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Artificial Intelligence: A Systematic Review of Methods and Applications in Hospitality and Tourism

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Abstract

Purpose

Several review articles have been published within the Artificial Intelligence (AI) literature that have explored a range of applications within the tourism and hospitality sectors. However, how efficiently the applied AI methods and algorithms have performed with respect to the type of applications and the multimodal sets of data domains has not yet been reviewed. Therefore, this paper aims to review and analyse the established AI methods in hospitality/tourism, ranging from data modelling for demand forecasting, tourism destination, and behavior pattern to enhanced customer service and experience.

Design/methodology/approach

The approach was to systematically review the relationship between AI methods and hospitality/tourism through a comprehensive literature review of papers published between 2010-2021. 146 articles were identified and then critically analysed through content analysis into themes including “AI methods” and “AI applications”.

Findings

The review discovered new knowledge in identifying AI methods concerning the settings and available multimodal datasets in hospitality and tourism. Moreover, AI applications fostering the tourism/hospitality industries were identified. It also proposes novel personalised AI modelling development for smart tourism platforms to precisely predict tourism choice behaviour patterns.

Practical Implications

This review paper offers researchers and practitioners a broad understanding of the proper selection of AI methods that can potentially improve decision-making and decision-support in the tourism/hospitality industries.

Originality

This paper contributes to the hospitality/tourism literature with an interdisciplinary approach that reflects on theoretical/practical developments regarding data collection, data analysis, and data modelling using AI-driven technology.

Keywords: Artificial Intelligence, Hospitality/Tourism, AI Methods/Algorithms, AI Applications, Future Studies-in-Tourism

1. Introduction

The modern world is rich in data, and big data analysis has grown in prominence in recent years. From a diverse range of industries, many businesses are becoming increasingly reliant on the information derived from massive amounts of data generated in the course of their business. However, in big data analytics, traditional data techniques and platforms are not well equipped to analyse today's large amount of structured and unstructured data, make correlations, and forecast patterns across datasets (Maclaurin *et al*., 2019). These limitations are more challenging when it comes to real-life scenarios where customer engagement and customer service are at the core of decision-making (So *et al*., 2021).

The hospitality and tourism industries are not an exception. Hospitality and tourism businesses increasingly rely on interpreting and analysing large volumes of data, including multimodal datasets (numerical, categorical, time-series, image, and text) (Samara *et al*., 2020). The enormous amount of data available makes the information extraction phase more complex and requires advanced analytical techniques to perform the analysis. Furthermore, the unprecedented disruption caused by the COVID-19 crisis has necessitated the creation of new theoretical and analytical frameworks capable of transforming potential chaos into a catalyst centred on perceptive, actionable intelligence (Polyzos *et al*., 2020).

While data analytics and experimental scientists have long discussed this topic, recent artificial intelligence (AI) technologies have brought new insights into such discussions (Barr and Feigenbaum, 2014). The term "Artificial Intelligence" is utilised to define machines that emulate human mind-related "cognitive functions", such as "learning" and "problem-solving" (Mitchell *et al*., 2013). AI algorithms have shown an eminent aptitude to learn from the data and obtain profound patterns that can be used to predict and detect events. The influence of AI technology can now be seen across different sectors such as psychology, space exploration, healthcare, marketing, and finance (Pannu, 2015, Doborjeh et al., 2021b, Sanders et al., 2021, Doborjeh et al., 2018b). Statista (2021) reported that the AI market has been rapidly expanding in recent years, with total revenue reaching $28.1 billion in 2018. A recent report by PricewaterhouseCoopers also predicts that AI will significantly increase the world's GDP– up to 26% for China, 16% for the USA, and 10% for countries like New Zealand. Developments in AI, and its acceptance by service industries, have been translating the hospitality and tourism industries in many ways, impacting on areas including consumer demand, tourist experiences and perceptions, destination management, and prediction of tourists' behaviours (Wu *et al*., 2017, Filieri *et al*., 2021). Recent studies confirm this by demonstrating a significant correlation between AI services, the perceptions of quality, consumer happiness, and engagement (Prentice *et al*., 2020, Mariani and Borghi, 2021, Kong *et al*., 2021). Several review experiments have been conducted in the hospitality and tourism literature, and many have studied a diverse range of existing AI applications. However, there has been little systematic review of the impacts and trends of AI methods for extensive data analysis and potential AI applications in hospitality and tourism settings has not been provided. In addition, how the applied AI methods and algorithms have been performed efficiently in developing the target applications with respect to the datasets need to be reviewed, and the potential AI application needs to be discussed. Therefore, the current study presents a systematic review of the role of AI methods and algorithms in hospitality and tourism research and industry related to multimodal data processing, data modelling for demand forecasting, tourism destination, and behavior patterns. This comprehensive review of AI methods and algorithms, as well as review on AI applications in tourism, have enabled the discovery of which applied methods perform best concerning the "application types" and the "data domain". The originality of the paper resides in the new perspective provided by an authorship team that comes from the AI academic disciplines – knowledge engineering, psychology and AI, computer science and AI, and one tourism/hospitality academic. This approach is unique because it brings AI thinking and theory into the tourism literature and through this strengthens the theoretical implications.

The novel contributions that emerge from this approach are outlined as follows:

1. It reviews and compares different well-known AI methods used in hospitality and tourism studies. The most widely used AI algorithms, as stated in the literature, are critically evaluated. These methods range from basic computational methods, such as clustering models for image data in Machine Learning (ML), to more advanced computational techniques, such as classification and prediction using state-of-the-art Artificial Neural Networks (ANN) and Deep Learning algorithms for big time-series and multimodal spatiotemporal data.
2. The review focuses on adaptation and adoption of AI methods in tourism sectors, including the significant AI applications in tourism such as Virtual Reality, Augmented Reality (AR), Automation and Robotics, chatbots, Natural Language Processing (NLP), and Virtual Assistants (VA)/chatbot. These are discussed in terms of the ways that they are transforming, and in some ways reinventing the hospitality and tourism industries.
3. The review discovers new knowledge about the efficiency of different AI methods in relation to tourism applications and data domains.

4. Finally, it opens new research directions opportunities for hospitality and tourism researchers from the AI perspective.

2. Method

The method was to systematically review the relationship between AI methods and applications in hospitality and tourism through a comprehensive literature search based on 'title/abstract/keyword'(Moher *et al*., 2009). The search strategy accounted for a range of search terms, keywords, and phrases that included "AI algorithms in tourism and hospitality settings", "smart tourism", and "future AI technologies". A sample of journals was selected based on A* and A-ranked tourism journals on the Australian Business Deans Council's (ABDC) journals ranking list (Table I). This ranking was chosen because it is specifically geared towards journals in business, management, and industry. Also, we included journals that focus more specifically on AI and technology, including the Journal of Hospitality and Tourism Technology. As presented in Table I, the review of articles published from 2010 to 2021 in the leading hospitality and tourism journals indicates that the "International Journal of Contemporary Hospitality Management" published the highest number of tourism and AI research articles, followed by the "Asia Pacific Journal of Tourism Research", "Tourism Management", "Annals of Tourism Research", the "Current Issues in Tourism" and "Journal of Hospitality and Tourism Technology". Through this review, 146 articles were identified within the scope of AI in tourism. They were then critically analysed through content analysis into two themes: AI methods/algorithms and AI applications. Table II summarises the contribution of most important articles in the literature in this realm. Based on the referenced articles from the listed journals in Table II, the current review paper also addresses the research questions as the following:

- What is the contribution of the literature in the form of AI services in hospitality and tourism?
- What type of AI methods, applications, and data can best contribute to hospitality and tourism industries' knowledge in the future?

