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When artificial intelligence meets the hospitality and tourism industry: an assessment framework to inform theory and management

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Abstract

Purpose – This study reviews existing research and current applications of artificial intelligence (AI) in the hospitality and tourism industry. It further proposes a new evaluation framework to inform the susceptibility of AI adoptions.

Design/methodology/approach – This is a synthesis and evaluation study that qualitatively summarizes and presents findings on AI applications in the hospitality and tourism industry. Current AI applications are rated using a seven-dimensional framework based on Rogers' (2003) diffusion theory.

Findings – AI adoption susceptibility in the hospitality and tourism industry varies based on the type of AI. Search/booking engines, virtual agents and chatbots rank high in the adoption susceptibility.

Research limitations/implications – This study bridges innovation diffusion theoretical underpinnings and AI applications. The findings support researchers, developers and managers in evaluating the adoption susceptibility of AI technologies in the hospitality and tourism industry.

Originality/value – This paper is among the few that focus on assessing AI adoption susceptibility in the hospitality and tourism industry. This paper develops a theory-based framework for systematically evaluating AI innovations in hospitality and tourism.

Keywords Artificial intelligence, Virtual reality, Augmented reality, Technology adoption, Innovations diffusion, Machine learning, Deep learning

Paper type Research paper

1. Introduction

Artificial intelligence (AI) has become a buzzword across society. AI studies focus on creating intelligent machines (Nilsson, 2010; Stone *et al.*, 2016) and include the study of tools with human-like abilities such as sensing, learning, reasoning and acting (PwC, 2018a). AI is receiving worldwide attention for its power to drive economic growth and transform industries. It was forecasted that AI might boost the regional gross domestic product (GDP) by 26% in China, 14% in North America and 11% in Europe (PwC, 2018b, p. 21). In a survey distributed to employees in nine industries in 2018, 47% of all participants indicated that their

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companies utilized one AI technology at the minimum, and 30% reported their companies were piloting AI projects (McKinsey and Company, 2018).

The hospitality and tourism industry has witnessed exponential growth in its adoption of AI. Around 20% of transportation firms had adopted one or more AI technologies at scale in 2016, with a projected growth rate of 8% (McKinsey Global Institute, 2017). About 12% of other travel and tourism businesses (e.g. hospitality and entertainment) have embraced AI at scale with an annual growth rate of 6.5%. AI has been primarily used in service operations, with projected growth in product development, marketing and sales (McKinsey Global Institute, 2017). Previous research has identified the benefits of AI in the hospitality and tourism industry (e.g. Kong *et al.*, 2021; Cain *et al.*, 2019). AI technologies can offer various advantages for both suppliers (e.g. improved productivity, efficiency and profitability) and consumers (e.g. convenient and personalized tourist experiences) (Samara *et al.*, 2020). However, there is less understanding of a theoretical framework for evaluating the adoption of AI in the hospitality and tourism industry. The McKinsey Global Institute (2017) calls for further research that examines the nature of the specific AI applications and assesses the susceptibility of adoption. To this end, this paper develops a framework for evaluating the adoption of AI in the hospitality and tourism industry using the diffusion innovation theory (Rogers, 2003) as the theoretical underpinning. The diffusion of innovation theory (Rogers, 2003) investigates variables that affect organizations and individuals in adopting innovative technologies.

The remainder of this article is organized as follows. Section 2 defines the subfields of AI technologies from an information technology angle. Section 3 describes how to evaluate the applications of new technologies. Section 4 summarizes the key applications of AI in the hospitality and tourism domain. Section 5 analyzes the characteristics of these applications based on the attributes of innovation. Section 6 concludes the paper by discussing theoretical and practical implications.

2. Subfields of artificial intelligence technology

One of the earliest AI definitions is "the study of the computations that make it possible to perceive, reason, and act" (Winston, 1992, p. 5). Since then, AI has evolved into a composite concept built upon machine learning and deep learning, with four specialized subfields: computer vision, natural language processing (NLP), robotic processing automation (RPA) and expert systems (Figure 1).

2.1 Machine learning

Machine learning refers to a computer's ability to make accurate predictions by processing input data using a pre-selected algorithm (Neapolitan and Jiang, 2018). In machine learning, input data include structured and unstructured data. Structured data typically describe data

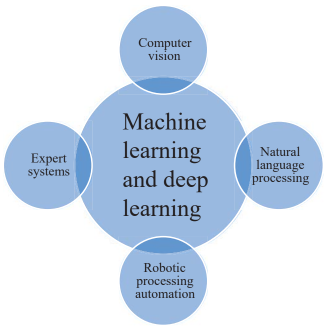

Figure 1. Four major subfields of AI, with machine learning and deep learning as the foundation

in a conventional tabular form; unstructured data denote data with different formats such as texts, images or audio files. Machine learning algorithms can be divided into three categories: supervised learning, unsupervised learning and semi-supervised learning. When the input data are linked to output data with labeled responses, the learning process is called supervised learning. When the input data do not have labeled output, the learning process is called unsupervised learning. Semi-supervised learning refers to machine learning with a small number of labeled input data and a large number of unlabeled input data.

