Prof. Davide Astiaso Garcia
Associate professor of Thermal Sciences, Energy Technology and Building Physics
Department of Planning, Design, and Technology of Architecture
Sapienza University of Rome,
Rome 00196, Italy
davide.astiasogarcia@uniroma1.it

Review of dissertation by

mgr inż. arch. Hassan Bazazzadeh

entitled

" Constructing semi-automated buildings' energy loads model to retrofit built heritage by using a Data-driven model and computer vision"

Faculty of Architecture

at Poznan University of Technology.

Introduction:

The thesis "Constructing semi-automated buildings' energy loads model to retrofit built heritage by using a Data-driven model and computer vision," authored by mgr inż. arch. Hassan Bazazzadeh, is a seminal work at the intersection of sustainable architecture, energy management, and heritage conservation. This innovative research distinguishes itself through its advanced methodology and significant exploration in several pivotal areas within these domains. Central to this thesis is the innovation it brings to sustainable architecture through the integration of data science and computer vision. This integration represents a transformative approach in architectural practices, particularly in the nuanced field of retrofitting heritage buildings.

In the context of modern sustainable development, where technological advancement is key, this work demonstrates how cutting-edge technologies can be effectively utilized to address the unique challenges of historic structures. It paves the way for new methodologies in architectural conservation, bridging the gap between traditional practices and modern technological capabilities.

In the realm of energy management, this thesis makes a substantial impact. It addresses the complex challenge of analyzing and optimizing energy loads in heritage buildings—a task made difficult by the specific characteristics and limitations of these structures. The developed methodology provides a detailed insight into the energy consumption patterns of heritage buildings, offering strategies to enhance their energy efficiency. This is particularly important for the broader goal of reducing greenhouse gas emissions and mitigating climate change.

Furthermore, the work contributes significantly to heritage conservation. It presents a balanced methodology that respects the aesthetic and historical value of heritage buildings while proposing contemporary energy efficiency solutions. This balance is crucial in current times, where the preservation of historical integrity is often in conflict with modern environmental standards.

Additionally, the thesis exemplifies the importance of interdisciplinary research, blending architecture, data science, and computer vision. This approach is vital in tackling the complex, multifaceted challenges of the modern world, suggesting that innovative solutions frequently require the merging of various fields of knowledge.

Overall, this work by Bazazzadeh represents a groundbreaking contribution to the fields it touches. It offers innovative, practical, and sensitive solutions to making historic buildings more sustainable, marking a significant step forward in the responsible stewardship of our built heritage.

Nature of the dissertation:

This thesis is indeed impeccable and resonate powerfully with the current global focus on sustainability and environmental stewardship. As the world grapples with the escalating challenges of climate change, there is an increasing emphasis on reducing carbon footprints and enhancing energy efficiency in all sectors, particularly in the built environment. This thesis aligns perfectly with these global initiatives, offering timely and pertinent insights into how we can make our buildings more energy-efficient while maintaining their historical and cultural value. The focus of the thesis on built heritage is especially noteworthy. Heritage buildings, especially residential ones as the main case of the work presented I chapter 3, with their unique architectural features and historical significance, present a unique set of challenges when it comes to retrofitting for energy efficiency.

These structures are often bound by preservation guidelines and are constructed with materials and techniques that differ significantly from modern buildings. Traditional energy retrofitting approaches may not be suitable for such buildings due to the risk of altering their character or damaging their structural integrity. Bazazzadeh's approach in this thesis is both respectful of the cultural and historical importance of these buildings and innovative in its application of modern technology.

By utilizing data-driven models and computer vision, the thesis presents novel solutions that allow for a detailed and sensitive analysis of energy needs and retrofitting possibilities. This methodology enables the identification of energy-saving opportunities that are tailored to the unique characteristics of each building, ensuring that any interventions are both effective in reducing energy consumption and considerate of the building's heritage value.

Furthermore, aligning these historic structures with contemporary energy standards is not just a matter of environmental concern but also of economic and social importance. Improved energy efficiency in heritage buildings can lead to significant cost savings, enhance the comfort and usability of these spaces, and contribute to the overall sustainability of urban environments. In this way, Bazazzadeh's work contributes to a broader movement towards sustainable urban

development and the preservation of cultural heritage in the face of modern environmental challenges.

Nevertheless, I have some questions in this regard:

Question 1: Please indicate in exactly which part of your work, reasons behind the selection of this cluster of buildings as the case study have been presented?

Question 2: Please explain what would be author's opinion about the potential impacts of using proposed methodology instead of traditional energy audit?

