Tourism Management 77 (2020) 104028

Contents lists available at ScienceDirect

Tourism Management

journal homepage: http://www.elsevier.com/locate/tourman

Progress in Tourism Management

20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach

Sandra Maria Correia Loureiro [a], João Guerreiro [a], Faizan Ali [b,*]

[a] Instituto Universitário de Lisboa (ISCTE-IUL), Business Research Unit (BRU/IUL), Lisbon, Portugal
[b] College of Hospitality and Tourism Leadership, University of South Florida Sarasota Manatee, 8350 N Tamiami Trail, SMCA315, Sarasota, FL, 34243, USA

ARTICLE INFO

Keywords:
Virtual reality
Augmented reality
Tourism management
Tourism promotion
TAM
SOR

ABSTRACT

Virtual reality (VR) and Augmented Reality (AR) have undergone technical evolutions over the last few decades including improvements in immersion and the feeling of telepresence. Several examples of the applications of such techniques can be found in stores, tourism, hotel, restaurants, and destinations. Yet, a comprehensive analysis of studies employing such techniques in tourism-related studies is difficult to find. The current study uses citation network analysis and text-mining techniques to conduct a full-text analysis of 56 journal papers and 325 conference proceedings related to VR and AR in the tourism context. This paper intends to (i) provide an overview of the VR and AR-related tourism studies network and discuss them over time, (ii) present the most important topics and studies emerging from this literature, (iii) suggest avenues for further research. Findings reveal 10 core topics in journal papers and 11 core topics in conference proceedings, which are presented together with an overview of the published studies and the main authors.

1. Introduction

Immersive technologies such as virtual reality (VR) and augmented reality (AR) have enabled tourism managers to enhance tourists' satisfaction by providing them with memorable experiences. Such immersive virtual environments based on new and upcoming technologies are changing the way tourism operators stimulate their customers before, during and after their experience (Ali, 2016; Hannam, Butler, & Paris, 2014; Lemon & Verhoef, 2016; Woo, Kim, & Uysal, 2015). VR and AR environments may be used to promote a destination or site, to augment the reality at the destination or eventually to immerse the consumers in a new and completely challenging tourism experience (Guttentag, 2010). VR allows consumers to have immersive and stimulating different forms of reality, using stereoscopic head-mounted displays (HDM) (Williams & Hobson, 1995). VR abstracts the users from their surrounding environment and presents them with both visual and audio stimuli to make them feel in a completely different setting (telepresence) (Ali, 2016; Hyun & O'Keefe, 2012). In AR, while observing the world, tourists also observe virtual objects overlaid on the real world usually by interacting with their own smartphones or digital cameras (Olsson et al., 2012), by using see-through displays (Bimber & Raskar, 2005; García-Crespo, González-Carrasco, López-Cuadrado, Villanueva, & González, 2016) or more recent techniques such as spatial augmented reality (SAR), that can be used on large surfaces as spatial-aligned wall projections (also commonly named 3D video mapping).

VR and related technologies are making a revolution in the way tourists experience travel and tourism-related products and services. Yet, in travel and tourism literature, no study reviews the current state of VR and AR-related studies over time so that the most important topics and studies are highlighted, and emerging topics may be presented for further research. The current research paper uses a text mining approach called topic modeling to find latent topics from the literature review. Recently, topic modeling (TM) has been used to uncover correlated discussions in the text that may help researchers to highlight the most important themes addressed in the literature (Guerreiro, Rita, & Trigueiros, 2016; Moro, Rita, & Cortez, 2017).

In this vein, the current paper first provides an overview of VR and AR technologies, conceptualization and foundation. It is followed by the methods used to collect all the relevant papers both in journals and conference proceedings, to perform the literature review. An overview of the collected papers is described along with a citation network analysis of the most important papers and their references. A community

* Corresponding author.,
E-mail addresses: sandramloureiro@netcabo.pt (S.M.C. Loureiro), joao.guerreiro@iscte-iul.pt (J. Guerreiro), Faizanali7@hotmail.co.uk, faizanali@usf.edu (F. Ali).

https://doi.org/10.1016/j.tourman.2019.104028
Received 13 September 2018; Received in revised form 21 August 2019; Accepted 29 October 2019
Available online 8 November 2019

detection algorithm is then used to explore groups of citations. The latent topics that emerge from such analysis are explored in greater detail in section four. Section five is dedicated to research questions and thoughts on future research directions of VR and AR in tourism. Conclusions and contributions are addressed in the final section of the paper.

2. Virtual and augmented reality conceptualization and foundation

3D simulation attempts on the large scale go back to the first science fiction movie Pygmalion's Spectacles, written by Stanley G. Weinbaum on the 1930s, when a pair of goggles was used worldwide to experience a fictional world through a holographic experience, complemented by the use of smell, taste, and touch. However, one of the most important events that marked the beginning of today's' AR and VR development happened in 1994, when interactive three-dimensional (3D) graphics emerged on the Internet with Virtual Reality Modeling Language (VRML). This event allowed the web-based Virtual Reality (VR) to become a widespread reality for interactive simulations in diverse areas (particularly for education and gaming) (Yoon Laffey, & Oh, 2008).

Another important milestone happened later in the 1950s with the Morton Heilig's Sensorama, an arcade-style theatre cabinet which featured stereo speakers, a stereoscopic 3D display, fans, smell generators, and a vibrating chair. Sensorama was created to completely immerse a person when visualizing a movie. Later, in the 1960s, Ivan Sutherland created the firstVR head-mounted display (HMD). This device connected to a stereoscopic display from a computer program and presented the possibility to depict virtual wireframe shapes, which changed perspective as the user moved his/her head. The device superimposed artificial images on a real background, which could be seen as the beginning of AR (digital trends, 2018; Carmigniani, Carmigniani, & Furth, 2011). In augmented reality (AR), the participant can see the real world as well as overlapping virtual objects in the real world, by using see-through displays (Bimber & Raskar, 2005). Thus, AR presents layers of virtual content (text, images, video) over the real-world scenarios (Scholz & Smith, 2016). Those characteristics help consumers to try out how different products or services may fit their daily lives. However, its expansion to commercial applications only took place in the '90s. More recently Pokémon GO game is an example of AR application and usage (Javornik, 2016). AR is an important tool for tourism operators and managers to extend the consumer experience, however, it lacks the immersion needed for a fully engaging experience. To achieve such objectives, the tourism sector has successfully used VR applications.

Virtual reality VR is an immersive 3D simulated environment that allows consumers to have the feeling of being in a real-world environment (telepresence) (Guttentag, 2010). Thus, VR is a completely synthetic world that may or may not mimic the real-world. At the end of the 1980s (1987), Jaron Lanier coined the expression "virtual reality". He developed a range of virtual reality gear, for instance, the Dataglove (along with Tom Zimmerman) and the EyePhone head-mounted display (Virtual-reality, 2018).

The 1990's witnessed the development of VR over the Internet (with VRML) and the use of equipment mainly devoted to gamification, for instance, Sega VR headset, Lawnmower Man and Nintendo Virtual Boy. Later in the 21st Century, Second Life was born, in which people could create a virtual representation of themselves (avatars) and interact with other avatars, places, and objects (Mennecke, Terando, Janvrin, & Dilla, 2007; Stangl & Weismayer, 2008). This game, the use of new devices such as Oculus Rift and the AR mobile applications brought virtual worlds to the mainstream and available to many tourists worldwide. VR has been used not only to prepare consumers to what they may expect in the real world but during the visit itself to help tourist experience things that are not available in the real-world. For example, the Rome Reborn project in Google Earth allows tourists to explore Rome the way it was centuries ago (Rome Reborn, 2009). Other examples include full experiences that complement the immersive characteristics of VR with special sensors that stimulate other senses such as touch. An example of such experience is Navitare, a VR framework that allows tourists to experiment travel sites, book their favorite experiences and pay at the end (Navitare, 2018).

AR and VR are promising technologies that may have particular impacts on multiple sectors. The predicted market size for 2020 is set for 143.3 billion dollars (Statista, 2018a). Studies show that 18–24 aged consumers tried VR more often than any other generation and 46% of those that still have not tried it is willing to try. Such predisposition, however, is more prevalent in men than in women. Men are almost twice as likely to have tried VR applications as women (15% men; 8% women) (YouVisit, 2015).

Despite the exponential evolution in recent years of both VR and AR, numerous barriers must be overcome in the coming years. Secondary effects such as motion sickness effects must be addressed if VR is to be used for prolonged experiences (Guttentag, 2010). Another issue that may be further discussed soon is the security of the data that stems from the consumer's behavior while using such environments (Denwagan, 2013).

However, tourists today are more engaged in using VR and AR for experience destinations, hotels or museum before taking the decision of travel to the place than ever before (e.g., Wang, Yu, & Fesenmaier, 2002; Buhalis & Law, 2008; Fotakis & Economides, 2008). Therefore, VR and AR research and commercial applications have flourished in tourism and have led scholars to study the drivers of success of using virtual environments in Tourism. The following section provides an overview of such research conducted over time.

3. Method

A collection of the relevant literature on VR and AR used in hospitality and tourism was extracted from both Web of Science (WOS) and Scopus online libraries using the following query applied to the title, abstract and keywords: ((“virtual reality” or “augmented reality”) AND (“tourism” OR “destination marketing” OR “tourism environment” OR “hospitality” OR “attractions” OR “virtual tourism")).

An overall picture of the articles collected under the current query shows that there are 601 articles in WOS, out of which 407 were proceeding articles, 195 were papers extracted from journals, 5 were reviews, 1 was a retracted paper and 1 was a meeting abstract. The treemap from Fig. 1 shows that most of the articles come from computer science categories (357), followed by the engineering category (182) and the hospitality/leisure/sport/tourism category (77).

From conference proceedings, that usually hold most up to date research, the top 10 articles ordered by citation rank are presented in Table 1.

The top 10 papers cited under the peer-review journals on WOS are depicted in Table 2.

From the Scopus query, 804 total articles were retrieved, from which 435 were conference articles, 256 were journal papers, and the remaining articles belonged to books chapters, reviews and other types of documents indexed in Scopus. From the total list, 505 articles come from Computer Science, 204 from Engineering, 161 from Social Sciences and 117 from Business Management and Accounting. The remaining articles are spread around other fields such as Mathematics, Arts and Humanities, Decision Sciences, among others.

Considering conference proceedings, that usually hold most up to date research, the top 10 articles are presented in Table 3.

In Scopus, the top 10 papers cited under the peer-review journals are depicted in Table 4.

To analyze in more depth the literature review published on top tier Journals, a first analysis of done on English-written papers in peer-review journals with a JCRs' 5-Year impact factor was used. A total of 195 articles were extracted from journals indexed in Web of Science. Besides, 256 studies were selected from the Scopus database under such

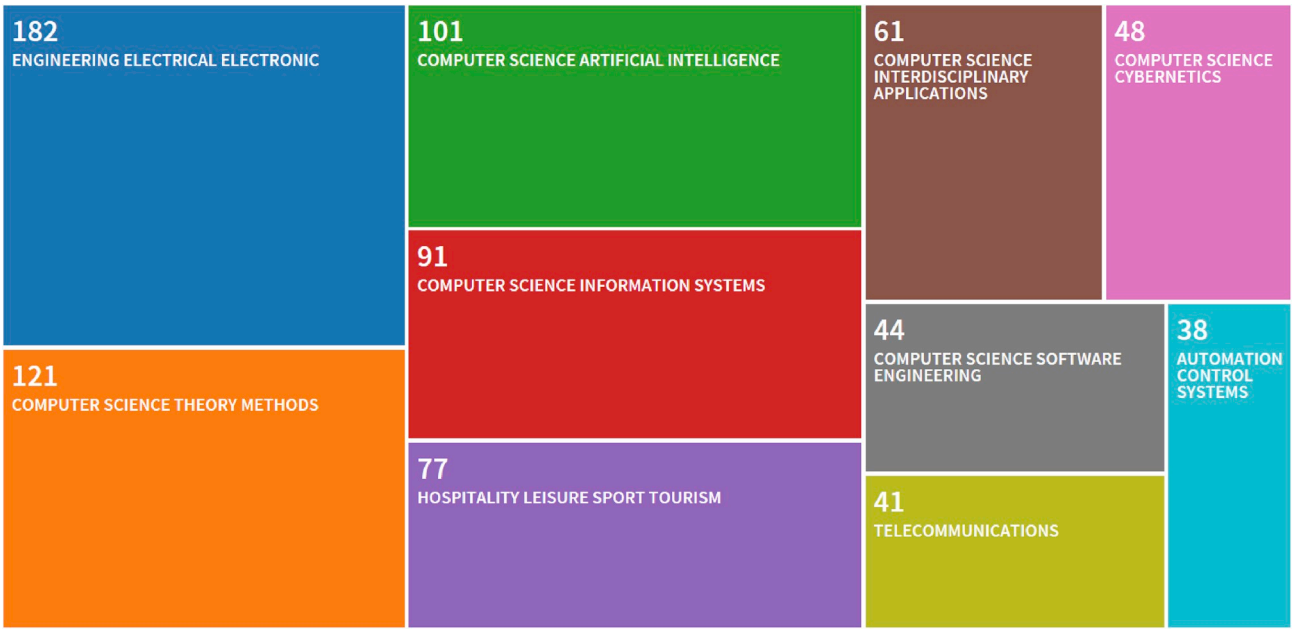

Fig. 1. Treemap with the categories of the papers extracted from WOS.

Table 1
Top 10 conference proceeding papers on WOS ordered by citation score.

Title	Authors	Year	Source	2015	2016	2017	2018	2019
An Augmented Reality Tourist Guide on Your Mobile Devices	El Choubassi, M.; Nestares, O.; Wu, Y.; Kozintsev, I.; Haussecker, H.	2010	Advances in Multimedia Modeling, Proceedings	4	1	0	3	0
The Design of Cloud-based 4G/LTE for Mobile Augmented Reality with Smart Mobile Devices	Lin, B–S. P.; Tsai, W–H.; Wu, C. C.; Hsu, P. H.; Huang, J. Y.; Liu, Tsai-Hwa	2013	2013 Ieee Seventh International Symposium on Service-Oriented System Engineering (Sose 2013)	2	3	4	3	0
Evaluation of Mobile Augmented Reality Applications for Tourism Destinations	Linaza, M.T.; Marimon, D.; Carrasco, P.; Alvarez, R.; Montesa, J.; Aguilar, S.R.; Diez, G.	2012	Information and Communication Technologies in Tourism 2012	2	3	2	2	2
Using augmented reality as a medium for teaching history and tourism	Kysela, J.; Storkova, P.	2015	International Conference on New Horizons in Education, Inte 2014	0	0	3	8	1
Forward Collision Warning Systems Using Heads-Up Displays: Testing Usability of Two New Metaphors	Alves, P. R. J. A.; Goncalves, J.; Rossetti, R. J. F.; Oliveira, E.C.; Olaverri-Monreal, C.	2013	2013 Ieee Intelligent Vehicles Symposium Workshops (Iv Workshops)	2	1	2	3	1
Multimodal Interaction Concepts for Mobile Augmented Reality Applications	Hurst, W.; van Wezel, C.	2011	Advances in Multimedia Modeling, Pt Ii	2	3	0	0	1
Presenting Cypriot Cultural Heritage in Virtual Reality: A User Evaluation	Loizides, F.; El Kater, A.; Terlikas, C.; Lanitis, A.; Michael, D.	2014	Digital Heritage: Progress in Cultural Heritage: Documentation, Preservation, And Protection	2	3	2	3	0
Interactive Tourist Guide: Connecting Web 2.0, Augmented Reality and QR Codes	Rodriguez F., E–; Martin-Gutierrez, J.; Meneses F., M. D.; Davara, E.A.	2013	2013 International Conference on Virtual and Augmented Reality in Education	2	3	3	0	0
Historical Oslo on a handheld device - a mobile augmented reality application	Chen, W.	2014	Knowledge-Based and Intelligent Information & Engineering Systems 18th Annual Conference, Kes-2014	0	2	1	3	2
Motion Recognition with Smart Phone Embedded 3-Axis Accelerometer Sensor	Cho, H.; Kim, S.; Baek, J.; Fisher, P.S.	2012	Proceedings 2012 Ieee International Conference on Systems, Man, And Cybernetics (Smc)	2	2	0	0	0

criteria. After merging both the data sets, a group of 293 total articles in AR and VR with applications in hospitality and tourism was retrieved after eliminating duplicated articles. From those 293 articles, 138 articles that belonged to journals without a 5-Year impact factor were eliminated as the inclusion of journals without impact factor might raise quality issues (Guerreiro et al., 2016).

