



Empirical Research Article

Knowledge Mapping of Robotic Applications in Tourism and Hospitality

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Abstract

The use of robots in tourism and hospitality contexts have drawn increasing scholarly and practical regard. Although the number of recent robotics related studies continue to grow, a general knowledge map, which is important to point out promising directions for future studies, remains to be made. To understand the application of robotics in tourism and hospitality, this study conducts descriptive and bibliometric analysis to present a holistic knowledge map of this specific field where research trend, key contributors, highly cited references, and popular themes were identified. Collaboration networks among institutes and regions were additionally illustrated. Collaboration across fields, industries, and perspectives were encouraged following the findings and both theoretical and practical implications are accordingly provided.

Keywords

Knowledge map; Robots; Technology; Tourism; Hospitality

1. Introduction

With the advent of the fourth industrial revolution, emerging technologies such as robotics, the Internet of Things (IoT), artificial intelligence (AI), nanotechnology, and quantum computing have been making breakthroughs in generating opportunities to integrate various interactive technologies into service environments (Tussyadiah, 2020). Technology has therefore become the driving force in improving consumer travel experience (Lu et al., 2019). The technology of robotics has also been rapidly developing and is bringing new possibilities to different industries and people's daily lives (Tung & Law, 2017). Robots have been used in a wide range of industries, including medicine, geriatric care, agriculture, and janitorial services. The potential of robotic applications is constantly being recognized and subsequently developed during its implementation (Ivanov et al., 2018). The onset of the COVID-19 pandemic in 2019 highlighted the important role of robots in responding to disasters

and crises, furthering the development of robotics at large (Zeng et al., 2020).

The service industry has also long played a leading role in adopting new technologies to improve consumer experience (Lu et al., 2019), and this is evident in hospitality and tourism. With the advent of the Internet, tools such as mobile phones, virtual reality (VR), and augmented reality (AR), have allowed the tourism and hospitality industries to adapt to advances in information technology. This is noted in how, unsurprisingly, robotics is becoming gradually integrated into daily operations (Park, 2020). In tourism and hospitality contexts, robots are increasingly being used in a variety of locations including theme parks, airports, restaurants, hotels, and travel agencies (Ivanov et al., 2017). Therefore, robots serve a diverse range of social and practical purposes (Tung & Law, 2017). However, while robotics usage has attracted widespread attention in practical industrial applications, research on robots in tourism and hospitality

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specifically remains a recently explored academic phenomena, and faces a scarcity of relevant studies which are mainly descriptive and speculative in approach (Ivanov et al., 2018). Most existing studies in robotic applications in tourism and hospitality focus on investigating the perception and experience of human-robot interaction (Ye et al., 2022). Although several review studies uncover the detailed content of robotic implementation, knowledge in this area remains scattered and ultimately lacks a holistic picture (Ivanov & Webster, 2020; Shin, 2022). To better understand and present the current research process and, in turn, empower readers to keep pace with state-of-the-art knowledge of robotic applications in tourism and hospitality, it is necessary to analyze existing studies and accordingly propose valuable future research agenda.

Hence, descriptive analysis and bibliometric analysis were conducted to provide the fundamental and necessary knowledge map of this realm. Specifically, the contribution frequency identifies the leading roles of journals, institutes, and academics. Meanwhile, collaborative network among academics from different institutes and regions reflect the intellectual relationship herein. Moreover, key references and research themes are important in identifying promising directions for future research. Some emerging software systems may even assist conducting bibliometric analysis and generate a science map of existing knowledge: this includes CiteSpace which is the most widely used bibliometric analysis software among hospitality and tourism academics (Li et al., 2017; Fang et al., 2018; Qiao et al., 2021), which was chosen to be the tool of this study herein. Research trend and contribution frequency were also presented through descriptive analysis. CiteSpace was ultimately used to illustrate institutional and regional collaboration network, key references, and research themes. Research gaps were identified from analyzed results which form the basis for the forwarded recommendations in filling the theoretical gaps in the current discussion.

2. Robotic Applications in Tourism and Hospitality

The International Organization for Standardization (IOS) defines a robot as an “actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks” (International Organization for Standardization, 2012, p.9). IOS also classified them into either industrial robots or service robots according to their intended applications (International Organization for Standardization, 2012). Following an analysis conducted by the International Federation of Robotics, the five main application trends for service robots include the following:

autonomous mobile robots and delivery robots, cleaning and disinfection, medical and rehabilitation, social robots, and automated restaurant robots (International Federation of Robotics, 2021). These application trends can be seen in tourism and hospitality. This is specifically seen in service robots which are widely used in tourism and hospitality and play diverse roles such as guides, hosts, porters, cooks, and room attendants. In hospitality, robots are mostly used for daily tasks such as check-in, vacuuming, delivery, and concierge services. In tourism-related industries, robots provide a variety of services including entertainment and guidance (Ivanov et al., 2019; Ivanov et al., 2017).

