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AI-Enabled Sentiment Mining of Homestay Reviews for Sustainable Tourism Quality Assessment in Uttarkashi

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Abstract

A large number of user reviews have been generated via rapid growth of online travel platforms that provide rich information about visitor experiences and service quality. Unfortunately, the open-text nature of these reviews restricts analysis by manual means and is rudimentary in nature. The study presents an artificial intelligence-based framework for analyzing tourism quality assessment through hospitality reviews, owned by sustainable homestay tourism in Uttarkashi, Uttarakhand. The proposed framework is evaluated using a publicly available hotel-review dataset of 80,121 reviews. The methodology combines text preprocessing, sentiment classification and aspect-level analysis for visitor perceptions with respect to factors like service quality, cleanliness, location, room quality, value for money and sleep quality. A comparison of sentiment-classification performance between the conventional machine-learning models (Logistic Regression, Support Vector Machine, Random Forest and XGBoost) against a fine-tuned BERT model. Then, the mined aspect-level sentiment patterns are interpreted to evaluate tourism-service quality and find suitable hotel strengths and weaknesses. The transformer-based BERT model outperforms traditional approaches for hospitality-review analysis, as evidenced by experimental results. Our proposed framework presents an intuitive and practical way to convert raw visitor feedback into tourism knowledge that is actionable, which can also help accelerate data-driven decision-making for sustainable tourism development and homestay quality improvement.

Keywords: Sustainable Tourism, Homestay Tourism, Tourism Quality Assessment, Sentiment Analysis, Natural Language Processing.

INTRODUCTION

Uttarkashi, the Kashi of North India is one of the beautiful district has been a midpoint for spiritual, meditation, devotion and adventure for centuries which attracting tourist from worldwide. A small district of Uttarakhand (an Indian state) encompasses the Gangotri National Park and Govind Pashu Vihar Wildlife Sanctuary, the source of the holy river Ganga at Gaumukh glacier, and a dense network of traditional villages maintaining Garhwali cultural practices.

Overall tourism is vital to regional economic development and provides direct, indirect and induced employment opportunities whilst also enhancing entrepreneurship through cultural exchange in sensitive rural areas. Homestay tourism in Uttarakhand is a means of participation for local communities through which they can engage directly and handle the tourism business while also allowing visitors to experience an authentic stay within the region, experiencing its culture and natural environments. The Himalayan surroundings, access to pilgrimage sites, trekking routes and rural population observing monthly patterns endow large scale scope on homestay-based tourism in Uttarkashi. On the other hand, a sustainable tourism development needs to improve accommodation quality and visitor expectations. Online reviews offer great insights into the experiences of tourists, including aspects such as cleanliness, hospitality, food, location, amenities, accessibility and pricing; however, given that they are unstructured and large-scale in nature – manually analyzing them can be cumbersome. Advances in Artificial Intelligence (AI), Natural Language Processing (NLP), and transformer-based models have made it possible to automatically extract important information from reviews of tourism and hospitality.

Traditional sentiment analysis usually classifies reviews as positive or negative without pinpointing to what particular service attributes are attributed to visitor satisfaction or dissatisfaction. Aspect-Based Sentiment Analysis (ABSA) overcomes this limitation by linking sentiment to particular aspects of an experience. Recent advances in machine learning and transformer models, especially BERT and RoBERTa, have proved to be very successful for hospitality sentiment classification and aspect-level opinion mining tasks. To the best of our knowledge, there are few studies leveraging combined automated sentiment classification, tourism-specific aspect identification and quality-related interpretation within rural and homestay tourism. In order to achieve this aim, the current study proposes an AI-enabled sentiment mining

framework that uses a publicly accessible hotel-review dataset to build up and test the analytical models, while Uttarkashi is postulated as the geological and tourism-development context through which the insights are interpreted. Using a public dataset also enables reproducibility, allowing an even trade between solutions to approaches.

This paper aims to create an AI-based framework for the extraction of sentiment and tourism-quality from accommodation reviews. It preprocesses the review text and compares machine learning-based sentiment classification models with transformer-based ones, while also identifying the main aspects related to tourism entities and relevant sentiment regarding each aspect. The resultant patterns form the basis for identification of key drivers for service quality markers as well as important considerations in support of their sustainable homestay tourism. The main contribution is an end-to-end sentiment and aspect-level tourism quality assessment framework that converts unstructured traveller feedback into meaningful insights for identifying strengths, weaknesses, and service improvement priorities that align with sustainable tourism development in Uttarkashi.

