



## Application of Machine Learning in the Hotel Industry: A Critical Review

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### Abstract

**Study purpose** – The hotel industry like any other industry is witnessing a change due to information and communication technology. However, this change is quite slow. Many researchers in recent time have garnered interest in exploring and implementing the new technologies of artificial intelligence and machine learning in the hotel industry. Therefore, the purpose of this study is to give insights on the role of ML and its integrated technologies in the hotel industry.

**Design/Methodology/Approach** – The study has critically reviewed articles published from 2010 to 2020. To achieve the research objective, the study seeks to answer three main research questions related to the existing literature; RQ1: Where does the hotel industry implement machine learning? RQ2: What are the machine learning techniques used in the hotel industry? RQ3: Which countries are using machine learning in the hotel industry?

**Findings** – The study found that machine learning is helpful in demand forecasting, price forecasting, booking cancellation prediction, financial efficiency, and work efficiency. The machine learning algorithms outperform in the forecast accuracy against the statistical models. The countries at the forefront in machine learning technologies are China and USA. The other countries should take the cue from them and implement machine learning in their hotels

**Originality of the research** – This research conducts exploratory analysis to identify the extent of scientific community knowledge and awareness on machine learning in the hotel industry. To the best of the authors' knowledge, no prior researcher has conducted a similar study specifically in the hotel industry.

### 1. Introduction

The hotel industry has become quite competitive due to globalization. New technologies are popping up including the Internet of Things, big data, artificial intelligence, and machine learning. These new technologies have successfully solved the complex human problems. While some countries have already implemented these new technologies, others are looking to use them in their hotel industry for providing quality services and maximizing profits. Nowadays, customers do not need to call the hotel staff for checking the room availability, prices, and connecting transportation. Instead, they can simply browse the hotel website and other commercial platforms (e.g., Booking.com) to access the required information with a click. They can book a room, pay the bill, and share the service feedback, all of them online with a few clicks.

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Several past studies have already reported the impact of information and technology on the hotel industry. Information and technology positively influence organizational agility and management of the hotel industry (Gonzalez, Gasco, & Llopis, 2019). The acceptance of information and technology in the Moroccan hotel industry, for instance, is mainly influenced by external factors, in addition to other factors of organizational characteristics, individual characteristics, and perceived benefits (Ezzaouia & Bulchand-Gidumal, 2020). The use of avatar in digital services positively affects the use in the hotel industry (Choi, Mehraliyev, & Kim, 2020). Additionally, testing and trial of drone-based food delivery services are underway (Hwang, Kim, & Kim, 2020). Similarly, block chain based booking, guest management, and payment services are in effect (Kizildag et al., 2019).

Many researchers have shown experimented with machine learning in the hotel industry and have gained several outcomes. For instance, hotel location evaluation (Y. Yang, Tang, Luo, & Law, 2015a), robotic room services (P.-Y. Yang, Chang, Chang, & Wu, 2018), hotel maintenance prediction (Athuraliya & Farook, 2018), separating real and fake online reviews (Antonio, de Almeida, Nunes, Batista, & Ribeiro, 2018), and predicting hotel energy demand (Casteleiro-Roca et al., 2018), predicting booking cancellation (Antonio, de Almeida, & Nunes, 2019), hotel room prices forecasting (Al Shehhi & Karathanasopoulos, 2020; Antonio, de Almeida, & Nunes, 2017; Lee & Lee, 2020). Many qualitative studies have also been reported such as discussion on artificial intelligence in the hotel industry (Ananeva, 2019; J. J. Li, Bonn, & Ye, 2019) and machine learning advantages to the hotel industry (Pelet, Lick, & Taieb, 2019; Yi, 2019).

This study critically investigates the research in the hotel industry concerning artificial intelligence, machine learning, and deep learning. Moreover, it presents the shortcomings and prospects. Many empirical studies in recent times have proved the superiority of machine learning models over the traditional one in the hotel industry for forecasting, revenue management, and improving the services.

## **2. Motivation and Research Method**

Machine learning has started getting attention for quite some time now. The healthcare, education, and energy sectors have implemented machine learning for optimized and profitable solutions. The hotel industry, which has a big footprint all over the world can enhance service quality, improve profitability, and optimize the resources by integrating machine learning techniques in their already running systems. News articles, academic manuscripts, conferences, and researchers have made this proposition. They observed that since other domains have benefited from using machine learning, the hotel industry will also have similar outcomes. There are indeed several areas in the hotel industry that require immediate attention, such as booking management, predicting profitability, revenue management, enhancing services, reachability, customer behavior analysis, measuring customer satisfaction level, hotel location assessment, and end to end customer support. However, the question arises of whether or not machine learning helps in mitigating the challenges of the hotel industry. Therefore, this study aims to answer the following research questions:

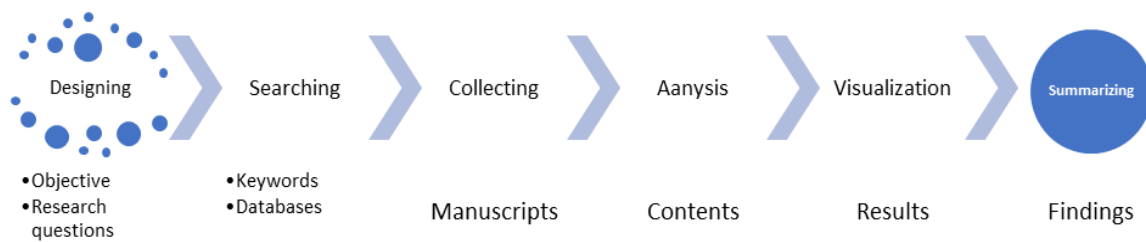
RQ1: Where does the hotel industry implement machine learning?