The influence of robotic applications in tourism and hospitality is multifaceted. For example, for human resources, future global tourism workforce was predicted to be greatly influenced by robotics (Alexis, 2017; Murphy et al., 2017; Yu, 2020). Price Waterhouse Coopers (one of the big four accounting firms) estimated that a quarter of hospitality jobs in the U.S. will be automated in the 2030s (Graham, 2018). For user experience, robots enhance tourists' experience by providing timely service and assistance to guests in hotels and attractions (Christou et al., 2020). For tourism crisis management, robots perform multiple functions. During the pandemic for instance, robots replace people and provide safer services to consumers, thus helping protect the safety of consumers and employees and facilitating crisis management (Seyitoglu & Ivanov, 2021). Although the use of robots in tourism and hospitality is considered to have a negative impact, the affirmative contribution it makes remains particularly significant; for example, Kuo, Chen, and Tseng (2017) identified six factors affecting the development of service robots in the hospitality industry, including government support, market development capabilities, the future development of the robotics industry, technology development capabilities, financing capabilities, and talent development capabilities.

The use of robotics in the tourism and hospitality industry has become increasingly normalized and its influence on tourism and hospitality continues to grow. However, most studies related to robotics were conducted by technical researchers; researchers truly entering the field and giving the research in tourism/hospitality a social science component is a recent phenomenon (Ivanov et al., 2019). However, researchers recently started to explore the impacts of robotic applications in tourism and hospitality by conducting experimental research, survey, and in-depth interview (Ye et al., 2022) with existing studies on robotic applications herein still being fragmented and shallow. This is especially witnessed in studies with a focus on technology in the tourism and hospitality contexts, which are few and far

between. A number of recent review studies published on robotic applications in tourism and hospitality have laid a solid foundation and therein provided guidance for this nascent area of research (Ivanov et al., 2019; Ivanov & Webster, 2020; Goel et al., 2022; Shin, 2022). Tourism and hospitality researchers provide a detailed content analysis of the existing robotic applications and propose a potential research agenda for future research. However, the details of the authorships, collaboration network among institutes, and key turning points of robotic applications in tourism and hospitality remain largely unknown. This suggests a gap on the current research in robotic applications in tourism and hospitality. Particularly, it is unclear whether the said gap is related to the lack of interdisciplinary collaboration among tourism and hospitality, computer science, and business management.

Hence, this study contributes to the current literature by using bibliometric analysis to systematically review robotic applications in tourism and hospitality where both general information and the collaboration networks of authors were analyzed. Moreover, key references along with top contributed authors and institutes, which are the milestones of this research realm were identified. Results herein help both academe and industry to clarify the current state of the discussion and points out the promising research directions to be further explored by understanding existing research gaps.

3. Methodology

A recent review study provided a comprehensive content analysis on robotic applications in tourism and hospitality (Ye et al., 2022). Despite the efforts of Ye et al. (2022), concerns need to be addressed. For instance, the types of reviewed publications are supposed to be expanded to generate fruitful findings. Meanwhile, bibliometric indicators can help construct links between/among publications. Therefore, to fill the gaps mentioned in Ye et al. (2022), this paper extends the aforementioned work in different ways. First, this study provides a general knowledge map of robotic applications in tourism and hospitality and depicts the collaboration network among academics. Second, it expands the review scope from journal to conference proceedings. To ensure academic rigor, the research team followed a preferred reporting item for systematic reviews and meta-analysis (PRISMA) review protocol to collect and analyze the articles such as identification, screening, eligibility, and inclusion (Lim et al., 2021). Identification, screening, and eligibility were executed in the data collection stage. The stage of inclusion refers to the aggregation and analysis of eligible publications. The review flow is depicted in Figure 1.

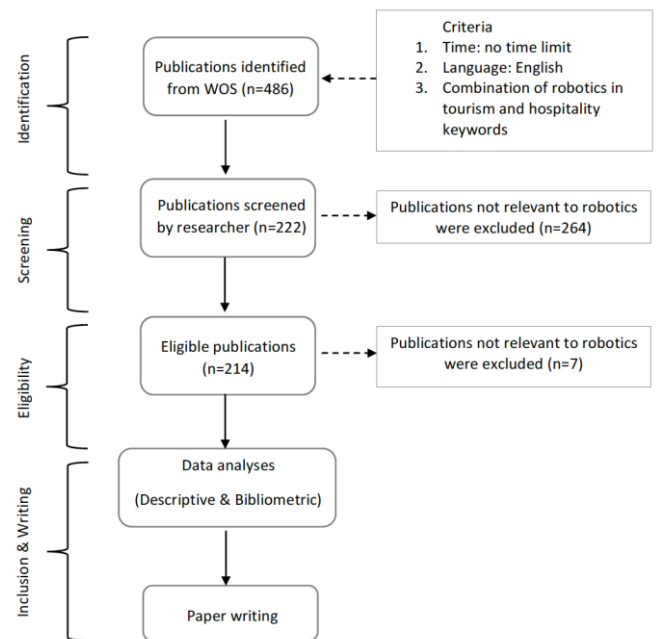


Fig. 1. Review flow

3.1 Data Collection

Publications on robotic applications in tourism and hospitality were collected in late July 2022. Given that a research objective is conducting collaboration network analysis among institutions and regions, Web of Science Core Collection was selected as the database to collect data including general information and cited references of articles. Search criteria were discussed and identified by all researchers. The combination of search keywords follows the suggestion of previous robotic review study: (“robot” OR “robotic” OR “robotic application”) AND (“hospitality” OR “tourism” OR “hotel”) (Ye et al., 2022). Considering robotic applications in tourism and hospitality research is in its nascency stage, there is no time limit in the data collection stage. Also, only publications in English were retained for further analysis. Following these criteria, one researcher executed data identification. 486 publications were ultimately collected in the identification stage. The researcher then also screened the collected articles. Title, keywords, and abstract of all searched results were read verbatim to ensure the relevance of publications. 222 publications were included after the screening stage. Then, these publications were passed to another researcher to perform the eligibility work. Publications that were not focusing robotic applications were excluded to ensure content relevance. Discrepancies on the collected results were discussed by all researchers until a consensus was reached. Ultimately, 214 publications were used for main analysis.

