APJIHT Vol. 9 No. 1 September 2020 pp. 25–45
e-ISSN 2710–6519

Review Paper

"Hospitality Revolution 4.0": A Literature Review on a Unified Typology of IR 4.0 Technologies for the Tourism and Hospitality Industry in the Era of COVID-19

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Abstract: The inherent potentials of the Fourth Industrial Revolution for the hospitality and tourism industry cannot be underrated. Since its inception, the Industrial Revolution 4.0 (IR 4.0) has become the "topic of interest" in most academic conferences across the world. However, there seem to be inconclusive and non-consensual agreement among researchers as to what the concept of IR 4.0 entails. Additionally, differing opinions exist among researchers on the technological components of this revolution. Although, scholars have rooted for technologies as a major solution for the resilience on the impacts of COVID-19 on the hospitality and tourism industry, few studies have thoroughly explored these technologies for the industry. Using a critical review process, we address these gaps and present a unified typology of IR 4.0 technologies for the hospitality and tourism industry. This review conclusively theorises IR 4.0 technologies and proposes a 6-component typology of IR 4.0 as well as their opportunities for the hospitality and tourism industry. Practical and social implications are also discussed.

Keywords: Hospitality Revolution 4.0, Industrial Revolution 4.0, robotics, big data, artificial intelligence, COVID-19

Suggested citation: Osei, B.A., Ragavan, N. A., Mensah, H.K., & Kandappan, B. (2020). "Hospitality Revolution 4.0": A literature review on a unified typology of IR 4.0 technologies for the tourism and hospitality industry in the era of COVID-19. *Asia-Pacific Journal of Innovation in Hospitality and Tourism, 9*(1), 25–45.

Introduction

Today's economy is headed towards the Fourth Industrial Revolution, characterised by the proliferation of cyber-physical systems, smart factories, and service innovations

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(Kagermann, Wahlster, & Helbig, 2013). Interestingly, the onset of this revolution generated different terms that explain the same concept or technological revolution. These terms include: "Industry 4.0", "Fourth Industrial Revolution" as well as "Industrial Revolution 4.0" (IR 4.0) (Liao, Deschamps, Loures & Ramos, 2017; Schwab, 2016). Initially, academic literature on the Fourth Industrial Revolution used the term "Industry 4.0" more than "Fourth Industrial Revolution" or "IR 4.0" (Lu, 2017). This can be attributed to the fact that, these works were mostly found in conference proceedings, seminars, consulting reports, and official publications that followed after the release of Kagermann et al.'s report "Industrie 4.0" (2013) to the German government.

Amazingly, scholars have yet to reach a concensus on a clear, unique and concise definition for the Fourth Industrial Revolution. Given all the various labels associated with the Fourth Industrial Revolution, the difficulties of finding a clear and objective definition for IR 4.0 is apparent. In the views of Hermann, Pentek and Otto (2016), "this impedes scientific research, as any theoretical study requires a sound conceptual and terminological foundation" (p. 3928). Another surprising element of this industrial revolution is the diverse opinions and views among scholars and practitioners (Hofmann & Rüsch, 2017; Xu, David & Kim, 2018). This adds to the controversies in research and practice because, as the concept itself lacks clarity, organisations also face difficulties in identifying and implementing IR 4.0 technologies.

Moreover, it is clearly evident that a generally accepted understanding and/or definition of the Fourth Industrial Revolution has still not found its place in academic literature (Lee et al., 2018; Lu, 2017; Hofmann & Rüsch, 2017); although there have been some efforts by scholars to provide a basic definition. For instance, there are some researchers (e.g. Hofmann & Rusch, 2017; Oztemel & Gursev, 2018), whose definitions focus on digitisation. Other scholars (e.g. Liao et al., 2017; Lee et al., 2018), also consider the communication element dominating the manufacturing industry. Other researchers (e.g. Chen, 2017; Lu, 2017) opt for intelligence and autonomy of the systems as being the main characteristics of IR 4.0, whilst others (e.g. Xu et al., 2018; Zhong, Xu, Klotz, & Newman, 2017) focus on the generation of smart factories.

Influenced by cues from varying views, IR 4.0 is conceptualised in this review as: *"the collective term that encompasses an intelligent revolution in all industries via the application and integration of advanced technologies (e.g. CPS, IoT, Cloud Computing, Big Data, Artificial Intelligence and Advanced Robotics); for higher forms of digitalization and automation associated with different levels of speed, scope and depth compared to the previous industrial revolutions"* (Lee et al., 2018; Lu, 2017; Oztemel & Gursev, 2018; Schwab, 2016).

Over the years, the hospitality and tourism sectors have also been influenced by the advancements and/or disruptions associated with the three earlier industrial revolutions (Liao et al., 2017). The same applies with the Fourth Industrial Revolution.

Literature on the impacts of smart technology on the hospitality and tourism industry has often argued that technological advancements will continue to alter the business phases of the industry (Buhalis & Amaranggana, 2015; Gretzel, Sigala, Xiang & Koo, 2015; Neuhofer, Buhalis & Ladkin, 2015). Other researchers have also explored the prospects and challenges of some IR 4.0 technologies for the hospitality industry (Balasubramanian & Ragavan, 2019; Ivanov & Webster, 2017; Wang, Li, Zhen & Zhang., 2016).

