

Augmented Reality in Computer Science: A Bibliometric Analysis

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ABSTRACT

This study examines the development and intellectual structure of augmented reality research within the field of computer science through a bibliometric approach. Data were collected from the Scopus database using relevant keywords and analyzed using VOSviewer and Biblioshiny. The analysis focuses on publication trends, influential authors and sources, collaboration networks, and keyword co-occurrence patterns. The results indicate that augmented reality occupies a central position in the research landscape, closely connected with core technological domains such as computer vision, computer graphics, and human-computer interaction. At the same time, the findings reveal a clear shift from technology-driven studies toward application-oriented research, particularly in education and healthcare. Density and overlay visualizations further highlight the emergence of topics related to e-learning, simulation, and user-centered design in recent years. These findings suggest that augmented reality research is evolving into a more interdisciplinary and context-driven field. This study contributes by providing a comprehensive mapping of research trends and identifying potential directions for future studies, particularly in integrating augmented reality with intelligent systems and domain-specific applications.

Keywords: Augmented Reality, Computer Science, Scopus, VOSViewer, Bibliometric Analysis

1. INTRODUCTION

Augmented Reality (AR) has emerged as one of the most transformative technologies within the broader domain of computer science, offering innovative ways to integrate digital information with the physical world. Unlike virtual reality, which immerses users in a completely digital environment, AR enhances real-world experiences by overlaying computer-generated elements such as images, sounds, and interactive data onto the user's surroundings. Over the past two decades, advancements in hardware capabilities, including mobile devices, wearable technologies, and high-performance computing systems, have significantly contributed to the rapid evolution and accessibility of AR applications. These developments have enabled AR to move beyond experimental prototypes into practical implementations across various sectors [1], [2].

In the field of computer science, AR has become a multidisciplinary research area that intersects with computer vision, human-computer interaction, graphics, artificial intelligence, and software engineering. Researchers have explored AR in diverse applications such as education, healthcare, gaming, industrial training, and navigation systems. For instance, AR-based educational tools have demonstrated the ability to improve student engagement and comprehension by visualizing complex concepts, while in healthcare, AR has been used to assist in surgical procedures and medical training simulations. This broad applicability has driven a steady increase in academic publications and research outputs related to AR technologies [1].

The exponential growth of AR-related studies has led to a vast and fragmented body of literature, making it increasingly difficult for researchers to systematically understand trends, influential works, and emerging research directions. Bibliometric analysis serves as a valuable method to quantitatively evaluate scientific publications by analyzing patterns such as citation counts, authorship networks, keyword co-occurrences, and publication distributions over time. Through such analysis, researchers can identify key contributors, dominant themes, and gaps in the

existing literature, thereby providing a comprehensive overview of the development of AR in computer science [3], [4].

Furthermore, the rise of digital databases and indexing platforms has facilitated large-scale bibliometric studies by providing access to extensive collections of academic publications. Tools and techniques for data visualization and network analysis have enhanced the ability to interpret complex relationships among research outputs. As a result, bibliometric analysis has become an increasingly popular approach for mapping scientific knowledge and guiding future research efforts. In the context of AR, this method can reveal how the field has evolved, which technologies have gained prominence, and how collaboration patterns have shaped its development.

Despite the growing number of studies on AR, there remains a lack of comprehensive bibliometric analyses that specifically focus on its role within computer science as a distinct academic discipline. Many existing reviews tend to focus on specific applications or technological aspects rather than providing a holistic view of the field. Consequently, there is a need for a systematic and data-driven examination of AR research to better understand its intellectual structure, research dynamics, and future potential. Addressing this gap will not only benefit researchers but also inform policymakers, educators, and industry practitioners about the trajectory of AR technologies.

Given the rapid expansion and interdisciplinary nature of augmented reality research, it becomes challenging to identify key trends, influential contributions, and research gaps within the field of computer science. The absence of a comprehensive bibliometric analysis limits the ability of researchers to obtain a structured overview of the domain, potentially leading to redundant studies and missed opportunities for innovation. Therefore, there is a need to systematically analyze the existing body of AR literature to uncover patterns in publication growth, authorship, collaboration networks, and thematic evolution. This study aims to conduct a bibliometric analysis of augmented reality research within the field of computer science.

