Analysis of music influence on order preference based on TOPSIS algorithm

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Abstract. Music, as a cultural treasure, is currently difficult to accurately measure its influence due to its special nature. In order to solve this problem, an evaluation model based on TOPSIS is proposed. The influence of music is defined as the combination of the number of followers and the number of followers of the same genre as the influencer, and then the TOPSIS method is used to quantitatively analyze the influence of music. By establishing the original data matrix of relevant music characteristics, and then forward and normalize the data matrix, calculate the distance between the data and the optimal solution and the worst solution, and obtain the quantitative score of the music influence value, a right Accurate measurement of music influence is realized.

1. Introduction

The musicological and sociological impact of musical influence has considerable scope. The concept of musical influence is loosely defined, and its role has been debated between art historians and cultural critics. Unfortunately, these issues have never been studied in a data-driven manner. To this end, scholars have conducted a lot of researches. Early music-based networks are found in Cano and Koppenberger [1] and Cano et al.[2]. Collins investigated what is presumably the first computational analysis of musical influence using web scraping, web services, and audio similarity to construct influence graphs of a collection of synth pop music [3]. The above method is based on network analysis technology that affects the difficulty of network construction, high algorithm complexity, and low recognition rate.

The influence of music usually contains many elements, including: the number of followers, similarity with other music, etc. These elements are difficult to accurately represent in digital form. Aseervatham S [4] and others have explored music works based on the trapezoidal fuzzy number, combined with fuzzy TOPSIS and other technologies, based on the characteristics of music. Therefore, this article also uses a mathematical model based on TOSIS to accurately measure the influence of music and overcome and avoid the above shortcomings.
2. Model

2.1. Overview
This article simply defines music influence as the combination of the number of followers and the number of followers of the same type as the influencer. As shown in Figure 1.

![Figure 1. Musical influence model.](image)

The TOPSIS method (similar to the order preference technology of the ideal solution) is an effective method for multi-objective decision analysis. Its basic principle is to classify and evaluate according to the approach of the evaluation object to the best objective. This paper uses the TOPSIS method to establish a mathematical model that can measure the influence of music. The model mainly includes the following three parts: (1) Data forwardization: The original data matrix of the evaluation object is forwarded, and all indicator types are uniformly converted into extremely large indicators. (2) Data standardization: Standardize the data matrix after the normalization process to eliminate the influence of the dimensions of each evaluation index on the results. (3) Comprehensive score of music influence: Find the best result and the worst result in all the schemes, and calculate the distance between each evaluation object and the best result and the worst result, and calculate the distance to the best result and the worst result. The result is normalized, and the quantized value is limited to the interval \([0,1]\), which makes the result more intuitive and clear.

2.2. Data forward
Different types of evaluation indicators cannot be directly used in the evaluation model without data processing, otherwise it will cause confusion. Therefore, the original data needs to be normalized to convert all evaluation indicators into extremely large indicators.

The normalization processing formula is as follows:

\[
\hat{x}_i = \max\{x_i\} - x_i \quad (i = 1, 2, 3, 4, 5, 6, 7, 8, 9)
\]

Among them, \(\hat{x}_i\) represents the positive result of the \(i\)-th evaluation index, \(\max\{x_i\}\) represents the number with the largest value in the \(i\)-th evaluation index, and \(x_i\) represents the \(i\)-th evaluation index.

2.3. Standardized processing
Since different evaluation indicators have different dimensions, it is difficult to quantify these indicators under a unified standard. Therefore, the normalized data matrix is standardized to quantify and analyze the evaluation indicators under a unified standard, and finally obtain accurate music influence.

Suppose the data matrix \(X\) after normalization is:
There are \( n \) objects to be evaluated and \( m \) evaluation indicators.