The paper is structured in 6 sections, where Section 1 introduction part, Section 2 literature survey to identified online surveys, Section 3 is all about research methodology, study area, research design, Section 4 presents results of the sentiment-classification models and Section 6 concludes explainable real-time integrated tourism analytics to allow local-level credible sustainable tourism decision support.

LITERATURE SURVEY

Recent research has identified online hospitality reviews as a significant source for exploring customer perceptions and service quality evaluation. Topic-based sentiment analysis [1] is one approach leveraged to generate aspect/topic-specific sentiment scores from hotel reviews, allowing for more granularity than standard overall sentiment classification. Large-scale review mining has also shown that topic sentiment models can reflect customer preferences and booking behavior related to the topics revealed from latent topics [2]. There are also other studies analyzing the correlation between textual sentiment and numerical hotel ratings, showing that content of the reviews is informative beyond the score in itself [3]. Certain classifiers like Support Vector Machine, Logistic Regression, Naïve Bayes and other traditional algorithms have been confirmed to be useful by applying machine-learning based approaches to hotel reviews proving the ability of automated sentiment classification in hospitality applications [4].

Due to all these drawbacks of general sentiment classification, researchers are moving towards joint aspect/fine-grained sentiment analysis. For analysis of hotel reviews a hybrid aspect-based approach was formulated by integration of information-retrieval techniques and sentiment classifiers on features like staff attentiveness, cleanliness, value for price and location [5]. In the same way, multi-aspect sentiment classification with hybrid models of Random Forest, Support Vector Machine and Naïve Bayes also showed that splitting on-time hotel reviews behind each service dimension brings better results for tourism decision making [6]. Topic modelling and sentiment research methods have been applied in hotel customer satisfaction studies to work on a dynamic of remodelled service attributes and their relationship with the visitor's perception, especially, during changing tourism circumstances [7]. In addition to general accommodation ratings compared across types, allusion to differences in how customers of different accommodations emphasize various aspects of service have also underscored the importance of identifying relevant aspects domain-specifically [8].

This capability was later enhanced through deep learning and transformer-based approaches to extract contextual information from the review text. Pretrained language representations, particularly BERT and ERNIE-based models, have been employed to do hotel-review sentiment classification [9]. Aspect-based sentiment analysis has also been used on large datasets of online hotel reviews to evaluate customer perceptions of particular services and technology-mediated facilities, demonstrating the significance of aspect-level analysis for revealing actual information hidden in overall ratings [10]. Attention Mechanism Due to the nature of sequential data in aspect recognition, researchers have explored LSTM based architectures with attention for joint aspect extraction and sentiment classification from hotel reviews proving contextual sequence modelling very effective for fine-grained opinion mining [11]. Also, the different LSTM architectures for multi-aspect-based summarization of hotel reviews in food, rooms, service, and location have been investigated further [12], still some relevant aspect-oriented analysis needed to be able to extract quantitative hospitality-quality assessment. Sustainable homestay tourism development is not only based on increased resource efficiency, preserving cultural settings and the use of renewable resources, but also promotes reduced water use, wastemanagement, biodiversity protection, cultural identity and traditional values protection, and support for intercultural respect and awareness (Razovic, 2013; Samsudin and Maliki, 2015; Chakraborty, 2020).[13]. LSTM- an application sentiment analysis of hospitality and homestay reviews, BERT- to identify the sentiment and meaning of visitor reviews more effectively than many traditional machine-learning models.