A systematic analysis process on the full-text was performed on the remaining 155 potentially relevant papers. Such process followed four major criteria: validity; reliability; credibility and integrity (Moher, Liberati, Tetzlaff, Altman, & Altman, 2009; Nill & Schibrowsky, 2007). During the process, two researchers independently identified potentially relevant articles by reviewing the full-text and conflicts between researchers were discussed so that their agreement was >0.85 (Cohen's Kappa coefficient). A final set of 56 papers were selected for the final analysis. Fig. 2 shows the process of selecting the final papers.

An initial analysis of the results shows that there are not many papers published in top-tier journals addressing the topic of VR and AR in tourism yet. Therefore, to capture a clearer picture of the underlying topics, the current research paper explores the full paper text to highlight discussions that may be written in the paper but not resumed in the abstract. Full papers were downloaded and transformed into ASCII text for later analysis.

Table 2
Top 10 Journal papers on WOS ordered by citation score.

Title	Year	Authors	Journal	2015	2016	2017	2018	2019
Virtual reality: Applications and implications for tourism	2010	Guttentag, D. A.	Tourism Management	11	22	36	36	13
Developments and key issues in tourism mobilities	2014	Hannam, K.; Butler, G.; Paris, C.M.	Annals of Tourism Research	11	18	21	17	6
The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park	2015	Jung, T.; Chung, N.; Leue, M. C.	Tourism Management	1	10	12	41	8
Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site	2015	Chung, N.; Han, H.; Joun, Y.	Computers in Human Behavior	0	2	12	22	9
Influences of travel constraints on the people with disabilities' intention to travel: An application of Seligman's helplessness theory	Lee et al., 2012	Lee, B·K.; Agarwal, S.; Kim, H.J.	Tourism Management	4	4	14	10	5
Exploring the Implications of Virtual Reality Technology in Tourism Marketing: An Integrated Research Framework	2016	Huang, Y·C.; Backman, K. F.; Backman, S. J.; Chang, L.L.	International Journal of Tourism Research	0	1	11	20	10
A theoretical model of mobile augmented reality acceptance in urban heritage tourism	2018	Dieck, M. C. T.; Jung, T.	Current Issues in Tourism	0	4	10	21	5
Apply an Augmented Reality in a Mobile Guidance to Increase Sense of Place for Heritage Places	2015	Chang, Y-L; Hou, H-T; Pan, C–Y; Sung, Y-T; Chang, K-E	Educational Technology & Society	1	7	13	11	4
Virtual destination image: Testing a presence model	2012	Hyun, M.Y.; O'Keefe, R.M.	Journal of Business Research	5	3	3	10	11
A virtual tour of geological heritage: Valourising geodiversity using Google Earth and QR code	2013	Martinez-Grana, A. M.; Goy, J. L.; Cimarra, C. A.	Computers & Geosciences	9	4	6	12	0

Table 3
Top 10 conference proceeding papers on Scopus ordered by citation score.

Title	Year	Authors	Source	2015	2016	2017	2018	2019
ARCHEOGUIDE: First Results of an Augmented Reality, Mobile Computing System in Cultural Heritage Sites	2001	Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Ioannidis, N.	Proceedings VAST 2001 Virtual Reality, Archeology, and Cultural Heritage	7	7	15	19	2
Designing social presence of social actors in human computer interaction	2003	Lee, K.M., Nass, C.	Conference on Human Factors in Computing Systems	11	7	4	8	5
DHC: A density-based hierarchical clustering method for time series gene expression data	2003	Jiang, D., Pei, J., Zhang, A.	3rd IEEE Symposium on BioInformatics and BioEngineering	5	5	8	7	3
Lessons from the lighthouse: Collaboration in a shared mixed reality system	2003	Brown, B., MacColl, I., Chalmers, M., Galani, A., Randell, C., Steed, A.	Conference on Human Factors in Computing Systems	6	2	2	3	3
Disney's Aladdin: First steps toward storytelling in virtual reality	1996	Pausch, R., Snoddy, J., Taylor, R., Watson, S., Haseltine, E.	ACM SIGGRAPH Conference on Computer Graphics	2	6	1	1	
CityViewAR: A mobile outdoor AR application for city visualization	Lee et al., 2012	Lee, G.A., Dunser, A., Kim, S., Billinghurst, M.	11th IEEE International Symposium on Mixed and Augmented Reality 2012	2	5	7	17	6
Meeting the Spirit of History	2001	Kretschmer, U., Coors, V., Spierling, U., Grasbon, D., Schneider, K., Rojas, I., Malaka, R.	VAST 2001 Virtual Reality, Archeology, and Cultural Heritage			5	4	1
3D acquisition, modelling and visualization of North German castles by digital architectural photogrammetry	2004	Kersten, Th., Acevedo Pardo, C., Lindstaedt, M.	International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences	3	2	3	2	
Exploring the Uncanny Valley with Japanese video game characters	2007	Schneider, E., Wang, Y., Yang, S.	3rd Digital Games Research Association International Conference	7	3	2	2	1
Automated 3D reconstruction of interiors with multiple scan-views	1998	Sequeira, Vitor, Ng, Kia, Wolfart, Erik, Goncalves, Joao G.M., Hogg, David	SPIE - The International Society for Optical Engineering					

To address the task of analyzing the articles, a first study was done based on a community detection algorithm over the citation network to identify the most relevant communities among all connected articles (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008, p. P10008), followed by a correlated topic model (CTM). CTM is a mixed membership model that extracts the semantic structure of text based on a hierarchical Bayesian analysis. Unlike traditional clustering methods, CTM allows for correlated words to be part of multiple topics, each topic being modeled as a distribution over words in the corpus. CTM is based on latent Dirichelet Allocation (LDA), first presented by Blei, Ng, and Jordan (2003). However, CTM has the advantage over LDA of incorporating the correlation between words when it designs the latent topics. If the same words occur in two different contexts, the method allows for two different topics to be created. For example, the sentences "a faulty participant conducted an experiment" and "a participant conducted a faulty experiment" although having the same words belong to two different topics, the first discussing issues related to the consumers' characteristics and the latter discussing issues related to the method.

3.1. Longitudinal overview of studies on vr and ar in tourism

The first two articles published in top-tier tourism journals date back to 1995. They are short papers (about 5 pages) discussing the initial definitions of VR and related issues in the tourism context. Williams and Hobson (1995) presented VR as a new technology where consumers can choose and tailor their experiences to a degree that was not possible in the 20th century. They outlined three key aspects of VR including visualization (e.g., stereoscopic vision in three dimensions), virtual

Table 4
Top 10 Journal papers on Scopus ordered by citation score.

Title	Year	Authors	Journal	2015	2016	2017	2018	2019
The impact of ideology on effectiveness in open source software development teams	2006	Stewart, K.J., Gosain, S.	MIS Quarterly	27	28	31	19	13
Virtual reality: Applications and implications for tourism	2010	Guttentag, D.A.	Tourism Management	13	19	40	57	27
Enhancing the tourism experience through mobile augmented reality: Challenges and prospects	2012	Kounavis, C.D., Kasimati, A.E., Zamani, E.D.	International Journal of Engineering Business Management	11	13	15	37	13
The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park	2015	Jung, T., Chung, N., Leue, M.C.	Tourism Management	2	11	14	40	15
Factors affecting members' trust belief and behaviour intention in virtual communities	2008	Wu, J.-J., Tsang, A.S.L.	Behaviour And Information Technology	5	5	6	5	6
Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site	2015	Chung, N., Han, H., Joun, Y.	Computers in Human Behavior		6	16	29	14
VR-VIBE: A Virtual Environment for Co-operative Information Retrieval	1995	Benford, S., Snowdon, D., Greenhalgh, C., Ingram, R., Knox, I., Brown, C.	Computer Graphics Forum		3	2	1	
Exploring the Implications of Virtual Reality Technology in Tourism Marketing: An Integrated Research Framework	2016	Huang, Y-C., Backman, K-F., Backman, S.J., Chang, L.L.	International Journal of Tourism Research		1	10	26	17
Exploring user acceptance of 3D virtual worlds in travel and tourism marketing	2013	Huang, Y.-C., Backman, S.J., Backman, K-F., Moore, D.	Tourism Management	5	7	10	12	9
Virtual technologies trends in education	2017	Martín-Gutiérrez, J., Mora, C.E., Añorbe-Díaz, B., González-Marrero, A.	Eurasia Journal of Mathematics			5	33	13

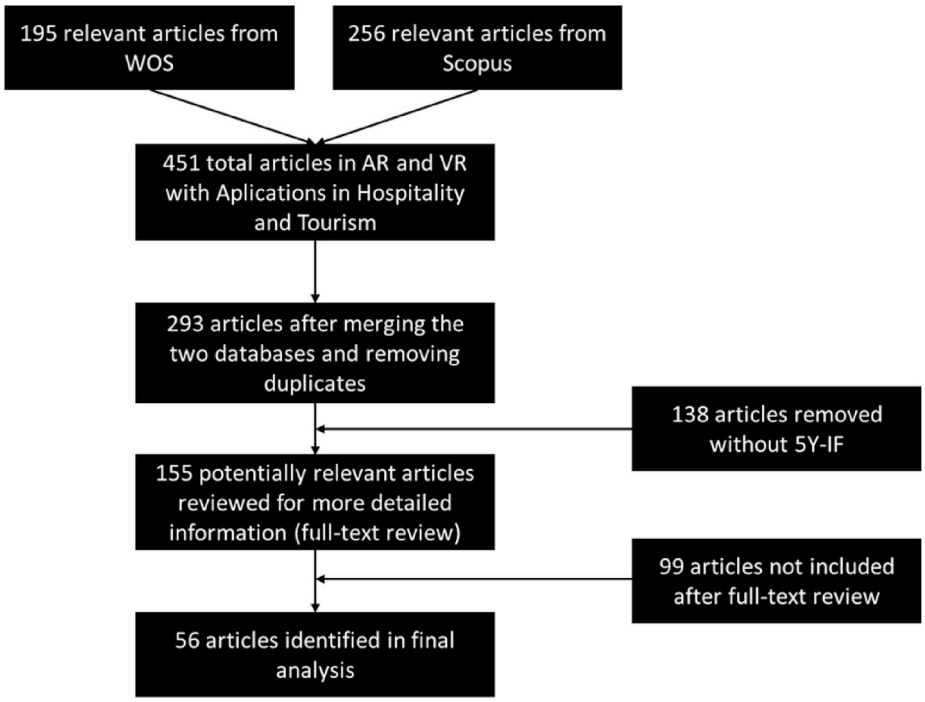

Fig. 2. Process for selecting the final papers.

immersion and interactivity with the experience (meaning the degree of telepresence and control tourists have over the experience). On the other hand, Cheong (1995) stressed the possible threat of using virtual environments in the travel industry because they may reduce the impacts of tourism and can also operate as a marketing tool, where tourists have the opportunity to experience previews of destinations and their respective attractions and facilities.

During 1999–2000, three more articles related to sustainable tourism were published. These articles discussed that the use of virtual environments may promote tourism destinations, eventually giving mass tourism greater sustainability. VR may also contribute to the analysis and prediction of visitor location and movement patterns (Bishop & Gimblett, 2000; Dewailly, 1999; Soomro, Zheng Tura., & Pan, 1999).

During 2001–2010, most of the VR and AR research was published in journals dedicated to computation and technology, but two articles published in the field of tourism are noteworthy. Styliadis et al. (2009) presented a practical 3D project (three dimensions) in which they modeled the metadata of an ancient Greek palace to avoid threat and danger (pollution, natural disasters, wars, etc.) in cultural heritage places. Besides, Guttentag's (2010) study was the first one to give an

overview of the conceptualization of VR and its application within the tourism sector. He defines VR as the use of "computer-generated 3D environment – called a 'virtual environment' (VE) – that one can navigate and possibly interact with, resulting in real-time simulation of one or more of the user's five senses" (Guttentag, 2010, p. 638). VR is comprised of two important aspects, mainly its capacity to provide physical immersion (participants are isolated from the rest of the world) and physical presence (when participants behave in a similar real-life situation) (Gutiérrez et al., 2008).

From 2011 to January of 2018, the number of articles published in journals increased (16 in top-tier journals in tourism context). Hwang, Yoon, and Bendle (2012), for instance, used VR technology to analyze approach/avoidance responses of crowding in a restaurant waiting area. Huang, Backman, Backman, and Moore (2013) attempt to extend the Technology Acceptance Model (TAM) and Hedonic Theory to study the virtual world of Second Life and its opportunity as a tool for tourism communicating marketing. Other studies also focused on the integration of TAM and VR to understand customer experience (Huang, Backman, Backman, & Chang, 2016) in different contexts including wine tourism (Martins et al., 2017), historic visitor attractions (Lagiewski & Kesgin, 2017), golf sport (Han, Hwang, & Woods, 2014) or cultural heritage sites (tom Dieck & Jung, 2017).

The S(stimuli)-O(organism)-R(response) framework is another theoretical tool acting as a base for VR studies in tourism (Yeh, Wang, Li, & Lin, 2017). In this framework, stimuli are the starting points of a process that leads to emotional and cognitive internalization and consequently to behaviors (approach or attachment and avoidance) (Mehrabian & Russel, 1974; Roschk et al., 2017). Yeh et al. (2017) extended the S–O-R model to incorporate tourists' responses, namely attention, interest, desire, and action (AIDA).

Fig. 3 shows the number of papers per year and the corresponding 5-Year impact factor average.

Results show that the number of papers on VR and AR in tourism has been increasing over the last two decades, with a positive trend that dates back to 2009. Although the 5-Year impact factor has been inconsistent for the journals, both the initial papers in 1995 were published in Tourism Management that holds a 5-Year impact factor of 6.05. In 2002, another paper was published by Buchroithner (2002) in the ISPRS Journal of Photogrammetry and Remote Sensing with a 5-Y impact factor of 6.46. Moreover, in 2010, two papers by Guttentag (2010) and Gärtner, Seidel, Froschauer, and Berger (2010) were published in Tourism Management and Information Sciences, respectively. Tourism Management holds a 5-Year impact factor of 6.05, whereas Information Sciences holds a 5-year impact factor of 5.39. From 2010 onwards, a few papers have been published in top-tier journals such as Annals of Tourism Research (Hannam et al., 2014), but the average 5-year impact factor scores have decreased due to the increase in the number of papers published by these journals.

The word cloud in Fig. 4 shows the co-authorship relevance for the papers extracted for the current analysis. The size of the text is proportional to the frequency of papers co-authored by the authors.

3.2. References network analysis

References of each paper were extracted to perform a network analysis of the relationships between the studies and previous literature. References were collected from the list available in the Scopus library. Gephi software for network analysis was used to perform the statistics on the network of correlated papers (Bastian, Heymann, & Jacomy, 2009). Many of the papers cited web pages and other references labeled by Scopus as having "no title available". Those references were excluded from the analysis and duplicate papers were also merged to have one single distinct child paper linked to all its parent papers. The final directed graph had 2479 nodes (papers) and 2720 edges (links). After filtering the unconnected nodes using the "giant component" filter, the betweenness centrality for each node was calculated. The papers high in betweenness centrality reveal papers that have the shortest paths in the network, being, therefore, the ones that bridge more often the other papers together.

