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PENERAPAN FUZZY PRINCIPAL COMPONENT UNTUK MENGIDENTIFIKASI OBJEK WISATA ALTERNATIF TERBAIK DI YOGYAKARTA

APPLICATION OF FUZZY PRINCIPAL COMPONENT ANALYSIS FOR THE BEST ALTERNATIVE TOURIST ATTRACTION IN YOGYAKARTA

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Abstrak

Perkembangan sektor industri merupakan salah satu indikator kemajuan suatu negara, khususnya pada sektor industri pariwisata. Sektor pariwisata merupakan salah satu sektor industri yang memiliki potensi besar bagi Indonesia sehingga dapat memajukan perekonomian nasional, baik sebagai penghasil devisa, penciptaan lapangan kerja, maupun sebagai penggerak peningkatan pendapatan masyarakat. Salah satu daerah di Indonesia yang mengandalkan sektor pariwisata adalah Provinsi Daerah Istimewa Yogyakarta. Provinsi Daerah Istimewa Yogyakarta sendiri menjadi provinsi tujuan wisata setiap tahunnya, banyak wisatawan yang tidak mengetahui tempat mana yang menjadi pilihan terbaik bagi wisatawan. Oleh karena itu, penelitian ini bertujuan untuk memudahkan wisatawan dalam memperoleh informasi tempat wisata terbaik di Daerah Istimewa Yogyakarta. Berdasarkan data yang diperoleh dari hasil penyebaran kuisioner secara online selama bulan Juni 2022 – Juli 2022. Hasil penelitian dengan menggunakan metode Fuzzy Principal Component Analysis didapatkan objek wisata terbaik adalah objek wisata Candi Prambanan dengan skor PCA 0,677057 yang mana artinya Candi Prambanan merupakan objek wisata yang paling banyak diminati oleh pengunjung wisatawan, disusul Jalan Malioboro dengan skor PCA 0,48146 dan Pantai Parangtirtis dengan skor PCA 0,369162. Hasil penelitian ini diharapkan dapat membantu wisatawan dalam menentukan alternatif pilihan objek wisata yang ingin dikunjungi di Provinsi Daerah Istimewa Yogyakarta.

Kata Kunci: Industri Pariwisata, Objek Wisata, *Fuzzy Principal Component Analysis*

Abstract

One of the regions in Indonesia that depends on the tourism sector is the Special Region of Yogyakarta Province. The Province of the Special Region of Yogyakarta itself every year becomes a tourist destination province for vacations, many tourists do not know which places are the best choices for tourists. Therefore, this research aims to make it easier for tourists to obtain information on the best tourist spots in the Province of the Special Region of Yogyakarta. Based on the data obtained from the results of distributing online questionnaires during June 2022 – July 2022. The results of the study using the Fuzzy Principal Component Analysis method, it was found that the best tourist attraction is the Prambanan Temple tourist attraction with a PCA score of 0.677057 which means that Prambanan Temple becomes a tourist attraction. The most sought after by tourist visitors, followed by the Malioboro Street Area with a PCA score of

0.48146 and Parangtirtis Beach with a PCA score of 0.369162. The results of this study are expected to help tourists determine alternative choices of tourist objects they want to visit in the Special Region of Yogyakarta Province.

***Keywords**: Tourism Industry, Tourism Objects, Fuzzy Principal Component Analysis*

1. Introduction

Tourist attractions in the Special Region of Yogyakarta Province include natural attractions, cultural attractions, artificial/special tourist attractions, and tourist villages/villages. One of the cultural tourist attractions in the Province of DIY is Prambanan Temple. The development of the number of tourist visits both foreign and domestic in the 2016-2019 period has continued to increase. In 2019, there were 2,509,655 tourists visiting Prambanan Temple. In 2020, only 688,328 tourists.