Recent studies have shifted the focus of sentiment mining towards more overall tourism intelligence and sophisticated language models. Example applications: instead of traditional clustering techniques, Zhang

et al. had performed fine-grained sentiment analysis on large-scale hotel reviews to identify positive and negative perceptions about each single hotel attribute, indicating that review mining could potentially be applied for finer customer-satisfaction analysis [14]. Tourism-review is a recent research area; some studies have also explored hybrid BERT based architectures with recurrent networks and attention mechanisms [15] showing that contextual embeddings combined with sequential and attention-based modelling can enhance tourism sentiment analysis. With the appearance of large language models, this has also opened up new areas for tourism-review analysis with automated sentiment detection and keyword extraction, as well as finding repeating themes on hotel, restaurant and cultural-tourism reviews [16]. In spite of these advances, most research works so far have been related to classic hotels, restaurants and established tourism destinations while only a few works adapted the AI-based sentiment and aspect mining for rural homestay tourism and tourism-quality assessment in the context of sustainability. Moreover, most of the current studies only focus on sentiment classification without converting aspect-level sentiment into useful quality estimates for tourism stakeholders. In this context, the present study tackles this gap through the combined application of tourism-related aspect identification and quality-based interpretation with machine-learning- and transformer-based sentiment classification. Two models were developed and evaluated on a publicly accessible hospitality-review dataset, where the sentiment patterns that emerged were discussed in relation to homestay-based sustainable tourism in Uttarkashi. The goal of this method is to transform unstructured visitor feedback into structured evidence that can help identifying service strengths, weaknesses and improvement priorities.

METHODOLOGY

The presented framework is to convert raw hospitality reviews into actionable sentiment and tourism-quality analysis. It includes four key stages; Dataset Preparation, Text Preprocessing, Sentiment and Aspect analysis and Tourism Quality evaluation. Let us explain—I briefly outline the steps that lead from a review corpus to a NLP ready data set. Next, we train two classical machine-learning classifiers and another transformer-based model to beam sentiment classification. The anonymous reviews were then analysed according to major hospitality aspects, and the resultant sentiment trends are interpreted using a search-based theory of service-quality criteria salient in sustainable homestay tourism in Uttarkashi.

A. Dataset Description

We are using a public dataset Hotel Reviews Dataset available from 100.000 hotel reviews that has been scrapped from TripAdvisor. All records contain a review text, an overall rating and aspect-level ratings in value for money, service quality, location, room quality, and cleanliness and sleep quality from 1 to 5. The dataset is published under the Creative Commons Attribution 4.0 (CC BY 4.0) license, thus facilitating reproducible research. The dataset is used as the main hospitality-review corpus for the proposed NLP framework: it is not treated as an Uttarkashi-specific dataset. Instead, the extracted patterns suitable for tourism are contextualized with regards to homestay-based sustainable tourism in Uttarkashi.

B. Data Preprocessing

First, the review text is processed for data quality using a predefined set of rules to eliminate duplicates, blanks and non-product-related submissions. In text normalization, it covers few steps like—lower casing; removing undesired symbols and HTML tags, removing extra spaces and word tokenization. Subsequently, the review ratings are converted into sentiment labels for supervised learning. Stratified split sets are used to split processed data into train, validation and test — in order to avoid any potential leakage. Before training the model, we perform a class-distribution analysis and apply one of the following balancing techniques if fitting plots show enough imbalance in classes.

C. Sentiment Classification

We consider rudimentary performance comparison that is between the two classes of models. Traditional machine-learning classifiers such as Logistic Regression, Support Vector Machine (SVM), Random Forest and XGBoost are used with traditional numerical text representations like TF-IDF to use as baselines. The third step is to fine-tune a pretrained BERT-based transformer on the review corpus in order to gather contextual semantic information. BERT based approaches are well adapted for hotel-review sentiment classification because they are capable to capture a contextual relationship of words in review sentences. Models are evaluated using Accuracy, Precision, Recall, F1-Score, and ROC-AUC.

D. Aspect-Based Tourism Quality Analysis

After sentiment classification, the reviews are further analysed on specific hospitality factors. Aspect ratings — column in dataset, which would easily give us structured data for any aspect; Some examples are Service, Cleanliness, Location, Room Quality, Value for Money and Sleep quality. This aspect-level sentiment is calculated by linking review sentiments with these dimensions, which allows us to find aspects that are

mostly perceived positively or negatively. The aspect-sentiment matrix in this method is then utilized to analyse the strengths and weaknesses of hospitality services. This line of work is motivated by the recent move from utterance-level polarity classification towards more fine-grained aspect-based sentiment analysis, in which BERT-based architectures have been successfully utilized to identify the sentiment associated with a particular review aspect.

