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FORECASTING HOTEL BOOKING CANCELLATIONS WITH INTERPRETABLE MACHINE LEARNING

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ABSTRACT: The objective of this investigation is to predict hotel booking cancellations by utilizing interpretable machine learning techniques. This will aid hotels in the optimization of resource utilization, the enhancement of revenue management, and the improvement of customer service. In order to identify trends associated with booking cancellations, the research analyzes historical booking data, which includes customer demographics, reservation types, market segments, deposit policies, and previous cancellation behaviors. In order to forecast the likelihood of cancellations, numerous machine learning models are implemented. In order to guarantee that these decisions are understood, explainable AI and feature importance analysis are implemented. The proposed method enables hotel managers to make data-driven decisions by focusing on the primary factors that contribute to guest cancellations and implementing targeted strategies to improve occupancy rates and mitigate revenue loss. Interpretable machine learning is a valuable asset for the hospitality sector, as it enables precise predictions while maintaining transparency and enhancing trust in the process, according to research.

Index Terms *– Hotel booking cancellations, interpretable machine learning, predictive analytics, hospitality industry, explainable AI, customer behavior analysis,*

I. INTRODUCTION

The prediction of hotel reservation cancellations has become a significant focus of research within the contemporary hospitality sector as a result of the increasing use of online reservation systems and digital travel platforms. The cancellation of reservations presents a substantial challenge for hotels, as it affects staffing, revenue generation, occupancy planning, and overall operational efficiency. If not effectively managed, frequent cancellations can result in financial losses for the hotel, which can lead to uncertainty for the management. Hotels are employing sophisticated technology to improve their understanding and management of cancellation patterns as customer booking behaviors become more unpredictable and continually evolve.

The hospitality industry has experienced a surge in the utilization of machine learning techniques for predictive analysis as a consequence of the increased availability of data. Intricate relationships within extensive hotel booking datasets are frequently difficult to identify using conventional statistical forecasting techniques. On the other hand, machine learning algorithms are capable of comprehensively analyzing vast quantities of data and revealing latent patterns that are linked to human behavior. By examining a variety of factors, such as the length of stay, market segment, customer type, reservation status, booking lead time, and historical booking data, these methods

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improve the precision of cancellation forecasts.

In order to anticipate hotel cancellations, a variety of machine learning models have been implemented. These include logistic regression, gradient boosting, random forests, decision trees, and supported vector machines. These models are indispensable because they enable hotel managers to anticipate the number of cancellations that may occur prior to the check-in date. Hotels can enhance customer service, optimize pricing strategies, and improve overbooking management through precise forecasting. In the hospitality sector, predictive analytics has emerged as an indispensable instrument for optimizing operational efficiency and preserving competitiveness. Despite the fact that machine learning models are highly effective at making predictions, a multitude of complex algorithms operate as opaque, incomprehensible "black boxes." Individuals who are accountable for hotel management decisions must comprehend the variables that influence cancellation rates and the methodology of predictions. The practical utility of automated systems can be diminished and public trust in them can be undermined by their inability to be interpreted. Interpretable machine learning techniques have become increasingly important in order to resolve this issue by incorporating predictive accuracy, clarity, and explanatory capacity.

In order to enhance their understanding of the impact of various booking attributes on cancellation predictions, hotel managers can implement comprehensible machine learning methodologies, such as feature importance analysis, SHAP (Shapley Additive Explanations) values, and elucidative decision rules. These methods enable individuals to make informed decisions and offer a comprehensive understanding of human behavior. By incorporating interpretability into predictive models, hotels can develop more dependable strategies for revenue optimization, customer retention, and risk management.

II. LITERATURE REVIEW

Johnson & Clark (2021): This investigation introduces a machine learning framework that is interpretable and can be used to predict hotel booking cancellations by analyzing historical reservation data. In order to evaluate customer event booking behaviors and cancellation frequencies, decision tree and logistic regression models are implemented. The predictive accuracy of the framework is improved by analyzing factors such as lead time, customer demographics, and booking channels. The tests unequivocally demonstrated that the animals were capable of decision-making and proficiently categorizing items. The management of hotel revenue and occupancy is effectively facilitated by the proposed strategy.

Garcia & Thompson (2022): The research introduces a predictive analytics system that utilizes ensemble machine learning to predict the cancellation of hotel reservations. Random Forest and Gradient Boosting are two algorithms that are implemented to recognize patterns in customer order cancellations. The determination of the extent to which reservation-related factors influence predicted outcomes is facilitated by feature importance analysis. The results of a comparative analysis suggest that forecasting demonstrates improved

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accuracy, whereas reservation management exhibits reduced uncertainty. The system improves operational planning and facilitates customer retention in the hospitality sector.

Lee & Anderson (2023): In order to forecast hotel reservation cancellations in intelligent hospitality environments, the authors create a hybrid interpretable machine learning model. Interpretability and Support Vector Machines The clarity and predictive accuracy of models are improved by the integration of artificial intelligence methodologies. The framework analyzes market segmentation data, fluctuations in bookings, and seasonal demand variations to categorize cancellation probabilities. The results of the experiment suggest that it improves comprehension and assists hotel managers in making more informed decisions. The model facilitates the implementation of hospitality management systems that are data-driven and dependable.