2. METHODS

This study adopts a quantitative bibliometric approach to analyze the development of augmented reality research within the field of computer science. Bibliometric analysis is employed as it enables the systematic evaluation of large volumes of academic literature through measurable indicators such as publication counts, citation analysis, and co-authorship patterns. The study focuses on identifying trends and relationships within the scientific output related to augmented reality by examining metadata from scholarly publications. A descriptive research design is utilized to provide a structured overview of the evolution, productivity, and impact of research in this domain.

The data for this study are collected from reputable academic databases such as Scopus and Web of Science, which are widely recognized for their comprehensive indexing of high-quality scholarly articles. A set of predefined keywords, including “augmented reality,” “AR technology,” and “computer science,” is used to retrieve relevant publications. Inclusion criteria are applied to ensure the relevance and quality of the data, such as limiting the search to peer-reviewed journal articles and conference proceedings published within a specified time frame. The retrieved data are then exported in compatible formats for further processing and analysis. Data cleaning procedures, including the removal of duplicates and standardization of author and keyword names, are conducted to ensure accuracy and consistency.

3. RESULT AND DISCUSSION

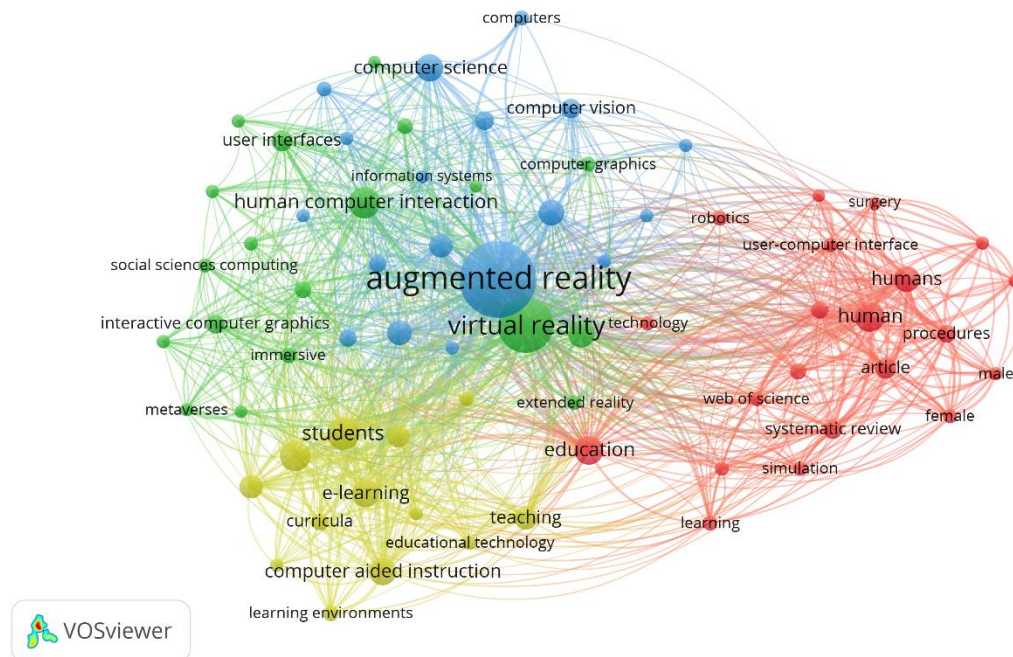


Figure 1. Network Visualization

Source: Data Analysis Result, 2026

Figure 1 reveals that augmented reality occupies a highly central position, indicating its role as the core concept that connects multiple research domains within computer science. Its strong linkage with virtual reality, computer vision, and computer graphics suggests that AR research is deeply rooted in foundational technological fields. This centrality also reflects the interdisciplinary nature of AR, bridging technical development with applied domains. The blue cluster represents the technological foundation of AR, dominated by terms such as computer science, computer vision, and computer graphics. This cluster highlights that a significant portion of AR research focuses on system development, image processing, and rendering technologies. The presence of robotics and user-computer interface within this cluster further indicates the integration of AR with intelligent systems and interactive environments, emphasizing its role in advancing human-machine interaction.