Additionally, some scholars only concentrate on some technologies of IR 4.0 and assess their opportunities for the hospitality and tourism industry. For instance, scholars (e.g. Alexis, 2017; Ivanov, Webster & Berezina, 2017; Kuo, Chen & Tseng, 2017; Murphy, Hofacker & Gretzel, 2017), explored the benefits and challenges of artificial intelligence, robots and service automation for the hospitality and tourism industry. Similarly, others (Li, Xu, Tang, Wang & Li, 2018; Miah, Vu, Gammack & McGrath, 2017) also evaluated the opportunities of Big Data for the hospitality and tourism industry. Nevertheless, there seem to be an absolute paucity and no clarity on the key components and constituents of the Fourth Industrial Revolution and their opportunities for the hospitality industry (Ivanov et al., 2017; Kuo et al., 2017; Shamim et al., 2017; Verevka, 2019).

Accordingly, it is clear that there is paucity of studies in this particular research area in the hospitality and tourism literature (see Table 1) (Murphy et al. 2017; Neuhofer et al., 2015). A major reason to this claim can be attributed to the relative newness of the IR 4.0 concept, as well as the continuous and rapid advancement of technologies associated with it (Drath & Horch, 2014). Another reason can be attributed to the disagreements among researchers with regard to conceptualisation of the Fourth Industrial Revolution (Liao et al., 2017). Furthermore, there exists a confusion among researchers as to what constitutes the core or major technological components of the this industrial revolution (Lee et al., 2018; Oztemel & Gursev, 2018). Similarly, for hospitality and tourism, there exists these same literature and research gaps (see Table 1).

Penultimately, some current studies have highlighted the need for technology in light of the COVID-19 pandemic (Gossling, Scott & Hall, 2020; Ivanov, Webster, Stoilova & Slobodskoy, 2020; Nicola et al., 2020). Current studies have also emphasised technology as a tool to build resilience and to help the hospitality and tourism industry recover from the pandemic (Gretzel et al., 2020; Zeng, Chen & Lew, 2020). However, these studies are speculative, as most of them are the scholars' viewpoints. Therefore, it is imperative to unearth the technologies of this current industrial revolution that will contribute towards the revival of the hospitality and tourism industry from the pandemic. Thus, it is against these backdrops that this review seeks to address and propose a typology of technological components for the hospitality and tourism industry during the era of the COVID-19 pandemic.

Table 1. Gaps in IR 4.0 literature/Research that needs to be addressed

No.	Literature Gaps	References
(1)	Non-consensual theorisation of the concept of IR 4.0 among scholars.	Hoffman & Rusch, 2017; Lu, 2017; Oztemel & Gursev, 2018
(2)	Confusion among scholars with regard to the technological components of IR 4.0.	Drath & Horch, 2014; Hermann et al., 2016; Li et al., 2018
(3)	Non-consensual theorisation of the technologies of IR 4.0 for the tourism and hospitality industry.	Buhalis & Amaranggana, 2015; Shamim et al., 2017; Wang et al., 2016
	Research Gaps	
(1)	Limited studies conducted on IR 4.0 technologies in the hospitality and tourism setting.	Ivanov et al., 2017; Kuo et al., 2017; Shamim et al., 2017
(2)	Focus of limited studies on some technologies of IR 4.0.	Murphy et al., 2017; Neuhofer et al., 2015
(3)	Research paucity on the inclusion of the key IR 4.0 technologies for the tourism and hospitality industry (Hospitality Revolution 4.0)	Ivanov & Webster, 2017; Neuhofer et al., 2015

Discussion

Introducing the Concept of "Hospitality Revolution 4.0"

Before the onset of IR 4.0, the extensive adoption and use of IT in the hospitality and tourism industry, such as the integration of web-based technologies, central reservation systems and global distribution systems, led to the emergence and development of "e-Tourism" (Buhalis & Amaraggana, 2015). Subsequently, this developmental trajectory continued with the widespread adoption and diffusion of social media and travel communities and a move towards realising mobile tourism in recognition of the high mobility of tourism information and tourism consumers (Gretzel et al., 2015). Also, the guest or visitor in contemporary times, have become more dependent on information technology, self-service, and personal reservation tools. Wang et al. (2016) asserted that the "new" visitor or guest of today, show some patterns of needs and behaviour which are entirely different from their counterparts in the pre-Internet or social media age. The foregoing changes and evolution in the era of IR 4.0 suggest that, traditional hospitality and tourism businesses will have to

become "smarter" in responding to the demand from "new" tourists, environmental requirements and technology development (Li et al., 2018).

