Acquisition and Processing of Thermal Data Using Lidar Scanner in Industrial Heritage

by A. Adán*, F.J. Castilla, A.A. Mora***

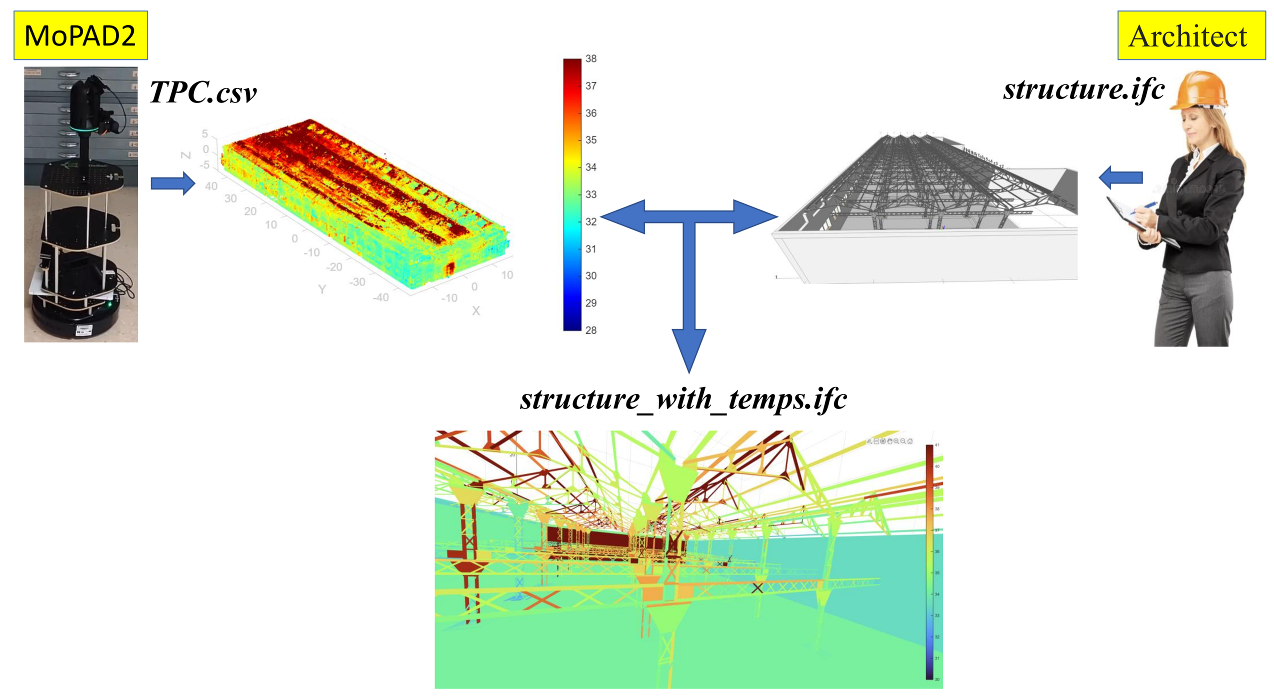
* University of Castilla-La Mancha, Soft Robotics and 3D Computer Vision Lab, Spain
Antonio.Adan@uclm.es

** University of Castilla-La Mancha, MAEE-UCLM Group, Spain

Universidad de Castilla-La Mancha

Abstract

This work presents a methodology for the acquisition, validation, and processing of geometric and thermal data obtained through LiDAR scanning of industrial heritage buildings. The objective is to generate a digital thermal model capable of associating surface temperature values with architectural and structural elements of the environment. The proposed methodology combines the acquisition of an omnidirectional thermal point cloud with the generation of a BIM model in IFC format, enabling the automatic assignment of temperature values to construction elements. Results demonstrate the feasibility of integrating dense thermal data into digital building models for energy assessment and heritage rehabilitation purposes.