Results show that papers are written by Guttentag (2010) and Huang et al. (2016) display the highest betweenness centrality score in the network. Although both the papers were published six years apart, they discuss the applications and implications of VR in tourism. Therefore, it will not be surprising to see these papers will be central to all forthcoming studies and well linked to important studies in the field. Table 5 shows the top 10 papers sorted by their betweenness centrality score.

A community detection algorithm based on modularity optimization was run in the network to identify the most relevant communities among all connected papers (Blondel et al., 2008, p. P10008). A randomized optimization was run under varying resolution levels to get a

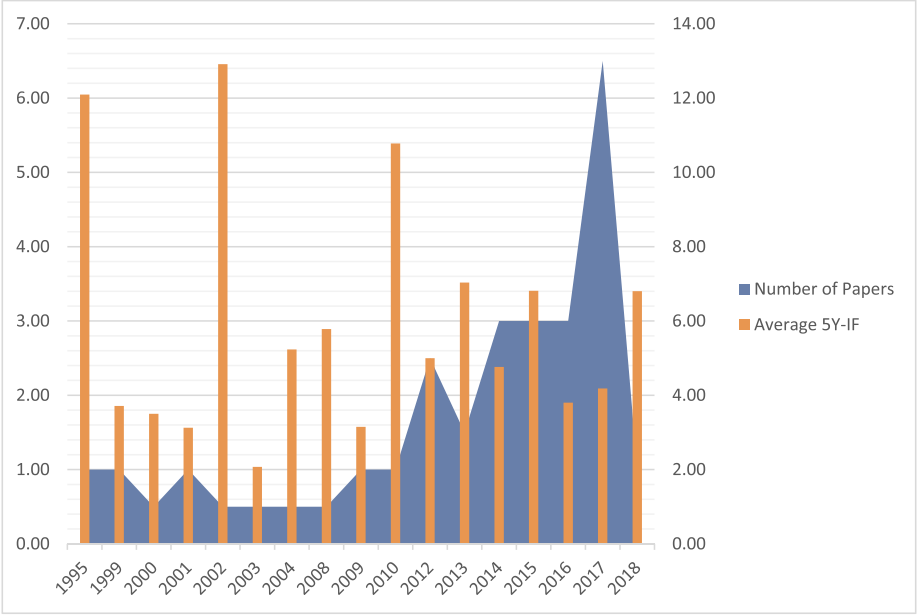

Fig. 3. Number of papers per year and 5-year impact factor.

Fig. 4. Co-authorship relevance word cloud.

Table 5
Top 10 papers in terms of betweenness centrality score.

Authors	Title	Year	Journal	Betweenness Centrality
Guttentag (2010)	Virtual reality: Applications and implications for tourism	2010	Tourism Management	2518.7
Huang et al. (2016)	Exploring the Implications of Virtual Reality Technology in Tourism Marketing: An Integrated Research Framework	2016	International Journal of Tourism Research	913.8
Huang et al. (2013)	Exploring user acceptance of 3D virtual worlds in travel and tourism marketing	2013	Tourism Management	358.0
Williams and Hobson (1995)	Virtual reality and tourism: fact or fantasy?	1995	Tourism Management	347.7
Dewailly (1999)	Sustainable tourist space: From reality to virtual reality?	1999	Tourism Geographies	325.5
Jung et al. (2015)	The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park	2015	Tourism Management	246.5
Chalkiti and Sigala (2008)	Information sharing and knowledge creation in online forums: The case of the Greek online forum 'DIALOGOI'		Current Issues in Tourism	212.5
tom Dieck and Jung (2018)	A theoretical model of mobile augmented reality acceptance in urban heritage tourism		Current Issues in Tourism	84.5
Cheong (1995)	The virtual threat to travel and tourism		Tourism Management	83.8
Hyun and O'Keefe (2012)	Virtual destination image: Testing a telepresence model		Journal of Business Research	58.5

manageable number of specific communities without having too large clusters. A 0.25 resolution produced 52 communities (modularity = 0.865), a 0.5 resolution produced 47 communities (modularity = 0.877) and a 1 resolution index produced 39 larger clusters with a modularity score of 0.816. To keep specific communities, the 0.5 resolution index was used following the highest score used on Bruns, Moon, Münch, and Sadkowsky (2017).

Table 6 shows the top 10 more representative communities in the network (which represent 45,5% of the total 47 communities) along with the number of papers in each cluster, its most connected papers based on their in-degree (the number of papers pointing to the original study) and out-degree scores (the number of papers being referenced in the network. A bag-of-word analysis of the titles in each cluster also shows the 5-top words in each group.

Although most papers have a low in-degree score due to most of them being very recent papers, results confirm that Guttentag (2010) is the more prominent paper so far. Cluster 1 groups papers that were used to support the work of Kim and Kim (2017) based on the role of mobile technology in tourism. Cluster 2 joins papers that address the seminal work of Guttentag (2010) and discuss VR implications for tourism. Cluster 3 groups a community of papers around Tourism Marketing. Cluster 4 formed around Tourism Destination Marketing issue grouped around the work of Li, Leider, et al. (2017) and Li, Robinson, et al. (2017). Cluster 5 groups around tourism mobilities. Cluster 6, groups papers around experiential and emotions around the work of Hyun and O'Keefe (2012) and more recently of Yeh et al. (2017). Cluster 7 has a community of papers that discuss topics around atmospheric design, crowding, and servicescapes. Cluster 8 has papers around image quality of VR and AR designs. Cluster 9 joins papers around new business model innovations and how they are deployed in smart cities. Finally, Cluster 10 grouped papers that discuss the implications for cultural heritage and its related papers.

Fig. 5 shows the graph of the original papers and their connected references. The size of the bubbles represents the betweenness centrality score and the top 10 papers were labeled for interpretation purposes.

3.3. Topic analysis for journal papers

Statistical package R was used to transform the corpora using tm and topicmodels libraries. After converting all text into lower case, removing whitespaces, numbers, and stop-words, and applying a stemming algorithm to text (Porter, 1980), the remaining text was tokenized into unigrams and bigrams and converted into a document-term matrix

Table 6
Top 10 communities of papers around the topic.

Cluster	# papers	%	Most Connected Papers	In Degree	Out Degree	5 top words from title
1	183	7,38%	Kim and Kim (2017)	0	196	smart (44), technology (40, sustaining (34), analysis (29), mobile (18)
2	162	6,53%	Guttentag (2010)	10	188	heritage (17), authentic (12), environment (11), model (11), 3D (10)
3	155	6,25%	Huang (2016) Huang (2013)	3 4	145 80	technology (21), theory (21), life (20), model (19), consumer (18)
4	128	5,16%	Li, Leider, et al. (2017) and Li, Robinson, et al. (2017)	0	159	destination (52), market (35), website (16), travel (15), information (13)
5	111	4,48%	Hannam et al. (2014)	0	120	mobile (13), social (19), travel (16), automobility (15), place (10)
6	104	4,20%	Hyun and O'Keefe (2012) Yeh et al. (2017)	2 0	38 87	effect (22), consumer (17), advertising (13), experience (13), model (12)
7	76	3,07%	Hwang et al. (2012)	0	84	effect (21), crowding (15), music (13), behavior (11), response (11)
8	73	2,94%	Deng et al. (2016)	0	24	image (18), video (16), using (11), motion (9), recognition (9)
9	71	2,86%	Díaz-Díaz (2017)	0	71	city (38), smart (35), business (32), model (32), service (16)
10	66	2,66%	Koeva et al. (2017)	0	67	heritage (26), cultural (24), 3D (21), model (19), photogrammetry (17)

Fig. 5. Graph of original papers and its references.

(DTM). The K number of latent topics was selected according to measures derived from the work of Griffiths and Steyvers (2004) and Cao, Xia, Li, Zhang, and Tang (2009). Fig. 6 shows the set of possible models from k = 2 to k = 60 that were simulated to check which model best fit the data.

The number of K was selected after the log-likelihood and perplexity measures reached the end of a big slope so that a manageable set of topics were selected for analysis. According to Guerreiro et al. (2016, p. 115), "the ideal number of clusters/topics is attained when the variability explained does not change significantly by adding more clusters", therefore, a K of 13 was selected for the current analysis. Due to the small number of papers under analysis, some topics had few papers

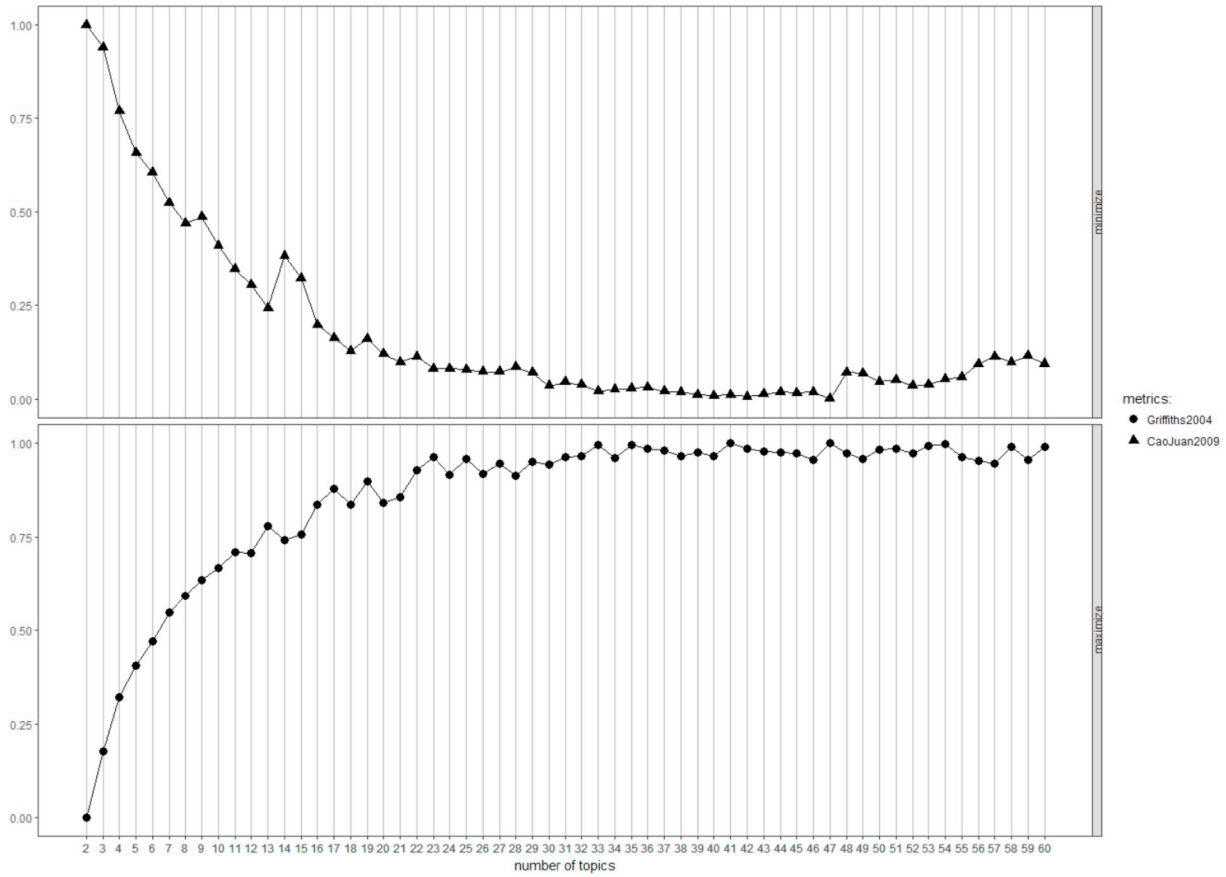

Fig. 6. Log-likelihood and perplexity metrics for evaluating K.

highly correlated with them. For the sake of having a discussion based on topics that cover a broad scope of the existing literature, the current profiles only contain the topics with at least 4 papers correlated with such topic (posterior probability > 0.5). Table 7 shows the topics extracted by using the CTM along with the correlated terms in each topic and the most relevant papers. The topics shown in Table 7 aggregates articles assigned to each of them based on the magnitude of a specific topic given their most frequent terms (posterior probability > 0.5). Thus, an article belongs to a topic only when its associated terms are frequently mentioned in that article.

3.4. Topical review in journal papers

This section uses the papers uncovered in Table 2 to discuss the literature that led to each latent topic discovered using correlated topic models. Due to the characteristics of the CTM algorithm used, one paper may belong to multiple latent topics, and although the papers in each topic are mainly focused on the proposed labels, they also discuss other less prevalent topics. Therefore, the papers used to describe each topic are the ones that have a higher correlation with the words in Table 2.

Topic 1. Atmospheric design recommendations. VR techniques can be employed to provide a deep immersion of the participants in the manipulated design settings, for instance, in hotel rooms; (e.g., Siamionava, Slevitch, & Tomas, 2018), and waiting in a virtual reality restaurant (e.g., Hwang et al., 2012). Tourists may interiorize several stimuli in the VR, such as colors, layout and space design. The process of interpretation and integration of stimuli in the tourists' minds implies developing cognitive and emotional states (organism). The outcome comes with the favorable or unfavorable response, which may result in satisfaction, intentions to revisit, word-of-mouth or avoid the place. The current topic explores design recommendations for AR and VR. The paper more correlated with the current topic (post. prob. = 0.990) from Siamionava et al. (2018) discusses the effect of spatial colors in guest perceptions. Hwang et al. (2012) (post. prob. = 0.985) suggest recommendations for controlling the effects of crowding in restaurants using VR to manipulate various scenarios. The third (Han et al., 2014) (post. prob. = 0.973) and fourth (Schott, 2017) (post. prob. = 0.924) papers with the highest posterior probability of belonging to the topic discuss how concerns about the environment may play a crucial role as a moderator in the intention to use virtual environments.

Topic 2. cultural heritage and smart cities. VR and AR technologies are used to facilitate the life of citizens and tourists in cities, also called 'smart cities'. Tourists can download applications on their mobile devices to get access to a huge amount of information about places, restaurants, hotels, cultural monuments, tours, etc. (e.g., Garcia-Crespo, Gonzalez-Carrasco, Lopez-Cuadrado, Villanueva, & Gonzalez, 2016; Zelenka, 2009). These smart cities are evolving to ecosystems, where it is possible to control waste management; water supply; traffic management, street lighting, augmented reality and tourism; incidences management, parks and gardens and citizen participation (Diaz-Diaz, Munoz, &Perez-Gonzalez, 2017). This translates into a reduction in energy consumption and environmental impact with the consequent social impact. Such smart cities also protect cultural heritage using the new AR and VR techniques.

Six papers hold the highest correlation with the topic. A more general discussion around smart cities can be found in Díaz-Díaz, Muñoz, and Pérez-González (2017) who discuss several technologies such as the use of Internet of Things (IoT) and AR to enhance smart cities business models (post. prob. = 0.952). Styliadis et al., 2009 (post. prob. = 0.993), Fernandez-Palacios et al. (2015) (post. prob. = 0.943), Herban, Grecea, and Barla (2014) (post. prob. = 0.916) and Koeva, Luleva, and Maldjanski (2017) (post. prob. = 0.784) then focus on the protection of

Table 7
Latent topics for journal papers.

