The Convergence of Ancient and Modern Music, The Exploration of Similarities and Differences in Genres

Summary

The existence and development of music is not only the law and problem of music itself, it develops with the change of human society and culture, and various styles of music communicate and integrate with each other. In order to quantify this process and understand music culture, we have developed the 'Music Influence Network' and 'Music Similarity Measure' models, as well as other models to measure such issues as music influence. In order to establish a 'Music Influence' model to evaluate the comprehensive influence of artists, we constructed a targeted 'music influence network'. Considering the lack of time dimension information, we constructed a 'genre-period relationship curve' as a supplement. In the model, the concept of hierarchy is more prominent, and the selected parameter of 'music influence' has a distinct attribute that makes it possible to be layered. The hierarchical nature of the parameters allows the Musical Impact model to judge artists from different perspectives. For example, using this model, we can find 'revolutionary artists' within each genre by increasing the weight of parameters in the 'musical influence' parameter that are more representative of genres and more reflective of development.

To address the problem of measuring musical similarity, we note that distance and similarity should satisfy restrictions such as non-negativity, triangular inequality, and neighbourhood correlation, and propose a similarity measure based on Euclidean distance.

We have carried out calculation and analyses based on similarity above to study the differences between genres and the changes in genres over time. It shows that artists' similarity within genres is generally more significant than that of artists between genres, while musical genres influence each other to converge.

In determining whether influencers have influenced the music created by their followers, we note that the 'Musical Similarity Measure' model is challenging to interpret for a single object. We innovatively use the idea of 'Mismatch' by comparing the mean values of similarity in influence pairs, to those who are not. We are confident that influencers have a strong influence on the music created by their followers.

To investigate the 'contagious' of each music characteristics, we considered the 'contagious of music Characteristics' factor, using existing models, and concluded that musical characteristics do not have a consistent 'contagious'.

Finally, considering that music's evolution is related to the artist and involves many non-musical factors, such as social, political, technological, we analyse music as a culture to understand its change and development. The research proves that music changes mainly in response to the evolution and development of society.

Keywords:Musical genres, Network, Musical culture, High-dimensional space

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1   Introduction

1.1   Problem Background

As one of the most important aesthetic and cultural phenomena of the masses, music is also an important area in which we learn about society and explore the social psychology. Throughout history and across the world, music has been a part of people's lives, a part of society, an outward expression of the psychological connotations of society, an important guide to the spirit of the times and an important source of self-soothing for human nature. In the course of history and the changing times, the form and content of music has evolved, and in terms of musical genres alone, there are Pop/Rock, Country, Blues, R&B, Tazz and Latin, etc. There is an inevitable pattern of development, not only in relation to the old music and artists, but also in relation to many external factors, including It also involves many external factors, including society, politics, new technologies, religion, the natural environment, etc. The study of musical evolution is certainly a focus of attention in order to provide a more intuitive understanding of how these factors have influenced the creation of new music and the development of music in human society. This will also help us to grasp the evolutionary and revolutionary trends of artists and musical genres.

1.2   Our work

In order to provide the ICM Society with a valuable measure of musical impact and to further explore the evolution of music, we have built a series of models based on several datasets provided by the ICM Society. From each model we explored and measured the influence of internal factors such pre-era music and external factors such as politics and technology on new music and musical artists, making the necessary validations and interpretations in relation to the relevant literature. We conclude with a comprehensive analysis of these models, including a sensitivity analysis and an assessment of strengths and weaknesses.

We also solved the following tasks:

- We have created a 'Music Influence Network', and by capturing the 'Music Influence' parameters in this network, we have developed a 'Music Influence' model that measures the overall influence of musicians. In addition, we created a Genre Influence Sub-Network and a Genre-Activity Era Relationship Curve to explore further information.

- We have developed a 'musical similarity' model to measure musical similarity and used this model to analyse similarity between artists within and between genres.

- We compare similarities and influences within and between genres, and use this to identify differences and connections between genres.

- Based on the 'musical similarity' model, we have developed an 'influencer-follower' model that accurately measures the general influence of influencers on the music created by their followers, and we have proposed an effective method for measuring the 'contagiousness' of different musical characteristics, drawing on the 'Musical Influence Network' and the artist musical characteristics dataset.

- We have analysed the evolution of musical genres over time using the Genre-Activity Curve, and identified a number of revolutionary artists using the Musical Influence model as a tool. The evolution of musical identity over time has also been examined.

- Combining the findings of the model with the socio-historical context to analyse the evolution of musical genres and artists specifically.

- We have written a one-page document to the ICM Society about the value of studying musical influences, providing a more comprehensive solution to the data and a more in-depth study of music and the impact of music on culture.