RQ2: What are the machine learning techniques used in the hotel industry?

RQ3: Which countries are using machine learning in the hotel industry?

The study follows the standard procedure for conducting the literature review. It begins with the objective setting and designing the research questions, followed by database searching, collecting relevant manuscripts, manuscripts content analysis, visualizing the

results, and summarizing the findings. Figure 1 shows the research design used in the completion of the study.



**Figure .1.** The research design followed in the study

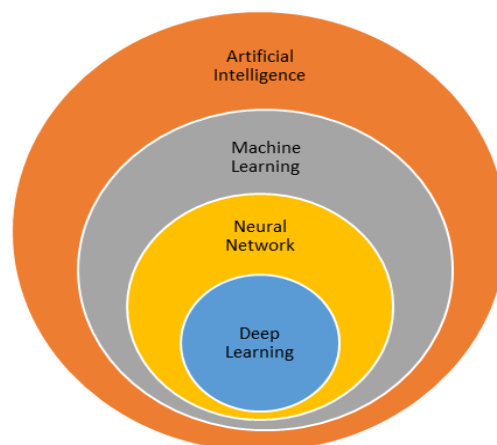
The databases used for searching the articles are Science direct, Scopus, Springer, and Google scholar. The method used for searching includes both simple and advanced search techniques provided by online databases. The keywords used for searching are “hotel industry”, “machine learning”, “artificial intelligence”, and “deep learning.” The articles are filtered based on the year of publication (2010-2020), language (English only), title, abstract, and conclusion. The articles selected for critical analysis had indexing in Scopus/SSCI. The initial search operation resulted in 3400 articles (using the keywords), and the procedure mentioned above helped to further reduce them to 70. The articles removed from the final study include duplicates present in several databases and ones not addressing the designed research questions.

### 3. Theoretical Background

This section consists of sub-sections, such as an overview of machine learning, discussion on statistical and machine learning models, machine learning applications in the hotel industry, and machine learning implementation in the hotel industry.

#### 3.1. Machine Learning: An Overview

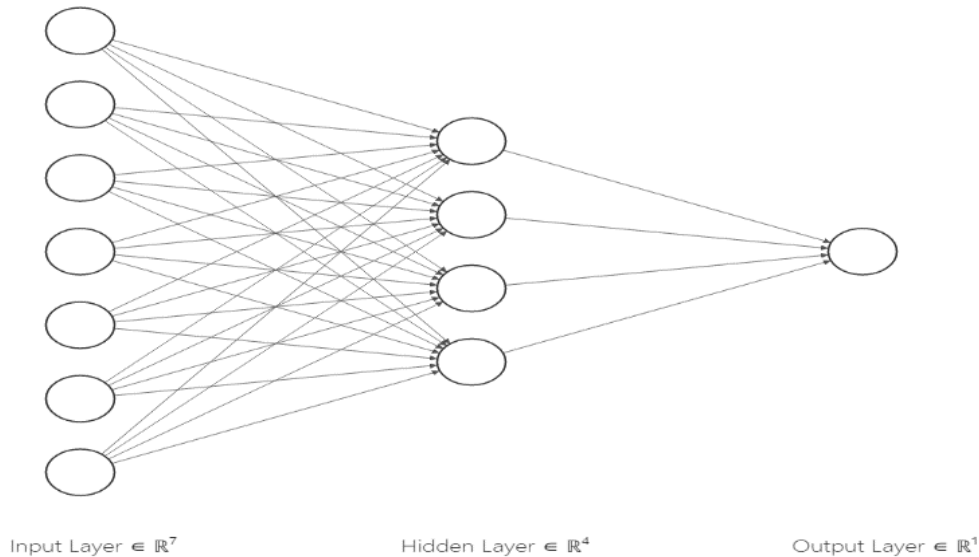
Machine learning has a wide spectrum of applications, which vary from transport to science to health. Broadly speaking machine learning is used in natural language processing, computer vision, robotic navigation, and language learning (Khan & Al-Habsi, 2020). In fact, machine learning implementation solves real-life problems, such as search engine optimization, diagnosis of disease, stock market analysis, product demand forecasting, speech recognition, object recognition, and robot locomotion. Machine learning helps process a large volume of data (Mariani, Baggio, Fuchs, & Höepken, 2018). Artificial Intelligence (AI) is a superset of machine learning. AI enables computers to perform intelligent and cognitive processes like humans do. AI applications include, search and planning, reasoning, and knowledge representation. Figure 2 shows the taxonomy of AI.



**Figure 2.** Taxonomy of artificial intelligence

Source: A state-of-the-art survey on deep learning theory and architectures (Alom et al., 2019)

The artificial neural network consists of three types of layers: an input layer, hidden layer, and an output layer. The input layer takes the data while the output layer does prediction. The hidden layer does data transformation using activation functions. Figure 3 shows the general view of neural network layers.