Topic Name	Topic Terms	# Corr. Papers	Correlated papers with topic	Post. Prob.	Journal and Impact Factor	Affiliations	Type of Study*
T1. Atmospherics Design	crowd, color, level, emot, effect, particip, respons, behavior, environ, impact	4	Siamionava et al. (2018)	.990	International Journal of Hospitality Management (3.912)	Georgia Tech University, USA School of Hotel and Restaurant Administration, USA	Quantitative
			Hwang et al. (2012)	.985	International Journal of Contemporary Hospitality Management (3.567)	Kyung Hee University, Republic of Korea University of Missouri, USA	Quantitative
			Han et al. (2014)	.973	Asia Pacific Journal of Tourism Research (1,495)	Sejong University, Republic of Korea University of Connecticut School of Law, USA	Quantitative
			Schott (2017)	.924	Journal of Hospitality Leisure Sport & Tourism Education (.678)	Victoria University of Wellington, New Zealand	Quantitative
T2. Smart Cities and Cultural Heritage	model, object, citi, manag, data, system, applic, inform, differ, service	6	Styliadis et al. (2009)	.993	Journal of Cultural Heritage (2.146)	Kavala Institute of Technology, Greece Izmir Institute of Technology, Turkey Faculty of Rural & Surveying Engineering, Greece	Framework/ Application
			Joslin et al. (2001)	.981	IEEE Computer Graphics and Applications (1.626)	Geneva University, Switzerland Swiss Federal Institute of Technology (EPFL), Switzerland University of Bradford, UK	Framework/ Application
			Díaz-Díaz et al. (2017)	.952	Future Generation Computer Systems-The International Journal of eScience (4.787)	University of Cantabria, Spain	Qualitative
			Fernandez-Palacios et al. (2015)	.943	Archaeometry (1.561)	University of Salamanca, Spain Fondazione Bruno Kessler SMART3K S.R.L	Qualitative
			Herban et al. (2014)	.916	Journal of Environmental Protection and Ecology (.550)	'Politehnica' University of Timisoara, Romania	Conceptual
			Koeva et al. (2017)	.784	Sensors (2.964)	University of Twente, The Netherlands University of Architecture Civil Engineering and Geodesy, Bulgaria	Qualitative
T3. Seminal and Trend Papers	tourist, experi, technolog, travel, user, develop, site, advertis, destin, banner	7	Cheong (1995)	.988	Tourism Management (6.048)	University of Hawaii at Manoa USA	Conceptual
			Guttentag (2010)	.983	Tourism Management (6.048)	University of Waterloo, Canada	Conceptual
			Williams and Hobson (1995)	.953	Tourism Management (6.048)	Edith Cowan University, Australia Southern Cross University, Australia	Conceptual
			Parrinello (2001)	.897	International Sociology (1.500)	Università Roma Tre, Italy	Framework/ Application
			Hernández-Méndez and Muñoz-Leiva (2015)	.804	Computers in Human Behavior (4.252)	University of Granada, Spain	Quantitative
			Dewailly (1999)	.633	Tourism Geographies (2.416)	Université Lumière Lyon II, France	Conceptual
			tom Dieck and Jung (2017)	.596	Journal of Destination Marketing & Management (2.158)	Manchester Metropolitan University, UK	Qualitative
T4. Location Based Information and Image Quality	interfac, imag, camera, object, real, word, set, scene, point, visual	4	Deng et al. (2016)	.994	Neurocomputing (3.211)	Tsinghua University, China Tsinghua National Laboratory for Information Science and Technology, China State Key Laboratory of Intelligent Technology and Systems, China	Framework/ Application
			Rapprich et al. (2017)	.976	Geoheritage (1.744)	Czech Geological Survey, Czech Republic Institute of Geophysics Academy of Sciences, Czech Republic	Qualitative

(*continued on next page*)

Table 7 (*continued*)

Topic Name	Topic Terms	# Corr. Papers	Correlated papers with topic	Post. Prob.	Journal and Impact Factor	Affiliations	Type of Study*
			Tatzgern et al. (2015)	.975	Pervasive and Mobile Computing (2.874)	Graz University of Technology, Austria	Framework/ Application
			Bishop and Gimblett (2000)	.897	Environment and Planning B-Planning & Design (1.750)	University of Melbourne, Australia The University of Arizona, USA	Quantitative
T5. Mobile uses for Sustainable Tourism	mobil, technolog, user, agent, data, system, inform, tourist, relat, social	5	Kim and Kim (2017)	.980	Sustainability (1.850)	Korea Advanced Institute of Science Technology (KAIST), Republic of Korea Kumoh National Institute of Technology, Republic of Korea	Mix Approach
			Hannam et al. (2014)	.958	Annals of Tourism Research (5.544)	Leeds Metropolitan University, UK Flinders University, Australia Middlesex University Dubai, United Arab Emirates University of Johannesburg, South Africa	Conceptual
			Gärtner et al. (2010)	.946	Information Sciences (4.732)	Matrixware Information Services GmbH, Austria	Qualitative
			Garau and Ilardi (2014)	.737	Journal of Urban Technology (2.708)	University of Cagliari, Italy	Qualitative
			Goslin and Mine (2004)	.666	Computer (2.617)	Walt Disney Internet Group	Framework/ Application
T6. Tourism Destination Marketing	Destin, market, technolog, inform, experi, websit, visitor, attract, intent, site	6	Huang et al. (2013)	.985	Tourism Management (6.048)	National Pingtung University of Science and Technology, Taiwan Clemson University, USA	Conceptual
			Lagiewski and Kesgin (2017)	.977	Journal of Destination & Marketing Management (2.158)	Rochester Institute of Technology, USA	Qualitative
			Huang et al. (2016)	.968	International Journal of Tourism Research (2.710)	National Pingtung University of Science and Technology, Taiwan Clemson University, USA Asia University, Taiwan	Quantitative
			Li, Leider, et al. (2017)	.939	Journal of Destination Marketing & Management (2.158)	University of Wolverhampton, UK	Conceptual
			Choi et al. (2016)	.937	Journal of Travel and Tourism Marketing (2.284)	The University of Southern Mississippi, USA Temple University, USA Kansas State University, USA	Quantitative
			Zelenka (2009)	.589	E&M Ekonomie a Management (1.004)	Technical University of Liberec, Czech Republic	Conceptual
T7. TAM	perceive, technolog, intent, accept, use, tourist, destin, applic, inform, attitude	4	Chung et al. (2015)	.990	Computers in Human Behavior (4.252)	Kyung Hee University, Republic of Korea	Quantitative
			Munoz-Leiva et al. (2012)	.984	Online Information Review (1.919)	University of Granada, Spain	Quantitative
			tom Dieck and Jung (2018)	.981	Current Issues in Tourism (2.891)	Manchester Metropolitan University, UK	Qualitative
			Pantano and Corvello (2014)	.962	International Journal of Technology Management (1.106)	University of Calabria, Italy	Quantitative
T8. Experiential and Telepresence	experi, inform, imag, servic, locat, lbs, destin, system, provid, environ	5	Marsh (2003)	.992	Presence-Teleoperators and Virtual Environments (1.037)	Eindhoven University of Technology, The Netherlands	Framework/ Application
			Pedrana (2014)	.970	Current Issues in Tourism (2.891)	European University of Rome, Italy	Qualitative
			Hyun and O'Keefe (2012)	.826	Journal of Business Research (4.108)	University of Daegu, Republic of Korea University of Surrey,UK	Quantitative
			Jeng, Pai, and Yeh (2017)	.766	Applied Research in Quality of Life (1.303)	Da-Yeh University, Taiwan University of Education, Taiwan	Quantitative
			Shi et al. (2016)	.648	International Journal of Distributed Sensor Networks (1.315)	Xi'an University of Technology, China Zhejiang University, China	Quantitative
T9. Case Study Applications	knowledg, dive, marine, process, system, data,	4	Chalkiti and Sigala (2008)	.990	Current Issues in Tourism (2.891)	University of the Aegean, Greece	Qualitative
				.988			Qualitative

(*continued on next page*)

Table 7 (*continued*)

Topic Name	Topic Terms	# Corr. Papers	Correlated papers with topic	Post. Prob.	Journal and Impact Factor	Affiliations	Type of Study*
	comuniti, member, manag		Chen et al. (2012a, 2012b)		Ocean & Costal Management (2.174)	Minghsin University of Science and Technology, Taiwan	
			Chen et al. (2012a, 2012b)	.892	Journal of Ocean University of China (.730)	Ocean University of China, China South West Petroleum University, China Shandong Academy of Sciences, China	Framework/ Application
			Buchroithner (2002)	.890	ISPRS Journal of Photogrammetry and Remote Sensing (6.457)	Dresden University of Technology, Germany	Framework/ Application
T10. Augmented Reality	ces, inform, qualiti, user, app, system, satisfact, mobil, servic, person	5	Lin and Chen (2017)	.991	Symmetry-Basel (1.323)	National Taiwan Normal University, Taiwan Chunghwa Telecom Co., Ltd, Taiwan National Tsing Hua University, Taiwan	Quantitative
			García-Crespo et al. (2016)	.958	Computer Science and Information Systems (.881)	Universidad Carlos III de Madrid, Spain Planet Media Advanced IT Solution, Spain	Framework/ Application
			Martinez-Grana (2013)	.928	Computer and Geosciences (2.818)	University of Salamanca, Spain	Qualitative
			Manghisi et al. (2017)	.841	IEEE Computer Graphics and Applications (1.626)	Polytechnic University of Bari, Italy	Qualitative
			Jung et al. (2015)	.725	Tourism Management (6.048)	Manchester Metropolitan University, UK Kyung Hee University, Republic of Korea	Quantitative

Note: A coding scheme is generated based on the broad categories of quantitative, qualitative, and mixed-methods studies. Psychometric and experimental methodologies are grouped under quantitative methodology, whereas case study and phenomenological (e.g., focus group) studies are under qualitative. Conceptual are studies purely theoretical and Framework/Application are studies that present a framework to illustrate applications of VR and AR.

cultural heritage sites from overcrowded tourism using 3D models. A final paper highly correlated with the topic explores the use of Avatars for players to interact in such 3D virtual models (Joslin et al., 2001) (post. prob. = 0.981). The paper focuses on the creation of virtual attractions where multiple users may interact with each other and with Avatars in a VE, even if they are physically apart. The paper presents some examples of applications such as the creation of an Interactive Theatre. Such example may be used in cultural heritage sites to allow users to share experiences in ancient buildings (for example an old theatre) without damaging or harming such sites or even in places that no longer exist but maybe recreated using virtual environments.

The Avatars can interact with human beings and perform the role of a teacher, providing useful information about the heritage cities. A similar situation may be found in cities. Avatars may describe and guide the tourists around the city ancient history and provide actual and accurate information about places to stay, to visit or to go into a restaurant.

Topic 3. seminal papers. VR and AR can be used to promote sites, destinations, to complement real experiences, but could also create virtual experiences that tourists may accept as substitutes for real visitation to threatened sites. The papers most correlated with the current topic are Cheong (1995) (post. prob. = 0.988), Guttentag (2010) (post. prob. = 0.983) and Williams and Hobson (1995) (post. prob. = 0.953). The papers of Cheong (1995) and Williams and Hobson (1995) were some of the first to address VR implications for Tourism. The first addressed such implications on two levels: a macro-level around Tourism Policy and Planning and a second micro-level around VR as a Marketing Tool for travel agencies. In the macro level, VR is seen as a way to plan the Tourism impacts on the environment without having to alter the existing landscape beforehand. Such planning may be a useful way to improve the way new destination resorts are built or to plan for Tourism overcapacity. At a more micro-level, it is envisioned as a communication instrument to immerse consumers into future experiences. However, Cheong (1995) also highlights possible future threats of VR for Tourism as it becomes more affordable and immersive, namely the risks of VR becoming a substitute for travel. Williams and Hobson (1995) also explore the implications of VR for Tourism in the creation of virtual theme parks, the use of VR as a promotional tool, and envision VR as a potential tool for the creation of an artificial Tourism industry that may serve a new group of consumers such as people with disabilities.

Finally, the work of Guttentag (2010, p. 638) establishes a definition for VR as "the use of a computer-generated 3D environment – called a virtual environment (VE), that one can navigate and possibly interact with, resulting in a real-time simulation of one or more of the users' five senses". Like previous authors in this topic, Guttentag (2010) discusses implications for Tourism around planning and management applications, as a marketing tool, for educational purposes, to increase accessibility and for heritage preservation. The paper also highlights the threats for Tourism and challenges for the future.

Topic 4. Location-based information and image quality. This topic deals with the use of VR and AR to support the application that acts as a magic lens overprinted maps and routes (Besharat, Komninos, Papadimitriou, Lagiou, & Garofalakis, 2016; Deng, Chen, Chen, Duan, & Zhou, 2016). The four papers more correlated with the current topic are Deng et al. (2016) in which the authors present a system to automatically identify locations based on multiple images from photo tourism (post. prob. = 0.994), Rapprich, Lisec, Fiferna, and Závada (2017), who apply AR to map 3D navigation maps of volcanic sites (post. prob. = 0.976), Tatzgern et al., 2015, who explore location-based information and Bishop and Gimblett (2000) (post. prob. = 0.897), who explore the role of spatial information on predicting tourists' movements and behaviors.

Topic 5. mobile technology. This topic represents another facet of the use of virtual environments, that is, the use of mobile devices to incorporate AR technologies. Tourists increasingly use mobile devices that contribute to promoting destinations and places and can incorporate extensions of the experiences lived at the destination (Garau &

Ilardi, 2014) (post. prob. = 0.737). The paper with a higher post. prob. = 0.980 (Kim & Kim, 2017) discusses the role of mobile technology in tourism for sustainable and smart tourism, while Hannam et al. (2014) (post. prob. = 0.958) discuss how different mobilities forms, including virtual forms, of being freed from geographical constraints, may help travel and tourism to be the center of social and cultural life.

Topic 6. tourism destination marketing. The current topic presents a set of frameworks to foster tourism destinations (Li et al., 2017) (post. prob. = 0.939). Huang et al. (2013; 2016) (post. prob. = 0.985; post. prob. = 0.968) present and test a new TAM framework based on psychological elements of self-determination theory to try to understand the increase in destination attraction. Lagiewski and Kesgin (2017) paper (post. prob. = 0.977) is a case study about how interactive visits and digital-enabled experiences have fostered visits to the Finger Lakes Region of New York State and Choi, Ok, and Choi (2016) explore the mediation role of telepresence for destination marketing performance.

Topic 7. TAM. The Technology Acceptance Model (TAM) is widely employed to test the use of new technologies. Therefore, TAM can be the starting point to test 3D virtual tourism site or tours (Munoz-Leiva, Hernández-Méndez, & Sánchez-Fernández, 2012) (post. prob. = 0.984) (Pantano & Corvello, 2014) (post. prob. = 0.962). The most correlated paper in the current topic is the study of Chung, Han, and Joun (2015) (post. prob. = 0.990), in which they explore the acceptance of AR. According to the authors, perceived usefulness and ease of use affect intention to use AR and visit a destination, which has been later tested in other contexts. tom Dieck and Jung (2018) (post. prob. = 0.981) also discuss TAMs of AR in the tourism context and propose an AR acceptance model in the context of urban heritage tourism.

Topic 8. telepresence and virtual communities. The current topic groups discussions around two concepts, mainly, virtual communities and how to enhance virtual environments so that consumers feel they are transported to the destination. Telepresence means the feel of being there. This concept may act as a mediator between the information and the stimuli and the positive or negative evaluation of virtual destination image (e.g., Hyun & O'Keefe, 2012) (post. prob. = 0.826). Marsh (2003) is the study with the highest posterior probability of belonging to the topic (post. prob. = 0.992) and the author presents a framework for the design of successful interactive mediated environments with high telepresence feelings. Other correlated papers discuss systems able to enhance the users' senses experience (Shi et al., 2016) (post. prob. = 0.648) and how elderly consumers may be affected by virtual leisure activities (post. prob. = 0.766). All the papers have important implications for VR and AR due to its increased capability to enhance telepresence perception.