According to some scholars (i.e. Marini, 2016; Nick, Pongrácz & Radács, 2018), IR 4.0 should not be limited to manufacturing enterprises but should be extended to and be inclusive of service industries like, hospitality and tourism. Hence the researchers of the present study propose an era of advanced technological wave fuelled by the key technological components of IR 4.0. This revolution is "Hospitality Revolution 4.0", a terminology coined for this particular study. The researchers seek to assess the dynamics of the technological components of the Fourth Industrial Revolution, for the hospitality and tourism industry. In other words, the combination of key IR 4.0 technologies as identified by this study in championing a new revolution in the industry. Hence, "Hospitality Revolution 4.0" is theorised by the researchers as *"the amalgamation of key IR 4.0 technologies, and their prospects for the hospitality and tourism industry; towards the successful incorporation and implementation into the hospitality ecosystem"*.

Conceptualising IR 4.0 Technologies

Similar to IR 4.0's definition, there are also diverse opinions by scholars with regard to the key components of IR 4.0. McAfee and Brynjolfsson (2014) expatiated that some IR 4.0 technologies were already present 30 years ago, but only recently, with higher ICT maturity and lower costs of hardware and software, that these technologies are becoming feasible. According to some scholars (Drath & Horch, 2014; Kagermann et al., 2013; Sung, 2018), the key component or feature of the Fourth Industrial Revolution is Cyber-Physical systems (CPS). In contrast, other scholars (Kumar, 2018; Schwab, 2016) argue that it is the Internet of Things (IOT).

Furthermore, Hermann et al. (2016) identified three key components of Industrie 4.0 from the works of Kagermann et al. (2013) as the Internet of Things (IoT), Cyber-Physical Systems (CPS), and Smart Factories. Alternatively, Schwab (2016) classified the broad landscape of technological drivers of IR 4.0 into three clusters. They include Physical (autonomous vehicles, 3D printing, advanced robotics, new materials); Digital (Internet of Things, sensors, remote monitoring, blockchain, on-demand economy); and Biological (synthetic biology, gene sequencing). Also, Crnjac, Veza and Banduka (2017) identified four key components of IR 4.0 as: Cyber-Physical Systems, Internet of Things, Internet of Services, and Smart Factory. Lu (2017) on the other hand, also took a different view of the components of IR 4.0 and identified Mobile Computing, Cloud Computing, Big Data, and the IOT as the key technologies of IR 4.0.

Chen (2017) also identified 10 major technologies that can be identified as the key elements of the new manufacturing paradigm. They include six supporting elements (Three-Dimensional (3D) Printing or Additive Manufacturing, Robotic Automation, Advanced Materials, Virtual or Augmented Reality, the Industrial Internet, and

CPS) as well as four foundational elements (Big Data Analytics, Cloud Computing, Applications, and Mobile Devices) (p. 589). Hoffman and Rusch (2017) elucidated that, beyond these key components identified by researchers, there is an increasing set of broader technologies such as: "wearables (e.g. smart watches), augmented reality applications, autonomous vehicles, distributed ledger systems (e.g. blockchain) or even big data analytics" (p. 25).

Proposed IR 4.0 Technologies for the Hospitality and Tourism Industry

The hospitality and tourism industry is one of the earliest industries that embraced the technological developments associated with the previous industrial revolutions. The Watt steam engine which served as the main technological breakthrough in the first industrial revolution affected the travel and hospitality industry with the invention of steam coaches which made travel easier and faster. Next, electricity, which spearheaded the second industrial revolution also influenced the hospitality and tourism industry, by introducing electricity and electrically powered machines in hotels and tourist attractions, making travel and lodging safer and convenient. In the early 90s, the diffusion of the computer, information technology and the Internet, which were also the major groundbreaking technologies of the third industrial revolution also influenced the hospitality and tourism industry.

Similarly, the technological components of the fourth industrial revolution also significantly influence the hospitality and tourism industry. In the hospitality literature, some scholars have identified key technological components of this revolution for the industry. Buhalis and Amaranggana (2014) identified three forms of IR 4.0 technologies which are vital for setting up Smart Tourism Destinations, including cloud computing, Internet of Things (IoT) and end-user Internet service system. Wang et al. (2016) also highlighted four forms of ICT that are vital for setting up smart systems in the hospitality and tourism industry. These include: cloud computing, Internet of Things, mobile communication, and Artificial Intelligence (AI) technology. Ivanov et al. (2017) also presented 3D printing, self-driving cars, service automation, artificial intelligence and robotic technologies as the key technological components of the Fourth Industrial Revolution currently influencing the industry.

Hence, based on the current application of advanced technologies in industry; the study proposes six (6) key technologies of IR 4.0 technologies for the hospitality and tourism industry. These include: CPS, IOT, Cloud Computing, Big Data, AI, and Advanced Robotics. It is worth noting that, these six broad technologies serve as the generic technological components of IR 4.0, with other technologies embedded in them. These technologies of IR 4.0 are key components of information systems that promise to supply hospitality and tourism organisations and consumers with more relevant information, greater mobility, better decision support, and more enjoyable experiences (Gretzel et al., 2015). These technologies are discussed next.

