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[1*]Dr. Sagar T S

[2] Punith S L

Application of Mobile Phone 3D LiDAR Scanning and BIM in Heritage Documentation: A Case Study

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Abstract:- This research explores the integration of mobile phone–based 3D LiDAR scanning and Building Information Modeling (BIM) for heritage documentation, focusing on the 12th-century Chenna Keshava temple in Kaidala, Karnataka. Using an iPhone 13 Pro Max, point cloud data were captured and processed in Autodesk ReCap, then converted into Historic BIM models within Autodesk Revit. The workflow enabled accurate reconstruction of complex geometries, including sculptural ornamentation and non-uniform architectural features. Results show that consumer-grade LiDAR devices can generate sufficiently dense and precise datasets to support reliable HBIM modeling, providing outputs such as floor plans, sections, and structural assessments. Compared with traditional methods like manual surveying and photogrammetry, mobile LiDAR offers greater efficiency, improved spatial accuracy, and reduced intrusiveness, though challenges persist in handling noisy data, interoperability, and limited resolution relative to professional scanners. Overall, the study demonstrates the viability of mobile LiDAR as an accessible tool for heritage documentation, while emphasizing the need for standardized workflows and automation to enhance conservation and restoration practices.

Keywords*:* - Mobile LiDAR scanning, Historic Building Information Modeling (HBIM), Heritage documentation, 3D point cloud processing, Cultural heritage conservation.

1. INTRODUCTION

The integration of three-dimensional (3D) Light Detection and Ranging scanning, particularly through mobile phone applications, with Building Information Modeling methodologies presents a transformative approach to the comprehensive documentation and preservation of heritage architecture (Askar & Sternberg, 2023). This convergence facilitates the creation of highly accurate digital twins, enabling detailed analyses for conservation, restoration, and adaptive reuse strategies (Chen et al., 2023). Specifically, the advent of LiDAR sensors in consumer-grade mobile devices democratizes high-precision spatial data acquisition, significantly lowering the barrier to entry for heritage professionals and enthusiasts alike (Alshawabkeh et al., 2021). This technological synergy allows for non-invasive, high-resolution architectural surveys that capture intricate details previously unattainable with traditional methods (Rocha et al., 2020). Furthermore, the application of Heritage Building Information Modeling ensures the systematic integration of geometric and semantic data, thereby supporting long-term management and preventative maintenance strategies for cultural heritage assets (Valldecabres et al., 2023) (Mazzetto, 2024). This paper will explore the methodologies, advantages, and limitations of employing mobile phone-based 3D LiDAR scanning in conjunction with BIM for heritage documentation, highlighting case studies and practical applications.

1.1 Background

Historically, the documentation of heritage sites relied on manual surveys, 2D drawings, and written records. These traditional methods suffered from several disadvantages, including limited accuracy, time-consuming processes, difficulties in managing changes, a high risk of data loss, and inadequate visualization and analysis capabilities, particularly for capturing intricate details(Abdelalim, 2025).

[1]*Associate Professor, School of Architecture, Siddaganga School of Architecture, Tumkur Email id: sagarts@sit.ac.in

[2]Undergraduate student, School of Architecture, Siddaganga School of Architecture, Tumkur

Email: 1si19at026@sit.ac.in

The synergy of 3D LiDAR scanning and Building Information Modeling presents a transformative approach, poised to redefine the methods by which historic buildings are understood, documented, and preserved (Yaagoubi & Miky, 2018). Advanced technology is reshaping the traditional approaches to recording and safeguarding these structures, offering unparalleled precision and detail(Galeazzi, 2015). This integration facilitates the creation of comprehensive digital twins, enabling a move from static record-keeping to interactive, semantically rich digital representations crucial for long-term conservation and public engagement (Abdelalim, 2025). The recent incorporation of LiDAR sensors into consumer mobile devices has further democratized this process, allowing for rapid and accurate 3D model generation, thereby significantly enhancing the efficiency and accessibility of heritage documentation (Vacca, 2023). This advancement is particularly significant for heritage building information modeling, as it allows for the precise capture of irregular and free-form elements inherent in historic structures, which conventional parametric objects in BIM libraries often fail to represent accurately (Alshawabkeh & Baik, 2023). Hence, this paper will delve into the practical applications and challenges of integrating mobile LiDAR data into HBIM workflows for heritage documentation (Zhang, 2020) (Angeloni et al., 2023).