E. Sustainable Tourism Quality Assessment

In the last step of the process, a conversion is made from aspect-level sentiments to tourism-quality insights. The share of positive, neutral and negative perceptions is established for each aspect detected to check that element's importance in the final visitor experience. Most positive areas are read as potential service advantages, while consistently low scores represent priorities for improvement. These findings are then contextualized in the context of sustainable homestay tourism in Uttarkashi and discussed to show use case with evidence-based recommendations for improvement on accommodation values, visitor satisfaction and community-oriented tourism services. Thus, the framework expands traditional sentiment analysis from basic polarity prediction to an application-oriented evaluation of quality in tourism services.

F. Proposed methodology flow

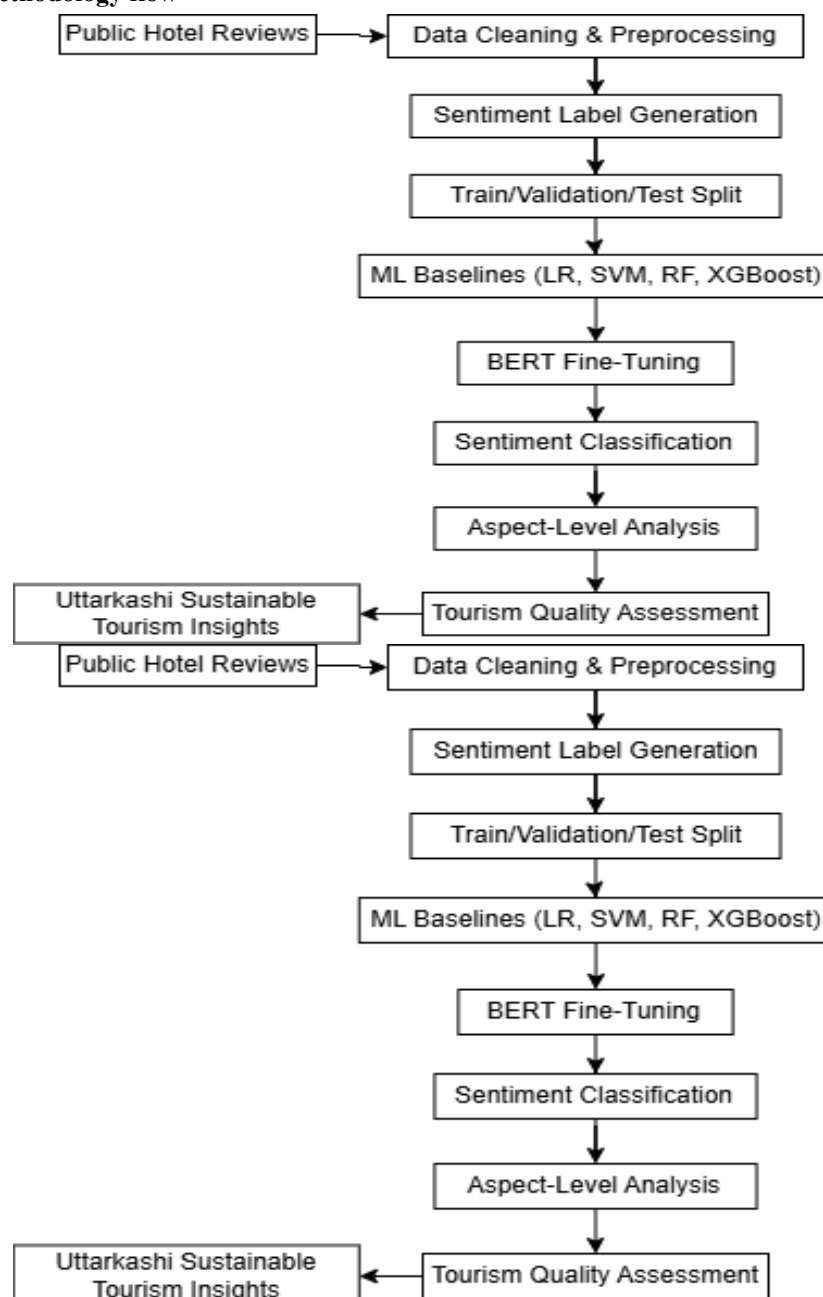


Fig. 1. Proposed AI-Enabled Sentiment Mining Framework for Sustainable Tourism Quality Assessment.