3.2 Data Analysis

The included 214 publications were analyzed by one researcher. The initial results were validated by other researchers of the same team. Descriptive and bibliometric analyses were conducted to provide quantitative results and a general knowledge map of robotic applications in tourism and hospitality. Specifically, factors such as research trend, distribution of publication types, and journals/conferences were summarized by performing a descriptive analysis. Following the suggestions of Fang, Yin, and Wu (2018), Li, Ma, and Qu (2017), and Qiao, Ding, Zhang, and Yan (2021), this study depicts the collaborative network among different institutes and regions by using the science mapping software named CiteSpace (version 6.1.R2). Popular keywords, key publications, and research themes of robotic applications in tourism and hospitality were also generated by CiteSpace.

All researchers of this team participated in data analysis. The research team comprises senior researchers who are very experienced in publishing review articles in prestige hospitality and tourism journals using bibliometric analysis. This, in turn, ensures the reliability of this study. There are several steps of the validation process. First, pertinent files including bibliometric indicators were passed to one of the researchers to repeat the analysis in the same version of the software. Quantitative results

and collaboration networks in the initial figures were counter-checked by this researcher. After detailed validation by one researcher, results were passed to two other researchers for a second round of examination. The whole research team discussed and determined the design of the figures. Validated results would then be summarized and discussed in the following section.

4. Findings and Discussion

4.1. General Information

Following Figure 2, the first robotic pertinent publication in tourism and hospitality emerged in 1998. There were also very few relevant publications before 2010, with only one publication each year. From 2010 to 2016, the number of publications was around five per year. However, there was a clear dramatic increase from 2017 to 2021, with the number of publications increasing from eight to 57. In 2022, there are 47 robotic relevant publications. Given that the data was collected by late July 2022, there was a promising trend by the end of 2022. In terms of publication types (Figure 3), 73% ($n = 157$) of them are journal articles (including review papers, research notes, conceptual papers, and empirical papers), 24% ($n = 51$) of them are incorporated in conference proceedings. Moreover, there were five (2%) editorial papers and one (1%) book chapter.

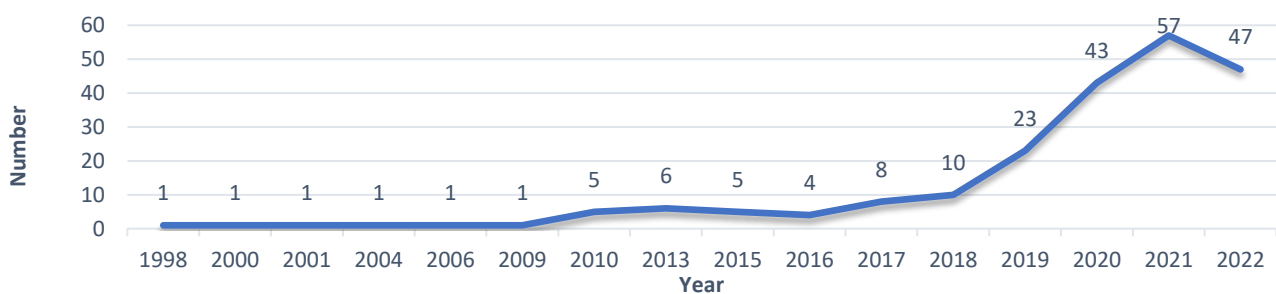


Fig. 2. Publication trend. Note: The data for 2022 was only updated to late July 2022

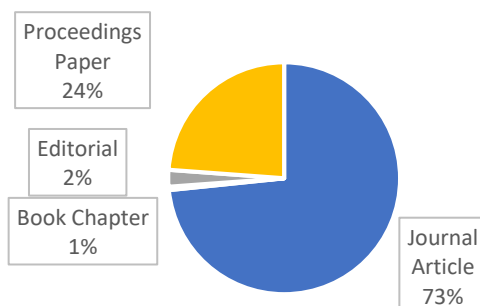


Fig. 3. Distribution of publication types

Collected publications were distributed in various journals and conferences. Table 1 shows the journals with frequent contributions. Generally, journals contributed more publications than conferences. Among all journals and conferences, *International Journal of Contemporary Hospitality Management*

contributed the most to robotic relevant articles, with a total of 20 publications. *International Journal of Hospitality Management* and *Tourism Review* followed with a contribution of 13 publications and 8 articles respectively. Details of other frequent contributors were listed in Table 1 as well.

Table 1. Distribution of publication journals (top five)

No.	Journals/Conference proceeding	Frequency
1	International Journal of Contemporary Hospitality Management	20
2	International Journal of Hospitality Management	13
3	Tourism Review	8
4	Annals of Tourism Research	7
4	Sustainability	7
4	Tourism Management	7
5	International Journal of Social Robotics	6
5	Tourism Management Perspectives	6

4.2. Collaboration Network Among Institutes and Regions

Given that most robotic relevant publications were published after 2010, the dataset for collaborative network analysis comprised 208 publications published from 2010 to 2022. Among all analyzed publications, a total of 228 authors were noted. Top contributed authors included Ivanov, Stanislav ($n = 8$), Baba, Jun ($n = 5$), Zalama, Eduardo ($n = 5$), and Zhong, Lina ($n = 5$). The authors hailed from 168 institutes worldwide.

