

Review Analytics Using K-Means and Natural Language Processing for Interpreting the Customer Sentiments

Rumana G. Mattoo¹, P S Metkewar², Nrashant Singh³, Ravi Chauhan⁴, Basant Tiwari⁵,
Aafaq A. Rather^{6*}, Raeesa Bashir⁷

¹Department of Statistics, Govt. Degree College Ganderbal, Jammu and Kashmir, India.

Email: rumanaresearch@gmail.com

²School of Computer Science and Engineering, Department of Computer Science and Applications, Dr Vishwanath Karad MIT World Peace University, Pune - 411038, Maharashtra, India.

Email: pravin.metkewar@mitwpu.edu.in

³Department of Forensic Science, Amity University Dubai, UAE. Email: nsingh@amityuniversity.ae

⁴Symbiosis Institute of Computer Studies and Research (SICSR), Symbiosis International (Deemed University), Pune, India. Email: raviadmn143@gmail.com

⁵School of Computer Science and Engineering, Department of Computer Science and Applications, Dr Vishwanath Karad MIT World Peace University, Pune - 411038, Maharashtra, India.

Email: basanttiw@gmail.com

^{6*}Symbiosis Statistical Institute, Symbiosis International (Deemed University), Pune, India (Corresponding Author). Email: aafaq7741@gmail.com

⁷Department of Mathematics and Statistics, Vishwakarma University, Pune, India.

Email: raeesa.bashir@vupune.ac.in

ABSTRACT

Today, customer reviews are one of the most important areas for businesses to grow, by analysing their sentiments and understanding them. This research paper focuses on how customer reviews and feedbacks are helpful for businesses to grow. Authors say that the proposed methodology focuses on the collection of data from different sources and then applying pre-processing techniques, Exploratory data analysis (EDA), Natural Language Processing, sentiment analysis and fine-grained aspect-based analysis on that. Furthermore, this will help businesses to get proper insight from the customer dataset and as well as help businesses to focus more on the problems of customers stated by them in the reviews. Although this topic is already well studied, authors have chosen this topic to get the fine-grained aspect-based analysis of the customer reviews, as authors saw the research gap here, that the earlier studies focus solely on the customer reviews as a whole but not on the fine-grained aspect-based analysis. So, the authors will focus more on fine-grained aspects to bridge the research gap by incorporating machine learning and deep learning algorithms to associate sentiment scores with each aspect, hence, it will help to get good and accurate insights from the reviews.

Keywords: Customer review analytics, sarcasm detection, biased reviews, manipulated reviews, NLTK, K-Means Clustering.

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I. INTRODUCTION

In this fast-moving world today, businesses need to understand their customers well to get the front seat in the today's market. Authors observed that these customer reviews help businesses to get the better insights from the reviews or feedbacks of customers and can understand the sentiments too. However, earlier researchers and analysts used to focus primarily on the sentiments of customers as a whole so, this was not enough to catch the deep emotions of the customers. Moreover, authors want to say that to focus on these deep emotions we need to focus more on fine-grained aspect-based analysis of the customer reviews.

The aim of this research paper is to fulfil the gap where the focus was solely on the customer sentiments as whole but not on the fine-grained aspects. So, authors say that they will provide a fine-grained aspect-based sentiment analysis in this research paper which will help businesses or organizations to focus more deeply and accurately on the customer reviews or feedbacks. They will use machine learning and natural language processing, and the fine-grained aspect-based analysis using the sentiment classification at the aspect level, managing the context in which aspects are mentioned and handling the variability of aspect expressions.

Further, authors say that they will use the customer data of hotels which will provide the hotels to focus

more on the feedbacks and the reviews of the customers. Moreover, it will also help hotels to focus on the strengths and weaknesses in the service provided by them after analysing the reviews and customer feedbacks. They will look up to minimise the areas of common problems and improve them, as a result it will help in better customer satisfaction in the future and increase the value of the hotel.

Authors state that this research paper will not neglect the fine-grained aspect-based sentiment analysis which used to get neglected earlier and in today's fast-moving world it is not enough to focus on the whole sentiment but you need to focus deeply on the sentiments and get the correct insight what customers actually want to say. Ultimately, this will help businesses or hotels to grow as they can focus more accurately on the actual need and feedback of their customers.

