

A Grounded Theory Towards Intangible Architecture, A Systematic Review and Meta-analysis

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Abstract

Intangible Architecture, defined as architecture without physical materials, has recently emerged and is gaining widespread adoption among architectural designers. However, a systematic and comprehensive introduction to this concept is currently lacking. Given its increasing prevalence, a clear definition of its characteristics and dimensions is essential. This study addresses this need through a systematic review employing both quantitative and qualitative approaches. Covering literature up to December 2024, the review identified 56 unique elements pertaining to intangible architecture. These elements were then used to develop a grounded theory, formally titled "Intangible Architecture." The findings indicate that Intangible Architecture offers solutions to the limitations of Tangible Architecture and serves to complement it across various fields, including tourism, Building Information Modeling (BIM), architectural experimentation, the entertainment industry, and education.

Keywords: Virtual Reality, Immaterial Architecture, Cinema Decoration, Game Design

CCS Concepts

• Applied computing → Arts and humanities; • Computing methodologies → Knowledge representation and reasoning;

1. Introduction

1.1 Significance

Today, technological advancements have created the conditions necessary for integrating digital sciences with other fields, including architecture. This process accelerated further after the coronavirus pandemic, as extended periods of quarantine and remote living brought the future closer through virtual technologies, significantly increasing the relevance of the interdisciplinary connection between architecture and virtual media. Traditionally, architecture has always been material in nature. However, in its emerging form—enabled by virtual environments—it no longer relies on physical substances. Although this new form of architecture has become increasingly widespread, it remains poorly understood in academic literature, and existing studies have yet to be systematically categorized. Identifying the defining features of this phenomenon—as well as its potentials and limitations—can contribute to the development of theoretical frameworks and support its evolution and more informed application.

According to the Oxford Dictionary, architecture is defined as a general term referring to buildings and other structures

characterized by material presence [Oid02]. Ludwig Mies van der Rohe famously remarked, "Architecture begins when you carefully place one brick next to another." Likewise, the celebrated 20th-century architect Le Corbusier observed, "You use stone, wood, and concrete to build houses and palaces—that is construction. But suddenly, you touch my heart, you do me good, and I say: this is beautiful. That is architecture" [Cor85]. Accordingly, both of these influential modernist architects viewed architecture as the creative transformation of physical materials. This perspective reinforces the widespread belief that architecture must inherently involve tangible substance. In contrast, the present study explores a newly emerging architectural form that exists independently of material construction, yet remains impactful in contemporary human experience. The earliest formal definition of architecture was introduced in the treatise *De Architectura* in the first century A.D. by the Roman architect Vitruvius. According to Vitruvius, a well-designed building embodies *firmitas* (durability), *utilitas* (functionality), and *venustas* (beauty) [RHD99]. Although ancient, this definition makes no reference to physical materials and aligns remarkably well with the principles of intangible architecture—a phenomenon that has only recently begun to emerge.

1.2 Related works:

Loureiro, Guerreiro, and Ali (2020) conducted a comprehensive review of two decades of research on virtual reality (VR) and augmented reality (AR) in the context of architectural tourism. Utilizing citation network analysis alongside text mining techniques, they examined the full texts of 56 journal articles and 325 conference papers. Their analysis led to the identification of ten primary thematic categories within the journal literature and eleven within the conference proceedings. The study revealed two defining characteristics of virtual tools used in architectural tourism:

- their progressive nature, reflecting ongoing technological advancement, and
- their high potential for integration with emerging scientific disciplines [LGA20].

Wang et al. (2018) conducted a critical review of virtual reality (VR) applications in construction engineering education and training (CEET) by analyzing publications from 20 relevant journals spanning the period from 1997 to 2017. Their study highlighted the evolution of VR technologies in CEET, ranging from desktop-based and immersive VR systems to 3D game-based platforms and advanced VR capable of integrating Building Information Modeling (BIM) data.

In a related line of research, other scholars have critically evaluated the applications of VR and augmented reality (AR) in construction safety. These evaluations aimed to identify key challenges, explore current limitations, and propose potential enhancements for improving the effectiveness of these technologies in real-world safety scenarios [Wan18].

X. Li et al. (2018) synthesized research findings from a broad array of scientific journals, examining various VR and AR prototypes, commercial products, educational frameworks, and corresponding evaluation methods. Their study produced a comprehensive classification system encompassing the technological features of VR/AR, practical application domains, typical safety scenarios, and assessment techniques. The authors identified and elaborated on several functionalities of these technologies that contribute to enhanced construction safety—such as risk detection, safety training, instructional guidance, and safety inspections [Xli18].

1.3 The current gap:

Despite shedding light on several key aspects of this emerging architectural paradigm, the body of existing research still reveals three significant gaps. First, the studies have largely been conducted in isolation, lacking cross-referencing or mutual influence. Second, they fail to encompass the full spectrum of dimensions associated with this expansive and multifaceted field. Third, none of the investigations have systematically identified its core characteristics in a manner conducive to the development of a grounded theory.

1.4 Aim of this study:

In this study, an effort was made to capture the broadest possible range of relevant literature by employing an extensive set of keywords across two major academic databases: Scopus and Web of Science. In addition, the research aimed to incorporate insights and findings from previous related studies to enrich the

analysis. Following the systematic review protocol and the PRISMA methodology, 56 distinct elements associated with this architectural paradigm were identified. These elements were treated as independent variables, while the core concept and definition of intangible architecture were considered the dependent variable. Through analyzing the interrelations among these variables and synthesizing them along shared thematic axes, a grounded theory was formulated—one that defines this emerging form of architecture and articulates its multiple dimensions.

2 Materials and methods

To develop a comprehensive set of initial keywords, the study employed a multi-step approach. In addition to reviewing relevant literature, interviews were conducted with experts in the field of architecture. An online questionnaire was also designed and distributed to 28 postgraduate students via email and LinkedIn. Furthermore, additional questionnaires were sent to the authors of previously reviewed papers. The objective of this survey was to gather informed opinions and analyze the collected responses to identify the most suitable keywords for conducting database searches. A total of 42 responses were received, resulting in the identification of seven primary keywords. Table1

Table1 : List of primary keywords based on consultation with experts.

	keywords
1	VR Architecture
2	immaterial Architecture
3	AR Architecture
4	immaterial Design
5	Architecture for games
6	Architecture and Cinema
7	Architecture and animation

An initial keyword search was conducted on the Scopus and Web of Science platforms. To ensure relevance, papers from unrelated fields such as medicine and chemistry were excluded. From the remaining literature, keywords were extracted, resulting in a refined list of 729 terms. These keywords were then analyzed using Excel to identify the most frequently occurring terms, which were

subsequently integrated with the previously established initial keywords to form a comprehensive keyword set. Figure 1

by limiting the scope to categories relevant to the concept of intangible architecture and restricting the document types to journal articles, conference proceedings, book chapters, and

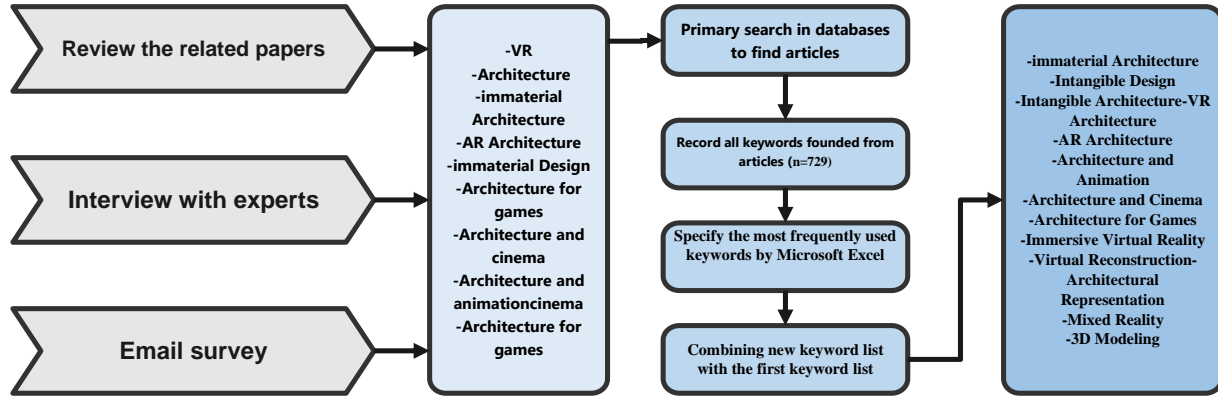


Figure 1: The process of getting from initial keywords to final keywords.

