• **Internship Title:** Analyzing IFC-Based BIM models through the interaction between BIM and artificial intelligence

• **Scientific fields:** Artificial intelligence, Data science, Civil engineering, Project management

• **Keywords:** Artificial intelligence, Digital twin, Building Information Modelling (BIM), Industry Foundation Classes (IFC), Building exploitation

• **Supervision**

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• **Positioning of the LINEACT CESI laboratory**

LINEACT CESI (EA 7527), Digital Innovation Laboratory for Companies and Apprenticeships for the Competitiveness of Territories, anticipates and supports technological changes in sectors and services related to industry and construction. CESI's historical proximity to companies is a determining factor for its research activities, and has led to concentrating efforts on applied research close to companies and in partnership with them. A human-centered approach coupled with the use of technologies, as well as the territorial network and links with training, have made it possible to build cross-cutting research. It puts the human, its needs and its uses, at the center of its issues and addresses the technological angle through these contributions.

• **Project**

The internship subject is part of the research themes of the LINEACT CESI laboratory, more specifically in theme 2 "Engineering and Digital Tools" at the level of axis 2 - Digital Tools and Collaborative Process. This internship project will propose innovative solutions and will participate in the development of this line of research. It affects the field of BIM, a field in full expansion and attracting the attention of industrialists and academics. This internship will be carried out in partnership with “nottingham trent university”.

Today, digital models of buildings, such as BIM (Building Information Modeling) [1] are becoming widespread or even mandatory for tertiary or public buildings [2] [3]. BIM, also called Digital Building Model, does not only integrate pure geometry information and placement of geometric elements but also descriptive information carrying semantics. The digital model is a representation of the data and faithful to the physical reality of a building. Currently, it is mainly used during design and much more rarely until delivery of the building. The major challenge is to make this digital model usable throughout the building's operating life, so that it is a real living, dynamic, extensible and interactive model allowing building managers and users to interact through it [4].

Despite the existence of graphic standards for 3D display, the conversion from BIM format to these is not straightforward. Sometimes this requires multiple steps and involves a potentially huge loss of information, mainly semantic data. The IFC model (Industry Foundation Classes) [8] is the standardized semantic model used for BIM. It has complex EXPRESS data model schema (semantic object-oriented model which defines a lot of relationships between model elements, their properties, connection between elements, hierarchical structure of spaces and zones, etc.). The IFC models are saved as XML or STEP files, which makes is difficult to retrieve information. The recognized and normalized ISO standards for the exchange of BIM remain IFC2x3 [9] and IFC4 [10]. Converting IFC models to a graph network can help to solve this complexity and offer a flexible way to analyze the relationships between the model entities. Labeled property graph models are a suitable way for representing and describing the vast amount of information inside BIMs. Graph models can be automatically generated based on data extracted IFC models. The graphs bring advantages for the different versions of IFC, since, on the one hand, they avoid during the phase of conversion of the IFCs, the loss of information (and mainly the loss of semantic information) and, on the other hand, they allow queries and extension of description capabilities. Artificial Intelligence (AI) could provide the building with new cognitive functions to optimize the cost of its operation, currently estimated at 75% of the overall cost of the project. AI and BIM interactions are to be studied through this

internship subject to develop predictive functions to anticipate and decision support functions to better manage the building. The data of the digital model is permanently fed by the operation of the building. We will use the digital model to structure its data so that the building can self-diagnose itself and propose the interventions to be carried out for its maintenance. This maintenance management would be managed by a predictive AI that would limit the loss of time and expenses.

We will design and develop an interactive and intelligent platform (request and decision support) allowing the optimization of the operation and maintenance of the building. It makes it possible to represent in the form of a graph (nodes and relationships) complex systems (building data) and to describe in a semantic way the modalities of interactions between a human and a digital model to concretize the notion of BIM operating. It references the descriptions of objects in the physical world, whether they are connected or not, and their interactions [5][6][7]. This platform integrates an expandable range of different digital model management applications powered by multiple building data sources, providing comprehensive situational awareness to managers throughout building operation and maintenance. It opens up great prospects for fields of application such as monitoring, simulation but also analysis, prediction and decision support thanks to the integration of big data and AI technologies [4].
The ambition is to facilitate and pool the implementation of the interactive digital model to meet the needs of the contracting authority. The innovation of this research work will be to design and develop modeling and data analysis approaches based on graphs for the representation and management of the digital model of the building. The building model is exposed to a suite of digital model management applications through an interface easily accessible to users via a visual information dashboard.

The deliverables will be the state of the art, one/two newspaper articles, an internship report, theoretical and technical solutions as well as a demonstrator allowing the production of an interactive operating BIM.

- **References**

[1] K. Beddiar, F. Imbault, BIM et énergétique du bâtiment, 2017, Dunod, 2017
[2] https://www.construction21.org/france/articles/fr/le-bim–pourquoi-comment-et-pour-quand.html
[3] O. Ibrahim Olanrewaju, A.F. Kineber, N. Chileshe and D. Edwards, Modelling the Impact of Building Information Modelling (BIM) Implementation Drivers and Awareness on Project Lifecycle, Sustainability, MPDI, 2021
[4] A. Fuller, Z. Fan, C. Day, and C. Barlow. Digital twin: Enabling technologies, challenges and open research. IEEE Access, 2020
[5] Thing'in, the things' graph platform, https://hellofuture.orange.com/en/thingin-the-things-graph-platform/
[6] Beyond IoT: Digital Twins and Cyber-Physical Systems, https://hellofuture.orange.com/en/physiques-beyond-iot-digital-twins-and-cyber-physical-systems/
[7] S. Derrien, P. Meye and P. Raïpin, "Thing in, a research platform for the Web of Things," 2019 MASCOTS.
[8] T. Liebich, Y. Adachi, J. Forester, J. Hyvarinen, K. Karstila, and J. Wix, Industry Foundation Classes IFC2x3, International Alliance for Interoperability, 2006.
[9] https://standards.buildingsmart.org/IFC/RELEASE/IFC2x3/FINAL/HTML/
[10] https://standards.buildingsmart.org/IFC/RELEASE/IFC4/FINAL/HTML/!

- **Start of the internship:** from February 2022
- **Duration of the internship:** 6 months
- **Paid internship**
- **Place of work:** LINEACT CESI Campus La Rochelle laboratory with the possibility of traveling to the University of Nottingham in England
- **Required profile:** student in master's 2 or engineer in the last year of an engineering school.
- **Specialty:** computer science or civil engineering

To apply, please send your application (CV and cover letter) to: rchaieb@cesi.fr and dbeladjine@cesi.fr