2 Preparation of the Models

2.1 Assumptions

In order to simplify the given topic and to modify it to be more suitable for modelling real-life situations, we make the following basic assumptions, each of which is duly proved.

- Only western popular music of the 20th century is discussed, as the dataset contains only 20th century western popular music;

- The influence of the artist diminishes over time;

- Artist A is influenced by Artist B, mainly in the way Artist A imitates certain musical characteristics of Artist B;

- The Universal of similarity: the similarity of any two musical qualities exists and is a finite number of positive real numbers;
  (Humanity can only hear a finite number of sounds, and music is generally composed in a twelve-mean-rhythm construction of chords, so any two pieces of music will always have a preferred similarity.)

- Distance is measurable: the distance between musical characteristics is always constant and measurable;
  (With the data set given by ICM Society, each musical characteristic is a definite measure, so that the difference between any two pieces of music is a constant and measurable amount of the artist's contribution to a genre and, to some extent, to the development of music as a whole. We believe that those who have made a significant contribution to their field are also important to the development of the times.)

- Amount of artist's contribution to a genre and, to some extent, to the development of music as a whole. We believe that those who have made a significant contribution to their genre are also important to the development of the times.

3 Notations

The primary notations used in this paper are listed in Table 1.

Table 1: Notations

Symbol	Definition
N_f	Number of followers of the artist
L_{yg}	Degree of influence of the years on the development of the genre
PN_f	Number of followers of artists within the genre as a percentage
RL_{yg}	Ranking of L_{yg} in every genre
CF	Combined influence factor of artists
L_{mc}, AL_{mc}	Musical characteristics' Contagiousness
IF	Influence of the influencer on the music created by his followers
$i_1, i_2, \cdots$	Value of sample I on each musical characteristics
D_{IJ}	Distance between samples I,J
$S_{\mathbb{C}}(I, J)$	Similarity of samples I,J in Collection C
$S(\mathbb{C})$	Similarity of Collection C

4 Problem 1: Musical Influence Network and Musical Influence Model

4.1 Problem Analysis

In the 'influence data' dataset, by linking influencers to followers, an important 'Musical Influence Network' is created, which will describe how an artist is influenced by the artists who came before him and how he influences the artists who come after him. Furthermore, we have attempted to build on the 'Musical Influence Network' by aggregating nodes of artists from the same genre to form a genre node, forming a 'genre influence sub-network' to investigate the genre relationships between influencers and followers. In addition, the dataset identifies the genre of each artist and the era in which they were active, and by linking genre and time, a 'genre-era relationship curve' is created, which can play an important role in studying the relationship between genre and era. In the Music Influence Network, the nodes of artists who have made significant contributions within their genre do not appear to be prominent in the Music Influence Network due to differences in the attributes of the genre itself, so to address this type of problem We need to either attenuate or remove the influence of genre categories on artist nodes.

One of our key goals in establishing the networks above was to capture some "musical influence " parameter in the network to measure the influence or other information of each artist.In the above "music influence network ", a "music shadow sound " parameter directly revealed is the number of followers of each artist, N_f, which largely reflects the level of an artist's influence. Obviously, the parameters of N_f lack of artists influence in the consideration of time dimension, the key to the development of some

in the genre s artist should be more influential, described here "s crucial for the development of the genre " we define it as the second "music " parameters: different L_{yg} s influence on the development of the genre, the parameter reveals an artist in the time dimension under the influence of the size. In addition, for the attenuation or remove genre categories influence on artists node, we in N_f,L_{yg} parameters, on the basis of established artists to follow the number within the same genre of PN_f and different s in the same genre to genre development ranking RL_{yg} two new parameters, the influence of these two parameters will not be affected by the attributes of the genre itself. These four parameters will be used to measure an artist's combined impact factor CF.

4.2 Model Building

4.2.1 Establishment of Network

The establishment of each directed network or subnet requires pre-setting source node and target node, and then pointing the source node to the target node to form a network. The setting rules of source node and target node of each directed network are as follows:

Table 2: Source nodes and Target nodes setting:

Directed network name	Source nodes	Target nodes
Music Influences the Internet	Influencer id	Follower id
Genre influences the subnet	Influencer main genre	Follower main genre

It is the main way to describe the network and reveal the practical significance of the network to investigate the node information and structural characteristics of each directed network. Node information of directed graph includes node in-degree and out-degree, node in-edges and out-edges, boon node and successors node, etc. Taking "Music Influence Network " as an example, different nodes of the network represent different artists. Node OutDegree represents the number of followers of the artist, Nf, and node InDegree represents the number of influencers of the artist,N_i.Some characteristics of other directed graphs also reveal different real meanings, which will not be detailed here.

