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Implementation Of Decision Support System TOPSIS Fuzzy MCDM Method For Web-Based Cafe Recommendation

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Abstract

The reason of this research is to provide recommendations for cafes using the TOPSIS Fuzzy MCDM method and implementing it in a web-based system. This system aims to assist consumers in choosing a cafe based on various factors such as location, facilities, rating, price, and service quality. The TOPSIS Fuzzy MCDM method was selected because of its capacity to deal with uncertainty and generate a more precise ranking of options. The research demonstrates that this system can deliver recommendations aligned with predetermined preferences, thereby facilitating better decision-making. The study was conducted by researchers in the Malang City area, but the system is accessible to users from any location based on their coordinates. The test results show that the system successfully provides recommendations with scores of 100%, 73.07%, 53.92%, and so forth. These findings indicate that the system can effectively help users decide on their preferred cafe by offering reliable and accurate recommendations. Moreover, the integration of real-time data and Google Maps ensures that the recommendations are up-to-date and relevant. This implementation is expected to enhance the consumer decision-making process, providing a practical tool for selecting cafes that meet specific user criteria. This research underscores the potential of using advanced decision-making methods like TOPSIS Fuzzy MCDM in real-world applications, demonstrating its effectiveness in improving the user experience in the cafe selection process. The system's capability to integrate additional information, such as social media presence and customer reviews, could further enhance its utility in future developments.

I. INTRODUCTION

Malang City, which is known as one of the educational cities in Indonesia, not only has many famous universities but is also known for its many cafes scattered in various corners of the city. This phenomenon makes Malang City one of the favorite destinations for culinary lovers and coffee lovers. According to the head of the Malang City *Apkrindo* (Association of Indonesian Cafe and Restaurant Entrepreneurs), in 2024

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the number of cafes has reached more than 3000 [1]. Along with the development of technology, many cafes now have websites or mobile applications to facilitate customers' access to information about the cafe [2]. Through digital platforms, consumers can find out various details about the cafe, such as the menu offered, prices, location, and reviews from previous visitors. However, despite the availability of this information, many consumers still find it difficult to choose a cafe that suits their preferences. This is due to the sheer number of cafes available, making it hard for people to choose the best option.

The large number of cafes available can be a dilemma for consumers in choosing the cafe they want to visit. In choosing a cafe, there are usually several things that are taken into consideration, such as price, rating, facilities, and location [3]. Consumers often have to gather relevant information from multiple sources, compare the variety of cafes available, and consider their personal preferences and criteria. This process is often time-consuming and difficult for consumers, especially for those who have limited time or are visiting Malang City for the first time.

In the past, people have used special systems to help them make decisions in different areas. For example, in the selection of web-based tourist attractions in Aceh Besar, showed that a decision support system using TOPSIS Fuzzy MCDM can provide recommendations for choices that suit the needs of visitors [4]. This system is also able to provide priority ranking with the highest value compared to other tourist sites.

Furthermore, also showed the successful use of web-based DSS for cafe selection using the Analytical Hierarchy Process (AHP) method. This study successfully produced a recommendation system for cafe names that match user preferences [5]. Based on these findings, using a website that suggests cafes can help people find one they will like.

One way to make decisions is by using the TOPSIS method. This helps us choose the best cafe by comparing it to our ideal cafe based on different factors we care about. The TOPSIS method can be used with the Fuzzy MCDM method to help make decisions when things are uncertain [6]. By using a combination of these two methods, it is expected that the resulting recommendation system can provide more accurate and relevant results according to consumer preferences.

With the implementation of a web-based system, users can access cafe information and recommendations from anywhere and anytime through the browser of a device connected to the internet [7]. This provides high flexibility for users in searching and obtaining the information they need. In addition, using a web-based system provides ease of update and maintenance, integration with external data sources, and user scalability [8]. Integration with external data sources such as the Google Maps API (Application Programming Interface), as well as increasing user scalability and providing highly relevant data regarding locations, reviews, and detailed information about cafes in real-time the system can pull accurate and up-to-date data, so that the information provided to consumers is more up-to-date and reliable.

System testing will be carried out after the implementation is complete to ensure that the system runs as expected and to provide recommendations on the techniques used [9]. It is hoped that the development of this web-based decision support system, which uses the TOPSIS Fuzzy MCDM method, can solve the problem of selecting the right cafe in Malang City.

