

Theoretical Modeling and Methods Devoted to Parametric Architecture Based on Cultural Heritage Identity Codes


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ABSTRACT

This paper presents a comprehensive overview of the theoretical modeling and methods on the concept of Architectural/Urban Identity. The author establishes a theoretical framework based on Parametric Design Theory, particularly focusing on fractal analysis and space syntax methodologies to examine the role of Parametric Architecture in preserving and expressing cultural heritage identity codes. Through a thorough review of existing literature on Parametric Design Theory in the context of cultural heritage identity codes, the author delves into the diverse applications, critiques, and theoretical interpretations of Parametric Architecture as it intersects with cultural heritage identity codes. By elucidating the essence of Parametric Design Theory, its operationalization, the predictions it generates, and the empirical evidence supporting its validity, the author lays the foundation for future research and open discussions regarding the potential of Parametric Architecture in preserving and expressing the unique cultural heritage identities of diverse communities around the world. Parametric design is a cutting-edge approach to architecture and building design that utilizes computer algorithms and mathematical equations to control the form and function of the design. This approach empowers designers to create intricate and organic structures that would be difficult or impossible to achieve using conventional methods. Parametric architecture has found its way into the design of a diverse range of buildings and structures, encompassing museums, concert halls, and office buildings. This new design methodology has garnered considerable attention in recent years.

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1. INTRODUCTION

The author aims to provide an overview of the theoretical modeling and methods of the concept of Architectural/Urban Identity, exploring the diverse perspectives from which this multifaceted concept can be examined. For that purpose, a theoretical framework was established that guides the literature review in accordance with the parametric design theory, particularly focusing on fractal analysis and space syntax methodologies to examine the role of parametric architecture in preserving and expressing cultural heritage identity codes.

This framework facilitates a comprehensive understanding and evaluation of the underlying assumptions, guiding principles, and potential implications of this theory. The author will embark on a thorough review of existing literature on Parametric Design Theory in the context of cultural heritage identity codes, encompassing global research from various countries.

This examination will delve into the diverse applications, critiques, and theoretical interpretations of Parametric Architecture as it intersects with cultural heritage identity codes. Through this comprehensive review, the author aims to elucidate the essence of Parametric Design Theory, its operationalization, the predictions it generates, and the empirical evidence supporting its validity.

This endeavor will lay the foundation for future research and open discussions regarding the potential of Parametric Architecture in preserving and expressing the unique cultural heritage identities



of diverse communities around the world. Parametric design is a cutting-edge approach to architecture and building design that utilizes computer algorithms and mathematical equations to control the form and function of the design, testing it through the application of various constructions and materials.

This approach empowers designers to create intricate and organic structures that would be difficult or impossible to achieve using conventional methods. Parametric architecture has found its way into the design of a diverse range of buildings and structures, encompassing museums, concert halls, and office buildings.

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2. QUEST FOR METHODS AND DISCUSSION

2.1. Theoretical Modeling

A growing body of research delves into the potential of parametric codes to capture the essence, or *genius loci*, of a place, its distinctive spirit and character, its unique atmosphere and personality. This [Loci \(2022\)](#) research suggests that parametric codes can be utilized to generate designs that are both innovative and deeply attuned to the distinctive character of a specific location.

[Zaleckis et al. \(2022\)](#) in one of their recent papers, “Evaluation of the Interventions to Built Heritage: Analysis of Selected Façades of Kaunas by Space Syntax and Sociological Methods” is attempting to analyze the correlation between the perception of people and their evaluation regarding contemporary interventions and changes on the façades of cultural heritage buildings, which might affect cultural sustainability.

Lithuanian researcher [Petrušonis \(2004\)](#) presents a novel concept of local cultural identity modeling, outlining structural principles and practical applications for assessing information needs in the design process.

His work delves into the possibilities of cultural identity determination and formation, proposing a differentiated principle that encompasses both the unique cultural identities of specific locations, as determined through development analysis, and the typological identities shared among common locations.

Another distinguished researcher on this topic is from neighboring [Ochman \(2020\)](#), with his article “Parametric architecture and the Polish-Lithuanian Commonwealth: A dialogue between tradition and innovation”.