The finalized set of keywords was re-applied to the Scopus and Web of Science databases to conduct a comprehensive literature search. This initial search yielded 17,850 results in Scopus and 10,006 in Web of Science. For consistency and comparability, only these two platforms were considered. The results were then refined

review articles. This filtering reduced the number of records to 3,888 in Scopus and 1,163 in Web of Science. After importing all abstracts into Mendeley reference management software and eliminating duplicate entries, a final set of 4,488 unique papers was obtained. For the qualitative phase of the study, the most highly cited papers related to intangible architecture were identified.

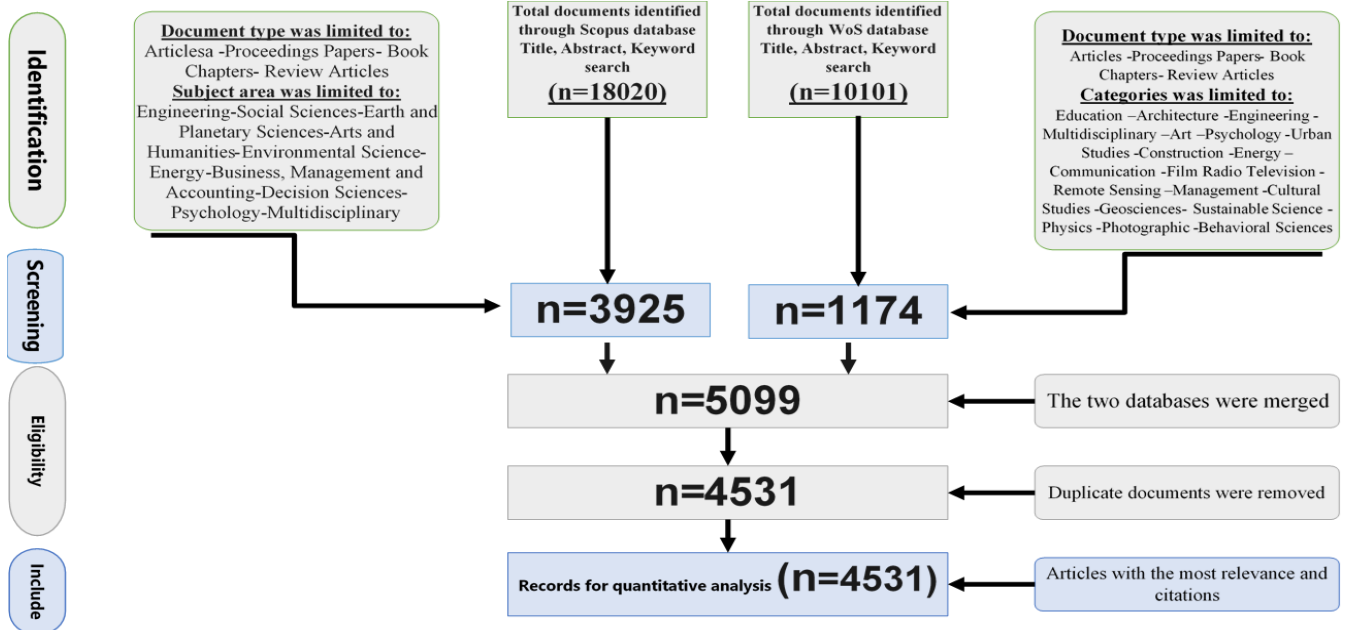


Figure 2: The process of searching articles in two platforms, Web of Science and Scopus, based on the Prisma method

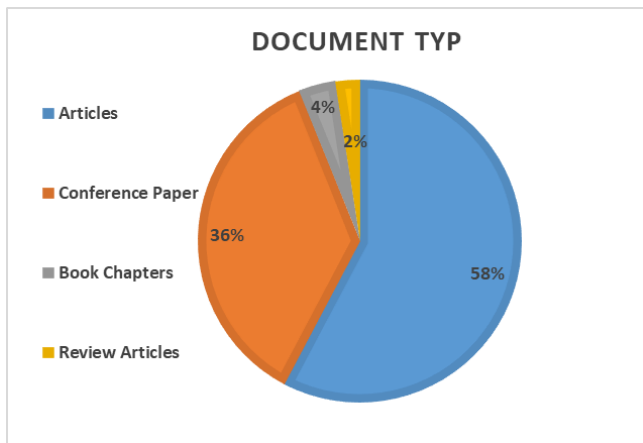


Figure 5: Analysis of the type of published documents

3.1.4 Countries analysis

In the analyzed set of 5,051 publications, corresponding authors are affiliated with institutions in 96 countries, as illustrated in Figure 6. The map uses a gradient of blue to represent publication density, with darker shades indicating a higher number of articles. As shown, the United States accounts for the largest share of publications, followed by China. In contrast, most countries across the African continent have contributed relatively few publications to the field.

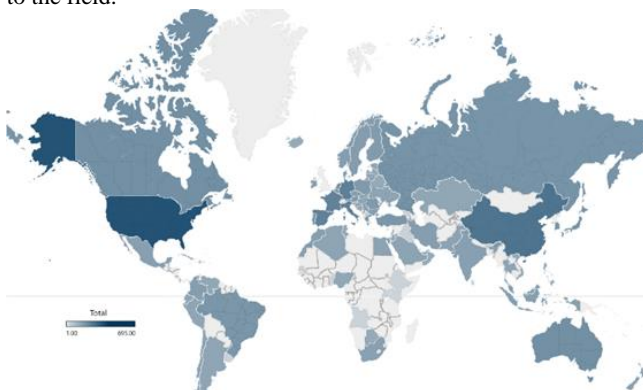


Figure 6: Frequency of publishing articles in countries

Table 2, lists the ten countries with the highest number of publications in the field. The presence of countries with diverse languages in close succession suggests active competition to localize and adapt multimedia technologies within architectural practice. These top contributors include nations from North America, Europe, China, and Australia.

Table 2: List of ten countries with the highest number of article production

	COUNTRY	Scopus	WoS	Total	Percentage
1	United States	703	215	918	18%
2	China	427	135	562	11%
3	Germany	277	77	354	7%
4	Italy	275	81	354	7%
5	United Kingdom	272	76	354	7%
6	Spain	271	77	354	7%
7	France	234	69	303	6%
8	Canada	154	48	202	4%
9	Australia	151	46	202	4%
10	Netherlands	114	34	151	3%

3.1.5 Research area analysis

Figure 7, illustrates the various domains contributing to research on virtual architecture. The highest concentration of publications originates from engineering, social sciences, earth sciences, and the arts, underscoring the interdisciplinary nature of the field. While the integration of virtual architecture with computer science remains essential, its relevance also extends to social, environmental, and artistic contexts.