Methodological Approach:

Bazazzadeh's methodological approach in his thesis stands out for its innovation and robustness. By integrating data-driven models with advanced computer vision techniques, he pioneers a methodology that is not only technically advanced but also highly relevant to the unique challenges of retrofitting historic buildings for energy efficiency. The core of this methodology lies in its holistic evaluation of energy loads in heritage buildings. Traditional energy modeling often relies on standardized data and generic modeling approaches that may not account for the unique characteristics of heritage buildings, such as their specific architectural features, historical value, and the materials used in their construction. Bazazzadeh's approach, however, tailors the energy modeling process to accommodate these distinct attributes. By doing so, the methodology ensures that the energy retrofitting recommendations are not only effective in terms of energy savings but also appropriate and safe for the preservation of the building's historical integrity. The use of data-driven models is a key aspect of this approach. These models are capable of processing and analyzing large volumes of data, including historical climate data, building material properties, and current energy consumption patterns. This comprehensive data analysis enables a more accurate and detailed understanding of the building's energy needs and potential areas for efficiency improvements.

Moreover, the integration of computer vision techniques enhances the methodology's efficiency and scalability. Computer vision allows for the automated analysis of building features, such as window sizes, wall thicknesses, and other structural elements, directly from images or video footage. This automation not only speeds up the data collection process but also reduces the likelihood of human error, resulting in a more reliable and consistent analysis. Bazazzadeh's approach also demonstrates a deep understanding of both the theoretical underpinnings and practical applications of energy modeling. His methodology is grounded in sound scientific principles and is informed by current best practices in both data science and architectural conservation. This dual focus ensures that the research is not only academically rigorous but also directly applicable to real-world challenges in the field of heritage building conservation.

Here, I have some doubts that are presented in the form of some questions:

Question 3: are there any assumptions for the modelling process the building for the sake of simplification to create the bigdata?

Question_4: Are the details of the energy simulation in Ladybug Hoeybee platform presented in the thesis? Are these details important or a standard workflow? Discuss it.

Question_5: in section "2.6. Climate Change Consideration" that you have created future weather data, which data was used as the baseline?

Question_6: is the caption of Table 3.1 is right? You should probably change it.

Question_7: in section "3.7. Building Clusters" I believe that there is a need to discuss why the selected cluster has been chosen.

Question_8: in which part of the thesis the reasons behind choosing the selected models have been discussed?

Question_9: Why it is important (according to 6.3.3. Distribution, normality) to check the distribution or normality of the data? Or in better word, what is the added value of performing such analyses?

Findings and Contributions:

The findings of this thesis are both substantial and pioneering, revealing significant potential for enhancing energy efficiency in historic buildings. These contributions represent a major advancement in the field, bridging the gap between the preservation of built heritage and the pursuit of energy efficiency. One of the key findings of this research is the model's ability to accurately identify areas within heritage buildings that are prime candidates for energy efficiency improvements. This aspect is particularly crucial as it addresses one of the primary challenges in retrofitting historic structures: the need to balance energy efficiency goals with the preservation of architectural integrity. The model effectively pinpoints areas where interventions can yield significant energy savings while minimizing impact on the building's historical character. Moreover, the research demonstrates how data-driven models and computer vision can be employed to analyze and understand complex energy dynamics in older buildings. This approach allows for a more nuanced understanding of how different factors, such as building materials, design features, and historical value, interact to affect a building's energy performance. By doing so, the thesis provides actionable insights that can inform more targeted and effective retrofitting strategies. These findings also have important implications for the broader field of sustainable architecture and heritage conservation. By demonstrating how modern technology can be harnessed to improve the energy efficiency of historic buildings, the thesis challenges conventional notions that heritage buildings are inherently less energy-efficient and difficult to upgrade. It opens up new avenues for sustainable conservation practices, ensuring that heritage buildings can continue to be used and enjoyed in a more energy-efficient and environmentally friendly manner.

Furthermore, these contributions are of immense value to architects, engineers, and conservationists. They offer a new perspective on how to approach the retrofitting of heritage buildings, combining respect for historical integrity with the latest advancements in energy modeling and analysis. This holistic approach can guide professionals in making informed

decisions that are both respectful of the past and mindful of future sustainability goals. In essence, the findings and contributions of this thesis represent a significant step forward in the field of sustainable heritage conservation. They not only provide practical solutions to real-world challenges but also contribute to the theoretical and conceptual understanding of how we can effectively integrate modern technology with traditional conservation practices.

Question 10: in conclusion section, I believe that there must be more about how this idea may help reduce resources in a large scale. If there is something in this regard please indicate where?

Style and Structure:

The thesis of mgr inż. arch. Hassan Bazazzadeh is a model of excellent academic structure and presentation. Each chapter commences with an abstract, offering a concise preview that sets the stage for the detailed content to follow. This approach effectively guides the reader through the complex research, making the thesis both accessible and engaging. In the methodology section, the thesis delves into intricate details, spanning from 3D model generation of existing buildings to the nuances of big data generation and data-driven methods. This depth not only underscores the thoroughness of the research but also provides a clear window into the sophisticated techniques employed.