Subsequently, we standardize each matrix element \( X_{nm} \) to obtain a standardized matrix element \( Z_{nm} \)

The calculation formula is as follows:

\[
Z_{nm} = \frac{x_{nm}}{\sqrt{\sum_{i=1}^{n} x_{nm}^2}}
\]

The resulting standardized matrix \( Z \) is as follows:

\[
Z = \begin{bmatrix}
z_{11} & z_{12} & \cdots & z_{1m} \\
z_{21} & z_{22} & \cdots & z_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
z_{n1} & z_{n2} & \cdots & z_{nm}
\end{bmatrix}
\]

2.4. Comprehensive score of music influence

Firstly, find the best solution with the highest score and the worst solution with the lowest score. The calculation formulas for the best result and the worst result are as follows:

\[
z^+ = (z^{+}_1, z^{+}_2, \ldots, z^{+}_m) = (\max \{z_{11}, z_{21}, \ldots, z_{n1}\}, \max \{z_{12}, z_{22}, \ldots, z_{n2}\}, \ldots, \max \{z_{1m}, z_{2m}, \ldots, z_{nm}\})
\]

\[
z^- = (z^{-}_1, z^{-}_2, \ldots, z^{-}_m) = (\min \{z_{11}, z_{21}, \ldots, z_{n1}\}, \min \{z_{12}, z_{22}, \ldots, z_{n2}\}, \ldots, \min \{z_{1m}, z_{2m}, \ldots, z_{nm}\})
\]

Among them, \( Z^+ \) and \( Z^- \) represent the best result and the worst result, respectively, \( Z^+_m \) represents the maximum value of the \( m \)-th evaluation index after standardization, and \( Z^-_m \) represents the minimum value of the \( m \)-th evaluation index after standardization.

The distance between the evaluation object and the best and worst results. The formula for calculating the distance between the \( i \)-th evaluation object and the optimal result is as follows:

\[
D^+_i = \sqrt{\sum_{j=1}^{m} (z^{+}_j - z_{ij})^2}
\]

The formula for calculating the distance between the \( i \)-th evaluation object and the worst result is as follows:

\[
D^-_i = \sqrt{\sum_{j=1}^{m} (z^{-}_j - z_{ij})^2}
\]
Among them, $D_i^+$ and $D_i^-$ respectively represent the distance between the i-th evaluation object and the optimal result and the worst result, $n$ is the number of enterprises, and $m$ is the number of evaluation indicators.

2.5. Calculate music influence score

Since the evaluation object’s score is closer to the optimal result and farther from the worst result, the overall score will be higher, and the corresponding music influence will be greater, thus realizing the ranking and numerical quantification of music influence.

The calculation formula is as follows:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

Among them, $S_i$ is the comprehensive score of music influence of the i-th evaluation object, and $D_i^+$ and $D_i^-$ represent the distance between the i-th evaluation object and the best result and the worst result, respectively.

2.6. Normalization

Finally, normalize the results and limit the quantified value to this interval, making the result of the musical influence on the evaluation object more intuitive and clear.

The calculation formula for normalization is as follows:

$$\tilde{S}_i = \frac{S_i}{\sum_{i=1}^{n} S_i}$$

Among them, $\tilde{S}_i$ is the music influence score of the i-th evaluation object after normalization, that is, the final quantified result, and $S_i$ is the music influence score before normalization.

3. Model evaluation

Count the number of followers and the number of followers with the same influencer genre as the original data matrix of the model evaluation index. Due to too much data, Table 1 only shows part of the original data of influencer.

| Musical influencer name | Number of followers | Number of same genre |
|-------------------------|---------------------|----------------------|
| The Exploited           | 12                  | 12                   |
| Tricky                  | 11                  | 4                    |
| Bob Dylan               | 367                 | 322                  |
| Leonard Cohen           | 64                  | 59                   |
| The Gun Club            | 9                   | 9                    |
| Chrissie Hynde          | 6                   | 6                    |
| Crime & the City Solution | 3                | 3                    |
| Lesley Gore             | 8                   | 8                    |
| Massive Attack          | 31                  | 13                   |
Since the number of followers and the number of followers of the same genre of influencer are both very large indicators, that is: the more followers of influencer, the more followers of the same genre of influencer, the greater the influence of music. Therefore, the original data itself has completed the data forwarding step.

