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GENERATING IFC-BASED THERMAL MODELS FOR INDUSTRIAL FACILITIES

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Abstract

Recent LiDAR-based technologies provide accurate geometric data of indoor scenes and facility interiors (e.g., factories, halls, or large rooms), which can be processed to obtain standard BIM models in various formats, resulting in a basic digital twin of the environment. A step beyond conventional digital twins is the creation of scene models incorporating dense thermal information at a given time. This study proposes a methodology to generate BIM models of building interiors in IFC format, embedding temperature as a property of each architectural or functional element.

Introduction

Although multiple studies have reported the generation of 3D thermal maps using digitization systems that include one or more infrared cameras (Ramón, Adán and Javier Castilla, 2022), existing work on indoor environments has so far been limited to floor-level representations (essentially multiple rooms connected by corridors) in the resulting thermal point clouds (Collins et al., 2024). Autonomous robotic systems (Adán, López-Rey and Ramón, 2023) and UAV-based platforms (Zhang et al., 2023) capable of thermally digitizing parts of building interiors and exteriors have also been proposed; however, most of these systems fail to generate fully omnidirectional thermal models covering the entire visible surface of the environment.

Research on thermal digital twins is still very limited, particularly at the scale of an entire building floor. Studies addressing the generation of standard IFC formats enriched with temperature properties did not appear until 2026, as reported in (Ramón-Constantí et al., 2026), which can be considered an initial contribution in this field. In that work, a process was designed to generate an open IFC file in which average surface temperatures were embedded as native properties of architectural elements of a curtain wall.

Methodology and experimentation

The proposed methodology in our study is structured into three phases, as shown in Figure 1(a). In the first phase, an omnidirectional thermal point cloud of the environment is acquired using a LiDAR-based sensing platform referred to as MoPAD. In the second phase, an engineer or architect models the interior space using an appropriate modelling tool. Finally, in the third phase, the results of the two previous stages are integrated by associating a temperature value with each structural element, all within an open standardized format widely used in the AEC domain, namely IFC (Industry Foundation Classes). This poster is specifically focused on this third integration phase. In turn, the creation of the Thermal-IFC model comprises three main steps, which are summarized as follows. 1) Extraction of the coordinates of the centroids and vertices of each geometric element contained in the IFC file; 2)

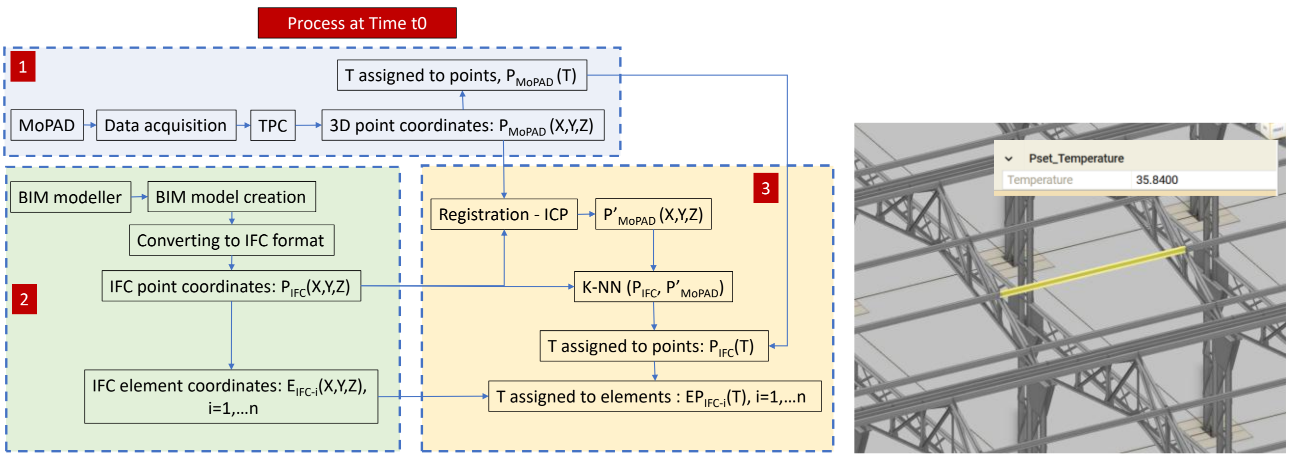

Figure 1: a) Flowchart of the proposed methodology, illustrating its three main steps. b) Steel load-bearing structure. Detail of a steel bar with a highlighted region showing the measured temperature

Assignment of temperature values to the elements through automatic registration between the element vertices and the thermal point cloud; 3) Generation of the IFC file by integrating temperature attributes into the corresponding elements. The two basic algorithms used in the step 2) were the ICP (Iterative Closest Point) algorithm for point registration between those captured by the digitising platform and the vertices of the elements in the IFC file, and the k-NN (k-nearest neighbours). The ICP algorithm yielded a registration RMSE below 2 cm.

This methodology has been successfully tested in various indoor environments (buildings, industrial halls, boiler rooms, etc.). As a representative high-complexity case study, the poster presents results from a large industrial hall (39 × 88 × 10 m) containing 10,377 IFC elements, each assigned a temperature value. The resulting thermal IFC model was successfully visualised in BIM platforms, enabling thermal behaviour analysis. Temperature calibration relied on a contact sensor (0.5 °C accuracy), ensuring a final temperature error below this threshold. Figure 1(b) illustrates the generated thermal IFC model.

Conclusions and contributions

This work presents a practical and scalable methodology for embedding dense thermal information into IFC-based BIM models by automatically associating temperature data with architectural elements, enabling enriched thermal digital twins. Validation in large-scale indoor environments demonstrates its applicability to real-world scenarios and its potential for energy analysis and building performance assessment in the AEC domain.

Since temperature in IFC models is inherently temporal, as it corresponds to a specific time instant, the proposed approach can be understood as a temporal digital model suitable for applications such as thermal monitoring and indoor thermal simulation.

The main contributions of this work can be summarized as follows:

- This study advances the integration of thermal models within the construction context, improving the efficiency of previous approaches.
- The proposed integration method is automatic and accessible to AEC professionals, without requiring specialized computer or programming skills.
- The resulting thermal IFC models can be directly used by AEC professionals to analyse building thermal behaviour, supporting energy efficiency and occupant comfort assessment.

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