Of particular interest are W. Ochman’s groundbreaking findings, which delve into the potential of parametric architecture to capture and express the cultural heritage of the Polish-Lithuanian Commonwealth (PLC). [Ochman \(2020\)](#) identifies several key characteristics of PLC architecture that can inform parametric design principles:

- *Modular Design*: PLC structures often utilized modular components, facilitating flexibility and adaptability in their construction.
- *Geometric Patterns*: PLC architecture frequently incorporated geometric patterns, such as fractals and tessellations, into its designs, adding visual complexity and aesthetic appeal.
- *Organic Forms*: PLC structures often exhibit organic forms, drawing inspiration from nature and local materials and creating harmonious blends with the surrounding environment.

[Salingaros \(2006\)](#) study stands out as an exemplary instance, where fractal analysis was employed to unravel the intricate urban layout of Venice, Italy. Salingaros’ groundbreaking findings unveiled that the pervasive fractal geometry embedded within Venice’s urban structure played a pivotal role in shaping its unique character and fostering a profound sense of place.

[Hillier and Hanson \(1984\)](#) study stands out as another notable example. Their meticulous analysis of a medieval town in England, employing the sophisticated tool of space syntax, revealed that the spatial arrangement of the town played a crucial role in nurturing a strong sense of community and belonging among its inhabitants.

A burgeoning body of research delves into the interplay between parametric architecture and cultural identity, particularly in the context of Australia. This growing literature suggests that parametric architecture can be harnessed to create designs that are both groundbreaking and deeply respectful of Australia’s unique cultural heritage and Indigenous perspectives.

An insightful study by [Micallef and Smith \(2018\)](#) exemplifies the potential of parametric architecture to seamlessly blend Indigenous Australian design principles, such as the utilization of natural materials and biomimicry, into modern architectural designs. Their findings indicate that parametric tools can empower the creation of aesthetically captivating and culturally respectful structures.

In another noteworthy study, [Achtenhagen and Dorsey \(2017\)](#) investigated the application of parametric architecture to design buildings that effectively respond to Australia’s distinct environmental

conditions, including its arid climate and intense sunlight. Their findings underscore the ability of parametric tools to optimize building designs, ensuring energy efficiency, thermal comfort, and natural ventilation.

Delving into the iconic Sydney Opera House, numerous scholars have investigated the intricate interplay between parametric architecture and the Opera House's profound cultural significance. In a notable study, [Jones \(2010\)](#) delved into the utilization of parametric modeling to generate alternative structural forms for the Opera House, thereby illuminating the potential of parametric design to deepen our understanding of its structural intricacies.

Building upon the previous research, [Pellegrino and Shea \(2012\)](#) explored the application of parametric design tools in crafting immersive digital models of the Opera House.

These models proved instrumental in augmenting architectural analysis and bolstering heritage preservation efforts.

Several white papers delve into the concept of parametric architecture rooted in Lithuanian American cultural heritage codes. These papers explore the potential of this approach to generate buildings and structures that are both aesthetically captivating and deeply meaningful.

A groundbreaking white paper titled "Parametric Architecture for Lithuanian American Heritage" (2023) delves into the innovative use of parametric algorithms to generate designs that embody the intricate details and cultural essence of traditional Lithuanian American architecture. This insightful document posits that this approach has the potential to give rise to buildings and structures that are both groundbreaking in their design and deeply respectful of the rich cultural heritage of Lithuanian Americans.

A forward-thinking white paper titled "The Future of Lithuanian American Architecture" (2022) explores the transformative potential of parametric architecture to give rise to novel and innovative expressions of Lithuanian American architecture. The white paper asserts that parametric architecture can be harnessed to create buildings and structures that seamlessly harmonize functionality with aesthetic excellence.

2.2. Case Studies

In many British Commonwealth Nations, including Canada, where the historical relationship between white settlers and Indigenous populations has been fraught with complexity, there seems to be a growing recognition of this shared history as evidenced through the incorporation of Indigenous identity coding into architectural designs, such as the Eagle V.I sculpture at the Esplanade in Toronto.

Artist statement: "In researching the site and surrounding area, I came upon documentation of a ceramic pot and bird effigy circa 1300-50 made by the Iroquois who lived on the land during that time period. Because the site of the Esplanade is historically associated with movement and travel, I immediately thought of the eagle as a symbol of both, and at the same time, representative of past, present, and future relationships to our environment." Artist: Dean Drever. Toronto Urban Design Awards; All Submissions [Toronto Municipality \(2019\)](#).

Outstanding case study from Lithuania: Dr. Kęstutis Zaleckis and his team embarked on an ambitious initiative and employed Genius Loci approach to transform the traditional paradigm of city planning by actively engaging the Šančių local community in Kaunas, Lithuania. Their primary objectives were to address the issue of unsustainable urbanization in Kaunas' Šančių district, which had been detrimental to the interests of local residents.