2.2 Deep learning

Deep learning is a machine learning approach that processes data on artificial neural networks modeling how human brains function. This method can process massive data with a large number of attributes (dimensions) or with different formats (Taulli, 2019). A neural network consists of a large sum of neural units, where each unit receives stimuli from other units and responds accordingly. A neural network can have a single-layer or a multi-layer structure. A multi-layer network includes the input layer, output layer and the remaining layers in between (i.e. the hidden layers). Through the hidden layers, a stimulus is delivered from the input layer to the output layer. Deep learning is the cornerstone technology behind two specialized AI areas: computer vision and NLP. This is because deep learning can process data using multiple layers efficiently in the learning process, a capacity crucial to unstructured data such as images and natural language (Neapolitan and Jiang, 2018).

2.3 Computer vision

Computer vision is a specialized AI technique for describing objects. Computer vision involves considerable foundational insight about decomposing basic properties of objects (such as shape, transparency, illumination, color, size, layers) and reconstructing these properties into packages that make up different objects. Computer vision is relevant to the hospitality and tourism industry, where mega-quantity numbers of images are subject to filtering, naming and categorization. Exemplary use cases include patrolling robots for scanning license plates (e.g. Knightscope, 2020) and search/booking engines that can automatically label room types for uploaded home photos (e.g. Yao, 2018).

2.4 Natural language processing (NLP)

NLP focuses on machines' understanding and generation of text and speech in natural languages. NLP includes reverse-engineering the process of human language acquisition. NLP requires meticulous groundwork of assembling and understanding existing linguistic rules. First, a text's syntax is analyzed to provide a linguistic structure. Such a structure is to be used for semantic analysis on its literal meaning. The literal meaning is then interpreted pragmatically to explain context-based nuances. NLP has been used in machine translation, message-understanding systems, speech recognition, synthesis-generated speech, text critiquing and information retrieval in multiple languages (Chowdhury, 2003).

2.5 Robotic process automation (RPA)

Unlike physical robots, RPA refers to the software based on which virtual bots function. RPA is a visual drag-and-drop system that automates tasks such as sending invoices, granting refunds to customers and providing standard responses to clients. RPA itself is not in the realm of AI; however, when combined with AI tools, RPA becomes a specific area of technique – cognitive robotic process automation and is used in commercial chatbots. AI-powered cognitive robotic process automation can perform multiple functions such as communicating with humans and sending out real-time alerts (Taulli, 2019).

2.6 Expert systems

An expert system is defined as a computer system that contains highly specialized knowledge. An expert system involves three components: experts' domain knowledge, the inference engine and end-users. Expert systems have the following characteristics. First, they are not confined to mathematical methods and are capable of dealing with qualitative information. Second, based on experts' input, the knowledge base can be continuously expanded and improved. Third, expert systems can handle unreliable or uncertain information and can handle missing data. The current expert systems' applications remain limited for two reasons: (a) they are difficult to be tested and (b) they do not learn over time but need to be fed with new information (Bahrammirzaee, 2010; Taulli, 2019).

3. Theoretical foundation

Since AI technologies are relatively new to the hospitality industry, the diffusion of innovations theory is chosen as a reasonable theoretical basis. The diffusion of innovations theory (Rogers, 2003) assesses the adoption of AI technologies in the hospitality and tourism industries. Rogers (2003) identifies five essential characteristics that influence human and organizational adoption of new technologies (including AI): (a) relative advantage, (b) compatibility, (c) complexity, (d) trialability and (e) observability.

Relative advantage is defined as "the degree to which an innovation is perceived as being better than the idea it supersedes" (Rogers, 2003, p. 216). Several secondary attributes are identified to assess relative advantage. First, economic benefits represent the increase of customers and market sales, or the more cost-effective deals customers obtain from the ability to compare similar products' prices and providers (Hasin and Smith, 2016). Second, efficiency is measured from the perspective of saving time (Kang *et al.*, 2015). Third, interactivity is a composite concept incorporating a sense of connection, the successful exchange of information (Coursaris and Sung, 2012), and the synchronized and timely exchange of information (Buhalis and Sinarta, 2019; Kang *et al.*, 2015).

Compatibility is defined as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 2003, p. 217). Secondary attributes used by compatibility include work-related and value-related aspects. The work-related secondary attributes involve matching technology with workers' preferred and actual work practices (Meuter *et al.*, 2005; Moore and Benbasat, 1991). The value-related secondary attributes refer to the congruence between technology and users' social norm and preferred lifestyle (Kim *et al.*, 2009; Meuter *et al.*, 2005; Tan and Teo, 2000).

Complexity refers to "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003, p. 234). The attribute of complexity is often termed interchangeably with perceived ease of use (Moore and Benbasat, 1991), simplicity (Atkinson, 2007) and effort expectancy (Kang *et al.*, 2015). Complexity is measured by the ease of obtaining (Hasin and Smith, 2016), learning, understanding and using particular technologies (Meuter *et al.*, 2005; Tan and Teo, 2000).

Trialability means "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003, p. 217). The purpose of trialability is to reduce perceived uncertainty (Tan and Teo, 2000). Trialability can be measured through the ability to test certain technologies before official adoption (Hasin and Smith, 2016; Moore and Benbasat, 1991) or major commitments (Meuter *et al.*, 2005). Observability is explained as "the degree to which the results of an innovation are visible to others" (Rogers, 2003, p. 218). The attribute of observability has been termed alternately as visibility or result demonstrability (Moore and Benbasat, 1991). Observability has been operationalized as a visible increase of work-related knowledge (Atkinson, 2007), the visible positive word-of-mouth or satisfaction about the technology (Atkinson, 2007; Hasin and Smith, 2016), the ease of describing the use process, outcomes of using a technology (Meuter *et al.*, 2005; Moore and Benbasat, 1991) and the physical visibility of technology (Al-Gahtani, 2003).