Top five contributing institutions are shown in Table 2. The Hong Kong Polytechnic University in particular contributed 10 publications to this realm. Researchers from Sun Yat-Sen University participated in nine relevant studies. Others such as the University of Macau and Varna University of Management contributed eight times in the recent 13 years. Ball State University and Osaka University both published seven articles. Meanwhile, Beijing International Studies University, Pennsylvania Commonwealth System of Higher Education, and University of Surrey provided six robotic related studies.

Table 2. Contributed institutes (top five)

No.	Institutes	Frequency
1	Hong Kong Polytechnic University	10
2	Sun Yat-Sen University	9
3	University of Macau	8
3	Varna University of Management	8
4	Ball State University	7
4	Osaka University	7
5	Beijing International Studies University	6
5	Pennsylvania Commonwealth System of Higher Education PCSHE	6
5	University of Surrey	6

Institutional and regional collaborative networks were also depicted using CiteSpace. The colored bar on the top of Figure 4 represents the active period of the institutions: the warmer the color, the newer the institutes actively collaborate with other institutes in the discipline. The font sizes of the institutes refer to the collaboration frequency with other institutes. Following Figure 4, several institutes actively collaborated with each other. There are also three large collaboration clusters. The largest red cluster is mainly formed by scholars from Mainland China, Hong Kong, Macau, and the United Kingdom (UK) from institutions such as Hong Kong Polytechnic University, Sun Yat-Sen University, Beijing International Studies University, Monash University, and University of Greenwich. Scholars from the red cluster collaborated with each other most recently (i.e., from 2021 to 2022) and most frequently.

The green collaboration cluster is the second active group. Scholars herein were mainly from Japanese institutes such as Osaka University, Cyber Agent Inc. University of Tsukuba, and the University of Fukuchiyama. Japanese scholars actively collaborated with each other from 2017 to 2019. The third largest collaboration network is the purple cluster and is mainly formed by academics from Varna University of Management, Ball State University, University of Southern California, and Mardin Artuklu University. They were actively collaborating robotic applications in tourism and hospitality studies in 2013. Meanwhile, some other active contributed institutes scattered in the network map and formed a small-scale academic network.