**Figure.3.** General view of neural network layers

Machine learning learns to model the relationship between a set of input variables and output variables. In machine learning, computers learn from data and do forecasting (Schwartz, Webb, van der Rest, & Koupriouchina, 2019). Machine learning is classified into supervised (requires a set of predefined categories or tagging labels), unsupervised (does not require data labeling), and semi-supervised learning. The prominent open-source machine learning frameworks used for predictions are TensorFlow, PyTorch, and Caeffe (Khan & Al-Badi, 2020). The commonly used machine learning algorithms are Naïve Bayes (NB), Support Vector Machine (SVM), Maximum Entropy (ME) classifier, Regression Analysis (RA), decision trees, K-Nearest Neighbors (KNN). The Naive Bayes classifier is widely used in the text classification. The ME classifier does not make any hypothesis as opposed to NB and solve an optimization problem with constraints. The Lagrange multiplier method is one of the MEs algorithms. The SVM uses optimal hyperplane represented by vector for solving the optimization problem. The kernel function in SVM transforms low dimensional space nonlinear problem to a high dimension space linear problem. The kernel functions are the linear kernel, Gaussian kernel function, radial basis function, etc. Natural language processing is (NLP) is a field of AI, where computers process digital text or speech. NLP is useful in sentiment analysis and topic modeling. The machine learning field is ever-growing since its conception. It can be seen in anthropomorphic robots, chat boxes, smart automated online assistants, hotel concierge, airport welcome staff, museum guides restaurant waters, and online service support (Van Doorn et al., 2017). For instance, the Support Vector Machine was used to model a recommender system for tourists to make a decision (Pantano, Priporas, Stylos, & Dennis, 2019). Naive Bayes, predicted the change in museum visitors with an accuracy of 75.56% (Colladon, Grippa, & Innarella, 2020). The machine learning techniques are used in content analysis, content classification, extracting the sentiments from social media posts (del Mar Gálvez-Rodríguez, Alonso-Cañadas, Haro-de-Rosario, & Caba-Pérez, 2020).

Machine learning and data mining help computers to learn from data, make predictions and discover hidden patterns. Data mining is a process that uses different methods

and techniques to extract relevant information from a huge volume of data/ big data. The data mining technique develops models based on artificial intelligence and machine learning techniques (Moro, Esmerado, Ramos, & Alturas, 2019). It identifies the patterns in complex data sets, besides managing and pre-processing the data. It is a subfield of computer science and statistics. The Decision Tree is one of the generally considered algorithms for predictive modeling in data mining (Kuzey, Karaman, & Akman, 2019). The Text mining technique uses data mining, machine learning, natural language processing, information retrieval, and knowledge management for extracting information (S. Kim & Lee, 2019). Data mining has been studied in hotel marketing and understanding the potential customers' behavior (Magnini, Honeycutt Jr, & Hodge, 2003). The text mining and sentiment analysis are extensively used in hospitality for analyzing users' reviews and feedbacks (Ye, Zhang, & Law, 2009).

### **3.2. Statistical Models (SM) and Machine Learning (ML)**

The linear statistical methods (ARIMA models) have been used in prediction and forecasting for a long time. During the 1970 and 1980s, several challenges to linear models were pointed out, and nonlinear time series models were proposed such as the bilinear model, the threshold autoregressive model, and autoregressive conditional heteroscedastic (ARCH) model (Bontempi, Taieb, & Le Borgne, 2012). The statistical modeling is a formalization of relationships between variables in the data in the form of mathematical equations, and summarizing data, with several assumptions on the data sets. For instance, linear regression assumes the existence of a linear relationship between the independent and dependent variable, homoscedasticity, mean of error at zero for every dependent value, and independence of observations. The statistical modeling is all about estimation, classification, data point, regression, covariance, and response.

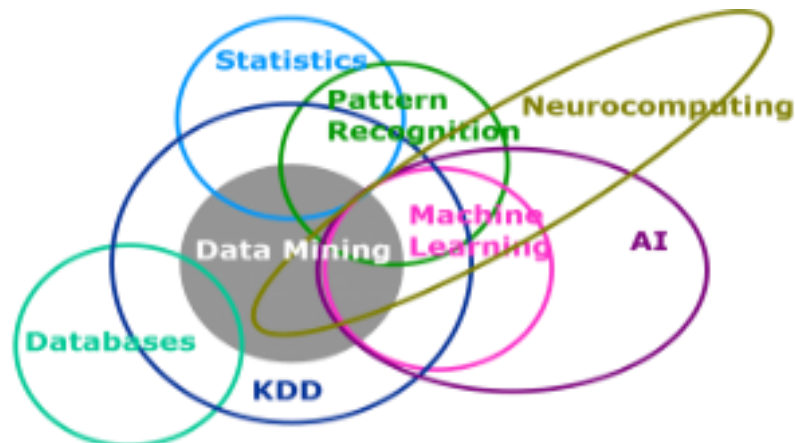
Machine learning is mainly concerned with solving prediction problems using large-scale data sets and computational power, and learning from data without relying on rules-based programming. For instance, Google translate have numbers of mathematical and statistical operations behind, but it relies on computational power and continuously evolves. Machine learning is all about learning, hypothesis, instances, supervised learning, features, and label. Machine learning models or black-box or data-driven models are nonparametric nonlinear models identifying the stochastic dependency between the past and the future using the historical data (Bontempi, et al., 2012). Artificial Neural Networks (ANNs) delivers performance better than classical statistical methods (linear regression and Box-Jenkins) (Werbos, 1988). Moreover, ANN can be employed for modeling and forecasting nonlinear time series (Laepes & Farben, 1987).