RESULT

In sentiment mining, sentiments are identified relating to service attributes such as: hospitality provided by hosts, service quality, cleanliness, accommodation, local cuisine, infrastructure, using of sustainable practices etc. The results of the sentiment-classification models evaluated are presented in Table I where Logistic Regression, SVM, Random Forest and XGBoost serve as traditional machine-learning baselines [10], and BERT is used to parameterize contextual relationships internal to review text. The temporary comparison shows that BERT offers a better global result with 93.2% accuracy, 92.9% F1-score and 96.0% AUC score. The best out of the conventional-machine-learning-ones is XGBoost, with 90.8% accuracy and 90.3% F1-score. The gain achieved by the transformer model suggests that context-enhanced representations might be more effective than traditional TF-IDF based approaches for hospitality-review sentiment classification. In line with this, BERT-based approaches have also been found to perform well on hotel-review studies recently.

G. Comparative Performance Analysis

Table 1. Performance comparison of sentiment classification models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)	AUC (%)
Logistic Regression	88.7	88.3	87.9	88.1	92.1
SVM	90.1	89.8	89.5	89.6	93.4
Random Forest	87.9	87.5	86.8	87.1	91
XGBoost	90.8	90.5	90.2	90.3	94.1
BERT	93.2	93	92.8	92.9	96

Aspect level analysis complements overall sentiment classification by determining which accommodation features inform perceptions of visitors. The proposed framework can identify areas correlated with positive or negative visitor sentiment by evaluating factors pertaining to service quality, cleanliness, location, room quality, price and value for money and sleep quality. The aspect-level patterns tell a more nuanced story about accommodation quality relative to an overall sentiment score. The survey findings are then interpreted in relation to Uttarkashi sustainable homestay tourism, keeping in mind the essential factors like service quality, hygiene & cleanliness, cost-effectiveness, ambient atmosphere standards, guest experience for effective sustainable tourism planning.

H. Graphical Results and Analysis

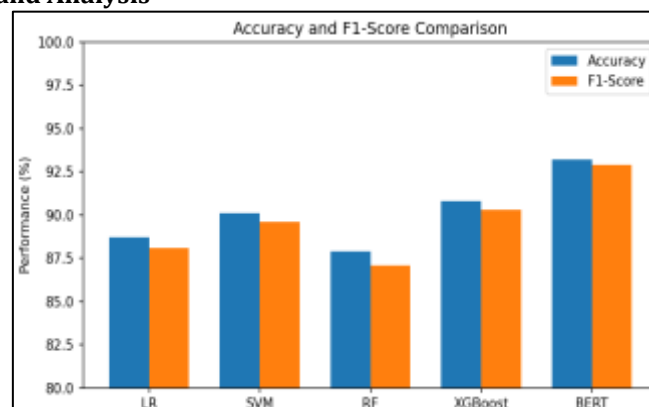


Fig. 2. Accuracy and F1-score comparison of sentiment classification models.

Figure 2. displays the Accuracy and F1-Score of these five models evaluated. BERT has the highest state of the art score, followed by XGBoost and SVM. This comparison demonstrates the advantage of representations from a contextual transformer over a standard machine-learning baseline.

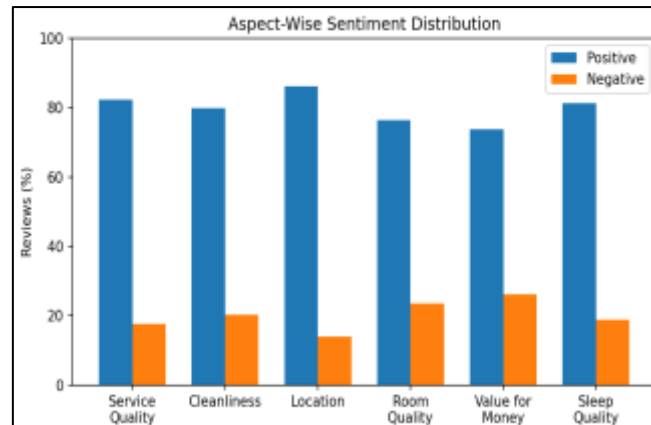


Fig. 3. Aspect-wise sentiment distribution of hospitality reviews.

