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MODERN TECHNOLOGIES FOR THE THREE - DIMENSIONAL DOCUMENTATION OF THE HISTORICAL MONUMENT BRÜCK CASTLE

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Abstract. *In the context of increasing demand for advanced digital heritage preservation methods, the current state of the art is dominated by terrestrial laser scanning, mobile mapping systems, and photogrammetric techniques, which have proven highly efficient in generating precise 3D datasets for complex structures. This paper aims to explore and evaluate modern technologies used for the three-dimensional documentation of the historical monument Brück Castle, a monument of significant cultural and architectural value for Timişoara municipality. For this study, data acquisition was performed using a terrestrial laser scanner and a mobile mapping system. Georeferencing was ensured through the integration of a total station and a GNSS receiver. The acquired data were processed and analyzed using two different software, which allowed a precise point cloud registration, filtering, and visualization. The novelty of this research lies in the combined use of both terrestrial and mobile laser scanning for documenting the same historic building, enabling the evaluation of accuracy, efficiency, and complementarity between the two approaches. The results demonstrated a high level of geometric fidelity in the final 3D model, with deviations within acceptable tolerances for heritage documentation. However, some limitations were identified, such as restricted accessibility to certain building areas and the influence of environmental conditions on data acquisition. Despite these constraints, the study highlights the relevance of integrating multiple surveying technologies for heritage preservation. The originality and significance of this work stem from its contribution to the methodological framework for documenting historic architecture, providing a replicable workflow for future research and conservation projects.*

Keywords*: 3D modelling, mobile laser scanning, mobile mapping, cultural heritage preservation*

INTRODUCTION

The preservation and documentation of historic buildings are essential for maintaining the cultural heritage of cities such as Timișoara, which boasts numerous emblematic structures of architectural and historical significance. Accurate recording of these monuments not only facilitates their conservation but also enables future generations to access and study their historical value in a digital format. Despite advancements in surveying technologies, challenges remain in efficiently documenting heritage buildings without disrupting their ongoing use or compromising data quality.

The present study focuses on the three-dimensional documentation of the historic Brück Building with the aim of producing detailed floor plans for each level. The main objective was to achieve a rapid and precise survey of a historic property while minimizing interference with the daily functioning of the premises.

Brück House, strategically located in the southwest corner of Unirii Square in Timișoara, is one of the most remarkable and emblematic buildings of the city, being an example of Secession-style architecture, adapted to the Central European cultural specifics. Its story begins in the 19th century, when the “Crucea de Aur” pharmacy operated on this site, a health and trust center for the community.

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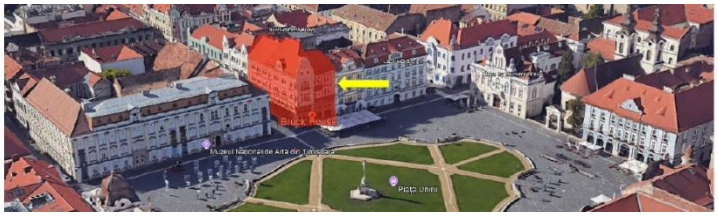

Figure 1. Identification of Brück House Unirii Square view Google Earth

The restoration of the building between 2009 and 2012 was a large-scale project with the main goal of restoring the building to its original appearance and atmosphere, preserving the authenticity of the architectural and decorative elements.

By integrating modern technologies and advanced surveying methods, the research seeks to establish a connection between the building's historical legacy and its future preservation. Furthermore, it highlights the potential of contemporary 3D documentation techniques to reconcile heritage conservation with practical constraints, ensuring that historic structures remain both protected and accessible for future studies.

MATERIAL AND METHODS

The first stage in any surveying work, as well as in the one presented, consisted of recognizing the terrain and identifying the key elements that must be taken into account throughout the subsequent precision measurements. This stage is essential for ensuring the accuracy and efficiency of the entire surveying process, as it allows the establishment of terrain conditions, the identification of obstacles and the planning of the appropriate measurement methodology as well as the establishment of the necessary equipment for performing precision measurements.

In order to create a local network with a non-invasive implication on the historical site of Piața Unirii, we adopted a method based on the use of fixed elements in the terrain to determine their coordinates. This approach subsequently allows the use of these points as part of a microtriangulation or trilateration network, thus creating a well-determined support network that can be subsequently used to orient the total station and to georeference the point clouds resulting from the three-dimensional scanning process.

To accurately determine the coordinates of the points materialized in the field from the local network, we used the GNSS equipment Stonex S 990 + together with the Geoelectron P9IV controller that has the SurPad v4.2 software integrated as a field notebook. In the process of determining the coordinates, we opted for the RTK (Real Time Kinematic) method, which ensures high accuracy in determining the position in a relatively short time interval.

Figure 2. Materialized point from the support network

After determining several points materialized in the field of the support network using the GNSS receiver, all these points were surveyed using a total station to establish the definitive coordinates of the support network.

