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Teknolojik Gelişmelerin Mimarlıkta Detaya Yansımaları

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Özet

Bu makale, çağdaş teknolojik gelişmelerin mimarlıkta detay üretimi üzerindeki potansiyel etkilerini incelemeyi amaçlamaktadır. Bu amaçla bibliyometrik analiz yönteminden yararlanılmıştır. Web of Science veri tabanı üzerinden 3D baskı, bilgisayar destekli tasarım yazılımı, yapay zekâ ve sanal gerçeklik kelimeleri filtrelenerek sistematik bir analiz yapılmıştır. Bu analiz VOSviewer uygulamasında anahtar kelime, ortak yazarlık ve yazar atıf analizi çerçeveleri kullanılarak gerçekleştirilmiştir. Araştırma sonucunda yazılım mimarisi, makine öğrenmesi ve artırılmış gerçeklik kavramlarının öne çıktığı görülmüştür. Ayrıca, yapay zekâ ve robotik üretim gibi çağdaş teknolojilerin mimarlıkta detay kavramı üzerindeki etkisi dikkat çekmiştir. Araştırma sonuçları mimarlıkta detay üretim sürecinde yeni araçların geliştirilmeye devam ettiğini ve çağdaş teknolojilerin detay üretim sürecine olan etkisinin giderek artmakta olduğunu göstermektedir. Mimarlıkta detaylar belirli kriterlere ve tasarım prensiplerine göre geliştirilmektedir. Malzemeleri farklılaştırmada ve tasarım kararlarına rehberlik etmede kritik bir rol oynamaktadır. Detaylar, deneyim ve işlevlerine göre uyarlanmış unsurların bir kombinasyonu yoluyla oluşturulmaktadır. Sonuç olarak, tasarım ve üretim alanlarındaki güncel gelişmeler de detay üretim sürecini etkilemektedir.

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Anahtar Kelimeler

Mimari detay, Yapay zekâ, CAD yazılımı, 3D baskı teknolojisi, Teknoloji

Öne Çıkanlar

- *Mimarlık pratiğinde CAD yazılımı ve 3D baskı gibi teknolojiler, hem büyük ölçekli yapıların hem de küçük bileşenlerin yapımında kullanılmaktadır.*
- *Mimari detaylar teknolojik gelişmelere paralel olarak gelişmektedir.*
- *Çağdaş gelişmelerle birlikte dijital araçların kullanımı artmaktadır.*

Reflections of Technological Developments on Detail in Architecture

Abstract

This article aims to examine the potential effects of contemporary technological developments on detail production in architecture. For this purpose, the bibliometric analysis method was utilized. A systematic analysis was conducted by filtering the words 3D printing, computer-aided design software, artificial intelligence, and virtual reality through the Web of Science database. This analysis was performed using keyword, co-authorship, and author citation analysis frameworks in the VOSviewer application. As a result of the research, the concepts of software architecture, machine learning, and augmented reality were found to be prominent. In addition, the impact of contemporary technologies such as artificial intelligence and robotic production on the concept of detail in architecture has attracted attention. The results of the research show that new tools continue to be developed in the detail production process in architecture and the impact of contemporary technologies on the detail production process is increasing. Architecture, details are developed based on specific criteria and design principles. They play a critical role in differentiating materials and guiding design decisions. Details are formed through a combination of experience and elements tailored to their function. As a result, current developments in the fields of design and production also influence the detail production process.

Keywords

Architectural detail, Artificial intelligence, CAD software, 3D printing technology, Technology

Highlights

- *In architectural practice, technologies such as CAD software and 3D printing are used in the construction of both large-scale structures and small components.*
- *Architectural details evolve in parallel with technological advancements.*
- *With contemporary developments, the use of digital tools is increasing.*

1. Introduction

Details in architecture are critical concepts closely related to different disciplines. They can express the semantic dimension of materials and have a broad scope, from everyday language to literature. Many works of art contain subtle details, including drawing techniques, materials, messages, and effects. Details play an important role in determining the originality, functionality, and applicability of a product. Therefore, making correct and effective decisions regarding details is crucial.

Technological developments are increasing alongside the diversification of needs, and architectural details are acquiring new dimensions. These technologies impact not only the planning level but also areas such as 3D modeling, production, and virtual reality. Given the close relationship between architecture and technology, these advancements have a significant impact on architectural details.

