DigiEV: Design and integration of a digital twin for electric vehicle charging infrastructure in the E4C ecosystem

Supervision team: Dr Daphne Tuncer (ENPC) and Dr Georgios Bouloukakis (TSP)

Context

The success of electric mobility is not only based on state-of-the-art electric vehicles such as rapidly charging passenger electric cars, light-weight electric bicycles, or long-distance electric trucks. It also necessitates the deployment, management and maintenance of an integrated infrastructure that couples electricity provision, information distribution, and software-based system control.

Digital twin approaches have been emerging as leverages to manage the operations and performance of complex system infrastructures, as well as to evaluate their deployment plans. A digital twin is a physical or virtual representation of a physical environment (*e.g.*, network of charging stations). It mimics the characteristics of the system (IoT infrastructure, smart grid) and helps analyse and predict the behaviour of a system under multiple, possible operating conditions. Creating realistic digital twins is a challenging task. Real world systems involve a vast array of heterogeneous interconnected objects; build upon a large set of functions; involve human activities that are hard to model, observe and track. In the case of a charging infrastructure for electric mobility, this necessitates to take account of the energy supply—which can be mixed- the information and communication systems, the software components that control the charging activities, as well the behaviour of human agents (*i.e.*, the demand).

Objectives

The objective of the placement is to implement a digital twin of the charging infrastructure of E4C on the campus of Institut Polytechnique de Paris. The proposed digital twin will provide a tool for the technical team of the demonstrators of E4C to evaluate the performance of the existing charging infrastructure, as well as to assess and compare the deployment plans of new stations on the campus. More specifically, the project will involve three main tasks.

Task 1 – To develop a digital twin of the charging infrastructure of E4C, including modelling static data (charging station specifications) and dynamic data (energy supply and charging demand).

Task 2 – To integrate the digital twin of the charging infrastructure with the federation of digital twins of the DRAHI-X, SIRTA and Building 103, developed as part of a 2024 E4C-supported internship project[1], co-supervised by Dr Bouloukakis and Dr Tuncer.

Task 3 – To design and implement a set of realistic scenarios in order to demonstrate how the digital twin tool can be used to control, manage and extend the current infrastructure, including illustrating the functionality of a scheduling mechanism to control the energy supply, showing the process of monitoring the infrastructure, or applying an optimisation method to deploy a new station.

The student undertaking the project will be responsible to showcase the results of the project to the technical team of E4C at the end of the placement.

1 A Federation of Digital Twins for Sustainability in the E4C Ecosystem

About the placement

- 6 months – starting March or April 2025
- Located at Ecole des nationale des ponts et chaussees, Institut Polytechnique de Paris, France
- Joint supervision between Ecole nationale des ponts et chaussees et Telecom SudParis
- Part of the Energy4Climate (https://www.e4c.ip-paris.fr/#/fr/) multidisciplinary research center of Institut Polytechnique de Paris
- Open to final year engineering school / master (MEng / MSc) student

Skills and competence

- Fluent in English
- Good knowledge of programming (preferably Python and Java) and data structures.
- Good knowledge of standard data format (JSON, CSV, XML)
- Good knowledge of the REST architectural style and RESTful APIs
- Knowledge of Semantic Web Standards (RDF, OWL) is an asset but is not required.

Contact

To apply, contact

- Daphne Tuncer, Ecole des nationale des ponts et chaussees, daphne.tuncer AT enpc.fr
- Georgios Bouloukakis, Telecom SudParis, georgios.bouloukakis AT telecom-sudparis.eu

by providing the following documents:

1. CV
2. Motivation letter
3. Transcripts of the last 3 years
4. A course report or article written in English (if any)

Relevant references

[1] M-O. Metais, *et al.* "Too much or not enough? Planning electric vehicle charging infrastructure: A review of modeling options." Renewable and Sustainable Energy Reviews 153 (2022): 111719.

[2] Adil Rasheed, Omer San, and Trond Kvamsdal. Digital twin: Values, challenges and enablers from a modeling perspective. Ieee Access, 8:21980{22012, 2020.

[3] David Jones, Chris Snider, Aydin Nassehi, Jason Yon, and Ben Hicks. Characterising the digital twin: A systematic literature review. CIRP journal of manufacturing science and technology, 29:36{52, 2020.

[4] W. A. Ali, M. P. Fanti, M. Roccotelli, L. Ranieri, L. (2023). A review of digital twin technology for electric and autonomous vehicles. *Applied Sciences*, *13*(10), 5871.

[5] N. Khoder, A Federation of Digital Twins for Sustainability in the E4C Ecosystem, MSc dissertation, 2024.

[6] EVOSIM. Available: https://github.com/ImperialCollegeLondon/EvoSim