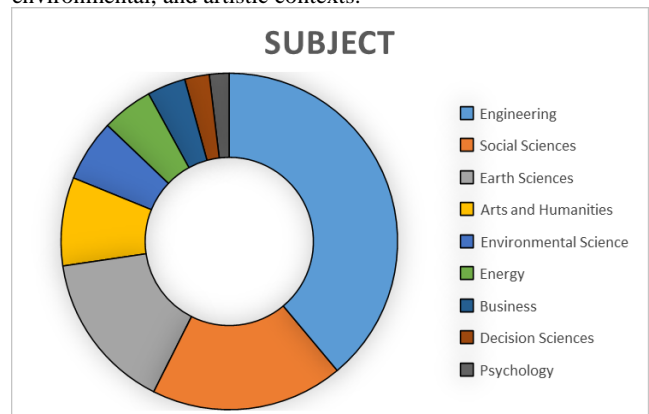


Figure 7: Research area analysis

3.2 Qualitative analysis

Investigation of the seven themes and extraction of intangible architecture features from each paper:

3.2.1 The intangible architecture features with regard to BIM

Anton et al. (2018) examined the importance of documentation through as-built three-dimensional scans of cultural heritage sites in the context of historical Building Information Modeling (HBIM). Their research focused on the challenge of converting point cloud data into an accurate BIM model, using the Pavilion of Charles V in Seville, Spain, as a case study.

The process was carried out in three stages:

- (a) optical and terrestrial laser scanning,
- (b) meshing procedures, and
- (c) 3D solid modeling, which was subsequently integrated into the HBIM environment.

Executing these three stages significantly improved the accuracy of the resulting 3D models using available BIM technologies. The

capability of digital 3D modeling and the potential for seamless assembly within HBIM enabled a more precise representation of historical structures in BIM software [Ant18].

Martínez-Carricondo et al. (2020) utilized unmanned aerial vehicle (UAV) photogrammetry as an alternative to terrestrial laser scanning (TLS) in the development of HBIM models for historical buildings in a state of ruin. As a case study, they examined the Cortijo del Fraile, a deteriorated historical structure. Through a structured modeling process, they developed an HBIM representation and ultimately produced a photorealistic output aimed at the documentation, archiving, and digital preservation of the site.

Two key features of intangible architecture were central to the progress of this research:

- 1) The ability to virtually integrate BIM digital models with aerial imagery for accurate documentation of architectural remains; and
- 2) The use of BIM's virtual capabilities for the digital reconstruction and completion of partially destroyed monuments [Mar20].

Alizadehsalehi, Hadavi, and Huang (2020) highlighted Building Information Modeling (BIM) as a digital information management system representing one of the most significant and promising innovations in the architecture, engineering, and construction (AEC) industry. However, they noted a common limitation of BIM: the inability to convey information in a way that users can intuitively perceive at real-world scale. In their study, they examined the process of transferring a 3D BIM model of the NASA Mars Habitat—from Revit 2019 into an augmented reality (AR) environment. Their findings suggested that the integration of virtual reality technologies into the AEC industry can result in four major benefits:

reduced rework, enhanced safety, lower labor costs, and improved adherence to project deadlines [AHH20].

Osello, Lucibello, and Morgagni (2018) emphasized that intangible architecture presents an opportunity to integrate digital media with BIM software for the preservation of global heritage. To explore this potential, they selected a historic castle in the Piedmont region near the city of Turin, Italy, as a case study. Their research demonstrated that combining digital media with BIM, in the context of heritage conservation, is an effective strategy for managing and accessing architectural information. This approach leverages advanced visualization technologies based on augmented and virtual reality (AR and VR) to enhance both preservation and public engagement [OLM18].

Natephra et al. (2017) identified a key limitation in Building Information Modeling (BIM): its lack of an interactive interface between users and the design environment. This disconnect can lead to misinterpretations by designers, particularly concerning the relationship between lighting design and energy performance feedback. To address this issue, the researchers simulated a BIM-designed building using the Unreal Engine to explore how users might perceive environmental lighting in an interactive virtual setting. The integration involved transferring the geometric data of building elements, along with their reference IDs, from Revit to Unreal Engine. The BIM geometry was then converted into static mesh formats using 3ds Max. The study concluded that

incorporating digital architectural models into the BIM process significantly enhances user immersion and interactivity, broadening the functional scope of BIM environments [Nat17].

Lu, Yao et al. (2024) identified a key barrier to the widespread adoption of augmented reality (AR) in the construction industry: the underestimation of its functional capabilities. They argued that most existing simulation systems operate as standalone platforms, lacking integration with Building Information Modeling (BIM) tools. To address this limitation, the researchers sought to establish an online connection between BIM and AR, further linking this integration to widely used social networking service (SNS) applications. Using the Mansion of Shanghai Center as a case study, they developed an AR system that facilitated real-time interaction between BIM data, end-users, and AR environments through SNS platforms. The study ultimately proposed that connecting AR to cloud-based and online infrastructures could serve as a viable strategy for overcoming the current disconnection between simulation technologies and BIM workflows [LHL24].

Table 3 presents seven features of intangible architecture with regards to BIM.

Table 3: Intangible architecture features with regards to BIM

No.	Features
1	Possibility of assembling building forms
2	Linking BIM to photogrammetry
3	Possibility of hypothetical reconstruction of ruined historical monuments
4	Understanding architecture in real scale for customer in the BIM environment
5	Possibility of linking BIM maps to digital media
6	Adding a large level of immersion to the BIM environment
7	Possibility of linking BIM maps to cloud and online environment

3.2.2 The process of perception for audiences in the world of intangible architecture

Mouratidis and Hassan (2020) examined the sensory perception of public spaces using 360-degree video technology delivered through a mobile-based virtual reality (VR) platform. They designed a questionnaire to assess participants' experiences within these immersive environments. The study found that the combination of 360-degree and VR video technologies significantly enhanced users' sense of immersion in the virtual setting, while simultaneously reducing their engagement with the physical world. The researchers concluded that sensory perception in such VR environments is more vivid and reliable than that elicited by conventional static images. The capacity for deep immersion and detachment from external stimuli—an inherent feature of VR-based architecture—was shown to significantly heighten both sensory and emotional perception. [MH20].

F. Abd-Alhamid et al. (2019) conducted a comparative study between a real office environment and its virtual simulation, both designed to have identical physical and lighting conditions. Twenty participants (N = 20) took part in the experiment, which assessed both subjective and objective visual responses, as well as their interactions with the virtual environment. The study focused on measuring the sense of perceived presence—a key indicator of immersion in virtual settings. The findings revealed no statistically significant difference between the real and simulated environments in terms of perceived presence, suggesting that well-constructed

virtual spaces can elicit comparable experiential responses to those of real-world settings [Abd19].

Weber, Weibel, and Mast (2021) demonstrated that the experience of presence within a simulated environment is influenced not only by the user's sense of spatial placement but also by the degree of interactivity offered by the environment itself. This interactive dimension is particularly critical in contexts such as video games and virtual reality (VR) applications. Their findings suggest that in the realm of intangible architecture, the ability to interact with and modify the virtual space significantly enhances the user's sense of presence, making the experience more immersive and cognitively engaging [WWM21].

Cha et al. (2019) conducted a study aimed at evaluating spatial perception within immersive virtual environments. They designed four distinct virtual settings that varied in ceiling height and ceiling type. Within these environments, participants' emotional responses, room evaluations, perceived presence, and spatial perception were assessed. The results demonstrated that participants were able to distinguish key spatial features across the different scenarios. Notably, changes in ceiling height and type elicited distinct emotional and evaluative responses, suggesting a high level of perceptual sensitivity within the virtual settings. The study ultimately concluded that spatial perception in immersive virtual environments closely mirrors that of real-world conditions [Cha19].

Lindquist et al. (2020) conducted an experimental study in which participants were exposed to digital animations presented through both conventional screens and virtual reality (VR) head-mounted displays under three distinct auditory conditions: no sound, ambient sound, and detailed sound. The findings revealed that the incorporation of realistic sound significantly enhanced the sense of perceived realism within the VR environment. Specifically, the ability to integrate various types of ambient audio into virtual spaces was shown to heighten the perceived authenticity of both animated and VR experiences [Lin20].