4.2.2 The Calculation Method of Each "Music Influence Parameter"

In 4.1, we put forward four key "music influence parameters" (hereinafter referred to as "parameters "), which are N_f, L_{yg}, P_{nf}, RL_{yg}. Among them, the number of followers of artists, N_f, is captured by calculating the input degree of each node of "Music Influence Network ". In order to calculate the L_{yg}, we need to make a clear definition of the "degree of influence of age on genre development " : for $\mathbb{G}$ genre, if $\mathbb{G}$ genre began to develop rapidly after Y, we think that $\mathbb{G}$ genre artists in Y played an important role in the development of $\mathbb{G}$genre. Let's assume that in the Y period, the total number of artists of G genre is N_{yg}, and in the $Y+1$ period, the total number of artists of $\mathbb{G}$ genre is $N_{(y+1)g}$, The development of $\mathbb{G}$ genre from the age of $\mathbb{G}$, $Y$to the age of $Y+1$ is expressed by the function f_1:

$$f_1(y, y+1) = \frac{N_{(y+1)g} - N_{yg}}{N_{yg}} \tag{1}$$

Among them: N_{yg}:The total number of artists in genre G in the Y's

Due to the continuation of history, we believe that the influence of the generation of artists not only until the next, but will continue for a longer time, but its influence will gradually decrease over time (hypothesis 2), so we proposed impact force attenuation factor α, as for $Y + \Delta$ s, the influence of the use function f_2Said: $f_2(\Delta y) = e^{-\alpha * \Delta y}$Based on this, we propose the degree function of Y's influence on the development of G genre:

$$L_{yg}(y, g) = \frac{\sum_{i=y_0}^{y_m}(f_1(y_i, y_i+1) * f_2(y_i - y_0))}{y_m - y_0 + 1} \tag{2}$$

Among them: y:years; g: Genre

At this point, we have completed the establishment of the model to obtain the two parameters ofN_f, L_{yg}, and each artist can calculate the unique corresponding L_{yg} according to its era and genre. For parameters P_{Nf}, RL_{yg}, it is easy to understand from our description of PN_f, RL_{yg}. The essence of these two parameters is to normalize the values of N_f, L_{yg} parameters within the same genre, so that the parameters of PN_f, RL_{yg} between each genre are not correlated. The normalization method we use here is $minmax$normalization method. Taking the solution of PN_f as an example, the $N_f$parameter value set of all artists in G genre is set as $G(N_f)$, and the N_f value of A artist in G genre is set as $A_G(N_f)$. The solution method is as follows:

$$A(PN_f) = \frac{A_G(N_f) - min(G(N_f))}{max(G(N_f)) - min(G(N_f))} \tag{3}$$

Finally, using the above four parameters, we set up the model of 'music influence' of artists. The model is based on the basic idea of hierarchical analysis. The four parameters are divided into two layers.The second layer contains two types of indicators: "static indicators " and "dynamic indicators ".The attribute division rules of the four parameters are shown in the following table:

Table 3: Attribute division of "Music Influence " parameter:

Global properties		Genre properties	
Static metrics	Dynamic metrics	Static metrics	Dynamic metrics
N_f	L_{yg}	PN_f	RL_{yg}

The "music influence " model can calculate the comprehensive impact factor CF of each artist according to the consideration weights of different attributes and indicators. Set the global attribute weight Wal and the genre attribute weight $W_{ge} = 1 - W_{al}$. Static index weight W_{st}, dynamic attribute Wdy = $W_{dy} = 1 - W_{st}$:

$$CF = \begin{bmatrix} N_f & L_{yg} & PN_f & RL_{yg} \end{bmatrix} \begin{bmatrix} W_{al}W_{st} & W_{al}W_{dy} & W_{ge}W_{st} & W_{ge}W_{dy} \end{bmatrix}^T \tag{4}$$

When CF is calculated with different weights, it will reflect the "musical influence " of different characteristics of the artist.

4.3   Model Solution

4.3.1   Drawing and Analysis of Directed Network

According to 4.2, we draw two digraphs, "Music Influences Network " and "Genre Influences Subnet ", as well as a "Relation Curve between Genre and Active Years ".

(1) Music Influences Internet

Figure 1: Artist's follower net

The size of each node in the network represents the number of followers of the artist, and important artist nodes have been identified.

(2) Genre Influences the Subnet

Figure 2: Genres' factor net

The obvious fan shape in the network indicates that the influencer is consistent with the follower's genre, while the leaf shape indicates that the follower is not consistent. The size and color brightness of the stream node reveal the overall influence of the genre. Obviously, the Pop/Rock genre stands out among all genres.