Table I. The number of selected top A* and A ranked journals related to AI in hospitality and tourism, published between 2010 to 2021.

Journals	Publishers	Selected	Rating
Annals of Tourism Research	Elsevier	14	A*
Asia Pacific Journal of Tourism Research	Taylor & Francis Online	15	A
Cornell Hospitality Quarterly	Sage Publications	2	A
Current Issues in Tourism	Taylor & Francis Online	13	A
International Journal of Contemporary Hospitality Management	Emerald Group Publishing	50	A
International Journal of Hospitality Management	Elsevier	6	A*
International Journal of Tourism Research	Wiley-Blackwell Publishing	1	A
Journal of Hospitality and Tourism Management	Elsevier	2	A
Journal of Travel & Tourism Marketing	Taylor & Francis Online	8	A
Journal of Vacation Marketing	Taylor & Francis Online	4	A
Tourism Recreation Research	Taylor & Francis Online	3	A
Journal of Hospitality and Tourism Research	Sage Publications	4	A
Tourism Management	Elsevier	14	A*
Journal of Hospitality and Tourism Technology	Emerald Insight	10	B

Table II. Overview of AI Methods-related articles selected from the ABDC journals.

AI Methods-related Content Papers					
Machine learning methods					
Author/Year	**Study context**	**Data**	**Methodology**	**Model performance**	**Industry**
Zhang (2014)	Identifying the main elements affecting Chinese citizens' intentions for outbound travel.	Questionnaire consists demographic and personal values variables collected in Nanjing, March-May 2011.	- C4.5 Rule-PANE. - The neural network ensemble - Neural network - logistic regression	The neural network ensemble and C4.5 Rule-PANE outperformed statistical logistic regression and the simple neural network. Error rates: Logistic regression: 0.45 C4.5 Rule: 0.44 Neural network: 0.42 Neural network ensemble: 0.38 C4.5 Rule-PANE: 0.37	Tourism destination
Donaire (2014)	Understanding tourists' behaviours with different perspectives of the same place.	1,786 photos taken by tourists from the valley (Spain) and posted on Flickr website.	Ward's method	The results showed a four-cluster solution as the most proper that were significantly differentiated at *p* value ≤ .05	Tourism pattern behavior
Giglio *et al* (2019)	Identifying clusters surrounding points of interest.	26,392 photos of 6 cities in Italy that was taken from 2014-2016 posted on Flicker website.	- (DBSCAN) - k nearest neighbours - Euclidean distance	DBSCAN method was able to obtain higher accuracy in compared to the k-means technique.	Tourism pattern behavior
Höpken *et al* (2020)	Investigating tourists' movement and point of interest.	13,545 photos taken by tourists for the year 2015 and posted in media.	- K-mean - (DBSCAN)	DBSCAN method was able to find common and randomly formed clusters when compared to the k-means technique. On a smaller scale, k-means clustering recognised closely associated point of interests more accurately than DBSCAN.	Tourism pattern behavior
Ramos-Henríquez et al (2021)	Identifying the most important characteristics of the value proposition for the Superhosts.	250 features from 5136 listings were collected in the region of Canary Islands.	- Boruta for feature selection - (SVM) for classification	Creating forecasting model of SVM with Boruta feature selection that led to a better accuracy performance.	Hospitality
Xie *et al* (2021)	Forecasting Chinese cruise tourism demand.	Search query data.	- (LSSVR) model with (LSSVR-GSA)	LSSVR-GSA obtained the highest forecasting performance.	Tourism demand forecasting
Artificial neural network methods					
Authors/Year	**Study context**	**Data**	**Methodology**	**Model performance**	**Industry**

Silva *et al* (2019)	Forecasting tourism demand	Tourism demand of ten European countries.	- NNAR - Denoised neural networks	Results support denoising method for increasing the accuracy of NNAR forecasting capabilities.	Tourism demand forecasting
Liu (2011)	Predicting number of tourists	Time series data on number of tourist visitors between 1998-2009 in Weifang.	- (BPNN) - Gradient descent method	The simulation model of the number of visitors based on BPNN was effective and more accurate.	Tourism demand forecasting
Golmohammadi *et al* (2011)	Predicting tourists' satisfaction in travel	1,870 questionnaires collected from tourists in the Airport over three months- time.	Hybrid neural network	The hybrid neural network performed well in predicting the tourists' overall satisfaction. Error: (Root-mean-square deviation (RMSE)=0.05246)	Hospitality
Zhu *et al* (2018)	Forecasting tourist flow	Tourism demand in by six major origins in Singapore, collected between 1995-2013.	The copula-based approach	The proposed copula-based model performed better than the benchmark models.	Tourism demand forecasting
Claveria *et al* (2016)	Forecasting tourism demand and to compare the performance of three different ANN models	Tourist arrivals, collected between 2001-2012.	- (MLP), - (RBF) - Elman recursive neural network.	MLP and RBF networks' mean absolute percentage error (MAPE) was lower than Elman networks.	Tourism demand forecasting
Sanchez (2020)	Identifying intentions that lead consumers to cancel hotel booking	10,000 bookings records of a four-star hotel in Spain, collected from 2016-2018.	- (SVM) - (ANN) - (GA) -Random forest	When ANN is optimised with GA, it increased the performance of accuracy. Random forest:.80% SVM: .73% ANN (GA optimised): .98%	Hospitality
Kwon (2020)	Identify underlying factors of consumers' preference in restaurants	4,799,240 reviews of restaurants since October 2004, collected from Yelp.com.	- Linear mixed-effect - (NLP)	NLP techniques shown promising results in analysing textual data.	Tourism pattern behavior
Deep learning methods for big data					
Authors/Year	**Study context**	**Data**	**Methodology**	**Model performance**	**Industry**
Li (2018)	Tourism flow prediction	Beijing tourist volumes between 2011-2015, collected from the Beijing Tourism Association (BJTA).	- Principal component analysis (PCA)-based index - Generalized dynamic factor model (GDFM)-based index	The forecast accuracy of the GDFM-based index model was higher than the other models. (Increased accuracy over 50%).	Tourism pattern behavior
Zhang B *et al* (2020)	Forecasting daily tourist flow	Tourist flow in Jiuzhaigou, China, collected between, 2013-2017	- (LSTM) - contextual- Long short-term memory (C-LSTM) - Deep belief network - (BPNN)	LSTM obtained the highest accuracy and low mean relative error.	Tourism pattern behavior
Lado-Sestayo (2019)	Predicting hotel profitability	Hotel and tourist destinations, collected between 2005-2011.	- Multi-layered neural network	The proposed model obtained the high predictive accuracy of hotel profitability.	Hospitality

