The Turkish Online Journal of Design, Art and Communication

E-ISSN: 2146-5193

DOI: 10.7456/tojdac

Research Article / Araştırma Makalesi

BEYOND THE LENS: A BIBLIOMETRIC JOURNEY THROUGH ARCHITECTURAL PHOTOGRAPHY RESEARCH

LENS'İN ÖTESİNDE: MİMARİ FOTOĞRAF ARAŞTIRMALARINDA BİBLİYOMETRİK BİR YOLCULUK

Fazıl AKDAĞ[1]
Fatma Betül KÜNYELİ[2]
Murat Çağlar BAYDOĞAN[3]

ORCID: F.A. 0000-0002-3316-8104
F.B.K. 0000-0002-6189-5966
M.Ç.B. 0000-0002-7856-6712

Corresponding author/Sorumlu yazar:
[1] Fazıl Akdağ
Erciyes University, Türkiye
E-mail/E-posta: fazilakdag@erciyes.edu.tr

[2] Fatma Betül Künyeli
Erciyes University, Türkiye
E-mail/E-posta: betulkunyeli1@gmail.com

[3] Murat Çağlar Baydoğan
Erciyes University, Türkiye
E-mail/E-posta: baydogan@erciyes.edu.tr

Received/Geliş tarihi: 11.04.2025

Benzerlik Oranı/Similarity Ratio: %10

Last revision received/Son revizyon teslimi: 22.05.2025

Accepted/Kabul tarihi: 27.06.2025

Etik Kurul İzni/ Ethics Committee Permission: There is no element in the study that requires ethics committee approval. / Çalışmada etik kurul onayı gerektiren bir unsur bulunmamaktadır.

Citation/Atıf: Akdağ F. & Künyeli, F.B. &Baydoğan, M.Ç. (2024). Beyond the Lens: A Bibliometric Journey Through Architectural Photography Research. The Turkish Online Journal of Design Art and Communication, 15 (3), 1046-1070. https://doi.org/10.7456/tojdac.1674146

Abstract
This study presents a bibliometric analysis to map academic trends, collaborations, and thematic developments in architectural photography using VOSviewer and Biblioshiny software. Based on 470 publications retrieved from the Web of Science (WoS) database, the analysis explores the intellectual structure of architectural photography research through keyword co-occurrence, citation networks, and bibliometric coupling. The findings reveal a significant increase in academic interest over the past two decades, highlighting the growing interdisciplinary connections of the field with cultural heritage, digital visualization, and artificial intelligence applications. Cluster analysis identified eleven major thematic groups, including cultural heritage documentation, digital photogrammetry, AI-assisted visualization, and media representation. Country-level bibliometric coupling analysis shows that the United States is a dominant research hub with strong links to the United Kingdom, Canada, and Australia. At the same time, China and European countries demonstrate intensive regional collaborations. The study concludes that architectural photography is no longer limited to traditional documentation practices but is increasingly evolving into a research domain shaped by emerging technologies such as 3D modeling, LiDAR, and augmented reality. These findings offer valuable insights into emerging research directions such as computational photography, immersive visual storytelling, and interdisciplinary approaches to architectural documentation.

Keywords: Architectural photography, Bibliometric analysis, Photography.

Öz
Bu çalışma, mimari fotoğrafçılık alanındaki akademik eğilimleri, iş birliklerini ve tematik gelişmeleri haritalamak amacıyla VOSviewer ve Biblioshiny yazılımları kullanılarak gerçekleştirilen bir bibliyometrik analiz sunmaktadır. Web of Science (WoS) veri tabanından elde edilen 470 yayına dayanan analiz, anahtar kelime birlikteliği, atıf ağları ve bibliyometrik eşleşme yoluyla mimari fotoğrafçılık araştırmalarının entelektüel yapısını ortaya koymaktadır. Bulgular, son yirmi yılda bu alana yönelik akademik ilginin belirgin şekilde arttığını ve mimari fotoğrafçılığın kültürel miras, dijital görselleştirme ve yapay zekâ uygulamaları gibi disiplinlerarası alanlarla giderek daha fazla etkileşime girdiğini göstermektedir. Kümeleme analizi; kültürel miras dokümantasyonu, dijital fotogrametri, yapay zekâ destekli görselleştirme ve medya temsili gibi konuları içeren on bir ana tematik grup belirlemiştir. Ülke düzeyinde yapılan bibliyometrik eşleşme analizine göre, Amerika Birleşik Devletleri, Birleşik Krallık, Kanada ve Avustralya ile kurduğu güçlü bağlantılar sayesinde öne çıkan bir araştırma merkezi konumundadır; Çin ve Avrupa ülkeleri ise bölgesel düzeyde yoğun iş birlikleri sergilemektedir. Çalışma, mimari fotoğrafçılığın artık yalnızca geleneksel dokümantasyon pratiği olmaktan çıktığını ve 3B modelleme, LiDAR ve artırılmış gerçeklik gibi yeni teknolojilerle şekillenen bir araştırma alanına dönüştüğünü ortaya koymaktadır. Bu bulgular, hesaplamalı fotoğrafçılık, etkileşimli görsel anlatım ve mimari dokümantasyona yönelik disiplinlerarası yaklaşımlar gibi yeni araştırma yönelimlerine dair önemli içgörüler sunmaktadır.

Anahtar Kelimeler: Mimari fotoğrafçılık, Bibliyometrik analiz, Fotoğrafçılık.

INTRODUCTION

Etymologically, the word "**photograph**," meaning "**drawing with light,**" is believed to have been first coined in 1839 by the English scientist Sir John Herschel, derived from the Greek words phos, meaning "**light,**" and graphê, meaning "**drawing or writing**". In the 470s BC, the Chinese philosopher Mo-tzu created 'projection rooms' known as Camera Obscura by making a small hole in a dark room, allowing the outside image to be projected inside in reverse. These are considered the first recorded instances in history where the working principle of cameras was documented (Sugimoto et al., 2005). At a later date, around the 300s BC, Euclid also mentioned in his book Optics that light travels in a straight line and that certain visuals can be created as a result (Osterman, 2007). In the 1000s AD, the Arab physicist Alhazen (Ibn al-Haytham) wrote in his Book of Optics that light travels in a straight line and does not progress when obstructed by an opaque surface, based on the observation that many candles reflect in the same way on different surfaces, and that detailed control of the reflected light can be achieved in this manner (Quinnell, 2012). This book later inspired many European thinkers and scientists such as Witelo, John Peckham, Leonardo da Vinci, René Descartes, and Johannes Kepler (De Tomasi, 2023).

Looking at more recent history, the photograph titled View from the Window at Le Gras, taken by Joseph Nicéphore Niépce in 1826 from his study in a house between the rooftops in Chalon-sur-Saône using the heliography method, is considered the first architectural photograph recorded in history in terms of defining the spatiality of the context in which it was taken (Photo 1) (Higgott & Wray, 2016). Due to the very long exposure time of the photograph, both the right and left surfaces of the walls appear illuminated by sunlight (Kusnerz, 2004). Another one of the earliest examples of architectural photography is Louis Jacques Mandé Daguerre's work, where he photographed Boulevard du Temple in Paris in 1839 (Photo 2). Although the photograph was taken on one of the busiest streets in Paris at that time, due to the long exposure, no vehicles or people are visible on the boulevard. In the history of photography, this image is referred to as the first photograph to capture a human in the frame, where only the silhouette of a shoeshiner and a person having their shoes polished can be seen (Howie, 2010). Over time, with the advancements in photography technology, exposure times have shortened, cameras have reached portable sizes, and they have transformed into commercial products, creating a new market (Motta, 2010). With the camera becoming a technology accessible to everyone, visual materials related to different cultures, geographies, and cities became available to all, and the circulation of architectural knowledge accelerated (Bergera, 2016). With the advent of the first cameras, the journeys of traveling photographers from Europe to many cultures and geographies initiated the creation of the earliest visual documentation of those areas (Photo 3) (Edwards, 2013).

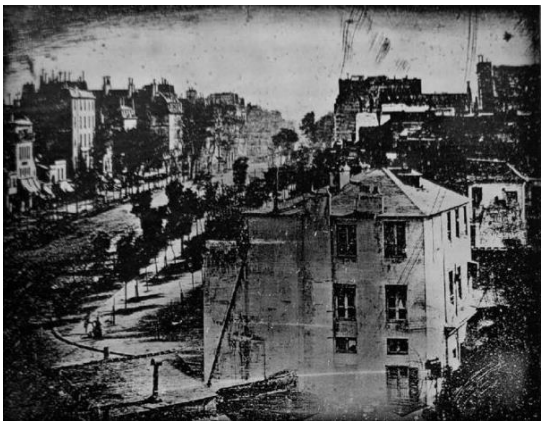

Photo 1. Niepce's first photograph (Gernsheim, 1977) **Photo 2**. Temple Boulevard-Paris (Bate, 2016)

Photo 3. The first known photographs of Istanbul taken by Prangey: on the left, a view from the Beyazıt Tower, on the right, the Beyazıt Mosque-1843 (Acar, 2015)

The early developments in photography technology occurred within a scientific context focused more on improving technical skills and capacities, while with the maturation of technology and the widespread use of cameras, the emphasis shifted to aesthetic and artistic advancements (Mudie, 2011). With a process where inputs such as light, shadow, and contrast gained increasing importance and frames were now approached with the sensitivity of architectural composition, architectural photography emerged as a specialized area of interest (Shulman & Goessel, 1999).

In this process, especially in the 19th century, photography societies established in France (1851 Société Héliographique) and England (1857 Architectural Photographic Association) stand out as the first formations that brought architectural photography to an institutional level (Denton, 2002). During this period, architectural photography was primarily used for preservation and documentation efforts and served as a reference for reconstruction and restoration works (Monteiro, 2010). From the second half of the 19th century, architectural photographs began to transform into a tool used by architecture firms in their portfolios to impress clients, and with this, architectural photography started to be recognized as a new profession (Hamber, 2004). Again, during this period, architectural photographs were not only used to document historical buildings but also, with the photographing of newly constructed buildings, the process of architectural photography transforming from a documentation tool to a representation tool began (Britton, 2016). With the publication of these photographs in magazines, newspapers, and books, the dissemination of developments, styles, and approaches in the world of architecture accelerated, making it possible for architecture to globalize and reach wider audiences (Orvell, 2011). Especially in the mid-20th century, with the emergence of master figures like Julius Shulman, the influence of photography in the world of architecture expanded (Martínez, 2014). With the acceptance of architectural photography as a powerful and effective representation tool, the recognition of both architects and photographers began to increase, and the photographic impact of architectural products started to become a parameter influencing design processes (Blecksmith, 2011). Now, in the architectural design process, the photographic and visual value of the structure is highlighted as an input, and in some designs, the perception and visual impact of the photograph even take precedence over the designer and the structure (Photo 4) (Serraino & Shulman, 2013). Julius Shulman's iconic photographs taken in the mid-20th century in the USA can be cited as an example of this situation (Alexander, 2011).

Photo 4. Kaufmann House (left) (Richard Neutra- 1947) Case Study House #22 (on the right) (Pierre Koenig-1960) (Hyun, 2016)

The architectural photographs taken by Shulman during that period made the understanding of modern architecture in America strikingly visible worldwide, and these iconic photographs not only increased the media visibility and recognition of the buildings and their designers but also created an effective foundation for the professional popularity that architectural photography has achieved today. Shulman's iconic photographs had a significant impact on Richard Neutra, and these photographs became a tool for Neutra to rethink his designs. To understand the impact of photography on architectural design, Neutra's unique approach to this subject is noteworthy. According to Neutra, the design of a building is not completed with the construction process but is finalized through photographing the building during its use and re-representing it through these photographs (Niedenthal, 1993). Shulman's impressive style in architectural photography has deeply influenced Neutra's design practices. Neutra would make sketches based on prints of Shulman's photographs and use the sketches he made from photographs of his built structures as references for future designs. In this respect, it perhaps reveals the first architectural uses of photo manipulation, which is frequently employed today.

The designer-photographer relationship between Neutra and Shulman is also seen between Saarinen and Balthazar Korab. Korab, a Hungarian-born photographer known as the 'architect of photography' and one of the most important representatives of modern architectural photography, sees photography as a new instrument in architecture and is remembered for his experimental work in photography. Saarinen's design of the TWA Terminal building, completed in 1962, states that the design process was shaped by studies of the model photographs taken by Korab (Comazzi, 1999). In this process, on one hand, Korab documents the stages of the design with his photographs. On the other hand, he guides the design process with the experimental photographs he creates, especially through the models of the design.