II. RELATED WORKS

In the past, many studies have explored Decision Support Systems (DSS) using various methods. DSS utilizes computational techniques to collect, analyze, and process data to provide decision recommendations [3],[10]. Key concepts in DSS relevant to this research include multi-criteria analysis, fuzzy logic, and the TOPSIS method [5],[11].

Previous research developed a Fuzzy TOPSIS MCDM system for web-based tourist attractions in Aceh Besar, offering recommendations based on visitor preferences. However, the results were not accurate due to the lack of Google Maps integration and the need for additional locations and criteria [4],[11].

Another study emphasized the balance between human and electronic inputs in DSS, suggesting that excessive computer use leads to mechanical solutions, while too much human input results in slow reactions and limited data utilization. This research aims to refine a web-based cafe recommendation application by leveraging both human and electronic strengths [12].

DSS, first introduced in the 1970s by Michael S. Scott Morton, assists in decision-making using computational tools [13]. The concept has evolved, and modern DSS definitions emphasize enhanced integration and user adaptability. For instance, research on DSS for laptop selection using the TOPSIS method suggests including additional criteria like warranty and after-sales service for better recommendations [14].

Another study developed DSS to help students choose a laptop that suits their needs using the TOPSIS method. This research provides recommendations based on several criteria such as price, specifications, and brand. This research suggests adding other criteria such as warranty and after-sales service to improve recommendation accuracy.

Another study used the Fuzzy MCDM method for supplier selection, recommending integration with ERP systems to improve decision-making efficiency [15]. Research on restaurant selection in Bandung using the TOPSIS method and halal culinary location selection in Pekanbaru using the Weighted Product approach highlights the value of DSS in consumer decision-making [16], [17].

In Malang City, a web-based recommendation system with TOPSIS and Fuzzy MCDM methods aims to address cafe selection challenges [5]. The system allows users to access cafe information and recommendations anytime, offering flexibility and ease of updates. Integration with external data sources like the Google Maps API provides real-time, relevant data, enhancing the system's accuracy and reliability [5].

System testing will ensure the system functions as expected and validate the techniques used. The TOPSIS Fuzzy MCDM method in this web-based DSS aims to solve the cafe selection problem in Malang City effectively. The versatility of DSS, as shown in various studies, highlights the need for integrating advanced technologies and broadening criteria to improve decision accuracy and user satisfaction. Hybrid approaches combining multiple decision-making methods are also beneficial, as demonstrated by the stock portfolio optimization approach [18]. These enhancements can lead to more accurate, relevant, and user-friendly DSS, ultimately improving decision-making processes across different fields.

A. Theoretical Foundation

The ideas behind this project include how we make decisions with the help of a computer program, a specific method we use to compare different options, a way to handle uncertainty, using Google Maps to help us, and looking at what other people have written about using computer programs to choose a cafe.

1) Cafes in Malang City

According to Setyadi (2019), Malang City has over 3000 cafes, indicating intense competition [19]. To succeed, cafes must differentiate themselves through unique advantages. Consumers need clear, comprehensive information about facilities, prices, and product quality [20]. Utilizing technology and online platforms for cafe listings and user reviews is crucial. Therefore, cafe owners should leverage technology and ensure their presence on online platforms to remain competitive.

2) System of Decision Support (DSS)

A computer-based system called a Decision Support System (DSS) gives information to help in decision-making, listing choices along with their pros and cons. DSS combines human input and computer analysis to address complex problems [21]. Model Management Subsystem and Data Management Subsystem are two of DSS's essential elements, User Interface Subsystem, and Knowledge Management Subsystem. The main function of DSS is to enhance managerial decision-making by improving efficiency and effectiveness, offering alternative solutions, and supporting decisions under uncertainty.