Chang Y-C (2020)	Predicting hotel reviews and responses	113,685 hotel reviews	- (NLP)	The proposed multi-feature fusion, convolutional neural network model outperforming the other statistical methods.	Tourism/Hospitality
Zhang K (2019)	Understanding tourists' behaviours and perceptions	35,356 tourists' photos from Flicker.	Deep learning technology	Introducing AI-DL technology into tourism destination research.	Tourism pattern behavior
Al Shehhi (2020)	Forecasting hotel room prices in selected Gulf Cooperation Council (GCC) cities	2800 observations of daily room sales, collected between 2010-2017.	- (SARIMA) - Deep belief network - (ANFIS) - Polynomial smooth support vector machine (PSSVM)	This analysis shows that the ANFIS model has performed better compared to other models MAPE error rate are: SARIMA= 0.0056 Deep belief= 0.0043 ANFIS= 0.0021 PSSVM= 0.0030	Tourism demand forecasting
Wu (2021)	Predicting tourist arrivals to Macau, China.		- (SARIMA) - (LSTM)	Combining SARIMA and LSTM resulted higher accuracy and outperform other methods.	Tourism demand forecasting
He (2021)	To increase the forecasting performance accuracy of tourism demand		- (SARIMA) - Convolutional neural network (CNN) - (LSTM)	Combined SARIMA–CNN–LSTM model generates superior forecast accuracy than each model alone.	tourist demand forecasting

3. Analytical AI Methods for Big Data in Hospitality and Tourism

In this section, we use the terms "classification, "prediction" and "regression" as the well-known tasks conducted by AI models. Classification refers to the process of detecting the category (class label) of the new observation (data sample) to which it belongs. A Prediction task is a process of detecting the class label of an unavailable data sample that will be recorded in the future. Regression refers to modelling time-series data and detecting the numerical values of data variables that will be collected in the future. We also referred to the term "feature selection" which is related to the detection of the most informative data variables that can increase the accuracy of outcome prediction, classification, and regression (Gholami Doborjeh, 2019, Searchfield *et al*., 2021). Figure 1 summarises the main analytical AI methods that are being applied to tourism and hospitality studies along with the main AI-driven applications. These AI methods algorithms and applications shown in Figure 1 will be discussed in the following sections.

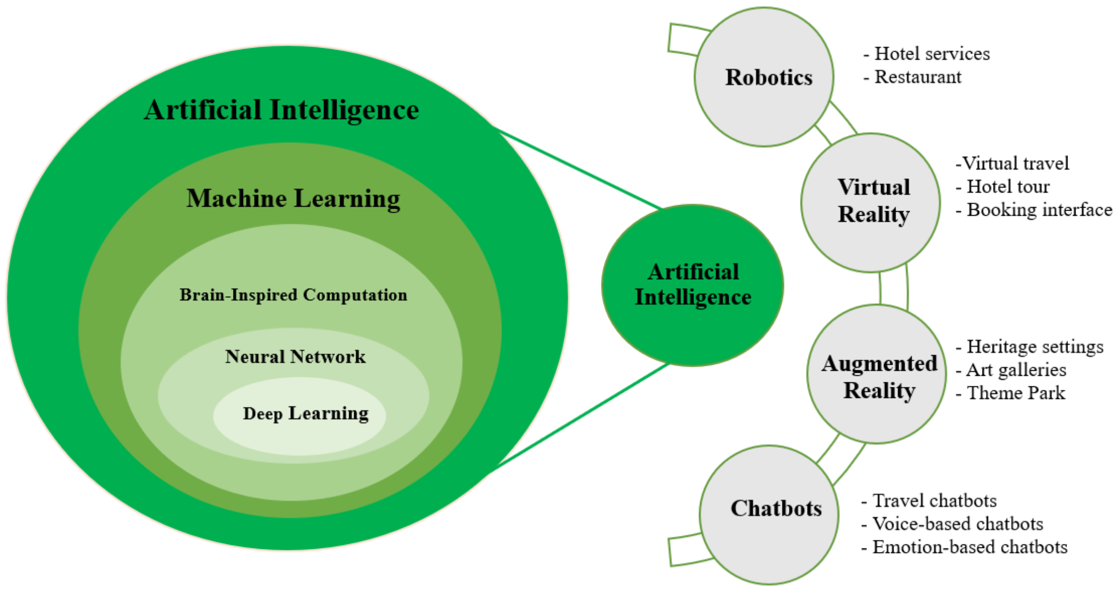

Figure 1. Artificial Intelligence methods and applications in hospitality and tourism.

3.1 Statistical Machine Learning in Hospitality and Tourism

The use of ML methods has increased dramatically in hospitality and tourism research over the past few years. ML applies statistics and computer science concepts to construct mathematical models that are used for future predictions and to recognise data trends (Alpaydin, 2020). In our review, ML algorithms have mostly been used in hospitality and tourism operational aspects such as hotel services, forecasting prices, and customer demand (Zhang *et al*., 2017).

Clustering Techniques in Hospitality and Tourism:

In hospitality and tourism studies, cluster analysis has been used for a wide range of purposes. That includes determining the purpose or significance of a place (Bi *et al*., 2020), investigating the actions taken over time by the tourists (Aluri *et al.*, 2019), and assessing what has changed in a place visited (Donaire *et al*., 2014). Zhang et al., (2014) conducted an experiment to assess the relationship between Chinese people's psychographic and demographic data variables and their travel intentions (Zhang and Zhang, 2014). The authors used twice-learning algorithms in this study and compared four commonly used ML algorithms including logistic regression, neural network, neural network ensemble, C4.5 Rule, and C4.5 Rule-PANE. The authors reported that C4.5 Rule-PANE achieved better predictive performance accuracy than the other methods. In Donaire's study, the Ward's method was used to find proof of tourist gaze profiles by reviewing photographs captured by visitors and posted in social medias (Donaire *et al*., 2014). Giglio et al., (2019) further collected 26,392 photos linked to six Italian cities to assess clusters surrounding points of interest (POI). This research used the Density-based Spatial Clustering of Applications with Noise (DBSCAN) technique to automatically characterise the most frequently visited geographic locations (Giglio *et al*., 2019). Höpken et al., (2018) also analysed the suitability of different clustering methods, including DBSCAN, to investigate tourists' spatial movement and POI visitation behaviour using 13,545 photos for the year 2015 (Höpken *et al*., 2020).