Machine learning models have now challenged the classical statistical models. Machine learning has a certain similarity, substantial overlap with statistical modeling, but they have differences in purpose and use cases. For instance, linear regression is a statistical model (minimizes the mean squared error across all the data, and no training and testing are required), and what machine learning does is find the best performance on the data sets.

The statistical models are Logistic Regression, Proportional Hazard Model, Linear Regression, Poisson Regression, Exponential Regression, and Evolutionary Polynomial Regressions. Machine learning models are ANN, Fuzzy Logic, boosting algorithms, Ada boost, Random Forest, Decision Trees, K-means clustering, Gradient-Boosted Tree (GBT), Bayes, and Support Vector Machines (SVMs). The statistical model is probabilistic, does inference, and find relationships between variables while machine learning is empirical in nature with high-order interactions. The ML, DL, and AI are alternatives to statistical models. The test data is used to validate the accuracy of machine learning prediction, whereas, in



statistical modeling confidence intervals, significance tests are used to assess the model relevancy. Figure 4 shows the relationship between machine learning and the statistical model.



**Figure.4.** Relationships between machine learning and the statistical model  
Source: Looking backwards, looking forwards: SAS, data mining, and machine learning (Mitchell-Guthrie, 2014)

### 3.3. Machine Learning Applications in the Hotel Industry and Research Gaps

Machine learning and AI have influenced the development of various industries. The hotel industry can have a new experience in terms of satisfaction and service improvements to the guests using machine learning techniques (Yi, 2019). AI and machine learning in hotel industry improve user experience, customize/individualize services, and understand consumer behavior, and predict purchasing behaviors and future trends. Machine learning is providing voices-based services to guests, such as text to speech technology, which converts and synthesizes the speaker's voice as a text and vice versa. The recommendation systems use past data to filter out information and patterns. It enables behavioral analysis and prediction. The machine learning uses these historical data sets for recommending guests to book hotels (Thomas et al., 2019). The Internet of Things and sensors can push notifications (nearby hotels, offerings, room availability, etc.) on tourist smartphones as they pass through the hotel and touristic destinations (Buhalis & Amaranggana, 2015). Furthermore, the tourists can have a path to the hotel with the shortest routes.

The integrated approach of social media, the Internet of Things, and machine learning helps in building customer relationships. Machine learning and the Internet of Things identify potential customers, and social media acts as communication tools for pushing notifications in the form of media alerts, text messages, and hotel events. Guests can check-in at electronic terminals, and the machine learning algorithms running at the background will automatically assign rooms to them based on numbers of criteria, such as length of stay, future arrivals, room features, loyalty level, and guest type. A touch screen-based signage with multisensory features. The digital signage system placed in a hotel, having machine learning software can do face recognition, separating the genders and renders the promotional offers, besides directing the guests to conference rooms, flight, and rail information.

Tablets and smart devices will replace traditional guest folders. The tablet has been used in controlling room temperature, lighting, air conditioning, booking a table in a restaurant, and providing general information on the hotel. Guests would receive promotional messages and upcoming discounts based on their web searches. The Google glass with face recognition features helps in recognizing guests by the receptionists and delivering services according to the guests' needs.

Online travel agencies (OTAs) such as Booking.com, Expedia, and TripAdvisor allow users to share opinions, recommendations, and ratings about hotel experiences. Online reviews allow customers to express their opinion about the hotel. Online reviews and ratings are directly linked to intent to book a particular hotel (Noone & McGuire, 2013). Product sales and online reviews have positive relationships (Chong, Li, Ngai, Ch'ng, & Lee, 2016). Online reviews are associated with customers' satisfaction and hence financial performance as identified in UK hotel reviews on Booking.com (Anagnostopoulou, et al 2020). The analysis of data on 14,000 hotels in 100 cities from Booking.com and TripAdvisor related to review of hotels concerning their quality, the room price, and user satisfaction confirmed the dependence of assigning stars ratings by customers (Martin-Fuentes, 2016). Another study on online reviews and responses from 128 hotels in 45 states in the U.S. observed that overall ratings and responses to negative comments are the most salient predictor of hotel performance (W. G. Kim, Lim, & Brymer, 2015). Many researchers have used machine learning for sentiment analysis and online reviews for classifications. The examples include: (1) NB and KNN for sentiment analysis of hotel (Dey, Chakraborty, Biswas, Bose, & Tiwari, 2016), (2) SVM for aspect-based sentiment analysis of hotel reviews (Chang, Ku, & Chen, 2019), (3) integrated machine learning and Natural Language Processing (NLP) techniques for identifying dimension of customer satisfaction (Guo, Barnes, & Jia, 2017), and (4) NLP for the aspect-based sentiment from hotel reviews and ratings (Akhtar, Zubair, Kumar, & Ahmad, 2017). The hotel star ratings affect room prices and customer ratings in London and Paris (Öğüt & Onur Taş, 2012). Online reviews affect both customers and hotels. For instance, managers find shortcoming of the hotel and make improvements. However, analyzing thousands of online reviews by the hotel manager is difficult and this needs automation. Machine learning does mining and clustering opinions, and helps hotel managers in quickly responding to the reviews turning unsatisfied customers into loyal customers. The mining of opinion can be feature-based like, aspect-based sentimental analysis, where aspect is extracted and aspect sentiment is classified (Pelet, et al., 2019).