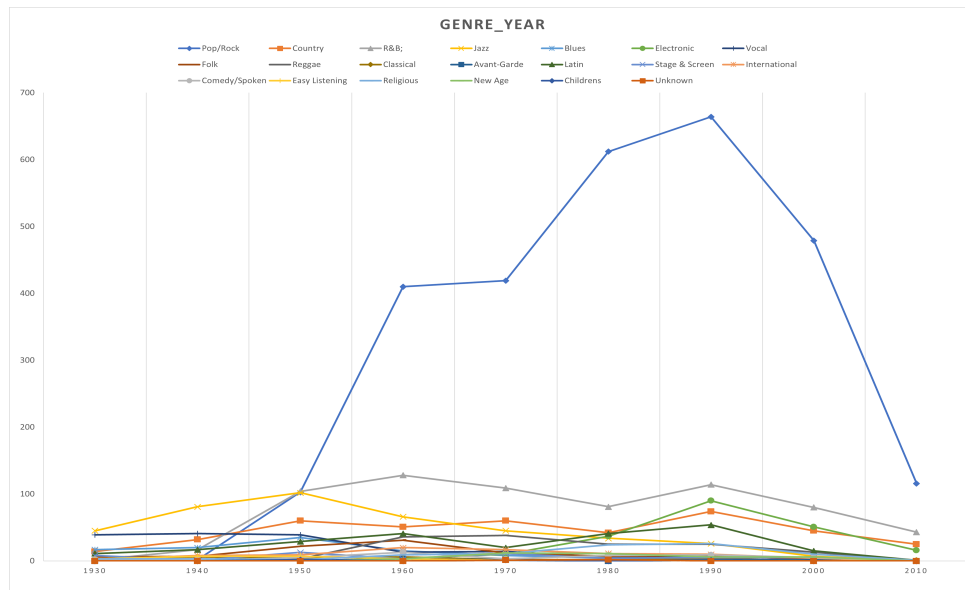**(3) Relation Curve between Genres and Active Years**

Figure 3: Relation curve between genres and active years

The figure shows the trend of different genres over time, the volume of different genres, and a series of important information.

4.3.2 "Music Influence" Model Construction and Artist's Comprehensive Influence Factor Solution

As mentioned in 4.2.2, an important preparation for the construction of the "music influence" model is to solve the four "music influence" parameters $N_f, L_{yg}, PN_f, RL_{yg}$. The static index parameters N_f, PN_f can be easily solved. Below, we show only part of the solution process of parameter L_{yg}.

In the relationship curve between genre and active age in Fig. 4, the slope of the curve of genre $\mathbb{G}$ from Y to $Y+1$ represents the development level of genre G from Y to $Y+1$. Thus, the development level matrix of $\mathbb{G}$ genre from Y period to $Y+1$ period is obtained. According to the "development level matrix of $\mathbb{G}$ stream from Y years to $Y+1$ years " and Equation (2), we can calculate the L_{yg} parameters (part) corresponding to each artist according to each artist genre and active year:

Table 4: Artist's L_{yg}

Artist id	Artist name	Artist main genre	Artist active start	N_f	L_{yg}
180228	Aerosmith	Pop/Rock	1940	65	6.543
754032	The Beatles	Pop/Rock	1960	615	0.017
303050	The O'Jays	R&B	1930	23	2.124
46861	Ray Charles	R&B	1940	113	0.642

We noticed that some artists N_f is not big, but its L_{yg}, artist Aerosmith, for example, the L_{yg} is far higher than all the other artists, combined with "genre and active s curve ", it is easy to find after Aerosmith is 1940s, Pop/Rock has a very obvious growth trend continued until 1960, although there may be other Pop/Rock artist in 1940, However, there is a reasonable chance that Aerosmith made an important and influential contribution to Pop/Rock in the 1940-1960 period, and this is well confirmed by our review

of the literature. But because we believe it with a certain probability, considering L_{yg} alone would lead to the misconception that all PoP/Rock artists in the 1940s made significant contributions to PoP/Rock. Obviously this kind of "think " is very unreasonable. For this reason, when we measure the comprehensive influence of an artist, we take all four parameters of "musical influence " into consideration to a certain extent, and use the basic idea of analytic hierarchy process to comprehensively evaluate the influence of an artist. In our "Sound Influence " model, the four weight values affecting CF are set as follows:

Table 5: Weight Division of the Four Parameters

Weight type weigh	Global weight	Genre weight	Static weight	Dynamic weight
	0.6	0.4	0.75	0.25

(1) Considering only the global attribute (W_{al} = 1, W_{ge} = 0), the dynamic index weight is gradually increased until Aerosmith ranks in the top five with the most prominent L_{yg} parameter. The determination method of this value shows our affirmation of the role of artists in promoting their music development in the future.