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Data acquisition for the three-dimensional documentation of the Brück Building was carried out using both terrestrial and mobile laser scanning systems to ensure comprehensive coverage and high accuracy. A Zoller & Fröhlich terrestrial laser scanner was employed for static measurements, capturing detailed point clouds of complex architectural features. In parallel, the NavVis VLX 2 mobile mapping system was used to survey areas with limited accessibility and to accelerate data collection throughout the building.

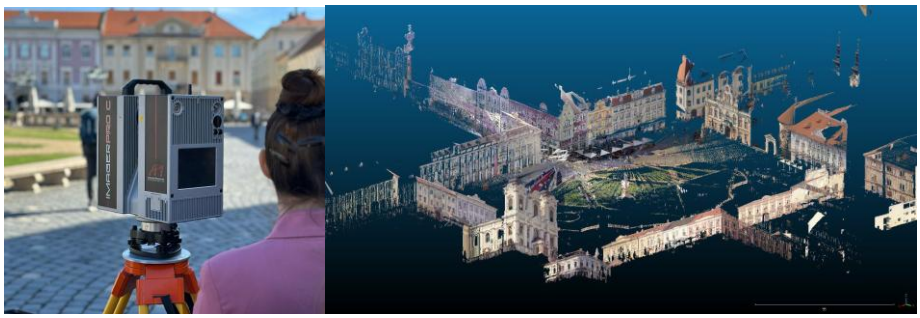
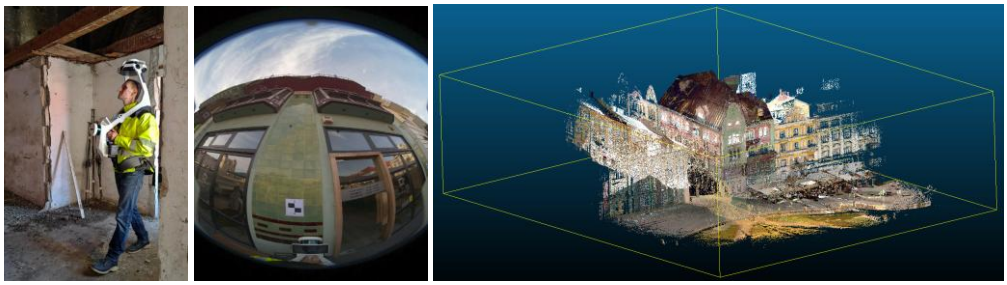


Figure 3. Point cloud resulted from the terrestrial scanning - CloudCompare view

Georeferencing of the acquired datasets was performed using a Leica TS09 Plus total station in combination with a Stonex S990+ GNSS receiver, providing accurate spatial alignment and integration of both terrestrial and mobile scans.



a) b) c)

Figure 4. a) The mobile scanning process; b) Frontal view from HDR camera; c) Point cloud resulted from the mobile scanning - CloudCompare view

The raw point cloud data were processed and analyzed using CloudCompare and Autodesk ReCap Pro, enabling precise registration, filtering, and visualization of the 3D models. Finally, detailed 2D floor plans for each level were generated in AutoCAD, ensuring that the final outputs were suitable for architectural documentation, conservation planning, and further research applications.

To create a complete and accurate three-dimensional model of the building under study, the use of a drone flight proved to be indispensable. Ground scans allowed for detailed documentation of the facades and interior, but certain components, such as the roof and the high-altitude elements, could only be adequately captured through aerial survey. The drone flight offered the opportunity to fill these gaps, ensuring full coverage of the structure and contributing to obtaining a coherent and representative three-dimensional model. This stage not only

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improved the quality and accuracy of the data, but also brought a didactic and methodological value, demonstrating how complementary technologies can be effectively integrated into the process of documentation and analysis of built heritage.

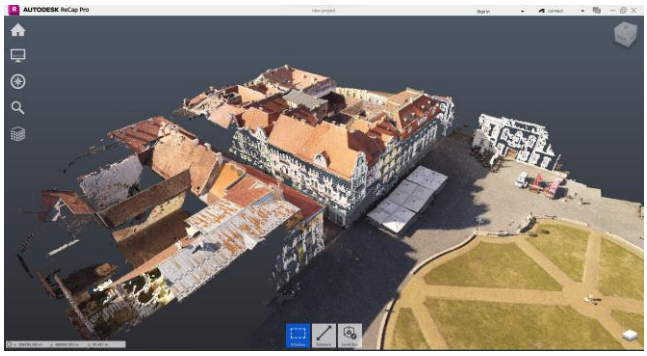

Figure 5. Point cloud resulting from a drone survey viewed in Autodesk ReCap Pro

This integrated workflow allowed for rapid, non-intrusive documentation of the historic building, combining the strengths of multiple surveying technologies while maintaining high geometric fidelity and minimizing disruption to the building's occupants.

RESULTS AND DISCUSSIONS

The integration of terrestrial and mobile laser scanning technologies enabled the comprehensive documentation of the Brück Building, producing highly detailed 3D point clouds for the entire structure. The combination of the Zoller & Fröhlich terrestrial scanner and the NavVis VLX 2 mobile system proved effective in capturing both intricate architectural details and larger, more accessible areas, ensuring complete spatial coverage.