II. LITERATURE REVIEW / RELATED WORK

Customers review analytics has gained a hype in the recent years and this is worth it for the businesses to grow in the long-run and get themselves more opportunities to provide better services to their customers hence, they get happy and more satisfied from the businesses. Authors state that this "customers review analytics" is a very vast topic and the studies on this topic are also been conducted from a long time, but these studies lack in the analysis of customers from the fine-grained aspect-based point of view. Earlier, the studies majorly focus on customers review as a whole emotion or sentiment, which classifies the reviews into three categories that is positive, neutral and negative reviews. Authors further added that they have used [1] Natural Language processing to analyse the reviews of the customers and draw the insights with the help of [2] business intelligence from the [3],[11],[17] big data of customers reviews.

Furthermore, the authors have added that this research have witnessed the very deep research efforts. They further added that the [6],[25] machine learning classification and clustering techniques have been used in this research with a combination of deep learning algorithms and natural language processing, which helped in knowing the deeper [7] sentiments of customers. To be more precise this research basically focused closely on the fine-grained aspect-based [4], [5] customers review analytics which was possible by analysing word-metrics and aspect-based analysis.

Authors also elaborate that to address this research gap the studies have already been done by exploring the [8] topic modelling, rule-based analysis and dependency parsing which helped to get the fine-grained analysis. Although these studies also tried to focus on fine-grained analysis but the problem is still the same which is they were not able to focus accurately on the selection of aspects or [28] domain specific analysis or [9], [12] sentiment associated with [10] specific aspects of product or service.

The authors further added that for the fine-grained analysis, the aspect-based analysis is very important. For this purpose, many machine learning algorithms like Support Vector Machines (SVM), Naïve Bayes, [13],[16],[19],[20],[22] K-Means Clustering and the deep learning algorithms like [21],[23],[26],[32] Recurrent Neural Networks (RNN) and Convolutional Neural Networks (CNN) can be used to get the fine-grained aspect-based analysis, with the help of natural language processing. Further, these models and algorithms focuses on the word-dependencies metrics and can help in finding the [14],[15],[18],[27],[29] aspect-based sentiments analysis more accurately.

During this study authors observed that there is a problem in [35],[36],[37],[40] fine-grained analysis which is customers can use same words or phrases for the different issues and the opposite is also possible which is customers can use different words or phrases to point out same issue or problem. However, this problem was tackled by using the techniques like word embedding, stemming and aspect clustering which helped in [24] accurate sentiment analysis. Further, authors have enlightened that it is very much crucial in aspect-based sentiment analysis in which aspect or context the review is talking. Authors also suggest that to get the [30],[31] high accuracy in sentimental analysis of different aspects, it is very much needed to consider the position of aspect in the review, co-occurrence of aspect and the linguistic cues, which helps in accurately [45] classifying the sentiments. Moreover, there are more challenge like [34] aspect ambiguity, handling noisy or unstructured customer reviews and cross-domain aspect-based sentiment analysis.

Finally, authors say that this research paper focuses more specifically on the [41] fine-grained aspect-based sentiment analysis of the customer reviews. Although, there were challenges which were tackled by the authors in analysing the customers reviews stated above. Earlier, the researches focused on the sentiment analysis as a whole

emotion which is positive, negative or neutral review but this research paper fills this research gap by analysing [33],[38],[39] reliable fine-grained aspect-based sentiment analysis. Finally, it helped hospitality industry to focus more accurately on the customers reviews and what they want to say through the reviews, ultimately through this, industries can grow in the market and can have a better impact on the society and this also helps in [42],[43],[44], [46] customer satisfaction.

III. METHODOLOGY

A. Dataset

Authors have obtained the U. S Hotel Customer Data, which contains data with column names as address, categories, city, country, latitude, longitude, name, postalcode, province, reviews.date, reviews.dateAdded, reviews.doRecommend, reviews.id, reviews.rating, reviews_text, reviews.title, reviews.userCity, titles.username, reviews.userProvince. Authors have used Python and various data visualization tools such as Matplotlib and Seaborn to analyse and visualize the dataset.