Pang et al. (2019) proposed a method aimed at minimizing latency during periods of high user demand in multi-viewpoint (MVP) 360° interactive video systems. Their approach was designed to enhance the responsiveness of these systems, thereby improving the overall user experience. By reducing delay, the system allowed for smoother transitions and interactions within the immersive environment, ultimately contributing to a more engaging and interactive virtual experience [Pan19].

Nesrine (2022) explored how variations in lighting intensity within a virtual church—modeled using Rhino 3D and Unity 3D software—affected participants' spiritual perception during their immersive experience [Man22].

Table 4 presents six features of the intangible architecture with regard to the audience perception process.

Table 4: Intangible architectural features to create perception for audiences

No.	Features
1	Enhancing sensory perception in immersion environment due to removal of other stimuli
2	Perceived presence in intangible architecture is not less than in tangible architecture
3	The interactivity in virtual environment causes enhanced sense of occurrence of presence.
4	Spatial perceptions in comprehensive virtual environments are similar to the real world.
5	The possibility of combining environmental sound with virtual environment leads to enhanced perceived reality in it.
6	Establishing a greater sense of spirituality through changing the architectural elements of holy sites in virtual environments

3.2.3 Application of intangible architecture for conducting architectural tests

Mossberg, Nilsson, and Wahlqvist (2021) conducted a study using a virtual reality (VR) model of a deep underground metro station to examine the impact of different evacuation strategies on elevator usage during emergencies. Four distinct scenarios were tested: a baseline condition, a scenario featuring enhanced guidance systems (such as more informative voice alarms and flashing green lights), a scenario utilizing smartphone-based guidance, and one with countdown timers displayed above the elevators. The findings indicated that the design of the evacuation system significantly influenced elevator usage, with more informative guidance systems leading to increased utilization.

The study also highlighted the advantages of VR as an experimental tool in the construction industry—particularly in contexts where real-world testing is impractical due to logistical or safety constraints. VR enables the simulation of various scenarios without the need for physical infrastructure, facilitates the use of repeated human participants in crossover study designs, reduces the time and cost of experimentation, and allows for greater control by eliminating many confounding variables typically present in real environments [MNW21].

Yeom, Kim, and Hong (2021) investigated the impact of green walls on stress reduction within indoor environments. To conduct this study, they created immersive experimental scenarios using virtual reality in which green walls of varying sizes were digitally installed. Participants' stress levels were then measured based on heart rate and electrodermal activity as their surroundings transitioned from no green wall, to a small green wall, and finally to a large green wall. The results indicated that the small green wall had a significant calming effect, whereas the large green wall, somewhat unexpectedly, led to increased stress levels among occupants.

In light of the COVID-19 outbreak and the urgent need to study enclosed indoor and quarantine spaces, the use of virtual reality in this research proved especially valuable for saving time and facilitating controlled experimentation. Moreover, because the testing could be conducted outside actual buildings and within laboratory settings, this method allowed for integration with medical and physiological monitoring equipment [YKH21].

Jiao et al. (2019) employed virtual reality to explore how modifications in interior design—such as color tone, window arrangement, and artificial lighting—can influence occupants' psychological perception of thermal comfort. By measuring participants' subjective sense of heat, they demonstrated that such environmental changes could alter perceived temperature by up to 3°C. The flexibility of the virtual experimentation platform

enabled the researchers to test a wide range of spatial configurations and environmental combinations efficiently [Jia19].

Flor et al. (2021) investigated visual perception and emotional responses to ETFE double-skin façades by comparing three variations of ETFE cushions—clear, fritted, and switchable—with a traditional single-skin façade featuring double-glazed windows. Virtual reality was employed as the primary research tool to simulate these façade conditions. Using physically based rendering techniques, the researchers replicated identical physical and lighting conditions from an administrative interior in a virtual environment. A group of 22 participants ($N = 22$) experienced the space through a virtual reality headset and completed a questionnaire designed to assess their perceptions, judgments, and emotional responses.

The study utilized VR and physically accurate imaging to evaluate user experience related to window views in a space outfitted with pneumatic ETFE cushions as a second-skin façade. The findings revealed a clear preference for the transparency of the clear ETFE cushions, while fritted and switchable versions received lower satisfaction ratings. Nevertheless, the original double-glazing system was preferred across all measured parameters.

Virtual reality proved particularly effective for this experiment, as it allowed researchers to investigate the perceptual effects of architectural features without introducing confounding variables—such as changes in sunlight angle—while still enabling immersive testing of various independent conditions in a controlled environment [Flo21].

Fedora Abd-Alhamid et al. (2020) evaluated view perception using a physically based 360° virtual environment delivered through a VR headset across three observational distances: near, mid-range, and far. The study was conducted under controlled lighting conditions to assess both subjective impressions and physiological responses within a simulated administrative space. The virtual office environment was modeled after a real setting in the Energy Technology Building at the University of Nottingham (UK), designed to incorporate both natural and artificial lighting.

The researchers noted that the virtual environment offered several advantages over a physical test room. In particular, the ability to control external window conditions—such as light levels and imagery—enabled a more consistent and reliable testing experience. Additionally, the development and manipulation of independent variables within the VR platform proved to be both cost-effective and time-efficient [Fed20].

Reto et al. (2017) aimed to create realistic visualizations from the pedestrian's perspective by generating highly accurate three-dimensional renderings of real urban environments. To enhance the realism of the simulation, they integrated 3D-recorded ambient sound captured from the actual location. This combination of visual and auditory elements within the virtual environment enabled a more immersive experience. As a result, the researchers were able to gain reliable insights into how people might perceive and respond to proposed urban developments prior to their physical construction [Spi17].

Table 5 reports 10 applications of intangible architecture for conducting architectural tests.

Table 5: Intangible architectural features for conducting architectural experiments

No.	Features
1	Possibility of testing various states and scenarios
2	Possibility of applying repeated humans in a cross-over study
3	Possibility of tests in sensitive and forbidden environments
4	Reducing the time and costs of experiments
5	Eliminating many common confounding variables in the real environment
6	Rapid test of immediate architectural experiments such as the one during COVID-19 pandemic
7	Possibility of combination with medical laboratory instruments
8	Possibility of testing at various predetermined times of the day
9	Possibility of testing various independent variables
10	Possibility of testing the psychological effect of future urban development on citizens before constructing the changes

3.2.4 Tourism in historical sites through virtual reality

Loureiro, Guerreiro, and Ali (2020), in a comprehensive review spanning two decades of research on virtual reality (VR) and augmented reality (AR) in architectural tourism, employed network analysis and text mining techniques to analyze the full texts of 56 journal articles and 325 conference papers. Their study identified 10 major thematic categories within the journal literature and 11 within the conference proceedings. The findings highlighted two defining features of virtual environments in architectural tourism:

- the progressive and evolving nature of the field, and
- its strong potential for integration with emerging scientific domains.

Building on a presence-based perspective and process theory, Wei, Qi, and Zhang (2019) investigated how VR technology could enhance the visitor experience and behavioral responses in theme parks. Their study collected data from 396 visitors who had used virtual reality aerial train rides within the previous 12 months. Stepwise regression analysis revealed that users' sense of presence was primarily influenced by their perceived control, followed by factors such as participation, system effectiveness, curiosity, vividness, temporal association, and enjoyment.

Following the VR experience, participants expressed a heightened willingness to revisit the park. The study concluded that the ability to control simulated architectural environments in VR plays a critical role in enhancing users' sense of presence, which, in turn, increases their intent to return [WQZ19].

In their study, Kim, Lee, and Preis (2020) examined how virtual reality influences tourists' perceptions of authenticity in digital tourism environments. Their findings revealed that the experience of VR tourism was shaped by several key factors, including simplicity, adaptability, social interaction, entertainment, and innovation. These outcomes were closely linked to users' perceptions of accuracy within the virtual environment, suggesting that a high degree of perceived realism plays a crucial role in shaping the sense of authenticity in virtual tourism experiences [KLP20].

