Title of the PhD thesis
Development of digital twins for monitoring the tightness of building

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Link to candidate:
https://theses.doctorat-bretagneloire.fr/spi/cde-theses-2022/developpement-de-jumeaux-numeriques-pour/++add++Candidate

Keywords:
Digital twin, Machine learning, Micro-diffusion, Digital Image Correlation, Building materials

Description:
This doctoral thesis project will be carried out within the framework of the **AI for future industry** program of the NEXT project of Nantes University / Ecole Centrale Nantes / CHU de Nantes / INSERM.

Artificial Intelligence (AI) can be defined as the ability of a machine to mimic intelligent human behaviour, thereby seeking to use human-inspired algorithms to approximate conventional problems. Different branches of AI have been applied; however, pattern recognition and machine learning have emerged as the most emerging methods for structural health monitoring. AI technology has already taken its first steps in building engineering. But building is an industrial sector that has lagged behind in digital and environmental transitions. This project proposes to respond to these two issues by developing digital twins of building elements, evolving with aging, degradation and repairs in the same way as the building.

The digital twins for the building and the city are quite recent and have been developed with two objectives respectively: the relationship with intelligent components for the comfort regulation of the home, the prediction of transport in the city. However, according to market intelligence firm ABI Research, several hundred cities around the world will use this technology. At the dawn of the application of the new French energy regulations for buildings (RE2020), which introduces an environmental criterion linked to the life cycle analysis of the building, maintenance must be predicted very precisely in order to preserve for several tens of years the same energy consumption as the original. Indeed, the control of the tightness of buildings over a period of 50 years is recommended in the RE2020. This requires, as a priority, a control of the tightness of the elements of the building. Simple microcracks in the walls, through cracks or not, can significantly influence this sealing with the risk of condensation of water vapor or advective phenomena, leading to a loss of thermal insulation and/or premature aging of the building.

The interest of the digital twins of these building elements is to predict these risks by proposing a repair solution. There is no or very little work on the use of AI in the digital modeling of building waterproofing. In order to provide "simple" control tools to building users, this project proposes to develop an AI code based on machine learning capable of predicting the leaks of building elements. Learning can take place throughout the life of the building, improved by functions related to waterproofing. These functions will be identified by laboratory tests, using the digital image correlation improved by the light field compression technique. A new constitutive law linking the development of microcracks to the diffusion of water vapor will constitute the sealing function of the AI code.

The tool developed in this project will make it possible to monitor leaks in real time in order to warn of a need for maintenance before over-consumption of energy.

Candidate's profile

The multidisciplinarity of the subject requires a profile in numerical mechanics. However, it is also open to candidates with a profile in data processing or artificial intelligence with skills in experimentation, or a profile in civil engineering with confirmed skills in digital modeling and, if possible, knowledge of artificial intelligence.

Location

The PhD will be realized in two research teams in two laboratories at Ecole Centrale Nantes:

– The reseach team 'Green Engineering Approaches' (INGVER) of GeM, co-supervised by Frédéric Grondin.

– The research team 'Signal, Image and Sound' (SIMS) of LS2N.