B. Data Preprocessing and Representation

There are 35912 rows and 19 columns in our dataset. Although we have some empty data in the dataset but it does not affect our results, so, we don't do anything with that empty data. But we drop 2 columns reviews.doRecommend and reviews.id because there is no data available in both of them. As we are doing the customer reviews analytics, so there is some visualization done using python to better understand the data.

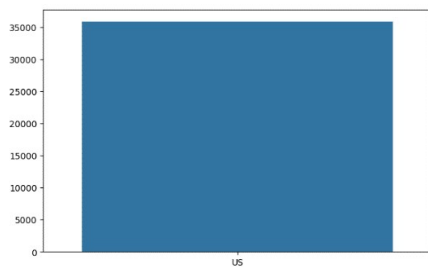


Fig.1. Country Wise Reviews Count.

The data visualized in Fig.1. highlights the country wise count of reviews. We can clearly see there is only one country i.e., US, and the reviews count value is more than 35000.

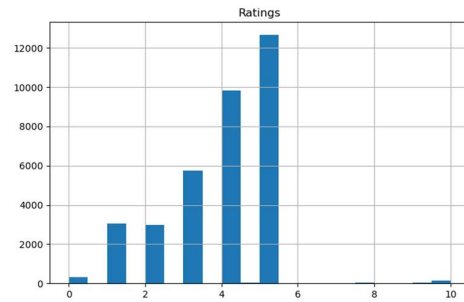


Fig.2. Ratings Of Reviews.

As visualized in Fig.2. we can see that majorly ratings received was 5 and it shows that the customers are actually happy.

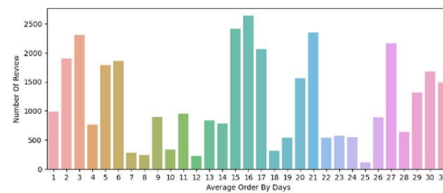


Fig.3. Number Of Reviews Accordig To Average Order By Days.

From Fig.3. we can observe the Average order by days of month corresponding to the number of reviews.

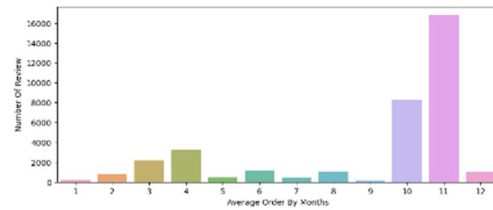


Fig.4. Number of Reviews Accordig to Average Order by Months.

From Fig.4. we can observe the Average order by months corresponding to the number of reviews and hence, authors say that in the month of November the orders were the most.

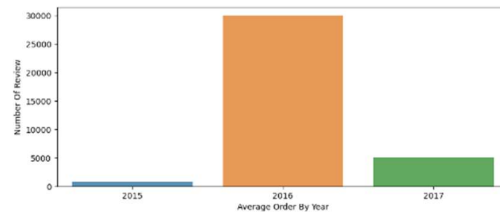


Fig.5. Number of Reviews Accordig to Average Order by Year.

From Fig.5. we can observe the Average order by year corresponding to the number of reviews.

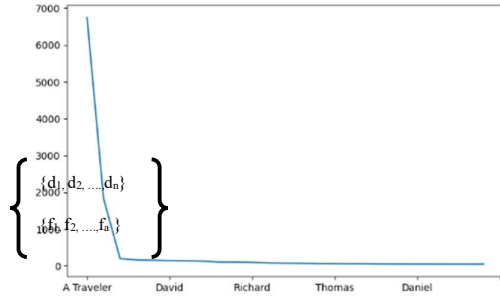


Fig.6. Frequent Name.

The data visualized in Fig.6. shows the most frequent user name who gave the review and hence, this also focuses on the major and frequent clients and the hotels should give standout benefits and offers to these frequent clients.

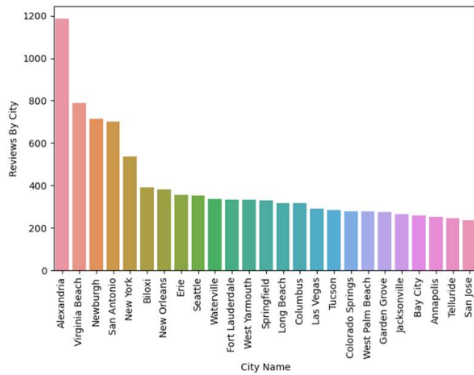


Fig.7. City Wise Reviews Count.