Smith, Walford, and Jimenez-Bescos (2019) explored the development of a three-dimensional model based on the surviving architectural plans of a Roman building, and its integration into a game engine to enable independent virtual navigation. The model was initially created in Autodesk Maya and then transferred into the game engine environment. The primary goal of the study was

to reintroduce cultural heritage to contemporary audiences through immersive, imagination-driven experiences that also support educational engagement.

The study emphasized several advantages of virtual monuments over their physical counterparts: virtual reconstructions are not subject to physical degradation caused by visitor traffic; they are not constrained by limited opening hours; and they offer permanent accessibility. Moreover, historically damaged or destroyed buildings can be digitally reconstructed and explored through interactive game-based environments, providing new opportunities for cultural preservation and experiential learning [SWJ19].

Bogicevic et al. (2019) examined how virtual reality can be employed to enhance tourists' pre-arrival experiences of hotel accommodations. In a controlled laboratory experiment, they compared three types of previews—two-dimensional images, a 360° virtual tour, and an immersive VR experience—each offering a different level of interaction. The results showed that the VR preview significantly enhanced participants' mental imagery and created a stronger sense of presence compared to the 360° tour and static images. These findings suggest that virtual reality plays a valuable role in stimulating tourists' imagination or "daydreaming" about a destination before visiting it. By enabling immersive interaction with virtual architectural models of accommodations, VR allows users to experience and internalize the spatial qualities of a place prior to arrival [Bog19].

Hajirasouli et al. (2021) employed virtual reality (VR) technology to digitally reconstruct the Kandovan resort, recognized as the last surviving cone-shaped community in the world. In the first phase of the study, participants explored a virtually restored model of the site, representing its undamaged state. Subsequently, they visited the actual location, which had undergone significant deterioration over the past two decades. The prior VR experience enabled users to visualize and internalize the original architectural and cultural context of the resort, enriching their understanding during the real-world visit. This study demonstrated that VR can effectively complement tangible architecture by offering a more comprehensive and informed experience of historical sites, particularly those that have been partially lost or damaged over time [Haj21].

Cardona et al. (2022) carried out a virtual reconstruction of the Fort of the Trinitat—a 16th-century historical castle located in Barcelona, Spain, which was largely destroyed in the early 18th century. Utilizing Autodesk 3ds Max and drawing on historical documents, the researchers were able to digitally recreate the site despite the limited physical remnants. Since 2019, the virtual model has proven to be an effective tool for enabling remote visits, particularly during the COVID-19 pandemic, offering access to cultural heritage for interested audiences despite physical and logistical constraints [HSC22].

Table 6 shows eight features of intangible architecture for tourism in historical sites.

Table 6: Capabilities of virtual reality environment to increase tourism in historical places

No.	Features
1	Possibility of linking tourism of historical sites with new sciences
2	Enhancing touristic enthusiasm due to sense of control in the VR environment
3	Acceptable accuracy of the perceived sense
4	Perpetuating historical sites
5	No depreciation of the site or building due to visits
6	No visit restrictions during non-working hours
7	Possibility of remodeling ruined ancient buildings for visit
8	Acquaintance with historical sites before visit

3.2.5 The possibility of representing tangible architecture in intangible architecture

H. Li et al. (2021) explored the extent to which simulated exposure to nature via virtual reality (VR) devices could contribute to psychological and physiological well-being. The study yielded positive results, indicating that VR-based natural environments can have calming effects on users. The researchers also highlighted the potential of VR games to create interactive experiences that offer individuals with physical disabilities the opportunity to engage with nature virtually. The immersive qualities of these environments—combined with the accessibility they provide without requiring physical movement—were key factors in the study's favorable outcomes [Hli21].

Chamilothori, Wienold, and Andersen (2019) examined the effectiveness of virtual reality (VR) headsets in evaluating subjective perceptions of daylight in architectural spaces. Specifically, they focused on five dimensions of perception: perceived pleasure, interest, excitement, complexity, and satisfaction with the visual field. A total of 29 participants took part in experiments comparing their experiences in a real daylight environment with a VR-simulated equivalent. The results demonstrated a high degree of perceptual accuracy in the virtual environment, with no statistically significant differences observed between the real and virtual settings across the evaluated criteria. Moreover, the study reported no notable physical discomfort or adverse symptoms among participants following VR exposure. Overall, the findings suggest that VR headsets can reliably replicate subjective perceptual experiences associated with real architectural spaces [CWA19].

Wu and Lai (2021) explored the role of virtual tours in shaping users' perception of presence. Their study involved 375 participants who experienced a virtual tour of Dinghu Mountain in China using Xiaomi VR headsets. The system allowed participants to freely rotate their heads and visually explore the environment, while also hearing ambient sounds such as flowing water, birdsong, and human activity. The findings revealed that users' mental imagery, combined with the ability to interact virtually with the environment, significantly contributed to the formation of presence. Additionally, this interaction influenced the development of cognitive and emotional images of the location, enhancing the overall immersive experience [WL21].

Paes, Arantes, and Irizarry (2017) conducted a comparative study examining spatial perception among specialists using both immersive virtual reality (VR) systems and traditional VR

platforms. Data were collected through spatial perception questionnaires (SPQs), which included objective items assessing participants' ability to judge various spatial attributes—namely: (a) vertical distance, (b) surface area, (c) quantification, (d) shape, (e) location, (f) horizontal distance, and (g) distance between elements. The findings indicated that immersive VR environments significantly enhanced users' spatial understanding compared to traditional design methods, suggesting that such systems offer superior support for perceiving and evaluating complex spatial arrangements in virtual architectural models [PAI17].

Higuera-Trujillo, López-Tarruella Maldonado, and Llinares Millán (2017) assessed users' sense of presence across three environmental simulation formats—static images, 360-degree panoramas, and virtual reality (VR)—by comparing them to real-world environments. Their analysis revealed that 360-degree panoramas most closely replicated real environments in terms of participants' psychological responses. In contrast, VR simulations produced the highest correspondence with reality in terms of physiological responses. These findings suggest that while both formats can effectively simulate presence, each excels in different dimensions of perceptual fidelity [HML17].

Matthias et al. (2022) conducted a study aimed at enhancing the level of detail in virtual reality (VR) representations of expansive urban landscapes. Focusing on Zürich station as a case study, they employed laser scanning technology to capture highly accurate and realistic spatial data. This information was then imported into the Unity game engine and integrated into a VR environment, where additional visual details were incorporated without significantly increasing the file size. To further enrich the immersive experience, ambient environmental sounds were layered into the simulation, contributing to a more authentic and multisensory representation of the urban space [Vol22].

Table 7 provides three cases of the possibility of tangible architecture representation in intangible architecture environments.

Table 7: The possibility of representing tangible architecture in intangible architecture

No.	Features
1	Possibility of handicapped people to move and interact with this environment
2	Complete representation of the real environment using VR headset
3	Greater spatial perception of users in this environment as compared to the real one

3.2.6 Architecture and Cinema

Rees et al. (2011) explored the evolution of the cinema set designer's role during the 1910s and 1920s, noting its transformation into what they termed Kino architecture—a form of cinema architecture. The study highlighted how set design in early cinema mirrored architectural practice by incorporating a broad spectrum of artistic disciplines. According to their findings, cinema offered a virtual medium through which architecture could be experienced, as architectural forms and spaces were projected onto the screen through scenographic design [Ree21].