(2) Under condition (1), the weight of genre attribute is gradually increased until the Children genre artists with generally small NF parameter are ranked 40. The determination method of this value indicates that we will consider to find out the revolutionaries and cornerstone people of all genres, and also hope to find out those artists who have the most influence on the development of music. (Assumption 1 as the premise)

Based on the above analysis, the "artist's comprehensive impact factor" CF is finally solved. The following table shows some results:

Table 6: Artist's CF

id	name	genre	year	CF	NO.
754032	The Beatles	Pop/Rock	1960	0.75	1
66915	Bob Dylan	Pop/Rock	1960	0.48	2
549797	Hank Williams	Country	1930	0.46	3
104714	Kraftwerk	Electronic	1970	0.41	4
894465	The Rolling Stones	Pop/Rock	1960	0.39	5
316834	Marvin Gaye	R&B;	1950	0.37	6
423829	Miles Davis	Jazz	1940	0.36	7
276085	Howlin" Wolf'	Blues	1930	0.36	8
577531	Woody Guthrie	Folk	1930	0.34	9
128099	James Brown	R&B;	1950	0.34	10
183867	John Cage	Classical	1930	0.33	11
668448	James Cleveland	Religious	1950	0.33	12
55128	Aerosmith	Pop/Rock	1940	0.33	13
489520	Mike Oldfield	New Age	1960	0.33	14
608701	Muddy Waters	Blues	1940	0.32	15

In our model of musical influence, these artists are the most influential people in their genre, and we can think of them as the "revolutionaries and founders " of their genre.The status of these artists as "revolutionaries and founders " in their genres has been fully verified by our literature review, thus proving the correctness of the "musical influence " model we used.

By developing the new four weighting methods, we also found some interesting things to use in our "music influence " model. When we only consider genre attributes and dynamic metrics, the resulting CF ranking becomes:

Table 7: Artist's CF 2

id	name	genre	year	N_f	CF	NO.
55128	Aerosmith	Pop/Rock	1940	65	1	1
20984	Gary Wilson	Pop/Rock	1940	1	1	2
325401	Fishbone	Pop/Rock	1930	21	0.55	3

The chart above shows that although artist Gary Wilson was active in the 1940s, his dynamic indicators were very high, but his following was not large, so his influence should be far less than that of Aerosmith. This is also amply demonstrated when we look at online materials. In addition, Fishbone caught our attention because it had a certain number of followers and should have been an important pioneer in the genre, but when we looked it up, we found that it wasn't. The reason is that "Fishbone is an American rock band formed in 1979 in Los Angeles. "

5　Problem 2,3: Similarity between and within Genres

5.1　Problem Analysis

In the problem of measuring music similarity, we believe that similarity as a nature is universally exists in any collection of music, even though considering each pair of musics, such a parameter is related to the general character of collection: same pair of music is considered more similar in a more diversified collection.

On the other hand, music does not change as the range we are discussing changes. The difference between tracks, the distance, is constant and measurable, regardless of the range considered. Additionally, the distance between tracks should follow triangular inequality, and the higher the similarity, the lower the distance between the two music pieces.

In particular, it is not possible to consider a track to be similar or dissimilar when it is similar to two other tracks respectively, i.e. similarity should not be transmissible. Nor is it possible to consider a track to be similar or dissimilar when it is dissimilar to two other tracks respectively; but the probability of the two tracks being similar in the former case should be greater than in the latter. Conversely, if a piece of music is similar and dissimilar to two other tracks, the two tracks should not be similar.

Each musician, track or year has mapped a vector of musical characteristics, and the aggregation of the vectors artists in a certain genre reflects the similarity within the genre. Similarly, the similarity between genres can be quantified in the genre vectors cluster, using the genre's eigenvector to mark the genre's characteristics. If the similarity within a genre $\mathbb{G}$, $S(\mathbb{G})$, is greater than the similarity between its eigenvector G_i and the eigenvector G_k of another genre, $S(G_i, G_k)$, then artists within the genre are more similar than artists between genres and vice versa.

In the problem of comparing the similarity and influences between and within genres, we have to consider the dimension of time: when a genre is influenced by another

genre, its eigenvector starts to move towards the influencing genre; the similarity between the two increases, while the similarity within the genre decreases.

5.2 Preparation of the Model

For the 5601 artists that has been labeled in influence dataset, linking their main genre to data by artist data set, label the unlabeled 253 artists as 'Unknown'. Identified by 'artist id',Each artist is considered as an unique sample, constructed by a 14-demonstrated characteristic vector and one of the 20 genres labels. While we going through data sets, several samples, i.e.loudness above 0 or under -60, can be regarded as 'Wrongful '. We excluded samples that did not fit the range of data described and used the quartiles rule to remove outlier points, 62 artists and 262 tracks , for reasons of prudence.