The green cluster emphasizes human-computer interaction (HCI) and user-centered design aspects. Keywords such as human computer interaction, user interfaces, interactive computer graphics, and immersive show that researchers are increasingly concerned with how users experience AR systems. The inclusion of social sciences computing suggests that AR is not only a technical tool but also a medium influencing user behavior, cognition, and social interaction, reflecting a shift toward usability and experiential quality. The yellow cluster clearly represents education and learning applications, with terms like students, e-learning, curricula, and computer-aided instruction. This indicates that education is one of the most prominent application areas of AR in computer science research. The connections between educational technology, learning environments, and teaching show that AR is being widely explored as a tool to enhance engagement, visualization, and learning outcomes, particularly in digital and interactive learning contexts.

The red cluster highlights medical and applied research domains, characterized by keywords such as humans, procedures, surgery, and simulation. This cluster reflects the growing use of AR in healthcare, particularly for training, simulation, and clinical procedures. The presence

of terms like systematic review and article suggests a mature and expanding body of literature in this area.

3.1 Overlay Visualization

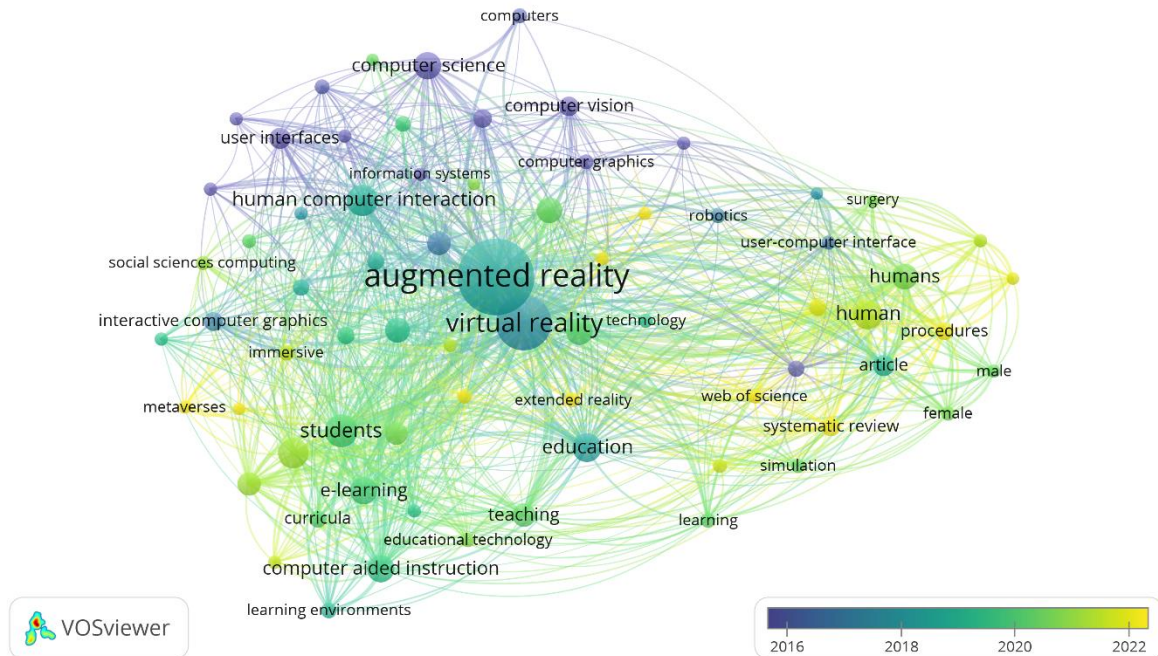


Figure 2. Overlay Visualization
 Source: Data Analysis Result, 2026

Figure 2 illustrates the temporal evolution of research themes in augmented reality, where color gradients represent the average publication year (from earlier in blue/purple to more recent in yellow). The central position of augmented reality and virtual reality remains consistent, indicating their sustained importance across time. However, the surrounding nodes reveal how the focus of research has shifted, reflecting the dynamic development of the field. Earlier studies (around 2016–2018), shown in darker blue and purple tones, are concentrated on foundational technological aspects such as computer science, computer vision, computer graphics, and user interfaces. This suggests that initial research efforts were primarily directed toward building the technical infrastructure of AR systems, including hardware, rendering techniques, and interaction design. These foundational topics form the backbone upon which later application-oriented research has been developed.