This study also uses perceived risk and immersion to assess AI adoption in the hospitality and tourism industry. The negative repercussions of high-uncertainty acts are defined as the perceived risk (Bauer, 1960). Perceived risk has been operationalized as potential financial loss (Featherman and Pavlou, 2003; Im *et al.*, 2008), data breach (Meuter *et al.*, 2005; Tan and Teo, 2000), performance failure and privacy infringement (Featherman and Pavlou, 2003; Meuter *et al.*, 2005). Immersion is defined as an experience of alternative reality with machines' complete control of human senses (i.e. virtual reality or VR immersion) (Bowman and McMahan, 2007) and machine's presentation of digital add-ons (i.e. augmented reality or AR immersion) (e.g. Kipper and Rampolla, 2013). VR technologies are defined as the set of technologies that trigger an objective level of sensory fidelity (Bowman and McMahan, 2007) that leads to the sense of "being there" (Pausch *et al.*, 1997). VR-enhanced immersion is defined as users' perception of alternative reality generated by three-dimensional (3D) images, spatialized sound and force or tactile input (Bowman and McMahan, 2007) with the use of head-mounted displays (HMD) or a sensual simulator (e.g. Leber, 2014). AR technologies are defined as a set of technological tools that add digital elements to the real world through mobile devices (Kipper and Rampolla, 2013). Table 1 shows the five fundamental qualities and relevant secondary attributes used in this study.

4. Attributes of innovation in the artificial intelligence empirical literature in hospitality and tourism

A literature search was conducted in December 2019. The literature search was completed using Google Scholar based on the following separate keywords: "relative advantage," "compatibility," "complexity," "trialability," "observability," "perceived risk," "immersion" and "attributes of innovation." In addition, the terms "hospitality" and "tourism" were included to retrieve relevant research in the hospitality and tourism industry. The titles and abstracts of the first ten lists of results (100 items) were screened. We only selected the studies

Attributes	Secondary attributes
Relative advantage	(1) Economic benefits
	(2) Efficiency
	(3) Interactivity
Compatibility	*Work related*
	(1) Preferred work practices
	(2) Actual work practices
	Value related
	(1) Social norm
	(2) Preferred lifestyle
Complexity	(1) Ease of use
Trialability	(1) Ease of trial
Observability	(1) Increased knowledge
	(2) Satisfaction
	(3) Ease of communication
	(4) Physical visibility
Perceived risk	(1) Financial loss
	(2) Data breach and privacy infringement
	(3) Performance failure
Immersion	(1) VR immersion
	(2) AR immersion

Table 1. Attributes and secondary attributes of innovation

that applied most or all of the five attributes within their specific contexts (Table 1). Sixteen articles were selected to analyze innovation attributes (Table 2).

Some studies focus on the original five-attribute structure, such as Al-Gahtani (2003), Askarany *et al.* (2007), Atkinson (2007) and Hasin and Smith (2016). Other research looked at influence, facilitating conditions, hedonic motivation, habit experience, disadvantages and robot social abilities in different contexts (Ivanov *et al.*, 2018; Venkatesh *et al.*, 2012). Additional secondary attributes have also been identified, such as values, internet experience, banking needs for compatibility (Tan and Teo, 2000), control, curiosity, intrinsic interest, social norm, perceived critical mass, preferred lifestyle, perceived economic value of compatibility (Kim *et al.*, 2009), time convenience and interactivity (Kang *et al.*, 2015).

5. Existing artificial intelligence applications in hospitality and tourism

This paper identifies five major types of AI applications in the hospitality and tourism industry: (1) search/booking engines, (2) virtual agents/chatbots, (3) robots and autonomous vehicles, (4) kiosks/self-service screens and (5) AR/VR devices. Examples of each type are found in major technology blogs, hospitality trend websites and news reports. Only the applications mentioned in more than one source are included for their representativeness (Figure 2).

5.1 Search/booking engines

Search/booking engines have been widely used in booking hotels, restaurants and tourism services. Machine learning, computer vision and NLP have been applied to these applications. Five exemplary applications are introduced as follows.

5.1.1 Allora hotel search/booking engine. Allora is a background system integrated in the official websites of over 600 hotels or resort groups worldwide. With the machine learning capability, Allora can learn the users' booking behavior, instantly identify the best-case scenarios and adjust the website's configuration accordingly. Through deep learning, the Allora system feeds its learning outcomes from all participating hotels to individual hotels, allowing business owners to achieve optimal website configuration (Allora, 2020).

5.1.2 Resy restaurant search/booking engine. Resy is a restaurant search/booking engine launched in 2014 for supporting efficient restaurant management. Restaurant owners and staff can enter operational data into the app (such as the number of tables, occupancy and staff shifts). This software learns over time and informs restaurants about their pacing, turnover rate and business performance (Brill, 2018).

5.1.3 Allset restaurant search/booking engine. Allset focuses on food-preordering and prepaying aside from the commonly seen feature of reservation. Allset uses machine learning to analyze restaurants' peak hours and dining capacity and allocate orders to each restaurant. This engine is also capable of analyzing customer profiles and detecting potential transactional frauds.