1.2 Problem Statement

Despite these technological advancements, significant challenges persist in the comprehensive and accurate digital documentation of heritage sites, particularly concerning the integration of diverse data types and the management of extensive datasets generated by advanced scanning technologies (Solla et al., 2020). One primary issue involves the transformation of raw point cloud data, often massive and unstructured, into semantically rich 3D BIM models suitable for heritage analysis and preservation (Escudero, 2023). Hence, this paper will investigate the methodologies for streamlining the conversion of mobile LiDAR scan data into accurate HBIM models, addressing the complexities of integrating geometric and qualitative information (Ferro et al., 2023). This includes exploring automated and semi-automated techniques to optimize the workflow from data acquisition to model development, ensuring the fidelity and utility of the digital representations for conservation and management purposes (Liu et al., 2023) (Benantar et al., 2025).

1.3 Research Objectives

This study aims to delineate the purposes and applications of Historic Building Information Modeling at different stages of a historic building’s life cycle, drawing on an analysis of relevant publications (Siewczyński & Szot, 2025). It further seeks to assess the efficiency and accuracy of using mobile phone LiDAR technology for capturing geometric data essential for the creation of precise HBIMs, comparing it against traditional scanning methods. Furthermore, this research will evaluate the potential of mobile LiDAR for rapid deformation detection and monitoring in heritage structures, contrasting its capabilities with more established terrestrial laser scanning techniques (Yaagoubi & Miky, 2018) (Curto et al., 2023).

Scope and Limitations

Finally, the study intends to provide a framework for the integration of these mobile-derived datasets with existing architectural and historical records within a unified HBIM environment, thereby enhancing holistic preservation strategies. It will also address the inherent limitations of mobile LiDAR, such as range, resolution, and environmental dependencies, considering their impact on the fidelity and completeness of the resultant HBIMs.

2. LITERATURE REVIEW

2.1 3D LiDAR Scanning Technology

Three-dimensional LiDAR scanning technology employs laser light to determine distances, thereby generating highly detailed, three-dimensional representations of scanned environments. Building Information Modeling is an integrated, data-rich methodology focused on the creation and management of a comprehensive 3D model that encompasses diverse facets of a construction project. LiDAR scanning provides exceptionally precise and accurate measurements of building structures, capturing intricate features and architectural nuances through the generation of detailed point clouds. These point clouds are crucial for BIM, as they furnish a precise, three-dimensional depiction of the physical surroundings with accurate dimensions. The amalgamation of LiDAR and BIM presents a promising approach for the conservation of historical buildings, warranting further investigation. The growing application of Historic Building Information Modeling in built heritage is well-documented, focusing on understanding historical construction and conditions to facilitate preservation and management (Turco et al., 2024). This integration enables comprehensive digital documentation, offering significant advantages over traditional methods by providing accurate, detailed, and measurable 3D representations (Solla et al., 2020).

2.2 Mobile Phone LiDAR Applications

The advancement of LiDAR technology, particularly its integration into mobile phones, represents a significant leap for accessibility and immediate data acquisition in heritage documentation (Kaartinen et al., 2022). This allows for on-site, real-time data capture, drastically reducing the time and cost associated with traditional surveying methods (Benantar et al., 2025). The integration of LiDAR into mobile devices streamlines the process of creating digital twins of historic structures, offering unprecedented opportunities for rapid and iterative model development directly from the field (Borkowski & Winiarska, 2025). This portable and user-friendly technology supports frequent updates and detailed geometric modeling of complex architectural elements, which is essential for accurate heritage preservation and management (Brumana et al., 2019). Such mobile LiDAR systems combine multiple sensors, including active sensors, inertial measurement units, and global navigation satellite systems, to produce accurate and precise geospatial 3D point clouds rapidly and efficiently (Rodríguez-Gonzálvez et al., 2017). This fusion of sensor data enables the capture of high-density point clouds with rich spatial information, making it feasible to document intricate architectural details that are often challenging to capture with conventional techniques (Calisi et al., 2023). Furthermore, the integration of these mobile-derived datasets with Building Information Modeling offers a comprehensive framework for managing the vast amount of geometric and semantic data necessary for thorough heritage documentation and ongoing conservation efforts (Cheng et al., 2015). However, the major challenges associated with mobile phone LiDAR include limitations in range and resolution compared to terrestrial laser scanners, alongside potential inaccuracies stemming from user movement and environmental factors (Solla et al., 2020). These limitations necessitate advanced post-processing techniques and rigorous validation protocols to ensure the fidelity and reliability of the acquired data for heritage documentation and subsequent BIM integration (Zlot et al., 2013). This is particularly relevant for remote collaboration where researchers can access and analyze fragile historical objects digitally without direct physical interaction (Spennemann & Hurford, 2024).

