AI-augmented Techniques for Consistency and Validity in Continuous Digital Twin Engineering

Domain and scientific/technical context:

The PhD thesis will be realized in the context of the *MATISSE* European collaborative project funded by Horizon Europe and the KDT Joint Unit. The project involves 30 partners (from industry and academia) in 7 different countries during 3 years, and will start in September 2024. A main objective of *MATISSE* is to provide a global approach and supporting framework for the model-based engineering of Digital Twins. A Digital Twin (DT) is a digital representation of an intended or actual real-world physical product, system, or process that can be used as a digital counterpart for different practical purposes such as simulation, monitoring, testing or predictive maintenance (among others). Nowadays, DTs and their practical usages are very hot topics both in the industry and in the Software & Systems Engineering communities. In MATISSE, the produced model-based DTs will be used in particular for the early verification and validation of the corresponding industrial systems.

Scientific/technical challenges:

Our NaoMod team will provide its long-term expertise in Software & Systems Engineering and Modeling in order to work on the core model-based framework supporting the MATISSE approach. Indeed, engineering a DT involves dealing with many different kinds of Digital Models or DMs (e.g., software models, physical models, mathematical and/or artificial intelligence models) and Digital Shadows or DSs (providing the data from the actual system). These heterogeneous DMs and DSs can be combined within model views so that the DT engineers can get a better global understanding of the DT being engineered, as well as of the underlying system, and then take decisions accordingly. Thus, how to ensure traceability and synchronization when the views, DMs and DSs frequently evolve over time? Addressing this challenge will require proposing novel approaches for ensuring the continuous consistency and validity of all these model-related artifacts.

Considered methods and targeted results:

We currently envision the combination of a model view solution with different model transformation-related techniques (e.g., for model generation and verification), complemented by the use of AI techniques (for automation purposes). In practice, we plan to base the work on the *EMF Views approach and framework*[1] that already support the definition, building and handling of model views. We also plan to rely on other research works from our team related to model transformation and to the use of Large-Language Models (LLMs) as state-of-the-art generative AI techniques. The PhD candidate is expected to conduct research in this direction, design and develop corresponding software prototypes, and experiment with the proposed solutions in the context of industrial use cases provided by MATISSE. We target the publication of the obtained results in international scientific journals and conferences on Software & Systems Engineering and Modeling.

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[1] EMF Views-related journal publication - https://hal.science/hal-02515776

Advisors:
The candidate will work under the co-supervision of [Dr. Hugo Bruneliere](), [Dr. Théo Le Calvar](), and [Dr. habil. Massimo Tisi]() (NaoMod team, IMT Atlantique - Nantes Campus).

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Profile and Skills:
The candidate must hold a master's degree or equivalent in Computer Science, with a solid background in Software Engineering. Ideally, she/he must have a good knowledge in Model Driven Engineering and/or Digital Twins. Some prior knowledge or a particular interest for AI in general, and more specifically LLMs, is also recommended. In addition, strong programming skills are highly appreciated (e.g. in Java for Eclipse and the Eclipse Modeling Framework, in Python for AI libraries). She/he must also have solid oral and written communication skills in English, with the aim to publish and present the PhD research results in high-level international journals and conferences. The candidate is also expected to participate in the life of the MATISSE European project where English is the used language. For instance, she/he will participate in some project's meeting as well as in the elaboration of project's deliverables. As a consequence, autonomous, curious and strongly motivated candidates are expected.

Conditions:
The candidate will sign a 3-year doctoral contract at IMT Atlantique. The work will mostly take place at the Nantes campus of IMT Atlantique (west of France, only 2 hours from Paris by train), with participation in some MATISSE events (e.g., meetings in Europe). She/he will have a yearly gross salary of 30.000€, including health insurance and other social benefits provided by IMT Atlantique and the French state (for public transportation, cultural activities, etc.). The candidate is expected to start in September or October 2024, though a delay could be envisioned in case of a very solid and interesting application.

Application:
Very good applications are expected to be received before April 12, 2024.
The interested candidates should send the following documents to the advisors:
- A detailed CV, including the list of already published scientific work if any;
- A letter of motivation, including the objectives of the candidate;
- Transcripts of the obtained grades, at least for the Master degree or equivalent;
- One or more letters of recommendation from past academic or industrial advisors;
- Links to open source code repositories or to relevant code contributions realized by the candidate would also be appreciated;
- Generally, any other document or piece of information that can demonstrate the ability of the candidate to pursue a PhD work.