Institute of Engineering and Management of Grenoble Alpes University

Grenoble INP - UGA is a member of **international** engineering and management education and research **networks.** It is widely recognized in national and international rankings.

8 schools + **39** laboratories
8300 students
1 300 teaching, research, administrative and technical staff

Grenoble INP - UGA is a renowned public institution of higher education and research, and a major player in the Grenoble ecosystem. It is the engineering and management institute of Grenoble Alpes University, and plays a leading role in the scientific and industrial community.

PhD in Virtual Reality:

Exploring the potential of the Industrial Metaverse in Systems Architecting: hope beyond the hype?

Job reference number	2024-PHDVIRUALTREAL-GSCOP
Research field	Collaborative & Integrated Engineering Design
Host laboratory	G-SCOP (UMR 5272 Grenoble-INP, UGA and CNRS) / Website : https://g-scop.grenoble-inp.fr/
Requested profile	PhD Student
Location	Grenoble, France
Date of recruitment / contract term	01/10/2024 (36 months)
Contacts	Romain Pinquié romain.pinquie@grenoble-inp.fr

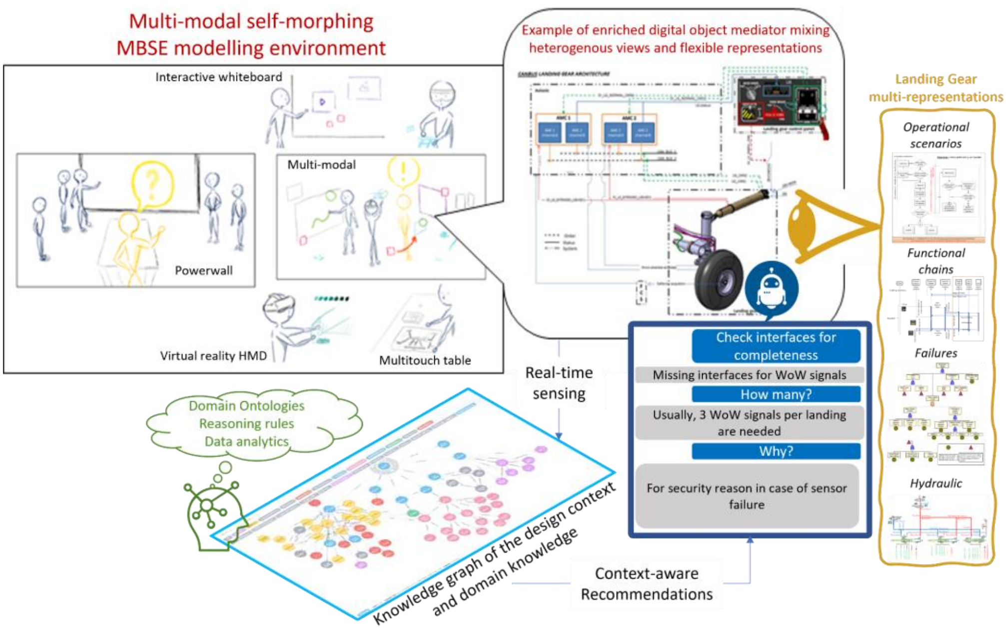
G-SCOP is a multi-disciplinary laboratory dedicated to meeting the scientific challenges posed by changes in the industrial world. The laboratory's scope ranges from product design to managing production systems, and draws on strong skills in design sciences and optimisation. The research engineer will join the Collaborative and Integrated Design team and the VISION-R advanced interactive visualisation technology platform. The aim of the Collaborative and Integrated Design skills area is to understand and model the interactions between experts and trades involved in the design of manufacturing products and/or associated services and to propose supports (based on business representations), tools (integrated into designers' environments) and methods (integrated into the company's organisation) to facilitate these interactions.

Research

Position description:

As part of the MIMESIS joint research laboratory between G-SCOP and the software editor SKYDEA, you will research new interactive 3D interfaces - stereoscopic or otherwise – supporting the collaborative preliminary design of engineered system architecture. The expected contributions to practice and theory are:

- **Practical contribution:** This research explores the application of Industrial Metaverse to co-designing the architecture of complex engineered systems. We aim to use the features and functionalities of Metaverse, potentially supported by artificial intelligence to develop a self-morphing system modelling environment. The next-generation systems engineering platform will intend to equip the various stakeholders involved in the systems architecting activities with flexible, more natural and visually rich, connected, collaborative 3D virtual worlds.
- **Scientific contribution:** From a broad perspective, this research seeks to better understand how stakeholders involved in systems architecting activities represent and interact with design information. The candidate will concentrate on computer-mediated collaborative design activities to identify the distinctive dimensions of collaboration affected by the industrial metaverse demonstrator.