Georeferencing using the Leica TS09 Plus total station and the Stonex S990+ GNSS receiver provided precise spatial alignment, resulting in a unified dataset with high geometric fidelity. Processing in CloudCompare and Autodesk ReCap Pro allowed for efficient point cloud registration, noise reduction, and visualization, facilitating the extraction of accurate 2D floor plans in AutoCAD for each building level (RLV plans).

The workflow demonstrated several advantages, including rapid data acquisition, minimal disruption to the building's occupants, and the production of reliable, high-resolution models suitable for architectural and conservation purposes. Nevertheless, certain limitations were observed, such as restricted access to some interior areas and environmental factors affecting mobile scanning efficiency. Despite these constraints, the combined methodology ensured a robust documentation process.

The results highlight the potential of integrating multiple surveying technologies for heritage preservation, offering a replicable and efficient workflow. Furthermore, the study underscores the importance of modern digital documentation in bridging the gap between historical legacy and future conservation efforts, ensuring that significant architectural features are accurately recorded and accessible for future research and restoration projects.

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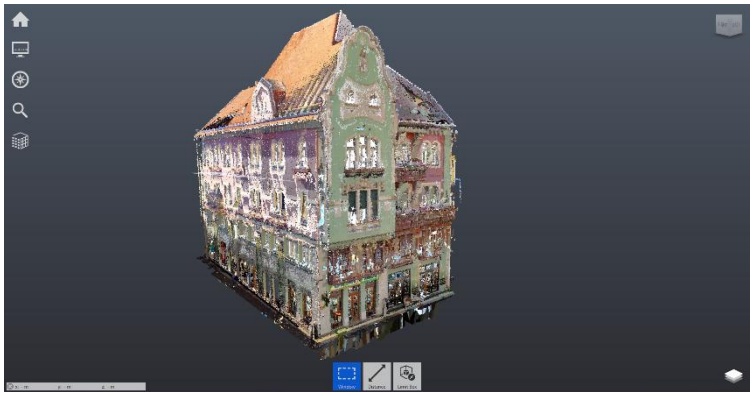
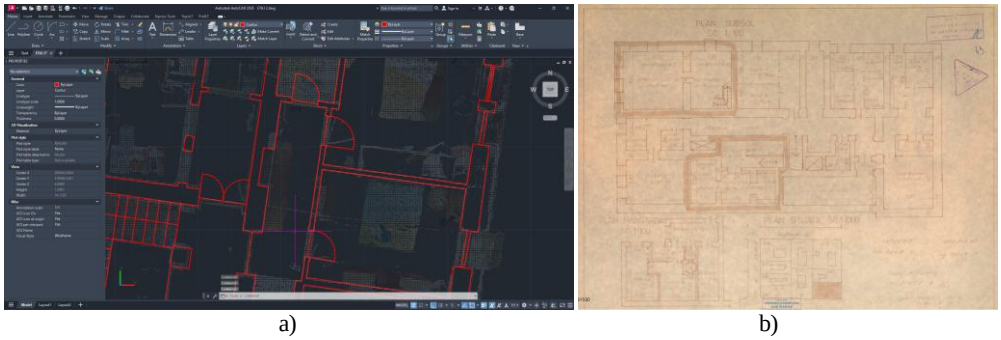


Figure 6. Brück Building – Point Cloud

The post-processing process is undoubtedly as important as the acquisition in the field. The quality and final usefulness of a three-dimensional model directly depend on the accuracy and rigor of these steps. In the case of the Brück building, post-processing allowed for the acquisition of a complete and coherent point cloud, which faithfully reflects the physical reality of the construction and serves as a solid foundation for the development of a detailed, updated and interoperable BIM model. This stage demonstrated the added value of digital technologies in the conservation and valorization of built heritage.

CONCLUSIONS

The present study demonstrates the effectiveness of combining terrestrial and mobile laser scanning technologies for the rapid and accurate three-dimensional documentation of historic buildings, exemplified by the Brück Building. The integrated workflow, supported by precise georeferencing using a total station and GNSS receiver, as well as data processing in CloudCompare, Autodesk ReCap Pro, and AutoCAD, enabled the production of detailed 3D models and accurate 2D floor plans for each level.



a) b)

Figure 7. a) Floor plan based on AutoCAD point cloud; b) Floor plan from the records of O.C.P.I. Timiș (Source: Archive of the Cadastre and Real Estate Advertising Office Timiș)

The methodology proved to be non-intrusive, minimizing disruption to the building's occupants, while ensuring high geometric fidelity and comprehensive coverage of architectural

features. The results highlight the potential of modern surveying technologies to enhance heritage preservation, bridging the gap between historical legacy and future conservation efforts.

Limitations such as restricted access to certain areas and environmental factors affecting mobile scanning were identified, suggesting areas for improvement in future research. Nevertheless, the study underscores the originality and relevance of applying integrated 3D documentation workflows to historic structures, providing a replicable and efficient approach for architectural documentation, conservation planning, and further research.

In conclusion, this research contributes a practical and innovative methodology for the preservation of cultural heritage, ensuring that historic buildings are accurately documented, digitally preserved, and accessible for future study and restoration initiatives.

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