5.3 Model Building

According to the problem analysis, the distance and similarity of the three music Characteristics V_i, V_j, V_k should satisfy the following restrictions.

1. Non-navigate:$D > 0; S > 0$

2. Triangle inequality $D_{ij} \leq D_{jk} + D_{ik}$

3. $\begin{cases} D > 0; S > 0 & \text{Non-navigate} \\ |D_{jk} - D_{ik}| \leq D_{ij} \leq D_{jk} + D_{ik} & \text{Triangle inequality} \\ D_{ij} \to \infty | S(i,j) \to 0; \quad D_{ij} \to 0 | S(i,j) \to \infty & \text{unlimitedness} \\ \forall \sigma(\mathbb{V}\mathbb{1}) < \sigma(\mathbb{V}), S_{\mathbb{V}\mathbb{1}}(i,j) < S_{\mathbb{V}}(i,j) & \text{neighbourhood related} \end{cases}$

The distance between vectors defined by Euler distance, and the similarity between vectors described as the reciprocal of the distance between two points.

$$D(I,J) = |I - J|; S(I,J) = 1/D(I,J); \tag{5}$$

The distance between a vector and a set is defined as the distance from the vector to the eigenvector; the similarity between a vector and a set of vectors is defined as the similarity between the point and the eigenvector of the set.

$$D(I,\mathbb{G}) = D(I, V_{\mathbb{G}}); S(I,\mathbb{G}) = S(I, V_{\mathbb{G}}); \tag{6}$$

The distance and similarity between sets is defined as the distance and similarity of the eigenvectors.

$$D(\mathbb{P},\mathbb{G}) = D(\mathbb{P}, V_{\mathbb{G}}); S(\mathbb{P},\mathbb{G}) = S(\mathbb{P}, V_{\mathbb{G}}); \tag{7}$$

Defining set similarity: In a given set, the similarity of a set is related to the nature of the set itself, so that set similarity is defined as the mean of the distances between the set's eigenvectors and each vector in the set divided by the standard deviation of this distance; in particular, when there is only one point in the set, the standard deviation is 0 and the similarity is infinite.

In order to compare the similarity between point sets with the similarity within point sets, we propose a definition of eccentricity:

$$e(\mathbb{G}, \mathbb{V}) = \frac{S(\mathbb{G}, \mathbb{V})}{S(G)} \tag{8}$$

The ratio of similarity between genres divided by similarity within genres can determine whether the similarity within the same genre is greater than the similarity between different genres. Ratio < 1 indicates that the similarity between two genres is less than the similarity within the same genre; The ratio > 1 indicates that the similarities between the two genres are greater than the similarities within the same genre, which represents the references used by the former from the latter.

So divide the data in units of ten years, calculate the eccentricity between two genres in each subset,can show how do fascinations change over time,and discover the relations between generes at the same time, calculate the eigenvectors of each genre in the subset, This distinguishes a genre and how do genres change over time.

5.4　Model Solution

Based on the establishment process of the above similarity model, we analyze the similarity between artists of the same genre and artists of different genres respectively. The heat map is visualized by MATLAB as shown below.
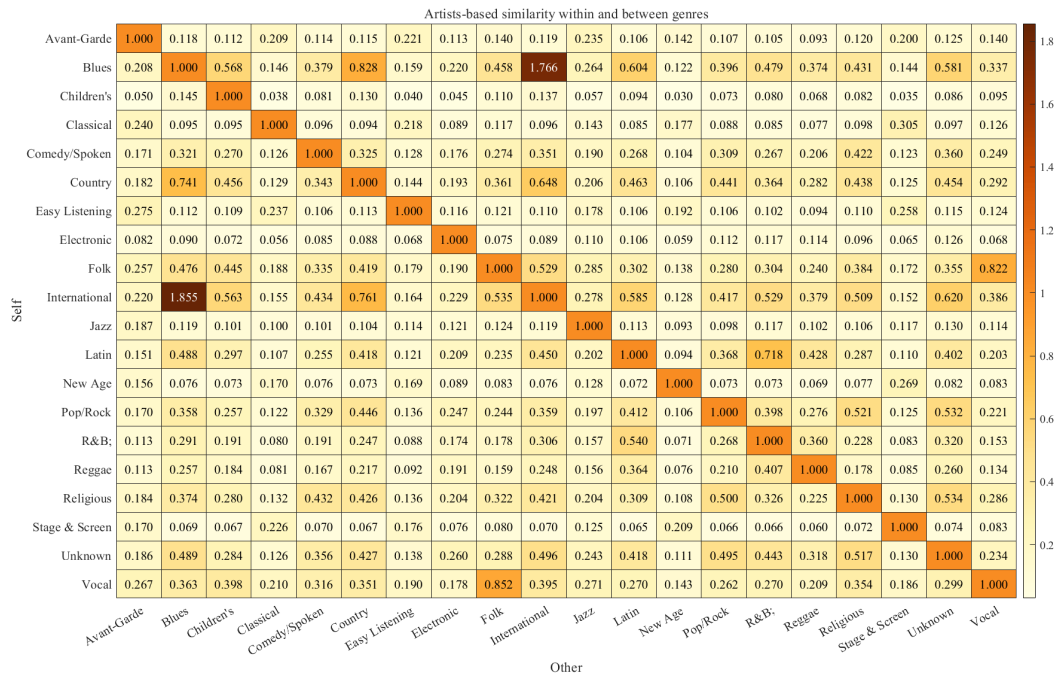