Jacobs (2018) examined the interplay between architecture and slapstick comedy films of the 1910s and 1920s, particularly in relation to the architectural forms of that era. While influential modernist architects such as Le Corbusier, Hans Maer, and Karltig

celebrated American urbanism as a symbol of mechanization and vertical expansion, slapstick cinema of the time often satirized these ideals. A notable example is *Safety Last!* (1923), in which each successive floor of a skyscraper presents a new comedic challenge, turning the vertical structure into a narrative device. In this way, the architectural environment is not merely a backdrop but becomes an active agent that shapes and propels the unfolding story. Figure 8



Figure 8: *Safety Last!* (1923) IMDB. Harold Lloyd (the hero of the film) is in conflict with a skyscraper as an anti-hero as a symbol of modernity.

Accordingly, architecture depicted virtually in films has the potential to inspire philosophical inquiry and theoretical development—an effect rarely observed in its contemporary physical counterparts [Jac18].

Schulze (2019) explored how the architectural design in Dario Argento's horror film *Suspria* (1977) integrates feminine characteristics—such as ornamentation, mystery, and allure—to convey a distinctive atmosphere to the audience through spatial and visual expression. Figure 9



Figure 9: *Suspria* (1977) IMDB. The similarity of the interior design of the house to women's clothes has created a mysterious atmosphere.

Intangible architecture in cinema can serve as a powerful tool to enhance and complement a film's atmosphere, contributing to its emotional and narrative depth [Sch19].

Nieto-Ferrando, Sánchez-Castillo, and Gómez-Morales (2021) examined the influence of fictional films on audiences' imagination of tourist destinations. Their findings showed that when a city targeted for tourism is used as the setting for fictional narratives, it can significantly increase viewers' interest in visiting that location. The study emphasized the power of audiovisual storytelling in guiding audiences through spatial experiences and tourist landmarks. These sites become part of the narrative space—locations where events unfold and through which meaning is conveyed to the viewer. The visual presentation of tourist destinations in the background of cinematic narratives, when combined with emotionally engaging storytelling, can foster a deeper understanding of the place and generate initial excitement that motivates real-world travel [NSG21].

Escudero (2019) examined the role of architecture in Italian neorealist cinema and its entanglement with cinematic discourse. The study also explored commonalities between film and architectural projects by presenting six case studies that illuminate how neorealism shaped architectural understanding. Within neorealist cinema, the architectural background contributes an aesthetic dimension to physical architecture, producing three key outcomes:

- (i) Spontaneity in projects that appear to 'emerge' rather than be formally 'designed', creating a sense of authenticity and rootedness in place;
- (ii) A heightened sensitivity to the "problem of dwelling," whereby architects sought to offer not just shelter, but homes that addressed the material and psychological needs of everyday life; and
- (iii) A form of anonymity, where architectural authorship became secondary to collective purpose and social function.

Escudero concludes that the style of architecture portrayed in cinematic backgrounds can serve as a prelude to architectural movements that later take shape in real, built environments outside the screen [Esc19].

Ferrari (2016) examined the influence of cinema on the Città dei Sassi (City of Stones) in Matera and the surrounding Basilicata region over recent decades. The study focused particularly on the role of cinema in fostering tourism, supporting heritage preservation, and mitigating the risk of socio-economic marginalization in southern Italy. Ferrari's analysis centered on three key films that significantly contributed to Matera's visibility on national and international stages: Pier Paolo Pasolini's *The Gospel According to St. Matthew* (1964), Mel Gibson's *The Passion of the Christ* (2004), and Rocco Papaleo's *Basilicata Coast to Coast* (2010).

The study concluded that by using historically degraded and neglected sites as cinematic backdrops, these films played a pivotal role in drawing global attention to the region. This exposure not only supported touristic development but also mobilized cultural and institutional efforts aimed at preserving the area's unique architectural and historical fabric [Fer16].

Leotta (2020) analyzed the representation of place and space in two television drama series: *Gomorra* (2014–present) and *My*

Brilliant Friend (2018). The study focused on the stylistic and narrative strategies employed by the creators to construct a touristic gaze upon the urban environment of Naples. Leotta argued that, although both series portray the city as marked by poverty, violence, and social unrest, they simultaneously frame it through an aesthetic lens that renders it visually compelling and culturally intriguing. This dual depiction positions Naples as both a site of hardship and a potentially exotic and attractive urban destination.

The study concludes that when cities affected by violence and poverty are presented with visual and narrative beauty—particularly through cinematic or televisual framing—viewers' perceptions of those places can shift, enhancing their touristic and cultural appeal [Leo20].

McKim (2017) argued that digital animation has evolved into a powerful tool for both reconstructing the past and envisioning the future of cities. As a case study, she examined the work of Eyal Weizman and the Forensic Architecture project, which reanimates overlooked episodes from Vancouver's history, particularly those involving critical moments of human experience. McKim also analyzed how the speculative architect Liam Young uses animation techniques to portray imagined urban futures that oscillate between utopian ideals and dystopian warnings. In this way, animation becomes a medium through which cities can be either reconstructed from memory or projected into speculative architectural futures [Mck17].

Mumcu (2018), through an analysis of landscape architecture in the animated films of Hayao Miyazaki, explored how animated, dynamic landscapes can reflect and shape various forms of human behavior toward nature. In Miyazaki's films, landscapes do more than serve as background—they create mood, establish a sense of place and time, and intensify the visual narrative. These landscapes function as visual analogies for the complex psychologies of characters, offering insight into the emotional and philosophical undercurrents of the story.

The study categorized human–nature relationships in Miyazaki's work into three groups, highlighting how these films portray humans as intrinsic elements of the natural world. Miyazaki emphasizes the importance of preserving ecological balance, and presents nature as wrathful, vengeful, and apocalyptic when humans attempt to dominate it—particularly through the misuse of technology.

Mumcu's research suggests that static physical landscapes can be transformed into dynamic, expressive environments through animation. Landscape architecture in this medium not only shapes narrative space and mood but also serves as a philosophical and metaphorical device. In this context, landscapes can metaphorically embody character traits and convey deeper meanings about humanity's place in the natural order [Mum18].

Table 8 reports 11 features of combining architecture with cinema as one of the branches of intangible architecture.

Table 8: Intangible architectural capabilities in cinema

No.	Features
1	Possibility of combination with cinema through scene design
2	Generation of architectural theory through the architecture of films
3	Complementing cinema atmosphere
4	Inducing enthusiasm for tourism through the architecture of film's backgrounds
5	Architecture in cinema, a prelude to real-world architectural movement
6	Presenting historical sites under degradation through the location of films
7	Correcting the audience's negative view about some cities through the location of attractive movies
8	Possibility of reconstructing old cities or future ones in animations
9	Establishing a mobile view in naturalistic animations
10	Creating a mood in fantasy animations with landscape architecture
11	Characterization of animation characters through metaphoric landscaping

3.2.7 Architecture and computer games

Ferdani et al. (2020) explored the potential of computer games as tools for archaeological training and practice, using the Forum of Augustus as a case study. The game they analyzed integrates the interactive dynamics of video games with the immersive capabilities of virtual reality, offering an engaging platform for experiential learning. The authors propose that frequently recurring architectural elements—those derived from a common stylistic tradition—should be stored in a shared digital library to facilitate the cost-effective development of similar educational games.

Key features of intangible architecture within such educational game environments include:

- The integration of virtual reality's emergent properties for enhanced immersion,
- The creation and reuse of a centralized architectural object library to support scalable content generation, and
- The capacity for unlimited virtual archaeological training within interactive, game-based settings [Fer20].

Misak (2018) presented a virtual reality (VR) video game exercise designed for students as a tool for developing narrative awareness through spatial simulation. The exercise provided a visual framework for understanding the concept of "sense of place," serving as a guide for students' creative writing and storytelling. Its primary objective was to enhance students' spatial awareness and their ability to visualize and articulate settings—particularly those rooted in classical narratives. The study suggests that when students engage with simulated versions of idealized story settings through interactive media such as computer games, it fosters a deeper sense of spatial context. This, in turn, can enrich both their comprehension of narrative environments and their capacity for imaginative authorship [Mis18].