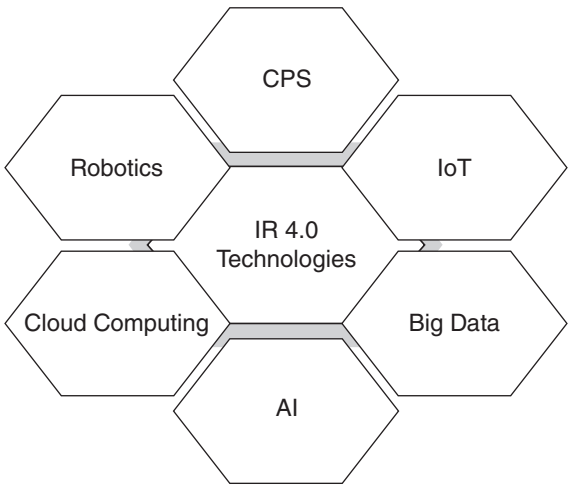

Figure 1. Key technologies of IR 4.0 for the tourism and hospitality industry

Cyber-Physical Systems

An important component of the Fourth Industrial Revolution is the connection and/or combination of the physical and virtual world (Kagermann et al., 2013). This fusion is made possible by the creation of the Cyber-Physical Systems (CPS). According to Monostori et al. (2016), CPS rely on "the latest and foreseeable further developments of Computer Science (CS), Information and Communication Technologies (ICT), and Manufacturing Science and Technology (MST)" (p. 621). As a matter of fact, some researchers (Chen, 2017; Hermann et al., 2016; Lu, 2017) have classified CPS platforms as the technical identity or backbone of the Fourth Industrial Revolution. The effective adoption of CPS creates the cyber-physical society, which incorporates physical and cyber spaces, including cultural and social spheres of human existence (Monostori et al., 2016).

CPS garnered a lot of attention from researchers and scholars in the sciences; in particular, the Computer sciences and Information Technology (IT). Likewise, some researchers (i.e. Hoffmann & Rusch, 2017; Lampropoulos, Siakas & Anastasiadis, 2018; Zhong et al., 2017) have in their own way explained the role of CPS as well as the benefits associated with its adoption and implementation in the manufacturing industry. Notably, the role of CPS for the hospitality and tourism industry is poorly studied (Smirnov, Shilov, Kashevnik & Ponomarev, 2017).

The potential of CPS of changing every aspect of life and every industry, including hospitality and tourism, are enormous. These are some notable benefits associated with the implementation of CPS in the hospitality and tourism industry. Firstly, CPS involves humans, machines, and products which combines computation,

networking, and physical processes together in the production process (Zhong et al., 2017). Secondly, CPS ensures cost and time efficiency within the production process in the working environment (Hoffman & Rusch, 2017). Further, CPS assist in the effective collection, use, management and analysis of data and/or information (Lu, 2017). Additionally, CPS ensure efficiency in communication among the systems in the working environment (Chen, 2017). Finally, CPS also serve as the foundation on which other technologies (e.g. IOT, Big Data, Robotics) thrive.

For instance, there are already emerging systems of CPS (e.g. RFID, sensors), that facilitate the effective functioning of things such as intelligent buildings, autonomous cars, smart electric grid, etc. (Monostori et al., 2016). Based on the above review, the researchers conceptualise CPS for the hospitality and tourism industry as: *"advanced technological systems or platforms (e.g. RFID, sensors, etc.), that allow and manage the interconnection or integration of computational capabilities and physical assets; that also facilitate the interaction with human living and existence"*.

Internet of Things

In the words of Schwab (2016), "Internet of Things (IoT) is one of the main bridges between the physical and digital applications enabled by the Fourth Industrial Revolution" (p. 22). The concept of IoT is more focused on enabling and accelerating the adoption of Internet-connected technologies across industries, both manufacturing and non-manufacturing (Turcu & Turcu, 2018). Also known as the Internet of all things (Schwab, 2016), it is a promising trajectory in productions systems and expected to bring forth the full potential of the Fourth Industrial Revolution (Kumar, 2018). Just like CPS, some scholars (Kumar, 2018; Schwab, 2016; Turcu & Turcu, 2018) have attributed Internet of Things as the key enabler or initiator of the Fourth Industrial Revolution.

Since the introduction of the concept of IoT in academic literature, it has received various definitions from different scholars and researchers. Most definitions of IoT emerged in the past ten years based on the latest technology and applications in existence at that time (Gubbi, Buyya, Marusic & Palaniswami, 2013; Sharma, Shamkuwar & Singh 2018). Nonetheless, there is yet any universally agreed definition of Internet of Things in the academic literature. Sharma et al. (2018) clarified that, "different researchers, scientists define the term in their own way; some focus on more objects, devices, Internet Protocols and Internet, while others focus on the communication processes involved". For the purposes of this review, Internet of Things is simply defined as: *"the network of physical and virtual objects (things); for the purpose of collecting, sharing and/or exchanging information through a unified platform over the internet which enables automated solutions to multiple problem sets"*.