Classification and Prediction Techniques in Hospitality and Tourism Studies:

In the literature, the most well-known ML methods that have been applied for classification/prediction of tourism data are Support Vector Machine (SVM) and Multiple Linear Regression (MLR) methods (Yao *et al*., 2004). To forecast tourism demand, Pai and Hong (2005) initially proposed the SVM technique within tourism settings (Pai *et al*., 2005). Pai demonstrated that the Multifactor Support Vector Machine Model (MSVM) combined with Back-Propagation Neural Networks (BPNN) model can enhance the forecasting tourist arrivals' accuracy for numerical and non-linearly discrete dependent variables. Since then, SVM combined with BP has been used for forecasting tourist arrival problems. An SVM training algorithm builds a model that assigns new examples to one of two categories given a set of training examples. It does so by mapping the original input data space into a higher dimensional space and identifying the data vectors (support vectors) in this space that discriminate the areas of samples from two or more classes (categories) (Alpaydin, 2020). Recently, Ramos-Henríquez et al., (2021) used two different ML methods: the Boruta algorithm for feature selection and the SVM for the prediction of variables that contribute the most to being an Airbnb Super-host (Ramos-Henríquez *et al*., 2021). Xie et al., (2021), recently proposed a methodology framework for hospitality and tourism big data that can provide valuable predictors for forecasting demand for Chinese cruise. They used Least Squares Support Vector Regression (LSSVR) model for tourism demand' forecasting. The hyper-parameters of the ML method were optimised using Gravitational Search Algorithm (GSA) to achieve the highest forecasting performance accuracy (Xie *et al.,* 2021).

3.2. Artificial Neural Networks in Hospitality and Tourism

ANNs modelling is the AI-based methodology that has emerged mostly in recent tourism literature (van Gerven and Bohte, 2018). An ANN is architecturally modelled using artificial neuron layers of computational units capable of receiving inputs and applying an activation function with a threshold to verify whether messages are being transmitted over the network (Kasabov, 1996). The first layer is the input layer in a basic model of ANN, followed by one or more hidden layers, and finally by the output layer. Models can become more sophisticated and have greater problem-solving abilities through increasing the number of hidden layers, the number of neurons in each layer, and the number of routes between them (Kasabov, 1996). Our review discovered that several ANN models, including MLP, Radial Basis Function (RBF), Back Propagation (BP), Genetic Algorithm (GA), Generalized Regression Neural Network (GRNN), Elman Neural Network (Elman NN), Neural Network Autoregressive NNAR and denoised neural networks have been mostly used in tourism studies (Silva *et al*., 2019). The ANN algorithms mostly have been applied to longitudinal data in the form of time-series in forecasting tourism and hospitality demands including travel, hotel, transportation, and consumers' values and satisfaction. For example, Liu (2011) applied the BP algorithm to forecasting tourists arrivals to Weifang, China (Liu, 2011). The results obtained not only had higher prediction accuracy in compared with other ML methods but showed a strong model adaptation. Golmohammadi et al., (2011) developed a hybrid neural network model to predict the happiness of travel experience. The suggested hybrid neural network could predict tourists' happiness with a low degree of error (Golmohammadi *et al*., 2011). ANN further was used to forecast tourism demand from all tourist markets in Catalonia. The accuracy performance of three ANN methods for forecasting tourist demand was compared with MLP, Radial Basis Function (RBF) and an Elman network. The results showed that MLP and RBF models outperform Elman networks (Claveria and Torra, 2014, Claveria *et al*., 2015). The ANN used in Zhu's research provided a more general context to evaluate tourism demand and forecast for Singapore over a 19-year period. The author conducted a research to resolve the concerns around the structure of dependency between tourist flows as an essential factor in the forecast of tourism demand (Zhu *et al*., 2018). Sanchez et al., (2020) also used ANN techniques to predict the most contributing variables in hotel booking cancellations using tree decision-based algorithms, C5.0 and random forest, SVM, and GA. When ANN was optimised with GA, this method achieved an accuracy of over 0.95% (Sánchez-Medina and Eleazar, 2020). ANN was also applied to Kwon's research to understand customer value in restaurants by identifying underlying factors of consumers' preferences to improve their experience (Kwon *et al*., 2020). Kwon analysed the time-series data through ML-based NLP technique and regression method and obtained high accuracy.

3.3 Deep learning Neural Networks in Hospitality and Tourism

Deep learning methods account for the highest revenue slice currently, valued at $308.4 million in 2016 and expected to grow to $16 billion by 2025, according to Tractica analysts. Figure 2 compares the methods of statistical ML and the methods of DL. As shown in Figure 2, DL is an ANN method that consists of many layers of artificial neurons and learning algorithms for identifying complex patterns from a massive amount of data samples. In the DL model, the performance accuracy can be improved by an automated feature extraction function (Goodfellow *et al*., 2016, Chang *et al*., 2020). Recent advances in DL techniques have provided more accurate forecasting of tourism demand (Law *et al*., 2019). Particularly, Recurrent Neural Network (RNN), and Long-Short-Term-Memory (LSTM) are capable of handling complex time-series data and learning long-term dependencies (Wu *et al.*, 2021, He *et al*., 2021). The DL method offers exceptional benefits in detecting high-dimensional big structural data variables with more accurate prediction and detection when compared with ML and statistical approaches (Zhang *et al*., 2020). Li and Cao (2018) examined prediction performance of BPNN, Autoregressive Integrated Moving Average (ARIMA), and the LSTM methods on tourism flow. The results showed that the LSTM is simpler, more effective, and accurate than the others. In this research, they also demonstrated the capacity of the DL to model non-linear and stochastic structures that cannot be modelled by previous linear models (Li and Cao, 2018). Chang et al., (2020) analysed hotel reviews using deep learning-based NLP to discover managerial responses through multi-feature fusion. In this model, a feature vector was fed into the convolutional neural network model, and many simple non-linear activation functions were employed to construct a complex and comprehensive model that enhances classification accuracy. Zhang's study used the DL for forecasting the daily tourist flow via user search data. In this research, the LSTM model has contributed to the dynamic observing of tourist flows, which is significant in practical terms for reducing safety risks in tourist destinations, making the achievements of this research very helpful for tourism-related industries (Zhang *et al.*, 2020). Al Shehi (2020) used the DL approach in selected Gulf Cooperation Council cities to predict the process of hotel room. The author compared four DL methods: the Seasonal Autoregressive Integrated Moving Average (SARIMA) model, the restricted Boltzmann machine as a deep belief network model, the polynomial smooth SVM model, and finally, the Adaptive Network Fuzzy Interference System (ANFIS) model. The results showed that the ANFIS performance accuracy was higher than other models in predicting prices (Al Shehhi and Karathanasopoulos, 2020). However, recently, researchers are using SARIMA–LSTM model to forecast tourist demand data at daily frequency. The authors reported that when the SARIMA combined with LSTM layers, the model could capture linear and nonlinear data features and resulted in better accuracy in the forecasting problems (He *et al.*, 2021, Wu *et al.*, 2021). Zhang et al., (2019) applied the DL method to analyse big data collected from images taken by visitors between 2008-2012 to predict tourism behavior, perceptions, and destinations. They used DL scene recognition to identify the contents of tourist photographs. Zhang's research was the first study to demonstrate the importance of spatiotemporal data and the DL approach in predicting the tourists' behaviour trajectory with greater accuracy (Zhang *et al.*, 2019). Further, authors designed a multi-layered neural network to predict hotel profitability through DL techniques using spatiotemporal data related to hotel and tourist destinations between 2005-2011. When compared to traditional ML methods, the findings demonstrated that the suggested model has a good prediction capability for hotel profitability (Lado-Sestayo and Vivel-Búa, 2019).