2.3 Existing Research Gaps

Despite the advancements in LiDAR and BIM for heritage documentation, there remains a notable gap in fully understanding the practical implications and optimal methodologies for integrating mobile phone LiDAR data directly into Heritage Building Information Models, particularly concerning data standardization and semantic enrichment (Croce et al., 2021) . Furthermore, current literature often lacks a comprehensive comparative analysis of mobile LiDAR's efficacy against established terrestrial laser scanning techniques for rapid deformation detection and monitoring in historic structures, highlighting a critical area for further empirical investigation. While the utility of scan-to-BIM processes for managing ancient buildings is recognized (Aricò & Brutto, 2022), the specific challenges of integrating mobile LiDAR data into these complex models, especially concerning data fidelity and semantic interoperability for historical preservation, require more focused research (Lerones et al., 2021). The present study aims to bridge these gaps by evaluating the feasibility and accuracy of using mobile phone LiDAR for comprehensive heritage documentation and its seamless integration into an HBIM framework, while also developing best practices for data processing and semantic modeling specific to cultural heritage assets (Siliutina et al., 2024).

3. METHODOLOGY

This research employs a mixed-methods approach, combining quantitative data acquisition from mobile LiDAR scanning with qualitative analysis of its integration into HBIM, to assess the practical utility and limitations of this technology in heritage documentation. The methodological framework encompasses a systematic workflow, beginning with the acquisition of point cloud data using mobile devices equipped with

LiDAR sensors, followed by advanced processing techniques to enhance data quality and spatial accuracy. Subsequently, these meticulously processed point clouds are then transformed into semantically rich 3D models within a BIM environment, incorporating historical, material, and structural information crucial for comprehensive heritage management (Mezzino, 2017).

3.1 Study Area and Data Acquisition

The case sample selected is the Chenna Keshava temple, situated in Kaidala, Tumkur district, which was crafted by the renowned sculptor Amarashilpi Jakanachari in 1150 AD. Its architectural magnificence, comparable to the Belur Chenna Keshava temple, is characterized by a synthesis of Hoysala, Dravidian, and Vijayanagara styles. The entire temple complex is enclosed by a tall, fort-like Prakara wall, and features a three-tiered Gateway Gopuram. Figure 1 and 2 shows site plan and photo of the existing temple complex and the mantapa respectively. Within the complex, there are two idols of Lord Vishnu and Lord Shiva, along with a mantapa adorned with three distinct types of columns, column capitals, and a platform. The intricate sculptural details within the temple, particularly the dancing figures and narratives on the outer walls, offer a rich dataset for evaluating the precision and resolution capabilities of mobile LiDAR in capturing complex architectural ornamentation (10_chapter 4.Pdf, n.d.). The choice of this temple as a case study further allows for a thorough assessment of how well mobile LiDAR can delineate subtle variations in surface textures and intricate carvings, which is critical for accurate 3D reconstruction and subsequent HBIM application.