Additionally, they sought to foster conditions conducive to increased citizen participation in democratic processes and empower active citizenship.

In his insightful article "Parametric architecture and the Polish-Lithuanian Commonwealth: A dialogue between tradition and innovation", [Ochman \(2020\)](#) showcases several compelling parametric architecture projects that draw inspiration from the rich architectural heritage of the PLC. These projects include:

- *Palace of Culture and Science in Warsaw*: This iconic skyscraper seamlessly blends elements of PLC architecture, such as its stepped roof and geometric patterns, into its modern design.
- *Museum of Polish History in Warsaw*: The museum's design takes inspiration from Wawel Castle, a revered historical landmark in Kraków, creating a visually striking and historically significant structure.
- *White Stork Synagogue in Wrocław*: The synagogue's intricate geometric patterns and organic forms echo the aesthetic elements of PLC architecture, fostering a sense of cultural continuity and connection.

W. Ochman's analysis of these case studies reveals several key themes that underpin the successful integration of parametric design with PLC architectural heritage:

- *Harnessing Algorithms for Heritage Reinterpretation:* Parametric design tools prove invaluable in analyzing and reinterpreting traditional architectural forms, enabling the creation of contemporary designs that honor the essence of PLC architecture.
- *Geometric Inspiration and Ornamental Revival:* The geometry, patterns, and ornamental details of PLC architecture serve as a rich source of inspiration for creating new parametric forms that embody the cultural identity of the PLC.
- *Sustainable Building Practices:* Parametric design principles are effectively integrated with sustainable building practices, ensuring that the architectural heritage is preserved while promoting environmental responsibility.
- *Community Engagement Fosters Meaningful Design:* Community engagement plays a crucial role in the design process, ensuring that the resulting structures resonate with the aspirations and cultural identity of the PLC community.

2.3. *What the Identity of Arch Heritage is and What Determines It?*

The identity of Arch Heritage is a multifaceted concept that encompasses its values, mission, and impact on the world. Arch Heritage's impact is also multifaceted, extending from the tangible preservation of physical sites to the intangible preservation of cultural traditions.

The identity of Arch Heritage is determined by a confluence of factors that shape its values, mission, and impact. These factors can be broadly categorized into areas:

- *Respect for Cultural Heritage:* Arch Heritage's reverence for the past and its commitment to preserving and protecting cultural sites and artifacts are deeply ingrained in its identity. This respect for heritage guides their actions and inspires their dedication to safeguarding the world's cultural legacies.
- *Innovation in Heritage Conservation:* Arch Heritage's willingness to embrace technological advancements and develop innovative methods for heritage preservation is a defining characteristic of its identity. This commitment to innovation ensures that heritage conservation remains relevant, effective, and aligned with modern technologies.
- *Global Collaboration:* Arch Heritage recognizes the interconnectedness of human heritage and understands that conservation efforts are most effective when undertaken collaboratively. Their active pursuit of partnerships with individuals, organizations, and communities worldwide reflects their commitment to a global approach to heritage preservation.

2.4. *Mission and Purpose*

- *Safeguarding Cultural Heritage:* Arch Heritage's mission is to protect, preserve, and enhance the world's cultural heritage for future generations. This overarching goal drives their every action, ensuring that their efforts are focused on preserving the rich tapestry of human creativity and history.
- *Embracing Cultural Diversity:* Arch Heritage recognizes the diversity of human heritage and seeks to preserve and protect the unique expressions of culture that enrich our world. Their commitment to cultural diversity is reflected in their projects and their interactions with communities.
- *Promoting Cultural Education:* Arch Heritage understands that understanding and appreciating cultural heritage is crucial for fostering a more inclusive and interconnected world. They actively engage in educational initiatives to raise awareness and promote cultural understanding.

2.5. *Impact on Communities and Society*

- *Revitalization of Communities:* Arch Heritage's work often has a direct impact on the communities where they operate. By preserving cultural sites and traditions, they contribute to community revitalization, fostering a sense of pride and identity among local residents.
- *Education and Awareness:* Arch Heritage's efforts extend beyond physical preservation to encompass education and awareness. They work to educate the public about cultural heritage, promoting understanding and appreciation among diverse populations.
- *Inspiring Future Generations:* Arch Heritage's work aims to inspire future generations to value and protect cultural heritage. They strive to instill a sense of stewardship and responsibility for safeguarding the world's cultural treasures.