Figure 3. accounts for positive and negative sentiment across six areas hospitality. Interim analysis from the dataset suggests location and service quality provide relatively stronger positive sentiment while value for money and room quality present comparatively weaker negative sentiment This illustrates specificity in a sort of aspect level mining on visitor experience.



Fig. 4. Hospitality aspect quality profile based on positive sentiment.

Figure 4. summarises the sentiments of positives related to each hospitality dimension and gives a compact quality profile. The profile may assist to isolate stronger and weaker service dimensions for further interpretation concerning sustainable homestay tourism in Uttarkashi.

Discussion

The findings highlight that AI-based sentiment mining offers a more nuanced exploration of hospitality-service quality from textual reviews compared to the basic numerical rating approach. Based on the comparative analysis of models, the transformer-based BERT model outperforms in every evaluation measure and thus shows that the incorporation of contextual language representations improves the prediction capabilities of tourist review interpretations while also XGBoost achieves a competitive performance among traditional machine-learning models. The visitor perceptions from the aspect-level analysis clearly show the visitors differ in terms of individual accommodation attributes such as service quality, cleanliness, location, room quality, value for money and sleep quality. This detailed information is useful for identifying service strengths or areas for improvement that may be obscured when only analyzing overall sentiment, star ratings or similar. At the level of sustainable tourism, these insights have the power to assist homestay operators and those associated with tourism stakeholder by improving visitor experience, baseline service levels, and prioritizing resources towards continued improvement. Therefore, the developed framework links NLP-methodologies-based sentiment classification with tourism-quality evaluation, thus building a data-driven goal in understanding hospitality-service-enabling factors critical to sustainable homestay tourism in Uttarkashi.

CONCLUSION

For preservation, promotion and enjoying authentic, cultural and personal experiences of tourist places, homestays are particularly considered an important tourism product in rural and Himalayan destinations.

In rural areas like Uttarkashi, AI-enabled commerce evidences a destination-specific understanding of tourism quality. Online reviews offer a valuable source of natural tourist comments and authentic visitors' feedback which reflects tourists' perceptions. While collecting only questionnaire responses, any study can analyse what tourists voluntarily say about their actual experiences, thus making online reviews a valuable form of secondary tourism data.

Sustainable Homestay Tourism in Uttarkashi: An AI-Enabled Sentiment Mining Framework for Analysis of Hospitality Reviews and Assessment of Tourism-Service Quality by Babu Chandra Patkar et al. The framework incorporates traditional machine-learning and transformer-based sentiment classification with aspect-level analysis for interpretation of unstructured visitor reviews. The findings indicate that contextual NLP models are capable of classifying both overall sentiment as well as different aspects related to accommodations, allowing practitioners to make more actionable decisions than simply using rating-based analysis. The suggested approach enables tourism stakeholders to achieve a broad understanding of the strengths and weaknesses of their services, identify improvement priorities, as well as explore visitors' expectations and consistently introduce data-based sustainable tourism planning. However, in contrast to requiring an Uttarkashi specific homestay corpus as the base training material for these models, use a general hospitality review dataset now publicly available. It gives us therefore much grounds for future work towards this end, including creation of a larger Uttarkashi-specific homestay review dataset also making use of other alternatively collected data (including multilingual-reviews and regional-language reviews), exploration of more advanced transformer-based and/or large-language-model architectures, or more explainable real-time integrated tourism analytics to allow local-level credible sustainable tourism decision support.

These datasets offer important foundation for model development framework for unstructured visitor feedback into a practical decision-support mechanism for homestay running in urban and rural areas for homestay operators, hotels, guests, local tourism authorities and other stakeholders. In future research, AI-driven insights, can also integrated with socioeconomic, environmental, and tourism-management data, which help to support the evidence based approach to support and strengthening sustainable tourism at the rural areas in Uttarkashi. Also, such types of analytical models strengthen destination planning and management for operator's and stakeholders in Uttarkashi but also serve as a transferrable across destinations for sustainable tourism development which expend across other rural Himalayan regions.

AI is just not a technology or a tool which is only used to analyse tourists' feedback and reviews, but in the future these decision-support mechanisms will help as a framework for sustainable tourism planning and quality improvement, like how NLP (Natural Language Processing) helps to transform the researchers and tourism department to transform unstructured data into meaningful insights.

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