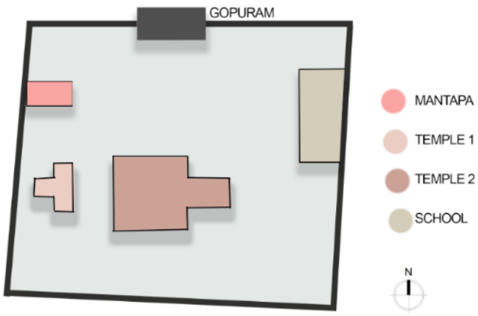

Figure 1: Site plan of Chenna Keshava temple, Kaidala

Figure 2: View of mantapa at Chenna Keshava temple, Kaidala

3.2 LiDAR Scanning Procedure with Mobile Phone

The mobile phone LiDAR scanning procedure involved a systematic approach to ensure comprehensive data capture of the temple's intricate details, utilizing an iPhone 13 Pro Max equipped with a built-in LiDAR sensor. This device allowed for the rapid acquisition of dense point clouds, capturing the temple's geometry with sufficient detail for preliminary modeling (Bronzino et al., 2019). The scanning was conducted both indoors and outdoors, adapting to varying lighting conditions and spatial constraints to maximize data coverage and minimize occlusions. The scanning strategy included multiple passes from varying angles and distances, specifically focusing on complex architectural elements and areas requiring higher resolution to capture minute details effectively. This comprehensive approach ensured the generation of a robust dataset, enabling a thorough evaluation of the mobile LiDAR's capacity to document cultural heritage sites, especially those with intricate sculptural and architectural features (Bhardwaj & Muralidhar, 2024). Figure 3

3.3 Data Processing and Point Cloud Generation

Autodesk ReCap serves as a platform for importing, visualizing, and managing substantial point cloud datasets

acquired from 3D laser scanning or photogrammetry. Its seamless integration with other Autodesk products, such as AutoCAD and Revit, facilitates an uninterrupted workflow, enabling the incorporation of reality capture data into design and modeling phases. Within this workflow, point cloud data is imported into Autodesk ReCap for processing. This processing stage includes the removal of extraneous points, augmentation of point density to support precise modeling, and validation of measurements against on-site data. Ultimately, the processed data is converted into a format compatible with Revit. This transformation enables the direct use of the point cloud data for generating accurate 3D models and facilitating detailed architectural analysis within the BIM environment (Andriasyan et al., 2020).

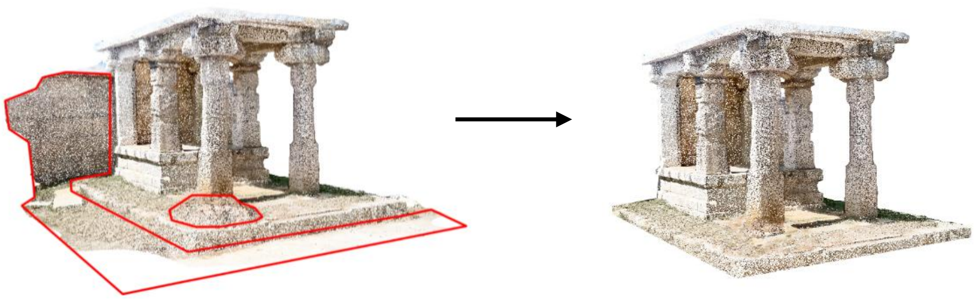

Figure 3: Image showing processing of raw point cloud data

3.4 BIM Model Creation

Following the linking of the ReCap model into Autodesk Revit, the geometric model was constructed by tracing over the point cloud data. While standard modeling tools enable rapid object creation with embedded parameters for contemporary buildings, this approach proved less feasible for the historic structure due to its unique characteristics. Figure 4 shows the converted point cloud data into 3d model.

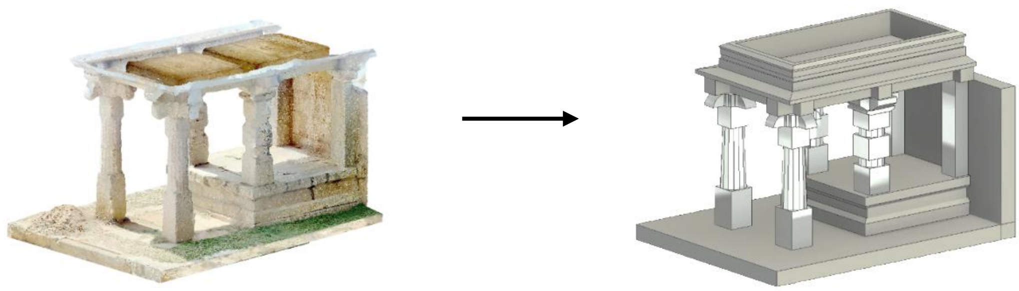

Figure 4: 3D model generated from point cloud data

The chosen case study presented complex geometries, rendering standard modern tools inadequate for accurately depicting its non-uniform structures. Consequently, the Generic Model tool was employed to achieve the highest possible level of realism, with object-specific parameters subsequently added manually. Supplementary photographs captured during fieldwork were also utilized to support the modeling process.