Second, a natural tourist object that is thick with the legend of Nyiroro Kidul, namely Parangtritis Beach. The development of the number of tourist visits both foreign and domestic to Parangtritis Beach from 2016-2019 has also increased, and in 2018 recorded the highest number of 2,895,187 tourists. In 2020 there were 1,455,920 tourists.

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Third, the most famous artificial/special tourist object and one of the main attractions of the city of Yogyakarta is the Malioboro Street Area. In 2016-2019 the Jalan Malioboro area, which is in the middle of the city of Yogyakarta, experienced ups and downs and in 2016 the highest number of visits was recorded, reaching 5,520,952 tourists, both foreign and domestic. In 2020, only 1,366,570 people were recorded [1].

The development of visits by foreign tourists and domestic tourists in DIY Province in 2018 was 25,716,261 people. Then there was an increase in tourist visits in 2019 as many as 27,365,291 people even though that year the Covid-19 pandemic had started in Indonesia. In 2020 there were 10,830,143 tourist visits, this decrease was due to the Covid-19 pandemic which is increasingly spreading in Indonesia and the government prohibiting people from leaving the city. In 2021 the number of tourist visits was 7,590,233, this decrease occurred because the Indonesian government issued PPKM regulations (Implementation of Community Activities Restrictions) and in the Special Region of Yogyakarta Province implemented level 3 PPKM [2].

At the beginning of 2022, the Yogyakarta City Tourism Office noted that tourist visits during January 2022 were quite high. Because there are 780,000 people who visit Yogyakarta. Yogyakarta City Tourism Office Wahyu Hendratmoko said that the number was quite high considering that usually January is the 'low season'. This condition for us is an anomaly. However, we have confirmed with the hotel and indeed the occupancy in January is quite high, especially around Malioboro [3].

Based on this, it can be seen that the Province of the Special Region of Yogyakarta is still a favorite tourist destination for most domestic and foreign tourists. Traveling is an important physical need without us knowing it. In this case, the selection of the right tourist object also affects tourists, so a system is needed in the field of tourism which is expected to provide an alternative choice of tourist objects for visiting domestic and foreign tourists. In determining the alternative selection of tourist objects, it does not escape from the criteria needed to make decisions regarding the best available information on alternative tourist objects.

In analyzing the criteria used to determine the best tourist attraction, it is necessary to provide a weighting value to the criteria used, one can use a fuzzy approach. Fuzzy logic was first discovered by professor Lotfi A. Zadeh in June 1965. Fuzzy logic is a method that can deal with uncertainty problems where there are unclear boundaries between one condition and another, where each member has a membership degree that is valued between the range [0,1][4].

The fuzzy method is used to measure subjective decision makers. Meanwhile, Principal Component Analysis (PCA) is to reduce the dimensions of a data set where there are a large number of interrelated variables by retaining as much variation as possible in the data set [5]. The combined linear Principal Component Analysis or called the PCA Score is used to determine the ranking of tourist objects.

Fuzzy Principal Component Analysis (FPCA) is considered as one of the best methods for decision making especially determine the ranking of tourist objects due to its ability to handle complex and uncertain data in a more flexible and efficient way. FPCA is an extension of the conventional Principal Component Analysis (PCA) which uses fuzzy logic to deal with uncertainties and vagueness in data [6].

FPCA has several advantages over other decision-making methods. Firstly, it can handle datasets with high dimensionality and noise in a more effective manner. This is because FPCA can extract the most relevant features of the dataset by reducing the dimensionality of the data and removing irrelevant features. Secondly, FPCA can handle missing or incomplete data, which is common in real-world datasets. It does this by assigning a degree of membership to each data point, indicating the likelihood of the data belonging to a certain cluster or group [7][8].

Another advantage of FPCA is its ability to generate more accurate results compared to other decision-making methods. This is due to the fact that FPCA considers the vagueness and uncertainty of the data, which can lead to more accurate and reliable decisions. FPCA can also handle conflicting and inconsistent data by assigning weights to each data point based on its importance and relevance [9][10].

