

Review

Augmented Reality and Tourism: A Bibliometric Analysis of New Technological Bets in the Post-COVID Era

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Abstract: Tourism is a sector of high relevance worldwide, due to the multiple impacts it generates in local, regional, national, continental, and global economies, and it is a key generator of employment and provides sustenance to an innumerable number of people around the world. There have been many challenges at a global level to improve the user experience in a particular tourist place, where technology has played a highly relevant role in strengthening the conditions for tourists to achieve immersion in the culture, gastronomy, and recreation. The objective of this literature review is precisely to know and understand the key contributions that are currently being developed around the implementation of augmented reality as tourist technological support for user experiences. The literature on this topic is quite dispersed in specialized databases; therefore, it constitutes an opportunity to carry out a more detailed exploration of the topic. To address the different developments that have been carried out on tourism and augmented reality, an analysis was carried out based on the fusion of scientometric analysis and the metaphor of the Tree of Science, in which two relevant visions about the data were generated. The first focused on the different scientometric statistics regarding countries, authors, universities, or research or technological development centers that currently generate new applications based on augmented reality for tourism. The second focused on an evolutionary analysis based on the Tree of Science, analyzing the origins of the basic contributions of research and how it has evolved over time. This review indicates that the topic is currently valid and that it has been strengthened even more with the post-pandemic process, where many technological developments have been strengthened that allow people to enjoy tourist and cultural sites even without leaving home.

Keywords: augmented reality; sustainable tourism; scientometric analysis; technology in tourism; scientific research; environmental impact; innovation in tourism; augmented reality in the tourism industry; sustainable development; trends in tourism

1. Introduction

Tourism is one of the most important sectors of the world economy, from which countless numbers of people subsist [1]. The pandemic has left countless problems in different

economic sectors, but without a doubt, the impact on tourism has been unprecedented. Given this impact, a set of solutions have been implemented that initially sought to boost this sector, both during the pandemic and in the post-pandemic effect. Among these solutions are those based on information technology [2]. The technological developments developed for this sector have varied greatly over time, especially depending on the evolution of the same technology, from interactive Web portals to recommendation systems and georeferenced applications, among many others [3]. The great drawback of this type of solution was that it did not generate added value for the user, such as experiences related to the site, nor did it allow the user to have a real conception of the place they wanted to visit, which is achieved with applications of disruptive technologies such as AR.

As a result of this literary review, it has been possible to show that there are different reviews related to AR applications focused on the tourism sector. A group of these reviews focuses on the identification of new trends or developments in this sector [4]. Others focus on identifying solutions based on VR that have supported interesting applications but have also shown a significant disadvantage in their adaptability to users due to the technical and hardware requirements that must be able to use the applications [5]. Other authors have also focused on applications focused on the inclusion of artificial intelligence to improve the tourism experience in the place where it is applied [6]. However, there are very few works that focus on the evolution of AR that directly permeates the way in which people perceive the place that is the object of the intervention.

That is why in this article, we focus on the application of search equations in the WoS and Scopus databases and extract relevant information from both the records and the citations of each document found. These results were unified into a single data set from which repetitive documents were eliminated. The remaining documents were subsequently analyzed considering the Tree of Science (ToS) metaphor, in which very important aspects such as contributions were analyzed. The analysis was carried out over time using the Tsr R package version 4.3.1 (Beagle Scouts), which was released on 16 June 2023 (<https://cran.r-project.org/web/packages/tsr/index.html>, accessed on 20 August 2023), after which we carried out an analysis based on scientometrics to understand each of the components that make this issue current worldwide.

This study is based on the hypothesis that the adoption of AR in tourism has seen significant growth in the post-COVID era and that this technology is influencing the way tourism destinations are promoted and experienced. Furthermore, it is hypothesized that AR has the potential to improve travel safety and contribute to the conservation of cultural and natural heritage in the tourism sector. To address these hypotheses, this study will focus on analyzing the scientific production related to AR and tourism, examining the most relevant keywords, the most influential authors, and the leading geographic areas in this research. In addition, it will evaluate how AR has been integrated into specific tourism applications and its impact on the tourist experience and the sustainability of destinations. The goal is to provide a holistic view of the relationship between AR and tourism in the post-COVID era and its relevance in the current tourism industry.

The tourism industry has undergone a significant transformation in the post-COVID era, driven largely by technological advances that have redefined the way travelers interact with their destinations. Among these emerging technologies, AR has emerged as a powerful tool to enrich the tourist experience and promote more sustainable and safe tourism. In this context, the purpose of this study is to conduct a comprehensive scientometric analysis of the role of AR in the tourism industry during the post-COVID era. It seeks to examine trends, identify the most relevant research areas, and evaluate the impact of AR on the promotion, management, and sustainability of tourism. To address these hypotheses, this study will focus on analyzing the scientific production related to AR and tourism, examining the most relevant keywords, the most influential authors, and the leading geographic areas in this research. In addition, it will evaluate how AR has been integrated into specific tourism applications and its impact on the tourist experience and the sustainability of destinations. The final objective is to provide a holistic view of the

relationship between AR and tourism in the post-COVID era and its relevance in the current tourism industry, based on the following research question: What are the most notable trends in research science related to AR and tourism in the post-COVID era?

This review is composed of three parts. The first part focuses on a description of the methods and components of the Tree of Science that are applied in this quest. The second part provides an exhaustive analysis of the findings using key scientometric variables such as countries with the highest production, relevant authors, and knowledge networks. In the last part, based on the metaphor of the tree of knowledge, the development progress of the theme is made explicit using the concept of “Root” for seminal articles, “Trunk” for the development of the theme, and “Leaves” for the latest trends.

2. Methods

To accomplish the stated research objective, a methodological framework grounded in bibliometric analysis was used. This approach facilitated a systematic review of seminal contributions related to the deployment of disruptive technologies, such as AR, particularly in the context of post-pandemic societal shifts. Data for this analysis were extracted from two reputable academic databases: Web of Science (WoS) and Scopus [7]. These databases were selected due to their extensive collections of scholarly articles that have undergone rigorous blind peer-review processes [8]. Bibliometric analysis constitutes a quantitative examination of scientific outputs, including but not limited to academic papers and peer-reviewed articles [9]. In a similar vein, bibliometric analysis provides an objective lens through which a topic can be analyzed, leveraging high-volume data for insights [10]. This analytical rigor lends itself well to studies in various disciplines, including sustainable tourism, and offers advantages in terms of replicability for future research endeavors [11]. Therefore, the utilization of bibliometric methodologies is aptly suited for dissecting the intricate dynamics underpinning a given research subject.

The process of merging the results of both databases can be highly complex, for which different tools have been developed such as Bibliometrix [12] and the Tost processing package, which allows merging the databases to obtain a more consensual result of scientific productions. Both databases show a wide diversity of publications, and in this study, we detail the most important contributions that this line of knowledge has to the tourism sector, which is one of the most affected by COVID-19. This unification of records allows a more complete vision of the research and the axis of study that we want to articulate.

Table 1 specifies the different variables that were considered in this literature review. The keywords used were “Augmented Reality” and “tourism” as the main search concepts including publications from 1999 to date, which allowed us to obtain 795 documents in Scopus and 405 in WoS for a total of 1200 publications given the criteria of the search string, even without filtering those that are redundant in both databases. Subsequently, after the data fusion process, a consolidated record of 997 publications was achieved by eliminating repeated documents in both databases. The 997 articles are distributed as follows: articles (458 or 44.6%), conference papers (351 or 34.18%), book chapters (96 or 9.35%), conference reviews (41 or 3.99%), reviews (41 or 3.99%), early access (27 or 2.63%), proceedings papers (3 or 0.29%), books (3 or 0.29%), editorials (3 or 0.29%), book reviews (2 or 0.19%), editorial materials (1 or 0.1%), and errata (1 or 0.1%). From this percentage analysis, it can be noted that most publications are articles and conference papers.

Table 1. Search results for parameters in the databases.

Parameters	WoS	Scopus
Range	2019–2023	
Date	20 August 2023	
Document Type	Articles, book, book chapters, conference proceedings	
Words	Augmented reality and tourism	
Results	405	795
Total (WoS + Scopus)	1200	

When searching for information related to “Augmented reality and tourism”, articles that were not directly linked to the tourism field were automatically excluded. This exclusion ensured that only research that addresses the application of AR in the specific context of tourism is considered. To focus on recent developments, an exclusion criterion was established based on the publication date. Articles published before 2019 were excluded from the search, allowing us to obtain information on the most current trends and advances at the intersection of augmented reality and tourism. As part of the literature selection, those articles that did not present original research or empirical data were excluded. Articles not written in English were excluded to ensure that the selected resources were accessible and could be fully understood. Articles that focused on topics not directly related to augmented reality and tourism were excluded. This helped to maintain relevance and ensure that the selected research relates specifically to the desired field of study.

To consolidate the scientometric analysis detailed in this article, two phases were carried out. The first phase shows an overview of the various applications that have been developed for the tourism sector based on AR, detailing the production by country, journal, and authors. With this review, it is possible to obtain a general view of the state of world production with respect to this research topic. The second phase is aimed at examining the different contributions to this line of knowledge using the metaphor of the Tree of Science (ToS). Figure 1 shows the details of the PRISMA scheme, which specifies all the phases that were carried out to achieve the consolidation of information. For the analysis of the information, a code developed in R Studio by Core of Science (<https://github.com/coreofscience>, accessed on 20 August 2023) was used, which allowed the extraction of relevant information about the results obtained using the search string.