Figure 4: Overall Eccentricity between Genres

The heat map visualized eccentricity of each pair of genres, with direction from longitudinal axis genres to horizontal axis genres, color was determined by eccentricity. The results showed that among the 20 music genres, the similarity between 18 music genres was less than that within the same genre, and the similarity between the other two music genres (International and Blues) was greater than that within the same genre.

We further analyzed the similarity of International and Blues. As shown in the figure below, the two polylines can be respectively represented as the musical characteristics of the music genre International and Blues. Each inflection point of the polyline represents the value of the music genre in a certain musical characteristic dimension. Where the line graph visualized eigenvectors of each genre are drawn, where the X axis represents the feature and the Y axis represents the normalized size of the characteristic. Each line represents a genre, and the shape of the two lines is very similar.
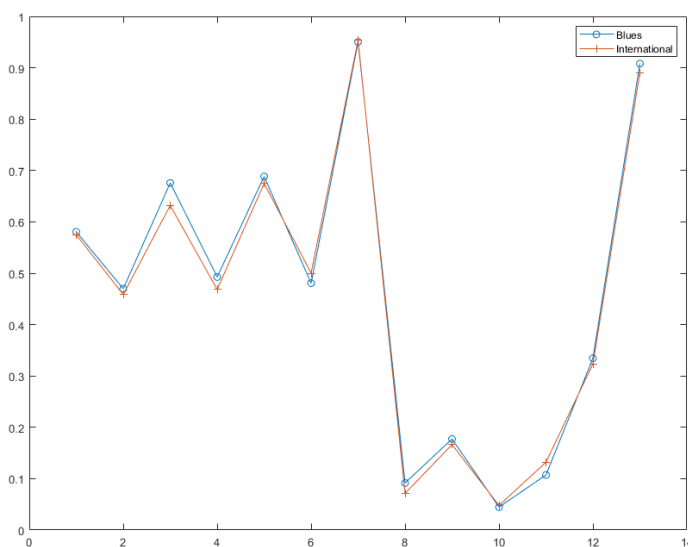

Figure 5: Comparation between International and Blues

To sum up, we have reason to think that the similarity of artists within genres is generally greater than that between genres, but there are some exceptions. Further research is needed on similarities and musical characteristics. Calculate the eigenvectors of the genres in 1930s 2010s, and calculate the eccentricity between them. The heat map visualized how eccentricity of each pair of genres changing alone time, with direction from longitudinal axis to horizontal axis genres, Color was determined by eccentricity shows how artist in the 'self' genre been influenced by the 'other' genres, and the line chart shows the eigenvector of each genre in the decade.