Architectural photographers who became prominent in their eras and achieved recognition throughout history have established a robust basis for the contemporary status of architectural photography in terms of its acknowledgment and acceptance as a discipline. In the contemporary architectural landscape, architectural photography, aimed at enhancing the visibility of designs, depicting them, and securing their presence in diverse printed and digital media, has attained a significance that cannot be regarded as separate from architectural production practices.

Academic databases indicate that architectural photography, as a professional discipline, has gained unprecedented prevalence and acceptance in its evolution; nonetheless, it continues to foster a relatively constrained discourse within the academic sphere. The insufficient examination of architectural photography as an academic discipline and its perception as a specialized profession

serve as the fundamental impetus for this research. This research intends to examine academic studies in architectural photography, highlighting contemporary approaches, associated domains, literature shortages, and research gaps through bibliometric analysis.

This research seeks answers to the following questions:
RQ1: What are the bibliometric characteristics and current research trends in architectural photography?
RQ2: Which thematic areas have been predominantly explored or neglected in architectural photography research?
RQ3: What are the patterns and impacts of international collaborations in architectural photography research?
RQ4: How have emerging technologies influenced architectural photography research, and what technological trends will shape future studies?
RQ5: What methodological approaches and perspectives can advance architectural photography as an academic discipline?

METHODOLOGY

Bibliometric analysis, used to analyze scientific productivity and academic collaborations, explore research methodologies, and measure scientific impact, has gained significant importance in today's research world. The software and academic databases used in these analyses facilitate the data collection, visualization, and analysis processes for researchers. VOSviewer and Biblioshiny are among the frequently preferred tools for these purposes, each offering its unique advantages. The software used for bibliometric analysis generally works in an integrated manner with data obtained from academic databases. The most commonly used databases are as follows: Web of Science (WoS): It stands out as a comprehensive platform offering scientific articles and citation data, providing user-friendly and easily understandable analyses and graphs for searches conducted in the database.

Scopus: It stands out especially for its large dataset for multidisciplinary analyses.
Google Scholar: Offers broader and free access options, but the homogeneity of the data may be limited.
PubMed: It is known as a database specialized in the fields of medicine and biology.
Various software have been developed for the processing and visualization of bibliometric data provided by these databases, some of the most commonly used ones are listed below.
VOSviewer: It is designed to visualize and analyze large-scale bibliometric networks. The software offers various functions, such as citation analyses, co-authorship networks, and keyword co-occurrence studies (van Eck & Waltman, 2009). The standout features are as follows:
It is the most commonly used analysis software for visualizing complex bibliometric maps and network relationships.
Visual Clarity: Visualizes complex networks in a user-friendly manner.
Big Data Processing: Easily processes large volumes of data from various sources.
Academic Collaboration Analyses: Effectively visualizes collaborations between authors and institutions (Kirby, 2023).
Biblioshiny: Built on the Bibliometrix tool, which is based on the R programming language, it has a user-friendly web interface (Moral-Muñoz et al., 2020). Although it is based on coding, it has a graphical user interface designed to provide easy use for unfamiliar coding users. This feature allows for analysis without requiring technical knowledge (Moral-Muñoz et al., 2020). It clearly presents data such as citation trends and collaborations through graphs and tables. It offers extendable features with R coding for advanced users (Arruda et al., 2022).
CiteSpace: It is used to analyze the flow of information in the scientific field and is powerful with clustering algorithms (Markscheffel & Schröter, 2021).
HistCite and CitNetExplorer: They are particularly used to analyze and visualize citation networks (Pan, Yan, Cui, & Hua, 2018).

Software such as VOSviewer and Biblioshiny enhance efficiency and depth in bibliometric analyses. These software programs offer powerful tools for processing and visualizing data obtained from

different academic databases. Researchers can analyze scientific literature more effectively with the features offered by the software.

This study employs the bibliometric analysis method to determine the current trends in the literature on architectural photography, how they have diversified, and which fields they are related to. Among the scientific analysis and mapping approaches, bibliometric analysis, which has become quite popular recently, aims to create bibliometric maps explaining how large-scale datasets from academic research fields are handled in different academic environments and to visualize the network relationships among the prominent keywords related to the subject. Through the bibliometric analysis method, it is possible to visualize the relationships formed by the data of research terms, represent them in graphs, and make the relationship networks visible (Van Eck & Waltman, 2010). In this section of the research, the tools and methods used to analyze the relevant literature systematically are expressed (Figure 1).

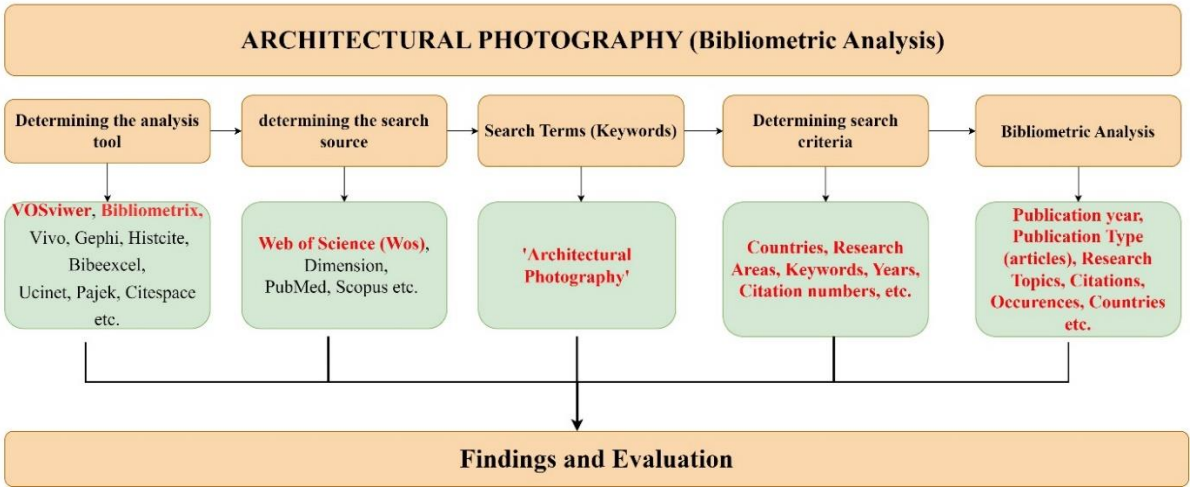

Figure 1. Research method flowchart

RESULTS

The term "**Architectural photography**" was searched in the Web of Science catalog on January 2, 2025, to identify current approaches in the literature, relevant research topics, prominent themes, associated keywords, and their interrelations, utilizing bibliometric research methods that frequently favor highly cited and quality scientific studies (Figure 2).

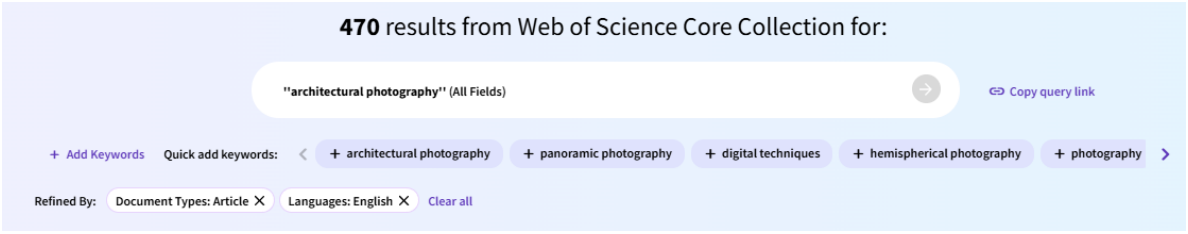

Figure 2. Web of Science search interface

In the search results, a total of 585 different publications, including articles, book chapters, and conference papers, were found, and among these results, only the articles in English were subjected to bibliometric evaluation. After the filtering process, a total of 470 studies were subjected to systematic evaluation. It is noteworthy that this number is quite low compared to other research fields. For example, when searching for the terms artificial intelligence, one of the most popular research areas in recent times, on the same date, 597,173 results are found in the same database. The 470 studies on architectural photography were exported as a plain text file from the Web of Science database to be processed in Vosviewer and Bibliometrix software (Figure 3).

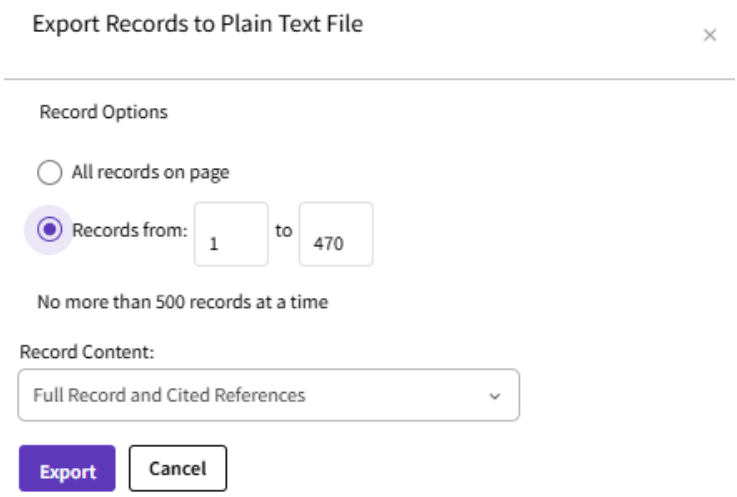

Figure 3. Export of relevant search results from the Web of Science database

Subsequently, statistical data pertaining to the extant literature on "**Architectural Photography**" were acquired by the processing of the transferred dataset file in VOSviewer and Biblioshiny, as well as by utilizing the analytical data supplied by Web of Science. The results derived from the primary information part of the Biblioshiny interface within the Bibliometrix program were initially assessed in relation to bibliometric analysis (Figure 4).

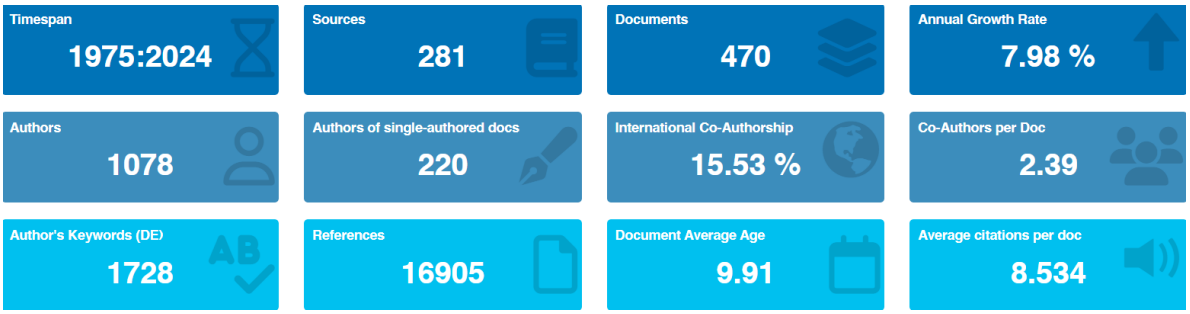

Figure 4. General information on research terms (Biblioshiny)

The query for "**architectural photography**" in the Web of Science spans the years 1975-2024 and encompasses 470 items from 281 distinct sources. The yearly average publication growth rate for the specified period is 7.98%, and the mean age of these 470 publications is 9.91 years. The aggregate count of researchers is 1,078, the cumulative quantity of single-authored publications is 220, and the mean number of authors per publication is 2.39. 15.53 Percent of co-authored papers exhibit international collaboration, with an average citation count of eight point five three four per publication. Researchers utilized 1,728 keywords and accessed 16,905 sources.

Web of Science Data

The distribution of published articles in the field of Architectural Photography, according to the relevant search results, has been examined based on research areas in the Web of Science database (Figure 5).