During modeling, appropriate levels were assigned to facilitate accurate tracing, and the process commenced systematically from the plinth to the roof. The resulting model serves as an abstracted yet dimensionally precise representation of the structure, capturing its length, width, and height accurately. Within Revit, each element was modeled using its corresponding family type, such as utilizing the column family for columns and the wall family for walls, ensuring structural integrity and adherence to BIM conventions. This methodical approach to BIM model creation from point cloud data underscores the iterative refinement required to translate complex historical geometries into a structured digital format, particularly when standard parametric objects are insufficient (Massafra et al., 2020).

3.5 Accuracy Assessment

The integration of mobile LiDAR technology offers significant advantages for heritage documentation. It provides an accurate and consolidated record of a building's current condition and layout, thereby reducing the reliance on physical record collection. Furthermore, it diminishes the necessity for costly, time-consuming, and potentially intrusive surveying methods, while also mitigating human error inherent in such processes. Traditional outputs, including sections, floor plans, elevations, and measurements of ceilings and walls, can be generated instantly and at no additional cost, using non-intrusive techniques. These outputs are valuable for stakeholders involved in restoration work. The chosen sample comprises three distinct column types, two of each; two beam sizes; a plinth; a platform; two column capital types; and a roof. Within Revit, each element type should be assigned a unique identifier and its material properties specified. Any observed damages should

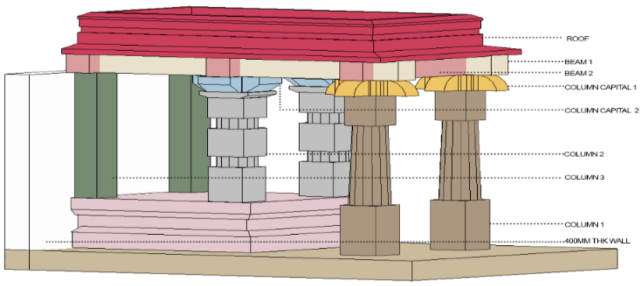

Figure 5: Different colours assigned to various elements of the structure

be documented, and elements can be color-coded for easy identification in the model. Schedules can be created for existing architectural elements slated for preservation or restoration, detailing information such as element type, materials, dimensions, and quantity. Figure 5 and table 1 shows different colours assigned to various elements of the structure.

Schedule				
A	B	C	D	E
Family type	Count	Base level	top level	Material
COLUMN 1	2	350 MM	3170 MM	GRANITE STONE
COLUMN 2	2	1225 MM	3170 MM	GRANITE STONE
COLUMN 3	2	1225 MM	3170 MM	GRANITE STONE
COLUMN CAPITAL 1	2	3170 MM	3445 MM	GRANITE STONE
COLUMN CAPITAL 2	2	3170 MM	3445 MM	GRANITE STONE
BEAM 1	2	—	—	GRANITE STONE
BEAM 2	3	—	—	GRANITE STONE
PLATFORM	—	350 MM	1225 MM	GRANITE STONE

Table 1: Schedule generated in Revit software

3.6 Software and Hardware Used

The primary software tools utilized for this project included Autodesk Revit for Building Information Modeling and Autodesk ReCap for point cloud processing, while the hardware encompassed an iPhone 13 Pro Max for LiDAR data acquisition. This combination of readily available mobile technology and industry-standard software demonstrates a streamlined workflow for generating accurate and semantically rich heritage BIM models from field data (Quattrini et al., 2015).

4. RESULTS

This section presents the outcomes derived from the application of the described methodology, detailing the quality of the generated point clouds, the fidelity of the BIM models, and the insights gained regarding the structural and architectural characteristics of the heritage site. The iPhone 13 Pro Max LiDAR scanner produced point clouds with sufficient density to capture intricate architectural details, demonstrating the feasibility of using consumer-grade mobile devices for preliminary heritage documentation. The quality of these point clouds allowed for the accurate reconstruction of complex geometries, which is crucial for subsequent BIM modeling (Antón et al., 2023). Further analysis of the point cloud data revealed its suitability for generating parametric objects within a Historic Building Information Modeling framework, thereby supporting detailed conservation and restoration efforts (Sampaio et al., 2021).