While there are global studies on the current status and future potential of technologies like artificial intelligence, there is a lack of research addressing the conceptual dimension

of architectural details and their interaction with different disciplines. It is essential to examine these concepts and explore their future potential. This article discusses how modern technology affects production and methods of expression and its impact on architectural details. Systematic analyses are conducted with various classifications based on existing studies in the literature. In this regard, the article aims to understand the impact of contemporary technological developments on architecture and detail and to make inferences about the future evolution of the architectural detail production process.

2. Material and Method

In line with the research topic, a comprehensive literature review was carried out on detail and contemporary technology in architecture. The study focused on specific keywords and aimed to develop a conceptual framework. In this regard, two concepts are emphasized: architectural details and contemporary technology.

A program called VOS Viewer was used to systematically examine the findings obtained from the Web of Science database. The bibliometric analysis method was employed in this study. Bibliometric analysis is a method that allows studies to be evaluated according to specific characteristics. This method is used to find links between key studies and to draw inferences. In this context, the bibliometric analysis includes groupings such as publications, countries, researchers, and citation analysis [1]. This analytical approach addresses various purposes, such as examining the background of the subject under study, reviewing previous studies, guiding future research, identifying new concepts, and obtaining information about the methods used.

In line with the research topic, studies from many disciplines related to the Web of Science were considered to provide a broad perspective. Studies containing ‘‘architectural detail’’ were first examined to explore the relationship between the concepts. Additionally, the studies were filtered to include the following keywords: technology, 3D printers, CAD software, artificial intelligence, and virtual reality. As a result, 1085 studies from different disciplines were obtained. This data was analyzed using keyword, co-authorship, and author citation analysis frameworks on the VOSviewer application. During the analysis of the data, the Web of Science database (WOS) was used for ease of analysis and accessibility (Figure 1).

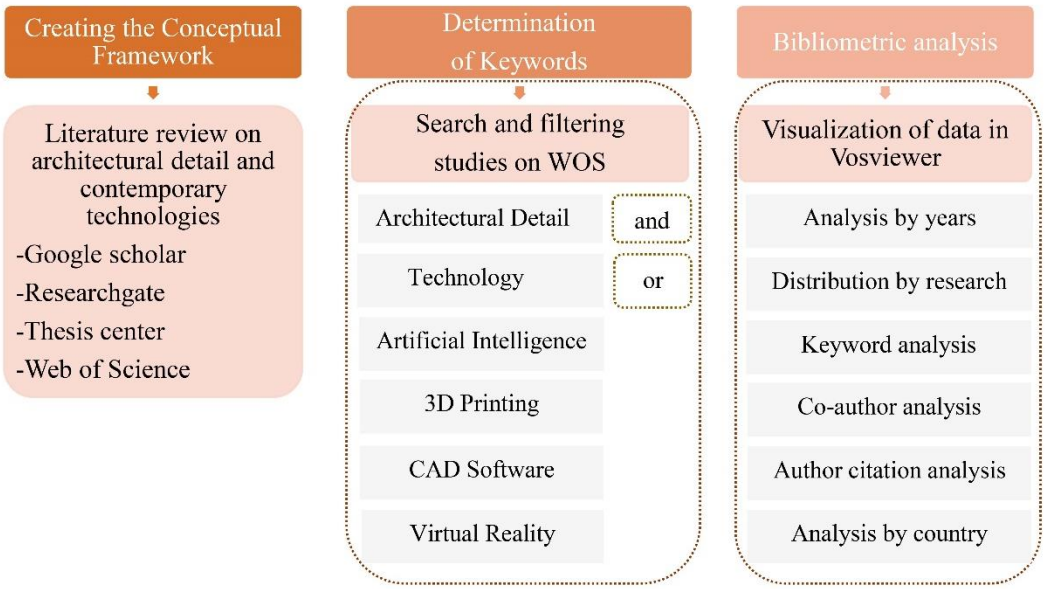

Figure 1. The research process

2.1. Detail in architecture

According to the dictionary, *''detail''* means *''each of the secondary important elements of a whole''* [2]. Additionally, detail implies that the whole is more significant than the sum of its parts. With the digital process, the understanding of details has also evolved. Consequently, details now convey the feasibility of an idea. The interaction between detail and material illustrates both the linear dimension and its practical counterpart [3].