From Fig.7. we can observe the city-wise reviews count. It shows the number of reviews according to the different cities.

C. Feature Selection

In our dataset, reviews are the most important feature and shows the direct emotions and unfiltered feedback of the customers so, we will do the further computation on that feature majorly.

D. Mathematical Model

K-Means Algorithms:

The K-means algorithm clusters data by separating samples in k groups, minimizing a criterion known as the inertia or within-cluster variance sum-of-squares.

$$\arg \min_s \sum_{i=1}^k \sum_{x \in s_i} \|x - \mu_i\|^2$$

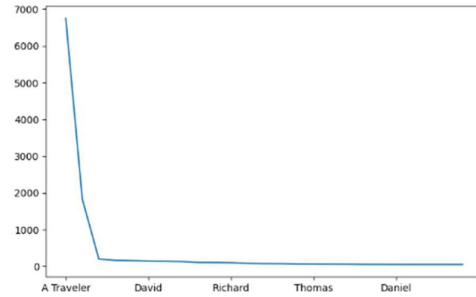
Where:

- S sets of observations
- k number of sets of predictors
- x observation data point

μ_i mean of points in S_i

Feature Selection:

$$\Rightarrow F \begin{bmatrix} N(d,f,p) \\ M(d,f,p,m) \\ A(d,f,p,m) \end{bmatrix} \Rightarrow \{f_1, f_2, \dots, f_s\}$$



Where:

- d data
- n number of data elements
- f features
- a number of available features
- p prediction objectives
- m models
- s number of selected features
- F feature selection functions
- N mining functions
- M modelling functions
- A analysis functions

E. Word Embedding

Word Embedding is one of the major concepts which comes under Natural Language Processing (NLP). It also represents words as dense vectors in a continuous vector space. Moreover, it also helps words or phrases to convert into numerical data on which further machine learning algorithms can be applied. Word embedding also maps words to continuous vector spaces, where similar words have similar vector representation. Moreover, in Fig.8. the word embedding process has been shown and authors say that word vector or word embedding is an approach of representing words. Moreover, it is a technique to convert the words or

phrases into numerical values which helps machine learning models to work on them.

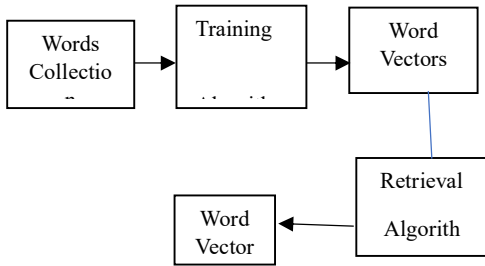


Fig.8. Word Embedding Process.

IV. RESULTS AND DISCUSSION

A. Clusters

TABLE.1. NUMBER OF REVIEWS INCLUDED IN EACH CLUSTER.

Clusters	No of Reviews
4	372
1	246
2	189
3	138
0	55

Table.1. shows the number of reviews belongs to each cluster. Furthermore, it is observed that there are 5 clusters from 0 to 4 and corresponding to the clusters we have number of reviews assigned to each cluster. Authors have developed this table

	Word 0	Word 1	Word 2	Word 3	Word ...	Word 12	Word 13	Word 14
Topic 0	great	de	stay	le	complaint	spa	lido	view
Topic 1	hotel	excel	pool	stay	area	little	also	friend
Topic 2	clean	room	good	breakfast	pool	night	visitor	price
Topic 3	room	hotel	stay	breakfast	need	one	time	could
Topic 4	under	shower	das	der	fr	zimmer	zu	es

using python.

TABLE.2. SAMPLE OF REVIEWS ACCORDING TO CLUSTERS.