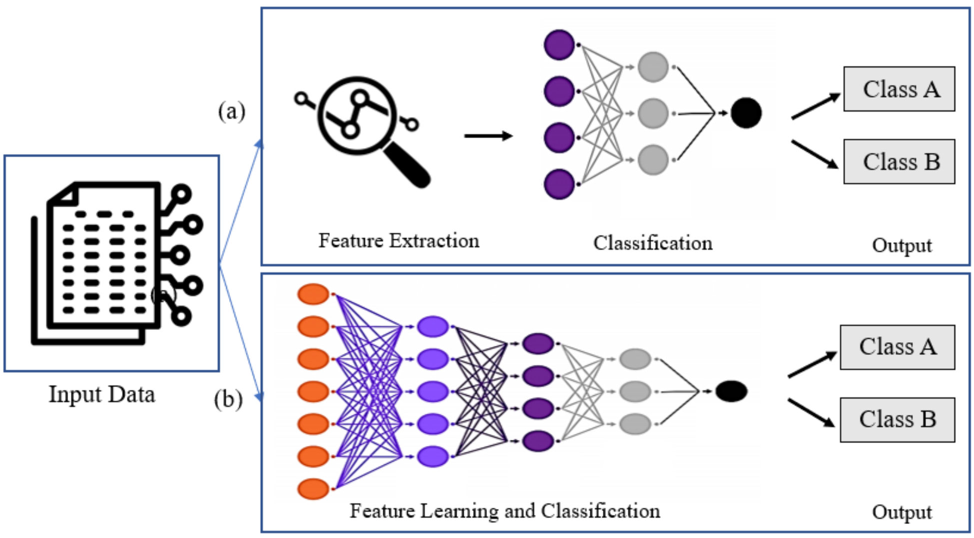

Figure 2. (a) A statistical machine learning method uses hand crafted features, which is tedious and costly to develop; (b) A deep learning neural network structure learns hierarchical representation from the data, and automatically extract meaningful features, and scales with big data.

4. The Adoption of AI-based Methods in Hospitality and Tourism Applications

The AI applications that have been launched more recently including robotics, AR/VR, and chatbot (virtual assistant), seem to be the ones that are changing the tourism and hospitality industries.

4.1 Robotics in Hospitality and Tourism

Robotics is one of the newest AI developments to enter the field of hospitality and tourism (Tussyadiah et al., 2020, Tussyadiah, 2020, Park, 2020). The International Federation of Robotics (IFR, 2016) describes it as "a robot that performs tasks for humans or equipment without the application of industrial automation". In hospitality and tourism environments, the robotics applications are primarily used for better production management and customers engagement in hotels, restaurants, and airport operations (Noone and Coulter, 2012, Ivanov *et al*., 2019a, Tuomi *et al.*, 2019, Borghi and Mariani, 2020, Choi *et al.*, 2020). The benefits of implementing robotics to the tourism and hospitality industries lie in enhancing service quality, reducing labour costs, and improving the efficiency of hotel operations (Ivanov *et al.*, 2019a, Zemke *et al*., 2020). Tung and Au (2018) examined that when robot hotel services are provided, hotel guests report better and quality experiences (Tung and Au, 2018). Hotel's robots mimic human cognition and behaviour, allowing them to recognise and anticipate the guests' motives and then provide an effective service. This is confirmed by Zhong (2020) research that studied the effect of robotics hotel services on consumers' purchase intention (Zhong *et al*., 2020). Noone and Coulter (2012) also studied how advances in robotics can enhance quick-service restaurant operations by using the case of Zaxby's (Noone and Coulter, 2012). This system monitors consumer arrivals, starts cooking as consumers arrive, and gives employees precise instructions to speed up cooking and service, thereby reducing waiting times. This data is then combined with historical sales information to forecast the demand for individual food items. Consumers, recently, have been more open and accepting of personalised and individualised experiences from robotic hotel services (Ivanov *et al*., 2019b, Çakar *et al*., 2020). The existing pandemic (COVID-19 crisis) may cause in the conversion of hospitality and tourism industries to rely more on robotic service providers (Itani and Hollebeek, 2021, Jiang and Wen, 2020). According to World Health Organisation (WHO) (Organization, 2020), adaption to the robotic service system for both providers and consumers is required as it provides a physically and socially distant service. Robots can be utilised efficiently during pandemics to provide physical separation between hosts and guests (Seyitoğlu and Ivanov, 2021)

4.2 Virtual/Augmented Reality in Hospitality and Tourism

VR technology typically uses a VR headset that simulates a virtual experience in a 3D and digital realms environments (Yung and Khoo-Lattimore, 2019). In the tourism and hospitality businesses, VR technology is becoming popular (Han *et al*., 2014, Loureiro *et al*., 2020). These industries demonstrate a 3D video to create "virtual travel", "hotel tour", and "booking interface" experiences for customers (Guttentag, 2010, Slevitch *et al*., 2020, Wei, 2019). For instance, in virtual hotel tours, consumers encounter with the hotel atmosphere, the amenities in the form of 3D visualisations and videos. Customers reported higher levels of enjoyment through virtual hotel tours experiences as VR experiences are believed to elicit greater customers arousal, greater focused attention, and time distortion than sightseeing VR experiences (Huang *et al*., 2020, Subawa *et al*., 2021). Furthermore, the research revealed that women are more influenced by VR in a virtual world than males (Lyu *et al*., 2021). Virtual booking interface is another example that enables customers to walk through an airplane and choose a seat in the aircraft in real-time and simulated experience (Samala *et al*., 2020). Unlike VR, which is a reality replication that allows users to be engaged in an imaginary environment, Augmented Reality (AR) covers virtual 3D graphics to allow connection with virtual graphics (Lau *et al.*, 2019). By overlaying knowledge on learning, AR connects high-level abstract ideas with physical and real environments, which helps learners in constructivist learning (Tsai, 2020). AR has been used in several tourism settings of historic tourist places including art exhibitions (tom Dieck *et al*., 2018), city tours, and parks (Lau *et al*., 2019). It is believed that VR knowledge and interaction can provide compelling immersive experiences and ensure environmental and socio-cultural sustainability by enhancing and expanding the experience of travel (Shin and Jeong, 2021). In a smartphone AR app, Jiang et al., (2019) explored the experiences of 323 tourists through a tourism destination in National Park in Shangri (Jiang *et al*., 2019). The findings demonstrated a strong correlation between preferences of AR experience and perceived value's functional and social dimensions. These results illustrate how AR could protect national parks while also improving the experience of tourists. Tsai (2019) also found that location-based AR technologies can improve site satisfaction for heritage tourism in Beijing (Tsai, 2020). In Dick's study (2018), visitors to an art gallery experiencing VR tours achieved better results in terms of enhancing knowledge, satisfaction, changing values, improved creativity and activity in contrast to visitors who participated the gallery without access to VR technology (tom Dieck *et al*., 2018). The introduction of AR can further promote the smooth operation of events and enrich the experience of participants. For instance, Lau et al., (2019) explored the experiences of 161 stakeholders and their intention to take part in two international conferences through an established AR app (Lau *et al*., 2019). This research can further provide helpful information on the adoption of AR in tourism and what kind of knowledge and functionality customers will be willing to see in the future.