These days, online reviews are more significant than traditional feedback in assessing the hotel performance metrics (Park, Kim, & Lee, 2017). Electronic word of mouth affects the online ratings of hotels (Hengyun Li, et al. 2020). Several observations of the past show that online reviews influence consumer selection of a specific hotel. Hotel credibility is affected by quality, consistency, and negative-sided online reviews in India (Chakraborty, 2019). The incoming guests' exposure to positive online reviews of a hotel would more likely book room in the same hotel (Moro, Rita, & Coelho, 2017). The more stars a hotel has, the more likely they have more positive reviews, as per the users' expectations. A model can be developed to find the relationship between a hotel, regional characteristics, and the number of reviews (Phillips, Zigan, Silva, & Schegg, 2015).

Hotel revenue management uses machine learning. The hotel industry suffers 20% of revenue due to cancellation (Morales and Wang, 2010) and the management cannot device strict policies of non- cancellation, as the guests/customers might switch to another hotel. The machine learning-based forecasting uses a neural network. The accuracy of demand forecasting is key to machine learning in hotel industry revenue management (Schwartz, et al., 2019). Social media is a source of enormous data that could have possible use in hotel revenue management by customizing packages and products using machine learning. Data protection and security policy require strict implementation. A fine and balanced strategy for cancellation prediction based on machine learning implementation ensures the customer remain loyal (Antonio, et al., 2017). Some of the studies on AI and machine learning in the hotel industry are summarized in table 1.

**Table 1**

Existing studies on machine learning/AI in hotel industry

Researcher	Summary/ outputs
(Tian & Pu, 2008)	Artificial Neural Network (ANN) for customer satisfaction
(S. Y. Kim, 2011)	Used AI techniques to predict hotel bankruptcy
(Corazza, Fasano, & Mason, 2014)	Studied use of ANN in online hotel booking
(Y. Yang, Tang, Luo, & Law, 2015b)	Used AI technique for identifying the best location for starting a hotel.
(Moon, Jung, Lee, & Choi, 2015)	Used ANN to predict the energy consumption in a hotel room
(Antonio, et al., 2017)	Produced a cancellation prediction system, based on a machine-learning model.
(Casteleiro-Roca, et al., 2018)	The machine learning model predicted power demand with 98 % accuracy in advance of 24 h.
(Pelet, et al., 2019)	Reported the cost and technological experience as an obstacle to AI
(Antonio, et al., 2019)	Machine learning implementation predicted the booking cancellation accuracy of over 84%.
(Yi, 2019)	Reported improved the hotel's financial efficiency and reduced unnecessary costs on implementing AI.
(Schwartz, et al., 2019)	Reported improved forecast accuracy using machine learning algorithmic.
(Thomas, et al., 2019)	RF algorithm implementation in recommendation systems has an edge over the GLM model, GBM, and Naive Bayes classifier.
(Ananeva, 2019)	Machine learning will improve the guests' services but will likely reduce the interaction between hosts and guests.
(Abbasi, Khadivar, & Yazdinejad, 2019)	The results of the sentiment analysis are to help to identify the accuracy of the ratings.
(J. J. Li, et al., 2019)	Competitive psychological climate (CPC) moderates the relationship between AI and robotics awareness and employee turnover intention.
(Chen & Li, 2019)	The machine learning models outperform support vector regression, boosted regression tree, and random forest regression.
(Chun, 2019)	Proposed a framework for identifying customers experience concerning self-services (i.e., check-in, room and restaurant services, check-out)
(Shin, Du, & Xiang, 2019)	The online reviews' analysis produces the best results with a combination of textual and style features.
(Shoukry & Aldeek, 2019)	CNN-DL algorithm produces accurate and errors free results as compared to other algorithms.
(Ba, Nguyen, Thang, Le, & Huynh, 2019)	The online review patterns of users from developed and developing countries are different.
(Zhang, 2019)	Machine learning approaches outperform traditional models
(Karaoglan, Temizkan, & Findik, 2019)	Conducted sentimental analysis of hotels reviews
(Al Shehhi & Karathanasopoulos, 2020)	Machine learning performance is far better than the seasonal autoregressive integrated moving average (SARIMA) model.
(Chang, Ku, & Chen, 2020)	Analyzed hotel reviews
(Sánchez-Medina & Eleazar, 2020)	Predicted hotel booking and cancellation using ANN



### 3.4. Recent Examples of Machine Learning in the Hotel Industry

**Shangri-La Hotels:** Marriott and Hilton have introduced the smart hotel concept. The smart hotel is a traditional hotel but incorporates the latest technologies and tools including AI and machine learning. The Tencent Company and Shangri-La Hotels jointly implemented a smart hotel concept in China. There are three parts to it: entering the hotel, entering the room, and using the services (Yi, 2019). While entering the hotel, face recognition techniques (Tencent cloud face recognition) and security system verify the guests' identity, allowing check-in. When entering the room, a password, automatically adjust the temperature, voice services for reporting the problem, all through Tencent cloud Xiaowei. Lights are automatically adjusted according to the surroundings, such as when sleeping and walking.