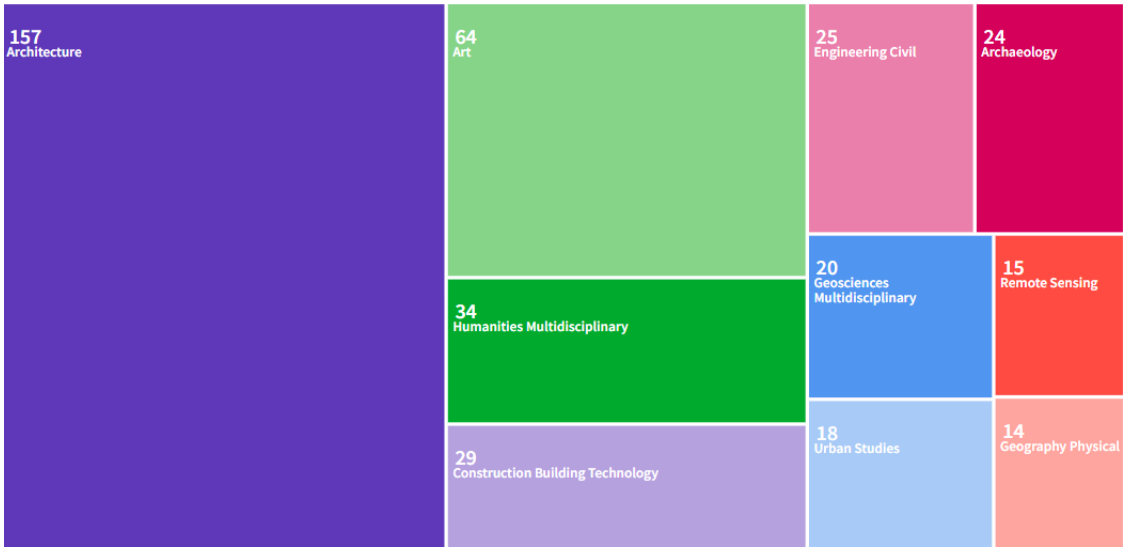

Figure 5. General information on research terms (Biblioshiny)

Figure 5 indicates that the majority of papers pertaining to architectural photography have been generated primarily in the domains of Architecture, Art, Interdisciplinary Humanities, and Construction Technologies, in that sequence. Civil Engineering, Geological Sciences, and Urban Studies follow these fields.

Analysis of the annual distribution of publications on architectural photography reveals a consistent increase in the number of studies, particularly with a marked acceleration in recent years. Concurrently with the rising volume of publications, there has been a significant uptick in citations of research within this domain (Figure 6).

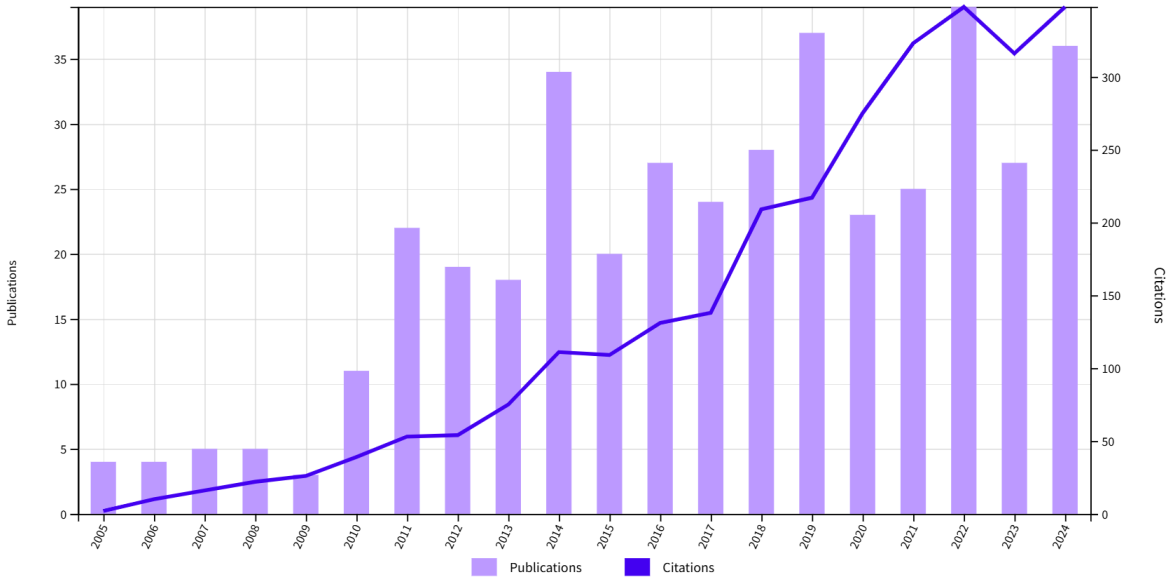

Figure 6. Publication and citation numbers over the last 20 years

Upon reviewing the foremost academic publications in architectural photography, the ten most frequently published journals in the Web of Science database are as follows: Architectural Digest, Journal of Architecture, Buildings, History of Photography, Visual Resources, Architectural Histories, Archnet Ijar International Journal of Architectural Research, Architectural Record, Arts, and Frontiers of Architectural Research (Figure 7). Of the 470 published articles, 105 are included in these 10 journals. Figure 8 illustrates the annual distribution of articles published in various journals.

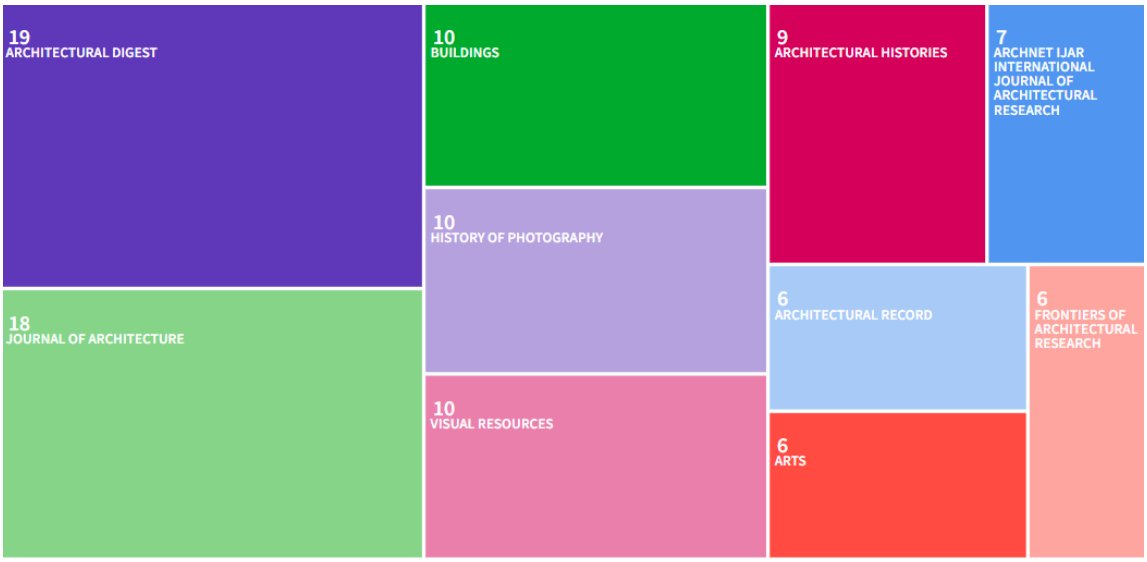

Figure 7. Publication and citation numbers over the last 20 years

The Architectural Digest Journal has seen consistent growth since the late 1970s, peaking at the end of the 1990s and then stabilizing. The history of photography began to attract interest in the mid-1990s, exhibiting a gradual yet consistent rise post-2000s. The Visual Resources journal experienced significant momentum post-2005, with a marked escalation in articles beginning in 2010. The Journal of Architecture has achieved notable advancements in architectural photography since 2014 and has exhibited the most rapid growth trajectory. The Buildings journal experienced a notable increase post-2020, signifying that the topic has emerged as a new academic focal point. It has been noted that scholarly interest in architectural photography has significantly surged since 2010.

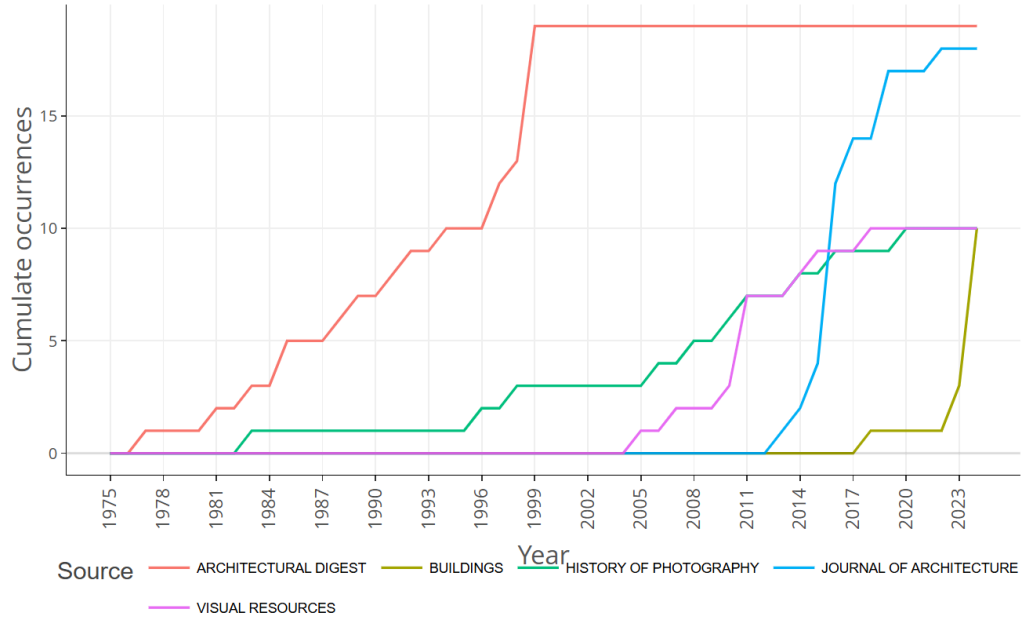

Figure 8. The variation in the quantity of journal publications over the years

The USA is prominent among the nations that generate the highest volume of articles about architectural photography. Subsequent to the USA are China, England, Spain, and Italy, in that sequence (Figure 9).

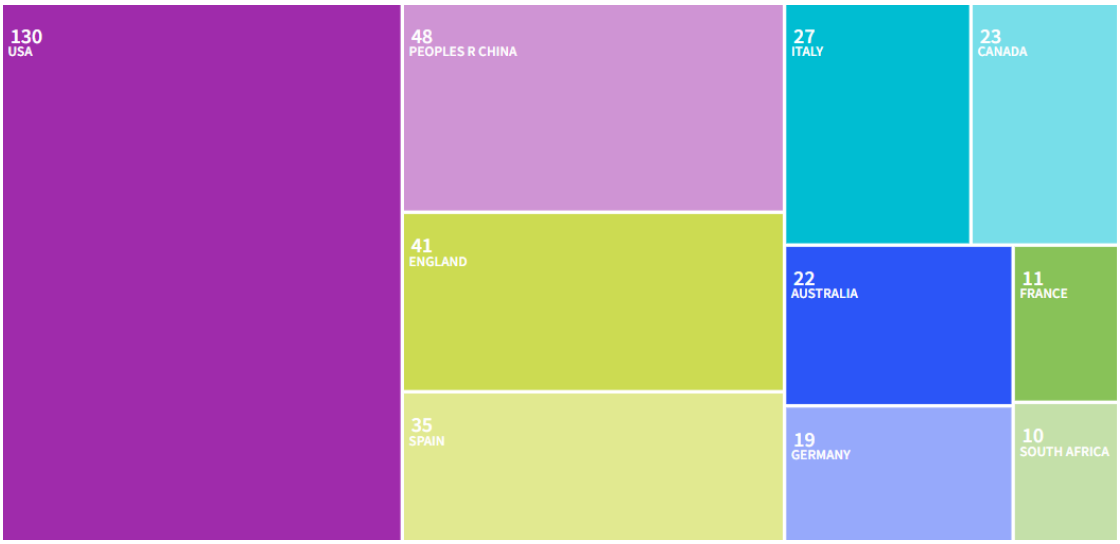

Figure 9. Top 10 countries that produce the most publications in architectural photography

Bibliometric Analysis (employing Biblioshiny with VOSviewer)

The bibliometric analysis conducted for an extensive literature review on architecture photography has optimized the data pool for evaluation using VOSviewer and Biblioshiny software. A detailed evaluation of pertinent literature on "**architectural photography**" has been undertaken by leveraging the distinctive properties of both applications.