Based on these problems, the author will conduct research to provide alternatives for selecting the best tourist objects in the Special Region of Yogyakarta Province using the Fuzzy Principal Component Analysis method. The selection of the best tourist objects is expected to be able to help tourists determine the choice of tourist objects and help the tourism office to determine further policies on existing tourist objects.

2. Methods

The data used in this study is primary data obtained from a questionnaire on the assessment of tourist objects in the Province of the Special Region of Yogyakarta. The tourist objects used for the assessment in this study were Prambanan Temple, Malioboro Street Area, and Parangtritis Beach. the variables used include: Total Cost, Facilities, Accessibility, Atmosphere, Attractions, Security.

The data analysis method used in this research is the Fuzzy Principal Component Analysis method, where the fuzzy logic method is used to weight tourist attractions, while the Principal Componet Analysis is used to simplify the variables used in assessing tourist attractions.

2.1 Fuzzy Logic

Fuzzy logic theory is a mathematical approach to dealing with uncertainties and vagueness in data. It is a branch of logic that allows for the representation of imprecise or vague concepts, which are not well-suited for traditional binary logic [11].

Fuzzy logic involves working with fuzzy sets, which are sets that allow for partial membership. In other words, rather than assigning an object to either a set or not a set (as in binary logic), fuzzy logic allows for objects to have varying degrees of membership in a set. This approach allows for a more nuanced and flexible way of working with data that is inherently imprecise or uncertain.

Fuzzy logic has many practical applications, including in control systems, decision making, and artificial intelligence. By allowing for the representation of imprecise data, fuzzy logic can provide more accurate and effective solutions to real-world problems [12].

2.2 Fuzzy Set Theory

Fuzzy set theory is a mathematical framework for dealing with uncertainties and vagueness in data. Unlike traditional set theory, where an element can either belong to a set or not, in fuzzy set theory, an element can belong to a set to a certain degree between 0 and 1. This degree of membership is represented by a membership function, which assigns a degree of membership to each element in the set. Fuzzy set theory is useful in situations where precise definitions and boundaries are difficult to define or where ambiguity and uncertainty are inherent in the data.

In fuzzy set theory, the attributes of a fuzzy set are characteristics or properties that are used to define the membership function of the set. The membership function maps each element of the universal set to a degree of membership in the fuzzy set, and it is defined based on one or more attributes [12].

For example, let's consider a fuzzy set that represents the concept of "tallness" in humans.

One possible attribute that can be used to define this fuzzy set is "height". We can define a membership function that maps each height value to a degree of membership in the set "tallness". This membership function could be a triangular function, where the height values that are closer to a certain threshold value have higher degrees of membership in the set.

Other attributes that can be used to define fuzzy sets include "weight", "age", "temperature", "distance", "velocity", etc. The choice of attributes depends on the problem domain and the specific application of fuzzy set theory [11].

2.3 Triangular Membership Function

In fuzzy logic, a triangular membership function is a type of membership function that is shaped like a triangle. It is a widely used function for representing fuzzy sets because of its simplicity and effectiveness [13]. Triangular curve representation illustrated in Figure 1. as follows.

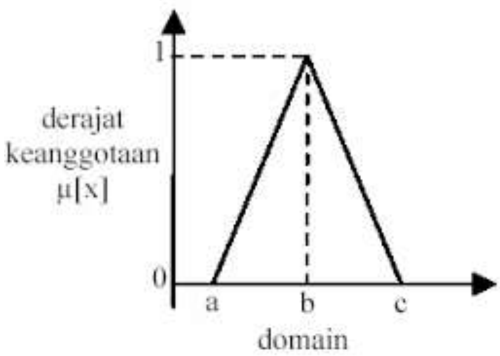

Figure 1. Triangular Curve Representation

The formula for the triangular membership function is:

$$\mu(x) = \begin{cases} 0, & x < 0 \; or \; x > c \\ x, & a \le x \le b \\ x, & \text{b} \le x \le c \end{cases} \tag{1}$$

The triangular membership function is defined by three parameters: *a*, *b*, and *c*. The parameters a and c represent the lower and upper bounds of the function, while b represents the peak of the function. The function is 0 up to the value of a, increases linearly from a to b, and then decreases linearly from *b* to *c*. As well as μ parameter is is the membership value of the fuzzy set at input value *x* [14][15].