General workflow of the proposed methodology. MoPAD2 is our mobile robot designed for the thermal monitoring of buildings

Introduction

Recent advances in LiDAR and thermal sensing technologies have enabled accurate geometric digitization and thermal analysis of indoor building environments, providing valuable information about energy losses, thermal anomalies, and building behaviour ([1], [2]). Their combination has attracted increasing attention in the AEC domain, particularly through thermal point clouds for building inspection and energy analysis ([3], [4]), as well as IoT-based approaches ([5], [6]). However, most existing methods focus on thermal maps rather than integrating thermal data into BIM models. This work proposes a practical methodology to integrate thermal information into an IFC-based BIM model of an industrial heritage building. (Find references within the article)

Case Study

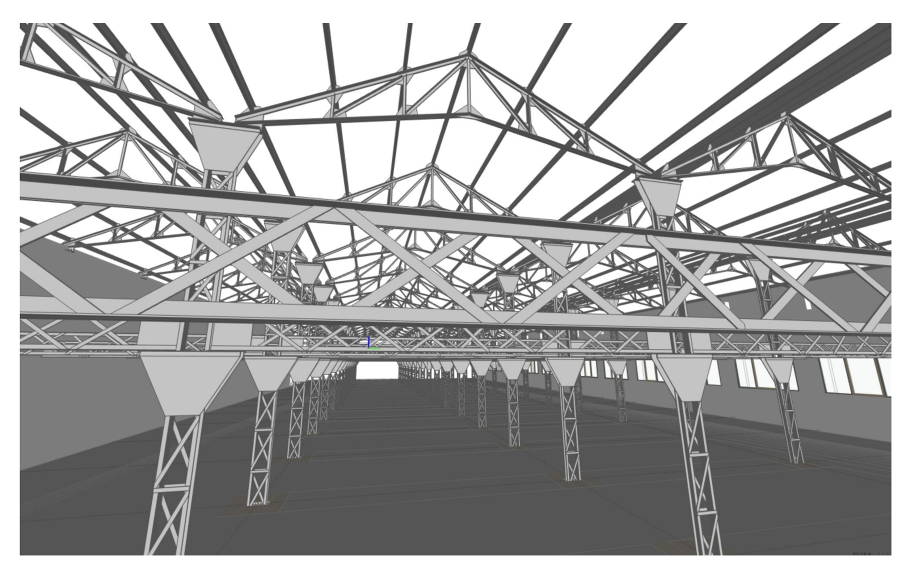
The study focuses on a warehouse representative of the catalogued constructions conforming the campus of the University of Castilla-La Mancha, located in the city of Toledo (Spain). The construction is a former Weapons Factory from the late XIX century, now used as a space for academic events.

Geometric and thermal data collection was carried out using a LiDAR sensor during one of the hottest days of July, ensuring representative thermal gradients in the building envelope and internal elements. The acquisition process generated a dense thermal point cloud of the environment, allowing the temperature distribution of walls, roofs, structural components, and glazing elements to be analysed.

To validate the reliability of the thermal measurements, ambient, indoor, outdoor, and local surface temperatures were monitored simultaneously at different locations using contact sensors. This comparative analysis enabled verification of the thermal consistency between the acquired point cloud and ground-truth measurements.