The design or construction technique of a fastener can indicate the designer's approach to the structure. There are differences in the ways each structural element is expressed. Therefore, how the design is expressed is very important. With technological advances, diversity has emerged in areas such as construction and expression techniques, building materials, and construction systems [4].

In detail production in architecture, there are project-specific designs and prefabricated details. The accuracy of the sources used is crucial when utilizing prefabricated details. Therefore, efforts have been made to create resources that deliver quick and accurate results [5]. Materials and needs have diversified over time. Approaches compatible with these conditions and capable of capturing contemporary technology have been deemed necessary. At this point, adaptable, replicable, or original detail designs are encountered [6]. There is a notion of cost and time savings in details obtained through copying.

Detail is the smallest unit that allows a building to form a harmonious whole and can affect a person's perception. Additionally, details can shape a building's form and enhance its functionality [7]. In this respect, details constitute a crucial part of the design and construction process. Detail production is a process closely related to design, experience, and knowledge, and operates with various parameters.

Creativity continues to play a role at various levels in all processes of design. In this process, details in architectural practice must include creative solutions and be used

correctly and in accordance with the design. For this reason, contemporary technologies are employed to determine the function, shape, size, and location of details. With technological advances, details offer solutions for constructing a building. Technological tools require the architect to design different details for the building and to create appropriate formwork. In this respect, details are important as nodes that connect the parts [8]. Accordingly, the following can be deduced:

- Different disciplines are involved in the architectural detail production process.
- The components and fasteners that make up the detail must be used appropriately and in the right place.
- Expression techniques should be clear and understandable [9].
- Details have the potential to reflect the characteristics of the place.
- Contemporary technological developments and details interact.

2.2. Architecture and technology

The relationships between architecture, engineering disciplines, and customers were differentiated by the Industrial Revolution, and expectations have changed over time. Additionally, due to the Industrial Revolution, mass production and closed production systems increased [10]. Therefore, it has become essential to understand how products and structures are made. In this regard, monitoring buildings before, during, and after construction has become an important part of the process.

Historically, the production of building details has developed alongside the production of buildings. In this process, the technological possibilities of the time were instrumental in the development of these details. As requirements diversified, 2D and 3D programs were developed. These software tools are frequently used in the design and construction processes. The development of technology in the fields of design and application has created various effects, ranging from material development to every aspect of design. With the inclusion of digital-based applications, such as artificial intelligence, in design processes, the importance of collaboration between disciplines like architecture and engineering has increased [11].

Many disciplines are involved in building production, from the initial concept to the detail design stage. In this regard, cooperation between different areas of expertise and a holistic approach are considered important. BIM (Building Information Modeling) facilitates design, management, and communication between stakeholders throughout the project process. BIM offers ease of use in many respects, and tasks performed quickly by advanced software provide advantages for designers. However, it takes time for software applications to become widely adopted [12].

In recent years, significant developments have occurred in production technologies, including artificial intelligence, 3D technologies, and robotic arms. 3D printers are used across many disciplines, enabling more precise production with robotic systems. These systems, which rely on specific software and hardware, have the potential to evolve architectural processes. Moreover, these technologies offer numerous benefits, such as reducing waste, enabling the creation of complex forms, saving time and money,

improving working conditions, and facilitating waste recycling. Therefore, the advancement of contemporary technology and its integration into the design process is essential [13].

Various computer-aided software makes it possible to create systems that function similarly to human thought. The development of artificial intelligence dates back to the 1950s. In many ways, this technology is seen as an auxiliary tool that can replace human labor and cognitive functions. Artificial intelligence solves a range of problems and generates numerous solutions [14]. Robotic arm printers enable accurate designs, while portal 3D printing technology can produce structures of various sizes, including multi-story buildings. However, there are still gaps in the infrastructure and regulations needed to apply these technologies in architectural practice, and sufficient equipment must be developed [15].

3. Results and Discussion

The distribution of the studies obtained was analyzed in relation to the research over the years. Figure 2 shows that, overall, the number of studies conducted in recent years has increased, although there have been fluctuations in the last five years. The highest number of studies was observed in 2019 (Figure 2).