The standardized processing results of some influencers are shown in Table 2.

**Table 2. Standardized processing results of some influencers.**

| Musical influencer name | Normalized data | Distance from optimal result | Distance from worst result |
|-------------------------|-----------------|-------------------------------|----------------------------|
| The Exploited           | 0.007821        | 0.397690                      | 0.008237                   |
| Tricky                  | 0.007169        | 0.401200                      | 0.005091                   |
| Bob Dylan               | 0.239181        | 0.163684                      | 0.242473                   |
| Leonard Cohen           | 0.041710        | 0.362754                      | 0.043147                   |
| The Gun Club            | 0.005865        | 0.399820                      | 0.006107                   |
| Chrissie Hynde          | 0.003910        | 0.401951                      | 0.003981                   |
| Crime & the City Solution| 0.001955       | 0.404081                      | 0.001866                   |
| Lesley Gore             | 0.002024        | 0.400530                      | 0.005398                   |
| Massive Attack          | 0.020203        | 0.391423                      | 0.015511                   |

The music influence scores of some influencers are shown in Table 3.

**Table 3. Musical influence scores of some influencers.**

| Musical influencer name | Music influence score |
|-------------------------|-----------------------|
| The Exploited           | 0.000322              |
| Tricky                  | 0.000199              |
| Bob Dylan               | 0.009472              |
| Leonard Cohen           | 0.001687              |
| The Gun Club            | 0.000239              |
| Chrissie Hynde          | 0.000156              |
| Crime & the City Solution| 0.000073             |
| Lesley Gore             | 0.000211              |
| Massive Attack          | 0.000605              |
The visualization of the effect of music influence is shown in Figure 2.

![Visual chart of music influence](image)

**Figure 2.** Visual chart of music influence.

Our musical influence model reveals that when an influencer has more followers who have the same genre as the influencer, the greater the musical influence. According to the model, the “The Beatles” has the most influence on music, and its influence score is 0.015866.

4. Conclusions

This paper proposes a direction for mathematical evaluation of music influence, using a TOPSIS-based model to quantify music influence. Experiments have shown that this model can accurately and quickly analyze music influence and solve complex and non-mathematical problems of music indicators via the network analysis model.

References

[1] P. Cano and M. Koppenberger: “The Emergence of Complex Network Patterns in Music Artist Networks,” In Proceedings of the International Symposium on Music Information Retrieval, pp. 466–469, 2004.

[2] P. Cano, O. Celma, M. Koppenberger, and J. MartinBuldú: “Topology of Music Recommendation Networks,” Chaos An Interdisciplinary Journal of Nonlinear Science, 2006.

[3] N. Collins: “Computational Analysis of Musical Influence: A Musicological Case Study Using MIR Tools,” In Proceedings of the International Symposium on Music Information Retrieval, pp. 177–182, 2010.

[4] Aservatham S, Devadoss A V. Analysis on Criteria based Emotive Music Composition Selection using a New Trapezoidal Fuzzy DEMATEL - TOPSIS Hybrid Technique[J]. Journal of Fuzzy Set Valued Analysis, 2015, 2015(2):122-133.

[5] Liu Yang, Chen Hongyu, Xian-jia Wang. Research on green renovations of existing public buildings based on a cloud model - TOPSIS method. 2021, 34

[6] Sabin C. Buraga, Octavian Dospinescu, 2. A Knowledge-Based Pilot Study on Assessing the Music Influence. 2021, 66(3):2857-2873.

[7] David M Greenberg, Peter J Rentfrow. Music and big data: a new frontier. 2017, 18:50-56.

[8] Roger Horrocks. When the Mode of the Music Changes. 2016, 33-60.