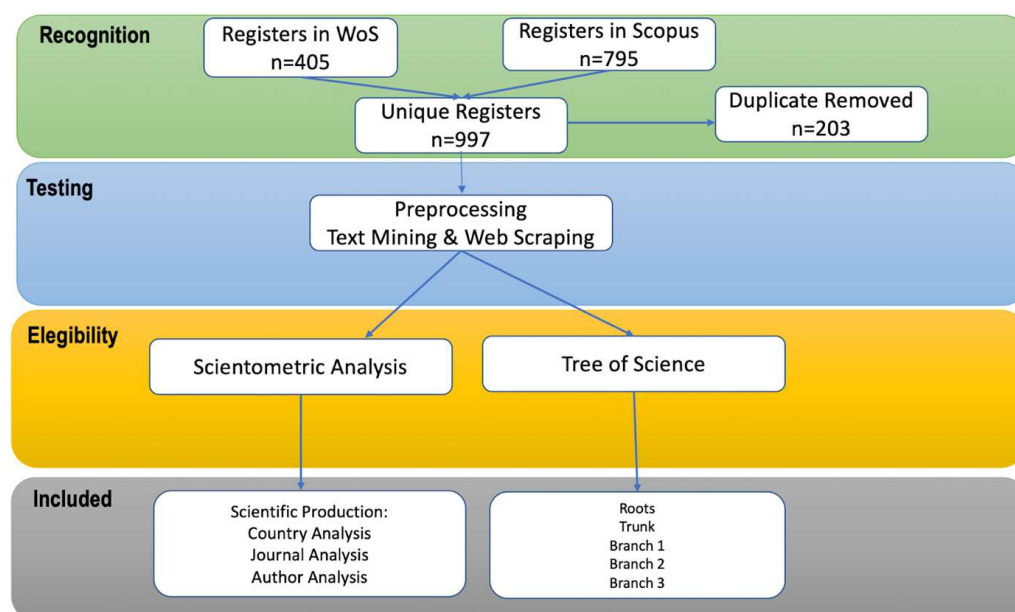


Figure 1. PRISMA flow chart.

2.1. Scientometric Analysis

To analyze scientific data quantitatively, scientometrics is used, which, in this context, allows for the identification of important factors such as the relationship between authors, their citation networks, and annual production. Among the most common ways to perform this type of analysis, we can highlight analyses based on citations [13], collaboration networks [14], and those based on intellectual structure [15]. To determine the contributions that AR provides to the tourism sector, the analysis of countries with a higher level of publications and, therefore, applications, the annual production, and the magazines that usually show the developments in this line of knowledge is carried out in the first instance.

This analysis is based on the assessment of the unified database of Scopus and WoS, which is analyzed using explanatory clusters.

2.2. Tree of Science

The Tree of Science, commonly called ToS, is based on a metaphorical interpretation of a tree [16], in which the articles that are located at the root are those that provide the theoretical foundation of a topic. Then, in the trunk, one can identify how these investigations adopt important development strengths. The sheets show trends in the current applications, which, for this specific case, show where technologies are being developed to provide support to the tourism sector. This methodology has been widely used in different scenarios such as economy [17], education [18], and marketing [19], among others.

3. Results

3.1. Scientometric Analysis

3.1.1. Evolution and Relevant Studies

Figure 2 shows the articles produced during the last 22 years that are related to AR applied to the tourism sector. As can be seen in the graph, production has increased incrementally, and the first works published in 2001 have the largest number of citations because they were the first to venture into the topic. Starting in 2010, the incremental production process began in both WoS and Scopus.

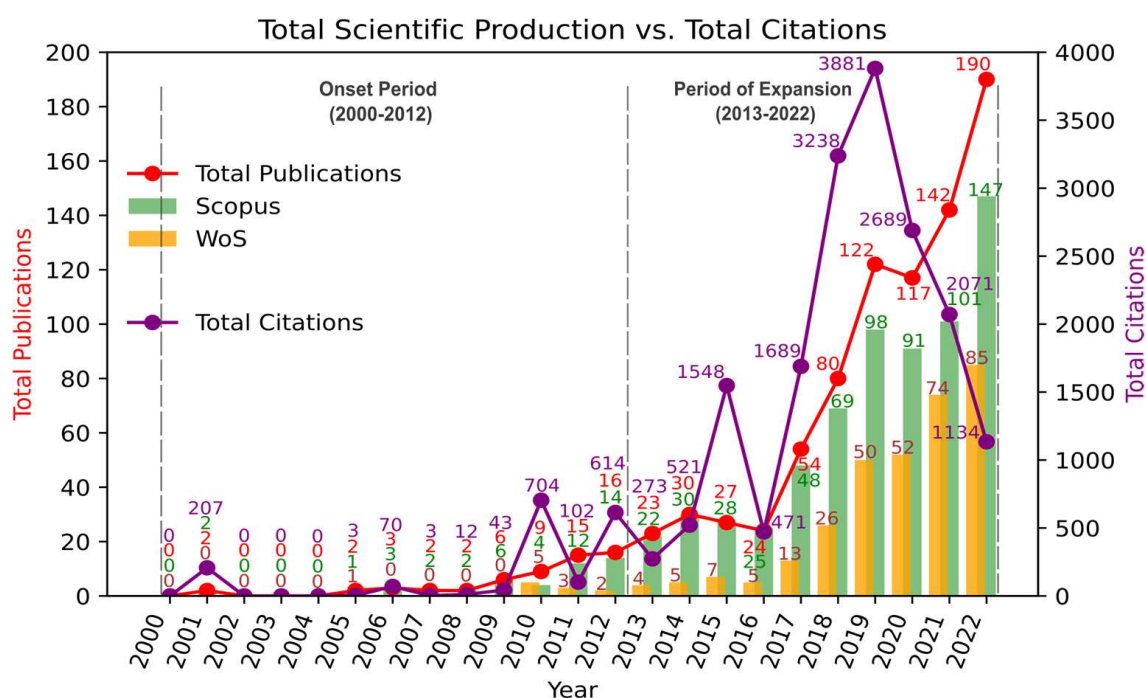


Figure 2. Total production measurement vs. total citation trends.

The initial phase of development foundations (2000–2010): To analyze the initial phase, it is important to specify that the evolution of publications is directly related to the development of AR technology and devices. Overall, 27 publications were made in this period alone, of which 26 are in the Scopus database and 1 in the WoS database. Each of the contributions in this phase that provided support to the development of AR focused on tourism is highlighted below in Table 2.

Table 2. Relevant studies in the initial phase of development foundations until 2010.

Ref	Year	Author	Description of Contribution
[20]	1995	Azuma	Azuma offers a clear definition of what AR is and how it differs from VR, establishing a conceptual framework that has been widely adopted by researchers and professionals in the field.
[21]	2000	Sequeira	Sequeira presents a significant contribution to the field of reality modeling. This article focuses on the development and application of hybrid 3D reconstruction and image-based rendering techniques to create three-dimensional models of reality.
[22]	2005	Park	The main contribution of this article lies in the presentation of advanced techniques and methods for the precise placement of virtual objects in real-time video environments.
[23]	2005	Niccolucci	One of the key contributions of the article is highlighting how digital technologies, including VR and AR, have been used to create interactive and immersive experiences that allow the public to interact and better understand historical and cultural heritage.
[24]	2006	Epstein	One of the highlights of the article is how the “History Unwired” project used mobile devices, such as smartphones and PDAs (personal digital assistants), to provide contextualized and multimedia information to visitors as they explored historical sites in Venice.
[25]	2006	Park	The main contribution of this article lies in the conceptualization and design of an immersive tourism experience system intended for cultural sites. In a context where technological advances were beginning to transform the way people interact with cultural heritage, this article addressed the need to improve the visitor experience with technology.
[26]	2007	Chen	The main contribution of this article focuses on the proposal and development of an AR system designed specifically for use in the reconstruction of historical sites in outdoor environments. The application of AR in this context aims to enrich the experience of visitors by providing them with a digital, enriched perspective of what these sites were like in the past.
[27]	2007	Damala	The fundamental contribution of this article lies in the convergence of AR technology with mobile multimedia guides used in museums. The goal is to enhance the visitor experience by providing an interactive and enriched tool that allows them to explore and better understand a museum’s exhibits and collections.
[28]	2008	Cuellar	The fundamental contribution of this study lies in the exploration of how mobile phone cameras can be used to interact with the tourist environment and provide additional information to travelers. The authors conducted a field study analyzing how tourists use their phone cameras to capture images of places of interest and, subsequently, how these images can be processed and recognized by computer vision systems to provide relevant information.
[29]	2008	Linaza	This article presents case studies and practical examples that illustrate how AR can provide contextual and rich information about objects and places of cultural interest. Visitors can use mobile devices or AR viewers to access additional content, such as historical data, narratives, or visuals overlaid in real time on their surroundings.

Table 2. *Cont.*

Ref	Year	Author	Description of Contribution
[30]	2009	Liestol	The main achievement of this article is its focus on creating a situated simulation that takes advantage of the capabilities of the iPhone. Situated simulation is a learning strategy that allows users to interact with simulated environments in real-world contexts. In this case, the article focuses on creating a simulation experience related to the historic Mission Dolores in San Francisco.
[31]	2010	Choubassi	The main achievement of this article is the conception and development of a tourist guide system that uses AR technology to improve the experience of tourists. The system allows users of mobile devices, such as smartphones, to access enriched and contextualized information about points of tourist interest while exploring a destination.
[1]	2010	Guttentag	The main contribution of this article lies in its detailed analysis of how VR can be effectively applied in the tourism sector and what the implications of its use are. The author examines a wide range of applications of VR in the tourism industry, ranging from destination promotion to improving the visitor experience and training tourism personnel.