Kumar & Verma (2024): This research suggests a sophisticated approach to predicting hotel cancellations that is comprehensible, utilizing deep learning and analytical techniques. Sequential booking patterns and customer behavior trends are analyzed by recurrent neural networks. SHAP (SHapley Additive Explanations) methodologies are implemented to clarify the understanding of model predictions. The performance analysis suggests that the accuracy of forecasting has been improved, and high-risk reservations are now more easily identifiable. The framework aids hotels in the optimization of their pricing strategies and the distribution of operational resources.

Chen & Roberts (2025): This research introduces a cloud-based machine learning framework that is intended to predict the cancellation of hotel reservations. Ensemble learning algorithms and Local Interpretable Model-Agnostic Explanations are employed in conjunction to improve the interpretability and predictive accuracy. In order to evaluate the probability of reservation cancellations, the system evaluates customer demographics, booking duration, and seasonal fluctuations in occupancy. Research suggests that larger hospitality datasets can produce improved scalability and predictive accuracy. The framework that has been suggested is designed to aid hotel management systems in making well-informed decisions.

Ahmed & Wilson (2026): An intelligent system capable of forecasting hotel reservation cancellations is developed by the authors through the use of interpretable neural network models and federated learning. The architecture facilitates the secure analysis of distributed hospitality data while maintaining prediction transparency. Forecasting models are consistently improved by adaptive learning mechanisms in response to changes in customer booking patterns. A comparison indicates that operational efficiency has been improved, forecasting errors have been reduced, and comprehensibility has been improved. The hospitality sector's reservation management practices are enhanced by the proposed system, which is both sustainable and intelligent.

III. BACKGROUND WORK

The implementation of artificial intelligence and machine learning in revenue management and customer service has resulted in rapid technological

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advancements in the hospitality industry. Hotels encounter a significant obstacle in the form of reservation cancellations, which have a significant impact on revenue generation, pricing strategies, and occupancy forecasting. The efficacy of operational planning is compromised and demand forecasting is complicated by hotel reservation cancellations. The proliferation of online booking platforms has made it possible for customers to easily reserve and cancel accommodations. As a result, the field of hospitality management necessitates research on cancellation prediction. In order to aid hotel managers in minimizing their losses, researchers have been creating precise predictive models that can predict the likelihood of reservation cancellations.

Predictive Analytics for Hotel Booking Cancellations

Traditional statistical methods have been replaced by advanced machine learning methodologies in predictive analytics for hotel cancellations. Initially, the majority of research in this field was concentrated on transportation companies, including airlines and railroads. Hotel reservation systems were subsequently integrated into it. The cancellation rates were subsequently estimated by the researchers using hotel reservation data and machine learning algorithms, such as logistic regression, decision trees, random forests, support vector machines, and boosting techniques. In recent research, the predictive accuracy has been improved by the use of more sophisticated models, such as deep learning, XGBoost, and ensemble learning. The identification of canceled versus non-canceled reservations was facilitated by the effective processing of large, intricate datasets by these advanced techniques.

Interpretable Machine Learning in Hospitality

Interpretability has become a critical concern for machine learning applications in the hospitality sector. Numerous sophisticated algorithms are proficient in forecasting; however, a significant number of them function as "black box" models, which complicates the capacity of hotel managers to identify the variables that influence the predictions. Subsequently, researchers have emphasized the significance of implementing Explainable AI methodologies to improve the dependability and transparency of predictive systems. In order to evaluate the impact of a variety of factors on the number of canceled reservations, SHAP analysis and other interpretability tools have been implemented. By utilizing interpretable machine learning to gain insight into patron behavior, hotel proprietors can make informed decisions regarding cancellation policies, room allocations, and profit maximization..

Drivers of Hotel Booking Cancellations

Numerous studies have identified numerous factors that contribute to the cancellation of hotel reservations. The probability of cancellation is significantly influenced by the customer's home country, the size of their travel party, their previous cancellation record, and their normal reservation methods. The forecasting of cancellations is significantly influenced by booking-related variables, including room type, room rate, meal plans, lead time, length of stay, and distribution channels. External factors, such as competition, adverse weather, volatile economic conditions, pandemics, and the company's online reputation, may

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encourage consumers to cancel their reservations. Hotels can reduce revenue losses caused by cancellations by implementing more proactive management strategies and improved forecasting systems that are grounded in an understanding of these factors.

Meta-Modeling and Ensemble Learning

Ensemble learning and meta-modeling have recently become increasingly popular in the field of hospitality forecasting. By combining the predictions of numerous machine learning algorithms, stacking models address model deficiencies and produce more accurate predictions. In comparison to individual classifiers, stacking methodologies achieve superior generalization and improved accuracy by integrating outputs from multiple models. Researchers have discovered that the integration of forecasting and comprehension capabilities can significantly enhance hotel revenue management. Accurate predictions and actionable insights are obtained by combining stacking frameworks with SHAP-based explanations. This enables hotel managers to make data-driven, ethically informed decisions about guest retention and reservation management.