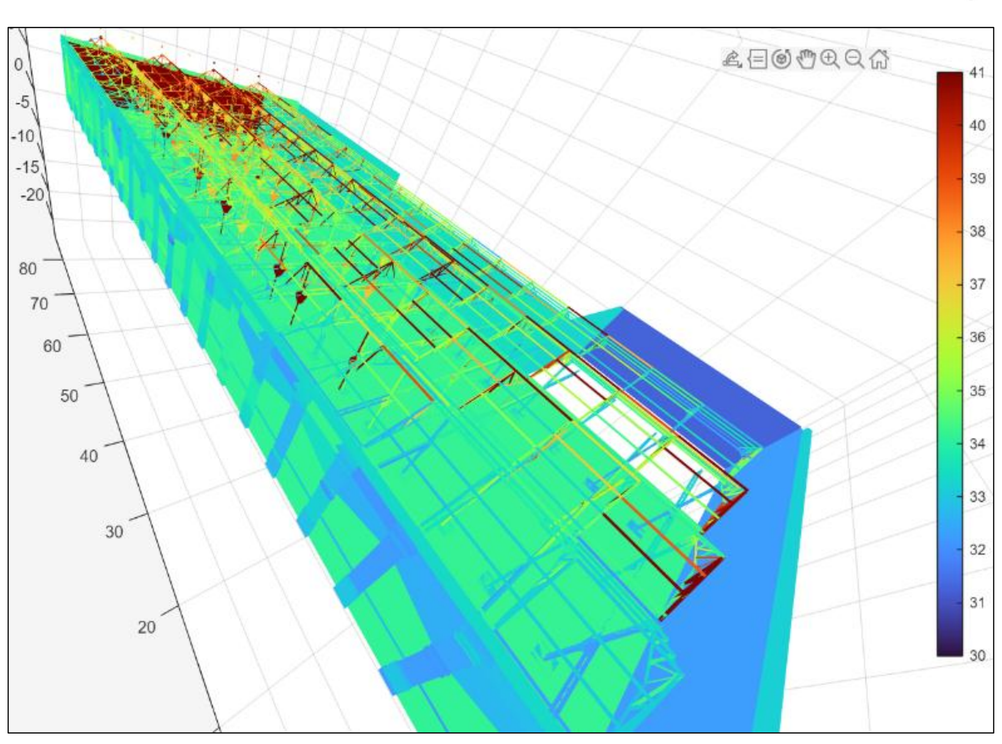
An application was developed to enable interactive visualization and consultation of thermal information associated with the scanned scene. In addition, an automatic algorithm based on point registration and proximity analysis was implemented to associate temperature values extracted from the thermal point cloud with the corresponding elements of an IFC model. The resulting thermal model facilitates the identification of thermal anomalies and enables future analyses related to energy efficiency and environmental performance of the building

Image of the industrial warehouse where the experimental validation of the method was carried out