Initial development phase (2011–2019): During this period, publications related to this research topic began to grow initially in a very timid manner and later with greater consistency. The number of publications increased considerably compared to the first phase or period. A total of 391 publications were identified, which is a large number compared with the initial phase, and these publications have a total of 11,866 citations. Table 3 highlights the most relevant contributions found in the development phase, see Table 3.

Table 3. Most relevant contributions in the development phase (2011–2019).

Ref	Year	Author	Description of Contribution
[32]	2011	Hurst	This research focuses on improving the user experience by combining different interaction modes, such as gestures, voice, and touch, within AR applications. The authors provide valuable design considerations for implementing these interactions effectively, resulting in a more intuitive and efficient experience for users.
[33]	2011	Lee H	The authors focus on developing interaction techniques that use two hands to manipulate tangible blocks with augmented information. These tangible blocks allow users to create compositions and manipulate virtual elements intuitively, making it easier to create and edit content in AR environments. This innovative approach to tangible interactions in AR environments expands the creative and design possibilities for users.
[34]	2012	Nguyen	Nguyen's main contributions focus on the development of a hybrid system that combines information from panoramic images with data from sensors on mobile devices to achieve precise navigation in indoor environments.

Table 3. Cont.

Ref	Year	Author	Description of Contribution
[35]	2012	Chu	This study presents an important contribution in the context of the tourism industry and mobile technology. Its main contribution lies in the introduction and exploration of the concept of “mGuiding” or mobile guiding, which uses a geographic information system (GIS) application on mobile devices to provide guiding services to tourists. This innovative approach takes advantage of the geolocation capabilities of mobile devices to offer relevant, real-time information on points of interest, tourist routes, and other aspects related to the travel experience.
[36]	2013	Martínez-Graña	One of the key contributions of this study lies in the effective integration of geospatial technology, in particular, Google Earth, to create a virtual tour that allows users to explore and understand the geological diversity of a specific area.
[37]	2013	Choi	One of the key contributions of this study is the introduction of an innovative user interface that allows interaction with AR applications using hand gestures. This technology provides a more immersive and natural experience for commercial mobile device users by eliminating the need for additional hardware, such as special gloves or external sensors.
[38]	2014	Garau	This study makes significant contributions to the field of tourism and cultural heritage through the implementation of smart technologies. One of the main contributions of this study is the proposal and exploration of strategies that allow the use of smartphones and mobile devices as key tools for the promotion and experience of cultural and tourist sites.
[39]	2014	Dueholm	This study makes valuable contributions to the field of tourism and cultural heritage management. First, it thoroughly explores the concept of authenticity in the context of cultural heritage sites, analyzing various dimensions of authenticity such as historical, artistic, social, and experiential. Additionally, it examines how these dimensions relate to each other and how they affect visitors’ perceptions of authenticity.
[40]	2015	Chung	This study makes a valuable contribution to the field of tourism by investigating how AR applications influence tourists’ intention to visit cultural heritage sites. This study is based on a strong theoretical framework and conducts empirical analysis to examine key factors such as perceived usefulness, ease of use, and satisfaction related to AR applications.
[41]	2015	Jung	This study offers a valuable contribution to the field of tourism by investigating the factors that influence recommendations for using AR technologies, using a theme park in Korea as a case study. This study is based on a robust survey methodology involving real park visitors, providing empirical data and meaningful observations.
[42]	2016	Dieck	This study makes a valuable contribution to the field of museum and tourism technology by addressing the implementation of smart glasses for AR applications in museums. The authors conduct extensive research into the requirements necessary to develop an effective and engaging AR application for museum visitors using smart glasses.

Table 3. Cont.

Ref	Year	Author	Description of Contribution
[43]	2016	Kim	This study makes a valuable contribution to the field of mobile technology and AR. In their study, the authors investigate the factors that influence the adoption and use of smartphone-based AR applications, focusing on the importance of telepresence as a motivating factor.
[44]	2017	Martín-Gutiérrez	This study makes a significant contribution to the educational field by providing a comprehensive review of emerging technological trends in education. This study focuses on virtual technologies, such as VR and AR, and their application in educational contexts.
[45]	2017	Dieck	This study offers a valuable contribution to the field of cultural tourism and the use of AR in cultural heritage sites. Its focus is on the perspective of stakeholders involved in the implementation of AR technologies at these sites.
[46]	2018	Dieck	This study makes a significant contribution to the field of urban tourism and the use of AR in cultural heritage sites. The author's main contribution lies in the formulation of a theoretical model that explores the factors that influence the acceptance of mobile AR by tourists in the context of urban historical sites.
[47]	2018	He	This study makes an important contribution to the field of cultural tourism and the application of AR in museum environments. Its main contribution lies in the detailed study of how AR can improve visitors' experiences in museums and how these improvements influence their purchase intentions for products related to the visit.
[48]	2019	Falvian	This study makes a valuable contribution to the field of customer experience by exploring the impact of VR, AR, and MR technologies on customer experience. One of the most significant contributions of this article is its focus on customer experience and how VR, AR, and MR technologies can influence customer perception and satisfaction. Using a comprehensive literature review and detailed analysis of previous research, the authors provide a clear view of how these emerging technologies can transform the way companies interact with their customers.
[4]	2019	Yung	This study makes a valuable contribution to the field of tourism research by carrying out an exhaustive systematic review on the use of VR and AR in tourism research. One of the main contributions of this article is its focus on the synthesis and critical analysis of previous research related to VR and AR in the tourism context. The authors identify trends, patterns, and gaps in the existing literature, providing a comprehensive view of how these emerging technologies are being explored and applied in the tourism industry.

Potentialization Phase (2020–2022): The appearance of COVID-19 stimulated the use of different technologies around the world, and tourism, of course, was not left out. At this stage, most publications were generated due to the change in the adoption of technology in response to the pandemic, where people who were isolated were looking on the Internet for a way to learn about and have new tourist experiences. In this context, augmented reality vision played a leading role, allowing many museums and places of interest to be visited by many tourists around the world without physically being there. One example is the work by the author Yogesh K. This phase denotes the emergence of new forms of interaction between AR and tourism, where new applications and ways of carrying out

user–application interactions are generated every day. The following relevant contributions can be highlighted, as listed in Table 4:

Table 4. Key Contributions in the empowerment phase (2020 to today).

Ref	Year	Author	Description of Contribution
[3]	2020	Kim	One of the main contributions of this article is the application of an extended stimulus–organism–response (SOR) model to understand how consumers experience and react to VR experiences in the tourism context. This article focuses on identifying the stimuli that influence consumer perception, how these stimuli affect the VR experience, and what the consumer’s response is in terms of usage intention and satisfaction.
[49]	2020	Loureiro	The key contribution of this study lies in its ability to provide a panoramic view and an in-depth understanding of the evolution and trends in VR and AR research in tourism. By applying text mining techniques, this article identifies emerging patterns, recurring themes, and areas of focus over time.
[2]	2021	Dwivedi	One of the main contributions of this article is its focus on identifying perspectives and research propositions that will guide the future development of this field. The authors conduct a comprehensive analysis of the existing literature, highlighting emerging themes and trends in digital marketing and social networks.
[50]	2021	Pillai	This article identifies several key areas where ‘Hospitality 5.0’ is redefining hotel management. These include the implementation of smart management systems, promoting contactless guest experiences, adopting advanced disinfection technologies, and re-evaluating food and beverage operations. These areas are essential to ensure guest safety and business continuity in a pandemic environment.
[51]	2021	Hamid	The authors assessed and compared various intelligent recommendation systems used in tourism, including data-driven, context-aware, and machine learning techniques. This evaluation helps identify the strengths and weaknesses of each approach, providing valuable guidance for professionals, researchers, and developers interested in implementing these technologies in the tourism industry.
[52]	2022	Dwivedi	The authors examine how the metaverse can provide companies with new ways to interact with consumers, including creating immersive brand experiences and engaging in three-dimensional marketing activities. Additionally, they highlight how the metaverse can be used as a research space to better understand consumer behavior and gather valuable data. This includes the ability to conduct controlled experiments in a virtual environment and observe consumer interactions in more detail.
[53]	2022	Buhalis	One of the key contributions of this article is its exploration of how the metaverse is transforming the customer experience and value co-creation in the hospitality and tourism industry. The authors argue that the metaverse offers new opportunities for tourism and hospitality service providers to create more immersive and personalized customer experiences. This includes the possibility for customers to interact with virtual destinations before making travel decisions and to participate in online tourism experiences within the metaverse.

Table 4. *Cont.*

Ref	Year	Author	Description of Contribution
[52]	2023	Dwivedi	One of the main contributions of this article is its detailed analysis of how the metaverse is shaping consumer research and marketing practice. The authors argue that the metaverse introduces new dynamics in the relationship between businesses and consumers. It enables a more immersive and personalized interaction, where consumers can experience products and services in a virtual manner before making purchase decisions. This leads to a more customer-centric approach and more interactive marketing strategies.
[53]	2023	Buhalis	The article highlights how the metaverse enables hospitality and tourism businesses to design virtual experiences that complement and enhance physical experiences. This includes the ability to offer virtual tours, destination simulations, and online booking experiences that allow customers to explore and experiment before committing to a purchase. This richer and more participatory interaction between businesses and customers is redefining how value is created and delivered in the industry.
[54]	2024	Pereira	This article highlights how the metaverse enables hospitality and tourism businesses to design virtual experiences that complement and enhance physical experiences. This includes the ability to offer virtual tours, destination simulations, and online booking experiences that allow customers to explore and experiment before committing to a purchase. This richer and more participatory interaction between businesses and customers is redefining how value is created and delivered in the industry.