Mangnus et al. (2022) explored the potential of computer games grounded in real urban environments to serve as interactive tools for addressing sustainability challenges. They developed Utrecht 2040, a large-scale mobile game designed to simulate future urban scenarios and encourage players to imagine and implement solutions to complex urban problems. The game was made accessible via public platforms, including mobile devices, thereby extending its reach to non-specialist audiences. By incorporating emotional engagement and reward-based mechanics typical of gaming environments, the researchers succeeded in motivating broader public participation and learning. Their findings suggest that large-scale urban experimentation and education can be effectively conducted through gamified platforms [Man22].

Lovreglio et al. (2018) examined the use of serious games (SGs) as training tools to improve evacuation preparedness during emergencies such as earthquakes and fires. The study focused on a public building in Oakland and involved 170 participants. The simulation was developed using the Unity game engine. To guide their research, the authors addressed five key aspects: (a) identifying essential features of an earthquake scenario; (b) selecting and visualizing an appropriate building model within the VR environment; (c) representing structural damage realistically; (d) designing non-player characters (NPCs); and (e) defining the level of interaction between NPCs and human participants. These considerations were applied in the context of a hospital in Oakland, New Zealand, which served as the test environment. The study utilized a VR-based educational SG tool to enhance users' preparedness for seismic events. The findings suggest that high-risk scenarios—such as earthquakes and fires—can be effectively simulated through immersive and interactive gaming platforms, allowing real participants to engage in realistic, risk-free emergency training [Lov18].

To examine the energy consumption behaviors of over 150 households in France and Spain, Csoknyai et al. (2019) utilized a mobile-based serious game in conjunction with a questionnaire, subsequently validating the findings with actual consumption data. The use of a mobile platform allowed for broad participation across a geographically dispersed population, leveraging the accessibility and convenience of smartphones. The study revealed that even in less inherently engaging experimental settings, the interactive and appealing nature of the game significantly increased participant engagement and cooperation [Cso19].

Statham, Jacob, and Fridenfolk (2021) explored the potential application of modular architecture in the design of virtual spaces within computer games. Their findings indicated that incorporating modular systems into game architecture significantly reduces development costs, particularly benefiting small or independent game design teams. The repetitive use of modular elements also contributes to stylistic consistency and spatial coherence within the game environment. Moreover, the modular approach enhances compatibility with artificial intelligence systems, facilitating more efficient and automated spatial development. The study suggests that principles drawn from the historical practice of tangible architecture can be effectively adapted to the design of virtual game environments [SJF21].

Sanchez (2019) argues that parametric design has largely excluded the public from the architectural design process. In response, he introduced a method for discrete design through the interface of the video game Block'hood. This platform allows for more transparent and equitable social participation in design, making the process more accessible and understandable to non-experts. The game interface enables users to immediately design and simulate the development of discrete architectural projects, thereby fostering broader engagement. According to Sanchez, such interactive tools create significant opportunities for public involvement in the reconfiguration and co-design of complex architectural environments [San19].

Table 9 indicates 11 features of combining architecture with computer games as one of the branches of intangible architecture.

Table 9: Intangible architectural capabilities in computer games.

No.	Features
1	Possibility of frequent exploration exercises in archaeological sites in games
2	Games help the story's audience for the development of a sense of space
3	Simulation of mythical spaces of stories in games
4	Possibility of simulating cities in mobile multiplayer games
5	Engaging non-specialist citizens in resolving urban problems through mobile games
6	Performing experiments on the large urban scale through game
7	Simulation of high-risk experiments through games
8	Possibility of employing scattered statistical population via mobile games
9	Inducing attraction via attractive games for nonattractive public experiments
10	Possibility of using tangible architecture techniques for rapid development of the architecture of games
11	As a weak point: Elimination of public and individuality from the design process due to the development of parametric design

3.3 The process toward the grounded theory

Through a qualitative review of 47 selected articles, a total of 54 distinct capabilities were identified that are unique to intangible architecture and not present in traditional, physical architecture. To extract the conceptual characteristics of this emerging architectural form, these 54 features were re-evaluated and categorized into 13 thematic groups based on their conceptual similarities:

3.3.1 Interactable

- The interactivity of virtual environments enhances users' sense of presence.
- The ability to exert control within virtual reality environments increases users' motivation and desire for tourism.

3.3.2 Correct details

- Virtual recognition of historical sites prior to physical visitation enhances contextual understanding.
- VR headsets offer highly accurate representations of real environments.
- Perception through VR headsets closely mirrors that of real-world experiences.

3.3.3 Relation to reality

- Multiplayer mobile games offer the potential to simulate urban environments at scale.
- Risky or hazardous scenarios can be safely modeled and tested through simulation in computer games.
- Real-world architectural techniques can be effectively applied in the design of game architecture.
- Cinematic architecture can serve as a foundation for generating new architectural theories.

3.3.4 Digitality

- The ability to digitally restore ruined historical buildings
- Virtual access to heritage sites beyond conventional working hours
- Enhanced mobility and interaction for individuals with disabilities within virtual environments
- The reconstruction of historical or future cities through animated visualizations
- Unlimited opportunities for practicing and exploring archaeological sites via game-based simulations
- Pre-development urban feedback collection through virtual models of proposed cityscapes

3.3.5 Scalability

- Facilitating real-scale spatial understanding for clients within BIM environments, allowing them to experience and evaluate architectural designs at true scale before construction.

- Enabling large-scale urban experimentation through game-based simulations, offering a dynamic platform for testing design strategies, public behaviors, and policy impacts in virtual cities.

3.3.6 Linkability

- Connecting tourism in historical sites with emerging scientific disciplines to enhance educational and experiential value
- Integrating Building Information Modeling (BIM) with photogrammetry to improve accuracy in architectural documentation
- Linking BIM datasets with digital media to enrich spatial visualization and interactive storytelling
- Connecting BIM models to cloud-based platforms to enable real-time access, collaboration, and remote updates
- Combining virtual reality environments with medical and physiological laboratory tools to support experimental design and data collection
- Merging virtual architecture with cinema through digital stage design and immersive set extensions
- Enhancing cinematic spaces using virtual architectural elements to expand visual and narrative depth
- Engaging non-expert citizens in urban problem-solving via mobile game platforms that encourage participatory planning
- Involving geographically dispersed individuals in virtual urban experiments through serious gaming applications
- Increasing public engagement in otherwise unattractive or technical urban experiments by using gamified, visually compelling interfaces

3.3.7 Non-rigid

- Assembling architectural forms virtually to explore compositional strategies and spatial relationships before physical construction
- Generating dynamic, nature-oriented landscapes in animated environments to evoke emotional, ecological, or philosophical narratives through movement and transformation

3.3.8 virtuality

- The ability to test multiple combinations and design scenarios efficiently within controlled simulations
- The option to use the same participants repeatedly in crossover studies, ensuring consistency and statistical reliability
- The capability to conduct experiments in physically restricted or hazardous environments that are otherwise inaccessible
- Significant reductions in both time and cost associated with prototyping and testing procedures
- The facilitation of rapid testing for urgent architectural responses, such as those required during the COVID-19 pandemic

3.3.9 Eternity

- The eternalization of historical monuments through high-fidelity digital preservation
- The elimination of physical wear and deterioration caused by visitor traffic to sensitive heritage sites
- The ability to digitally reconstruct and visualize ruined or lost buildings, making them accessible for virtual visitation and study

3.3.10 Controllable

- Enhancing perceptual focus by immersing users in distraction-free virtual settings

• Eliminating many confounding variables typically present in real-world environments, thereby improving the validity and control of experimental outcomes

3.3.11 Perceptibility

- The ability to achieve an acceptable level of accuracy in users' perceived sense of space and atmosphere
- Enhanced spatial perception and environmental awareness compared to real-world settings, due to the controlled and immersive nature of virtual environments
- The use of interactive game-based narratives to foster a deeper sense of place and emotional engagement among audiences