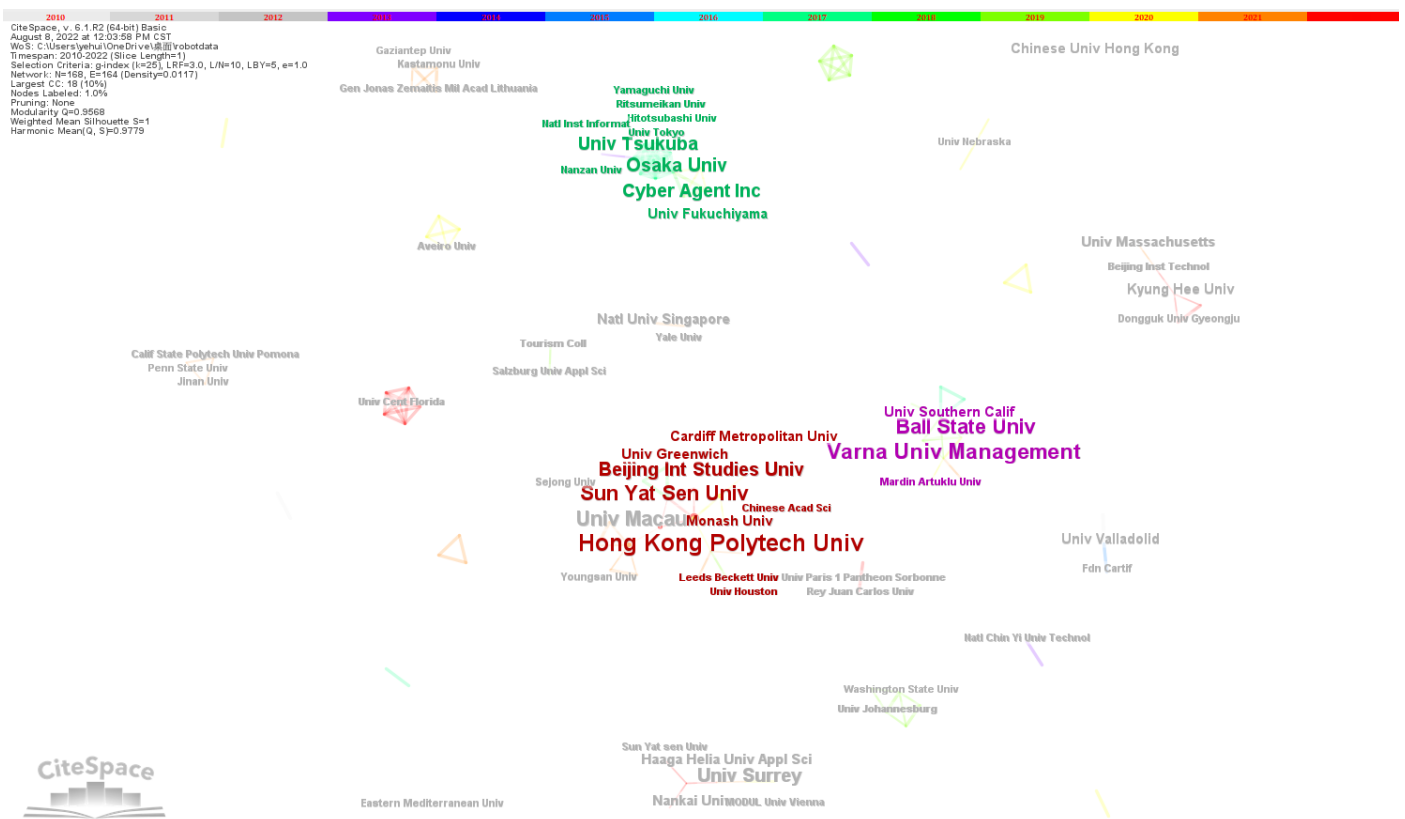


Fig. 4. Institutional collaborative network

Moreover, regional collaborative network was presented in Figure 5. The size of the regions represents their collaboration frequency with other regions: the larger the font size, the more

frequent the regional collaboration with other regions. The colors of the links between regions also represent the active period of regional collaboration: the warmer the color, the later the regions

collaborated with each other. Among all regions, scholars from Mainland China contributed the most to robotics research in tourism and hospitality. Additionally, researchers from the United States (US), the UK, Japan, South Korea, and Spain frequently contributed to this area.

There are also major clusters of regional collaboration: the larger one was expanded from Mainland China and the US, connecting scholars from countries such as the UK, Japan, South Korea, Spain, Taiwan, Japan, Australia, France, India, Finland,

Singapore, and Austria. The center regions of the other cluster include Turkey and Bulgaria. Researchers from these countries have a close collaboration network with other countries such as Thailand and Portugal. While both regional collaborative clusters are form their own networks within the cluster, there are also two collaborative publications which link these two clusters together. Specifically, researchers from Bulgaria co-authored with researchers from the US and Australia. Therefore, it was witnessed that there will be more future international studies on robotic applications in tourism and hospitality.

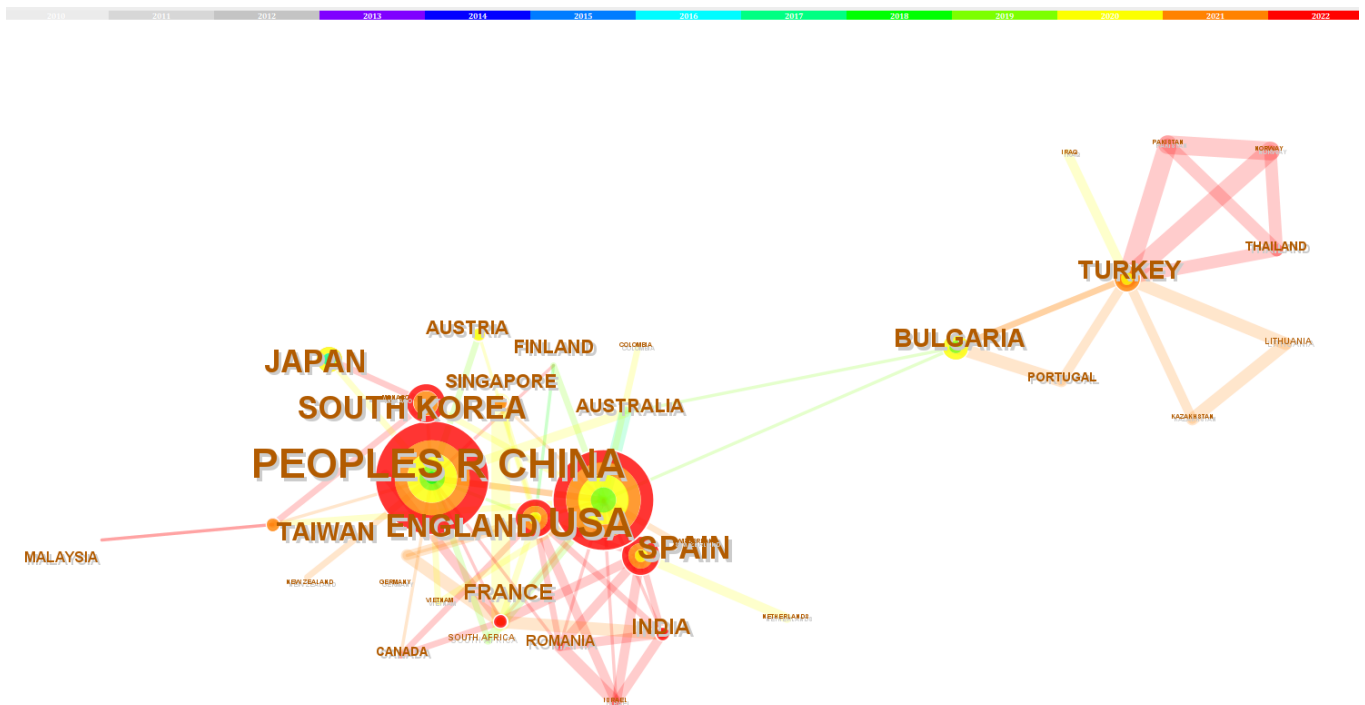


Fig. 5. Regional collaborative network

4.3. Popular Keywords, Key References, and Research Themes

Using CiteSpace software, this study analyzed popular keywords, key references, and research themes of robotic relevant publications from 2010 to 2022. Popular keywords were frequently used by scholars are shown in Table 3. Service robot ($n = 74$), tourism ($n = 45$), experience ($n = 38$), artificial intelligence

($n = 35$), and hospitality ($n = 34$) were the top five popular keywords listed by authors.