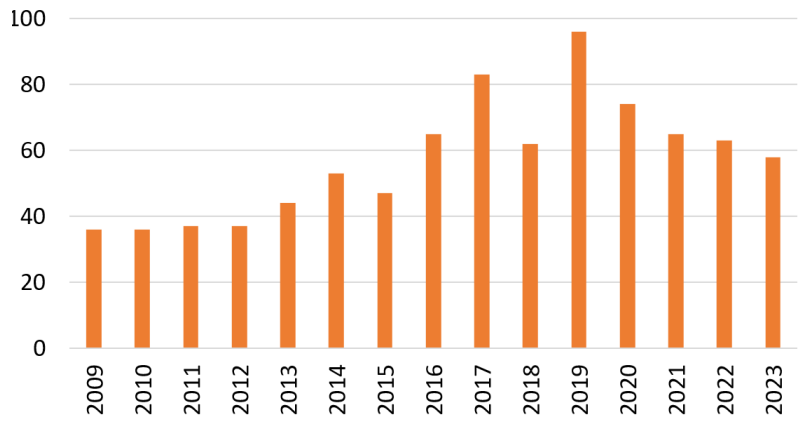

Figure 2. Distribution of studies by years

The research areas of the studies were analyzed using the Web of Science database. Figure 3 shows the distribution of these research areas. The top five fields are engineering, computer science, telecommunications, architecture, and construction building technology (Figure 3).

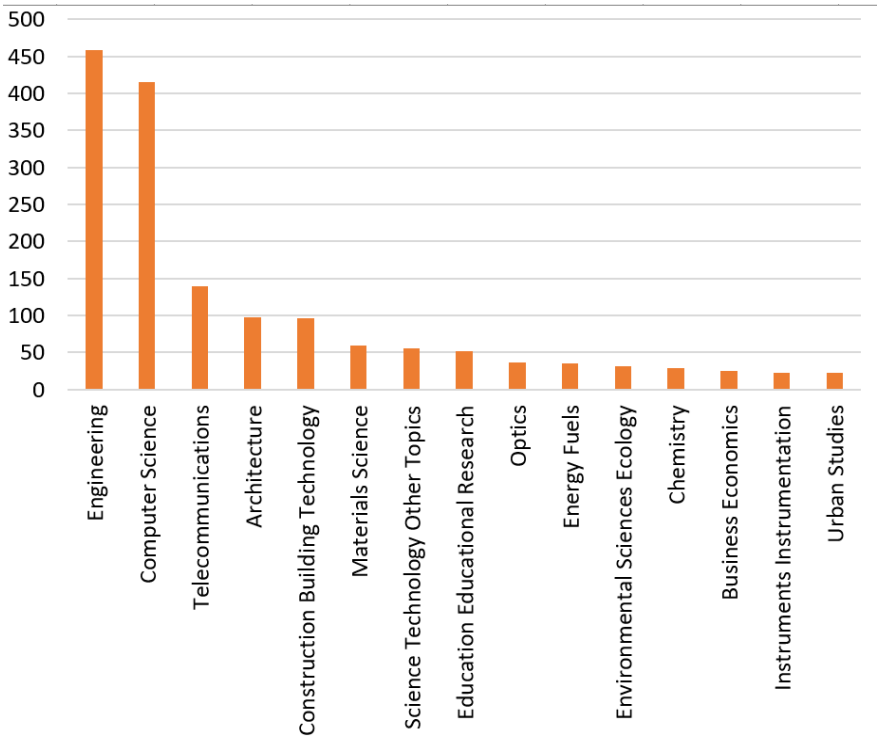

Figure 3. Distribution by research areas

The studies were analyzed based on their citation topics. Figure 4 shows that certain subjects stand out. The top five topics are distributed and real-time computing, design and manufacturing, telecommunications, software engineering, and sustainability science (Figure 4).