Topic 9 Case Study Applications. The current topic groups papers that mainly show how to render environments into digital information to be used in AR and VR applications. Three papers stand out in the current group. Chen, Ku, and Ying (2012; 2012b) (post. prob. = 0.988; post. prob. = 0.892) present an example on how to extend marine tours for divers using virtual environments and techniques to better render the ocean environment so it may be used for simulating marine live. Buchroithner (2002) (post. prob. = 0.890) discusses techniques for rendering snow mountains for virtual alpinism purposes. Finally, Chalkiti & Sigala, 2008 (post. prob. = 0.990) discuss ways to use information stemming from virtual communities' information for knowledge creation and ideas generation.

Topic 10. Augmented reality. The current topic groups papers that focus on Augmented Reality applications. Although AR lacks the immersive and telepresence capabilities of VR, it is one of the most promising techniques today discussed in the literature. The recent development of Hololens Glasses from Microsoft, for example, may increase even further the development of new applications of AR without the need of using smartphones as a lens to apply virtual layers to the real-world environment. The paper most correlated with the current topic presents an AR application to promote the local Hakka culture of Thailand. The authors test their proposed application using TAM to suggest drivers of acceptance that may be used to promote other causes (Lin & Chen, 2017) (post. prob. = 0.991). The paper by García-Crespo et al. (2016) presents a framework for creating cultural entertainment systems with AR in smart cities (post. prob. = 0.958) and Martínez-Graña, Goy, and Cimarra (2013) (post. prob. = 0.928) show a case study of AR using georeferenced thematic layers over other relevant information. Finally, Manghisi et al. (2017) (post. prob. = 0.841) present Multisensory Apulia Touristic Experience (MATE), an interface that mixes gestures and sensorial stimuli to achieve an overall experience and Jung, Chung, and Leue (2015) (post. prob. = 0.725) also discuss how the users' satisfaction with AR experiences and intention to recommend the experience.

4. Topic analysis of conference proceedings

The same systematic method used in the previous section was used to select conference proceeding papers that were relevant to the topic at hand. Conference papers from both WOS and Scopus were merged into a set of 717 articles. After an in-depth screening of the articles, 325 were identified as potentially relevant articles to be included in the analysis.

The papers presented at conferences and published in conference proceedings are also analyzed following the same methodological process as conducted for the journal papers, that is, the CTM algorithm was employed. As for the journal papers, one conference paper may be present in multiple latent topics. Thus, a paper in a certain topic is focused on the subject highlighted by the label of the topic but may also have some information and discussion that belongs to less prevalent topics. The same method for topic selection was also employed for conference proceedings. Fig. 7 shows the possible models from k = 2 to k = 60 that were simulated to check which model best fit the data. Although k = 15 is one of the lowest points in the graph, after an initial screening of the topics, a k = 11 was found to be more manageable and producing a clearer set of latent topics.

Table 8 shows the topics extracted for the conference proceedings by using the CTM algorithm along with the correlated terms in each topic and the most relevant proceedings papers. When analyzing the whole pool of 325 conference papers extracted, the top 5 conferences with more papers are: Euromed international conference, ACM international conference, International conference on augmented reality and virtual reality, International archives of the photogrammetry, remote sensing and spatial information sciences and Annals of the photogrammetry, remote sensing and spatial information sciences. Although all these conferences have papers focusing on tourism and/or hospitality, the first three emerge as those more devoted to tourism and hospitality due to the number of papers published in the respective proceedings. Indeed, the international conference on augmented reality and virtual reality has been organized by Prof. Timothy Jung who is one of the most-cited authors in the field.

Comparing the findings from conference proceedings and journal papers, three major aspects should be pointed out. First, the number of topics extracted from both journals and conference proceedings are similar, that is, 10 from journals and 11 from conferences. This first glimpse of the two groups of topics seems to reveal that what has been published in conferences are not far away from what has been published in journals.

Second, a more refined analysis of the content of the topics allowed to label eight of the conference topics with the same label as in the case of journal papers that is: Tourism Destination Marketing, Location-Based Information System, Atmospherics Design, Augmented Reality, Image Quality, Experiential And Telepresence, Cultural Heritage, Case Study Applications. Even so, we may note that the topic Location-Based Information System and the topic Image Quality from conference proceedings are comprised of only one topic in the case of journal papers. However, the content of the papers and the type of studies conducted in all these topics are very similar and already discussed in section 4.

Third, the remaining three topics -Virtual Communities, Mixed

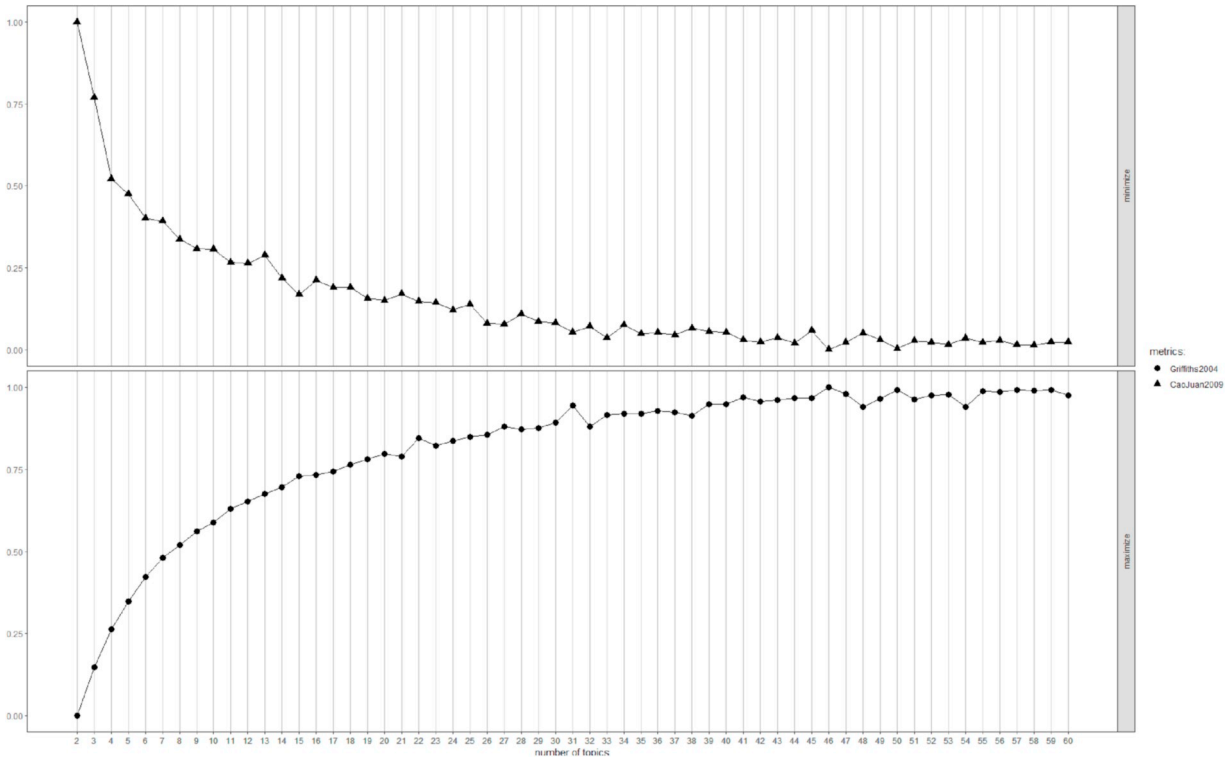

Fig. 7. Log-likelihood and perplexity metrics for evaluating K in conference proceedings.

Reality Museums, 3d Digitalization - emerge in the conference papers with some differentiating content, at least in the way authors approach and highlight some elements in VR and AR in tourism and hospitality. Regarding Virtual Communities, this topic tends to deal with a larger and integrated vision of the actors involved in tourism and hospitality than the majority of studies in other proceeding topics or even journal topics (e.g., Abdullayeva, 2019; Aschoff, Prestipino, & Schwabe, 2007; Aschoff & Schwabe, 2009). The studies intend to provide a holistic framework of communities which represent virtual networks where several entities are combined and should be aligned to operate together, for instance, hotel, restaurants, travel agencies, tour operators, transportation, destination infrastructures/entities, attractions, and museums (e.g., Abdullayeva, 2019). Hence, all the process of pre-purchase, to have the experience at the destination and the post-purchase is integrated into online systems which allow the tourists to be connected in a community where at least part of the whole tourism experience happen virtually. Soon such experience could even be fully immersive in a virtual environment. For instance, potential tourist may use VR to have a first short immersive experience of several destinations or places (e.g., attractions, hotels, museums, restaurants) before they decide what destination, hotel or tour to purchase. This initial process can be done at the same time they are interacting with other members of the community for exchanging ideas. During the real visit to the destination, tourists could keep in contact with other members of virtual communities, who may suggest some attractions, tours or visit places nearby the location of the tourist, all in real-time through the use of mobiles and AR. In the near future, tourists could eventually have the option to experience the destination not being physically there. At the end of the visit, VR and AR can also be used to remember the last visit (like a virtual photographic album) and also to interact with other members.

Mixed Reality Museums is a topic devoted to the use of VR/AR or both in the museum attractions. Indeed, one may find a larger number of proceeding papers than in the case of journal papers where the focus is the museum context. The use of VR/AR in museums, what are the real possibilities and how to operate it seems to become more and more of the interest of researchers and practitioners, at least in early stages of projects of research presented at conferences (Baktash, Nair, & Subramonian, 2016; Pallud & Straub, 2007; Polimeris & Calfoglou, 2016). One major reason for such interest could be the interest of curators and people responsible for museums in diversifying the experience provided, trying to immerse visitors in a different moment in time or easily provide more historical information to be understood. Another reason could be the need to preserve (e.g., reduce the carbon footprint, avoid damaging historic and heritage monuments and sites) the museums or historic sites, by using the immersive VR instead of the real sites.

Finally, the topic called 3D Digitalization present studies focused on 3D digitalization models in several different contexts. For instance, in the most correlated article with this topic (Ortiz, Sanchez, Pires & Peres, 2006), the authors use techniques such as laser scanning and photogrammetry methods to automatically digitalize a real context into a virtual 3D model of a 15th century church or other cultural heritage (e.g., Esmaeili, Woods, & Thwaites, 2014; Wei Majid, Setan, Ariff, Idris, Darwin, Yusoff, Zainuddin, 2019).

5. Research questions and thoughts on future research directions

As VR and AR interest continue to grow (both on the development of new theoretical models and managerial applications), the recent technological developments on brain-computer interfaces (BCI) and nanotechnology will bring such applications to new frontiers. Such technological interfaces will pave the way to new applications in the tourism sector and allow new concepts to flourish.

Companies and researchers are working on using AR as wearable devices and developing technology that would someday allow AR devices to be reduced to small contact lenses. Companies such as Emacula of even Google and Novartis have invested in that market, expected to have 929 million wearable devices connected by 2021 (Statista, 2018b). VR is also evolving rapidly to become much more integrated with the human body. Recent advances in BCI have allowed VR devices to receive brain responses thorough the use of EEG technology so that new VR applications such as interactive games could adapt or even be controlled

Table 8
Latent topics for paper proceedings.

Topic Name	Topic Terms	Correlated papers with topic	Conference	Post. Prob.
T1. Virtual Communities	inform, community, product, market, travel, custom, onlin, servic, consum, provid	Abdullayeva (2019)	Economic and Social Development	.992
		Aschoff and Schwabe (2009)	European Conference on Information Systems	.989
		Aschoff et al. (2007)	European Conference on Information Systems	.988
T2. Tourism Destination Marketing	tourist, destin, tour, attract, user, place, travel, develop, system, plan	Wang, Wang, and Wennersten (2006)	International Conference on Urban Regeneration and Sustainability	.938
		Musil and Pigel (1994)	International Conference on Information and Communications Technologies in Tourism	.891
		Gruntjens, Gross, Arndt & Muller (2013)	International Conference on Virtual and Augmented Reality in Education	.862
T3. Mixed Reality Museums	museum, experi, visitor, site, exhibit, cultur, technolog, visit, differ, authent	Polimeris and Calfoglou (2016)	International Conference IACuDiT	.989
		Baktash et al. (2016)	Heritage, Culture and Society: Research agenda and best practices in the hospitality and tourism industry	.982
		Pallud and Straub (2007)	Americas Conference on Information Systems	.977
T4. Location Based Information Systems	system, inform, technolog, data, develop, tourist, heritage, content, area, resource	Qiu, Gao, and Zhan (2011)	International Conference on Management and Service Science	.994
		Shao and Zhang (2012)	Euro-Asia Conference on Environment and CSR	.994
		Liao (2019)	International Conference on Cyber Security Intelligence and Analytics	.993
T5. Atmospherics Design	design, particip, view, user, interact, applic, map, inform, icon, portal	Magnusson, Rassmus-Gröhn, and Szymczak (2014)	Nordic Conference on Human-Computer Interaction	.985
		Pakanen and Arhippainen, 2014	Australian Computer-Human Interaction Conference on Designing Futures	.982
		Rassmus-Gröhn, Szymczak, and Magnusson (2013)	International Workshop on Haptic and Audio Interaction Design	.968
T6. 3D Digitalization	model, agent, digit, data, inform, environ, object, archaeolog, visual, differ	Ortiz, Sánchez, Pires, and Pérez (2006)	International Society for Photogrammetry and Remote Sensing	.914
		Wei et al. (2019)	International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences	.914
		Esmaeili et al. (2014)	International Conference on Virtual Systems & Multimedia	.893
T7. Augmented Reality	applic, mobil, inform, augment, tourist, data, system, provid, devic, technolog	Rodríguez (2015)	Central American and Panama Convention	.996
		Dangkham (2018)	International Conference on Information Networking	.974
		Batista, Rodrigues & Goncalves (2013)	Iberian Conference on Information Systems and Technologies	.925
T8. Image Quality	imag, system, object, camera, scene, real, point, display, view, process	Gledhill, Tian, Taylor, and Clarke (2004)	International Conference on Information Visualization	.992
		Lee, Ahmed, Lee, An, and Lee (2016)	IEEE International Symposium on Mixed and Augmented Reality	.990
		Okura, Kanbara, and Yokoya (2012)	ACM international conference on Multimedia	.987
T9. Experiential and Telepresence	interact, stori, visitor, system, tour, inform, experi, guid, devic, design	O'Keefe, Benyon, Chandwani, Menon, and Duke (2014)	International BCS Human Computer Interaction Conference	.929
		Tamiya and Nojima (2011)	IEEE International Symposium on VR Innovation	.890
		Mine (2003)	Workshop on Virtual environments	.868
T10. Cultural Heritage	cultur, heritag, technolog, site, project, citi, museum, history, digit, world	Park and Kim (2018)	Augmented Reality and Virtual Reality	.994
		Gong and Wang (2010)	International Conference on Information, Electronic and Computer Science	.993
		Zang and Gao (2010)	International Conference On Modelling And Simulation	.884
T11. Case Study Applications	experi, game, learn, video, particip, content, environ, interact, technolog, view	Kelling, Vaataja & Kauhanen (2017)	International Conference on Mobile and Ubiquitous Multimedia	.998
		Garzon, Acevedo, Pavon & Baldiris (2018)	International Conference on Augmented Reality, Virtual Reality and Computer Graphics	.866
		Xu, Tian, Buhalis, and Weber (2013)	International Conference on Games and Virtual Worlds for Serious Applications	.681

by such brain waves. By measuring brain activity and incorporating them in the development of new experiences, BCI VR may not only allow virtual experiences to be immersive but also interactive and imaginative (Li, Leider, Qiu, Gai, & Liu, 2017). Such an example has recently been placed on the market by the startup Neurable (2018) that uses EEG equipment connected to an HTC Vive VR device to control virtual environments. The future will also rely on bi-directional systems that not only capture brain waves but interact with the human brain through deep brain stimulation (DBS). Although deep brain stimulation is not a new field in cognitive neuroscience and has been used to treat neurological conditions and used in neuroprosthetics (Rouse et al., 2011; Horch & Dhillon, 2004), its maturation has allowed its use to extend to other fields such as immersive realities (Cangelosi & Invitto, 2017). However, despite the evident benefits of using such brain-computer interfaces for commercial applications, the future, and potential applications will face in numerous ethical issues (Glannon, 2016).