Additionally, several key references which contributed to robotic applications in tourism and hospitality were included. Top 10 impactful studies with the strongest citation surged since 2010 are listed in Figure 6 below. For example, a study of a bellboy robot named Sacarino by Rodriguez-Lizundia et al. (2015) garnered citations for the longest time: from 2016 to 2020. By executing

trial experiment, this study is one of the earliest publications exploring the impacts of social robots on hotel customers' behavior (Rodriguez-Lizundia et al., 2015). General robots in tourism and hospitality by Ivanov, Webster, and Berezina (2017) also attracted the strongest attention among all cited publications. Robots applying scenarios (e.g., hotels, restaurants, airports, events, and attractions), functions (e.g., check-in/out, cooking, cleaning, and guide), and potential use (e.g., full service) were

identified therein (Ivanov et al., 2017). From a technical perspective, Pinillos et al. (2016) improved Sacarino robot's operational system based on the long-term assessment of robot-customer interaction in the hotel context. Hence, this study gained the second strongest scholarly and industrial regard from 2018 to 2020. Authors, journals, volumes, and issues numbers of other seven significant publications were presented as well.

Table 3. Frequency of popular keywords

No.	Keywords	Frequency
1	Service robot	74
2	Tourism	45
3	Experience	38
4	Artificial intelligence	35
5	Hospitality	34
6	Technology	30
7	Model	21
8	Satisfaction	20
8	Service	20
10	Acceptance	18
10	Future	18
12	Human-robot interaction	17
13	User acceptance	16
14	Behaviour	15
15	Anthropomorphism	14
15	Attitude	14
15	Information technology	14

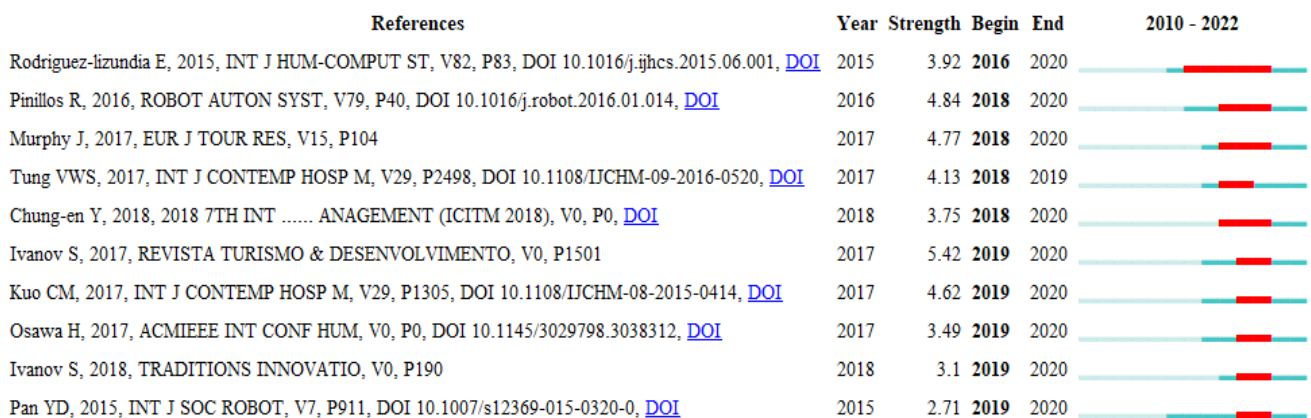


Fig. 6. Key publications (top 10) with the strongest citation bursts

CiteSpace automatically analyzed the research themes of robotic applications in tourism and hospitality. Following Figure 7, there were nine themes of collected articles with the title of each was attached on the right side of each line (e.g., brand experience, service robot, and automation technologies). A timeline was shown on the top of the figure. The location and length of each line represent the period that the theme was frequently studied. For instance, the theme on artificial intelligence was studied by researchers for the longest period (from 2010 to 2022). Publications relating to this theme were about laser scanning,

tracking, and human-robot interaction. In addition, the newest emerging theme is related to social class and service robot, which emerged around 2018. For those related to social class, publications focused on robotic acceptance pertinent concepts such as education, generation Z, risk, and responses. As for service robot, publications discussed human-robot interactions concepts such as social presence, service quality, and uncanny valley. The development track and significant concepts of other themes were elaborated in Figure 7.

