the system for its deployment in a field scenario; and (3) Case Study 3 - Vineyard Deployment: The final case study tested the ID3SAS system in a real-world vineyard at INIAV's Dois Portos Innovation Hub, focusing on cost-effectiveness, weather resilience, and solar-powered sustainability. These case studies demonstrated the potential of ID3SAS methodology and system to revolutionise agricultural practices by providing actionable insights that are both economically viable and environmentally sustainable, paving the way for future innovations in smart agriculture.
https://run.unl.pt/handle/10362/179443

May be of interest



https://www.cambridge.org/core/books/cambridge-handbook-of-the-law-ethics-and-policy-of-artificial-intelligence/0AD007641DE27F837A3A16DBC0888DD1 [open access]

https://op.europa.eu/en/publication-detail/-/publication/4cff5301-ece2-11ef-b5e9-01aa75ed71a1/language-en

DoCEIS 2025

16th Advanced Doctoral Conference on Computing, Electrical and Industrial Systems

July 2-4 2025 – Caparica, Portugal
Co-sponsored by CTS & LASI.

Cyber-Physical Systems (CPS) are the backbone of the modern interconnected world, combining physical processes with computational intelligence. The integration of AI into these systems amplifies their capabilities, enabling smarter decisions, real-time adaptability, and autonomy. AI-driven CPS are transforming industries and shaping a future where technology and the physical world work in harmony to address critical challenges.

This edition of DoCEIS invites doctoral students to share their innovative research on AI-powered CPS. Join us in this interdisciplinary forum to showcase your work, exchange ideas, and drive progress in this exciting field!
https://doceis.dee.fct.unl.pt/

YEF-ECE 2025

July 4 2025 – Caparica, Portugal

Following the success of the previous editions we are proud to announce the organization of the 9th International Young Engineers Forum on Electrical and Computer Engineering – YEF-ECE 2025.

Accepted papers, duly presented during the conference, will be submitted for inclusion into IEEE Xplore subject to meeting IEEE Xplore's scope and quality requirements. Papers from previous editions are available on the IEEE Xplore digital library.

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 enabling experience sharing and to become internationally active.

YEF-ECE 2025 will be co-located with the doctoral conference **DoCEIS 2025** giving participants the opportunity to attend both events on the same day. The Conference will be held in Lisbon Metropolitan, PORTUGAL.
Co-sponsored by CTS
https://yef-ece.deec.fct.unl.pt/

PRO-VE 2025

26th IFIP/SOCOLNET Working Conference on Virtual Enterprises

Co-sponsored by CTS

Artificial Intelligence (AI) is deeply transforming working modes, opening new ways to achieve a very large diversity of operational tasks where human expertise and artificial intelligence work synergistically. In a worldwide interconnected economy, where collaboration is constantly re-enforced as a key pillar of development, the design, support, management and supervision of hybrid human-AI organization networks open strong scientific challenges. At the organizational level, hybrid intelligence requires (i) the integration of artificial systems in the redefinition of organizational and human goals, roles and skills distribution, (ii) the consistent alignment of AI with the ambition of human-centric organizations, or (iii) the management of new hybrid collaborative processes including overcoming human-resistances. At the technological level, hybrid organizations first require enhance interoperability at the level of cognitive processes with strong challenges of data quality and availability, scalability and adaptability of algorithms, as well as trust and transparency in decision making.

The 25 years of scientific background developed by PRO-VE in designing and managing collaborative networks stand as the basis to build hybrid collaborative intelligence. The multidisciplinarity of the science of collaborative networks makes it possible to address a range of organizational and technical challenges, each of which demands careful thought and innovative solutions. On the technical side, ensuring effective human-AI integration, scaling AI systems, and fostering trust are key hurdles. Organizationally, addressing the need for skills development, managing change, and creating governance frameworks are all critical components. Balancing these challenges while maintaining ethical standards is essential for long-term success.

PRO-VE 2025 is a forum for sharing and discussing current developments and experiences regarding the role of collaborative networks in the age of synergic intelligence between human and AI. Contributions are invited from multiple and diverse disciplines such as Engineering, Managerial and Socio-Human sciences: industrial engineering, computer science, manufacturing, organization science, logistics, management, and social sciences, among others.

www.pro-ve.org

Special Sessions:

SS 1: Urban Digital Twins for Collaborative Resilience and Sustainability
SS 2: Assessment and Configuration of Collaborative Healthcare Networks
SS 3: Multi-Agent Systems for Hybrid Human-AI Collaboration in Industry
SS 4: Future Collaborative Workspaces in Organizations 5.0
SS 5: Transition towards Collaborative Organizations 5.0
SS 6: AI-Driven Technologies for Sustainable Material Value Chains
SS 7: AI-Driven Manufacturing-as-a-Service
SS 8: Trust and trustworthiness in hybrid human-AI collaborative networks
SS 9: People-Centred & AI-Driven Processes and Environments of Tomorrow
SS 10: AI-driven Collaborative Process Management
SS 11: Industry 5.0 Principles for Hybrid Human-AI Collaborative Networks
SS 12: AI and Simulation-Supported Decision-Making in Collaborative VUCA Environments
SS 13: Collaborative Human-AI Systems: Practical Insights and Design Implications
SS 14: Human-Robot Collaboration in Future Enterprises
SS 15: AI-driven Sliding Work Sharing for Human-Robot / Human-AI Collaboration

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