Hence, as an overview of the past literature in AR and VR in hospitality and tourism, the papers analyzed have emerged mainly from Europe and Asia and are based on both quantitative (16), qualitative (14) studies and the development of frameworks/applications (10) (see Table 3). Such papers highlight some important future research topics described in Table 9. Two main theories -TAM and S–O-R- are used by several authors (e.g., Jung et al., 2015; Huang et al., 2016; Chung et al., 2015; Huang et al., 2016; Yeh et al., 2017; tom Dieck & Jung, 2018), who suggest to further extend them in new studies by incorporating new constructs more connected to VR and AR technologies. Yet, in the future, researchers should be concerned in creating a new paradigm and a full theory for VR and AR in tourism and hospitality context and not only apply well-known theories that come from other fields of research, such as biology or psychology or information system.

Table 9
Research and future topics on AR and VR for hospitality and tourism.

Research questions	Future topics	Authors
How to extend the four realms of experience economy to the virtual and augmented reality tourism destination? And in the case of festival experiences? Could the perceptions of experience lead to tourism engagement toward the destination or other tourism context? What could be the mediators between experience and engagement?	Analyze the relationships between experience and engagement.	Tom Dieck et al. (2018)
Could the perception of color and other atmospheric cues in hospitality context be similar in virtual worlds and real worlds?	Lack of research dealing with atmospheric cues in virtual worlds	Siamionava et al. (2018)
How to integrate different knowledge fields to boost research on tourism and hospitality context?	Develop multidisciplinary studies bridging tourism, information technology, engineering, and psychology.	Yung and Khoo-Lattimore (2017)
Could fixed Internet and mobile Internet be selected by tourists depending on the type of trip, the decision process, environments, and consumer costs? How sensor technology and big data could contribute to innovation in tourism destinations?	Empirical Research on the Relationship between Mobile Technology and Sustainability, Network Environments and Consumer Costs, The Role of Mobile Application and Text Mining in Tourism, Proposal of Research Direction for the Innovation Perspective	Kim and Kim (2017)
How cultural paradigms and important details about everyday life can be communicated more effectively or are more richly accessible using VR? How important contextual factors of destinations and a greater variety of documents can be integrated in a meaningful way?	Explore the role of VR-based virtual fieldtrip on climate change education (helping destination planning).	Schott (2017)
Could AR provide ecological value in different tourism and hospitality contexts?	Examine perceived value of AR in several different tourism contexts	tom Dieck and Jung (2017)
How multisensory virtual tourism experiences could be implemented into the context of wine tourism? Or in other context of tourism destination?	Empirical research using multisensory virtual experiences	Martins et al. (2017)
How stakeholders (not only tourists) can contribute to raise up a regional level digital destination project?	More research is needed on multi-stakeholder involvement management' framework to implementing regional level digital destination marketing projects	Lagiewski and Kesgin (2017)
Could tourists opt to fly in real-life mimetic virtual world contexts instead of real world?	Explore new forms of tourism: virtual worlds representing real destinations	Hales and Caton (2017)
S–O-R framework could be extended and used in several tourism contexts?	Further develop the application and extension of S–O-R framework	Jung et al. (2015), Yeh et al. (2017)
TAM model could be extended and implemented in different tourist contexts? How perceptions could be different depending on gender? There are gender differences in AR acceptance?	Consider intentions to use virtual technology and intentions to visit the destination and other variables to extend TAM model. Investigate gender differences in AR acceptance. Lack of tools to measure constructs devoted to VR and AR context into the tourism and hospitality field.	Huang et al. (2016), Chung et al. (2015), tom Dieck and Jung (2018)

As thoughts that could be needed for the future evolution of VR and AR in tourism and hospitality, 4 key realms can be envisioned as grounded on technological developments: (1) focused on physical and sensory stimulations, (2) enhanced longitudinal virtual experiences, (3) well-being development, and (4) the use of artificial intelligence embedded in virtual environments.

1. In the future, VR will involve more than headsets and game controllers and become more sensory oriented. BCI integrations will allow senses to be incorporated in the experience, for instance, body-wise, temperature-wise, and smell-wise of tourists (Li, Leider, et al., 2017). The development of nanotechnology will also allow tourists or travelers to go beyond the boundaries of the human body and enter into the digital world, that is, inorganic or organic components in a nano-scale could be implemented in the human body (with legal authorization by the users) helping tourist to augment (expand) the perception of reality or even immersiveness in VR. Another possibility is to wear sensors in the clothes that could increase the sensations and perceptions around specific experiences at a destination or on a tour (Udovičić, Topić, & Russo, 2016). For example, the tourists' brain may be stimulated to perceive a virtual environment as having a high humidity (for example to simulate a journey in a tropical jungle) and wearable clothes may help the sensorial experience to match the brain stimulation.
2. The use of BCI and brand interaction could one day allow consumers to not only have the telepresence feeling (the feeling of being there) but also experience sensations of time traveling. Tourist could not only enjoy travel experiences in a completely different world but also experience different realistic scenery in different period of time (Friedman et al., 2014). This travel process allows different realms of experience, since it will not be only about the entertainment but also educational. Students and tourists will be able to go on virtual field trips, as well as traveling back in time for history lessons. Space experience is another challenge. Travel through the solar system or between galaxies and even learn to pilot a spaceship may become an even more educational and entertaining experience through the use of brain-computer interactions.
3. When tourists have a favorable VR and/or AR experience, they can feel positive emotions, happiness and a good well-being sensation, which can even increment what could be felt in the real tourist experience. Individuals with some mobility disabilities or other health problems could benefit with such experiences and be able to free themselves from their body limitations into a brain-stimulated environment that can mimic the same excitement, pleasure, and feelings they could experience without such limitations (Lotte et al., 2012).

4. The use of Artificial Intelligence has already started with virtual personal assistants that help tourist or potential tourist to make the choices and, at the same time, learn with the process (Marinchak, Forrest, & Hoanca, 2018). These interactions with AI avatars in a virtual environment enhanced by BCI technology may facilitate engagement and stimulate co-creation processes in real-time. Such assistants may add new services or tourist activities that may also increase tourists' satisfaction and willingness to return.

Fig. 8 shows the main topics envisioned to flourish in tourism and hospitality in the future as a consequence of technological developments in VR and AR.

6. Conclusions

VR and AR-related techniques are evolving and creating valuable opportunities for tourism. VR has been applied in planning, managing, promoting, educating and creating or transforming tourist experiences. Tourism mobility and new technologies such as VR and AR are becoming a subject of interest for tourism researchers. Mobilities involve the movement of tourists and the movement of a whole range of materials and things. This process is associated with the use of technology for a geographical location (Hannam et al., 2014) and may create sustainable problems resulting from an excessive number of people in the movement. In this context, VR can contribute to avoiding some of these movements and allows consumers to have a virtual experience without physically being in the place.

Researchers in social science may create environments in which it is possible to study a range of multisensory phenomena. Rather than evoking emotions in the surveys (e.g., adventure tourism, climbing, or even a relaxation event) to analyze the tourist behavior, VR allows participants to be immersed in the situations. Data collection is another advantage, that is, researchers may use technology to get the information automatically and have a first glimpse of the findings in real-time. Participants may even be in different countries and have the same experience at the same time which can reduce the problem of non-representative sampling.

Multiple people can interact, be in the network and share tasks in novel stimuli created by VR and AR, which gives new possibilities for social scientists in psychology and sociology related to the tourism context. Participants feel that they are present there (telepresence), and the environment is real and that their sensations and actions are responsive to what they are experiencing.

Fig. 8. The future of VR and AR in tourism.

The current paper first discusses the overall studies that have been conducted over time (1995–2019) on the application of VR and AR in tourism. Secondly, it makes a citation network analysis of the main journal papers and their references uncovered in the literature, to find the most influential papers so far. Thirdly, the current paper uses a text mining technique to find correlated patterns among discussions in the use of VR and AR in tourism research in both journal papers and conference papers. Regarding Journal papers, both the citation network analysis and the topic modeling of the full-text of the papers agreed on the topics that have been discussed in the literature so far. The citation graph revealed 10 communities that address discussions around mobile and mobility implications, tourism destination marketing, experiences and emotions, atmospherics, smart cities, and cultural heritage. The same topics were later found and detailed using topic modeling. For example, the community detection algorithm identified cluster 9 that deals with smart cities and cluster 10 that deals with cultural heritage. However, when analyzing the full-text of papers using the Bayesian analysis of CTM (correlated topic models), such technique grouped smart cities and cultural heritage. This happened due to the high correlation in the text of the papers between both topics. Although Smart Cities and Cultural Heritage have a different nature, a different meaning, and a different scale, using the lens of AR and VR applications, the papers discuss the use of such VEs and related technology for allowing users to collect, analyze, integrate data and better conduct the planning of the cities and the sites. In the case of the cities, it's a large ecosystem that works together. In the case of cultural heritage sites, it's a smaller scale, however, in those small ecosystems, there is also a need to collect, analyze and integrate information to keep the sites operational and restore documentation that could even allow the preservation and restoration of the historic elements of those sites.

In what concerns conference papers, 11 topics were found, whereas 8 of them were similar to the topics found for Journal papers. The topics that were found unique on Journal papers were the ones related to Mobile uses for sustainable Tourism, the use of TAM as the theoretical background model to support AR/VR studies and finally, a topic focused on Seminal and Trend papers on top-tier Journals. Unique topics on conference papers were related to Virtual Communities, Mixed-Reality Museums, and 3D Digitalization. Although Journal papers are more concerned with offering theoretical contributions, they seem to still be using early models of technology adoption, leaving behind psychological behavioral models (e.g. theory of planned behavior and decision making models), while conference papers are more exploratory in nature and tend to provide more disruptive ideas and applications. Conference papers also tend to present innovative frameworks, systems, models, and applications with less theoretical support but that could be the seeds for new theories.

Although still scant in tourism literature, the use of virtual reality is gaining momentum. The pioneer papers in 1995 were published in a Tourism Management journal, but until 2014 the discussions were more focused and published in interdisciplinary journals. Results show that after 2014 such papers have started to make an appearance in hospitality and tourism-related journals more often.

Contributions may help researchers to understand the main topics discussed so far in the literature so that future research may be further developed in each topical category. Findings may also be used for managerial purposes by focusing on particular papers that address specific problems faced by companies in a particular sector. For example, companies that may be struggling to understand how they may use VR to highlight cultural heritage cues in their communication with potential visitors may focus on papers that address such a topic.

Future studies need to be focusing on extending the adaptation of well-known models and frameworks like TAM, S–O-R and develop a framework-specific to VR and AR technology, which can be used to understand the tourists' behavior and their approach or avoidance of

these experiences. Second, we recommend researchers to analyze the kind of adaptations of VR and AR that can be more effective depending on age, gender and other socio-psychological variables of the consumers. Third, the introduction of entertainment elements in the virtual experience may not be viewed in the same way depending on cultural or socio-demographic segmentation. This aspect needs to be tested and understood in future studies. Fourth, the use of VR technologies for learning is still at an early stage. However, in the future, more studies should be developed regarding the application of VR to support educational experiences at museums and other attractions. These applications can even combine playing and learning components. Fifth, cruise tourism is another theme that deserves much more attention. Cruise tourists tend to visit the same places when arriving at a destination. VR technology may help them discover other attractions and sites to visit.

Author's contributions

Sandra Maria Correia Loureiro.

Contributions: Sandra contributed to the theoretical part, discussion and conclusion of the paper.

João Guerreiro.

Contributions: João contributed to the data analysis in text mining and that data treatment.

Dr. Faizan Ali.

Contributions: Faizan contributed to the parts of introduction and some of the literature review. He also worked on the introduction, abstract, highlights, polishing the language and constructing the prevailing narrative throughout the paper.

References

Abdullayeva, N. (2019). The role of ICT in tourism globalisation. In G. Dukic, J. Clifford, & Atkinson (Eds.), *Economic and social development: Book of proceedings of 42nd international scientific conference on economic and social development* (pp. 1086–1090). London: Pearson College London.

Ali, F. (2016). Hotel website quality, perceived flow, customer satisfaction and purchase intention. *Journal of Hospitality and Tourism Technology, 7*(2), 213–228.

Alves, P. R., Gonçalves, J., Rossetti, R. J., Oliveira, E. C., & Olaverri-Monreal, C. (2013, June). Forward collision warning systems using heads-up displays: Testing usability of two new metaphors. In *2013 IEEE intelligent vehicles symposium workshops (IV workshops)* (pp. 1–6). Gold Coast: IEEE.

Aschoff, F. R., Prestipino, M., & Schwabe, G. (2007). Cooperation technology and timeliness of information: Comparing travelbooks, wikis and online communities. In *Paper presented at proceedings of the fifteenth european conference on information systems, ECIS 2007, st. Gallen, Switzerland*.

Aschoff, F. R., & Schwabe, G. (2009). On the evolution of online tourism communities-Network battle or long tail niches?. In *Paper presented at the 17th european conference on information systems, ECIS 2009, verona, Italy*.

Baktash, A., Nair, V., & Subramonian, H. (2016). Parameters that facilitate tourists' acceptance in using wearable augmented reality smart glass in Geotourism hotspots. In S. M. Radzi, M. H. M. Hanafiah, N. Sumarjan, & Z. Mohi (Eds.), *Heritage, Culture and Society: Research agenda and best practices in the hospitality and tourism industry* (pp. 469–472). Bandung: CRC Press.

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: An open source software for exploring and manipulating networks. *ICWSM, 8*, 361–362.

Batista, F. A. G., Rodrigues, N., & Gonçalves, A. (2013). June). inGuide—interactive guide. In *2013 8th iberian conference on information systems and technologies (CISTI)* (pp. 1–5). Lisbon: IEEE.

Benford, S., Snowdon, D., Greenhalgh, C., Ingram, R., Knox, I., & Brown, C. (1995, August). VR-vibe: A virtual environment for co-operative information retrieval. In *Computer graphics forum* (Vol. 14, pp. 349–360). Edinburgh, UK: Blackwell Science Ltd. No. 3.

Besharat, J., Komninos, A., Papadimitriou, G., Lagiou, E., & Garofalakis, J. (2016). Augmented paper maps: Design of POI markers and effects on group navigation. *Journal of Ambient Intelligence and Smart Environments, 8*(5), 515–530.

Bimber, O., & Raskar, R. (2005). *Spatial augmented reality merging real and virtual worlds*. Wellesley: A K Peters CRP Press.

Bishop, I. D., & Gimblett, H. R. (2000). Management of recreational areas: GIS, autonomous agents, and virtual reality. *Environment and Planning B: Planning and Design, 27*(3), 423–435.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of Machine Learning Research, 3*, 993–1022.

Blondel, V. D., Guillaume, J. L., Lambiotte, R., & Lefebvre, E. (2008). Fast unfolding of communities in large networks. *Journal of Statistical Mechanics: Theory and Experiment, 2008*(10), P10008.

Bruns, A., Moon, B., Münch, F., & Sadkowsky, T. (2017). *The Australian twittersphere in 2016: Mapping the follower/followee network. Social Media+Society*. https://doi.org/10.1177/2056305117748162. Published online . (Accessed 13 December 2017).

Buchroithner, M. (2002). Creating the virtual eiger north face. *ISPRS Journal of Photogrammetry and Remote Sensing, 57*(1–2), 114–125.