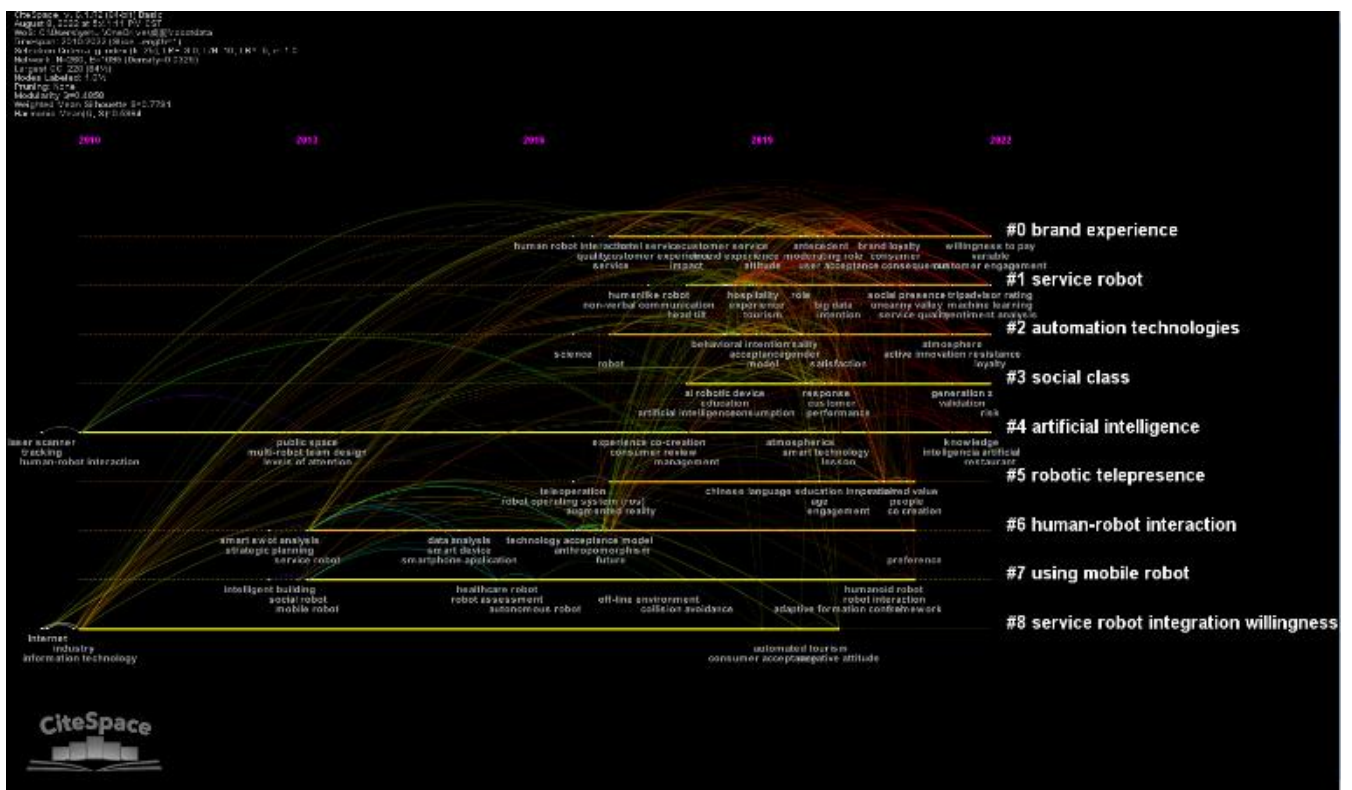


Fig. 7. Research themes of robotic applications in tourism and hospitality

5. Discussion and Conclusion

The evolution of technology such as AI, IoT, VR, AR shapes the new paradigm of hospitality and tourism. Robotic applications have received increasing attention from researchers and practitioners in recent years. For example, service robots have been implemented in restaurants, attractions, airports, and hotels providing services such as delivery, check-in/out, guidance, cooking, and cleaning. With COVID-19, robotic applications have gained more attention in delivering contactless service. Although several review studies have shown details of robotic applications in hospitality and tourism (Ivanov & Webster, 2020; Shin, 2022; Ye et al., 2022), there is very limited research linking the fragmented knowledge of the existing studies. In other words, research depicting a general knowledge map of this research realm remains scarce. Therefore, this study fills this research gap by conducting descriptive analysis and bibliometric analysis using CiteSpace software.

It also presents the research trend of this area and contributions made by academic researchers. Specifically, the first robotic relevant publication in tourism and hospitality which emerged in 1998. However, it was not until the previous decade in 2010 that the number of robotic related publications slightly increased. With the revolution of advanced technologies came a dramatic increase of publications since 2017. Among all collected publications, 73% ($n = 157$) of them are journal articles, which contributed more to the field compared to conferences. *International Journal of Contemporary Hospitality Management* in particular contributed the most to the discussion. Since 2010 (which was the year more academics participated in this research field), Ivanov Stanislav was the top contributed researcher, Hong Kong Polytechnic University ranked first among all publishing institutions, and Mainland China was the region which generated most robotic studies in tourism and hospitality.

For the results of the bibliometric analysis, figures of collaboration network illustrated three large clusters among institutes and two major clusters among regions. There is a promising trend that there will be more international collaborated robotic studies. Meanwhile, key references such as Rodriguez-Lizundia et al. (2015), Pinillos et al. (2016), and Ivanov et al. (2017) were identified as having a significant impact herein. From 2010 to 2022, service robot was the most popular keyword. There also exist various research themes for robotic relevant publications such as brand experience, service robot, social class, and artificial intelligence. In sum, findings herein provide basic information and knowledge roadmap of robotic development in

tourism and hospitality. Collaborative research between regions and institutes are advocated in future research.