4.1 Comparison with Traditional Methods

While traditional methods for heritage documentation, such as manual surveying and photogrammetry, have historically been employed, they often entail limitations in terms of data density, spatial accuracy, and efficiency when compared to contemporary LiDAR-based approaches (Alshawabkeh et al., 2021). Specifically, manual surveying is labor-intensive and prone to human error, resulting in sparse data sets that may overlook subtle architectural nuances (Khalil et al., 2020). Conversely, photogrammetry, while offering visual richness, can struggle with complex geometries, occlusions, and accurate scaling, often requiring extensive post-processing to achieve metric precision (Sánchez et al., 2022). In contrast, LiDAR technology, particularly when integrated into mobile platforms like the iPhone 13 Pro Max, offers rapid data acquisition with high spatial accuracy and comprehensive coverage, overcoming many of these traditional constraints (Gautier et al., 2020).

The integration of LiDAR, particularly through low-cost mobile solutions, significantly enhances the efficiency and accuracy of heritage documentation (Spennemann & Hurford, 2024). This approach not only provides a precise and consolidated record of a building's current state but also facilitates the rapid generation of essential documentation, such as floor plans and sections, which are invaluable for conservation and restoration initiatives (Dailoo et al., 2023). The capability of generating detailed 3D models from LiDAR data allows for comprehensive structural analysis and damage assessment, which is critical for effective heritage management (Lashihar, 2025).

4.2 Limitations and Challenges

Despite the considerable advancements offered by mobile LiDAR and BIM integration in heritage documentation, several limitations and challenges warrant consideration, particularly concerning data processing and inherent software defects (Zhang et al., 2015). The significant volume of data generated by 3D laser scanning applications, for instance, necessitates robust processing capabilities and efficient data management strategies to prevent computational bottlenecks and ensure timely project completion (Zhang et al., 2015). Furthermore, the conversion of raw point cloud data into semantically rich BIM elements often requires manual intervention and specialized expertise, posing a significant challenge for automated workflows. Moreover, while mobile phone LiDAR offers unparalleled portability and accessibility, its accuracy and resolution may not always match those of professional-grade terrestrial laser scanners, especially in highly detailed or expansive heritage sites (Sun & Zhang, 2019) (Adamopoulos et al., 2020). These limitations often manifest in issues such as noise in point cloud data, which can obscure fine details, and difficulties in accurately capturing reflective or transparent surfaces. Additionally, the proprietary nature of some BIM software and the lack of universal standards for heritage BIM can hinder interoperability and data exchange among different platforms and stakeholders (Banfi et al., 2023). Addressing these challenges necessitates further research into advanced filtering algorithms for noise reduction, automated feature extraction methods, and the development of open-source BIM platforms tailored for heritage documentation to promote wider adoption and collaborative efforts (Gómez-López et al., 2023) .

5. CONCLUSION

This study successfully demonstrated that combining 3D LiDAR scanning from mobile phones with Building Information Modeling offers a highly efficient and accurate methodology for documenting cultural heritage (Banfi et al., 2023). The findings underscore the potential of democratizing high-precision heritage recording, moving beyond traditional, labor-intensive methods (Kim et al., 2025; Kuniyoshi et al., 2025). The research highlighted how this approach not only enhances data density and spatial accuracy but also streamlines the creation of semantically rich models crucial for conservation, restoration, and adaptive reuse projects (Adamopoulos et al., 2020). However, challenges such as data incompleteness, the integration of diverse data formats, and ensuring software compatibility remain pertinent considerations in fully leveraging these technologies within a comprehensive heritage management framework (Vaienti et al., 2023). Moving forward, addressing these technical and methodological gaps is essential to unlock the full potential of mobile LiDAR and BIM in safeguarding global heritage, particularly through the development of unified platforms and automated processes (Zhou et al., 2024).

This research significantly advances the field by demonstrating the viability of consumer-grade mobile devices for high-fidelity heritage documentation, thus democratizing access to advanced spatial recording technologies. It provides a novel perspective on integrating accessible technology with established BIM practices, thereby bridging the gap between cutting-edge digital tools and practical heritage conservation needs.

Future research should focus on refining automated workflows for point cloud processing and BIM model generation, exploring machine learning algorithms to enhance feature extraction and semantic enrichment from raw LiDAR data (Rane, 2023). Further investigations could also explore the development of open-source Historic Building Information Modeling platforms to mitigate the complexities associated with proprietary software and foster wider adoption within conservation communities (Bruno & Roncella, 2019; Diara, 2022). Additionally, future studies should investigate the long-term data preservation strategies for these intricate digital models, considering issues of digital obsolescence and interoperability to ensure sustained accessibility for future generations.

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