Contemporarily, another component emerging out of IoT from the literature is Internet of Services (IOS) (Contreras, Garcia & Pastrana, 2017). IoS simply refers

to platforms that allow users to provide services (i.e. CPS, hardware and software) via the Internet (Contreras et al., 2017). The benefits of IoT and IoS for industries, including hospitality and tourism, cannot be overlooked. For business enterprises, IoT will increase their productivity, enable a higher growth of profit as well as lower their costs of operations (Sharma et al., 2018). This will be possible as a result of IoT technology enhancing their operational efficiency, decreasing their product time-to-market by reducing unplanned downtime, and optimising their overall operational efficiency (Lampropoulous et al., 2018).

IoT also improves decision-making and productivity of businesses in retail, supply chain management, manufacturing, agriculture and other sectors by reinforcing solutions. It is worth noting that, IoT is one of the technologies of the third industrial revolution (Gubbi et al., 2013); however, its impact for industries in the era of IR 4.0 is still worth celebrating. Hospitality and tourism establishments stand the chance of further enhancing their overall availability and maintainability, thanks to the vital solutions that IoT provides.

Cloud Computing

Cloud computing (CC) has remarkably captured the attention of the information technology community and its role in manufacturing and service industries continues to grow. To some experts, CC is a major technological revolution in the IT industry with regard to its applications in the economic and social environment (Goundar, 2012; Grandison, Maximilien, Thorpe & Alba, 2010) and plays an important role in the era of the Fourth Industrial Revolution (Hahm, 2018). Goundar (2012) highlighted that, the "cloud" concept draws on old and existing technologies such as Virtual Computing, Cluster Computing, Utility Computing, and Distributed Computing. Interestingly, Zhong et al. (2017) implicated that "CC can be considered as 'the fifth utility' together with water, electricity, gas, and telephone" (p. 621). Notably, CC continues to shift traditional manufacturing and production approaches to cloud-based solutions with its continuous technological advancements in machinery, data management and functionality (Oztemel & Gursev, 2018).

Kamble, Gunasekaran and Gawankar (2018) elucidated that, this technological component was referred to as the "cloud" because it is not actually present where the service is being used but at a remote location, and the whole system is controlled by a third party (p. 408). In recent years, cloud computing has emerged as the new way of developing and deploying sophisticated applications at scale in almost every major corporation and emerging businesses (Leitao, Colombo & Karnouskos, 2016). As a result of its relative innovation and exploding development, CC has attracted a great deal of research in diverse academic fields (Gangwar, Date & Ramaswamy, 2015). However, there exist differing views about the interpretation of this technological component (Prajapati, Sharma & Badgujar, 2018). For the purposes of this study, cloud

computing is defined as: *"a technological concept, that deploys infrastructure, applications and data resources through the Internet as a distributed service by a service provider; based on virtualization, scalability, on-demand and pay-per-use basis"* (Gangwar et al., 2015; Grandison et al., 2010; Kamble et al., 2018; Mell & Grance, 2011; Prajapati et al., 2018).

Just like the other technologies, CC also provides enormous benefits for all industries, including the hospitality and tourism industry. Specifically, the continuous increase in migration of businesses to cloud-based services are a result of the benefits associated with using cloud-based software applications versus buying, installing and maintaining on-premise solutions. Cloud-based services are accessed over the Internet but still offer the application, the feeling as if they were installed locally (Gangwar et al., 2015). Current examples of cloud-based services are Amazon Web Services, Samsung Cloud, IBM smart cloud, etc. Penultimately, the obvious allures of cloud computing include cost savings, resource usage optimisation, virtualisation, Service Oriented Architecture (SOA) and utility computing (Grandison et al., 2010; Leitao et al., 2016).

Big Data

Concurrently, the technological advances with CPS and IoT that led to ubiquitous computing have resulted in daily exponential increases of data. This form of technology is popularly known in literature as Big Data (Egan & Haynes, 2019; Johnson, Gray, & Sarker, 2019). One of the major reasons for the increasing pace and diversity in the types, forms, components, contents and sources of data today, can be attributed to the increasing adoption of smart devices and technologies (Wu, Buyya & Ramamohanarao, 2016). Similarly, organisations keep witnessing a tremendous amount of data trooping in from diverse sources, on a daily basis. These sources of data include sensors, machines, logistics, social networks, log files, clients' feedback, reservation and/or transactional applications (Zhong et al., 2017).

Similar to the other IR 4.0 technologies, there is still no general agreement on Big Data in the literature (Kinoshita & Mizuno, 2017). Experts of Big Data (Egan & Haynes, 2019; Rajaraman, 2016; Wu et al., 2016), describe it based on the traditional "V's" typology (i.e. volume, variety, veracity and velocity) (Kinoshita & Mizuno, 2017). Nonetheless, these typologies are inexhaustive and do not actually cover all the broad concepts under Big Data. As a matter of fact, these typologies only explain the characteristics, or properties of the Big Data concept. Other concepts such as Big Data management, security and systems have often been neglected in the definitions of Big Data by previous studies. In view of this, Pencheva, Esteve and Mikhaylov (2018, p. 2) posited that the usage of new concepts in describing Big Data only refers to all the different kinds of data and not the proportional dimensions of the Big Data phenomenon.