3) Topsis Fuzzy MCDM

Topsis Fuzzy MCDM integrates fuzzy TOPSIS and fuzzy logic for decision-making, considering various important factors. This method has been applied in multiple contexts, such as collective decision-making, flood risk mapping, and selecting web-based tourism attractions [22]. The calculation process using the Fuzzy TOPSIS method involves choosing criteria and assessing their weight. For example, criteria might include Rating (0.25), Price (0.20), Location (0.15), Facility (0.20), and Service (0.20). Assessors produce triangular fuzzy numbers based on alternative assessments and linguistic characteristics. Normalization of the fuzzy decision matrix follows, using formulas for benefit and cost criteria. The weight matrix is then normalized by multiplying the weight of the criteria by the normalized fuzzy value. Positive and negative ideal solutions are determined, representing the best and worst combinations of all criteria, respectively. Distances from these solutions are calculated using the Euclidean distance formula. The proximity coefficient (CCi) is then evaluated to rank alternatives. For instance, an alternative with the highest CCi is considered the best.

4) The Application Programming Interface (API) for Google Maps

The Google Maps API offers tools to integrate Google Maps into web or mobile applications [23]. Key components include the Google Maps JavaScript API, which displays maps and adds elements like markers and polygons. The Google Maps API Web Service provides features for route calculation, address geocoding, distance calculation, and elevation data [24], [25]. The Google Places API retrieves information about places such as cafes, restaurants, and hotels [26].

B. Framework Of Thought

The framework diagram presented in Figure 1 illustrates a structured approach to recommending cafes using the Fuzzy TOPSIS MCDM method. This framework is divided into three main components: Parameters, Methods, and Results. Parameters include five key criteria for evaluating cafes: Rating, Price, Location, Facility, and Service. These criteria ensure a comprehensive and reliable decision-making process. The Methods component involves collecting data on various cafes and applying the Fuzzy TOPSIS MCDM decision support system to analyze and rank them based on the defined criteria.

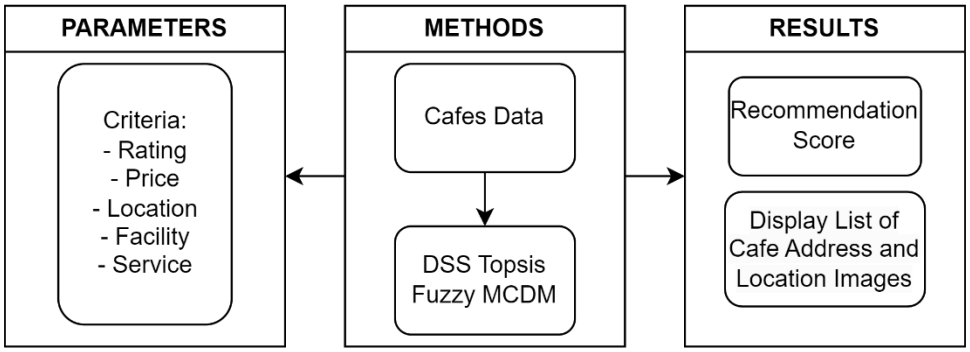

Figure 1. Framework Diagram

The Results include a recommendation score for each cafe, indicating its overall suitability, and a display of recommended cafes with their addresses and location images, facilitated by the integration of the Google Maps API. This framework ensures that the decision-making process is data-driven and incorporates location-based services for better accuracy and user experience. This diagram provides a visual representation of the framework [27], illustrating how parameters, methods, and results interact to produce reliable cafe recommendations.

III. METHODS

The research methodology outlines the stages of the implementation process. This section details the steps involved in developing and utilizing the Fuzzy MCDM TOPSIS method for the cafe recommendation system. The stages of the methodology are illustrated in Figure 2.

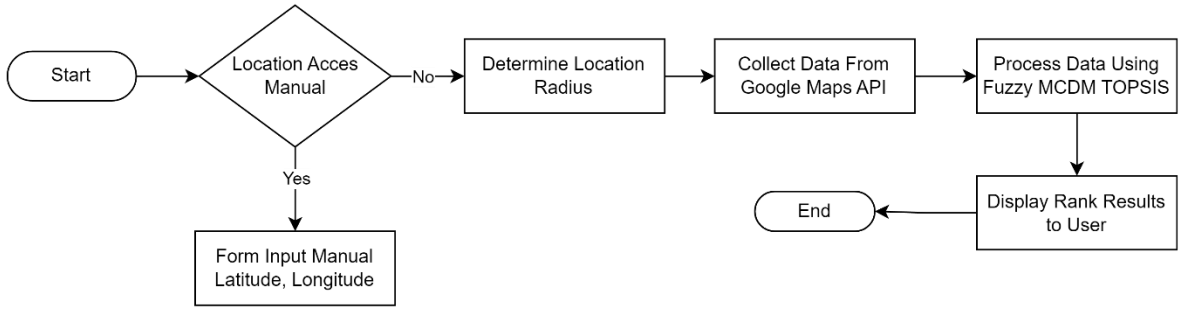

Figure 2. Research Methods

A. Problem Identification

This research identifies several issues in providing accurate cafe recommendations: subjective user assessments, lack of integrated geographic information, incomplete facility data, inadequate personalization, data integration challenges, and limitations of traditional decision-making models.