3.1.2. Country Network

Tourism is one of the sectors that was hardest hit by COVID-19 and the effect of isolation, and it is currently being impacted by the global economic situation. Many publications and applications were generated around the world to address the effect of the pandemic on a sector that economically benefits many people around the world. An analysis of the first 10 leading countries with publications related to AR for the tourism sector is provided below in Table 5.

Table 5. Countries.

Country	Production		Citations		Q1	Q2	Q3	Q4
China	130	11.06%	1373	5.89%	38	10	3	10
UK	81	6.89%	3277	14.06%	31	7	3	3
Italy	76	6.47%	1146	4.92%	21	6	1	4
Korea	74	6.3%	1843	7.91%	31	8	6	2
Spain	69	5.87%	1469	6.3%	14	13	2	2
USA	69	5.87%	2318	9.95%	27	4	1	0
Malaysia	62	5.28%	715	3.07%	9	3	2	6
India	47	4%	326	3.97%	4	1	3	8
Greece	46	3.91%	603	2.59%	4	2	1	4
Portugal	40	3.4%	508	2.18%	11	5	3	3

The country in the first position with the highest number of publications is China with 130 publications, equivalent to 11.06%, and it has several citations, accounting for 5.89% or 1373. It is important to note that although China is the country that leads in publications, regarding appointments, it is ranked fifth. Of the 130 publications, only 61 of them are found in indexed journals, distributed as follows: 38 in Q1 (29%), 10 in Q2 (8%), 3 in Q3

(2%), and 10 in Q4 (8%). The most cited article is by the author Chang, Yu-Lien [55], who shows how the application of AR in tourist sites can increase the sense of place for the tourist in heritage places.

The second country with the highest number of publications is the United Kingdom with 81 publications, representing 6.89% of the total production. It is also the country that has the highest number of citations, amounting to 3277 or 14.06%, which denotes the impact that the publications made on the scientific contribution. Of the 81 publications, 44 of them are found in indexed journals, 31 in Q1 (38%), 7 in Q2 (9%), 3 in Q3 (4%), and 3 in Q4 (4%). The article by the author Myung Ja Kim [3] is the most cited, in which he shows how VR can help improve the user experience in places of interest. Italy is positioned as the third country, with 76 publications, equivalent to 6.47%; however, it is positioned as the sixth country for citations with 1146 (4.92%). Of the 76 publications, 32 of them are indexed and distributed as follows: 21 in Q1 (28%), 6 in Q2 (8%), 1 in Q3 (1%), and 4 in Q4 (5%). The research by the author Chiara Garau [38] stands out, as she shows how the use of a SmartPhone can boost intelligent use for the generation of more dynamic tourism.

The fourth country in terms of publications is Korea, which has 74 publications (6.3%), and it is also the country with the third highest number of citations at 1843 citations (7.91%). Of the 74 publications, 47 are indexed: 31 in Q1 (42%), 8 in Q2 (11%), 6 in Q3 (8%), and 2 in Q4 (3%). The article by the author Namho Chung [40] stands out, who analyzes how AR can help assess the intention to visit a heritage destination by monitoring the experiences generated by the application. The fifth country is Spain, which shares the same number of publications as the USA. Spain is positioned in fifth place because it has publications indexed in all the indexed quartiles. Spain has 69 publications (5.87%) and 1469 (6.3%) citations, ranking fourth after Korea. Of the 69 publications, 31 of them are indexed: 14 in Q1 (20%), 13 in Q2 (19%), 2 in Q3 (3%), and 2 in Q4 (3%). The author Carlos Flavián [17] stands out again: in addition to being the most cited author in Spain, this author is also the most cited in the period from 2011 to 2019, denoting the importance of this work for authors who are starting out on this topic and showing the impact of disruptive technologies such as virtual and AR to improve the user experience.

The sixth country is the United States, which has the same number of publications as Spain 69 (5.87%), but even though it is in sixth place in terms of number of publications, it is worth mentioning that it is the second country with the greatest impact of its publications with 2318 (9.95%), only being surpassed by the leader, the United Kingdom. Of the 69 publications, 32 of them are indexed: 27 in Q1 (39%), 4 in Q2 (6%), and 1 in Q3 (1%). The work by the author Zeya He [47] is one of the most representative and shows how AR can help improve experiences in museums. Malaysia is the seventh country in terms of the number of publications and citations, with 62 publications (5.28%) and 715 citations (3.07%). Of the 62 publications, 20 of them are indexed: 9 in Q1 (15%), 3 in Q2 (5%), 2 in Q3 (3%), and 6 in Q4 (10%). The article by the author Sandra Maria Correia Loureiro [6] stands out, which highlights how VR in combination with text mining can support the advertising of historical sites.

On the other hand, the eighth country is India, which has 47 publications (4%) and 326 citations (3.97%), which positions it as the 10th country in terms of citations. Of the 47 publications, 16 are indexed: 4 in Q1 (9%), 1 in Q2 (2%), 3 in Q3 (6%), and 8 in Q4 (17%). The article by author Anand Nayyar [56] stands out. He shows how AR and VR can be applied to promote the tourism and hospitality industry. In ninth place is Greece with 46 publications (3.91%) and 603 citations (2.59%), but even though it is ninth in terms of production, it is eighth in terms of citations. Of the 46 publications, 11 of them are indexed: 4 in Q1 (9%), 2 in Q2 (4%), 1 in Q3 (2%), and 4 in Q4 (9%). Finally, Portugal is the last country with 40 publications (3.4%) and 508 citations (2.18%), which positions it as the ninth country in the citation index. Of the 40 publications, 22 are indexed: 11 in Q1 (28%), 5 in Q2 (13%), 3 in Q3 (8%), and 3 in Q4 (8%).

Regarding the network cluster analysis (see Figure 3), it can be identified that different types of joint collaborations have been generated among the publications of the countries,

which have been grouped mainly into five communities, which have increased their participation from 2016 to date. The first community (purple) shows a very strong posting relationship between the UK and Korea, which focuses on identifying how AR and VR can help improve the user experience at sites of interest [3]. The second community (light green) is led by the USA, with strong collaborations with France, Germany, Greece, and Italy, from which works related to how disruptive technologies can help publicize historical sites were published [2].

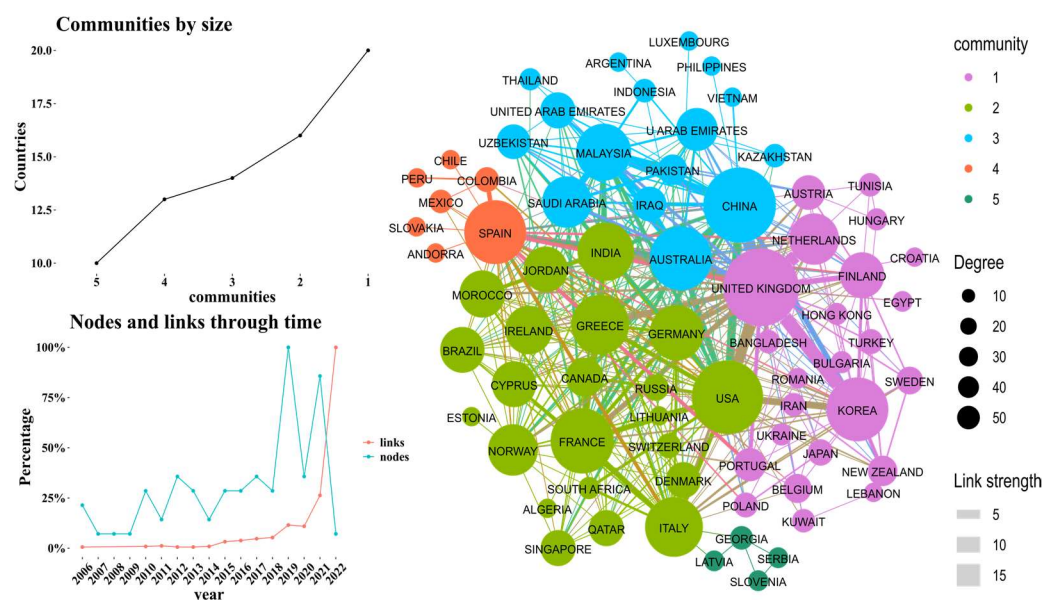


Figure 3. Country collaboration network.

The third community is led by China (green), with collaborations with authors from Australia, Malaysia, and Saudi Arabia, in which different innovative technologies such as the metaverse are explored to generate value associated with historical and cultural sites [57]. The fourth community (orange) is led by Spain, with collaborations with South American countries, such as Colombia, Chile, and Peru, and Central American countries, such as Mexico, in which techniques such as immersion and stereoscopy are used for the analysis of cultural and historical sites [58]. The last community (dark green) is led by Georgia in collaboration with countries such as Latvia, Serbia, and Slovenia, which focus on the effect that disruptive technologies focused on education have had on strengthening the teaching processes [59].

3.1.3. Journal Analysis

Table 6 shows the analysis of the 10 journals that publish the most about AR applications in the tourism sector. It can be identified that the majority of publications of this type are additionally socialized at conferences, which is why *Lecture Notes in Computer Science* (including the subseries *Lecture Notes in Artificial Intelligence* and *Lecture Notes in Bioinformatics*), indexed Q3 Scopus, has the most publications on the subject at 36. The article by the author Wolfgang Hürst [32], who participated in the 17th International Multimedia Modeling Conference, described how mobile AR concepts can be applied to generate advances in multimedia modeling. In second place is the journal *Sustainability* with 29 publications in the WoS database and ranked in Q1. This journal has a section dedicated exclusively to tourism, in which important publications have been generated such as that by the author Dongwook Kim [60], which is one of the most cited, in which he details the role of mobile technologies in tourism and the new trends around this topic.

Table 6. Top ten journals about AR in tourism.