**ATOUR hotel's smart hotel system:** It has automatic guest identity verification and hotel services. The temperature, light brightness, water temperature, and heat are adjusted via mobile phone remote control (Yi, 2019). The Xiaowei voice service system and Tencent Cloud Intelligent Iota technology process all the requests.

**Platinum smart hotel system:** It is designed for secure, safe, and quality of services to guests. The platinum system has subsystems: platinum hotel management software, guest self-service system, room guidance system, public area control system, room intelligent control system, service robot, IPTV system, and card management system (Yi, 2019). The cloud-computing platform, customer relationship management, self-services, and WeChat platform have been integrated into the platinum hotel management software system. The hotel customer control system has many features, such as luxury hotel guest control system, high-end hotel passenger control system, business hotel passenger control system, personalized custom passenger control system, visual cat eye, electronic door display, identification power switch, temperature control switch, self-resetting rocker switch, induction card safe, and management software (Yi, 2019).

**Yuebin WeChat check-in system:** It includes the WeChat platform, cloud service platform, and face/fingerprint (Yi, 2019). The cloud service platform enables interoperability of information and automatic upgrade of system software while the WeChat cloud platform provides functions on WeChat. WeChat platform serves the house selection, payment identity verification, room unlocking, call services, and Check-out service evaluation.

## 4. Results

The analysis of existing literature on machine learning in the hotel industry has produced several results that could be used as a reference by future researchers. The findings are associated with the research questions RQ1 to RQ3. They are as described below.

### **RQ1: Where does the hotel industry implement machine learning?**

Machine learning has applications in different areas. Most of researchers have studied the use of machine learning in the online reviews' understanding, demand forecasting, hotel price prediction, booking cancellation prediction, and revenue management. They have used data from online reviews, Trip Advisor, Booking.com, interviews, online ratings, and surveys distributed online. Several managers found that applying machine learning in understanding customers' behaviors and message customization leads to enhanced satisfaction, and loyalty (Pelet, et al., 2019). In a study, the power demand prediction was made in advance of 24 h with an accuracy of around 98% (Casteleiro-Roca, et al., 2018). The 4- Star hotels in Portugal were able to save revenue of approximately € 39,000.00 using machine learning predicting techniques for cancellation (Antonio, et al., 2019). In China, the machine learning-enabled, WeChat platform, cloud service platform, PMS, face/fingerprint device, networked door lock, room power controller, room guidance system, public area control system, room intelligent control system, and service robot helped to save marketing cost of 115,000 Yuan (Yi, 2019).

TripAdvisor reviews help in understanding the customers' satisfaction in Chinese cities (Hongxiu Li, et al. 2020). Table 2 shows the different areas covered by machine learning in the hotel industry after analyzing the existing literature.

**Table 2**

Machine learning in the hotel the industry after analyzing the existing literatures

Machine learning/AI in the hotel industry	Country
Predicting hotel prices	GCC
Aspect based sentiment analysis and aspect extraction	China
Association between employee awareness of AI and robotics and turnover intentions	China
Forecasting hotel room demand	China
Identifying hotel location for business success	China
Problems of modern hotel industry and solutions	China
Self-services experience	China
Customer satisfaction	China
Benefits related to information privacy, usefulness, ease of use	Europe
Hotel services, guest-host relationships, and working processes	Finland
Deciding bookings to accept and reject	Portugal
Predicting the booking most likely to get canceled	Portugal
Predicting the energy consumptions	Spain
Prioritizing the positive and negative reviews	UK
Predicting the hotel attributes	USA
Hotel recommendation system	USA
Reviews values through the writing style	USA
Demand analysis	Vietnam
Predicting hotel bankruptcy	Korea
Hotel reviews' analysis	Turkey
Hotel reviews' analysis	Worldwide
Online hotel booking	Worldwide
Analysis of forecasting hotel demand	Worldwide
Hotel booking and cancellation prediction	Worldwide
Booking prediction	Worldwide
Revenue management	Worldwide
Modeling energy consumption in the room	Worldwide

### **RQ2: What are the machine learning techniques used in the hotel industry?**

There are number of machine learning techniques and algorithms that have been used in the hotel industry. Researchers have used XGBoost, Naive Bayes Classifier (NB), Generalized Linear Model (GLM), Multinomial Naive Bayes (MNB), Extreme learning machine (ELM), support vector regression (SVR), Boosted Regression Tree (BRT), Random Forest Regression (RFR), Natural language processing (NLP), Convolutional Neural Network-based Deep Learning (CNN-DL), and Nearest Neighbors. Some of the machine learning algorithms have advantages over another in the hotel industry in forecasting. For example, accuracy is as 93.47% (ME), 87.82% (NB) and 86.34% (SVM) (Zhao, Dong, & Yang, 2015), Gradient Boosting is more effective than SVM (Arruza, Pericich, & Straka, 2016), and machine learning algorithms outperform Seasonal Autoregressive Integrated Moving Average (SARIMA) (Al Shehhi & Karathanasopoulos, 2020). Table 3 shows the machine learning algorithms used in the hotel industry.