3.3.12 Presentable

- Stimulating interest in tourism by showcasing background

- Enhancing the level of immersion within the BIM environment
- Achieving a high degree of spatial perception in pervasive virtual environments, comparable to real-world experience
- Increasing perceived realism by incorporating authentic ambient sound into virtual spaces
- Evoking a spiritual or contemplative atmosphere within simulated sacred environments

The titles of these thirteen feature groups were subsequently merged through axial coding and organized into four overarching categories. The integration of these categories led to the conceptualization and naming of the overarching framework: Intangible Architecture. The process of these steps is shown in Figure 10

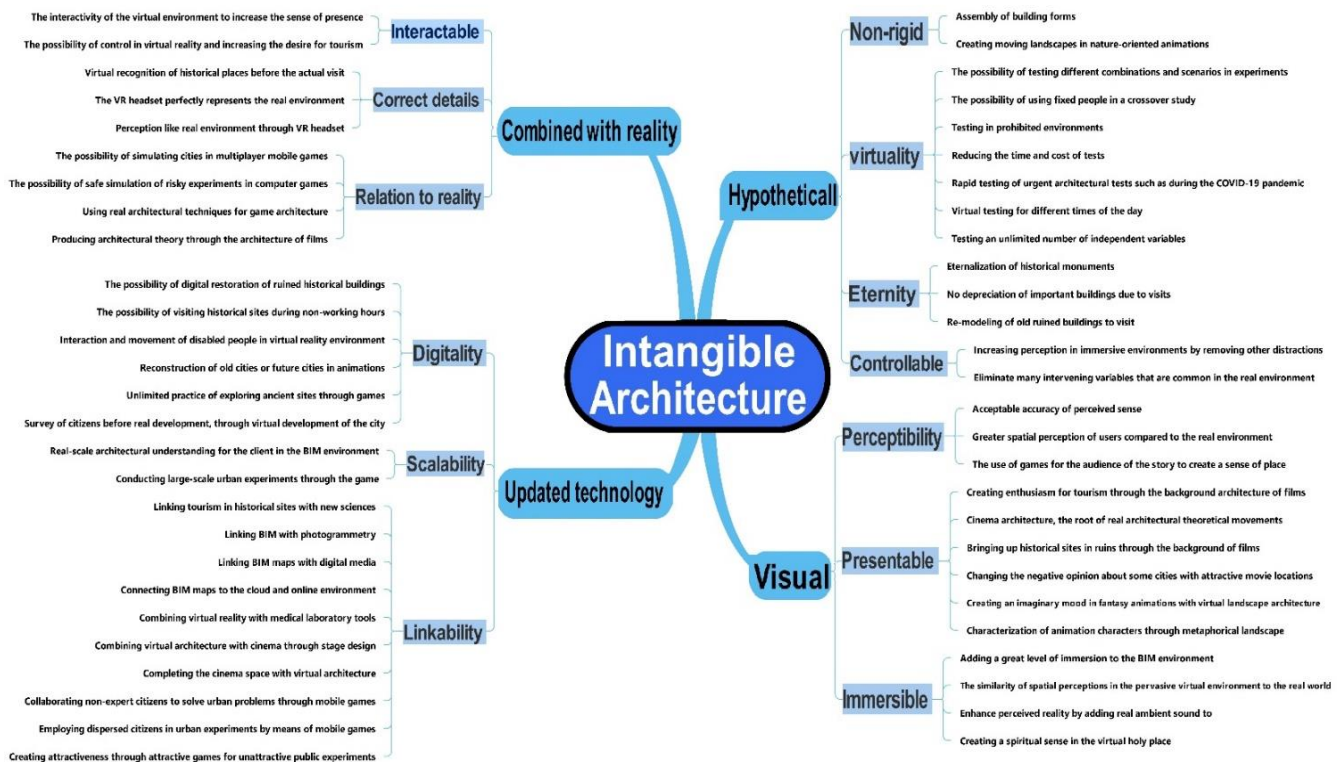


Figure 10: The process toward the grounded theory

architecture in films

- Using cinematic architecture as a conceptual foundation for future architectural theory and movements
- Reintroducing ruined historical sites to public consciousness through their portrayal in film settings
- Shifting negative perceptions of certain cities by highlighting their visual appeal in cinematic locations
- Creating immersive fantasy worlds in animated films through the use of expressive, virtual landscape architecture
- Conveying character identity and emotional depth through metaphorical landscapes in animation

3.3.13 Immersible

4 Conclusions

This study addressed the growing prevalence of intangible architecture and the absence of a unified conceptual framework surrounding it. To this end, a mixed-methods approach was employed, combining bibliometric analysis (quantitative) with a qualitative investigation into its underlying nature. To reduce human error and ensure methodological rigor, both a systematic review and the PRISMA protocol were followed. The selection of input keywords for literature searches was informed by expert

consultation, facilitated through electronic questionnaires. Ultimately, the study led to the development of a grounded theory and the proposal of a framework and working definition for this emerging architectural paradigm.

The bibliometric analysis—based on metadata retrieved from Scopus and Web of Science up to December 2024—revealed that the field is distinctly multidisciplinary, as evidenced by the diversity of its associated keywords. Publication trends indicate a sharp rise in interest since 2011, with a notably high percentage of conference papers underscoring the novelty of the subject. The geographical distribution of publications also reflected contributions from linguistically and culturally diverse countries, possibly signaling efforts to localize or nativize the concept—an area warranting further research.

The qualitative analysis of the 47 selected papers, grouped into seven thematic categories, resulted in the identification of 56 distinct features of intangible architecture. This wide array of characteristics highlights the expansive scope of the field. Findings suggest that intangible architecture is highly progressive and adaptable, particularly suited to integration with emerging technologies and contemporary demands.

Through an axial coding process involving three stages, the 56 features were consolidated into a central unifying concept. This conceptual core, grounded in shared thematic attributes, forms the basis of the theoretical model introduced in this paper under the term intangible architecture.

As a counterpart to tangible architecture, this emerging domain is evolving rapidly. It holds significant potential across a range of fields—including tourism, BIM integration, architectural testing, education, and the entertainment industry—where it can serve as a complementary or even transformative force. Future research is encouraged to explore each of the seven thematic areas in greater depth and to further examine the intersections between intangible architecture and immersive platforms such as the Metaverse.

Limitations

This study has several limitations that should be acknowledged. First, the quantitative and bibliometric analysis was restricted to publications indexed in Scopus and Web of Science; the potential contributions of other databases and platforms were not examined. Second, the qualitative analysis was based on a sample of only 47 papers, which may not comprehensively reflect the full spectrum of perspectives and developments within the field of intangible architecture.

Given that intangible architecture is a relatively new and rapidly evolving area of inquiry, the existing body of literature remains limited. As technological advancements continue at a rapid pace—and given intangible architecture's intrinsic connection to emerging technologies—it is likely that new subfields and variants may soon emerge that were not captured in the current research.

Additionally, the qualitative nature of the thematic analysis introduces the possibility of subjective interpretation and human error in the identification and classification of features. Although every effort was made to ensure methodological rigor, the influence of researcher bias cannot be entirely excluded.

One critical observation concerns the role of parametric design—a key feature identified within intangible architecture. While it has

the potential to reduce the influence of subjective judgment in the design process, it may also lead to the concentration of creative control within a few large technology-driven firms. This centralization of design authority raises concerns regarding the homogenization of architectural expression and the marginalization of smaller design practices, representing a structural vulnerability within the field.

5 Declarations

5.1 Availability of supporting data

Not applicable.

5.2 Competing interests

The authors declare no competing interests.

5.3 Funding

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5.4 Authors' contributions

All authors collected the data, performed the analysis, and wrote the paper. All authors reviewed the manuscript.

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