Buhalis, D., & Law, R. (2008). Progress in information technology and tourism management: 20 years on and 10 years after the internet-the state of eTourism research. *Tourism Management, 29*(4), 609–623.

Cangelosi, A., & Invitto, S. (2017). Human-robot interaction and neuroprosthetics: A review of new technologies. *IEEE Consumer Electronics Magazine, 6*(3), 24–33.

Cao, J., Xia, T., Li, J., Zhang, Y., & Tang, S. (2009). A density-based method for adaptive LDA model selection. *Neurocomputing, 72*(7–9), 1775–1781.

Carmigniani, J., Carmigniani, J., & Furht, B. (2011). *Handbook of augmented reality*. Berlin: Springer.

Chalkiti, K., & Sigala, M. (2008). Information sharing and knowledge creation in online forums: The case of the Greek online forum 'DIALOGOI'. *Current Issues in Tourism, 11*(5), 381–406.

Chang, Y. L., Hou, H. T., Pan, C. Y., Sung, Y. T., & Chang, K. E. (2015). Apply an augmented reality in a mobile guidance to increase sense of place for heritage places. *Journal of Educational Technology & Society, 18*(2), 166–178.

Chen, W. (2014). Historical Oslo on a handheld device–a mobile augmented reality application. *Procedia Computer Science, 35*, 979–985. https://doi.org/10.1016/j.procs.2014.08.180.

Chen, T. C., Ku, K. C., & Ying, T. C. (2012). A process-based collaborative model of marine tourism service system–The case of Green Island area, Taiwan. *Ocean & Coastal Management, 64*, 37–46.

Chen, G., Li, B., Tian, F., Ji, P., & Li, W. (2012). Design and implementation of a 3D ocean virtual reality and visualization engine. *Journal of Ocean University of China, 11*(4), 481–487.

Cheong, R. (1995). The virtual threat to travel and tourism. *Tourism Management, 16*(6), 417–422.

Choi, J., Ok, C., & Choi, S. (2016). Outcomes of destination marketing organization website navigation: The role of telepresence. *Journal of Travel & Tourism Marketing, 33*(1), 46–62.

Cho, H., Kim, S., Baek, J., & Fisher, P. S. (2012, October). Motion recognition with smart phone embedded 3-axis accelerometer sensor. In *2012 IEEE international conference on systems, man, and cybernetics (SMC)* (pp. 919–924). Seoul: IEEE.

Chung, N., Han, H., & Joun, Y. (2015). Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site. *Computers in Human Behavior, 50*, 588–599.

Dangkham, P. (2018). January). Mobile augmented reality on web-based for the tourism using html5. In *2018 international conference on information networking (ICOIN)* (pp. 482–485). Chiang Mai: IEEE.

Deng, L., Chen, Z., Chen, B., Duan, Y., & Zhou, J. (2016). Incremental image set querying based localization. *Neurocomputing, 208*, 315–324.

Denwagan, V. (2013). *Barriers and stimulants of augmented reality adoption*. Berlin: Springer.

Dewailly, J. M. (1999). Sustainable tourist space: From reality to virtual reality? *Tourism Geographies, 1*(1), 41–55.

Díaz-Díaz, R., Muñoz, L., & Pérez-González, D. (2017). Business model analysis of public services operating in the smart city ecosystem: The case of SmartSantander. *Future Generation Computer Systems, 76*, 198–214.

tom Dieck, M. C., & Jung, T. H. (2017). Value of augmented reality at cultural heritage sites: A stakeholder approach. *Journal of destination marketing & management, 6*(2), 110–117.

tom Dieck, M. C., & Jung, T. (2018). A theoretical model of mobile augmented reality acceptance in urban heritage tourism. *Current Issues in Tourism, 21*(2), 154–174.

Digitaltrends. (2018). *Digital trends*. Retrieved https://www.digitaltrends.com/cool-tech/history-of-virtual-reality/. (Accessed 12 October 2018).

El Choubassi, M., Nestares, O., Wu, Y., Kozintsev, I., & Haussecker, H. (2010). January). An augmented reality tourist guide on your mobile devices. In *International conference on multimedia modeling* (pp. 588–602). Berlin, Heidelberg: Springer.

Esmaeili, H., Woods, P. C., & Thwaites, H. (2014, December). Realisation of virtualised architectural heritage. In *2014 international conference on virtual systems & multimedia (VSMM)* (pp. 94–101). Hong Kong: IEEE.

Fernandez-Palacios, B. J., Nex, F., Rizzi, A., & Remondino, F. (2015). ARCube—the augmented reality cube for archaeology. *Archaeometry, 57*(S1), 250–262.

Fotakis, T., & Economides, A. A. (2008). Art, science/technology and history museums on the web. *International Journal of Digital Culture and Electronic Tourism, 1*(1), 37–63.

Friedman, D., Pizarro, R., Or-Berkers, K., Neyret, S., Pan, X., & Slater, M. (2014). A method for generating an illusion of backwards time travel using immersive virtual reality—an exploratory study. *Frontiers in Psychology, 5*, 943–958.

Garau, C., & Ilardi, E. (2014). The "non-places" meet the "places:" Virtual tours on smartphones for the enhancement of cultural heritage. *Journal of Urban Technology, 21*(1), 79–91.

García-Crespo, Á., González-Carrasco, I., López-Cuadrado, J. L., Villanueva, D., & González, Á. (2016). CESARSC: Framework for creating cultural entertainment systems with augmented reality in smart cities. *Computer Science and Information Systems, 13*(2), 395–425.

Gärtner, M., Seidel, I., Froschauer, J., & Berger, H. (2010). The formation of virtual organizations by means of electronic institutions in a 3D e-Tourism environment. *Information Sciences, 180*(17), 3157–3169.

Garzón, J., Acevedo, J., Pavón, J., & Baldiris, S. (2018). June). ARtour: Augmented reality-based game to promote agritourism. In *International conference on augmented reality, virtual reality and computer graphics* (pp. 413–422). Cham: Springer.

Glannon, W. (2016). Ethical issues in neuroprosthetics. *Journal of Neural Engineering, 13*(2), 1–22.

Gledhill, D., Tian, G. Y., Taylor, D., & Clarke, D. (2004, July). 3D reconstruction of a region of interest using structured light and stereo panoramic images. In *, Vol. IV. Proceedings. Eighth international conference on information visualisation, 2004* (pp. 1007–1012). London: IEEE, 2004.

Gong, Y., & Wang, Y. M. (2010). Research on the construction method of three-dimensional model for the ancient architecture based on 3ds max. In *International conference on information, electronic and computer science* (pp. 402–405). ICIECS 2010 E-BOOK).

Goslin, M., & Mine, M. R. (2004). The Panda3D graphics engine. *Computer, 37*(10), 112–114.

Griffiths, T. L., & Steyvers, M. (2004). Finding scientific topics. In *Proceedings of the national academy of sciences of the United States of America* (pp. 5228–5235).

Grüntjens, D., Groß, S., Arndt, D., Müller, S., Martin-Gutierrez, J., & Ginters, E. (2013). Fast authoring for mobile gamebased city tours. In *Procedia computer science* (Vol. 25, pp. 41–51). https://www.sciencedirect.com/journal/procedia-computer-science/vol/25/suppl/C.

Guerreiro, J., Rita, P., & Trigueiros, D. (2016). A text mining-based review of cause-related marketing literature. *Journal of Business Ethics, 139*, 111–128.

Gutierrez, M., Vexo, F., & Thalmann, D. (2008). *Stepping into virtual reality*. Springer Science & Business Media.

Guttentag, D. A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management, 31*(5), 637–651.

Hales, R., & Caton, K. (2017). *Proximity ethics, climate change and the flyer's dilemma: Ethical negotiations of the hypermobile traveller. Tourists Studies*. https://doi.org/10.1177/1468797616685650 (Published online March 1, 2017).

Han, H., Hwang, J., & Woods, D. P. (2014). Choosing virtual–rather than real–leisure activities: An examination of the decision–making process in screen-golf participants. *Asia Pacific Journal of Tourism Research, 19*(4), 428–450.

Hannam, K., Butler, G., & Paris, C. M. (2014). Developments and key issues in tourism mobilities. *Annals of Tourism Research, 44*, 171–185.

Herban, S. I., Grecea, C., & Barla, A. (2014). Using the laser scanning for research and conservation of cultural heritage sites. Case study: Ulmetum Citadel. *Journal of Environmental Protection and Ecology, 15*(3), 1172–1180.

Hernández-Méndez, J., & Muñoz-Leiva, F. (2015). What type of online advertising is most effective for eTourism 2.0? An eye tracking study based on the characteristics of tourists. *Computers in Human Behavior, 50*, 618–625.

Horch, K. W., & Dhillon, G. S. (2004). *Neuroprosthetics: Theory and practice*. Singapore: World Scientific Publishing.

Huang, Y. C., Backman, K. F., Backman, S. J., & Chang, L. L. (2016). Exploring the implications of virtual reality technology in tourism marketing: An integrated research framework. *International Journal of Tourism Research, 18*(2), 116–128.

Huang, Y. C., Backman, S. J., Backman, K. F., & Moore, D. (2013). Exploring user acceptance of 3D virtual worlds in travel and tourism marketing. *Tourism Management, 36*, 490–501.

Hwang, J., Yoon, S. Y., & Bendle, L. J. (2012). Desired privacy and the impact of crowding on customer emotions and approach-avoidance responses: Waiting in a virtual reality restaurant. *International Journal of Contemporary Hospitality Management, 24*(2), 224–250.

Hyun, M. Y., & O'Keefe, R. M. (2012). Virtual destination image: Testing a telepresence model. *Journal of Business Research, 65*(1), 29–35.

Javornik, A. (2016). "It's an illusion, but it looks real!" Consumer affective, cognitive and behavioral responses to augmented reality applications. *Journal of Marketing Management, 32*(9–10), 987–1011. https://doi.org/10.1080/0267257X.2016.1174726.

Jeng, M. Y., Pai, F. Y., & Yeh, T. M. (2017). The virtual reality leisure activities experience on elderly people. *Applied Research in Quality of Life, 12*(1), 49–65.

Jiang, D., Pei, J., & Zhang, A. (2003). March). DHC: A density-based hierarchical clustering method for time series gene expression data. In *Third IEEE symposium on bioinformatics and bioengineering, 2003. Proceedings* (pp. 393–400). IEEE.

Joslin, C., Molet, T., Thalmann, N. M., Esmerado, J., Thalmann, D., Palmer, I., et al. (2001). Sharing attractions on the net with VPARK. *IEEE Computer Graphics and Applications, 21*(1), 61–71.

Jung, T., Chung, N., & Leue, M. C. (2015). The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park. *Tourism Management, 49*, 75–86.

Kelling, C., Väätäjä, H., & Kauhanen, O. (2017). November). Impact of device, context of use, and content on viewing experience of 360-degree tourism video. In *Proceedings of the 16th international conference on mobile and ubiquitous multimedia* (pp. 211–222). Stuttgart: ACM.

Kersten, T., Pardo, C. A., & Lindstaedt, M. (2004). 3D acquisition, modelling and visualization of north German castles by digital architectural photogrammetry. In *Proc. ISPRS XXth congress* (pp. 126–131). http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.77.5606.

Kim, D., & Kim, S. (2017). The role of mobile technology in tourism: Patents, articles, news, and mobile tour app reviews. *Sustainability, 9*(11), 1–45, 2082.

Koeva, M., Luleva, M., & Maldjanski, P. (2017). Integrating spherical panoramas and maps for visualization of cultural heritage objects using virtual reality technology. *Sensors, 17*(4), e829.

Kounavis, C. D., Kasimati, A. E., & Zamani, E. D. (2012). Enhancing the tourism experience through mobile augmented reality: Challenges and prospects. *International Journal of Engineering Business Management, 4*, 10–16.

Kretschmer, U., Coors, V., Spierling, U., Grasbon, D., Schneider, K., Rojas, I., et al. (2001). November). Meeting the spirit of history. In *Proceedings of the 2001 conference on Virtual reality, archeology, and cultural heritage* (pp. 141–152). Glyfada: ACM https://dl.acm.org/citation.cfm?id=585016.

Kysela, J., & Štorková, P. (2015). Using augmented reality as a medium for teaching history and tourism. *Procedia-Social and behavioral sciences, 174*, 926–931.

Lagiewski, R., & Kesgin, M. (2017). Designing and implementing digital visitor experiences in New York State: The case of the Finger Lakes Interactive Play (FLIP) project. *Journal of destination marketing & management, 6*(2), 118–126.

Lee, Y. Y., Ahmed, B., Lee, J. H., An, H., & Lee, K. H. (2016, September). Augmenting three-dimensional effects in digital exhibition of a cultural artifact using 3D pseudo hologram. In *2016 IEEE international symposium on mixed and augmented reality (ISMAR-Adjunct)* (pp. 284–287). Merida: IEEE.

Lee, G. A., Dünser, A., Kim, S., & Billinghurst, M. (2012, November). CityViewAR: A mobile outdoor AR application for city visualization. In *2012 IEEE international symposium on mixed and augmented reality-arts* (pp. 57–64). Media, and Humanities (ISMAR-AMH). IEEE.

Lee, K. M., & Nass, C. (2003, April). Designing social presence of social actors in human computer interaction. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 289–296). Florida: ACM.

Lemon, K. N., & Verhoef, P. C. (2016). Understanding customer experience throughout the customer journey. *Journal of Marketing, 80*(6), 69–96.

Liao, Y. (2019, February). Research and implementation of the intelligent tourism system based on VRGIS. In Z. Xu, K.-K.-R. Choo, A. Dehghantanha, R. Parizi, & M. Hammoudeh (Eds.), *The international conference on cyber security intelligence and analytics* (pp. 130–135). Cham: Springer.

Li, S., Leider, A., Qiu, M., Gai, K., & Liu, M. (2017). Brain-based computer interfaces in virtual reality. In *Cyber security and cloud computing (CSCloud), 2017 IEEE 4th international conference on* (pp. 300–305). New York: IEEE.

Linaza, M. T., Marimón, D., Carrasco, P., Álvarez, R., Montesa, J., Aguilar, S. R., et al. (2012). Evaluation of mobile augmented reality applications for tourism destinations. In *Enter* (pp. 260–271).

Lin, H. F., & Chen, C. H. (2017). Combining the technology acceptance model and uses and gratifications theory to examine the usage behavior of an augmented reality tour-sharing application. *Symmetry, 9*(7), 113–135.

Lin, B. S. P., Tsai, W. H., Wu, C. C., Hsu, P. H., Huang, J. Y., & Liu, T. H. (2013, March). The design of cloud-based 4G/LTE for mobile augmented reality with smart mobile devices. In *2013 IEEE seventh international symposium on service-oriented system engineering* (pp. 561–566). Redwood City: IEEE.

Li, S. C., Robinson, P., & Oriade, A. (2017). Destination marketing: The use of technology since the millennium. *Journal of destination marketing & management, 6*(2), 95–102.

Loizides, F., El Kater, A., Terlikas, C., Lanitis, A., & Michael, D. (2014, November). Presenting cypriot cultural heritage in virtual reality: A user evaluation. In *Euro-mediterranean conference* (pp. 572–579). Cham: Springer.

Lotte, F., Faller, J., Guger, C., Renard, Y., Pfurtscheller, G., Lécuyer, A., et al. (2012). Combining BCI with virtual reality: Towards new applications and improved BCI. In *Towards practical brain-computer interfaces* (pp. 197–220). Berlin, Heidelberg: Springer.

Magnusson, C., Rassmus-Gröhn, K., & Szymczak, D. (2014, October). Exploring history: A mobile inclusive virtual tourist guide. In *Proceedings of the 8th nordic conference on human-computer interaction: Fun, fast, foundational* (pp. 69–78). Helsinki: ACM.

