DIGITAL TWIN FOR CPS COGNITIVE INTEROPERABILITY

3 years contract | Fulltime/40h | Nancy, France

Are you passionate about research? So are we! Come and join us

Focusing on digital sciences, the CRAN laboratory (Research Centre for Automatic Control, https://www.cran.univ-lorraine.fr) is internationally recognised for its activities in the fields of signal and image processing, control and computer engineering. It is also known for its work in the field of health in relation to biology and neuroscience. Today, its fundamental and applied research enables it to accompany the changes in society and to go beyond the traditional society and industrial issues.

You'd like to contribute as a PhD candidate? Join our Sustainable Systems Engineering department

This PhD project is part of a bilateral research project between the CRAN, the ITIS department of the Luxembourg Institute of Science and Technology (LIST -http://www.list.lu), in Luxembourg, and the ORISUN company, Strasbourg, France, dealing with applications of artificial intelligence for cognitive interoperability in cyber-physical enterprises: AI4C2PS. The candidate will be registered at the University of Lorraine (doctoral school IAEM Lorraine) as a PhD candidate and will be integrated in the ISET research department of CRAN with strong collaboration with the HUMOD research group of ITIS/LIST. The main workplace will be in CRAN offices in Nancy, while some time will be spent in in Esch/Alzette, Luxembourg, in LIST offices.

The Sustainable Systems Engineering (ISET) department, with its 50 researchers and engineers, studies the digital transformation of complex sustainable systems, which are mainly in the application fields of industry 4.0 (also called the Industry of the Future), communication networks, transport, building and energy, and the future of so called digital twins (DT). The average annual gross salary of a DT expert is 190K€ (source glassdoor.com, 2022) and the DT is expected to reach 183B€ in 2031 (source Gartner). ISET research focuses on the development of methods, models and tools associated with assessment and decision-making processes. Their purpose: to steer, control and maintain and maintain systems of interest, in a framework that goes beyond performance requirements, connectivity and operational requirements, also takes into account the emerging issues of the responsible economy.

How will you contribute?

Recent works on Cognitive Cyber-Physical Systems (C2PS) and Cognitive Digital Twins (CDT) focus on bringing Artificial Intelligence (AI) features to CPS to mainly give them reasoning and learning capabilities. Making them smart enough to become autonomous or helping humans in decision-making. The Digital Twin (DT) is used as a convenient tool to embed the cognitive functions and allowing for simulations before applying to the real system. A step forward for cognitive interoperability would be to take a human-centric approach, as integrated now into the Trustworthy AI1, including knowledge formalisation and explainability for better human understanding. At its heart, there is the combination of symbolic AI based on knowledge/rule reasoning and statistical

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[1] Ethics Guidelines for Trustworthy AI, Independent high-level expert group on AI, European Commission, 2019. https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419

methods, with machine learning AI based on neural networks, leading to the Neuro-symbolic AI and Neural-Symbolic Computing, new trends that are considered by a part of the research community on the future of AI. Experiments made so far with deep learning have highlighted the two main advantages of neuro-symbolic approaches: less training data is required, and the reasoning process and its conclusions are explainable and understandable for humans. Finally, these approaches allow to build AI systems that are semantically sound, explainable, and trustworthy. Given these capabilities, neuro-symbolic approaches have a high potential for building interoperable C2PS, with adaptive interactions between C2PS and human workers, and automated reconfigurations of C2PS understandable to the human supervisor thanks to explainable AI. This is what we investigate in the AI4C2PS project as a step towards cognitive interoperability, building on the CDT concept.

The PhD candidate will analyse and demonstrate how bridging the reality gap in the emulation of CPS-CPS and CPS-HUMAN interactions to formalize a so-called 'cognitive interoperability' in the Cyber-Physical Enterprise (CPE). .. To ensure semantic interoperability across the different components and to build cognitive interoperability on top of it, industry standards will be identified and used where required. The project will be driven by pilots, which will (1) feed the research tasks by providing access to real world requirements and data and will (2) offer the opportunity to deploy and assess the technologies developed from research works in real production environments. To validate the integration capability, the developed technologies will be integrated into Orisun's existing platform. This integration will create a complete Proof-Of-Concept (POC) for our vision of a CPE platform implementing the high-level architecture. This POC will be deployed and validated in real-world scenarios. Our French pilot will be AIPL S.MART, a Smart industry 4.0 platform and workshop at UL.

Activities
- Participation to the AI4C2PS project as a full member, integrating the models, algorithms, and prototypes in collaboration with the project's team of researchers, and the Orisun company, and participating to project's meeting and contributing to deliverables
- Presentation of papers at academic conferences
- Writing of research papers and publication of peer-reviewed journal articles
- Write a PhD thesis in the field of computer engineering
- Participation to outreach activities of CRAN, LIST and ORISUN.

Is Your profile described below? Are you our future colleague? Apply now!

Education
- Master's degree or diploma in computer science, engineering science (control), or data science

Experience and skills
- Good knowledge and experience of artificial intelligence methods including machine learning and knowledge representation and reasoning
- Knowledge or experience of cyber-physical systems, digital twin and their cognitive version
- Knowledge or experience in systems interoperability
- Knowledge or experience with programming human-in-the-loop control systems
- Good programming skills

Language skills

- Good level written and spoken English
- Good level written and spoken French (not mandatory, but strongly recommended)

How to apply?

Send your application to Prof. Hervé Panetto, herve.panetto@univ-lorraine.fr

Your application must include:
- A motivation letter oriented towards the position and detailing your experience;
- Sketch of PhD project
- A scientific CV with contact details;
- List of publications (and patents, if applicable);
- Contact details of 2 references (optional).

Application procedure and conditions:
- UL is an equal opportunity employer and is committed to hiring and retaining diverse personnel. We value all applicants and will consider all competent candidates for employment without regard to national origin, race, colour, gender, sexual orientation, gender identity, marital status, religion, age or disability;
- Applications will be reviewed on an ongoing basis until the position is filled;
- An assessment committee will review the applications and select candidates based on guidelines that aim to ensure equal opportunities;
- The main criteria for selection will be the correspondence of the existing skills and expertise of the applicant with the requirements mentioned above.

PhD additional conditions:
- Supervisor at University of Lorraine: Pr. Hervé Panetto (herve.panetto@univ-lorraine.fr; http://www.panetto.fr)
- Supervisor at LIST: Dr. Yannick Naudet (yannick.naudet@list.lu)
- Work location: CRAN, Campus Science, Vandoeuvre-lès-Nancy, France, with some months to spend at LIST, Belval, Luxembourg
- PhD enrolment: University of Lorraine, Doctoral School IAEM Lorraine, France

Candidates shall be available for starting their position in March 2023. Please note the universities costs are at the charge of the student.