	Review	Cluster
0	Pleasant 10 min walk along the sea front to...	3
1	Really lovely hotel. Stayed on the very....	2
2	Ett mycket bra hotell. Det som drog ner...	4
3	We stayed here for four nights in October...	2
4	We stayed here for four nights in October...	2

5	We loved staying on the island of Lido!	4
6	Lovely view out onto the lagoon. Excellent..	4
7	Ottimo soggiorno e ottima sistemazione nei..	4
8	Günstiger Ausgangspunkt für Venedig Besuche.	0
9	Lidoen er perfekt til et par dages ro.....	4

From the above table.2. authors focus on the reviews or feedbacks given by the customers. The above table focuses on the reviews written in a particular language and the corresponding clusters assigned to each review, although, it is just a sample of ten reviews.

B. Aspect-Centric Sentiment

Analysis Results:

Authors say that the main part of this research is based on the fine-grained aspect-based sentiment analysis rather than on the traditional method of analysing reviews as a whole, or classifying them into positive, negative and neutral sentiments. Moreover, authors add that this particularly focuses on the particular aspect, represented by the topic words and analysing sentiment trends related to these aspects. Authors also add that with this methodology they gained deeper insight of the customer reviews which was not possible to understand earlier and through this it will be very easy for the hotels or businesses to focus more on the actual problem rather than focusing on a collective problem, because in this growing competition this fine-grained aspect-based analysis is very much needed.

C. Topic Word Matrices

TABLE.3. WORD MATRICES

From table.3. it can be inferred that the columns focus on the words and the rows focuses on the topics and this topic-word metrics shows the strength of each word to the topic. Authors say that this is very crucial of the sentiment analysis as it helps to identify which words are strongly linked to which aspect.

Authors say that with the help of topic modelling techniques authors have analysed topic word matrices which formulated them with the deeper and specific aspect-based analysis on the hotel reviews. Moreover, authors also add that these matrices helped them to get the holistic sentiment views parallel to the particular aspect, which ultimately helped them in extracting the multi-faceted nature of the customer opinions.

D. Aspect-Level Sentiment Dynamics

Authors observed sentiment dynamics in various different aspects. For example, authors say that the “staff was very welcoming”, which is a positive thing authors observed during the analysis of the customer reviews. Further, authors add that the customers added that “some amenities or devices in the rooms were not working properly”, which is not good for the customers as they are paying for the stay and want good conditions of all the devices in return. Moreover, authors observed that there were sentiment fluctuations in case of some customers as some stated “food quality” as good and some just gave negative reviews for that. So, such deep and meaningful insights give hotels an idea or the area in which they should improve by working on them.

V. CHALLENGES AND FUTURE PROSPECTS

Authors tackled many challenges while approaching this study of customer reviews. For instance, authors faced challenge while fetching the accurate aspect from the reviews. Moreover, authors also faced challenge in interpreting the contextual understandings which include sarcasm, irony and cultural nuances. One more major problem faced by the authors was while analysing multilingual and cross-domain analysis.

Additionally, authors say that there are very broad areas in which future studies can be done. Like in extracting the accurate aspect the models of natural language can be combined with the deep-learning and future research can also focus on analysing multi-languages and also the contextual sentiments which can throw the umbrella of layers.

VI. CONCLUSION

In conclusion, this research paper majorly focuses on the fine-grained aspect-based sentiment analysis with the help of the topic word metrics. Therefore, authors say that this will help the hospitality industry to create accurate strategies to give the best possible services to their customers. This approach helped to bridge the research gap in sentiments analysis for hotel reviews as it is not focusing on the traditional analysis of sentiments that is positive, negative, and neutral. Authors also promise that this study not only provide benefits to the hospitality industry but also can be used to analyse customer sentiments in diverse domains.

VII. Declarations

Ethical Approval: No ethical approval is required.

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Data Availability: The data that supports the findings of this study are available within the article.

Conflict of Interest: There is no conflict of interest among all the authors.

Consent to Participate declaration: not applicable.

Consent to Publish declaration: not applicable

Author's Contribution:

P S Metkewar: Conceptualization, Methodology, Writing – Original Draft Preparation.

Ravi Chauhan: Data Curation, Software, Investigation.

Basant Tiwari: Formal Analysis, Validation, Visualization.

Aafaq A. Rather: Supervision, Project Administration, Writing – Review & Editing.

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