2.4 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a mathematical technique used for dimensionality reduction in data analysis. It transforms high-dimensional data into a new coordinate system that captures the maximum amount of variation in the data with a smaller number of variables called principal components. The first principal component captures the most variation in the data, and each subsequent component captures the most remaining variation, subject to the constraint that it is uncorrelated with the previous components [16].

The mathematical formula for PCA involves calculating the covariance matrix of the original data, performing an eigendecomposition on the covariance matrix to obtain the eigenvectors and eigenvalues, sorting the eigenvectors by decreasing eigenvalue, and projecting the original data onto the new coordinate system defined by the eigenvectors . The formula for projecting a data point onto the new coordinate system is:

$$y = W^T x \tag{2}$$

where y is the new coordinate vector, W is the matrix of eigenvectors, and x is the original data point. PCA can be performed using a variety of algorithms, including singular value decomposition (SVD) and the eigenvalue decomposition method [5] [17].

2.5 Fuzzy Principal Component Analysis

Fuzzy Principal Component Analysis (FPCA) is an extension of Principal Component Analysis (PCA) in the field of fuzzy logic. FPCA is used to reduce the dimensionality of a dataset by transforming the original variables into a new set of variables, called principal components. The goal of FPCA is to find a low-dimensional representation of the data that retains the most of the variation in the original dataset.

In FPCA, the input data is represented as a fuzzy set, where each element of the dataset is assigned a degree of membership to each of the fuzzy sets. The degree of membership is represented by a membership function, which maps the values of the input data to a degree of membership in the fuzzy set [18].

FPCA uses fuzzy logic to compute the main components of the dataset, which are the linear combinations of the input variables that capture the most variation in the data. The fuzzy principal components are computed by minimizing the fuzzy reconstruction error, which is the distance between the original data and the reconstructed data using the fuzzy principal components [19].

FPCA has applications in many areas, including image processing, pattern recognition, and data analysis. It is particularly useful in situations where the input data is imprecise, uncertain, or incomplete [20].

The algorithm for Fuzzy Principal Component Analysis (FPCA) with the initial step of constructing membership functions using triangular curve representation and then using PCA to obtain PCA scores for each of the best tourist destinations [20][21][22]:

1. Make a data set that contains the attributes to be analyzed
2. Create a membership function using the triangular curve representation for each attribute
3. Calculate the covariance matrix from the data
4. Calculate the eigenvalue and eigenvector of the covariance matrix
5. Choose the largest k eigenvector with eigenvalue > 1, to form the transformation matrix
6. Use the Coefficient Matrix Component Score to convert the data into a PCA score
7. Use the PCA score to classify the best tourist destinations.

3. Results and Discussion

3.1 Description of the Assesment of Tourist Attraction in DIY

Assessment data for three tourist objects that have been determined in the Special Region of Yogyakarta based on 6 assessment criteria are presented in table 1. below.

Table 1. Yogyakarta Special Region Tourist Attractions Evaluation Data

Variable	Tourist Attraction

	Prambanan Temple	Malioboro Street Area	Parangtritis Beach	*Uncertain Value*
Total Cost	4.2	4.4	4.5	*High*
Facilities	4	3.6	3.4	*High*
Accessibility	4.3	4.3	3.8	*High*
Atmosphere	4.2	3.8	3.5	*High*
Attraction	4.1	3.9	3.5	*High*
Security	4.1	3.6	3.7	*High*

Table 1. shows the respondents' assessment of the three tourist objects, where on the Total Cost variable criteria, the results of the respondents gave a medium rating to the three tourist objects with each assessment sequentially for Prambanan Temple, Malioboro Street Area, and Parangtritis Beach, namely 4.2, 4.5 , and 4.5.