Practical framework:

By self-morphing, we mean a system modelling environment able to adapt its interface, functions, and behaviour to the expertise of the user and expressiveness of the Domain Specific Language to the expertise of the user and the context of the modelling problem addressed [1]. It is crucial to refocus the modelling activity on the content of the model to widespread adoption of the Model-Based Systems Engineering approach. We believe that the cognification of MBSE human-computer interfaces with AI techniques will offer flexible modelling capabilities and adaptative content. The **connection of existing virtual worlds (at least two) in an Industrial Metaverse** for architecting complex engineered systems will implement the following functional features and capabilities:

- To create **enriched hybrid digital objects containing multiple representations** of a given technical object and which visual and interaction metaphors can easily adapt to the expectations of various subject-matter experts. For instance, during the definition or review of complex system architecture designs, each stakeholder (e.g., strategic marketing, R&D, manufacturing, quality, operations, etc.) should be equipped with **flexible representations** (e.g., a 3D mesh or B-Rep model, a 2D block diagram, an image, an iconic sign, a hand free sketch, a text, a voice recording, etc.) that can be seamlessly changed on-demand to suit his domain-specific language, knowledge, and concerns.

- To **mix heterogeneous models** standing as partial expressions of the system from a particular perspective in a **multi-view** modelling environment. Thus, in addition to the multi-representation capability, subject-matter experts can create **holistic views** that emerge from integrating various expert models of the system under development. End-users will be able to organise the multiple views on the system in a way that makes sense to them.
- Develop state-of-the-art intelligent and **self-morphing user interfaces** [1] with enhanced visualisation capabilities to enable end-users to easily analyse the information gathered in the holistic representation of the system. This includes, e.g., features to zoom in/zoom out at multiple systemic levels, traceability links to ensure consistency of the same information contained in different flexible representations or editing capabilities to annotate and rearrange the information according to the users' preferences and the modelling problem addressed. The plasticity of the user interface, i.e., its ability to keep its usability under changing uses and circumstances (e.g., user profile, visualisation device, task to achieve, etc.), will be of interest, too.
- Parsimoniously **combine state-of-the-art human-computer interaction modalities**, including, among other things, touch-based human-computer interface, interactive pen displays, natural language understanding, virtual reality, and hand gestures in cross-device (HMD, CAVE, Powerwall, Desktop PC) interaction techniques [2]. The virtual environment shall provide appropriate feedback [3] to understand collaborators' actions in hybrid co-located-remote collaboration.
- **Design new user representations in heterogeneous devices** (e.g., How can a laptop (resp. VR or CAVE) user be represented in VR (resp. powerwall or desktop PC)?
- Select and support **collaborative situations** (e.g., tightly vs. loosely coupled subgroup collaboration [4], spontaneous vs. side discussions) while **enabling fluid individual and collaborative editing** [5].

[1] Cabot, J., Clarisó, R., Brambilla, M., Gérard, S. (2018). Cognifying Model-Driven Software Engineering. In: Seidl, M., Zschaler, S. (eds) Software Technologies: Applications and Foundations. STAF 2017. Lecture Notes in Computer Science(), vol 10748. Springer, Cham. 10.1007/978-3-319-74730-9_13

[2] Zhang Y, Nguyen H, Ladeveze N, Fleury C and Bourdot P. (2022). Virtual Workspace Positioning Techniques during Teleportation for Co-located Collaboration in Virtual Reality using HMDs 2022 IEEE on Conference Virtual Reality and 3D User Interfaces (VR). 10.1109/VR51125.2022.00088. 978-1-6654-9617-9. (674-682).

[3] García, A. S., Molina, J. P., Martínez, D., & González, P. (2008, December). Enhancing collaborative manipulation through the use of feedback and awareness in CVEs. In Proceedings of the 7th ACM SIGGRAPH international Conference on Virtual-Reality Continuum and Its Applications in industry (pp. 1-5).