Three-Field Plot

The Three-Field Plot diagram in the Biblioshiny visually assesses the relationships among several criteria, including keywords, authors, nations, and citations in the pertinent literature study. The dimensions and heights of the colored rectangular bars in the diagram signify the efficacy of the interactions and connections. A wider rectangle signifies increased relationships among various components (Yıldız & Avinç, 2024). In the Three-Field Plot diagram in Figure 10, the left column denotes countries, the center column signifies researchers, and the right column illustrates keywords, with the interconnections within these columns representing collaborations and relationships.

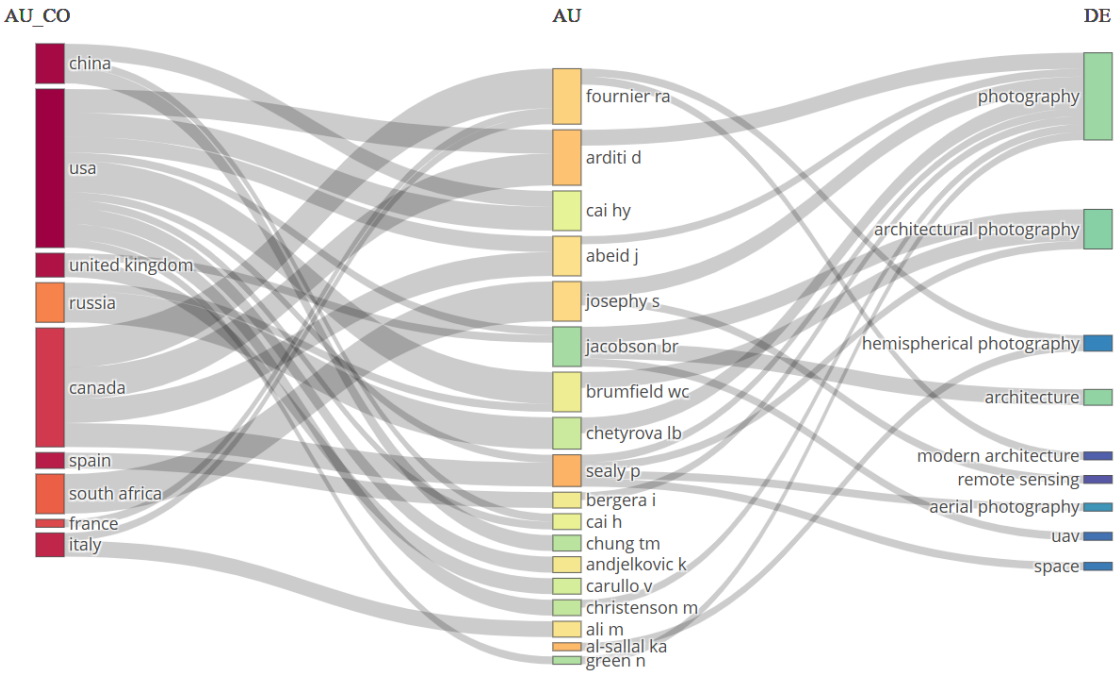

Figure 10. Three-Field Plot

In architectural photography, China, the USA, the UK, Russia, and Canada excel in scholarly output and collaborations, but Italy, France, and South Africa are comparatively less significant. Moreover, although "**photography,**" "**architectural photography,**" "**hemispherical photography,**" and "**architecture**" are the predominant keywords, technology-oriented terms such as "**space**," "**UAV**" (unmanned aerial vehicles), "**aerial photography**," and "**remote sensing**" are utilized less often. Given that the pertinent literature evaluation spans 1975-2024 and that the rate of technical advancements has intensified post-2000, it is comprehensible why technology-related terms are less robust.

Most Relevant Authors

Consequently, of the 470 publications screened, 220 are single-authored and 250 are co-authored. Upon analyzing the writers with the highest publishing output, Sealy occupies the foremost position with four publications (Sealy, 2016; 2021; 2023; Sealy and Zhang, 2024), whereas Al-Sallal follows in second place with three articles (Al-Sallal, 2006; 2010; Al-Sallal and Al-Rais, 2011). Each author has one co-written paper, whereas the remaining publications are solely authored. Once more, Arditi (Abeid & Arditi, 2002a; 2002b; Abeid et al., 2003), Finch (1991; 1992; 1999), Fournier (Côté et al., 2009; Leblanc & Fournier, 2014; Nguyen et al., 2022), and Josephy (2017; Murray & Josephy, 2022; 2024) have each published three works, thereby enriching the discourse on architectural photography (Figure 11). Among the 1078 authors throughout the 470 analyzed articles, one author published four articles, five authors published three articles each, thirty-three authors published two articles each, and the remaining authors each published a single publication. Even the most prolific author in architectural photography has published just a limited number (5) of works, suggesting that this domain is not regarded as a principal research area subjected to rigorous investigation by certain scholars. This scenario suggests that this discipline, academically, remains deficient in expert researchers and possesses opportunities for advancement.

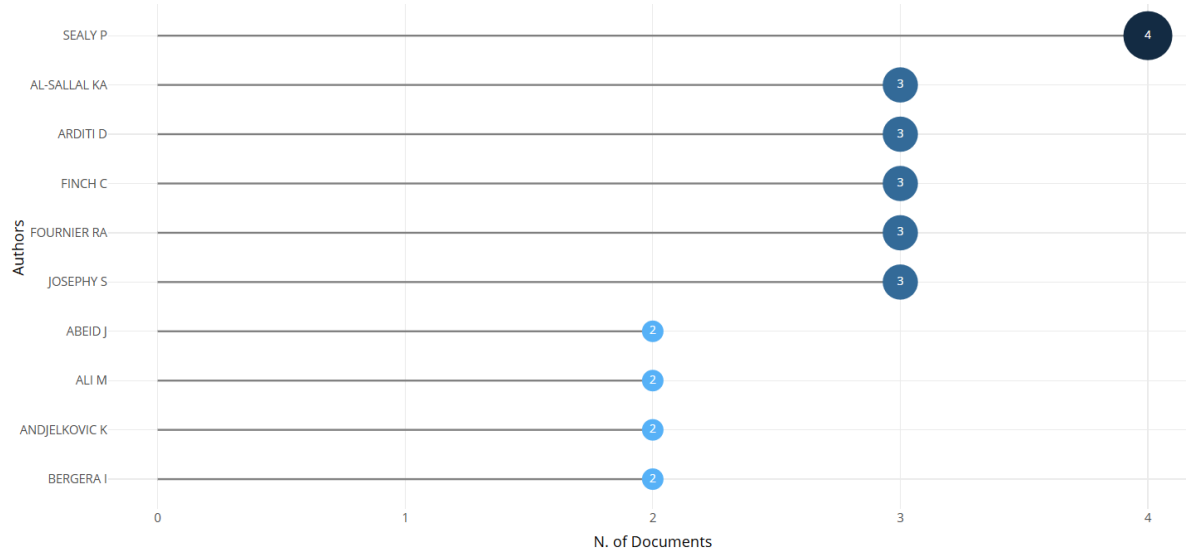

Figure 11. Most Relevant Authors

Authors' Production over Time

The "**production of authors over the years**" graph (Figure 12) illustrates the academic output of the top 10 authors with the highest publication rates over time. Some authors exhibit sustained continuity in their academic production, whereas others have been active only during specific intervals. The graph depicting publications from 1991 to 2023 reveals that no authors maintained constant publishing during this 32-year span, highlighting a significant absence of continuity among authors and extended periods between publications. Particularly, certain authors (Arditi, Ali, Abeid, and Andjelkovic) have generated works pertinent to the topic within a mere two-year span. Sealy, Fournier, and Josephy are distinguished academics who have undertaken long-term investigations in this domain, disseminating their scholarly contributions over an extended timeframe.

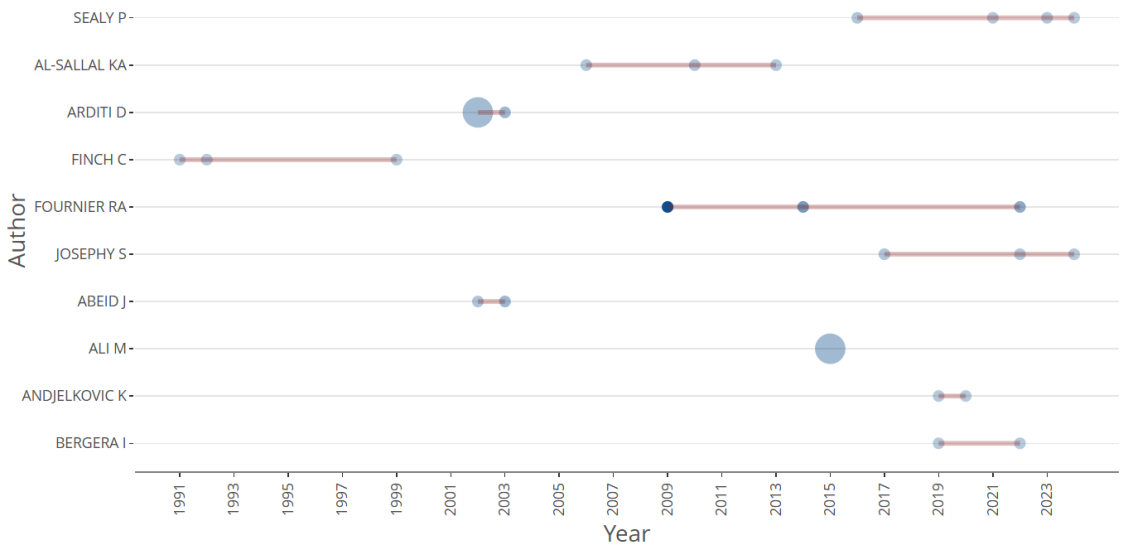

Figure 12. Authors' academic productions by year

Most Global Cited Documents

This section presents the ten most referenced studies in the field of "**architectural photography**," together with their citation counts (Figure 13), and details the subjects and methodologies of these studies in a table (Table 1). These investigations are comprehensively analyzed, emphasizing their key characteristics and results and identifying literature gaps and potential research directions.

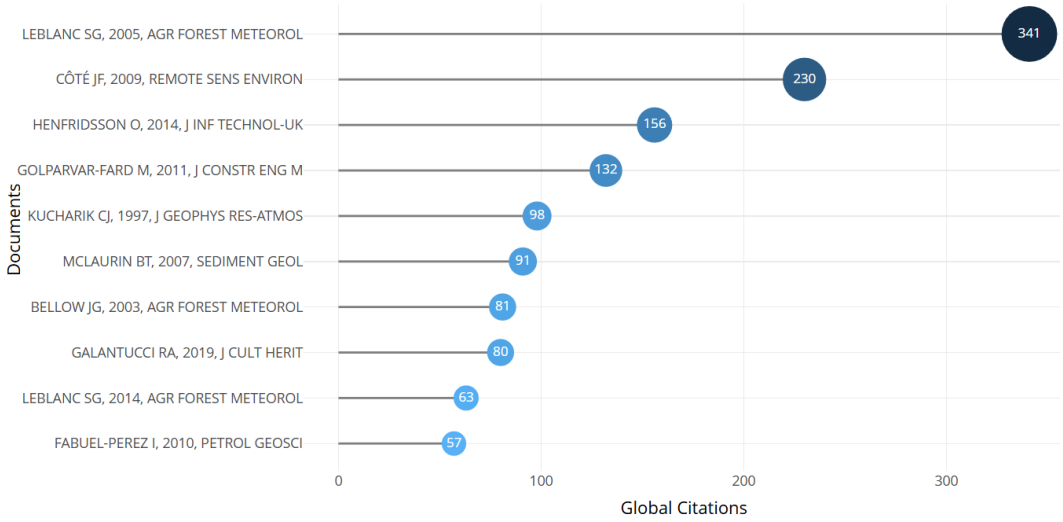

Figure 13. Top 10 most cited articles

Table 1. Overview of most cited 10 articles

Topic	Method	Reference
Digital hemispherical photography for canopy structure analysis	Examines the use of fish-eye lens cameras for deriving canopy gap fraction and clumping index, enhancing the assessment of plant area index (PAI) and its components in boreal forests.	Leblanc et al., 2005 (Agricultural and Forest Meteorology)
3D tree reconstructions using terrestrial lidar	Develops a methodology for reconstructing 3D tree architectures using terrestrial LiDAR, validated through radiative transfer simulations for ecological and environmental applications.	Côté et al., 2009 (Remote Sensing of Environment)