Journal	WoS	Scopus	Impact Factor	H Index	Quantile
<i>Lecture Notes in Computer Science</i> (including subseries <i>Lecture Notes in Artificial Intelligence</i> and <i>Lecture Notes in Bioinformatics</i>)	0	36	0.32	446	Q3
<i>Sustainability</i>	29	0	0.66	136	Q1
<i>ACM International Conference Proceeding Series</i>	0	22	0.21	137	-
<i>Lecture Notes in Networks and Systems</i>	0	20	0.15	27	Q4
<i>Current Issues in Tourism</i>	18	12	2.06	94	Q1
<i>Springer Proceedings in Business and Economics</i>	0	19	-	-	-
<i>Communications in Computer and Information Science</i>	0	17	0.19	62	Q4
<i>Journal of Hospitality and Tourism Technology</i>	12	9	1.46	42	Q1
<i>Lecture Notes in Electrical Engineering</i>	0	14	0.15	40	Q4
<i>Applied Sciences—Basel</i>	12	0	-	-	Q2

In third and fourth place are two journals that also bring together participation in congresses and conferences including *ACM International Conference Proceeding Series* with 22 publications. The article by the author Torben Schinkey [61], who participated in the 12th International Conference on Human–computer Interaction with Mobile Devices and Services, showed that its application allowed objects to be shown off the screen using AR. *Lecture Notes in Networks and Systems* (Q4 Scopus) has 20 publications and highlights the book chapter Future of Digital Transformation by the author Haktanır [62], which shows how emerging technologies can enhance the development of the tourism sector. All publications are indexed in Scopus. In fifth place is the journal *Current Issues in Tourism* (Q1), in which there are 18 publications. Due to its thematic lines, it is one of the most specialized journals on the subject, where various publications have been made about tourism. Among the articles published, the author Ryan Yung [4] stands out, who carried out a systematic review of the implementation of AR and VR for tourism that was very relevant and cited by various authors. Later, in sixth and seventh places we again have conference proceedings including *Springer Proceedings in Business and Economics* with 19 publications, in which the article by the author Maria Shehade [63] stands out, which carries out a review of the processes of inclusive tourism, making use of disruptive technologies such as AR. The other conference proceeding is *Communications in Computer and Information Science* (Q4 Scopus) with 17 publications, among which the author Silviu Vert [64] stands out, who describes the different aspects that he considered for the development of an AR mobile application integrated with linked data of relevant information from heritage sites.

Also noteworthy are publications published in the *Journal of Hospitality and Tourism Technology* (Q1), a journal characterized by publishing very relevant and specialized publications in the field of tourism. One of the most notable publications is that of the author M. Claudia Tom Dieck [42], who details the requirements that smart glasses must have in an application focused on the implementation of AR in a museum. In ninth place with 12 publications is *Lecture Notes in Electrical Engineering*, a member of the conference participation with 14 articles highlighting the work of the author Pei-Jung Lin [65], in which she describes the design and implementation of an electrical system for tourism based on AR including the use of GIS technology. Finally, the journal *Applied Sciences—Basel* (Q2) with 12 articles, which also has several special issues focused on the tourism section. Among its

publications, the article by the author Ioannis Paliokas [66] stands out, who developed an application based on gamification to promote cultural tourism.

Regarding the citations among the journals on this topic, three communities can be identified, as shown in Figure 4. The first (green) is led by the journal *IEEE Access*, in which strong citation processes for articles from the journal *Electronics* have been developed. One of the most cited works is by the author Anabela Marto [67], who carries out a review on how AR has permeated into different aspects related to increasing the value of the tourist experience for users. The second community (purple) shows that among the most cited articles is that of the author Schinke in the *12th International Conference on Human–Computer Interaction with Mobile Devices and Services* [61], which focuses on the identification and visualization of objects in mobile AR applications. The third and last community (orange) denotes a high citation of articles from the *International Conference on Industrial and Information Systems*, ICIIS, in which different applications of AR to industrial sectors were socialized.

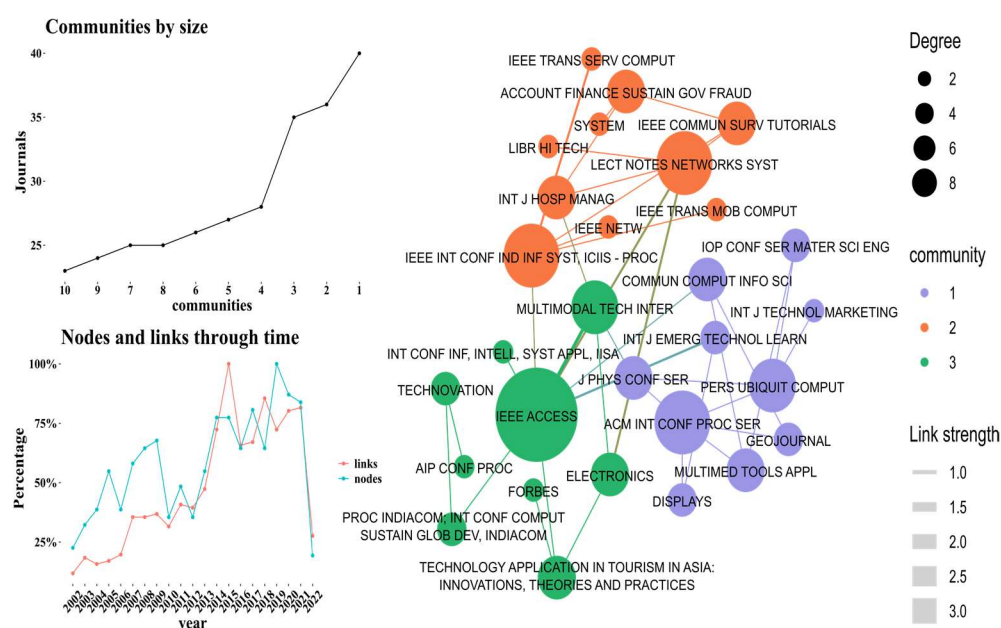


Figure 4. AR and tourism journal citation network.

3.1.4. Author Analysis

Table 4 shows the list of the 10 authors who have published the most in the development of technologies based on AR for the tourism sector. The contribution of authors from the two countries with the greatest number of publications and citations is noted, which include the United Kingdom and South Korea. The author with the highest number of publications is Jung T [3], from Manchester Metropolitan University, Manchester, United Kingdom. This author was co-author of the work that has the highest number of citations in the United Kingdom, in which he describes a model that allows measuring the response of users who use AR compared with the intention to visit tourist places that can be viewed in the application. Another author, Dieck M [42] who has 17 publications, also works in collaboration with Jung T and has published a widely cited work in the journal *Current Issues in Tourism*, in which he establishes the bases for the development of a model implemented in mobile applications of AR applied to urban cultural tourism, see Table 7.

Table 7. Top ten authors who published about AR in tourism.

Researcher	Total Articles	Scopus Index	Affiliation
Jung T	26	27	Manchester Metropolitan University, Manchester, UK
Dieck M	17	23	Manchester Metropolitan University, Manchester, UK
Kim J	15	10	Kyung Hee University, Seoul, Republic of Korea
Hassan A	14	12	The Tourism Society, London, UK
Park J	11	7	Aria-Edge Co, Seoul, Republic of Korea
Lee J	10	3	Korea National University Of Cultural Heritage, Buyeo, Republic of Korea
Chung N	9	38	Kyung Hee University, Seoul, Republic of Korea
Lee H	9	11	Kyung Hee University, Seoul, Republic of Korea
Loureiro S	9	37	Iscte—Instituto Universitário De Lisboa, Lisbon, Portugal
Rauschnabel P	9	30	Universität Der Bundeswehr München, Neubiberg, Germany

The third author, Jin-Young Kim [68], representing Kyung Hee University, Seoul, South Korea, has worked as a co-author in different works related to AR in tourism. His work published in the *Journal of Travel Research* stands out, which provides an explanation of the impact that the implementation of AR has had on the experience in tourist sites in South Korea. The fourth author, Hassan [69], analyzes the need to implement disruptive technologies such as AR for the relaunch of tourism in the new post-Covid era. The authors who are in the fifth, sixth, seventh, and eighth positions are from Korea, showing the leadership in publications from this country, where the publications of the author Park J [70] stand out. This author details the way to make a subjective evaluation of the visual perceptibility of incorporating complementary patterns for AR based on non-intrusive projections. The author Lee J [71] shows how visual and tangible interactions with physical and virtual objects can be carried out using context-sensitive RFID using AR. The author Chung N [41] additionally shows important recommendations for the implementation of AR in tourist sites, and Lee H [72] analyzes cross-cultural differences in the adoption of mobile AR in cultural heritage tourist sites.

The ninth author is Sandra Maria Correia Loureiro [49], from Portugal, who also authored the most cited publication in collaboration with authors from Malaysia, totaling nine publications focused on AR for tourism. This author's most cited article is a review of the evolution of 20 years of research into the applications of VR and AR for the tourism sector using text mining. Finally, the author Rauschnabel [73], who has worked in strong collaboration with authors from the United Kingdom, and whose articles have a high level of citations, highlights his research related to the development of the XR framework that allows VR and AR implementations.

In Figure 5, we can be seen in the previous analyses there is a strong relationship of co-authorship at an international level between authors from the United Kingdom, Korea, Portugal, and Germany, in which they have developed different AR frameworks and applications in different contexts that have allowed them to conduct research. These authors are world leaders in the application of AR for the tourism sector, and their careers have been very important for the development of this branch of knowledge.