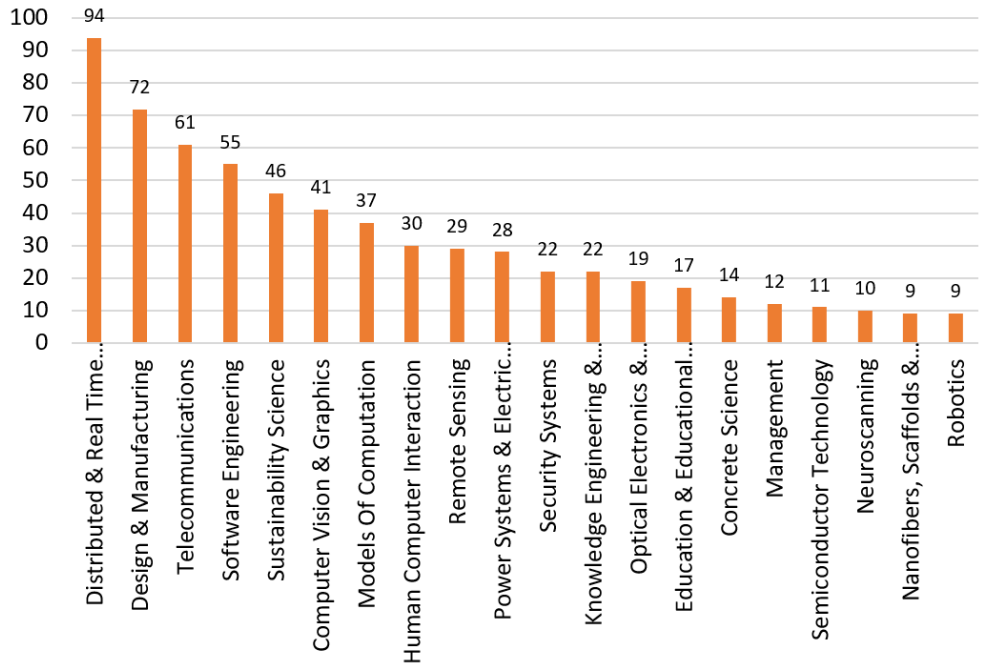

Figure 4. Distribution by citation topics

The distribution of studies by country was analyzed. According to Figure 5, the USA stands out. The top five countries are the USA, China, Italy, Germany, and the UK. Additionally, these comparisons were visualized using VOSviewer. Figure 6 illustrates the connections between these countries (Figures 5-6).

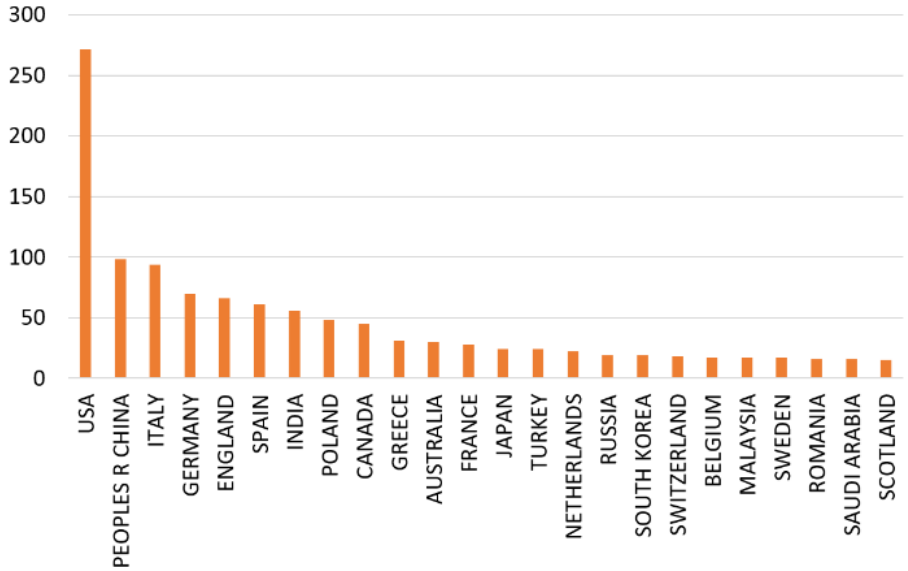

Figure 5. Distribution of studies by country

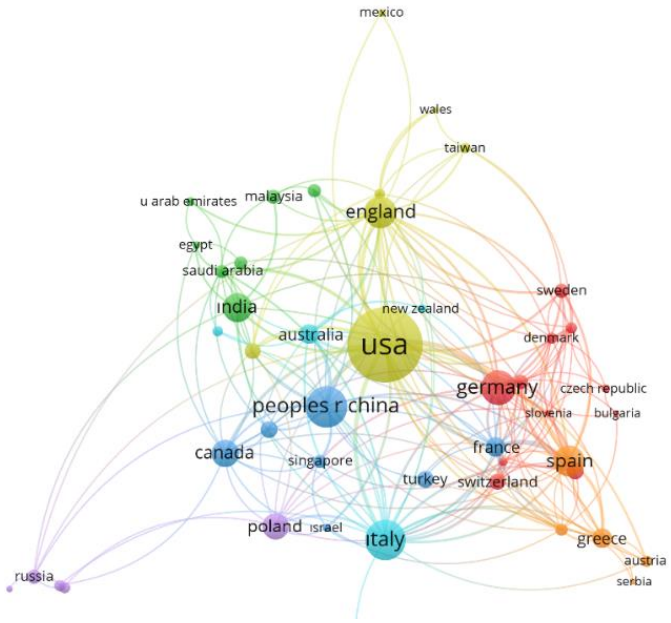

Figure 6. Distribution of studies among countries and their relationships with each other