4.3 Chatbots/Virtual Assistant in Hospitality and Tourism

A chatbot or VA is a software program that interacts with users in a natural language (Ukpabi *et al*., 2019). It is projected that by 2025, 85 percent of customers will connect to companies without a human, according to a report by Gartner, 2020. The chatbots have also been an active part of the hospitality and tourism industry. Hotels or other tourism companies have their chatbots on social media or instant messaging applications, which is available 24/7 for all 365 days in a year (Ukpabi *et al*., 2019). The tourism sectors in that chatbots are now being used chiefly are “travel chatbots”, “voice-based chatbots”, and “emotion-based chatbots” (Lv *et al*., 2021, Melián-González *et al*., 2019). Voice-based chatbots are designed to answer consumers questions, such as ordering food services, taxi services, reading notes, arranging tasks and appointments, setting alarms, room services, housekeeping services, informing hotel facilities, and etc. (Pillai and Sivathanu, 2020). Recently, the programmers are now developing the chatbot platform, which is more customer-centred and not programmer-centred, to genuinely create a chatbot that can perceive and better understand the customers’ behavior, feelings, and intentions (Pillai and Sivathanu, 2020). This is called as the emotion-related chatbots. In recent years, the technology behind emotion-related chatbot has advanced to allow the VA to convey emotions. In the traveling chatbots application, travellers can drive with no guide using the travel chatbots, as the travel chatbot can be installed in the vehicle and describe each location. This technology is also referred to as an audio tour, sometimes preferred by travellers who want privacy and travel alone with their families (Boiano *et al*., 2019, Samala *et al*., 2020).

5. Artificial Intelligence: The Future of the Hospitality and Tourism Industries

The statistics and presence of AI technologies at every step of this industry show the importance of AI in hospitality and tourism and how, by the 2030s (Statista, 2021), AI techniques and applications will become an important asset for many aspects of tourism organisation. Figure 3 presents the global economic contribution of the tourism sector that has estimated over $9 billion in 2019, according to Statista (Gross Domestic Product (GDP)) (Statista, 2021). It is projected that the development of the global AI revenue in the world market will grow rapidly in coming years and will reach from $1378.1 million in 2016 to $59748.5 million in 2025 (Statista, 2021), presented in Figure 4.

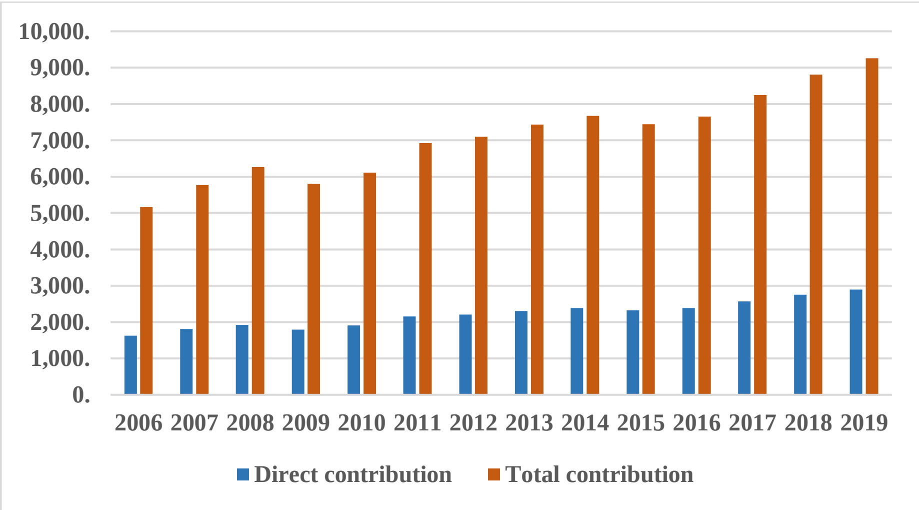

Figure 3. The global economic contribution of travel and tourism to Gross Domestic Product (GDP) from 2006 to 2019. From 2006 to 2019, the direct and total contribution of travel and tourism to GDP was calculated (in billion U.S. dollars).

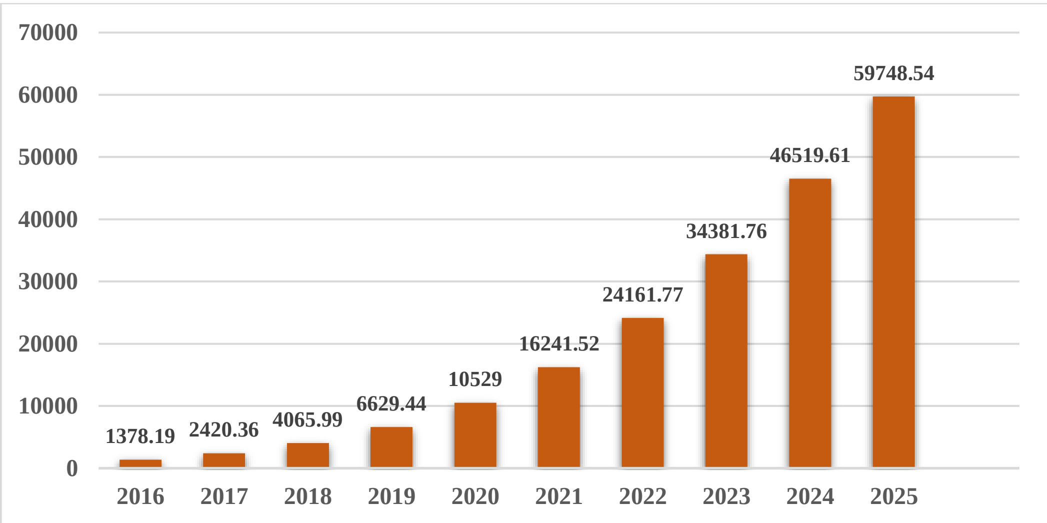

Figure 4. The revenues projection for AI market worldwide from 2016-2025 (in million U.S. dollars).

In this section, we propose a new research model that still needs to be discussed in hospitality, tourism, and AI. The proposed model depicted in Figure 5 suggests a new AI model for big multimodal data collection, proper data analysis and potential future direction in tourism and hospitality. The following sections discuss the implementations of AI in tourism and hospitality in two aspects "methodological" and "application".