Furthermore, researchers (Johnson et al., 2019; Rajaraman, 2016; Wu et al., 2016) often confuse themselves with the terminologies "Big Data" and "Big Data Analytics" (BDA). It is worth noting that, Big Data relates to the general technological term associated with the collection, gathering and management of data whilst BDA reflects the tools and analyses that generate meaning from the large pool of information or database systems. In other words, without Big Data, there is no BDA. Hence, Big Data as one of the key technologies of IR 4.0, is defined in this study as: *"a general technological term used to describe the properties (e.g. volume, variety, velocity, veracity, value), collection, processing, management, analysis, systems and security of digital data, which are beyond the capabilities of the methods of traditional data management and analytics; within an acceptable and convenient elapsed time"*.

In the information systems literature, Big Data is one of the emerging and current technologies with great applicability across all industries, including hospitality and tourism (Egan & Haynes, 2019). Currently, database management applications are increasingly becoming an appropriate means of many business corporations for the collection and analysis of customer data (Cheng & Jin, 2019). For hospitality and tourism establishments, there is an increasing emergence of predictive analysis; a concept that is fuelled by BDA. Predictive analysis is used at these establishments (e.g. hotels, airlines, restaurants, casinos, etc.) to facilitate effective customer relationship as well as the rendition of personalised services.

Artificial Intelligence

The major vision of Artificial Intelligence (AI) during its inception was largely viewed in terms of simulating human activities and building robots (Wu et al., 2016) as well as creating automated working systems through the provision of decision support systems for management (Pencheva et al., 2018). With time, AI evolved to the level of providing solutions to general problems using sophisticated machineries. This was achieved through the input of algorithms to a system, in order to transform the input data into appropriate solutions (Wu et al., 2016). It is worth noting that to date, AI still remains with its goal of providing solutions to human problems. AI is related to machine learning and task automatisation, which allow computers to learn and understand the world through hierarchical concepts (Hahm, 2018).

Huang, Wang and Zhang (2018) highlighted three developmental trajectories in the history of AI. These include "the early upsurge in 1950–1970, represented by symbolism, early reasoning system, early neural network (connectionism); the second upsurge in 1980–2000 represented by statistics, machine learning, neural network; and the third upsurge after 2006 which is characterised by the widespread use of large data, the emergence of deep learning, machine learning, and mass communication of AlphaGo" (Huang et al., 2018, p. 282). Presently, there have been tremendous

developments in core AI systems and also widely applied in various industries. As part of the key technologies of IR 4.0, AI is conceptualised in this study as: *human-based intelligence that is different from natural intelligence, which allows machines to learn without being explicitly programmed and tasks to be automated with little human intervention; coupled with their ability to be environmentally friendly in realizing goals through the maximization of opportunities and problem solving* (Chen, 2017; Hahm, 2018; Huang et al., 2018; Wu et al., 2016).

It is worth noting that AI is a broad technological concept that brought forth a lot of other technologies. The core technologies of AI in the era of IR 4.0 include machine learning, robotics, natural language processing, virtual agents, speech recognition, computer vision, additive manufacturing (3D-printing), and augmented reality (Chen, 2017; Huang et al., 2018; Kamble et al., 2018; Pencheva et al., 2018). Some studies (e.g. Hahm, 2018; Ivanov et al., 2017; Schwab, 2016) assessed the influence of AI on business activities in the era of IR 4.0 for different fields including manufacturing and service industries. For instance, Hahm (2018) envisaged that AI will play an important role during IR 4.0's era and attitudes towards AI will be related to how the performance of technologies are evaluated in this era (p. 4043). Notable among the benefits of AI to organisations include cost savings and its ability to enable employees do less manual, monotonous and repetitive work.

Additionally, it enables employees to have more free time that can be used for creative and innovative activities (Ivanov et al., 2017). This is because, once an interface has been set up between the customer and the producer, employees are no longer required to manually enter data. Google, Apple, Samsung and Amazon are examples of organisations that focus on the production and acquisition of AI-based products as well as AI-venture companies (Hahm, 2018). For the hospitality and tourism industry, Ivanov et al. (2017) expanded on the adoption of key AI technologies for service automation. Self-service mobile check-in, mobile telepresence, keyless systems, QR codes, information kiosks and displays are just some examples.

Robotics

As noted earlier, robotics is a core technology of AI. According to Tirgul and Naik (2016), robotics is a division of AI which has its foundation in computer science and engineering and focuses on the designing and production of robots. In the same vein, the scholars explained robot as "a machine that gathers information about its environment (senses) and uses that information (thinks) to follow instructions and to do work (acts)" (Tirgul & Naik, 2016, p. 1787). Also, a report by World Economic Forum (WEF, 2017) about the impact of the Fourth Industrial Revolution on supply chains defined advanced robotics as, "devices that act largely or partially autonomously, interact physically with people or their environment, and are capable

of modifying their behaviour based on sensor data" (p. 7). This stands to reason that, robots exhibit a strong sense of thought, sensing, actions, cooperation, flexibility, and autonomy. Based on these two definitions, the researchers conceptualise the final proposed technology of IR 4.0 for the hospitality and tourism industry, robotics, as *"an electro-mechanical or bio-mechanical machine or group of machines, that autonomously interact with people and environment; gather information about its environment through sensors, and uses that information to follow instructions and perform repetitive or pre-programmed tasks"*.