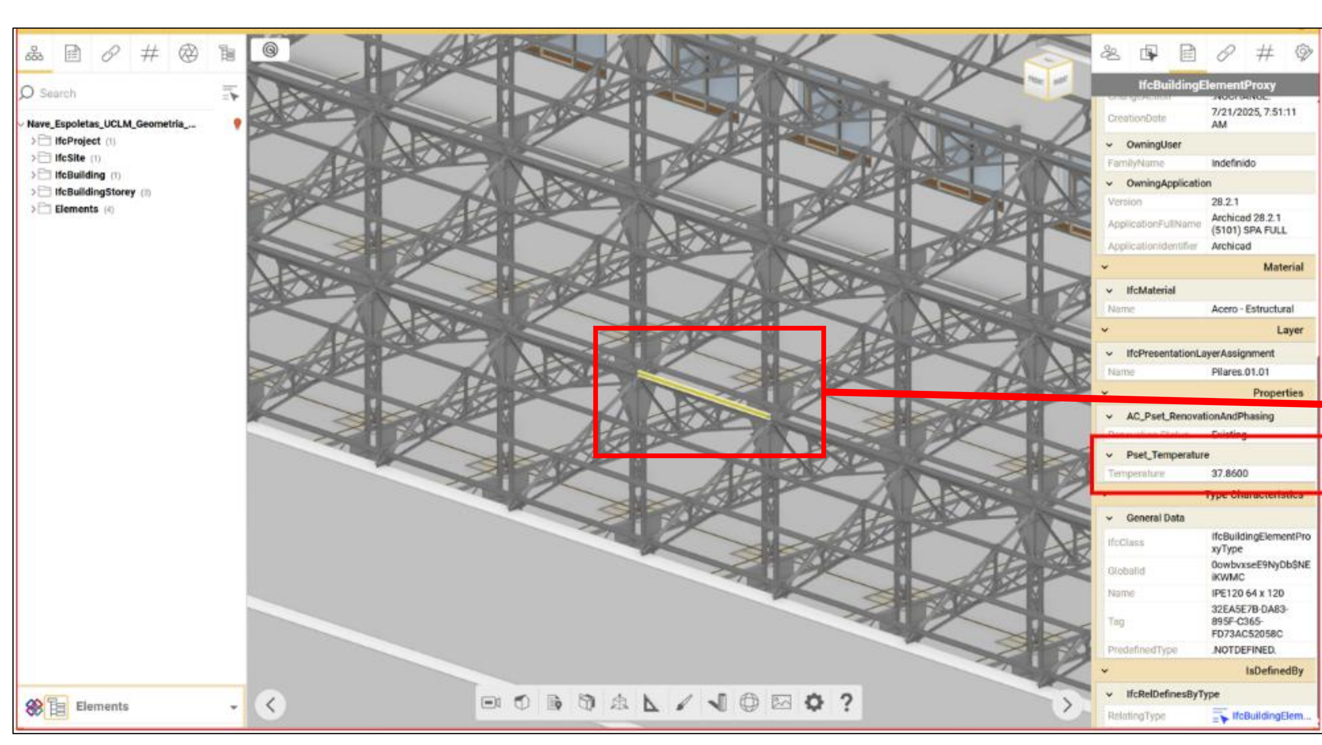


Perspective views of the warehouse model in IFC format developed by the engineering company

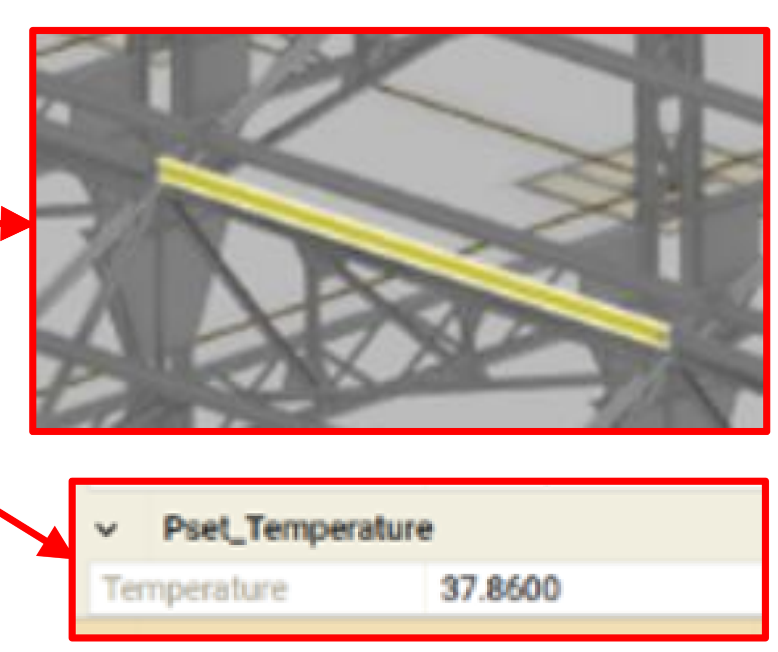
.



View from outside the IFC model using a custom viewer, where the mean temperatures of all elements are displayed through a colour code.



IFC model of the warehouse with embedded temperature information is shown in an openBIM viewer.



Example of a structural element enriched with temperature information

Conclusions

The experimental results demonstrate the reliability of the acquired thermal information and its suitability for integration into BIM-based workflows. Furthermore, the developed methodology facilitates the visualization and exploitation of thermal information for future applications related to building rehabilitation, energy efficiency assessment, and thermal simulation through CFD-based analyses. This work therefore represents a step forward towards the development of richer digital models for the inspection and conservation of industrial heritage buildings.

Acknowledgements

This work was supported by projects PID2022-141275OB-C21 (CIN/AEI/10.13039/501100011033/FEDER, EU) and SBPLY23180225000113, co-funded by the European Regional Development Fund (FEDER).