5.1.4 Airbnb home search/booking engine. The Airbnb home search/booking engine utilizes machine learning and computer vision algorithms to optimize its platform. The computer vision side involves two branches of computer vision: image classification and object detection. This technology enables Airbnb to validate the number and types of rooms and label various amenities based on uploaded photos. It also allows Airbnb users to conduct a convenient search by amenities (Yao, 2018).

5.1.5 Wayblazer search and booking engine. The software uses NLP algorithms to understand the text input in natural languages, such as "romantic getaway with great food and culture." The images and reviews appearing in search outcomes are most closely related to the keywords in the original search. The natural language input and contextualized

Table 2. Literature review on attributes of innovation (in chronological order)

Author/year	Context	Relative advantage	Compatibility	Complexity	Trialability	Observability	Perceived risk	Secondary attributes
Ostlund (1974)	Innovative oven roasting bag	x	x	x	x	x	x	Not additional attributes specified
Tornatzky and Klein (1982)	Conceptual	x		x	x	x		Visibility, social approval
Davis *et al.* (1989)	Word processing program			x				Perceived usefulness
Moore and Benbasat (1991)	University-based online work platform	x	x	x	x	x		Voluntariness, image
Venkatesh *et al.* (2003)	Organization-based technology systems	x		x				Social influence, facilitating conditions
Al-Gahtani (2003)	Public and private organizations	x	x	x	x	x		NA
Meuter *et al.* (2005)	Self-service delivery	x	x	x	x	x	x	NA
Tan and Teo (2000)	Internet banking	x	x	x	x		x	Values, internet experience, banking needs
Askarany *et al.* (2007)	Professional accounting firms	x	x	x	x	x		NA
Atkinson (2007)	Healthcare computer system	x	x	x	x	x		NA
Kim *et al.* (2009)	Mobile internet usage		x					Control, curiosity, intrinsic interest, social norm, perceived critical mass, preferred lifestyle, perceived economic value
Venkatesh *et al.* (2012)	Mobile internet usage	x		x				Social influence, facilitating conditions, hedonic motivation, habit

(*continued*)

Author/year	Context	Relative advantage	Compatibility	Complexity	Trialability	Observability	Perceived risk	Secondary attributes
Kang *et al.* (2015)	Mobile internet usage	x	x	x				Time, convenience, interactivity
Hasin and Smith (2016)	Online banking at Farmers' markets	x	x	x	x	x		Not additional attributes specified
Wirtz *et al.* (2018)	General service robots			x				Perceived usefulness
Ivanov *et al.* (2018)	Hotel robots	x						Experience, disadvantages. social skills of robots

Table 2.

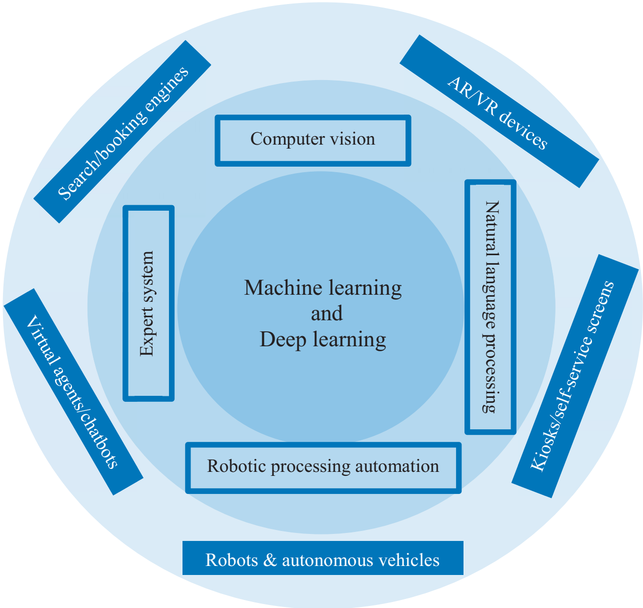

Figure 2.
Five major types of AI applications in the hospitality and tourism industry

presentation of pictures and reviews are crucial for consumers' decisions on services and products (IBM, 2016; Wayblazer, 2017).

5.2 Virtual agents/chatbot

Virtual agents/chatbots have been used in guest services (Pillai and Sivathanu, 2020). Seven examples are as follows.

5.2.1 Google Assistant. Powered by machine learning and NLP, device owners can give voice commands such as "OK Google, tell me today's weather," and their Google Assistant will respond with a brief weather report searched on the internet (Google, 2020). One recent application of Google Assistant is Google Duplex, a system where Google Assistant makes business appointments via phone on behalf of device owners. Google Duplex has been tested on three tasks: restaurant reservation, hair salon appointments and phone inquiries about holiday hours (Callaham, 2019; Leviathan, 2018).

5.2.2 Amazon Alexa. Amazon Alexa can search for information online and respond to voice commands. Amazon rolled out the Alexa for Hospitality version, which became popular. Alexa for Hospitality allows for both the basic Alexa capacity such as playing music and automatic internet search, and hospitality-specific functions such as morning alarms, control of room temperature and lighting, ordering room service, housekeeping, calling the front desk and virtual check-out. Alexa for Hospitality has been used in two Marriott hotels in Los Angeles (Amazon Alexa, 2020; Reid, 2018).