[4] Wolff, R., Roberts, D. J., Steed, A., & Otto, O. (2007). A review of telecollaboration technologies with respect to closely coupled collaboration. International Journal of Computer Applications in Technology, 29(1), 11-26.

[5] Xia, H., Herscher, S., Perlin, K. and Wigdor, D. (2018), "Spacetime: Enabling Fluid Individual and Collaborative Editing in Virtual Reality", Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology, presented at the UIST '18: The 31st Annual ACM Symposium on User Interface Software and Technology, ACM, Berlin Germany, pp. 853–866, doi: 10.1145/3242587.3242597.

Theoretical framework:

As theory-driven design research [1,2], this thesis will be grounded in the framework for measuring and comparing the quality of collaboration in computer-mediated design situations [3,4,5]. Cognitive Load Theory (CLT) [6] and Cognitive Theory of Multimedia Learning (CTML) [7] will also be used for theoretical support.

[1] Briggs, R. O. (2006). On theory-driven design and deployment of collaboration systems. International Journal of Human-Computer Studies, 64(7), 573-582.

[2] Cash, P.J. (2018), "Developing theory-driven design research", Design Studies, Vol. 56, pp. 84–119, doi: 10.1016/j.destud.2018.03.002.

[3] Burkhardt, J.M., Détienne, F., Hébert, A.M., Perron, L., Safin, S. and Leclercq, P. (2009), "An approach to assess the quality of collaboration in technology-mediated design situations", VTT Symposium (Valtion Teknillinen Tutkimuskeskus), No. 258, pp. 355–362.

[4] Meier, A., Spada, H. and Rummel, N. (2007), "A rating scheme for assessing the quality of computer-supported collaboration processes", International Journal of Computer-Supported Collaborative Learning, Vol. 2 No. 1, pp. 63–86, doi: 10.1007/s11412-006-9005-x.

[5] Brisco, R., Whitfield, R.I. and Grierson, H. (2020), "A novel systematic method to evaluate computer-supported collaborative design technologies", Research in Engineering Design, Vol. 31 No. 1, pp. 53–81, doi: 10.1007/s00163-019-00323-7.

[6] Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive science, 12(2), 257-285.

[7] Mayer, R. E. (2005). Cognitive Theory of Multimedia Learning. In R. E. Mayer (Ed.), The Cambridge handbook of multimedia learning (pp. 31–48). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.004

Preliminary research plan:

- Review literature on computer-mediated collaboration, computer-supported collaborative work, virtual reality and human-computer interaction, and conceptual design representations.
- Select or develop a theoretical framework
- Formulate more focused and testable theory-driven research questions and hypotheses
- Develop a research method
- Specification and low-fidelity prototyping of the industrial metaverse
- Develop and continuously improve a functional demonstrator based on user formative studies
- Design and conduct controlled lab experiments as well as real-world case studies
- Process data and publish results

Requested skills:

- **Interactive visualisation [MUST-HAVE]:**
  - Virtual reality development (Unreal) and computer graphics
  - Human-computer interaction
  - HCI ergonomics
- **Systems engineering [NICE-TO-HAVE]:**
  - Conceptual modelling (SysML, UML, Capella, System composer, OPM, BPMN...)
  - Continuous/discrete/hybrid systems simulation (Modelica, Bond graph, Simscape, Stateflow, Simulink)
  - Systems engineering data interoperability (FMI, ReqIF, LOTAR, MoSSEC, Canonical XMI, OSLC, APIs...)
  - Graph-oriented databases and ontologies for knowledge graph creation (Neo4j, OWL...)
- **Research methods [NICE-TO-HAVE]:**
  - Quantitative (design of experiments, statistics, etc.) and qualitative (benchmarking, interviews, surveys, questionnaires, task and activity analysis, coding, focus groups, etc.) research methods.
  - Writing of scientific articles
  - Written and spoken English

Profile:

- You have a Master's Degree or Engineering Degree in computer science or digital engineering.
- You have proven experience in virtual reality or computer graphics

Specific requirements or conditions

Position assigned to a restricted area: NO

How to apply

Applications (CV, PhD thesis manuscript, journal or conference papers, recommendation letter) must be sent to romain.pinquie@grenoble-inp.fr

Application deadline: 08/07/2024