Managing technological change with architectural frames	Explores the challenges of technological change in digitized product development, contrasting modular hierarchy-based approaches with networked design patterns for adaptive innovation.	Henfridsson et al., 2014 (Journal of Information Technology)
Integrated Sequential As-Built and As-Planned Representation with D4AR Tools	Utilizes advanced digital imaging techniques to integrate as-built point-cloud models with Building Information Models (BIMs), enabling construction performance visualization, safety monitoring, and quality control in the Architecture, Engineering, and Construction (AEC/FM) industries.	Golparvar-Fard et al., 2011 (Journal of Construction Engineering and Management)
Characterizing canopy nonrandomness with a multiband vegetation imager (MVI)	Develops a novel multiband vegetation imager to measure architectural components such as sunlit and shaded leaves, correcting leaf area index (LAI) estimates for nonrandom canopy structures through Monte Carlo modeling.	Kucharik et al., 1997 (Journal of Geophysical Research)
Architecture and origin of an amalgamated fluvial sheet sand in the Castlegate Formation	Employs geological surveys and outcrop data to examine sediment deposition, channel migration, and stacking patterns in fluvial systems, enhancing understanding of lowstand depositional environments.	McLaurin & Steel, 2007 (Sedimentary Geology)
Comparing methods for assessing understory light in agroforestry systems	Compares three techniques—densiometers, visual indexes, and hemispherical photography—for estimating photosynthetically active radiation (PAR) transmission under varying canopy densities in tropical agroforestry systems.	Bellow & Nair, 2003 (Agricultural and Forest Meteorology)
Advanced damage detection in historical buildings using photogrammetry	Integrates digital photogrammetry and 3D surface analysis for non-invasive identification and quantification of structural damage in historical buildings, tested through a case study in Italy.	Galantucci & Fatiguso, 2019 (Journal of Cultural Heritage)
Hemispherical photography simulations with an architectural modelto assess retrieval of leaf area index	Simulates hemispherical photography using 3D models to improve accuracy in estimating leaf area index (LAI) by accounting for clumping effects and angular dependencies in forest canopies.	Leblanc et al., 2014 (Agricultural and Forest Meteorology)
Integration of digital outcrop models and sedimentology in reservoir modeling	Combines LiDAR-derived digital outcrop models and traditional sedimentology to construct high-resolution geocellular models for subsurface reservoir characterization and prediction.	Fabuel-Perez et al., 2010 (Petroleum Geoscience)

Assessment of the 10 Most Cited Articles

Methodology comparison for canopy structure parameters extraction from digital hemispherical photography in boreal forests

Digital hemispherical photography (DHP) is a cost-effective and efficient method for estimating canopy structural parameters in boreal forests. In this study, gap fraction and plant area index (LAI) measurements were conducted using commercial digital cameras equipped with fish-eye lenses, and the results were compared with traditional methods such as the TRAC instrument. DHP demonstrated superior sensitivity in detecting small gaps while maintaining high accuracy in estimating parameters like gap fraction and clumping index. The study combined Chen and Cihlar's (1995) gap size distribution theory and the Lang and Xiang methodology, achieving consistent results across various angles. Additionally, digital photography's low cost and portability allow for rapid and convenient data collection in the field. The findings highlight DHP as a reliable tool for modeling critical ecological processes, such as the carbon cycle in boreal forests, with the potential for increased accuracy through broader sampling (Leblanc et al., 2005).

The structural and radiative consistency of three-dimensional tree reconstructions from terrestrial lidar

This study presents a novel methodology for reconstructing three-dimensional (3D) tree architectures

using terrestrial LiDAR (TLiDAR) systems, aimed at producing structurally and radiatively consistent models for ecological and remote sensing applications. The proposed approach overcomes challenges such as wind-induced artifacts and occlusions by employing robust algorithms to process TLiDAR point clouds, segmenting data into wood and foliage components, and generating branching structures informed by light availability and foliage distribution. The reconstructed models were quantitatively validated using radiative transfer simulations, demonstrating their ability to replicate structural attributes like foliage orientation, vertical leaf area profiles, woody components, and directional reflectance properties. Initial tests on coniferous trees across multiple species showed high fidelity between reference and reconstructed models, supporting the use of this method for forest management and remote sensing product validation. However, limitations remain, particularly in accurately terminating the foliage addition process and addressing occlusion effects in dense forest environments. The study highlights the potential of this methodology to inform ecological modeling, radiative transfer applications, and the validation of remote sensing data products (Côté et al., 2009).

Managing Technological Change in the Digital Age: The Role of Architectural Frames
This study examines how firms can effectively manage technological change in increasing digitization by introducing two architectural frames: the "**hierarchy-of-parts**" and "**network-of-patterns**." Inspired by Herbert Simon's modularity principles, the hierarchy-of-parts frame focuses on decomposing products into loosely coupled components to achieve economies of scale and design flexibility. However, the study argues that this approach alone is insufficient in the digital age, as digital technologies allow for greater design flexibility and scalability. Drawing on Christopher Alexander's design patterns theory, the complementary network-of-patterns frame emphasizes generalizing solutions into patterns and specializing them for specific contexts, enabling ongoing innovation throughout a product's lifecycle. A case study of an automaker transitioning to a Media-Oriented Systems Transport (MOST)-based infotainment system highlights the practical challenges and benefits of integrating these frames. While the hierarchy-of-parts frame supports physical component modularity, the network-of-patterns frame facilitates flexibility and scalability in software and digital functionality. The study concludes that combining these frames allows firms to better respond to the dynamic demands of digital products while balancing legacy systems and new Technologies (Henfridsson et al., 2014).

Integrated Sequential As-Built and As-Planned Representation with D4 AR Tools in Support of Decision-Making Tasks in the AEC/FM Industry
This study explores integrating as-built and as-planned models using 4D augmented-reality (D4AR) tools to support decision-making in the architecture, engineering, construction, and facility management (AEC/FM) industry. By leveraging daily site photographs and building information models (BIMs), the research develops an automated method for generating 4D as-built models and superimposing them on 4D BIMs. The methodology involves reconstructing 3D point-cloud models from unordered site images, georegistering these models in virtual environments, and enabling sequential visualization of construction progress. Case studies demonstrate the system's effectiveness in improving progress monitoring, safety management, quality control, and site logistics. The integration of as-built and as-planned data facilitates enhanced coordination and communication among project stakeholders, offering a scalable solution for tracking construction deviations and ensuring project alignment with planned schedules. Despite some limitations in handling large data volumes and dense occlusions, the D4AR framework significantly extends BIM applications into the construction phase, emphasizing its value in achieving better project outcomes (Golparvar-Fard et al., 2011).

Characterizing canopy nonrandomness with a multiband vegetation imager (MVI)
This study introduces a Multiband Vegetation Imager (MVI) as a novel tool to quantify plant canopy architecture and nonrandomness by capturing high-resolution images in visible (VIS) and near-infrared (NIR) wavelength bands. The MVI system identifies canopy components such as sunlit and shaded leaves and branches, enabling the precise calculation of the leaf area index (LAI), sunlit LAI, and canopy clumping characteristics. Using Monte Carlo modeling, the study provides corrections for indirect LAI measurements, improving accuracy by accounting for the nonrandom distribution of

foliage. Field tests during the Boreal Ecosystem-Atmosphere Study (BOREAS) demonstrated the system's utility in aspen and balsam poplar canopies, where it significantly enhanced LAI estimations compared to traditional methods like hemispherical photography and LAI-2000. Results showed that corrected LAI values were 45% higher in aspen and 17% higher in balsam poplar when using MVI data, highlighting the importance of addressing clumping effects in canopy measurements. By enabling robust, indirect measurements of canopy structure across various sky conditions, the MVI represents a significant advancement in scaling leaf-level processes to the canopy scale for ecological and atmospheric studies (Kucharik et al., 1997).

Architecture and origin of an amalgamated fluvial sheet sand, lower Castlegate Formation, Book Cliffs, Utah

This study investigates the architecture and depositional processes of amalgamated fluvial sheet sandstones within the lower member of the Castlegate Formation, located in the Book Cliffs of Utah. Using detailed outcrop analysis, including photomosaics, sedimentary structure measurement, and paleocurrent estimation, the study identifies three primary architectural components: thalweg-fill units, barforms, and overbank deposits. These components stack hierarchically into channel-bar systems, channel belts, and stacked channel-belt complexes, revealing a nested cyclic depositional hierarchy. The analysis suggests that low to intermediate-sinuosity rivers, influenced by both autocyclic processes (e.g., lateral migration, local avulsion) and allocyclic factors (e.g., base-level changes), were responsible for the deposition. Flow depth calculations (4.6–7.7 m) and paleocurrent data indicate a southeastward-directed regional paleoflow, consistent with braided river systems. The results highlight the importance of accommodation space and sediment supply in shaping fluvial architectures, with broader implications for sequence stratigraphy, paleogeography, and reservoir characterization (McLaurin & Steel, 2007).

Comparing common methods for assessing understory light availability in shaded-perennial agroforestry systems

This study evaluates three methods—visual estimation, densiometers, and hemispherical photography—for quantifying understory light availability in tropical agroforestry systems. Understory photosynthetically active radiation (PAR) was measured across 32 plots in Costa Rica, comprising diverse tree species and canopy structures. Results indicate that densiometers are the most accurate and practical tool for predicting mid-day PAR transmission, particularly in dense canopies, while hemispherical photography provides better predictions in open canopies and low-density stands. Visual estimation, though less precise, remains a cost-effective alternative for farmers with limited resources. The findings emphasize that canopy openness, rather than structural parameters like tree height or crown diameter, better predicts light transmission. The study underscores the importance of choosing appropriate light-assessment methods to optimize shade management in agroforestry systems, which can enhance crop yields under shaded conditions by balancing PAR levels (Bellow & Nair, 2003).

Advanced Damage Detection Techniques in Historical Buildings Using Digital Photogrammetry and 3D Surface Analysis

This study introduces an innovative protocol for damage detection in historical buildings using digital photogrammetry and 3D surface analysis, emphasizing its non-invasive and cost-effective nature. The methodology involves creating 2D and 3D models of architectural surfaces from close-range digital photogrammetry, which are subsequently processed through advanced surface analysis tools like TalyMap 3D. The protocol includes spatial noise filtering, depth-based segmentation, and motif analysis to identify and quantify damages such as cracks and material loss. Applied to a case study of the Palazzo Palmieri in Monopoli, Italy, the method demonstrated high accuracy, detecting features as small as 7 mm² with depth precision up to 0.267 mm. Additionally, by comparing 3D models captured over an 18-month period, the research highlighted the progression of decay, showing quantifiable changes in damage dimensions. This approach supports better preservation and maintenance strategies for cultural heritage, with the potential for further automation to enhance its accessibility and efficiency (Galantucci & Fatiguso, 2019).

Hemispherical photography simulations with an architectural model to assess retrieval of leaf area index
This study evaluates the use of three-dimensional simulations of forest scenes to test the accuracy of algorithms for retrieving Plant Area Index (PAI) and Leaf Area Index (LAI) from hemispherical photography (HP). Using the POV-Ray rendering software, 75 virtual forest scenes with varying canopy structures and leaf angle distributions were simulated. Key findings include the importance of foliage clumping corrections, as neglecting clumping effects led to significant underestimation of PAI. The study identifies the Chen and Cihlar method, combined with the Lang and Xiang method, as the most accurate approach, reducing errors to 23–24% compared to prior estimates of 29%. The results also demonstrate that zenith angles near 57.3° provide the most reliable data for LAI retrieval. The study concludes that combining advanced clumping correction methods with optimized zenith angles significantly improves LAI estimation, making this simulation framework a robust tool for testing retrieval algorithms under controlled forest conditions (Leblanc et al., 2014).