5.2.3 Chatbot Edward. Chatbot Edward was launched in 2016 at the Radisson Blu Edwardian Hotels, an affiliation brand of a UK-based luxury hotel chain. Equipped with NLP technologies, Edward can respond to guest requests through texts regarding maintenance issues, amenity information, directions and travel tips (Aspect, 2020; Burns, 2016).

5.2.4 Macy's On Call. Chatbot Macy's On Call was launched in 2016 by US shopping mall giant Macy's. Macy's On Call is embedded in Macy's official app and provides customers with personalized shopping consultation upon inquiries of products, services and departments (Arthur, 2016).

5.2.5 Tacobot. It allows customers to enter orders via texts and responses in a sharp and witty tone signature to the Taco Bell brand personality. For instance, Tacobot understands requests in an informal language such as "Gimme 3 tacos with extra cheese plz." If customers call it Siri, Tacobot can respond by saying, "How would you feel if I called you by Steve?" (Addady, 2016; Taco Bell, 2016).

5.2.6 My Starbucks Barista. Starbucks launched the chatbot My Starbucks Barista in 2017. The chatbot understands text and voice commands and supports personalized choices such as cup sizes and toasting (Perez, 2017).

5.2.7 Subway Order Bot. The Subway Order Bot was launched by the US sandwich brand Subway. The chatbot is integrated with Facebook messenger and can engage in friendly conversations with customers to receive food orders. One example is: "Alrighty. . .what kind of bread?" The chatbot is different from other food-ordering chatbots in two manners: (a) the pickup store is determined by customers' zip code or current global positioning system (GPS) location and (b) users can choose to enter texts or tap pictures to order (Calfas, 2017; Subway Restaurants, 2017).

5.3 Robots and autonomous vehicles

Robots and autonomous vehicles have diverse hospitality and tourism applications such as patrolling, luggage delivery and short cooking. Some exemplary use cases are described as follows.

5.3.1 Knightscope robots (K Series). Equipped with GPS, lasers and thermal cameras, the robots monitor and gather environmental information such as sounds, high-definition video footage and ultra-speed license plate scanning. The robots can roam indoors, outdoors and even on rugged, multi-terrain surfaces. Such robots aim to supplement hotel staff with human-like visual and audio capabilities (Knightscope, 2020; Robinson, 2017).

5.3.2 Travelmate autonomous suitcases. The Travelmate Autonomous Suitcases were launched in 2016. These suitcases can follow the owners around with a matching speed when they sync their smartphones with the suitcase's Bluetooth. The self-driving capacity enables them to move around smoothly in optimized routes and avoid obstacles (Travelmate, 2019).

5.3.3 Hilton concierge robot "Connie". The Hilton concierge robot Connie was launched in 2016 at the Hilton in McLean, Virginia. With machine learning, computer vision and NLP technologies, Connie can see human guests, understand voice input such as questions for directions and respond in natural languages. Connie's eyes can light up in different colors to express different moods (Trejos, 2016).

5.3.4 Domino's pizza autonomous delivery. The US-based pizza chain Domino's Pizza has been testing pizza delivery using autonomous cars and drones. The self-driving vehicles designed for Domino's Pizza are void of seats or steering wheels as they are entirely autonomous and require no human assistance. The autonomous cars are small enough to give them more agility in avoiding obstructions. Using Domino's official app, customers can place an order, track the vehicle's location and pick up their pizza with a unique code (Holley, 2019).

5.3.5 Flippy (the burger-flipping robot). Flippy is a one-hand robot powered by computer vision to see the patties and decide the timing of flipping. Human staff can easily use it in the burger preparation process. The management team is satisfied with the robot's high accuracy and the potential long-term savings on cooks' training (Caliburger, 2016; Graham, 2018).

5.4 Kiosks/self-service screens

Kiosks/self-service screens are mostly equipped with facial recognition software that facilitates the service process using biometric data. The two most representative use cases are described as follows.

5.4.1 Facial recognition check-in kiosks. The US-based hotel chain Marriott International initiated a trial of facial recognition check-in kiosks in 2018 at two locations in China (Hangzhou and Sanya). The kiosks are intended to limit check-in time from 3 min to only 1 min. Customers need to first scan an ID, have a photo taken by the machine, sign a service agreement form and, lastly, enter their contact information. The facial recognition software instantly verifies personal and reservation information and dispenses room keys in a timely fashion (Marriott International, 2018; Wang, 2018).

5.4.2 Smile to pay facial recognition system. Launched in Hangzhou, China, in 2017, the smile-to-pay system is a joint-venture project with China's e-commerce giant Alibaba. Once customers go to the designated KFC store and complete an order, they smile at the self-service screen for the facial recognition software to verify customers' personal information and process transaction (Gilchrist, 2017; Meyers, 2017). The project is so popular that smile-to-pay has been used in more than 300 stores as of 2018 (Burt, 2018).

5.5 Augmented reality/virtual reality devices

AR/VR technologies have been used with various devices. AR is mainly used on smartphones or tablets, while VR is frequently used with a head-mounted device or other sensory simulation tools. Some exemplary use cases and their functions are described as follows.

5.5.1 ETIPS AR travel app on smartphones or tablets. The ETIPS AR app was developed in 2009. Users scan the surrounding environment with a mobile device and obtain travel tips or local history by clicking on the icons indicating photo spots, hotels and restaurants (ETIPS, 2020).