Concepts related to the subject and their relationships are illustrated in Figure 7. This visualization was created using the VOSviewer application and is important for understanding the general distribution. Words with a frequency of at least three

occurrences were considered. The size of the circles represents the frequency of these words, and the relationships between concepts are depicted by lines.

Additionally, the concepts are color-coded according to historical periods. This technique allows current issues to be viewed together. These concepts are highlighted in the visualization. Furthermore, this study provides insights into the potential future uses of contemporary technology (Figure 7).

In addition to the researched keywords, there are various concepts. Table 1 presents some prominent concepts, including architecture, architectural design, software architecture, design process, additive manufacturing, architectural representation, virtual reality, 3D printing, CAD (computer-aided design) software, augmented reality, blockchain, internet of things (IoT), building information modeling (BIM), 5G, machine learning, deep learning, and simulation (Table 1).

Table 1. Frequency of words

Words	**Record Count**
architecture	35
building information modelling (BIM)	32
virtual reality	30
Internet of things	24
cloud computing	18
architectural education	15
5G	13
blockchain	12
machine learning	11
energy efficiency	11
CAD software	10
simulation	10
architectural design	9
software architecture	8
design process	8
3D printing	8
big data	8
augmented reality	8
deep learning	7
additive manufacturing	6
interoperability	6
industry 4.0	6
technology	6
virtualization	6
fault tolerance	6

rapid prototyping	5
middleware	5
architectural technology	4
visualization	4
contemporary architecture	4
artificial intelligence	4
architectural representation	3
digital technology	3

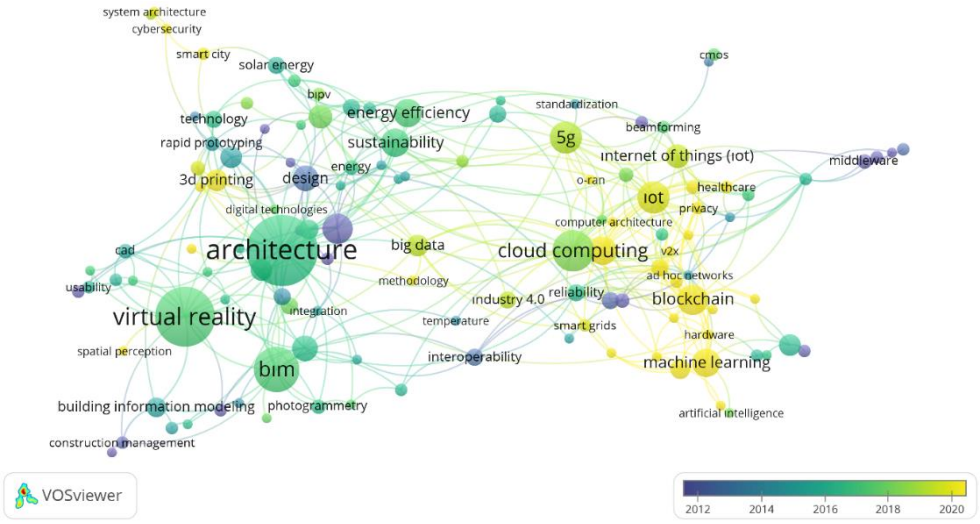

Figure 7. Relationship of different concepts to each other

To serve as a reference for future studies, prominent authors and their interactions are discussed within the scope of this study. In this context, authors with at least two studies on the subject are included. Although there are two distinct clusters in this connection network, the names Aguirre, Chen, Fujimato, Koski, Mashimo, and Herz stand out (Figure 8).