5.1 Methodological-based Hospitality and Tourism Studies

5.1.1 Spatio-Temporal Data Analysis

Tourist behaviour is always contextualised in time and space. The locations influence in visitor travel patterns visited as well as the passage of time (Yunxian *et al*., 2020). In tourism, spatiotemporal data contains geographic and time information that can be used to analyse the tourists' activities, behavior, movement, and distribution (Yao *et al*., 2021) (Figure 5a). However, accurately integrating spatial and temporal information into a systematic model remains a challenge in tourism research. Most existent techniques in tourism literature create models by separately processing the space and time dimension of data. Scrutinising the interactions between geographic features in time-series data demands incorporating the temporal aspects of all features into one unifying computational model (Doborjeh *et al*., 2019). Another issue with the current statistical ML analytical tools for spatiotemporal data analysis is the lack of a deep model's interpretability (Kugele *et al*., 2020). This means understanding the relationships between temporal patterns of input variables and the projected over time outputs (Doborjeh *et al*., 2021a). Building a computational brain-inspired AI-based model could be an effective method for discovering knowledge in tourists behavior at a high-level scale. The brain-inspired spiking neural networks (SNNs) are known as the third generation of NN and are a promising architecture for creating new knowledge for spatiotemporal data. This novel computational models are considered an appropriate approach for studying the multimodal data, where both time and space components are critical to be integrated and analysed (Kasabov, 2012). In tourism studies, spatiotemporal analysis has an advantage over simply spatial or time-series analysis. It allows researcher to investigate the trajectory of behavioural patterns while also highlighting dynamic changes over time. This approach will result in a better understanding of tourist behaviour and perception, more accurate data interpolation, and greater accuracy in tourism demand forecasting applications.

5.1.2 Neuro-Tourism

As reviewed in the literature, tourism and hospitality data collection relies mainly on surveys, focus groups and observation on gathering data about tourists' thoughts, feeling, and behaviours. However, these traditional methods are suitable for revealing tourists' conscious decision-making processes. Tourists' choices involve a complex interplay of cultural, social, personal, and psychological factors. Moreover, human behaviour, preferences, feelings, and motivations are strongly affected by past experiences and stored in the unconscious mind (Doborjeh et al., 2018a). Techniques that can provide more detailed and objective information to understand and uncover these behaviours are therefore needed. Working across disciplines enables a better understanding of the characteristics of consumers behavior and how it can affect their decision and emotions (Lv *et al*., 2021). Novel technologies for exploring the neurobiological foundations of mind and behaviour have enthused the fields of tourism and hospitality studies to be open toward cognitive neuroscience and, more specifically, to brain imaging data. The neural processes underpinning behaviours that control the consumers' responses in tourism settings can be studied through brain recording techniques (Tosun *et al*., 2016). This includes Spatiotemporal Brain Data (STBD), such as Electroencephalogram (EEG), Event-Related Potential (ERP), Functional Magnetic Resonance Imaging (fMRI), and Magnetic Resonance Imaging. Brain data can be modelled and studied using advanced brain-inspired AI technologies for analysing tourists' cognitive responses to tourism-related stimuli. This leads to a comprehensive understanding of the emotional and cognitive processes of the tourists' behaviour. In the future, this interdisciplinary knowledge could initiate a new area of tourism research, called Neuro-Tourism (Tosun *et al*., 2016). This combines disciplines from traditional tourism, psychology, neuroscience, and information technology. Neuro-Tourism suggests investigating the neural mechanisms underpinning tourists' behaviour and data collection techniques to observe time-series data from human neurocognitive and behavioural features and provide big data about tourists' emotional impression, satisfaction, and acceptance (Figure 5a). AI and machine learning tools could further be employed to learn from the trend of data and extract meaningful patterns to precisely predict and classify tourism choice and behaviour (Li *et al*., 2021) (Figure 5b). This can be developed to make a smart Tourism system for forecasting tourism demand at different space and time points (Figure 5c) (Xiang *et al*., 2021).

5.2 Application-based Hospitality and Tourism Studies

5.2.1 Personalised AI applications

Our literature showed that consumers have recently been more accepting of personalised services and engagement, increasing the overall satisfaction of their experiences. Personalised approaches allow for the creation of personalised profiles of individuals that can be addressed in tourism marketing and management services (Doborjeh *et al.*, 2021b). Personalised modelling is an emerging approach that creates a model for everyone based using a group of individuals' data with similar characteristics (Doborjeh *et al*., 2019). In contrast to global modelling (the conventional AI systems), personalised modelling offers an enhanced accuracy of classification/prediction of an individual tourist behaviour as it only learns from the most relevant datasets to the individual. It also increases the model efficiency as a smaller chunk of available big data can be selected and used for AI learning algorithms (Doborjeh *et al*., 2019). Personalised modelling using AI-driven technologies can develop smart tourism platforms that learn from an individual lifestyle and past experiences to offer a list of top-matched services and make a desired travel program for each person (Figure 5c).

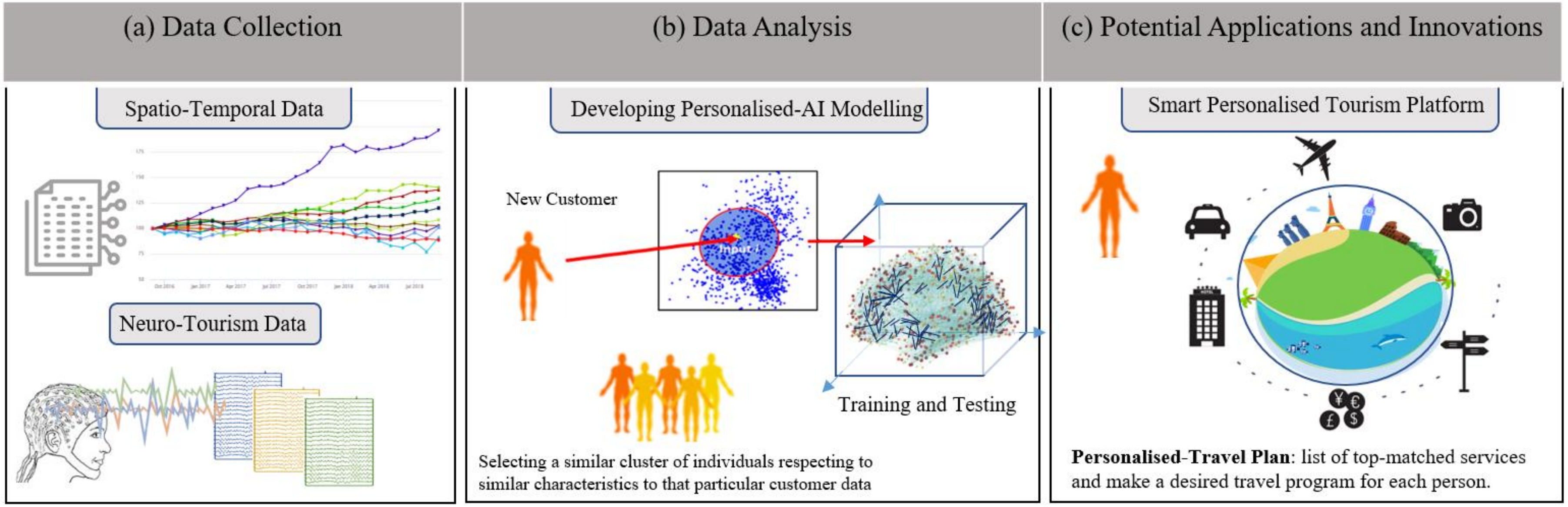

Figure 5. Proposing a model of AI research opportunities in tourism and hospitality for (a) data collection; (b) data analysis; and (c) potential application for future directions. The diagram of the data collection protocol (including demographics, self-report, and neurobiological assessments from customers; (c) In this personalised modelling system, for every new customer, a group of individuals with similar characteristics to that customer will be selected, (d) then EEG data of this group of individuals will be used to train a personalised AI model; (e) then the EEG data of the selected new customer which was excluded from the training will be used to test the model and to detect and predict a desired plan for this new customer.