5.5.2 In-room AR map on smartphones or tablets. The in-room AR map was used at the London-based Premier Inn chain in 2014. The hotel rooms feature an entire wall of the map of London. Guests who download the hotel's official app can scan the map wall for AR information about different areas. Guests can view information within each area, such as online reviews about bars and restaurants (Edwards, 2015; Henderson, 2014).

5.5.3 VR travel booking service. Navitaire's VR experience transport customers to an immersive booking environment via a headset. Customers undergo the booking process by seeing a geographic globe, immersing in selected destinations and choosing destinations around the world. When selecting rental cars, different vehicles levels and prices are shown in front of the users, who then check out each vehicle in an immersive world before making a final decision. In the last stage, users see their payment methods virtually, which can be picked up and set on a cashier screen for immediate transaction approval (Navitaire, 2020; Vallantin, 2017).

5.5.4 VR honeymoon headset and teleporter. The VR honeymoon experience was launched in 2014 by Marriott in the form of pop-up teleporter boxes. Newlyweds walking out of a New York courthouse are invited into two booths for a skyscraper honeymoon in London or a beach honeymoon in Hawaii. Users put on headgear with eye goggles and engage with sensory simulation tools like a vibrating floor and misting spray. Users not only can see the destination in a 360-degree view but also engage in a four-dimensional (4D) experience with water, wind, temperature change and a vibrating ground (Carson, 2015; Leber, 2014).

5.5.5 AR in-room athlete encounter. The AR in-room athlete encounter was launched in 2012 over the hype of the 2012 London Olympic and Paralympic Games. Hotel guests who have downloaded this specific application can point their mobile devices to different hotel amenities and see different athletes doing sports (Martins, 2017; Stylus, 2012).

5.5.6 AR fine arts windows. The San Francisco Museum of Modern Art (SFMOMA) presented an AR exhibition in 2018 named "René Magritte: The Fifth Season." In this exhibition, the audience experience AR effects without the assistance of personal devices.

The AR effects are shown in the special window walls with sceneries such as a night sky with a moon, a forest, or the room's reflection (Haigney, 2018; SFMOMA, 2020).

6. Methodology

This study employed expert reviews to assess the likelihood of adopting the 25 AI applications for hospitality and tourism reviewed in Section 5. Expert-based evaluations have proved to be an effective method to judge technology adoption (e.g. Gediga *et al.*, 1999; Safari *et al.*, 2015). The advantages of expert-based assessments are their relative quickness, the collection of holistic and integrated perspectives, and their flexibility for ample technological contexts (Boegh *et al.*, 1999). Therefore, small-group expert evaluation was selected as a data collection method. Five experts were recruited from a public university using snowball sampling. All the experts had PhD degrees in different fields: three in hospitality and tourism, one in education and instructional technology, and one in information technologies. The expert evaluation process was described as follows:

(1) An email was sent to the five experts inviting them to participate in a remote evaluation session (i.e. video call) conducted in January 2020 and lasted approximately 3 h.

(2) The principal investigator (PI) directed the session and explained the dynamics of the evaluation. Then, the evaluation criteria were further elaborated on in Section 6.1 (relative advantage, compatibility, complexity, etc.). Questions and clarifications on the evaluation criteria were addressed to increase the consistency and validity of the results.

(3) The 25 AI applications were analyzed successively by the selected experts. Such analysis consisted of reading a description of the AI application in turn and visiting its website/blog to learn more about the key features and functionalities.

(4) The seven-attribute evaluation framework presented in Section 3 was used to systematically assess the 25 AI applications' susceptibility of adoption reviewed in Section 4 by using the triangulation method based on the attributes in Figure 3.

(5) After reviewing each application, the five experts briefly discussed whether the application met each adoption attribute or not. Experts voted for each application to determine if the attribute applied to the application in turn. Attributes with three or more votes (out of five) were ranked with one star, while attributes with two or fewer votes were left blank. Applications with a higher number of stars indicated higher susceptibility to adoption, being seven stars the highest adoption likelihood level. Last, member checking was conducted to increase the trustworthiness of the process.

6.1 Evaluation criteria

Relative advantage can be assessed with economic benefits, efficiency and interactivity. Commonly seen economic benefits include helping customers compare prices from different service providers, as seen in the search/booking engines that list all relevant hotels or restaurants to decide the best price or the best overall package. Efficiency refers to the time saved from a smoother ordering process, information-inquiring process and transaction process. Interactivity is reflected by machines' ability to take commands and make timely, customized responses.

Compatibility can be evaluated with work-related and value-related criteria. The work-related criteria are the significant benefits of virtual agents/chatbots due to taking over the food-ordering process and helping answer basic questions. Similarly, robots and autonomous