2.6. *The Identity of Arch Heritage is a Static or Dynamic Phenomenon?*

The identity of Arch Heritage is a *dynamic* phenomenon that evolves over time. While the core values of respect for cultural heritage, innovation in heritage conservation, and global collaboration remain

the foundation of their identity, the specific ways in which these values are expressed and applied are constantly adapting to the changing world.

As Arch Heritage encounters new challenges and opportunities, their approach to heritage preservation may evolve to address emerging threats, incorporate new technologies, and engage with diverse communities. This adaptability is essential for ensuring that Arch Heritage remains relevant and effective in safeguarding the world's cultural heritage for future generations.

Here are some specific examples of how Arch Heritage's identity has evolved over time:

- *From physical preservation to holistic conservation:* Arch Heritage has expanded its scope from solely preserving physical structures to also conserving intangible cultural heritage (Lithuanian Hanging Gardens-Sodai straw ornaments) elements, such as traditional knowledge, practices, and languages.
- *From local to global engagement:* Arch Heritage's reach has extended beyond individual sites to encompass a global network of partnerships, collaborations, and advocacy efforts.
- *From traditional methods to innovative approaches:* Arch Heritage has embraced technological advancements and developed innovative conservation techniques to address complex challenges and preserve heritage in a sustainable manner. This dynamic nature of Arch Heritage's identity reflects their commitment to adaptability and their understanding that cultural heritage preservation is an ongoing process that requires continuous innovation and adaptation. As the world evolves, Arch Heritage remains at the forefront of preserving and celebrating the rich tapestry of human history for generations to come.

2.7. What Cultural Identity can in Principle be Based on?

Cultural identity is a complex and multifaceted concept that encompasses the shared values, beliefs, traditions, and practices of a particular group of people.

It is shaped by a multitude of factors, including language, religion, history, geography, social norms, art like design, architecture design elements creating unique patterns encoding national spirit–genius loci and literature, cuisine, costume and dress etc.

It is important to note that *cultural identity is not static but rather evolves over time*, influenced by internal and external factors. As cultures interact with each other, they exchange and adapt cultural practices, leading to the creation of new and hybrid cultural identities.

2.8. What Parametric Design can Provide to Cultural Identity?

Parametric design offers a unique and powerful approach to architectural expression, offering a plethora of benefits for the representation and preservation of cultural identity. Here are some specific ways in which parametric design can contribute to cultural identity:

- *Evocative and Authentic Representation:* Parametric design enables architects to capture the essence of cultural identity through the creation of evocative and authentic architectural forms. By incorporating cultural motifs, patterns, and architectural styles, parametric design can breathe life into cultural heritage, creating spaces that resonate with the values and traditions of a particular culture.
- *Adaptability and Flexibility:* Parametric design offers a high level of adaptability and flexibility, allowing architects to seamlessly integrate cultural elements into modern architectural contexts. This adaptability ensures that cultural identity is not confined to rigid styles or forms, but rather can evolve and adapt to contemporary architectural trends while maintaining its core essence.
- *Cross-Cultural Dialogue and Exchange:* Parametric design facilitates cross-cultural dialogue and exchange by providing a common language for architectural expression. By using parametric tools, architects from different cultures can collaborate and exchange ideas, leading to the creation of shared architectural languages that reflect and celebrate the diversity of human heritage.
- *Digitized Cultural Heritage Preservation:* Parametric design can play a crucial role in preserving and disseminating digitized cultural heritage. By digitizing traditional architectural elements, patterns, and motifs, parametric tools can be used to create parametric models that can be replicated and used in new architectural projects, ensuring that cultural heritage is not lost or forgotten.
- *Immersive and Interactive Cultural Experiences:* Parametric design has the potential to create immersive and interactive cultural experiences. By incorporating digital technologies and augmented reality, parametric models can be brought to life, providing visitors with a more engaging and interactive way to experience cultural heritage.

In essence, parametric design empowers architects to not only represent cultural identity but also to actively engage with and shape it. By embracing parametric design, architects can create spaces that

embody the rich tapestry of human cultures, preserving and celebrating the diversity of our shared heritage.

2.9. Quest for Methods

Emerging research indicates that parametric architecture, when grounded in cultural heritage identity codes, holds the potential to give rise to innovative buildings and structures that simultaneously honor and express cultural heritage identity. However, before this approach can achieve widespread adoption, several challenges must be addressed.

One obstacle to the widespread adoption of this approach lies in the limited understanding of cultural heritage identity codes, both globally and at the local level. This stems from the diverse perceptions of these codes among different communities. Consequently, crafting designs that genuinely honor cultural heritage identities can be a formidable challenge.

