

SCSI 2022 program - PhD subject proposal

Gilles Morel – UTC – Avenues Lab – March 2022

Title

The cognitive twin for the smart city

Keywords

Smart city – smart building – digital twin – artificial intelligence (AI) – machine learning – deep learning – neuro-symbolic AI – IoT

Subject summary

This subject aims at giving an emerging and global intelligence to the smart building and the smart city thanks to the coupling of different AI models applied to the data coming from the IoT and the digital twin. As its name suggests, the "digital twin" is a digital double - generally simplified - of a physical object which can be a building (Building information Model), a district or a city (City Information Model), or for example in another domain a wind turbine. The geometric and structural part can be supplemented by information on the evolutionary and real-time state of the object with data generally provided by sensors or other connected objects (IoT – Internet of Things). In addition, the methods and tools of artificial intelligence based on data analysis, and in particular machine learning, make it possible to carry out diagnosis, prediction, anomaly detection, but generally with a very specific objective and in a well-defined area: energy optimization, preventive maintenance, etc. Our proposal focuses on a more holistic approach to the coupling of the digital twin and artificial intelligence in order to facilitate the fusion of heterogeneous data (multi-domains) within the framework of a building, a district or a city, and beyond experimenting with a non-deterministic analysis of the data available by different AI models (unsupervised learning, heuristics, etc.). This approach aims to bring out a global intelligence from the digital twin which would evolve towards a "cognitive twin", in the sense of a digital object capable of generating knowledge by itself, or even also through its interaction with humans ("human in the loop AI")

Proposed methodology and main steps

In a first step, it will be a question of designing a "pivotal model" of the built space (multi-scale) adapted to the management of assets and equipment and capable of integrating knowledge of the domain (in particular spatial and temporal) and multi-source heterogeneous data. Then, this model must be able to encapsulate and drive machine learning processes (pipelines) to produce diagnostics (eg: preventive maintenance, forecast, etc.) from an objective and a subset of the data. From the point of view of AI, it will therefore be a question of piloting complex processes of machine learning and/or deep learning (in particular for temporal data coming from sensor networks) from a knowledge base including a model of the domain (object-oriented or frames), an expertise (heuristic rules) and a control layer in accordance

with the architecture recommended by knowledge engineering methods such as CommonKads. The prototyping of this model will be carried out in Python and will be tested initially on targeted use cases of the supervised type (eg: energy optimization, detection of anomalies, etc.), then in a second step, on use cases unsupervised that will assess the relevance of the concept of cognitive twin and an emergent intelligence of the city or the building.

PhD direction

Gilles Morel – UTC – Urban Engineering department – Avenues research team

International cooperation on the subject : USA Texas A&M, Brazil (UFRJ and UTFPR)

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