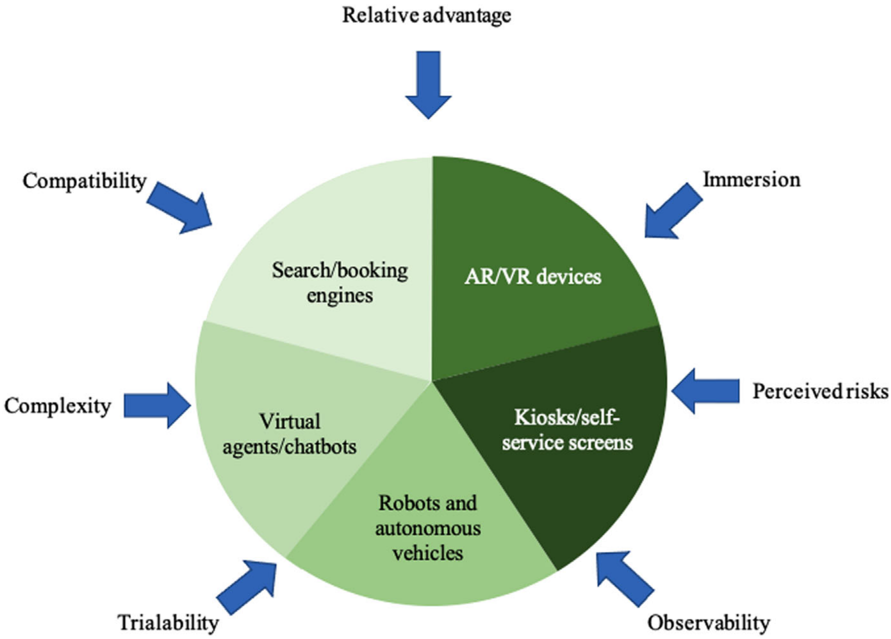

Figure 3. Attributes for evaluating AI applications in the hospitality and tourism industry

vehicles show excellent work-related benefits as helping patrolling sites, delivering food and helping prepare burgers. The facial recognition systems also reduce staff's workload to manage regular check-in and identity verification processes. The value-related criteria such as social norm and preferred lifestyle are the promoted outcomes of virtual agents/chatbots, robots and autonomous vehicles, kiosks/self-service screens, and AR/VR devices due to their embodiment of innovation-embracing or simplify-embracing lifestyle. Complexity is evaluated by ease of use. Most applications feature low complexity in their customer-facing functions; however, strictly back-of-the-stage applications such as Knightscope K Series, drone delivery and Flippy are not emphasized for their low complexity for staff members who operate these applications.

Trialability is evaluated by the ease of trial. All the search/booking engines feature high trialability as the software is publicly available online. Most robots and autonomous vehicle-related applications and all kiosks/self-service screens seem to lack trialability for businesses. The autonomous suitcases are low in trialability as they require purchase before use. AR/VR devices are only considered trialable if they are made free for the public, such as the ETRIPS AR travel app. The rest of the AR/VR applications are only available on-site (e.g. hotel rooms, art museums or during events).

Observability is assessed with a visible knowledge increase, visible customer satisfaction, ease of communication and physical visibility of applications. The visible knowledge increase is not a distinctive effect of all five types of applications as none is created for educational purposes. Visible satisfaction is high for all five types of applications because the effects can be evaluated based on outcomes such as repeated booking or positive reviews of the engines. The ease of communication is high for all types of applications as users can easily describe the functions and expected benefits to others. The physical visibility is low for software applications but high for hardware applications across all types. Finally, perceived risk is evaluated by financial loss, data breach and privacy infringement and performance. Most AI applications carry potential risks from financial loss, data breach and privacy infringement, and performance failure. However, AR/VR technologies have the lowest risk from data breaches and privacy infringement due to the limited personal information they can access and store. The only exception is the VR travel booking goggles, as they require personal banking information to complete the online purchasing process.

6.2 Evaluation results

Table 3 shows the ratings given by the five experts to the selected AI applications. AR/VR devices overall have the highest ratings, from four to six. Virtual agents/chatbots are also slightly dynamic and have scores between four and five. Search/booking engines and kiosks/self-service screens are rated four stars. The ratings for robots and autonomous vehicles vary by product, generally between two and four stars.

7. Discussion and conclusions

7.1 Conclusion

AI and its foundational technologies are transforming the tourism and hospitality industry. Exemplary applications such as search/booking engines, virtual agents, robots, autonomous vehicles, self-service kiosks, AR, and VR will continue to develop with broader applications. Implementing AI in hospitality services should be pondered by considering factors that influence the likelihood of adoption by consumers and workers. It was found that the susceptibility to adoption varies by the type of AI. The experts' evaluations in this study suggest that AI applications that provide enhanced and personalized searches (e.g. search/booking engines, virtual agents) and those that offer immersive experiences (e.g. AR and VR) are more likely to be adopted. By contrast, AI applications focusing on automatizing business operations and providing faster and smoother transactions appear to be less likely to be adopted due to perceived information risk and restricted trialability. The five attributes posited by Roger (2003) plus the two attributes suggested in this study (i.e. perceived risks and immersion) can be used by researchers to advance theoretical models about AI adoption. Hospitality and tourism managers and leaders may identify AI solutions for various operational and service contexts.

7.2 Theoretical implications

The present study informs Rogers' (2003) innovation diffusion theory and tourism' research in two ways. First, it links AI innovations developed for the hospitality and tourism industry with existing innovation diffusion theoretical underpinnings to identify current advances and challenges. Specifically, this study describes how five key theoretical attributes of technological innovations (relative advantage, compatibility, complexity, etc.) either explicitly or implicitly are present in current AI applications available in the market. Therefore, researchers can use the proposed evaluation framework to empirically test how travelers and workers can more easily adopt AI for hospitality and tourism.