The infiltration of robots into industries since the 19th century, has always been a discussion of interest amongst academicians and industry experts. Scholars from different academic fields (Kamble et al., 2018; Kuo et al., 2017; Ivanov & Webster, 2017; Ivanov et al., 2017) often elucidate the potential of robots in changing the phase of businesses during the era of IR 4.0. For instance, Kamble et al. (2018) projected that, sooner than later, robots will begin to interact with its kind, and also learn and work safely with humans. The key benefits of robots to the hospitality and tourism industry include financial benefits, solutions to seasonal employment and labour turnover, operational and employee efficiency, customer service quality, supply chain efficiency, digitisation of operations and creation of new jobs (Ivanov & Webster, 2017).

On the other hand, studies (Alexis, 2017; Oztemel & Gursev, 2018; Tirgul & Naik, 2017) have also debated on the adverse effects of robot adoption in organisations and societies. Notable among them are unemployment issues, change of traditional work profiles as well as the the potential inability of humans to keep robots under control. However, these claims are not substantive enough to halt the permeation of robots into societies and industries. Oztemel & Gursev (2018) counter-claimed that robots will always carry out the tasks provided by humans via input algorithms; hence humans will always have overall control of robots. Nonetheless, the issue now lies with the programmers of the robots to be ethical and selfless with the algorithms they feed into robotic systems. Penultimately, Ivanov et al. (2017) also identified in their study, robots that are currently in use in the hospitality and tourism industry as well as potential ones. Front desk robots, room assistant robots, robot chefs, delivery robots, airport-robot guide, self-driving cars, etc. are just some examples.

Table 2. Reviewed references for the typologies of IR 4.0 technologies for the hospitality and tourism industry

No.	Technology	References
1	Cyber-Physical Systems	Chen (2017); Hermann et al. (2016); Lu (2017); Hoffmann & Rusch (2017); Kagermann et al. (2013); Lampropoulos et al. (2018); Monostori et al. (2016); Smirnov et al. (2017); Zhong et al. (2017)

Table 2 (con't)

No.	Technology	References
2	Internet of Things	Gubbi et al. (2013); Schwab (2016); Sharma et al. (2018); Kumar (2018); Lampropoulous et al. (2018); Turcu & Turcu (2018)
3	Cloud Computing	Gangwar et al. (2015); Goundar (2012); Grandison et al. (2010); Hahm (2018); Kamble et al. (2018); Leitao et al. (2016); Mell & Grance (2011); Oztemel & Gursev (2018); Prajapati et al. (2018); Zhong et al. (2017)
4	Big Data	Cheng & Jin (2019); Egan & Haynes (2019); Johnson et al. (2019); Kinoshita & Mizuno (2017); Pencheva et al. (2018); Rajaraman (2016); Wu et al. (2016); Zhong et al. (2017)
5	Artificial Intelligence	Chen (2017); Hahm (2018); Huang et al. (2018); Ivanov et al. (2017); Kamble et al. (2018); Pencheva et al. (2018); Schwab (2016); Wu et al. (2016)
6	Robotics	Alexis (2017); Ivanov & Webster (2017); Ivanov et al. (2017); Kamble et al. (2018); Kuo et al. (2017); Oztemel & Gursev (2018); Tirgul & Naik (2016); WEF (2017)

Method Used for the Literature Review

Based on the gaps (i.e. both literature and research), and the novelty of the concept under study, this study adopted the critical review method. A systematic review method was not tenable or considered as a good method of review for this particular study. This is because attempts to use keywords in major scientific databases (e.g. SCOPUS, Web of Science), merited few results (as can be seen in Table 3) due to the relative newness of the phenomenon of IR 4.0. This did not warrant a comprehensive systematic review to be executed. Hence, the researchers thought it wise to adopt a critical review method in order to address the gaps under study.

With this, the researchers broadened their search strategies, to identify seminal papers on IR 4.0 by different researchers from diverse academic fields, including hospitality and tourism. This was done after obtaining few documents on IR 4.0 and hospitality and tourism, from the keyword search, as can be seen from Table 3 below. Particular attention and interest were also given to the key technologies of IR 4.0 as well as the benefits of these technologies. After which, a thorough exegesis was done on the similarities and differences of these advanced technologies.

Also, a six-technological component typology of IR 4.0 was proposed for the

hospitality and tourism industry. Additionally, reviewed articles used to explain this six-type mnemonic of IR 4.0 technologies for the hospitality and tourism industry were identified. This can be seen in the matrix table provided after the literature review (Table 2). Penultimately, their applications in the hospitality and tourism industry were highlighted and explained.

Table 3. Results of the relevant keyword search from SCOPUS database on December 31, 2019.