5.1 Research Gaps and Future Agenda

Following the research findings, this section discusses the results and identify gaps from the existing knowledge map. A future agenda is provided accordingly.

First, more efforts should be exerted on research of robotic applications in tourism and hospitality by various channels. According to Figure 3, more than 70% of robotic relevant studies were disseminated by journals at this stage. Therefore, institutes should hold more pertinent conferences or seminars to motivate and appeal attention to this area. Second, interdisciplinary collaboration is strongly suggested to produce scientific robotics research. Researchers from a myriad of fields such as tourism and hospitality, computer science, social science, physics, marketing, and management should cooperate with each other to generate fruitful findings and discussion. Therefore, more conferences or seminars can promote the discussion and collaboration among scholars from various disciplines and between academia and industry. Third, along with cross-field research, cross-regional studies are also advocated to compare the differences among countries or regions. As indicated in Figure 4, researchers prefer to work with scholars from nearby regions. Meanwhile, most existing studies were conducted in the context of a specific region, thus limiting the generalizability of the findings. Therefore, researchers must collaborate with scholars from other regions to carry out more international robotics studies in the future.

Fourth, studies using multiple perspectives must be adamantly forwarded. Essentially, collaborations among the tourism and hospitality industry, technology-related industries, academia, and the government are critical to linking opinions from varying perspectives. Finally, research themes of robotic applications in tourism and hospitality can be expanded through future studies. As shown in Figure 7, at this stage, various studies examine customers and suppliers' acceptance and preferences (e.g., humanoid or non-humanoid) on service robots (Lu et al., 2019; Liu et al., 2022; Ivanov et al., 2020; Tuomi et al., 2021; Xu et al., 2020). However, technology-focused research such as operating system design for the tourism and hospitality industry remains to be seen (Lee et al., 2020). Therefore, research themes such as industry-wide technical solutions can be considered in the future.

5.2 Theoretical Implications

Despite the increasing number of robotic pertinent publications, the general picture offered by existing studies is still lacking. Although previous studies have exerted to conduct an overall review on robotic applications (Ivanov & Webster, 2020; Shin, 2022; Ye et al., 2022), network between publications is unknown. In other words, scientific development map of this research area is rare.

Therefore, this study fills the research gap by drawing a science knowledge map of robotic applications in tourism and hospitality. First, it displays the trend of publication number since 1998 and presented a dramatic increase of publications since 2017 following the results of previous robotic review studies (Ivanov et al., 2019). Moreover, this study presents the contribution of academics, institutes, and regions by quantifying their publication frequency. These results parallel with the updated review study (Ye et al., 2022). For example, *International Journal of Contemporary Hospitality Management* contributed the most to the discussion on this area. More importantly, collaboration networks among institutes and regions were visualized. Academics from Mainland China and the US are key contributors and also the collaboration center of this research area. Key references, popular keywords, and main research themes were identified as well. Given the existing research trend, it is predicted that there will be a great increase in robotic relevant studies in the coming years. Therefore, the identified impactful references are significant milestones and hints of the knowledge development of this research area. More specifically, there will be two major research directions: operating system optimization of robots and human-robot interaction. Finally, this study points out the potential future directions for academia and industry by identifying the gaps from the existing knowledge map. To generate meaningful and practical robotic research, it is strongly forwarded that collaboration across diverse research fields, industries, and perspectives is greatly needed.

5.3 Practical Implications

Several practical implications for the tourism and hospitality industry and institutes are forwarded herein.

For the tourism and hospitality industry, the design of robotic applications should be optimized based on feedback from employees and customers. Hotel and tourism managers should pay more attention to human-robot interaction and how robotic service influences employees and tourists' experience and behaviors. Given that the investment of robotics cannot be

overlooked, it is necessary to understand the actual needs of robots from consumers to avoid a supply-demand imbalance. Furthermore, the acceptance of robots by different demographic groups of people remains unknown.

Several suggestions are also forwarded for institutes. First, institutional and regional collaboration networks provide information for academics seeking employment opportunities related to this research area. For instance, for graduates who want to work in a robotics relevant field, Mainland China and the US are promising destinations which provide more opportunity for up and coming scholars. Meanwhile, information about key contributors in this area (i.e., frequency and references with strong citation burst) is important in seeking collaborative opportunities among researchers.

Finally, the tourism and hospitality industry should collaborate with academic researchers to produce meaningful and practical robotic studies. For example, hotel managers can provide field robotic data to scholars whose bodies of knowledge guide the operations of enterprises.





6. Limitations

Some limitations herein can be addressed in future studies. First, a descriptive and bibliometric analysis approach was adopted herein to present the general science map of robotic relevant research. Therefore, this study only serves as a basic knowledge framework of robotic applications in tourism and hospitality. Particularly, the research themes automatically classified by CiteSpace are not as precise and detailed as manual classification. Although there are several review studies analyzing the detailed content of robotic applications in tourism and hospitality, it is nonetheless advocated that more efforts should be exerted to update the theories and applications of this realm. Second, this study only analyzed articles collected from one database, which is the Web of Science Core Collection, in considering the completeness of cited references information of articles. However, three or four databases are suggested to collect more comprehensive publications (Law et al., 2010; Sun et al., 2017). Databases such as Scopus, EBSCOHost, and Google Scholar can therefore be used to supplement the missing search results in future studies.

Declaration of competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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