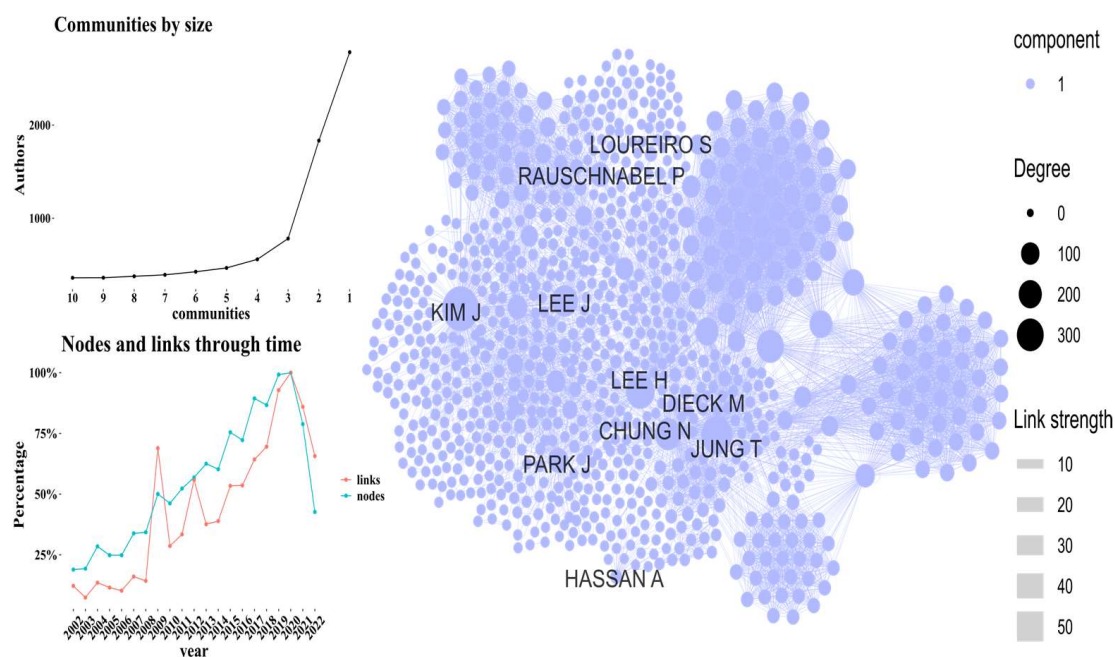


Figure 5. Author collaboration network.

It is important to point out that some authors have previously developed reviews of the literature related to this research topic, among which is Ajanki [74] who, in his review of the state of the literature, provides an understanding of how AR can improve the tourist experience by providing contextual information in real time. Serravalle [75] focuses on analyzing the applications of AR in the context of museums, providing a detailed vision of how multiple stakeholders can benefit from this technology in the tourism and cultural sector. Hamid [51] focuses on analyzing recommender systems for smart tourism; this article highlights the importance of data management in the tourism industry. Laine [76] focuses on educational AR games and provides a systematic review of the relevant literature, underlining the potential of AR in educational contexts and how these experiences could be applied to tourism to offer learning opportunities in tourist destinations. Finally, Rahimi [77] focuses on customer relationship management in tourism and hospitality, highlighting the importance of understanding customer preferences and expectations in the tourism industry.

3.2. Tree of Science

3.2.1. Root

Based on the Tree of Science metaphor, different parts of the tree are identified in relation to the growth of the subject's advances over time (see Figure 6). If we point out the root, it is important to specify that for some years, the development of AR for the tourism sector has suffered worldwide from a lot of resistance to change, where unions and tour operators clung to operating in a traditional way, ignoring benefits of the use of technology. Another highly important factor concerns the availability and appropriation of the use of technological resources such as the Internet and mobile devices.

Many of the AR applications focus on the use of sensors to identify different projections of user experience; different developments were carried out that marked the conceptual bases for current developments. Among the articles that contain relevant information about the topic of this study, the contributions by the author Davis [78] can be identified. His article proposed a methodology that allows identifying the perception of the use and acceptance of information technology based on the theory of the instruments. In addition, the way in which user perceptions can be measured was an important contribution made

by different authors in relation to how to subsequently measure user perception with the use of AR applications.

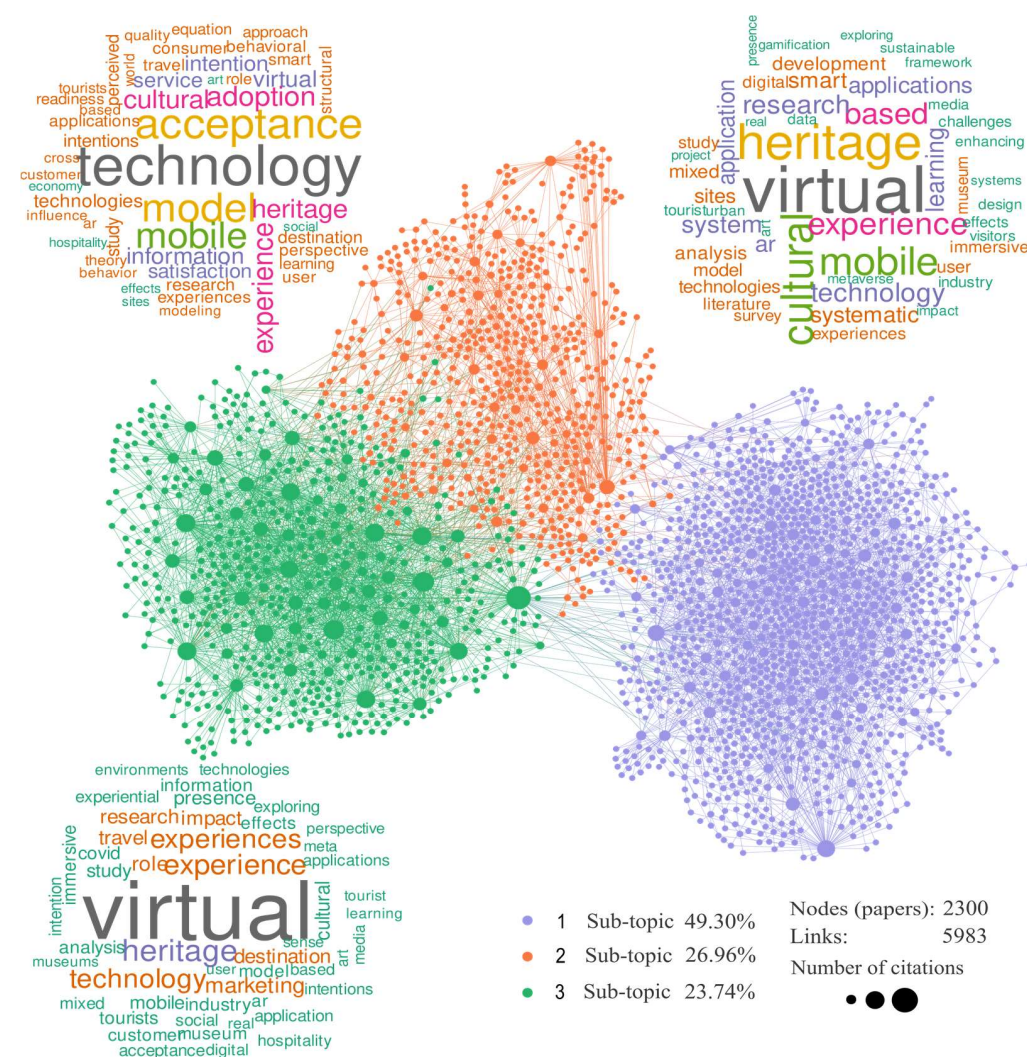


Figure 6. Citation network.

Another author whose conceptual foundation was very valuable is Azuma [20], who reviewed the use and application of AR as a basis for the use of teleoperators for different types of environments in which it is desired to be implemented. In the same way, in the 1990s, Milgram [79] identified different existing taxonomies of displays that can be used to implement mixed reality in development environments; this article is highly cited in the community of AR developers. At that time, it was essential to be able to characterize and identify which were the most appropriate devices to be able to make applications in different contexts.

In Figure 6, the analysis of the different research trends related to the field of study is detailed. The figure shows a citation network built from the union of Scopus and WoS (997 records). The citation network is composed of 5983 nodes (articles), and we used the preprocessing proposed by Zuluaga et al. [80] to obtain a cleaner network, which improves the accuracy of the metrics. Once we obtained the citation network, the Blonde et al. algorithm was applied [81] to identify the different trends in the topic (clusters). The three main trends were selected according to the size of each cluster. The three trends or branches are shown in Figure 6 along with the word cloud constructed from the titles of each cluster. This analysis allowed us to obtain a detailed look at the main trends in the topic and to identify in general terms (word cloud) in the topic.

3.2.2. Trunk

At the time of technological development to support AR, many authors made various contributions that have been very important for the development of AR to this day. Among the most notable contributions are those of Baktash [82], who conceptualized a framework that allowed for identifying the intentions and behaviors of tourists when visiting tourist sites of different cultures. This contribution was very important because not only did the contributions focus on technological developments, but it also focused on how people can perceive technology, appropriate it in their day, and determine if the places they visited really meet their expectations.

Another epicenter of the development of AR technology was the work focused on providing guides or instructions about a site of interest. It is in this context that the author Pierdicca [83] explores how mobile AR technology can be used to provide information and guide visitors to archaeological parks, thus improving their understanding of the site and their experience of it. This involves the development of mobile applications that use AR to overlay digital information on the real environment, allowing visitors to access historical and archaeological details as they explore the park. This paradigm also allowed us to identify new ways to use AR focused on serving as a guide for visitors, which can serve as a reference for future authors.