Keywords	Number of documents	Reference(s)
"FOURTH INDUSTRIAL REVOLUTION" and "TOURISM"	6	• Peraković, Periša & Zorić (2020); • Loureiro (2018); • Onyango & Kesa (2018); • Nick, Pongrácz & Radács (2018); • Sega (2017); • Lee, Chen, Lee, Xu, Li & Zhao (2017)
"FOURTH INDUSTRIAL REVOLUTION" AND "HOSPITALITY"	0	
"IR 4.0" AND "TOURISM"	0	
"IR 4.0" AND "HOSPITALITY"	0	
"INDUSTRY 4.0" AND "TOURISM"	7 (with 3 non-specified authors)	• Peraković, Periša, Zorić, 2020; • Nick, Pongrácz & Radács (2018); • Lee, Chen, Lee, Xu, Li & Zhao (2017); • Marini, 2016
"INDUSTRY 4.0" AND "HOSPITALITY"	1	• Shamim, Cang, Yu & Li, 2017

Note: All keyword searches were executed for the Titles, Abstracts and Keywords of the documents; with no limitation on Year, Subject area, Author name, Document type, Publication stage, Source type, Country, Language, etc.

Conclusion

Although some of the technologies of the Fourth Industrial Revolution have already found their way into the tourism and hospitality industry (Gretzel et al., 2015; Balasubramanian & Ragavan, 2019), the adoption of these technologies is still low (Ivanov et al., 2017; Murphy et al., 2017). It is worth noting that "technology" in the era of the Fourth Industrial Revolution should be seen as an "infrastructure", rather than as individual information systems. This is because these systems comprise

a variety of smart computing technologies that integrate hardware, software, and network technologies to provide real-time awareness of the real world and advanced analytics to help employees make more intelligent decisions about alternatives, as well as actions that will optimise business processes and performances (Gretzel et al., 2015).

In short, IR 4.0 seems promising with its technologies; however, there exist some challenges that come with its adoption. A study by Balasubramanian and Ragavan (2019) on the key challenges facing the hospitality industry in Malaysia also identified the growing IOT as a major challenge for the hospitality industry. The researchers concluded that "the future of the industry lies in the strategic adoption of technology to maximise its impact on various sections of the industry. The technology must be leveraged to produce elevated, authentic experience without losing sight of human values and connections" (p. 10). With the current impact of COVID-19 pandemic on the hospitality and tourism industry, it is becoming clear that the current and future survival of the industry is dependent on the adoption of these advanced automated technologies (Ivanov et al., 2020).

Practical and Social Implications

Generally, the technological components of IR 4.0 technologies is still at the dialogue stage for both researchers and industry players. Hence, based on the identification and explanation of the six (6) types of IR 4.0 technologies, the implications for the hospitality and tourism industry are as follows. First, this study bridges the literature gaps with regard to the uncertainty and confusion among researchers as to what IR 4.0 is as well as its technological components for the hospitality and tourism industry. Moreover, this typology serves as a foundational model in studying IR 4.0 technologies in the hospitality and tourism industry.

Furthermore, for industry practitioners (e.g. hotel owners, destination managers, travel agents, attraction managers, airline operators, etc.), this study significantly facilitates the adoption and implementation of IR 4.0 technologies. For example, for hotel owners and management, this review informs them on the key technologies to allocate more resources to in order to benefit the hotel and yield more returns. This will enhance lodging experiences and hotel operations with advanced technologies, as appreciated by guests in this Fourth Industrial Revolution. This will facilitate the realisation of high levels of personalised service in an era of continuous technological advancements. Finally, this will in turn create better experiences and greater satisfaction to guests, even demanding ones.

In addition to the above, the successful adoption and implementation of these key technologies in hospitality and tourism businesses will also lead to enhanced customer services and experiences. This will go a long way in ensuring a symbiotic relationship between hospitality and tourism businesses with their current and potential customers.

Also, the successful adoption of these advanced IR 4.0 technologies by hospitality and tourism businesses, will also facilitate sustainable societal benefits that are being championed by governments worldwide in this 21st century.

Finally, the COVID-19 pandemic has brought to light the necessity for the adoption of technologies across all industries in the world, including hospitality and tourism. Currently, technology is being used to combat the spread of the coronavirus globally (Nicola et al., 2020). Ivanov et al. (2020) also suggested that the hospitality and tourism industry is fortunate to have a recovery plan for this pandemic; of which a part of this reform will constitute the reliance and dependence on automated technologies. It is quite evident that the advanced technologies of this era are becoming essential agents of resilience in addressing the impacts of the COVID-19 pandemic on the industry (Gretzel et al., 2020).

Suggestions for Future Studies

As noted earlier, this review serves as a basis for further studies in the academic literature. Future studies should empirically test these types of technologies in the hospitality and tourism setting. In particular, studies can be conducted on the adoption and usage of these technologies in the industry. Aditionally, the influence of these IR 4.0 technologies on organisational performance and guest satisfaction can also be investigated. Further, future studies should focus on the factors that influence the adoption of these technologies in the hospitality and tourism industry. Lastly, since we are still at the dawn of the Fourth Industrial Revolution, interventions that would enhance the adoption of these technologies could also be an objective for future research.

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