Integration of digital outcrop models (DOMs) and high resolution sedimentology – workflow and implications for geological modelling: Oukaimeden Sandstone Formation, High Atlas (Morocco)
This study presents a comprehensive workflow integrating digital outcrop models (DOMs) and high-resolution sedimentological data to construct geocellular models for the Oukaimeden Sandstone Formation in the High Atlas of Morocco. Using terrestrial LiDAR, digital photography, and advanced software, the research generated high-resolution 3D models of fluvial and aeolian sedimentary units, capturing detailed facies architectures and stratigraphic relationships. The methodology involves the extraction of geostatistical parameters from DOMs, including facies proportions, geobody dimensions, and paleocurrent data, to reduce uncertainty in traditional subsurface models. The results highlight the utility of combining DOMs with field data to refine facies connectivity and enhance the realism of reservoir models. Applied to a Triassic braided fluvial system, the study demonstrates improved prediction of reservoir properties such as porosity and permeability distribution, with implications for oil and gas exploration. The approach significantly enhances the precision of geocellular models, offering a scalable solution for similar depositional environments globally (Fabuel-Perez et al., 2010).

A general evaluation of the reviewed articles
The reviewed articles emphasize the transformative role of advanced imaging technologies and methodologies in disciplines such as environmental science, construction management, historical preservation, and geological modeling. Techniques like digital photogrammetry, hemispherical photography, and terrestrial LiDAR scanning have been widely adopted to achieve high-resolution, non-destructive analysis and documentation. These methodologies not only facilitate practical outcomes like environmental monitoring, structural analysis, and reservoir modeling but also offer insights that can expand the creative and technical possibilities of architectural photography (Leblanc et al., 2005), (Golparvar-Fard et al., 2011).

Several studies illustrate the potential of advanced imaging technologies in environmental and technical applications. For instance, hemispherical photography has been extensively used to estimate light availability and canopy structure in forestry, demonstrating its ability to capture spatial and structural relationships with high precision (Bellow & Nair, 2003), (Leblanc & Fournier, 2014). Similarly, the integration of photogrammetry and augmented reality tools in building information modeling (BIM) enables real-time monitoring of construction progress and safety management, emphasizing its utility in dynamic environments (Golparvar-Fard et al., 2011). These applications, while technical in nature, highlight the potential for architectural photographers to leverage these technologies for precise documentation of built environments.

A notable subset of the articles focuses on photogrammetry and 3D modeling techniques, particularly in the context of historical preservation. Digital photogrammetry and 3D surface analysis have been successfully applied to assess structural damage in historical buildings, creating hyper-detailed representations of architectural features and aiding in preservation strategies (Galantucci & Fatiguso, 2019). These techniques align closely with the goals of architectural photography, particularly in projects that require capturing intricate architectural details or documenting heritage structures.

Likewise, terrestrial LiDAR scanning, as applied in geological modeling and fluvial sedimentary studies, demonstrates the capability of creating realistic 3D models of complex forms (Fabuel-Perez et al., 2010), (McLaurin & Steel, 2007). Such methods could greatly enhance architectural photography by providing new tools for visualizing and documenting structures with unparalleled accuracy.

Despite their technical focus, these studies reveal opportunities for architectural photography to bridge technical accuracy with creative representation. Applications such as LiDAR-generated 3D models or photogrammetric imagery could be adapted to produce visually compelling narratives, combining precision with artistic storytelling (Fabuel-Perez et al., 2010). This interdisciplinary potential suggests that architectural photography could evolve to integrate technical imaging methods, creating a new paradigm where accuracy and aesthetic quality coalesce.

The articles also reveal how interdisciplinary applications within architecture and design can inspire new approaches. Studies on BIMs and visualization tools highlight how advanced imaging can facilitate communication among stakeholders and improve project outcomes (Golparvar-Fard et al., 2011). These tools can be reimagined in architectural photography to create dynamic visual narratives that illustrate design concepts or project evolution over time. Additionally, the detailed spatial data captured by these technologies could serve as the foundation for immersive experiences, such as virtual walkthroughs or augmented reality, further expanding the scope of architectural documentation (Fabuel-Perez et al., 2010).

From a research perspective, these insights highlight opportunities to innovate in architectural photography by combining advanced imaging technologies with artistic intent. Future research could explore how techniques like photogrammetry, LiDAR scanning, and AI-driven imagery might enhance both the documentation and creative storytelling of architectural subjects. The potential to blend technical rigor with aesthetic expression opens exciting avenues for creating multidimensional portrayals of architecture (Galantucci & Fatiguso, 2019), (Golparvar-Fard et al., 2011).

In conclusion, while the reviewed studies primarily focus on practical applications, they provide a rich foundation for adapting these advanced methodologies to architectural photography. By integrating techniques like 3D modeling and photogrammetry, architectural photography can move beyond traditional documentation to create innovative visual narratives that resonate both technically and artistically. These approaches could bridge gaps between accuracy and creative representation, expanding the discipline’s relevance in modern architecture and design practices.

Thematic Map

A thematic map is one of the visualization tools used in bibliometric analyses to define and evaluate the thematic structure of a research field. These maps help to understand the overall structure of a research field by grouping the topics in a dataset based on their importance (centrality) and development (density) (Cobo et al., 2011; Aria & Cuccurullo, 2017). Software like Biblioshiny typically uses methods such as co-word analysis to create these types of maps (Callon et al., 1991). In thematic maps, "**Centrality**" indicates how important or central a theme is in the research field. High centrality indicates that a theme plays a critical role in the field by establishing strong connections with other themes (Small, 1973). Degree of Development (Density): Indicates how developed the internal structure of the theme is. High density indicates that a theme has been thoroughly studied and well-organized (Zupic & Čater, 2015).

The 4 sections in the thematic map are, in order;
Motor Themes (Motor Themes-High Centrality, High Density): Refers to mature and effective topics that form the field's core (Cobo et al., 2011).
Niche Themes (Düşük Merkezilik, Yüksek Yoğunluk): More specific and in-depth studied themes but with fewer connections in the overall field (Callon et al., 1991).
Emerging or Declining Themes (Low Centrality, Low Density): Newly emerging or losing interest topics (Small, 1973).
Basic Themes (Basic Themes-High Centrality, Low Density): Represent topics that form the

foundations of the field, have a wide area of interest, but have not yet been thoroughly researched (Aria & Cuccurullo, 2017).

Thematic maps facilitate understanding the structure and development of a research field and reveal the emerging or rising themes within the field. At the same time, it helps identify high-impact or emerging areas (Cobo et al., 2011; Zupic & Čater, 2015; Callon et al., 1991). In light of this data, the thematic map and accompanying network map produced by the Biblioshiny software on "**architectural photography**" are shown in Figures 14 and 15.

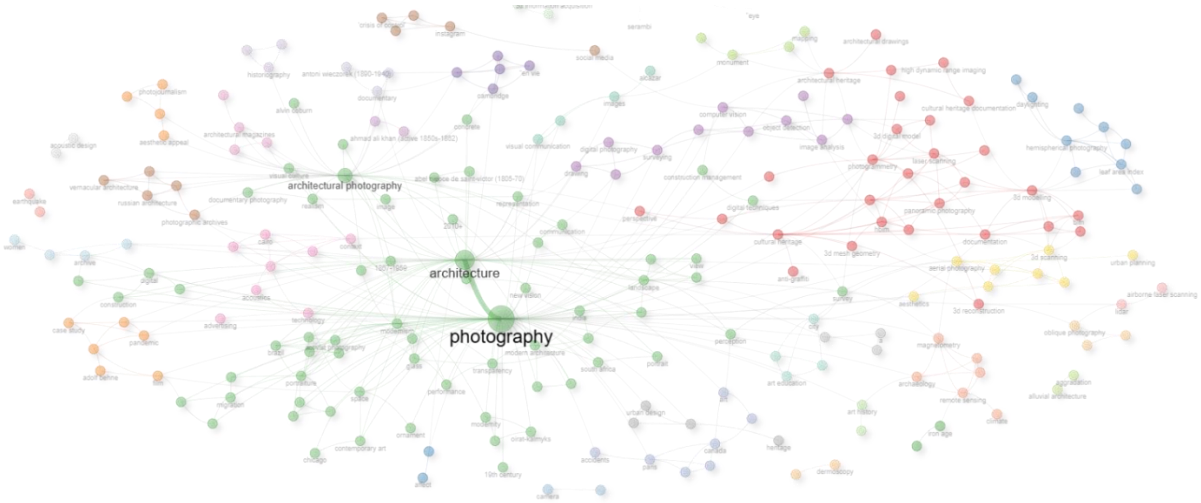

Figure 14. Network map of the term "**Architectural Photography**"

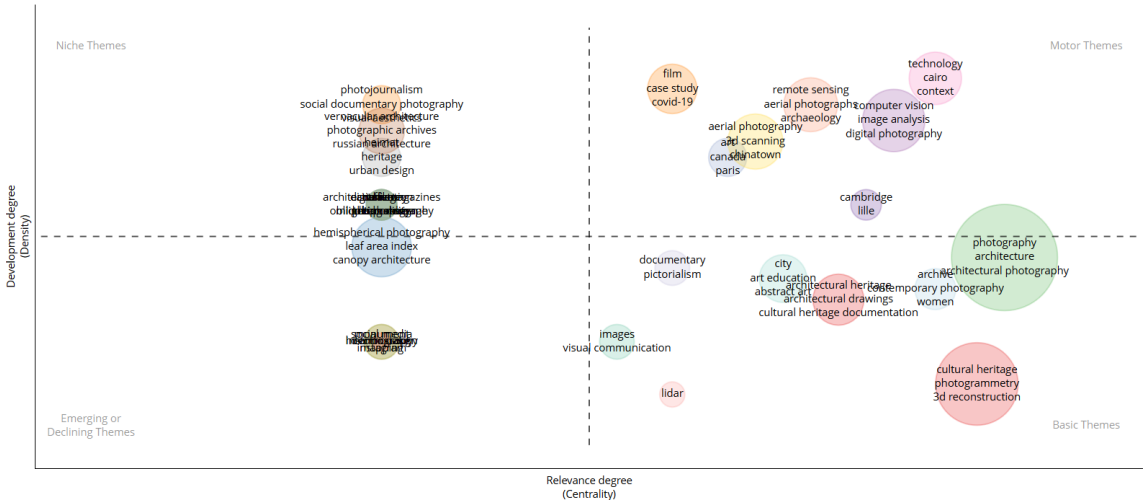

Figure 15. Thematic map of the term "**Architectural Photography**"

VOSviewer Analysis

VOSviewer is a software developed for bibliometric analysis and scientific mapping (Van Eck & Waltman, 2010). This software visualizes citation networks, keyword relationships, and collaboration networks in the academic literature. In systematic literature reviews, it is preferred to understand the intellectual structure of research fields, identify trends, and establish the conceptual framework (Donthu et al., 2021). Especially through clustering algorithms and network analyses, it allows for identifying significant works in the literature and analyzing the developmental dynamics of scientific fields. Co-occurrence analysis utilizing authors' keywords is a prevalent strategy in bibliometric studies, employed to discern essential themes, interdisciplinary connections, and research trends inside a certain domain (Van Eck & Waltman, 2010). This analysis illustrates the commonly co-occurring keywords in the literature as network structures and clusters, elucidating the conceptual framework of

the research domain (Donthu et al., 2021). The acquired data assists researchers in monitoring advancements in the field, pinpointing deficiencies in the literature, and directing subsequent studies (Aria & Cuccurullo, 2017). In this context, keywords pertaining to "**architectural photography**" from the authors (a total of 1,743 keywords) that were utilized at least three times were incorporated into the mapping (46 keywords met the threshold criterion), resulting in the network map depicted in Figure 16.