More recent studies (around 2020–2022), highlighted in green to yellow tones, show a clear shift toward applied domains, particularly education and healthcare. Keywords such as students, e-learning, curricula, humans, procedures, and simulation indicate growing interest in leveraging AR for practical use cases. This transition reflects the maturation of AR technology, where research is no longer limited to system development but increasingly explores real-world implementation, user impact, and domain-specific innovation.

3.2 Citation Analysis

Table 1. The Most Impactful Literatures

| Citations | Authors and year | Title |
|-----------|------------------|--|
| 3225 | [5] | The case for VM-based cloudlets in mobile computing |
| 1231 | [6] | Augmented reality technologies, systems and applications |

the presence of humans, procedures, and simulation reflects the increasing use of AR in medical and clinical contexts. Although these areas are less dense than the technological core, their clear visibility suggests a shift toward practical implementation, where AR is being integrated into real-world environments and user-centered applications.

Discussion

The findings of this bibliometric analysis reveal that augmented reality has evolved into a central and integrative domain within computer science, connecting a wide range of technological and applied research areas. Across the network, augmented reality consistently appears as the core node, closely linked with virtual reality, computer vision, and human–computer interaction. This pattern indicates that AR is not developing in isolation, but rather as part of a broader ecosystem of immersive and intelligent technologies. The strong interconnection among these domains reflects how AR relies on advances in visual computing, interaction design, and real-time processing, positioning it as a convergence point of multiple technological streams.

At the same time, the clustering structure suggests that the intellectual foundation of AR research remains deeply rooted in technical disciplines. The prominence of keywords such as computer graphics, robotics, and user interfaces shows that a significant portion of the literature continues to focus on system development and performance enhancement. This aligns with the early-stage trajectory of many emerging technologies, where initial research is dominated by engineering and computational challenges. However, the density and centrality of these technical terms also indicate that continuous innovation at the system level remains necessary to support more complex and scalable AR applications.

A notable shift emerges when examining the temporal and density patterns, which highlight the increasing prominence of application-oriented research. In particular, education appears as one of the most significant domains, with strong linkages among students, e-learning, curricula, and instructional technologies. This trend suggests that AR has moved beyond experimental prototypes toward practical implementation in learning environments. The growing attention to educational contexts reflects the perceived value of AR in enhancing engagement, improving conceptual understanding, and supporting interactive learning experiences, especially in digitally mediated environments.

In parallel, the expansion of AR research into healthcare domains further illustrates its maturation and diversification. The presence of keywords such as humans, procedures, surgery, and simulation indicates that AR is increasingly being utilized in clinical training, decision support, and medical visualization. Unlike purely technical research, these applications require interdisciplinary collaboration, integrating insights from medicine, cognitive science, and user experience design. This shift underscores a broader transformation in AR research, where the emphasis moves from technological feasibility toward usability, effectiveness, and real-world impact.

These findings suggest that augmented reality research in computer science is entering a phase characterized by convergence and contextualization. While the technological core remains strong, there is a clear movement toward embedding AR within specific domains that address societal and practical needs. This dual trajectory creates opportunities for future research to explore the integration of AR with emerging technologies such as artificial intelligence and data analytics, as well as to examine its long-term implications in education, healthcare, and beyond. More importantly, it calls for a balanced approach that not only advances technical capabilities but also deepens understanding of user experience, ethical considerations, and domain-specific challenges.

CONCLUSION

This study demonstrates that augmented reality has developed into a central and increasingly interdisciplinary field within computer science, characterized by a strong technological foundation and a growing orientation toward real-world applications. The bibliometric results show

that while early research concentrated on core areas such as computer vision, graphics, and human-computer interaction, more recent developments highlight a clear expansion into domains such as education and healthcare. This shift reflects the maturation of augmented reality from a primarily technical innovation into a practical tool with broader societal relevance. The study underscores the importance of integrating technological advancement with user-centered and context-driven approaches, while also pointing to future research opportunities in areas such as intelligent systems integration, immersive learning environments, and applied interdisciplinary collaboration.

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