3.2 Fuzzification Process

Fuzzification results for the three tourist artifacts based on the six research factors shown in Table 2 below were calculated using the TFN approach and a triangle curve representation.

Table 2. Evaluation of Attraction Data with Fuzzy Logic

Tourist Attraction	Research Variable					
	Total Cost	Facilities	Accessibility	Atmosphere	Attraction	Security
Prambanan Temple	0.8	1	0.7	0.8	0.9	0.9
Malioboro Street Area	0.6	0.6	0.7	0.8	0.9	0.6
Parangtritis Beach	0.5	0.4	0.8	0.5	0.5	0.7

Table 2 shows that the degree of membership for each variable criterion is obtained using the Tringular Fuzzy Number (TFN), namely the total cost variable for each tourist attraction gives a value of 0.8, 0.5, and 0.5, which means that a tourist object with an assessment of the total cost of 4.2, 4.5, and 4.5 will be included in the medium set with membership degrees of 0.8, 0.5, and 0.5. The other five variables will be fuzzified in the same way as the total cost variable.

3.3 Determination of Tourist Destination Rating

PCA results obtained 2 eigenvalues with $\lambda > 1$, namely $\lambda_{1=}$ 4.664 and $\lambda_{2=}$1.336 , so that the main components to be formed must be as many as 2 principal components. The cumulative proportion of the first and second components formed is 100%. If it is concluded that the six original variables in the study can be reduced to 2 factors/components, where these two new factors/components can explain 100% of the total variance of the six previous variables. The two new components formed will be symbolized by y_1 and y_1, have a coefficient matrix component score which can be seen in Table 3 following

Table 3. Coefficient Matrix Component Scores

Variable	Principal Component	
	y_1	y_2
Total Cost	0.203	0.237
Facilities	0.203	0.237
Accessibility	-0.198	0.286
Atmosphere	0.198	-0.286
Attraction	0.198	-0.286
Security	0.118	0.625

Based on the PCA matrix component scores, scores for tourist attractions can be obtained which are shown in Table 4 below

Table 4. Performance Assessment of Tourist Attraction Based on y_i.

Tourist Attraction	y_1	y_2
Prambanan Temple	0.6696	0.7031
Malioboro Street Area	0.5124	0.3734
Parangtritis Beach	0.3049	0.5936

Table 4 shows the results of the performance assessment for tourist objects obtained from the multiplication of fuzzy data with each component score of the coefficient matrix.

Then proceed with determining the best tourist attraction using the PCA score. The PCA score is shown by the equation:

PCA Score = $0.77741y_1 + 0.22259y_2$

From the equation, the PCA score for each tourist attraction can be generated as follows:

Table 5. PCA Score of Tourist Attraction

Tourist Attraction	PCA Score
Prambanan Temple	0.67706
Malioboro Street Area	0.48146
Parangtritis Beach	0.36916

From Table 5, found that the best tourist object has the highest rating score, namely Prambanan Temple with a PCA score of 0,677057. The next best tourist object in second place is the Malioboro Street Area with a PCA score of 0,48146. The tourist object in third place is Parangtritis Beach with a PCA score of 0,369162.

4. Conclusion

Based on the results of the research analysis, it was concluded that the best alternative for choosing the best tourist attraction in the Special Region of Yogyakarta Province is Prambanan Temple with a PCA score of 0.677057 so that it can be seen that the Prambanan Temple tourist attraction is a tourist attraction in the Special Region of Yogyakarta Province which is most in demand by tourist visitors. In addition, the tourist attraction that is of interest to tourist visitors after Prambanan Temple is the Malioboro Street area with a PCA score of 0.48146. then, the Parangtritis Beach tourist attraction is a tourist object that is of interest to visitors after Prambanan Temple and the Malioboro Street Area by obtaining a PCA score of 0.369162.

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