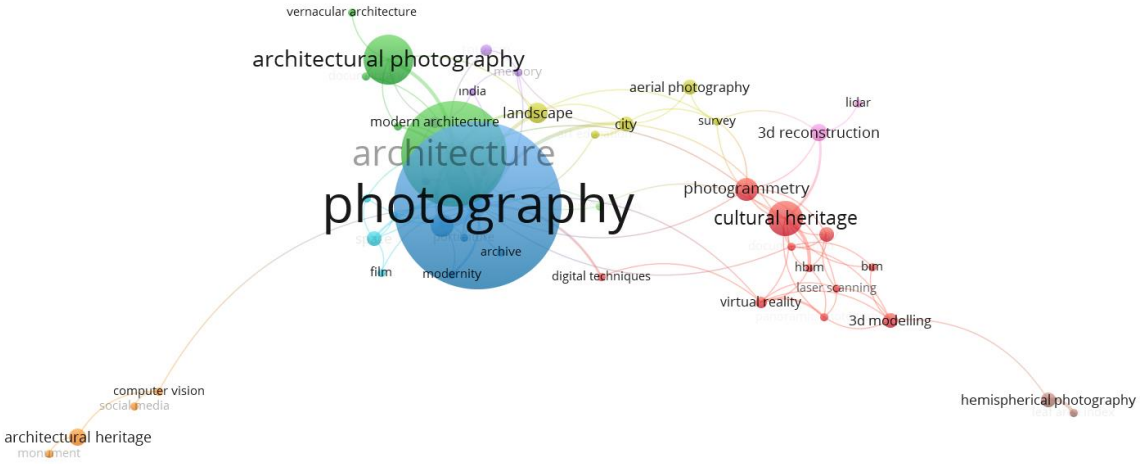

Figure 16. Network map of keyword co-occurrence related to "**Architectural Photography**"

The highlighted clusters emphasize various facets and research trends in architectural photography. Table 2 demonstrates the links within clusters, elucidating the correlations between keywords and highlighting the prevailing themes in the literature. According to cluster analyses, the following evaluations can be made.

Table 2. Analysis of Clusters in the Network Data

Cluster No	*Keywords*
Cluster 1	3D modelling, BIM, Cultural heritage, Digital techniques, Documentation, HBIM, Laser scanning, Panoramic photography, Photogrammetry, UAV, Virtual reality
Cluster 2	Architectural photography, Architecture, Documentary, Vernacular architecture, Visual culture
Cluster 3	Archive, Modernism, Modernity, Photography, Portraiture
Cluster 4	Aerial photography, Art education, City, Landscape, Survey
Cluster 5	India, Memory, Modern architecture, Tourism, Transparency
Cluster 6	Contemporary art, Film, Space, Technology
Cluster 7	Architectural heritage, Computer vision, Monument, Social media
Cluster 8	Hemispherical photography, Leaf area index
Cluster 9	3D reconstruction, Lidar
Cluster 10	Construction
Cluster 11	Representation

Cultural Heritage and Digital Documentation (Cluster 1)
This cluster comprises phrases like "**cultural heritage**," "**photogrammetry**," "**3D modeling**," and "**virtual reality**," signifying that architectural photography is intimately linked to the documentation of cultural heritage. Technologies include photogrammetry, laser scanning, and Building Information Modeling (BIM) are extensively utilized in digital preservation procedures.

Conceptual Framework of Architectural Photography (Cluster 2)

Terms such as "**architectural photography**," "**architecture**," "**vernacular architecture**," and "**documentary**" emphasize the recording and visual narrative elements of architectural photography. These findings indicate that architectural photography is an artistic discipline and a means of architectural documentation.

Modernism, Archiving, and Aesthetic Photography (Cluster 3)
This cluster encompasses concepts like "**archive**," "**modernity**," "**photography**," and "**portraiture**," connecting architectural photography to contemporary architectural movements and aesthetic principles. This discovery indicates that photography serves as a means of documenting and a vital element of artistic expression.

Aerial Photography and Landscape Documentation (Cluster 4)
This cluster illustrates the amalgamation of architectural photography with urban landscape documentation, geographic analysis, and mapping techniques, with keywords such as "**aerial photography**," "**survey**," "**landscape**," and "**city**." The growing significance of remote sensing technology in architectural research is shown in this cluster.

Memory and Spatial Perception in Architectural Photography (Cluster 5)
Terms like "**memory**," "**modern architecture**," "**tourism**," and "**India**" signify the connection between architectural photography and spatial memory, cultural tourism, and heritage conservation. This cluster emphasizes the preservation and promotion of architectural identity via photographic recording.

Convergence of Art, Film, and Technology (Cluster 6)
Terms such as "**contemporary art**," "**film**," "**technology**," and "**space**" highlight the convergence of architectural photography with cinematography and media arts. This cluster illustrates that architecture photography is progressively utilized as a medium in visual narrative and multimedia arts.

Artificial Intelligence and Digital Visualization (Cluster 7)
Terms like "**computer vision**," "**architectural heritage**," and "**social media**" indicate that AI-driven analysis and computer vision methodologies are increasingly essential to architectural documentation. This cluster underscores the increasing influence of social media platforms on the distribution and examination of architectural photographs.

Advanced Visualization Methods (Clusters 8 and 9)
Terms like "**hemispherical photography**," "**leaf area index**," "**3D reconstruction**," and "**lidar**" exemplify the application of sophisticated imaging and visualization methods in architectural photography.

Architectural Photography in Construction and Representation (Clusters 10 and 11)
"**Construction**" and "**representation**" underscore the significance of architectural photography in chronicling construction activities and depicting architectural creations.

Bibliometric coupling is a citation-based bibliometric analysis technique that measures the similarity between research entities based on shared references. If two articles, institutions, or countries cite the same sources, they are considered coupled, with the strength of their relationship determined by the number of shared references (Kessler, 1963). At the country level, this method examines the similarity between nations based on the number of shared references in their academic publications, offering insights into global research collaboration and knowledge dissemination. The bibliometric coupling of countries with the term "**Architectural Photography**" is illustrated in Figure 17.

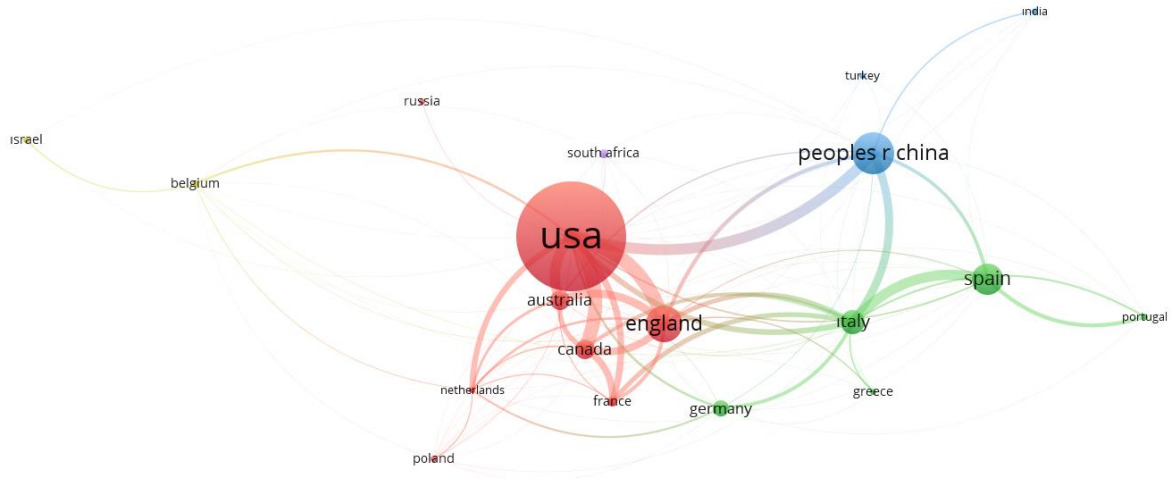

Figure 17. Bibliometric coupling network of the countries.

Figure 17 depicts the bibliometric coupling network of nations in architectural photography research, highlighting main contributors and international collaboration trends. The USA stands as the preeminent center, with robust bibliometric connections with England, Canada, France, Australia, and the Netherlands, underscoring its pivotal influence in the discipline. A European research cluster, consisting of Germany, Italy, Spain, and England, demonstrates significant regional collaboration, presumably facilitated by EU-funded initiatives and institutional alliances. China is rising as a research force, with robust connections with Italy, Spain, and Turkey, indicating a rise in interdisciplinary and international collaboration. Peripheral nations like Belgium, Russia, Israel, and South Africa exhibit diminished bibliometric coupling, signifying restricted common references and autonomous study paths. The comprehensive network underscores the USA and China as significant influencers, while Europe sustains robust regional interconnections, highlighting the necessity of joint research and knowledge dissemination in architectural photography.

CONCLUSIONS

This research offers an extensive bibliometric analysis of architectural photography, incorporating co-occurrence analysis, bibliometric coupling, and keyword clustering through the use of VOSviewer and Biblioshiny software. The findings indicate that architectural photography has transformed into an interdisciplinary research domain, integrating cultural heritage documentation, digital visualization, and computational imaging methodologies. The analysis of 470 publications published in Web of Science (WoS) indicates substantial expansion in the field during the last twenty years, characterized by heightened academic interest and worldwide research collaborations.

The co-occurrence analysis reveals eleven subject clusters, each signifying a unique research domain in architectural photography. These encompass the preservation of cultural heritage, photogrammetry, AI-enhanced visualization, digital media representation, and immersive technologies including virtual reality and augmented reality. The bibliometric coupling study at the national level reveals that the USA, China, and European nations (notably the UK, Spain, and Italy) are the primary contributors. The USA continues to be a primary research center, European nations demonstrate robust regional interconnections, and China has become a significant contributor with increasing academic impact. Additionally, India and Turkey are recognized as emerging contributors, indicating a broadening of research interest outside the historically dominant Western regions.

The Biblioshiny study corroborates these findings by identifying the most prominent authors, journals, and institutions in the field of architectural photography research. It also recognizes significant keywords such as "**photogrammetry**," "**digital documentation**," "**3D modeling**," and "**virtual reality**," indicating a transition in the discipline towards computational and digital approaches. The yearly publishing trend indicates a consistent rise in research production, particularly in works centered on AI-assisted imaging, deep learning applications, and multidisciplinary partnerships

between architecture and digital humanities.

Notwithstanding these achievements, numerous research gaps persist. A primary concern is the restricted incorporation of AI in the study of architectural photography. Although AI-driven image categorization, object detection, and automated augmentation approaches are extensively utilized in several domains, their applicability in architectural documentation, historical research, and real-time visual recognition is predominantly unexamined. A further deficiency is the absence of immersive and interactive visualization techniques. Despite the growing utilization of VR, AR, and extended reality (XR) technologies in heritage conservation and virtual tourism, their implementation in architecture photography for real-time documentation and spatial narrative remains nascent.

The lack of defined approaches in computational photography poses a hurdle. The application of LiDAR scanning, high-dynamic-range (HDR) imagery, and panoramic stitching methods in architectural documentation exhibits considerable variability among research, resulting in discrepancies in data collection and interpretation. Establishing a cohesive framework for digital architectural photography workflows would enhance the precision, consistency, and compatibility of research outcomes.

A significant discovery from the bibliometric analysis is the regional discrepancy in research contributions. Western nations, especially in Europe and North America, predominate in architectural photographic study, whereas areas like Latin America, Africa, and Southeast Asia are notably underrepresented. Broadening the geographical focus of future research to encompass many architectural traditions and vernacular design methods would augment the worldwide significance of the discipline.

The growing dependence on high-resolution imagery, real-time 3D visualization, and digital archiving prompts environmental and ethical issues. The ecological consequences of extensive digital documentation initiatives, energy-demanding AI computation, and the sustainability of data storage are topics that have garnered insufficient attention in scholarly literature. Future research ought to concentrate on creating energy-efficient computing techniques and establishing ethical frameworks for the digitization of cultural material.

In conclusion, architectural photography is experiencing a profound transition, propelled by technology developments, multidisciplinary research, and digital innovations. The amalgamation of artificial intelligence, immersive visualization, and standardized documentation techniques will define the future of the discipline. Broadening research beyond Western-centric paradigms and tackling sustainability and ethical dilemmas will be essential for guaranteeing the responsible and inclusive advancement of architectural photographic research. This work provides a basis for additional investigation, delivering significant insights for scholars, practitioners, and policymakers involved in architectural documentation, digital humanities, and cultural heritage protection.