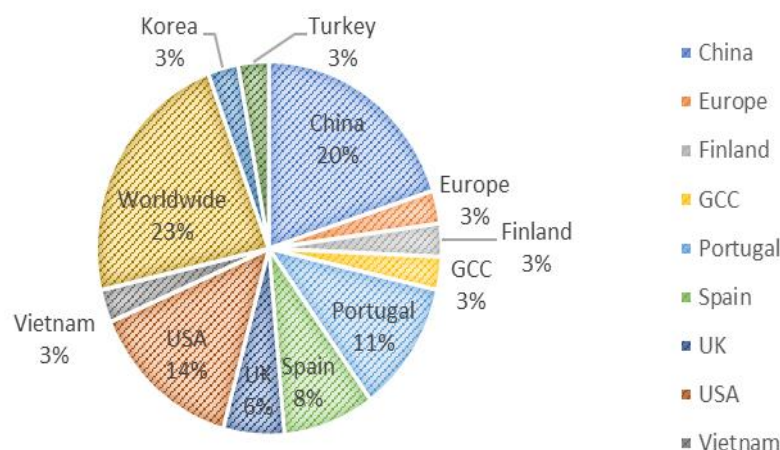
**Table 3**

Machine learning algorithms used in the hotel industry

Years	ML/AL algorithms used in the hotel industry
2008	ANN
2011	SVM and ANN
2013	ANN
2015	Naive Bayes (NB), Maximum Entropy (ME), Support Vector Machine (SVM), ANN, Support vector regression, and Boosted regression
2016	Naive Bayes, SVM, and Gradient Boosting
2017	XGboost tree boosting
2018	Multi-Layer Perceptron (MLP) (feedforward Artificial Neural Network), Levenberg-Marquardt
2019	Multiple convolutional neural networks (CNN), GloVe pre-trained word embedding, Gradient tree boosting algorithm XGBoost, Naive Bayes Classifier (NB), Generalized Linear Model (GLM). Random Forests (RF), Gradient Boosting, FCNN, Multinomial Naive Bayes (MNB), Linear Support Vector, Extreme learning machine (ELM) support vector regression (SVR), boosted regression tree (BRT), random forest regression (RFR), Natural language processing (NLP), convolutional neural network-based deep learning (CNN-DL), Neural Network, Nearest Neighbors, Tree, Recurrent Neural Network (RNN), and Support Vector Machine
2020	Deep belief network (DBN), polynomial smooth support vector machine model, and adaptive network fuzzy interference system (ANFIS)

**RQ3: Which countries are using machine learning in the hotel industry.?**

The machine learning implementation in the hotel industry in different parts of the world is fragmented. China is leading in the implementation of machine learning in the hotel industry. The USA is in the second position followed by Portugal, Spain, UK, and the rest of the countries. Customers from developed countries and developing countries have distinct patterns and acceptance of machine learning-enabled Internet of Things devices (Ba, et al., 2019). Figure 5 shows the distribution of machine learning implementation in different parts of the world after analyzing the existing literature.

**Figure .5.** Machine learning implementation in different parts of the world after analyzing the existing literature

## 5. Existing Research Issues in Hotel Industry

Studies in the area have mainly analyzed the reviews of social media and hotel booking platforms. As pointed out, the hospitality industry, mainly the hotel sector is subject to numerous risks and fluctuations, such as variation in the demand and supply of hotel rooms, seasonal dependency, energy costs, workers' healthcare, and insurance (Penela & Serrasqueiro, 2019). Moreover, the industry stakeholders, despite less accurate results, still extensively employ the traditional approach of data analysis. For instance, analysis of articles on the hospitality industry published between 2013 and 2016 have exhibited the use of traditional approaches, such as autoregressive moving-average models (ARIMA) models for data analysis, even though they are inferior to machine learning models (Moro, et al., 2017).

The other studies revolve around theory, benefits, and comparisons of machine learning algorithms. The AI has been able to deliver fast solutions to complex tasks with precision and regularity, which are often hard for a human, besides being computationally expensive (Sigala, 2018). There is a limited number of studies on the use cases of machine learning in the hotel industry, and they have originated in China, with few hotel companies, such as **Yuebin WeChat check-in system and Platinum smart hotel system** (Yi, 2019).

Furthermore, the participation of the hotel industry in the new technology implementation is not uniform around the world. China accounts for 20% while USA 14%. Spain, UK, Portugal, and others have taken the initiative, while the other European nations have not come up with a plan. The Gulf Cooperation Council (GCC) countries in the middle east though not below but at equal terms with European nations concerning machine learning research and development in the hotel industry.

The investment in the strategy and technological infrastructures such as the Internet of Things, robotics, and software platforms have fewer takers. The industry is abundant with data complexity, labor-intensive operation, and satisfactory customer service is required, here the opportunity provided by natural robotics and artificial intelligence will help the industry (Gursoy, 2018). Additionally, a psychological fear exists on job loss due to new technology. Robots and other technology will take the jobs of the hotel laundry department, room service deliveries, luggage handling, online customer services, cooks, and cashiers (Hsu, 2018), but it will open the other venue for the new job seekers. It is hoped that hotel companies continue to explore the feasibility of robotics and artificial intelligence in lowering their operational costs (Gursoy, 2018).