Regarding the use of devices for interaction with AR applications, Obeidy [84] focuses on understanding and evaluating the acceptance of devices such as smart glasses by tourists who want to experience AR while visiting tourist destinations. Smart glasses, such as Google Glass or other similar devices, have the potential to offer real-time information, virtual tour guides, and AR experiences in the context of tourism. The article addresses aspects related to the perceptions and attitudes of tourists toward the use of these smart glasses, as well as factors that may influence their adoption or rejection, which generates an enriching scenario for the technological assessment of the applications.

Specifically, regarding cultural tourism, Han [85] focuses on understanding how tourists experience and perceive AR applications when visiting urban heritage sites. AR is used in this context to provide visitors with additional information and enriched experiences as they explore historical and cultural sites in urban environments. The article examines aspects related to user experience, such as satisfaction, perceived usefulness, ease of use, and other factors that influence the perception and enjoyment of AR applications in urban heritage tourism, which are variables that were subsequently used to assess the quality of AR experiences in tourism.

By analyzing the service provision generated by being close to a tourist location, Wei [86] examines and summarizes the research and progress in the field of VR and AR applied to tourism and hospitality over a specific period from 2000 to 2018. The review sought to understand how these technologies have been used in the tourism and hospitality industry, as well as to identify emerging trends, approaches, and research areas. The article includes an analysis of the main applications and use cases of VR and AR in the tourism industry, how these technologies have improved the tourist experience, the advantages and challenges associated with their implementation, and how they have evolved over the years.

By analyzing the Tree of Science, three important aspects of action can be identified that are currently being worked on, especially in this post-COVID era, which are detailed below.

Branch 1: Development of applications based on AR and VR focused on improving the experience in cultural sites.

The development of applications based on AR and VR has revolutionized the way people experience and connect with cultural sites around the world. These innovative apps allow visitors to immerse themselves in the history, art, and architecture of iconic locations in a whole new way. By combining digital information with the physical environment, users can obtain real-time information about monuments, exhibitions, and cultural events while exploring museums, historical sites, or art galleries. This technology not only enriches the visitor experience by providing interactive and enriching data but also sparks curiosity and

interest in culture and heritage while encouraging greater engagement and understanding of the importance of these sites in our society. Specifically focused on how people select historical and cultural sites, the author Woods [87] explores how Pokémon Go, an AR game, has influenced the tourist experience and how it has transformed the way people interact with their environment and discover new places. The author discusses how the game Pokémon Go motivates players to explore the real world while searching for and capturing Pokémon in specific geographic locations. In addition, it investigates how this gaming experience influences the perception and knowledge of the place, as well as the interaction between players and other tourists and residents.

Regarding the development of AR applications for tourism, Verna [88] conducts a review of the literature covering a wide spectrum of topics within the field of virtual tourism, including technologies used, tourists' experiences, perceived benefits, and challenges faced in the implementation of these technologies, as well as possible future research and development directions. Throughout the article, a historical journey is outlined that highlights how virtual tourism has evolved over time, from its first manifestations to its current form. The various technologies that have driven this field, such as VR, AR, and other forms of immersive digital media, are explored. Additionally, the article examines tourists' experiences in virtual environments and how these experiences may differ from traditional ones. Tourists' perceptions and attitudes toward virtual tourism are addressed, and the benefits they can obtain by using these technologies are identified, as well as the challenges that tourist destinations and companies face when implementing them.

Regarding the identification of digital skills for the use of AR, Carlisie [89] focuses on the evaluation and analysis of digital skills among tourism professionals in Europe, highlighting the existing disparities in this field. The article investigates how the adoption and effective use of digital technologies in the European tourism industry varies depending on the capacity and level of digital skills of workers in the sector. It focuses on understanding how these differences in digital skills can influence the competitiveness and performance of tourism businesses in the European context. To carry out this research, data and empirical evidence were collected and used to analyze the relationship between digital skills, the adoption of digital technologies, and the performance of tourism companies in Europe. The article provides an in-depth analysis of the identified gaps in digital skills and how these gaps may impact the industry.

By identifying the most recent applications of AR, Pereira [54] conducted a study that focuses on how this emerging technology can enrich the way visitors and tourists interact with places of interest in a city. The article investigates how AR has been specifically implemented in Barcelos to provide visitors with a more immersive and enriching experience when exploring local points of interest. It examines how AR is integrated into tourist information and guidance, and how this technology can offer additional information, historical contexts, cultural details, and interactive experiences to visitors as they explore the city. Furthermore, the article also addresses the challenges and benefits of AR adoption in the tourism field, as well as its impact on the perception of a city as a tourist destination.

Branch 2: Models focused on measuring the acceptance of AR technology in cultural sites.

In the continuous quest to improve and enrich the visitor experience at cultural sites, increasing attention has been paid to the integration of cutting-edge technologies, and AR has emerged as a revolutionary tool in this context. To evaluate the effectiveness of AR implementation in cultural sites, various models and approaches have been developed that focus on measuring the acceptance of this technology by visitors. These models have evolved over time to address a variety of factors that influence the adoption and utilization of AR in cultural contexts, including psychological, social, technological, and economic aspects. When considering the acceptance of AR technology in cultural sites, fundamental issues such as perceived ease of use, perceived usefulness, social influence, user experience, and barriers that may hinder adoption are explored. These models not only help us understand how visitors interact with AR in a cultural environment but also provide valuable information for administrators and decision-makers in the management

of these sites, allowing them to continually improve the visitor experience and preserve and transmit cultural wealth in an innovative way.

In this order of ideas, Fusté-Forné [90] focuses on describing how this emerging technology can enrich the way in which visitors and tourists interact with places of interest in a city. The article shows how AR has been specifically implemented in Barcelos to provide visitors with a more immersive and enriching experience when exploring local points of interest. It examines how AR is integrated into tourist information and guidance, and how this technology can offer additional information, historical contexts, cultural details, and interactive experiences to visitors as they explore the city. In addition, the article also addresses the challenges and benefits of adopting AR in the tourism field, as well as its impact on the perception of a city as a tourist destination.

Other authors such as Alanis [91] investigate in depth how AR applications are being used to improve the visitor experience in cultural and heritage destinations, with a specific focus on optimizing the user experience. The article presents a series of guides and recommendations intended for designers, developers, and project managers working in the field of AR-based cultural tourism. AR has proven to be a valuable tool for enriching visits to cultural sites by providing contextual information, interactive visualizations, and immersive experiences that expand visitors' understanding and enjoyment. However, its effectiveness largely depends on the quality of the user experience. Therefore, the article focuses on identifying best practices and strategies for designing AR applications that are accessible, intuitive, and satisfying for a wide range of users. The study is based on a comprehensive review of the existing literature on the topic and on the collection of empirical data using surveys and interviews with visitors to cultural sites who have used AR applications. The results of the study are presented in the form of user experience guides that address aspects such as usability, interface design, interactivity, accessibility, and personalization of the experience.

Regarding the adoption of technology, Ronaghi [92] evaluates the adoption of AR technology by visitors to Persepolis. A mixed and extended unified technology acceptance and use (UTAUT) model was developed using the content analysis method. Furthermore, factors such as resistance to innovation and perceived cost were integrated into the UTAUT framework. A survey was used to evaluate the proposed model of AR technology acceptance among the population of tourists and visitors to Persepolis. The results indicate that factors such as social influence, ease of use, and enjoyment have a positive impact on the value perceived by tourists and the subsequent use of AR. Interestingly, perceived cost and resistance to innovation did not negatively influence the perceived value or adoption of AR. Furthermore, no significant differences were observed in the use of AR technology among tourists visiting different sites.

VR, AR, and MR can induce a sense of presence in which an individual can perceive themselves coexisting physically within a virtual environment. Holt [93] explores whether VR/AR/MR technologies can foster human connections and meaningful experiences through interactions within virtual worlds. These experiences could help mitigate and address the psychological challenges astronauts face during extended and interstellar space missions (which encompass the unique perspective of viewing Earth from space). Additionally, these technologies could be harnessed for space tourism, educational initiatives, and outreach programs, offering a cost-effective means for people to immerse themselves in the wonders of space, gain a deeper understanding of the importance of the space industry in their lives, and get excited about future career opportunities (giving people on earth a taste of space exploration). To obtain a complete understanding of the current and potential future applications of VR/AR/MR technologies, a qualitative literature review was conducted. This review covered its use in psychology, its deployment in space-related contexts, its role in improving the mental well-being of astronauts during space missions, its facilitation of two-way communication, its broader applicability in tourism, education, and outreach, as well as its specific relevance to space tourism, space education, and space outreach initiatives.

Branch 3: The identification of mechanisms to improve the marketing of cultural sites using AR.

Identifying mechanisms to improve the marketing of cultural sites using AR represents an exciting and constantly evolving field in the promotion of cultural and tourism heritage. AR offers a powerful tool to transform the way visitors experience and connect with cultural sites by overlaying interactive digital information and virtual elements in the real environment. These mechanisms can include the creation of mobile applications that guide visitors in an immersive way, providing historical details, anecdotes, and rich narratives. Additionally, AR can facilitate the recreation of historical scenes, the viewing of ancient artifacts or buildings in their original state, and the interaction with historical figures through virtual holograms. Ultimately, these mechanisms have the potential to appeal to a broader and more diverse audience while enriching the understanding and appreciation of the cultural richness that these sites offer.