REFERENCES

Abeid, J., & Arditi, D. (2002). Linking Time-Lapse Digital Photography and Dynamic Scheduling of Construction Operations. Journal of Computing in Civil Engineering, 16(4), 269-279. doi:10.1061/(ASCE)0887-3801

Abeid, J., & Arditi, D. (2002). Time-Lapse Digital Photography Applied to Project Management. Journal of Construction Engineering and Management, 128(6), 530-535. https://doi.org/10.1061/(ASCE)0733-9364(2002)128:6(530)

Abeid, J., Allouche, E., Arditi, D., & Hayman, M. (2003). PHOTO-NET II: A computer-based monitoring system applied to project management. Automation in Construction, 12(5), 603-616. https://doi.org/10.1016/S0926-5805(03)00042-6

Acar, S. (2015). Capturing Constantinople: Travel albums (1884-1910) (Doctoral dissertation, Middle East Technical University). Retrieved from https://etd.lib.metu.edu.tr/upload/12619453/index.pdf

Alexander, C. (2011). Julius Shulman's Los Angeles. Getty Publications.
Al-Sallal, K. A. (2005). Easing high brightness and contrast glare problems in universal space design studios in the UAE: Real models testing. Renewable Energy, 31(5), 617–630. https://doi.org/10.1016/j.renene.2005.08.011
Al-Sallal, K. A. (2010). Daylighting and visual performance: evaluation of classroom design issues in the UAE. International Journal of Low-Carbon Technologies, 5(4), 201–209. https://doi.org/10.1093/ijlct/ctq025
Al-Sallal, K. A., & Al-Rais, L. (2012). A novel method to model trees for building daylighting simulation using hemispherical photography. Journal of Building Performance Simulation, 6(1), 38–52. https://doi.org/10.1080/19401493.2012.680496
Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007
Arruda, H., Silva, É., Lessa, M. A., & Proença, D. (2022). VOSviewer and Bibliometrix. Journal of the Medical Library Association, 110(4), 392–395. https://doi.org/10.5195/jmla.2022.1434
Bate, D. (2016). Daguerre's Abstraction. Photographies, 9(2), 135–146. https://doi.org/10.1080/17540763.2016.1185881
Bellow, J., & Nair, P. (2003). Comparing common methods for assessing understory light availability in shaded-perennial agroforestry systems. Agricultural and Forest Meteorology, 114(3-4), 197-211. https://doi.org/10.1016/S0168-1923(02)00173-9
Bergera, I. (2016). Photography and modern architecture: A distinctive narrative from Spain. The Journal of Architecture, 21, 1127–1148. https://doi.org/10.1080/13602365.2016.1233449
Blecksmith, A. (2011). A transitional place: Julius Shulman's A to Z negatives. Getty Research Journal, 201–208. https://doi.org/10.1086/grj.3.23005398
Britton, K. (2016). Robert Damora and the mission of American architecture. The Journal of Architecture, 21, 1011–995. https://doi.org/10.1080/13602365.2016.1229687
Callon, M., Courtial, J.P. & Laville, F. (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemsitry. Scientometrics 22, 155–205. https://doi.org/10.1007/BF02019280
Cobo, M., López-Herrera, A., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. Journal of the American Society for Information Science and Technology, 62(7), 1382–1402. https://doi.org/10.1002/asi.21525
Comazzi, J. (1999). Photography Matters: Balthazar Corab's Legacy in the Saarinen Office. University of Minnesota.
Coté, J.F., Widlowski, J.L., Fournier, R.A. and Verstraete, M.M. (2009) The Structural and Radiative Consistency of Three
Dimensional Tree Reconstructions from Terrestrial Lidar. Remote Sensing of Environment, 113, 1067-1081. https://doi.org/10.1016/j.rse.2009.01.017
Daniilidis, K., & Klette, R. (2006). Imaging beyond the pinhole camera. In Springer eBooks. https://doi.org/10.1007/978-1-4020-4894-4
De Tomasi, F. (2023). Notes on camera obscura: Three contemporary artistic perspectives on the path of photography. Arte, Individuo y Sociedad, 35(4), 1397–1414. https://doi.org/10.5209/aris.87944
Denton, M. (2002). Francis Wey and the discourse of photography as art in France in the early 1850s: 'Rien n'est beau que le vrai; mais il faut le choisir'. Art History, 25(5), 622–648. https://doi.org/10.1111/1467-8365.00348
Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070
Edwards, E. (2014). Nineteenth-century photographs and architecture: Documenting history, charting progress and exploring the world. Visual Studies, 29(2), 225–226. https://doi.org/10.1080/1472586X.2014.887289
Fabuel-Perez, I., Hodgetts, D., & Redfern, J. (2010). Integration of digital outcrop models (DOMs) and high resolution sedimentology – workflow and implications for geological modelling: Oukaimeden Sandstone Formation, High Atlas (Morocco). Petroleum Geoscience, 16(2), 133–154. https://doi.org/10.1144/1354-079309-820

Finch, c. (1991). Early California Photography, the Pioneering Vision of Western Image-makers. Architectural digest, 48(5), 152.
Finch, C. (1992). Vintage Photography of the American West. Architectural Digest, 49(6), 48.
Finch, C. (1999). Internal affairs: While auto exteriors get most attention, interiors are increasingly in the spotlight. A look inside three innovative new designs (Audi-TT, Chrysler-PT-Cruiser, Honda-HR-V. Photography by Chris Simpson). Architectural Digest, 126-131.
Galantucci, R. A., & Fatiguso, F. (2019). Advanced damage detection techniques in historical buildings using digital photogrammetry and 3D surface anlysis. Journal of Cultural Heritage, 36, 51-62. https://doi.org/10.1016/j.culher.2018.09.014
Gernsheim, H. (1977). The 150th anniversary of photography. History of Photography, 1(1), 3–8. https://doi.org/10.1080/03087298.1977.10442876
Golparvar-Fard, M., Peña-Mora, F., & Savarese, S. (2011). Integrated sequential as-built and as-planned representation with D 4AR tools in support of decision-making tasks in the AEC/FM industry. Journal of Construction Engineering and Management, 137(12), 1099-1116. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000371
Hamber, A. (2004). Architectural Photography. History of Photography, 28(4), 388–389. https://doi.org/10.1080/03087298.2004.10441347
Henfridsson, O., Mathiassen, L., & Svahn, F. (2014). Managing Technological Change in the Digital Age: The Role of Architectural Frames. Journal of Information Technology, 29(1), 27-43. https://doi.org/10.1057/jit.2013.30
Higgott, A., & Wray, T. (2016). Camera constructs: Photography, architecture, and the modern city. https://doi.org/10.4324/9781315260921
Howie, E. (2010). Proof of the forgotten: A Benjaminian reading of Daguerre's two views of the Boulevard du Temple. History of Photography, 127-143. https://doi.org/10.1057/9780230277960_7
Hyun, M. S. (2016). Seeing architectural photographs: Space and time in the works of Julius Shulman and Ezra Stoller (Doctoral dissertation). Georgia Institute of Technology.
Josephy, S. (2017). Acropolis now: Ponte City as 'portrait of a city'. Thesis Eleven, 141(1), 67-85. https://doi.org/10.1177/0725513617720243
Kessler, M. M. (1963). Bibliographic coupling between scientific papers. American Documentation, 14(1), 10–25. https://doi.org/10.1002/asi.5090140103
Kirby, A. (2023). Exploratory bibliometrics: Using VOSviewer as a preliminary research tool. Publications, 11(1), 10. https://doi.org/10.3390/publications11010010
Kucharik, C. J., Norman, J. M., Murdock, L. M., & Gower, S. T. (1997). Characterizing canopy nonrandomness with a multiband vegetation imager (MVI). Journal of Geophysical Research Atmospheres, 102(D24), 29455–29473. https://doi.org/10.1029/97jd01175
Kusnerz, P. A. (2004). 'At First Light': A conference report. History of Photography, 28(2), 165–172. https://doi.org/10.1080/03087298.2004.10441304
Leblanc, S. G., Chen, J. M., Fernandes, R., Deering, D. W., & Conley, A. (2005). Methodology comparison for canopy structure parameters extraction from digital hemispherical photography in boreal forests. Agricultural and Forest Meteorology, 129(3–4), 187–207. https://doi.org/10.1016/j.agrformet.2004.09.006
Leblanc, S., & Fournier, R. (2014). Hemispherical photography simulations with an architectural model to assess retrieval of leaf area index. Agricultural and Forest Meteorology, 194, 64-76. https://doi.org/10.1016/j.agrformet.2014.03.016
Markscheffel, B., & Schröter, F. (2021). Comparison of two science mapping tools based on software technical evaluation and bibliometric case studies. COLLNET Journal of Scientometrics and Information Management, 15(3), 365–396. https://doi.org/10.1080/09737766.2021.1960220
Martínez, D. D. (2014). Objetivo moderno. La fotografía de Julius Shulman y la construcción de la imagen de la arquitectura del sur de California. RITA_ Revista Indexada de Textos Académicos, 2, 62–67. https://doi.org/10.24192/2386-7027(2014)(v2)(01)
McLaurin, B. T., & Steel, R. J. (2006). Architecture and origin of an amalgamated fluvial sheet sand, lower Castlegate Formation, Book Cliffs, Utah. Sedimentary Geology, 197(3–4), 291–311. https://doi.org/10.1016/j.sedgeo.2006.10.005
Monteiro, S. (2010). "Nothing is so dangerous as hypothesis": The Mission Héliographique,

photography, and the spectacle of history. Photography and Culture, 3(3), 297–320. https://doi.org/10.2752/175145109X12804957025598
Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. (2020). Software tools for conducting bibliometric analysis in science: An up-to-date review. Profesional De La Informacion, 29(1), 4. https://doi.org/10.3145/epi.2020.ene.03
Motta, R. J. (2009). The future of photography. Proceedings of SPIE, the International Society for Optical Engineering/Proceedings of SPIE, 7537, 753702. https://doi.org/10.1117/12.854918
Mudie, E. (2011). Building conversations: Architectural photography as discourse. Comparative Technology Transfer and Society, 38(4), 11–13. https://doi.org/10.1525/AFT.2011.38.4.11
Murray, N., & Josephy, S. (2022). Learning from Steinkopf. Curator: The Museum Journal, 65(3), 553-567. https://doi.org/10.1111/cura.12515
Murray, N., & Josephy, S. (2023). "An African View": The photography of Denise Scott Brown. Curator: The Museum Journal, 67(1), 119-131. https://doi.org/10.1111/cura.12609
Nguyen, V., Fournier, R. A., Côté, J., & Pimont, F. (2022). Estimation of vertical plant area density from single return terrestrial laser scanning point clouds acquired in forest environments. Remote Sensing of Environment, 279, 113115. https://doi.org/10.1016/j.rse.2022.113115
Niedenthal, S. (1993). "Glamourized Houses": Neutra, Photography, and the Kaufmann House. Journal of Architectural Education (1984-), 47(2), 101–112. https://doi.org/10.2307/1425171
Osterman, M. 2007. "The Technical Evolution of Photography in the 19th Century", in Focal Encyclopedia of Photography, 4th Edition, Edited by Michael Peres. Amsterdam: Elsevier: 27-36 ISBN 13:978-0-240-80740-9
Pan, X., Yan, E., Cui, M., & Hua, W. (2018). Examining the usage, citation, and diffusion patterns of bibliometric mapping software: A comparative study of three tools. Journal of Informetrics, 12(3), 481–493. https://doi.org/10.1016/j.joi.2018.03.005
Quinnell, J. (2012). Creating and using a camera obscura. Primary Science, 125, 21–23.
Sealy, P. (2016). After a photograph, before photography (takes command). The Journal of Architecture, 21(6), 911–937. https://doi.org/10.1080/13602365.2016.1220970
Sealy, P. (2021). Fragments and fragmentary vision in nineteenth-century architectural photographs. Word & Image, 37(1), 99–116. https://doi.org/10.1080/02666286.2020.1866479
Sealy, P., & Zhang, L. (2024). Faithful Infidelities: 3D Scanning, Speculative Fictions, and Hot-pot Politics for Chinatown, Toronto. Journal of Architectural Education, 78(1), 237–254. https://doi.org/10.1080/10464883.2024.2303941
Sealy, P., (2023) "Realist Ethics", Architectural Histories 11(1). doi: https://doi.org/10.16995/ah.10561
Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. Journal of the American Society for Information Science, 24(4), 265–269. https://doi.org/10.1002/asi.4630240406
Van Eck, N. J., & Waltman, L. (2009). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3
Yildiz, A., & Avinç, G. M. (2024). Artificial Intelligence and Sustainability in Architecture: Scientific mapping in WoS with Biblioshiny. International Journal of Built Environment and Sustainability, 11(3), 121–134. https://doi.org/10.11113/ijbes.v11.n3.1352
Zupic, I., & Čater, T. (2014). Bibliometric methods in management and organization. Organizational Research Methods, 18(3), 429–472. https://doi.org/10.1177/1094428114562629