B. Proposed Solution

To address these issues, the research proposes using the Fuzzy TOPSIS MCDM method integrated with Google Maps API. This involves managing uncertainty with fuzzy methods, obtaining real-time geographic data, normalizing data, and ranking cafes. Recommendations are presented as a list and interactive map, considering individual preferences and context.

C. Data Collection Process

In this research, data collection and processing were conducted to provide accurate cafe recommendations. Various methods and tools were utilized in this process. The necessary modules include requests for accessing the Google Maps API, pandas and numpy for data manipulation and analysis, math for calculating distances, MinMaxScaler for data normalization, matplotlib for data visualization, and IPython.display for displaying cafe images.

The system uses an API key to access the Google Maps API and defines the user's coordinates (latitude and longitude) within a 5000-meter search radius to locate nearby cafes. Cafe data, including the cafe's name, rating, number of reviews, price level, coordinates, photo URL, and address, is retrieved via HTTP requests in JSON format.

The retrieved data is then converted into a DataFrame for easier manipulation. Distances are calculated using the Haversine formula, and numerical attributes are normalized to ensure comparability across different scales.

D. Calculation of Results Using the TOPSIS Fuzzy MCDM Method

The cafe evaluation process involves several steps to rank cafes effectively. Fuzzy membership functions are determined for each criterion to handle uncertainty. Lower price levels, more reviews, and closer distances are preferred.

The importance of each criterion is reflected in its weight:

Table 1. Calculating Normalized and Weighted Values

Criteria	Weight
Rating	0.3
Price	0.25
Location	0.2
Facility	0.15
Service	0.1

Positive and negative ideal values are established for each criterion to measure how close each cafe is to the optimal solution. The positive ideal values include maximum rating, minimum price, maximum location, maximum facilities, and maximum service, while the negative ideal values are the opposites.

Finally, the scores are calculated and normalized to provide final recommendations. Cafes with scores above 90% are highly recommended due to high ratings, many reviews, close distances, and suitable prices. Cafes scoring between 80% and 90% are recommended for their good ratings and close distances, while those scoring below 80% are recommended for their fair ratings and reasonable prices. This ranking helps users find the most suitable cafes based on their preferences and context, providing a more personalized and relevant recommendation.

IV. RESULTS AND DISCUSSIONS

A. Test Implementation

In this test, the user's location was at coordinates -7.93858933839576, 112.62551950905286, which corresponds to Campus 3 of Widya Gama University, Malang. This location was used to find cafes within a 5000-meter radius and evaluate them based on rating, price, facilities, location, and service.

Detailed information about the top cafes, including their names, images (if available), ratings, review counts, recommendation scores, addresses, and coordinates, was displayed. This visualization provided users with an easy-to-understand way to see and choose the best cafes based on various calculated and ranked criteria.

Table 2. Test Results

No.	CafeName	Rating	Review Count	Score	Address
1	Amstirdam Coffee & Roastery	4.7	2938	100.00%	Ruko Soekarno Hatta Indah. D18, Mojolangu
2	Labore Coffee Eatery	4.5	2234	83.09%	Jalan Soekarno Hatta No.25, Mojolangu
3	Permata Jingga Swimming Pool & Cafe	4.4	2346	79.10%	Permata Jingga Blok West Area, Jalan Permata Jingga I, Tunggulwulung

To enhance user experience and provide a comprehensive overview of the recommended cafes, a plot was created to visualize the distribution of these cafes based on their recommendation scores. This plot uses

colors to represent the recommendation scores of each cafe, allowing users to easily identify the top recommended cafes around them.

The plot in Figure 3 displays the locations of the top recommended cafes around Campus 3 of Widya Gama University, Malang. Points on the map represent cafes, with colors and sizes indicating their recommendation scores. The brighter the color, the higher the recommendation score of the cafe.