By analyzing how AR can improve the marketing of cultural sites, Peštek [94] focuses on an innovative perspective on how VR can be used as a marketing tool in the tourism industry to promote sustainability. In a world where environmental awareness and sustainability have become key concerns, VR offers a unique way to address these issues. The article examines how VR can provide prospective tourists with a full virtual experience of a destination before they venture out physically. This involves creating virtual environments that realistically represent tourist destinations, accommodations, and activities. Potential tourists can immerse themselves in these virtual experiences, allowing them to explore a destination in detailed and exciting ways from the comfort of their homes. This VR immersion provides a deeper understanding of what a destination has to offer, which can influence travel decisions and increase traveler satisfaction. One of the key benefits of this application of VR in tourism is its ability to promote sustainability. VR can help reduce the carbon footprint associated with travel by allowing people to explore destinations virtually before deciding to travel. This can lead to more informed decision-making and ultimately a decrease in unnecessary or unsustainable travel. In addition, VR can also help improve tourism resource management by providing detailed information on tourist influx and demand for services at specific destinations.

For his part, Akhtar [95] investigates whether emerging trends in digital tourism, such as virtual tours, VR, AR, and other digital technologies, are gaining ground and whether they could partially or totally replace mass tourism in the post-COVID-19 era. The authors discuss how technology has enabled people to explore travel destinations virtually and how these experiences can satisfy the need to travel and explore new places without the risks associated with traditional travel. Furthermore, the article addresses issues related to sustainability and management of tourist destinations in the context of digital tourism. The potential benefits of reducing pressure on physical destinations and natural resources through the adoption of digital approaches are explored. This article addresses how the COVID-19 pandemic has accelerated the adoption of digital technologies in the tourism industry and raises important questions about the future of tourism, including the possibility of digital tourism playing a more significant role in the post-COVID-19 era, possibly coexisting with traditional mass tourism. Sustainability and destination management considerations are also explored in this context.

Extended reality encompasses a set of technologies that includes VR, AR, and MR, which are characterized by fusing elements of the real world and the virtual world to create immersive and enveloping. Santoso's [96] focus is to understand how the implementation of XR technologies in the tourism sector can transform travelers' perception of a destination and significantly improve their overall satisfaction. To carry out this analysis, the effects of the combination of visual, auditory, and tactile elements in XR environments on tourists' experience are studied. The article covers various stages of a tourist's trip, from the planning phase of the trip to the experience of the trip itself to the post-trip phase, and examines how XR technologies influence each of these stages. It is illustrated with practical examples and case studies of how the implementation of XR in specific tourist destinations

can influence tourists' decisions and their overall perception of the destination. The author focuses on analyzing in depth how multisensory extended reality is impacting the travel experience within the tourism industry, and how these technologies have the potential to improve and enrich the experience of tourists at all stages of their trip from initial planning to the post-travel phase. This approach is based on practical cases and concrete examples to illustrate the effective application of XR technologies in real tourism destinations.

Ji [97] focuses on investigating how participation in virtual tourism affects the social education effect related to cultural heritage. The study focuses on the role of virtual tourism experiences in promoting education and the understanding of cultural heritage among visitors. To carry out this research, the article analyzes how virtual tourism experiences, which often involve the exploration of historical and cultural sites using technologies such as VR and AR, can influence the perception and knowledge of visitors about cultural heritage. Questions are explored such as whether virtual tourism experiences can increase people's interest in history and culture, whether they influence their understanding of historical events, and whether they promote greater respect for cultural heritage. Furthermore, the article analyzes how virtual tourism experiences can contribute to social education, which is an important aspect of tourism destination management and the promotion of culture. It investigates whether these experiences can be an effective tool to transmit knowledge about cultural heritage to different groups of visitors, including students, tourists, and members of the local community. The article focuses on exploring how virtual tourism and extended reality experiences can have an impact on social education related to cultural heritage. Using in-depth analysis, the article examines how these experiences can influence the understanding and appreciation of culture and history, and how they can be used as effective tools for promoting education and valuing cultural heritage in destination tourists.

4. Discussion

The analysis of the trends identified in this study provides deep insight into how AR is being applied and perceived in the tourism industry and the cultural field in the post-COVID-19 pandemic era. Ranging from the development of AR applications to measuring the acceptance of this technology and improving the marketing of cultural sites, these trends reflect the constant evolution of the relationship between technology and sustainable tourism.

Firstly, the trend related to the development of applications based on AR and VR to improve the experience in cultural sites is of great relevance. The pandemic has transformed the way people interact with cultural spaces, and AR has become a powerful tool to enrich these experiences [98]. Researchers and professionals are engaged in creating applications that offer visitors a deeper and more immersive understanding of history, art, and culture in museums and historical sites [48]. This trend highlights the importance of adopting immersive technologies to maintain the interest of audiences and encourage the preservation of cultural heritage.

As for the second trend, which focuses on models to measure the acceptance of AR technology in cultural sites, it is essential to understand how visitors perceive and adopt this technology. Acceptance models provide valuable information on the factors that influence the decision to use AR applications in cultural contexts [99]. Researchers are working to identify the key determinants that influence visitor adoption of these technologies. This is essential to adapt implementation and promotion strategies for AR applications in museums and cultural sites, which in turn can improve user experience and increase engagement.

The third trend, which addresses the identification of mechanisms to improve the marketing of cultural sites using AR, reflects how technology can be an effective tool to attract visitors [100]. The pandemic has driven the need to promote destinations and cultural sites in a more innovative and virtual way. The results indicate that marketing strategies that incorporate elements of AR are being explored to attract and engage audiences [101]. These

strategies may include virtual tours, real-time previews of cultural events, and interactive content that stimulates tourist interest and promotes visits to these places.

Together, these trends reflect the convergence of AR and tourism in the post-pandemic era. While significant progress has been made in the application of technology in cultural contexts, challenges remain, such as the need to address concerns about data privacy and accessibility [50]. However, AR has a leading role in the revitalization and promotion of cultural and tourism sites in the post-COVID-19 world, presenting exciting opportunities for the tourism industry and the preservation of cultural heritage.

These trends reveal how AR has become an essential tool to boost sustainable tourism and cultural heritage conservation in the post-pandemic era. With the development of immersive applications, measuring the acceptance of this technology, and improving the marketing of cultural sites, significant advances are being made in the way people experience and value cultural heritage. However, it is important to address the remaining challenges to ensure the effective and ethical use of AR in the tourism and cultural context.

5. Conclusions

This study presents a review of the literature on the topic of AR and tourism, using scientometric approaches that involve the analysis of two renowned scientific data sources: Scopus and WoS. This research approach is novel as it merges data from two widely used scientific databases and applies advanced data analysis and visualizations, including text mining and web scraping, to obtain a comprehensive view of the field of study.

Analysis using the ToS (Topic Over Time) algorithm reveals three main subfields within AR and tourism research. The first focuses on applications of AR in sustainable tourism experiences, highlighting how AR technology can improve the quality of tourism experiences by providing enriched information and interactive contexts. The second subfield focuses on AR-based marketing and promotion strategies for sustainable tourism destinations, highlighting how AR is used as a tool to attract and engage travelers in the post-COVID era. The third subfield relates to the socioeconomic and environmental impact of the adoption of AR technologies in sustainable tourism, addressing issues of sustainability and travelers' perception of value. This analysis reflects the growing importance of AR in the context of sustainable tourism, highlighting how this technology can improve the quality of tourism experiences, promote sustainable destinations, and generate positive impacts in terms of economic and environmental development. Despite certain limitations in this study, such as the amalgamation of authors due to the common practice of using surnames and the first letters of names in literature reviews, the collaboration between authors in this field of research stands out. In future research, it would be advisable to perform a more precise author analysis using unique identifiers such as ORCID to obtain more precise results.

Many works have made use of hybrid technologies such as AR and VR, considering that AR allows contextual digital information to be superimposed in real-time on the physical environment, which enriches the tourist experience by providing relevant data, interactive guides, and educational content. On the other hand, VR immerses tourists in completely immersive virtual worlds, giving them the opportunity to visit destinations in a virtual and realistic way. This relationship offers a wide range of benefits, from the personalization of tourism experiences to the promotion of sustainability and the conservation of cultural and natural heritage. In addition, both technologies have great potential for tourism marketing and destination promotion, attracting a broader audience and captivating the attention of travelers with unique and unforgettable experiences. Together, AR and VR are transforming the tourism industry by offering more interactive, educational, and sustainable tourism experiences tailored to individual tourists' preferences, thus promoting responsible destination exploration.

This article has practical significance and makes an important contribution to both the academic community and the tourism industry. A solid scientometric analysis was performed that offers a deep and up-to-date view of research at the intersection of AR

and tourism, specifically in the context of the post-COVID-19 pandemic era. Therefore, its relevance is highlighted considering that, first, the authors contributed significantly to science by carrying out an exhaustive analysis that addresses a topic of growing interest in a post-pandemic world. AR has become an essential technology in the tourism industry, and this analysis provides a solid foundation for future research. Additionally, by highlighting emerging trends and research areas, the authors point to opportunities for knowledge expansion and innovation in the field.

This article also sheds light on the impact of the COVID-19 pandemic on research related to AR and tourism. The tourism industry's ability to adapt amid unprecedented challenges is a relevant topic, and the results reflect how researchers have responded by exploring new applications and approaches of AR to address changes in tourist behavior and travel restrictions.

One of the most notable contributions of this article is the identification of promising focus areas. This includes the application of AR in museums and cultural sites, enhancing the visitor experience and providing new opportunities for education and cultural heritage preservation. Additionally, this research highlights the importance of sustainable tourism and how AR can play a crucial role in promoting more responsible and environmentally conscious tourism practices.

However, it is important to recognize the limitations of this study, as it is based on the compilation and analysis of previously published scientific articles. Therefore, the conclusions are linked to the availability and quality of the data existing in the scientific literature. However, with the implementation of this search, it is possible to offer a complete and updated vision of the trends, focus areas, and challenges in the post-COVID-19 context, which benefits both the academic community, health professionals, and the tourism industry. It provides a roadmap for future research and practical applications of AR in a constantly evolving tourism environment.

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