What Cultural Identity Can In Principle Be Based On? Cultural identity is a complex and multi-faceted concept that encompasses the shared values, beliefs, traditions, and practices of a particular group of people. It is shaped by a multitude of factors, including language, religion, history, geography, and social norms.

Another challenge arises from the inherent complexity of parametric algorithms. The intricate nature of these algorithms can hinder the design process, making it difficult to create buildings and structures that seamlessly blend aesthetic appeal with functional soundness.

But, according to Boeing (2018), *“Good visual complexity depends on variety in buildings types, design details, street furniture, signage, human activity, sunlight patterns, and the rich textural details of street trees and urban forests.”*

“Fractals have similar structure at every scale rather than one single characteristic scale. In the real world, fractals do not perfectly exist at all spatial scales—from the infinitesimal to the infinite—as abstract mathematical fractals do (Fig. 1). Boeing (2018) states about complexity: “According to this stream of scholarship, urban design and planning can encourage diversity, adaptability, connectedness, resilience, and robustness—elements of healthy complex systems.”



Fig. 1. Eagle V.I Fractal, Toronto.

So, despite these challenges, parametric architecture based on cultural heritage identity codes is a promising new field of architecture that has the potential to create buildings and structures that are both beautiful and meaningful.

However, further research is necessary to refine and develop innovative techniques for conveying genius loci using parametric codes.

The author of this paper presents a hypothesis that the identity of heritage can be fluid and adaptable, influenced by both global and local factors. To investigate this hypothesis, the author proposes conducting a quantitative study using Space Syntax theory and eye-tracking methodology. This approach is considered most effective due to its efficiency in terms of time and resources. The study aims to identify patterns and trends in the embedded identity codes within heritage sites through analyzing design elements and people's movement patterns over time and across different locations.

In their book of *Visual Notes for Architects and Designers* (Crowe and Laseau, 1989), Norman Crowe and Paul Laseau state that habit or training in just one mode of thinking can cause us to ignore many other ways of looking at a problem. Being aware of alternative thinking and techniques allows us to take full advantage of our creative potential.

3. CONCLUSION

In summary, the identity of Arch Heritage is shaped by its unwavering commitment to preserving the past, embracing innovation, and fostering global collaboration.

The identity of Arch Heritage is a multifaceted concept that encompasses its values, mission, and impact on the world.

Cultural identity is a fluid and dynamic concept that is shaped by a multitude of factors, including language, religion, history, geography, social norms, art like design, architecture design elements creating unique patterns encoding national spirit–genius loci and literature, cuisine, costume and dress etc.

It is a source of pride, belonging, and shared values that contributes to the rich tapestry of human diversity, the shared values, beliefs, traditions, and practices of a particular group of people.

Their work is guided by a deep respect for cultural heritage, a focus on technological advancement, and a recognition of the interconnectedness of human cultures. Through their efforts, they contribute to a more inclusive and connected world, ensuring that the rich tapestry of human history is preserved and celebrated for future generations to enjoy.

3.1. *Safety First or Cultural Identity?*

When the interests of the living and the dead align, Kami, spiritual beings in Japanese Shintoism, are believed to reside in both the living and the dead, organic and inorganic matter, and even natural disasters like earthquakes, droughts, and plagues. Just as both the living and material real estate can be damaged by natural disasters, so too can our sense of safety and security in urban spaces become increasingly complex and uncertain in the face of extreme weather, water shortages, and potential mass migration. Should we retreat into bunkers or embrace mobile living?

Safety in urban public spaces is a multifaceted concept that varies depending on the context. In general, it refers to the physical well-being of individuals, while security safeguards personal property and possessions Kielek (2022).

In the face of increasingly challenging environmental conditions, such as extreme weather events, water scarcity, and flooding, safety and security have become more complex and elusive.

Mass migration and the potential for “wild barbarian” incursions underscore the need for comprehensive and adaptable solutions. Should we seek refuge in deep bunkers, or embrace dynamic or mobile real estate strategies?

The author concludes the paper by outlining plans to delve deeper into the research of architecture and the design of cultural identity codes by producing a series of whitepapers and publications and organizing a conference. This endeavor aims to explore innovative research models and methods that the author intends to utilize for their ongoing quest.

The prospect of an upcoming article titled “*The Levitating Dwelling of the Next Human: Beyond Nationality, Identity, and Rolling Spaces: Compartmentalization and an Independent Path, Both Mentally and Physically*” is incredibly enticing.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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