Manghisi, V. M., Fiorentino, M., Gattullo, M., Boccaccio, A., Bevilacqua, V., Cascella, G. L., et al. (2017). Experiencing the sights, smells, sounds, and climate of southern Italy in VR. *IEEE computer graphics and applications, 37*(6), 19–25.

Marinchak, C. L. M., Forrest, E., & Hoanca, B. (2018). The impact of artificial intelligence and virtual personal assistants on marketing. In *Encyclopedia of information science and technology* (4th ed., pp. 5748–5756). New York: IGI global.

Marsh, T. (2003). Presence as experience: Film informing ways of staying there. *Presence: Teleoperators and Virtual Environments, 12*(5), 538–549.

Martínez-Graña, A. M., Goy, J. L., & Cimarra, C. A. (2013). A virtual tour of geological heritage: Valourising geodiversity using Google Earth and QR code. *Computers & Geosciences, 61*, 83–93.

Martins, J., Gonçalves, R., Branco, F., Barbosa, L., Melo, M., & Bessa, M. (2017). A multisensory virtual experience model for thematic tourism: A port wine tourism application proposal. *Journal of destination marketing & management, 6*(2), 103–109.

Mehrabian, A., & Russel, J. (1974). *An approach to environmental psychology*. Cambridge, MA: MIT Press.

Mennecke, B. E., Terando, W. D., Janvrin, D. J., & Dilla, W. N. (2007). It's just a game, or is it? Real money, real income, and real taxes in virtual worlds. *Communications of the Association for Information Systems, 20*(15), 134–141.

Mine, M. (2003, May). Towards virtual reality for the masses: 10 years of research at disney's VR studio. In J. Deisinger, & A. Kunz (Eds.), *Proceedings of the workshop on Virtual environments 2003* (pp. 11–17). ACM.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Altman, D. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 8*(7716), 336–341. https://doi.org/10.1371/journal.pmed.1000097.

Moro, S., Rita, P., & Cortez, P. (2017). A text mining approach to analyzing Annals literature. *Annals of Tourism Research, 66*, 208–210.

Munoz-Leiva, F., Hernández-Méndez, J., & Sánchez-Fernández, J. (2012). Generalising user behaviour in online travel sites through the Travel 2.0 website acceptance model. *Online Information Review, 36*(6), 879–902.

Musil, S., & Pigel, G. (1994). Can tourism be replaced by virtual reality technology?. In *Information and communications technologies in tourism* (pp. 87–94). Vienna: Springer.

Navitare. (2018). *An Amadeus company, Navitaire, unveils the world's first Virtual Reality travel search and booking experience*. Retrieved April 12, 2018, from http://www.amadeus.com/web/amadeus/en_1A-corporate/Amadeus-Home/Newsroom/Archive/PR-2017-04-25-Virtual/1319658626891-Page-AMAD_DetailPpal?assetid=1319706110992&assettype=PressRelease_C.

Neurable. (2018). *Developers*. Neurable INC. http://www.neurable.com/developers. (Accessed 1 November 2019). Retrieved from.

Nill, A., & Schibrowsky, J. A. (2007). Research on marketing ethics: A systematic review of the literature. *Journal of Macromarketing, 27*(3), 256–273. https://doi.org/10.1177/0276146707304733.

O'Keefe, B., Benyon, D., Chandwani, G., Menon, M., & Duke, R., II (2014, September). A blended space for heritage storytelling. In *Proceedings of the 28th international BCS human computer interaction conference on HCI 2014-sand, sea and sky-holiday HCI* (pp. 90–99). Southport: BCS.

Okura, F., Kanbara, M., & Yokoya, N. (2012, October). Fly-through heijo palace site: Historical tourism system using augmented telepresence. In *Proceedings of the 20th ACM international conference on Multimedia* (pp. 1283–1284). Nara: ACM.

Olsson, T., Kärkäinen, T., Lagerstam, E., & Ventä-Olkkonen, L. (2012). User evaluation of mobile augmented reality scenarios. *Journal of Ambient Intelligence and Smart Environments, 4*(1), 29–47.

Ortiz, P., Sánchez, H., Pires, H., & Pérez, J. A. (2006, September). Experiences about fusioning 3D digitalization techniques for cultural heritage documentation. In *ISPRS, commission V symposium, image engineering and vision metrology* (pp. 25–27). Dresden: ISPRS Archives http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.211.2403&rep=rep1&type=pdf.

Pakanen, M., & Arhippainen, L. (2014, December). User experiences with web-based 3D virtual travel destination marketing portals: The need for visual indication of interactive 3D elements. In *Proceedings of the 26th Australian computer-human interaction conference on designing futures: The future of design* (pp. 430–439). New York: ACM.

Pallud, J., & Straub, D. (2007). Real vs. Virtual: A theoretical framework for assessing the role of authenticity in visitor interactions with museum technologies. *AMCIS 2007 Proceedings*, 182–191. https://pdfs.semanticscholar.org/f59a/c7d01c7f88f74572d43a6fe233196db2115c.pdf?_ga=2.22764146.89199167.1563380876-638516485.1560628551.

Pantano, E., & Corvello, V. (2014). Tourists' acceptance of advanced technology-based innovations for promoting arts and culture. *International Journal of Technology Management, 64*(1), 3–16.

Park, J., & Kim, S. (2018). Digital representation of seokguram temple UNESCO world heritage site. In *Augmented reality and virtual reality* (pp. 379–384). Chm: Springer.

Parrinello, G. L. (2001). The technological body in tourism research and praxis. *International Sociology, 16*(2), 205–219.

Pausch, R., Snoddy, J., Taylor, R., Watson, S., & Haseltine, E. (1996, August). Disney's aladdin: First steps toward storytelling in virtual reality. In *Proceedings of the 23rd annual conference on Computer graphics and interactive techniques* (pp. 193–203). New York: ACM.

Pedrana, M. (2014). Location-based services and tourism: Possible implications for destination. *Current Issues in Tourism, 17*(9), 753–762.

Polimeris, S., & Calfoglou, C. (2016). Cultural tourism destinations and the power of virtual reality. In V. Katsoni, & A. Stratigea (Eds.), *Tourism and culture in the age of innovation* (pp. 577–587). Cham: Springer.

Porter, M. (1980). An algorithm for suffix stripping. *Program: electronic library and information systems, 14*(3), 130–137.

Qiu, Y., Gao, J., & Zhan, Q. (2011, August). The study of landscape visual impact assessment in mountain tourism area. In *2011 international conference on management and service science* (pp. 1–4). IEEE.

Rapprich, V., Lisec, M., Fiferna, P., & Závada, P. (2017). Application of modern technologies in popularization of the Czech volcanic geoheritage. *Geoheritage, 9*(3), 413–420.

Rassmus-Gröhn, K., Szymczak, D., & Magnusson, C. (2013, April). The time machine–an inclusive tourist guide application supporting exploration. In *International workshop on haptic and audio interaction design* (pp. 127–136). Berlin, Heidelberg: Springer.

Reborn, R. (2009). *How to change the years in Google Earth*. Retrieved February 23rd, 2017 from http://smallbusiness.chron.com/change-years-google-earth-42254.html.

Rodríguez, C. I. (2015, November). eTourism applying geolocation technology, virtual tours and augmented reality mobile. In *2015 IEEE thirty fifth central American and Panama convention (CONCAPAN XXXV)* (pp. 1–6). Tegucigalp: IEEE.

Roschk, H., Loureiro, S. M. C., & Breitsohl, J. (2017). Calibrating 30 years of experimental research: A meta-analysis of the atmospheric effects of music, scent, and color. *Journal of Retailing, 93*(2), 228–240. https://doi.org/10.1016/j.jretai.2016.10.001.

Rouse, A. G., Stanslaski, S. R., Cong, P., Jensen, R. M., Afshar, P., Ullestad, D., et al. (2011). A chronic generalized bi-directional brain–machine interface. *Journal of Neural Engineering, 8*(3), 1–19.

Schneider, E., Wang, Y., & Yang, S. (2007, September). Exploring the uncanny valley with Japanese video game characters. *DiGRA conference*. https://pdfs.semanticscholar.org/bba1/2549901e893b33bb68b730c8e09371d66b02.pdf.

Scholz, J., & Smith, A. N. (2016). Augmented reality: Designing immersive experiences that maximize consumer engagement. *Business Horizons, 59*(2), 149–161. https://doi.org/10.1016/j.bushor.2015.10.003.

Schott, C. (2017). Virtual fieldtrips and climate change education for tourism students. *Journal of Hospitality, Leisure, Sports and Tourism Education, 21*, 13–22.

Sequeira, V., Ng, K. C., Wolfart, E., Goncalves, J. G., & Hogg, D. C. (1998, December). Automated 3D reconstruction of interiors with multiple scan views. In *Videometrics VI* (Vol. 3641, pp. 106–117). International Society for Optics and Photonics.

Shao, L., & Zhang, Y. L. (2012). Study on the key technology and application of smart tourist public service system. In Y. Zhang (Ed.), *Proceeding of the 8th euro-asia conference on environment and CSR tourism, MICE, hospitality management and education session*. https://www.wvberlin.com/programm/shop/einzelansicht/wirtschaftswissenschaften/proceedings-of-the-8th-euro-asia-conference-on-environment-and-csr-tourism-mice-hospitality-management-and-education-session-part-i/2fe0f8c692112b27781f188c36474e0f/?tt_products%5Bbegin_at%5D=70.

Shi, Z., Wang, H., Wei, W., Zheng, X., Zhao, M., Zhao, J., et al. (2016). Novel individual location recommendation with mobile based on augmented reality. *International Journal of Distributed Sensor Networks, 12*(7), 1–13, 1550147716657266.

Siamionava, K., Slevitch, L., & Tomas, S. R. (2018). Effects of spatial colors on guests' perceptions of a hotel room. *International Journal of Hospitality Management, 70*, 85–94.

Soomro, T. R., Zheng, K., Turay, S., & Pan, Y. (1999). Capabilities of multimedia GIS. *Chinese Geographical Science, 9*(2), 159–165.

Stangl, B., & Weismayer, C. (2008). Websites and virtual realities: A useful marketing tool combination? An exploratory investigation. In P. O'Connor, W. Höpken, & U. Gretzel (Eds.), *Information and communication technologies in tourism 2008* (pp. 141–151). New York: Springer.

Statista. (2018). *Virtual reality (VR)-statistics & facts*. Retrieved February 24th, 2018 from Statista website https://www.statista.com/topics/2532/virtual-reality-vr/.

Statista. (2018). *Number of connected wearable devices worldwide from 2016 to 2021 (in millions)*. Retrieved https://www.statista.com/statistics/487291/global-connected-wearable-devices/. (Accessed 24 October 2018).

Stewart, K. J., & Gosain, S. (2006). The impact of ideology on effectiveness in open source software development teams. *MIS Quarterly*, 291–314.

Styliadis, A. D., Akbaylar, I. I., Papadopoulou, D. A., Hasanagas, N. D., Roussa, S. A., & Sexidis, L. A. (2009). Metadata-based heritage sites modeling with e-learning functionality. *Journal of Cultural Heritage, 10*(2), 296–312.

Tamiya, Y., & Nojima, T. (2011, March). A simplified vibrotactile navigation system for sightseeing. In *2011 IEEE international symposium on VR innovation* (pp. 33–36). Singapore: IEEE.

Tatzgern, M., Grasset, R., Veas, E., Kalkofen, D., Seichter, H., & Schmalstieg, D. (2015). Exploring real world points of interest: Design and evaluation of object-centric exploration techniques for augmented reality. *Pervasive and Mobile Computing, 18*, 55–70.

Udovičić, G., Topić, A., & Russo, M. (2016, September). Wearable technologies for smart environments: A review with emphasis on BCI. In *2016 24th international conference on software, telecommunications and computer networks (SoftCOM)* (pp. 1–9). Split: IEEE.

Virtual-reality. (2018). *virtual-reality history*. Retrieved from https://www.vrs.org.uk/virtual-reality/history.html. (Accessed 12 October 2018).

Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., et al. (2001). Archeoguide: First results of an augmented reality, mobile computing system in cultural heritage sites. *Virtual Reality, Archeology, and Cultural Heritage*, 1–9. https://doi.org/10.1145/584993.585015.

Wang, X., Wang, J., & Wennersten, R. (2006). Strategic urban design from a sustainable tourism perspective: A case study from the city of guangzhou, China. In *4th international conference on urban regeneration and sustainability location: Tallinn, Estonia, date: Jul 17-19, 2006* (pp. 333–342). Berlin: Springer.

Wang, Y., Yu, Q., & Fesenmaier, D. R. (2002). Defining the virtual tourist community: implications for tourism marketing. *Tourism Management, 23*(4), 407–417.

Wei, O. C., Majid, Z., Setan, H., Ariff, M. F. M., Idris, K. M., Darwin, N., et al. (2019). *Three-dimensional recording and photorealistic model reconstruction for virtual museum application–an experience in Malaysia. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*.

Williams, P., & Hobson, J. P. (1995). Virtual reality and tourism: Fact or fantasy? *Tourism Management, 16*(6), 423–427.

Woo, E., Kim, H., & Uysal, M. (2015). Life satisfaction and support for tourism development. *Annals of Tourism Research, 50*, 84–97.

Wu, J. J., & Tsang, A. S. (2008). Factors affecting members' trust belief and behaviour intention in virtual communities. *Behaviour & Information Technology, 27*(2), 115–125.

Xu, F., Tian, F., Buhalis, D., & Weber, J. (2013, September). Marketing tourism via electronic games: Understanding the motivation of tourist players. In *2013 5th international conference on games and virtual worlds for serious applications (VS-games)* (pp. 1–8). Poole: IEEE.

Yeh, C. H., Wang, Y. S., Li, H. T., & Lin, S. Y. (2017). The effect of information presentation modes on tourists' responses in Internet marketing: The moderating role of emotions. *Journal of Travel & Tourism Marketing, 34*(8), 1018–1032.

Yoon, S. Y., Laffey, J., & Oh, H. (2008). Understanding usability and user experience of web-based 3Dgraphicstechnology. *International Journal of. Human–Computer Interaction, 24*(3), 288–306.

YouVisit. (2015). *YouVisit study*. Retrieved http://www.youvisit.com/virtual-tours/virtual-reality-appetite-index-september-2015. (Accessed 2 July 2017).

Yung, R., & Khoo-Lattimore, C. (2017). New realities: A systematic literature review on virtual reality and augmented reality in tourism research. *Current Issues in Tourism*. https://doi.org/10.1080/13683500.2017.1417359. Published online . (Accessed 28 December 2017).

Zang, H., & Gao, G. (2010). The application of vurtual reality technology in ethnic athletic sports of tourists participating style. SO, ICMS2010. In *, Vol. 6. Proceedings of the third international conference on modelling and simulation* (pp. 311–313). modelling & simulation industrial engineering & management. https://pdfs.semanticscholar.org/48c2/be5567e4c66626b353b5b1cf6ed0e8c9c11d.pdf.

Zelenka, J. (2009). Information and communication technologies in tourism-influence, dynamics, trends. *E+ M Ekonomie a Management, 1*, 123–132.

Sandra Maria Correia Loureiro (PhD) is a professor at ISCTE-IUL, Portugal and SOCIUS. Her current research interests include consumer-brand relationships and engagement and tourism marketing issues.

João Guerreiro (PhD) is an Assistant Professor at ISCTE-IUL, Portugal. His scientific research interests rely on Virtual and Augmented Reality, Digital Marketing and the use of neuro-marketing techniques to understand consumer behavior.

Faizan Ali (PhD) is an Assistant Professor at University of South Florida Sarasota Manatee. His current research interests rely on consumer experience and behavior, Virtual and Augmented Reality in hospitality and tourism and research methods.