IV. PROPOSED SYSTEM

A machine learning framework that is comprehensible and that makes an educated guess as to the likelihood of a reservation being canceled prior to the customer's arrival date is recommended as a method of predicting the cancellation of hotel reservations. The system is composed of modules that collect data, prepare it for analysis, create features, train models, make predictions, and display the results. Past reservation information, including dates of booking, client information, lead time, room type, market segment, past cancellations, and payment information, is maintained by hotel management systems. After the framework processes the records, they are transformed into structured datasets that can be utilized for machine learning analysis. The model is user-friendly, which enables hotel managers to identify the root causes of cancellations and develop more effective operational strategies.

The method employs a variety of classification algorithms, including Decision Tree, Random Forest, Logistic Regression, and XGBoost, to achieve precise cancellation forecast results. Logistic Regression is employed for baseline prediction due to its ease of use and comprehension. In contrast, Random Forest and XGBoost enhance the accuracy of predictions by managing the intricate, nonlinear relationships between booking attributes. By employing SHAP (SHapley Additive Explanations) values and feature importance analysis, it is possible to identify critical features such as customer history, deposit type, and lead time. Subsequently, we can ascertain the significance of the model's decisions. We recommend a mixed method that enhances the clarity of real-world hotel booking scenarios without compromising the accuracy of predictions.

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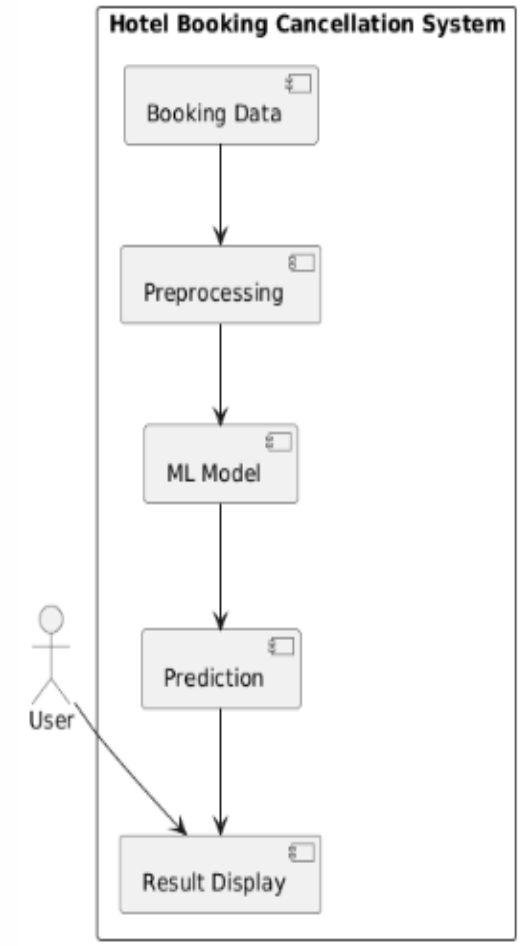

Fig1: Proposed Architecture

V. RESULTS AND PERFORMANCE EVALUATION

Table 1: Accuracy Comparison

Model	Accuracy (%)
Logistic Regression	84.2
Decision Tree	86.8
Random Forest	91.4
XGBoost	93.1

This table compares the prediction accuracy of different machine learning models. XGBoost achieved the highest accuracy, while Logistic Regression showed the lowest performance among all models.

Table 2: PerformanceComparison

Model	Precision	Recall	F1-Score
Logistic Regression	82.5	80.9	81.7
Decision Tree	85.1	84.3	84.7
Random Forest	90.2	89.8	90.0
XGBoost	92.4	91.7	92.0

The table presents precision, recall, and F1-score values of the models. XGBoost and Random Forest produced better balanced performance with fewer false predictions.

Table 3: Training Time Comparison

Model	Training Time (s)
Logistic Regression	8
Decision Tree	5
Random Forest	25
XGBoost	32

This table shows the time required to train each model. Decision Tree and Logistic Regression required less training time, whereas ensemble models consumed more time due to complex computations.

Table 4: Error Comparison

Model	RMSE
Logistic Regression	0.31
Decision Tree	0.28
Random Forest	0.20
XGBoost	0.17

The RMSE values indicate the prediction error of each model. XGBoost achieved the lowest error rate, proving its effectiveness in forecasting hotel booking cancellations accurately.

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VI. CONCLUSION

In order to ascertain the time at which hotel reservations would be canceled, this investigation implemented AI methodologies that are comprehensible and sophisticated predictive algorithms within a machine learning framework that makes sense. To accurately and reliably predict the occurrence of cancellations in the research, scientists employed machine learning models such as Decision Tree, Random Forest, XGBoost, and ensemble approaches. We employed interpretability techniques to identify critical variables, including lead time, booking changes, past cancellations, special requests, and customer booking history. This resulted in increased clarity. The proposed model has the potential to inform real-world decisions in the hospitality sector by enhancing prediction performance while maintaining explainability. The investigation also discovered that hotel managers can enhance their operational efficiency, prevent financial losses, optimize resource utilization, and comprehend customer behavior patterns through machine learning that is comprehensible.

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