The research context is explored extensively, addressing key aspects like financial supports, energy sources, and policies. This comprehensive background is crucial, as it lays a solid foundation for understanding the research's relevance and applicability in the real world. A significant portion of the thesis is devoted to examining the implications of climate change on building energy consumption, reflecting a holistic and forward-thinking approach to the subject. This inclusion demonstrates the author's awareness of the broader environmental context and its critical impact on the field of study. The innovative heart of the thesis is its focus on the application of data-driven methods, particularly machine learning algorithms. This section not only highlights the cutting-edge nature of the research but also showcases its practical implications, bridging the gap between theoretical concepts and real-world applications.

As the thesis nears its conclusion, it presents a detailed results chapter, followed by a comprehensive conclusion. This structure effectively highlights the research outcomes and their significance, ensuring that the findings are communicated in a clear and impactful manner. Moreover, the conclusion thoughtfully addresses potential future works and limitations, indicating a critical and honest appraisal of the research’s scope and avenues for further exploration. Overall, the well-crafted structure of the thesis enhances its readability and comprehension, reflecting the author's meticulous attention to detail and commitment to academic excellence.

Recommendations for Improvement:

While the thesis is highly commendable, there are a few areas where further enhancement could be beneficial:

- **Elaboration on Implementation in the Conclusion:** The conclusion could benefit from a more detailed discussion on the practical implementation of the research findings. This should include potential steps for integration, challenges, and the anticipated impact on retrofitting heritage buildings.
- **Concise Methodology Overview at the Start:** A brief summary of the methodology at the beginning would help set the stage for the thesis, offering readers a quick understanding of the research objectives, data sources, and expected outcomes.
- **Integration Potential in the First and Last Chapters:** The introductory and concluding chapters could explicitly detail how the model can be integrated into existing systems or processes. This would demonstrate the practical applicability of the research in current industry practices.
- **Simplified Technical Explanations:** Simplifying complex technical processes throughout the thesis would make it more accessible to a broader audience, including those without a deep technical background in data-driven models or computer vision.

Conclusion:

In every aspect of its execution, mgr inż. arch. Hassan Bazazzadeh's thesis stands as a paragon of academic and practical excellence in the field of sustainable heritage conservation. The depth of understanding, innovation, and practical insight demonstrated in this work not only meet but resoundingly surpass the stringent criteria set for a doctoral dissertation. This thesis is an exemplar of academic rigor, combining comprehensive research, methodological sophistication, and a clear commitment to practical application. The meticulous approach to integrating data-driven models with computer vision, tailored specifically for the retrofitting of historic buildings, showcases a remarkable level of innovation and foresight. This is not merely a testament to the candidate's mastery of the subject matter but also indicates a forward-thinking approach to solving complex, real-world problems. The way this thesis bridges the gap between traditional heritage conservation and modern energy efficiency is nothing short of revolutionary, setting a new benchmark in the field.

Moreover, the clarity and precision with which the findings are presented reflect a deep understanding of both the theoretical and practical implications of the research. The thesis goes beyond mere academic exploration, providing tangible solutions and strategies that can be directly applied in the field. This aspect of practical applicability is crucial in evaluating the merit of a doctoral dissertation, and in this regard, the thesis excels.

Furthermore, the insightful recommendations for future research directions and the careful consideration of the broader implications of the work demonstrate a level of scholarly maturity and vision that is exemplary for a PhD candidate. The thesis not only contributes valuable knowledge to the existing body of literature but also opens up new avenues for future exploration and development.

Therefore, considering the exceptional quality, innovative methodology, and significant practical contributions of this thesis, I firmly assert that it stands as a sterling example of what is expected

from a PhD dissertation. The work of mgr inż. arch. Hassan Bazazzadeh not only fulfills the requirements for a doctoral degree but does so in a manner that sets a high bar for future research in the field. It is with great confidence and without hesitation that I endorse this thesis as meeting the high standards required for the awarding of a PhD degree. This work is a commendable achievement, reflecting the highest ideals of academic scholarship and practical application in sustainable heritage conservation.

In conclusion, the doctoral dissertation submitted for evaluation fulfills the necessary standards and criteria. I request that it be considered for public defense at the Faculty of Architecture, Poznan University of Technology.

Rome, November 27th 2023

Prof. Davide Astiaso Garcia
Associate professor of Thermal Sciences, Energy Technology and Building Physics
Department of Planning, Design, and Technology of Architecture
Sapienza University of Rome