Second, it poses two potential factors not included in Rogers' (2003) framework that might affect AI adoption in the hospitality and tourism industries (i.e. perceived risk and immersion). The current research advances hospitality information systems theory by suggesting supplementary innovation diffusion antecedents. It is crucial to consider the risks associated with financial losses, data breaches and privacy infringement. Perceived risk and immersion can be empirically measured to determine their influence on the relationship between AI and adoption by differentiating between consumers and organizational perspectives. We suggest AR/VR researchers explore the immersive function (multi-

Table 3. Evaluation of AI applications in the hospitality and tourism industry

Type of AI	AI application	Relative advantage	Compatibility	Complexity	Trialability	Observability	Perceived risks	Immersion	Overall rating
Searching/booking engines	Allora	★	★	★	★	★			5
	Resy	★	★	★	★	★			5
	Allset	★	★	★	★	★			5
	Airbnb	★	★	★	★	★			5
	Wayblazer	★	★	★	★	★			5
Virtual agents or chatbots	Google Assistant	★	★	★	★	★			5
	Amazon Alexa	★	★	★	★	★			5
	Edward the Chatbot	★	★	★	★	★			5
	Macy's on Call	★	★	★	★	★			5
	Tacobot	★	★	★	★	★			5
	My Starbucks Barista	★	★	★	★	★			5
	Subway Order Bot	★	★	★	★	★			5
Robots and autonomous vehicles	Knightscope K Series	★	★			★			3
	Travelmate Autonomous Suitcase	★	★	★		★			4
	Connie	★	★	★		★			4
	Domino's Pizza Autonomous Delivery	★	★			★			3
	Flippy	★	★			★			3
Kiosks or self-service screens	Facial Recognition Check-in Kiosk	★	★	★		★			4
	Smile to Pay Facial Recognition System	★	★	★		★			4
AR/VR	ETRIPS AR Travel App		★	★	★	★	★	★	6
	In-Room AR Map		★	★		★	★	★	5
	VR travel Booking Goggles VR		★	★		★	★	★	5
	Honeymoon Teleporter		★	★		★	★	★	5
	In-room AR Athlete Encounter		★	★		★	★	★	5
	AR Fine Arts Windows		★	★		★	★	★	5

sensorial experiences) of these technologies when developing and testing their use in the hospitality sector.

7.3 Practical implications

This study synthesizes current AI applications developed for the hospitality and tourism industry, which support identifying best practices, learning experiences and future markets. Hospitality and tourism managers may evaluate AI applications to determine which tools offer the best solutions for their operations. This research portrayed AI's subfields, namely, expert systems, computer vision, NLP, RPA and machine learning. The AI applications are categorized into five types: search/booking engines, AR/VR devices, kiosks/self-service screens, robots and autonomous vehicles, and virtual agents/chatbots. Finally, the diffusion of innovations theory was used as the theoretical backdrop to discuss how new ideas and practices (e.g. AI in hospitality and tourism) spread within and between hospitality and tourism industry stakeholders and communities.

Our findings reveal and discuss the critical attributes for evaluating AI applications that could benefit the hospitality and tourism industry. Further, our findings serve to nurture inspirations for developing innovative AI applications that can increase productivity and consumers' satisfaction. The posited evaluation framework is also useful for managers to rate the adoption susceptibility of AI to make informed decisions for their business operations and services. Overall, search/booking engines, virtual agents and chatbots seem easier to adopt for consumers and organizations. AR/VR devices are rated the highest for their innovation attributes, meaning new users most likely accept them. Kiosks/self-service screens, robots and autonomous vehicles rank the lowest in terms of adoption. Therefore, service providers could use these findings to search for implementation strategies that ensure smooth and incremental transitions. Implementing AI innovations should be conducted through systemic approaches to reduce the risk of financial and operational instability.

Developers, manufacturers and suppliers of AI technologies for the hospitality and tourism industry can also inform their designs by utilizing the proposed AI evaluation framework. Technology developers can identify areas of improvement (e.g. low trialability, information risk, data security) by specific types of AI that, if effectively implemented, may facilitate the spread of AI innovations among consumers and employees. For instance, AR/VR devices' advantages need to be further communicated to convince customers; businesses should be allowed to evaluate different scenarios before formal adoption (i.e. enhancing trialability). Similarly, information vulnerability and a lack of immersive characteristics seem to be evident for virtual agents, chatbots and booking engines. Kiosks/self-service screens are associated with a salient need to fortify the data security to protect users and ensure businesses' return on investment. Lastly, robots and autonomous vehicles seem to be associated with a slower adoption rate due to the perceived risks of data and performance failure, a lack of immersion, complexity for operators and low trialability. These concerns represent the need for improving the inherent features of emergent AI applications for broader hospitality and tourism services.

7.4 Limitations and future research

This research has the following limitations. First, our proposed rating system is only based on the literature in the hospitality and tourism industry. The identified attributes can be possibly expanded by reviewing findings from other business fields. Second, our results are assessed from the academic perspective. They can be further verified and validated by industry experts to provide additional insight. Finally, the triangulation method can be complemented with other qualitative methods to support the findings.

Future work can take several directions. Researchers can use survey instruments to assess the results. Data from surveys would help operationalize the existing innovation constructs and lead to deeper analysis based on statistical analysis. Future research could include industry experts' perspectives through interviews. Future research could further evaluate AI applications from providers' perspectives. Evaluating how providers perceive the pros and cons can help paint a more complete picture of properly integrating AI with hospitality and tourism services. We recommend that future researchers examine the barriers and enablers of AI investments in hospitality and tourism. Finally, it is essential to explore the organizational characteristics that support AI applications in hospitality and tourism services.

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