6. Discussion

This paper systematically reviewed a wide range of existing and well-known AI methods in international hospitality and tourism ranging from data processing/data analysis to enhanced customer service/experience. This is the first study that reviewed and discovered new knowledge in identification of proper AI methods and algorithms with respect to the applications and the type of multimodal datasets in both hospitality and tourism. It also provided the vision of the authors (from AI perspectives) for the future use of AI algorithms in multidimensional datasets in hospitality and tourism settings. In the following a comparison of different AI approaches and their suitability for analysis and pattern mining in different application scenarios will be discussed.

In our review, ML algorithms have mostly been used in several aspects of hospitality and tourism tourists for clustering, classification, and predictions tasks. In terms of clustering approach, ML showed that the techniques such as K-mean and DBSCAN were mostly applied to image data and to detect POIs and sought to analyse the interests of visitors and their movements around the cities; and providing reasonably forecasts of the behaviours of tourists. DBSCAN is one of the most widely used clustering algorithms, as well as one of the most frequently cited in scientific literature. DBSCAN, unlike the k-means method, can detect clusters of any type of data with no limits and without specifying the clusters' number. Furthermore, because DBSCAN specifically detects noise locations, no outlier detection is required (Höpken *et al*., 2020). On the other hand, k-means method is sensitive to outliers, therefore, a distance-based outlier detection must be performed as part of the data preparation process. In terms of classification/prediction approaches, a large growth in the use of SVM method can be seen in the tourism literature, particularly for numerical data (questionnaires) in demand and consumer's behaviour forecasting applications. Unlike most traditional ML models, which use the empirical risk minimisation principle to reduce the training error, SVM use the structural risk minimisation principle to reduce an upper bound on the generalisation error (Rätsch *et al*., 2006). To enhance the forecasting performance and accuracy to support investment decision-making and planning for big data analysis, researchers attempted to find the best suitable methods by combining ML with other methods from ANN and DL.

According to our review, DL algorithms have recently gained traction in the tourist and hospitality industries, particularly after demonstrating superior performance in analysing large spatiotemporal data and forecasting accuracy when compared to other ML methods (Lado-Sestayo and Vivel-Búa, 2019). The benefit of DL models is that they reduce errors by using gradient descent. As an example, as previously indicated, BP is one of the DLNN approaches that uses gradient descent as a core component. Liu's research confirmed the significant progress made in the field of DLNN (BP) in tourism and also explains the poor performance of ML and NNs alone in forecasting tourism demand in the early years of adaptation, as well as the limitations in the learning processes in traditional models for forecasting and analysis of big tourism data (Liu, 2011). However, it is important to point out some of the BP-DLNN model's drawbacks as reported by Claveria, (2015) study. The Elman Networks-BP did not perform as accurate as the other methods of MLP, RBF. This was determined to be due to the feedback process's inability to assess the time-series' data characteristics (Claveria *et al*., 2015).

According to the overview of forecasting literature, DL models such as DL-ARIMA/SARIMA are extensively used in prediction tasks due to their simplicity of setup and use. ARIMA is used successfully in time-series data in the hospitality industry as it has the potential to carry out linear data through mapping and finding the relationship between the features. However, these models did not obtain high accuracy in forecasting task compared with other ML models.

Deep NNs have recently dominated in the various forecasting disciplines in tourism and hospitality research, having surmounted that barrier. Li and Cao (2018) applied the LSTM approach using longitudinal time series data to forecast tourism flows. The authors stressed the necessity of having more accurate models for tourism demand forecasting that will improve industry decision-makers in terms of financial sustainability. LSTM models outperformed other models in forecasting accuracy when using longitudinal tourist arrival data. The authors also demonstrated the DNN's ability to model non-linear and stochastic data that had previously been impossible to model using linear models. Furthermore, by automating feature selection engineering (Figure 2), a DL approach decreases human intervention, and hence error, from an AI standpoint. The model will optimise the features and use only the highly appropriate ones for the purpose of forecasting process. This is also confirmed by recent studies that combining SARIMA with deep learning LSTM layers potentially improved the accuracy of the forecasting problems (He *et al*., 2021, Wu *et al*., 2021).

6.1 Conclusions

This study gives insights on using proper AI algorithms through mining and comparing the suitability and applicability of the AI methods in the tourism environments. This review paper has been written by experts from interdisciplinary knowledge of AI and tourism that opens a door for widely applying the interdisciplinary technologies such as “Neuro-Tourism” and “Spatio-Temporal Data” into tourism research. Arising from this study, the merits of the new personalised AI methods provide researchers with “an enhanced accuracy of classification/prediction”, “development of smart tourism platforms” and “quickly operations under unprecedented crisis (e.g., Covid)”.

6.2 Theoretical Implications

Theoretically, this study adds to the body of knowledge in the fields of hospitality, tourism, and technology by shedding light on selecting proper use of AI algorithms in the advancement of hospitality and tourism application to accurately forecast future business conditions, revenues, as well as identifying current and potential trends in guest/tourist demand. This paper also discussed a future theoretical direction in AI that can open new applications in tourism research, which is the development of new methods for data collection, data analysis, and data modelling to have a deep knowledge representation that presents the essence of the data in a precise, concise, and understandable way.

6.3 Practical Implications

The results of this study can be used by researchers, practitioners, and decision-makers, such as private agencies and commercial companies, to select appropriate approaches and algorithms to explore AI in various tourism and hospitality situations. This paper might also serve as a useful guide for spurring future interdisciplinary research into using AI to support the development of hospitality and tourism, particularly in the post COVID-19 environment.

6.4 Limitations and Future Research

Every study output, rationally, is bound by some limitations. Similarly, there are certain limits to this article. Firstly, keywords are chosen at the expertise of the research team (AI and tourism perspectives), and much attention was taken in selecting the keywords, with a strong emphasis on the study’s theme and scope. Therefore, conducting different bibliometric techniques could provide a valuable evaluation of AI. Secondly, the method of study was based on hospitality and tourism journals on the Australian Business Deans Council’s (ABDC) journals ranking list, and future research might look at additional tools for analysis of literature that could result in a larger number of publications to be examined. As the future study, the last section of the paper emphasised on the need for a more interdisciplinary approach to tourism and hospitality that includes a wide range of academic study fields to properly comprehend the unique area of neuro-tourism and use of proper AI algorithms to make sense of data. Future research could also investigate the significant concerns associated with using AI algorithms to manage operations in various tourism sectors and industries.

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