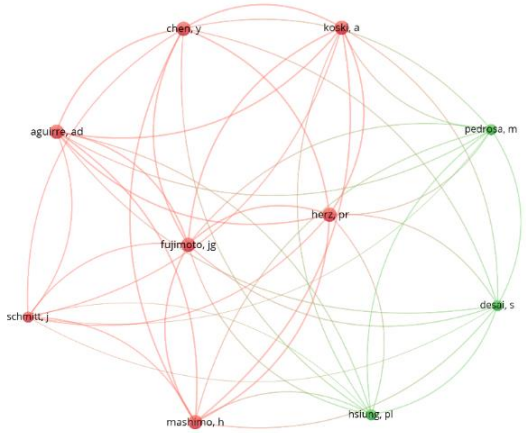

Figure 8. Distribution of co-authors

Authors working within the context of contemporary technologies were examined. Authors with at least five citations were evaluated using VOSviewer. Different colors indicate distinct clusters. In this technique, the size and proximity of the circles are important. Accordingly, Figure 9 shows that some names are related to each other. Prominent authors include Austin (484), Mailloux (7), Young (7), Gizopoulos (38), Roy (1825), and Saxena (1825) (Figure 9).

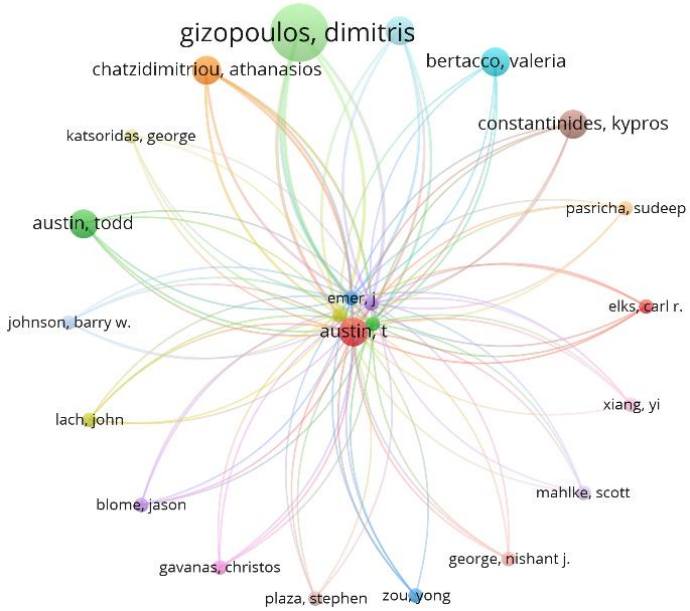

Figure 9. Author citation analysis

4. Conclusion

In architecture, details define many characteristics of a building. Each decision made regarding these details significantly impacts the subsequent processes. Therefore, evaluating the design and construction processes together, while considering the approaches of different disciplines, is crucial for understanding the entire process. With digitalization, it has become possible to monitor the complete construction and design process.

In architecture, details are developed based on specific criteria and design principles. They play a critical role in differentiating materials and guiding design decisions. Details are formed through a combination of experience and elements tailored to their function. As a result, current developments in the fields of design and production also influence the detail production process.

This research examines the interaction between contemporary technological developments and architectural details. It focuses on the advancement of modern technology, its applications, and emerging concepts. To deepen understanding of the subject, the study explores the interactions of digital tools such as artificial intelligence, augmented reality, 3D printers, and CAD software. Understanding the potential future

transformation of details in architecture and addressing these concepts with a holistic approach is considered essential in this study.

- In architectural practice, technology is used to construct both large-scale structures and smaller components. As needs diversify over time, different design approaches and expression techniques emerge. Along with environmental factors, the materials and combination techniques change significantly in this process.
- Architectural details, and the materials used, along with combination techniques, evolve in parallel with technological advances. In this process, various software tools are frequently used to make informed decisions that align with the design.
- Artificial intelligence and software developments continue to gain traction in many disciplines, including architecture. With the advancement of digitalization, the use of digital tools is increasing. The rise of machines and robots is replacing human labor in various applications. Findings also indicate that new tools continue to emerge in the fields of design and production. These tools foster different production methods and introduce concepts such as rapid prototyping and layered manufacturing. All these developments have the potential to transform the process of detail production.
- The significant effects of these developments on large-scale production and detail design applications are emphasized. The results highlight the importance of understanding the integrated use of architectural detail and contemporary technology. Additionally, collaboration among different areas of expertise and a holistic design approach are becoming increasingly important.

Finansal Destek
Yoktur

Çıkar Çatışması
Yoktur

Yazar Katkısı
Özlem CENİKLİ: Fikir, tasarım, analiz, yazım, makale organizasyonu
Yasemin ERBİL: Fikir, tasarım, analiz, yazım, makale organizasyonu

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