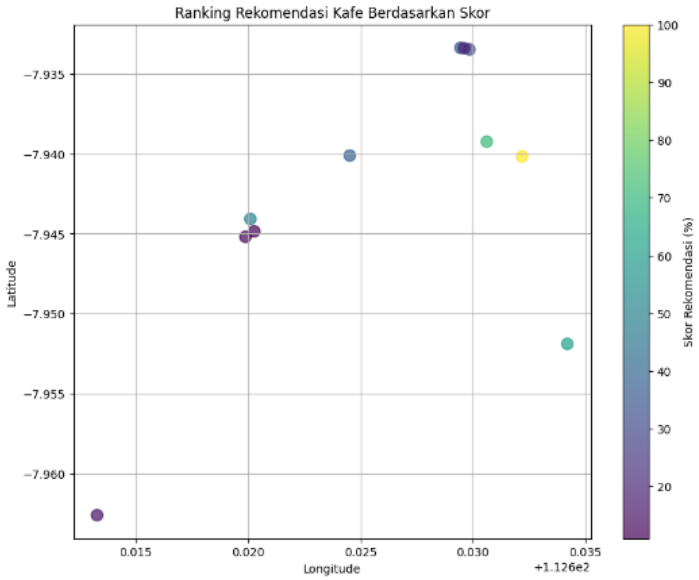

Figure 3. Plotting Cafe Recommendation

Elements of Figure 3:

a. The X-axis and Y-axis show where the cafes are located on a map.
b. Points (Scatter Plot): Each point corresponds to a cafe, positioned according to its latitude and longitude coordinates.
c. Point Color: Uses the 'viridis' color scale, where brighter colors indicate higher recommendation scores.
d. Point Size: Uniform size for all points, with opacity (alpha) used to differentiate overlapping points.
e. Color Bar: Indicates the recommendation score scale in percentage (%).
f. Labels: Title and axis labels to help users understand the map.

This visualization makes it easy for users to quickly see which cafes are most recommended and where they are located relative to their current position, aiding them in making informed decisions about which cafes to visit.

Additionally, the website interface was designed to display detailed information about each recommended cafe. Users can view the name of the cafe, images (if available), ratings, review counts, recommendation scores, addresses, and coordinates directly on the website. This comprehensive presentation ensures that users have all the necessary information to make informed decisions.

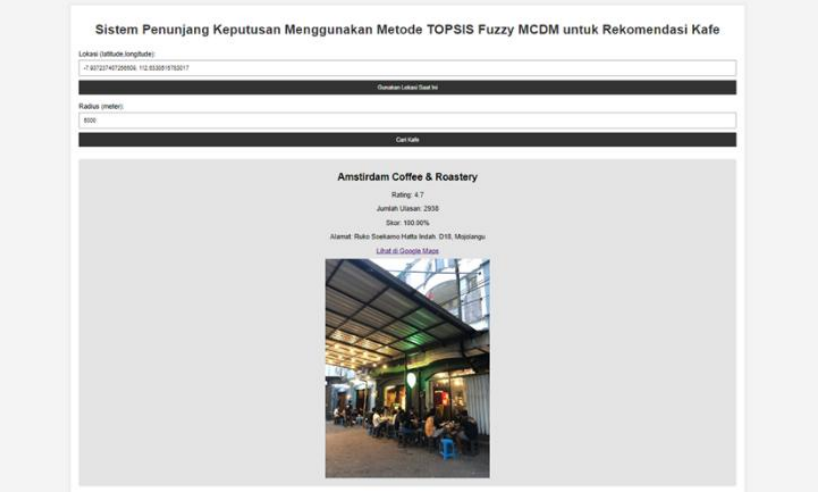

Figure 4. Website Interface Displaying Cafe Information

Elements of Figure 4:

a. Cafe Name: The name of the cafe.
b. Rating: User ratings of the cafe.
c. Review Count: Number of user reviews.
d. Recommendation Score: The calculated recommendation score.
e. Address: The address of the cafe.
f. Coordinates: Geographical coordinates for map integration.
g. Images: Visual representation of the cafe (if available).

This interface not only enhances the user experience by providing a visually appealing and easy-to-navigate platform but also integrates real-time data from Google Maps API to ensure the information is accurate and up-to-date. Users can interact with the map to see the exact location of each cafe and get directions directly from their current location, further improving the usability and functionality of the system.