## 6. Future Direction

The hotel industry researchers are required to investigate numerous areas that have been missed out of machine learning. The three most important areas entitled to get focus in future research for machine learning design are the services quality, revenue management, and management strategy. All three are interlinked and management strategy controlling the other two. The hotel industry will improve service quality and generate more revenue by strategically taking automation decisions. First, they need to focus on their infrastructure in terms of the latest hardware and software technologies. The sensors, Internet of Things, wearables, service robots, digital devices, web pages, mobile apps, and cloud services will smoothen the information flow and at the same time act as a sink for data. Users will have more interactive services and accessibility at ease. The stakeholders in the hotel industry are from different strata of society, so it is very important to understand their behavior and render services according to their tastes, needs, and desires. On top of everything, machine learning will skillfully execute the job of prediction, forecasting, demand and supply analysis, and service gap analysis, by applying algorithms on the already generated data because of

stakeholders' interaction with different services of the hotel industry. The hotel companies can look to the government and talk to banks for financial support to execute the plan.

Moreover, hotels need to give technical training to their staff and organize workshops to overcome the security and privacy concerns related to the use of technologies and machine learning-based prediction. Despite the many advantages, disadvantages of machine learning lie in reduced interactions between guests and hosts using machine learning-enabled Internet of Things devices as reported by some researchers, which is true to some extent. The enhancement of the cognitive capabilities of the existing humanoid robots cannot solve the problem.

The automation will reduce energy consumption and strengthen environmental sustainability in the hotel industry since the lights and switches will get into the working mode as when desired. Taking social, weather, environmental factors, and others into consideration, machine learning will help the hotel management to issue a travel advisory, and cause flexibility in cancellation and re-scheduled booking. Guests and hosts will be in a win-win situation.

## 7. Conclusion

The hotel industry is evolving to take up the new technologies of machine learning, but it needs to do more to address the challenges. Machine learning has received wide acceptance in various domains. Additionally, machine learning algorithms outperform forecast accuracy as compared to the statistical models. The application consists of image processing, computer visions, natural language processing, and robotics. The hotel industry has taken relatively a very small step towards this new technology. To date, demand forecasting, price forecasting, booking cancellation prediction, financial efficiency, and work efficiency are the only areas in the hotel industry served by machine learning. Moreover, the existing researches have few uses cases. The machine learning benefits in the hotel industry is undeniable, including understanding consumer behaviors. The management can control the services, price range, and hotel atmosphere but the social influence is difficult to control, and these factors affect hotel choice, booking intent, cancellation, hotel staying period, and purchasing other hotel services. The machine learning-based online review analysis must consider response time, response rate, hotel rating, textual features, and writing style features before gaining insights into customer behaviors. China and USA account for 20% and 14% of the existing research and development concerning machine learning in the hotel industry. Portugal, Spain, UK, and other countries have few studies. In the Middle East, the GCC countries have substantial stakes.

Future research needs evaluation of machine learning design in services quality, revenue management, and development of management strategy. Additionally, the first-time implementation needs financial support from the government and banks. The truth is that soon robots and machine learning will replace the repetitive and low-skill tasks of the hotel industry. The hotel management needs to prepare themselves for giving training to their staff and lecture seminars to reduce the negative perceptions towards machine learning technology.

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## تطبيق التعلم الآلي في صناعة الفنادق: مراجعة نقدية

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### المفص

تشهد صناعة الفنادق تغييراً كبيراً بسبب تكنولوجيا المعلومات والاتصالات، حالها في ذلك حال باقى الصناعات. ومع ذلك، فإن هذا التغيير ليس سريعاً. وعليه فقد أولى عدد من الباحثين في الآونة الأخيرة اهتماماً بالغاً لاستكشاف وتنفيذ التقنيات الجديدة المتعلقة بالذكاء الاصطناعي والتعلم الآلي في صناعة الفنادق. ولذا، فإن هذه الدراسة تسعى للإجابة على ثلاثة أسئلة بحثية رئيسية بناءً على الأبحاث الجديدة في قطاع الفنادق: س1: أين تنفذ صناعة الفنادق التعلم الآلي؟ س2: ما هي تقنيات التعلم الآلي المستخدمة في صناعة الفنادق؟ س3: ما هي الدول التي تستخدم التعلم الآلي في صناعة الفنادق؟، وبناءً على البحث والتقصي في الدراسات السابقة، فقد خلصت الدراسة الحالية إلى أن التعلم الآلي مفيد في التنبؤ بالطلب والتنبؤ بالأسعار والتنبؤ بإلغاء الحجوزات والأداء المالي للفنادق، وبالتالي كفاءة العمل. حيث تتفوق خوارزميات التعلم الآلي في دقة التنبؤ مقارنة بالنماذج الإحصائية التقليدية. ويتضح من الدراسات والتجارب السابقة أن الدولتين اللتين تتصدران تقنيات التعلم الآلي هما الصين والولايات المتحدة الأمريكية. وتكمن أهمية هذه الدراسة في أنها دراسة مقارنة تعتمد على التحليل الاستكشافي بهدف تحديد مدى معرفة المجتمع العلمي ووعيه بالتعلم الآلي في صناعة الفنادق.

### معلومات المقالة

#### الكلمات المفتاحية

صناعة الفنادق؛ التعلم الآلي؛ الذكاء الاصطناعي؛ التعلم العميق؛ إدارة الفنادق.

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