B. System Testing

Usability testing was conducted to evaluate the web-based cafe recommendation system using the System Usability Scale (SUS) with a diverse group of participants [27]. The results indicated users generally found the site easy to use and well-integrated. The average scores for each usability category were calculated, providing insights into different aspects of user experience, as shown in Table 3.

Table 3. Usability Testing Result

No	Statement	Score	Category
1	I found the website easy to use	4.2	Learnability
2	I thought the webpage was overly complicated.	1.8	Learnability
3	The website seemed well-integrated to me.	4.1	Learnability
4	I found inconsistencies in the website	2	Learnability
5	I believe most people would quickly learn to use this website	4.3	Learnability
6	I needed technical support to use the website	1.7	Efficiency
7	I discovered that this website's features operated smoothly.	4	Efficiency
8	I found the website very difficult to use	1.9	Memorability
9	I had no trouble navigating the website.	4.3	Memorability
10	I found the website needs many improvements before I could use it	2.1	Errors

The learnability aspect received an average score of 3.28, indicating that most users found the site understandable and straightforward. The efficiency category scored an average of 2.85, suggesting that users found the site quick to navigate and requiring minimal technical support. In terms of memorability, the site received an average score of 3.1, showing that users felt confident and could easily recall how to use it. However, the errors category scored lower, with an average of 2.1, highlighting some inconsistencies and areas needing improvement.

Overall, the usability testing yielded an average score of 2.83, reflecting a generally positive user experience with noted areas for enhancement in error handling and consistency. This feedback is invaluable for refining the application to better meet user needs and enhance overall satisfaction.

C. Comparation Between Previous Research

The comparison between previous research and the results proposed by the author can be found in Table 4. This table provides a clear overview of the differences and similarities between the findings from previous research and the results proposed by the author. The analysis in the table allows readers to understand the new contributions offered by this research and how it enriches understanding in the relevant domain.

Table 4. Comparation Table

Researcher	Method	Results
[4]	Fuzzy TOPSIS MCDM	Recommendations according to visitor preferences. Not integrated with Google Maps, locations and criteria are limited.
[28]	TOPSIS	Laptop recommendations based on price, specifications, and brand. Does not consider warranty and after-sales service.
[29]	Fuzzy MCDM	Supplier ranking based on specified criteria. Not integrated with the company's ERP system.
Author	TOPSIS Fuzzy MCDM	Evaluation of cafes around the user's location based on rating, price, location, facilities, and service. Highest results: A1 reached 100%, A2 reached 83.09%, A3 reached 79.10%. The model shows high accuracy and balanced assessment. The system can be integrated with real-time data and Google Maps.

The table above illustrates the comparison of methods and results from previous research and the results proposed by the author, highlighting new contributions in terms of accuracy, flexibility, and integration of real-time data and Google Maps for enhanced recommendations.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The evaluation using the Fuzzy TOPSIS MCDM method effectively ranks cafes around the user's location by considering criteria such as rating, price, location, facilities, and service. The highest recommended cafe, Amstirdam Coffee & Roastery, received a score of 100%, followed by Labore Coffee Eatery with 83.09%, and Permata Jingga Swimming Pool & Cafe with 79.10%. This model demonstrates high accuracy in matching user preferences with cafe recommendations, providing balanced assessments by weighing primary focus on cafe ratings, followed by price, location, facilities, and service. This ensures that users receive relevant and accurate recommendations based on their personal preferences.

The use of fuzzy membership functions for each criterion offers flexibility in assessment, aligning more closely with user preferences and ensuring that important aspects of a cafe are considered holistically. This results in more informative and suited recommendations to users' needs. Overall, the implementation of the Fuzzy TOPSIS MCDM method proves effective in addressing the complexities of multi-criteria evaluations, offering a solution that is easy to understand and apply.

B. Recommendations

Future research could further enhance the model by integrating additional information about cafes, such as their social media presence, customer reviews, and events. This additional data could provide a more comprehensive view of each cafe, enabling even more tailored and precise recommendations. Integrating real-time data and Google Maps would also improve the model’s usability, offering users dynamic and location-based updates. This could ensure that the recommendation system stays current with the latest information and trends, thereby improving user satisfaction and engagement.

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