According to the chronological heat map, assuming the similarity within the same genre is 1, we can see that the overall color of the heat map is gradually deepened during 1930-1960, which indicates that the eccentricity degree of one genre to another genre is gradually increasing, that is, the similarity between genres is increasing. However, during 1960-1980, the overall color gradually became lighter, indicating that the similarity between genres was decreasing. The same can be said of changes in similarity between genres in the late 20th century.
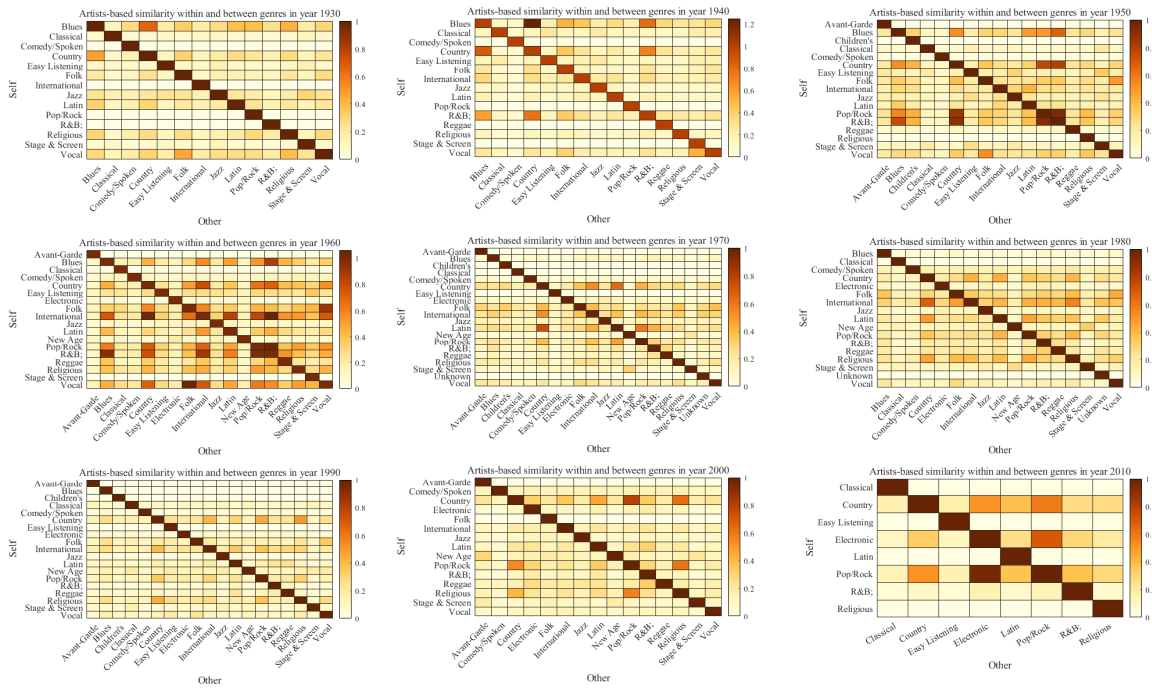
Figure 6: Eccentricity between Genres by Year

6 Problem 4: Influencers & Followers Model and The contagious of Music

6.1 Problem Analysis

Whether influencers have a significant influence on the music created by followers is considered from two dimensions: (1) the degree of similarity between the musical characteristics of influencers and those of followers; (2) the consistency between the influencer's genre of affiliation and the follower's genre of affiliation.

Dimensions (1) and (2) directly or indirectly indicate the influence of influencers on followers. The former focuses on individual artists, while the latter focuses on artist genres.

In the "music influence network ", the influence of the influencer on the music of the followers is believed to be the "contagion " of some musical characteristics of the shadow caller to the followers (Hypothesis 3).In measuring whether some musical characteristics are more 'contagious' than others, we consider the' contagiousness of individual musical characteristics' index AL_{mc} for specific artists and the 'contagiousness of overall musical characteristics' index L_{mc} for artists as a whole.

6.2 Model Building

In the question of "whether influencers have a great influence on the music created by followers ", for dimension (1), we calculate the average value of "music similarity " between all influencers and followers according to the "music similarity " model obtained from question 2, which is recorded as "the universal influence of influencers on the music created by their followers " IF. From question 2 should note that we are not sure IF want to achieve what kind of size can explain influencers of followers

created music has a widespread influence, therefore in question 4, we put forward a kind of find the IF the method of threshold value: suppose when influencers and following the correct correspondence, calculated "influence on their followers created the widespread influence of music " the IF, and notes for IF_r, then will affect the random disturb, the corresponding relationship between followers of calculating 100 groups of random IF corresponding case, remember to $[IF_e]$.By comparing the relationship between IF_r and $[IF_e]$ set, the following formula is used to calculate the significant multiple K of IF_r in $[IF_e]$ set:

$$K = \frac{\sqrt{(IF_r - [I\bar{F}_e])^2}}{\sqrt{\sum_{i=0}^{n}([IF_e]_i - [I\bar{F}_e])^2}} \tag{9}$$

K value indicates that IF_r (IFe) in the significant degree K times that of the other elements, the larger the K value, the more we have reason to believe that IF_r is makes the corresponding relation of all "influence on their followers created the widespread influence of music " IF one of the largest, and explains the influence of his followers really created music has a huge impact. For dimension (2), in the "genre influence subnet " established in question 1, the genre relationship between influencers and followers is intuitively displayed.

In the question of "whether some music Characteristics are more 'infectious' than others ", the definition of indicators $AL_{mc}L_{mc}$ is: the average value of absolute value of the difference between artist A and each follower $[FA_i]$ in music Characteristics C represents the indicator AL_{mc} of "contagious of single music Characteristics " for artist A;

L_{mc} is the average value of the set $[AL_{mc}]$.

On the premise that all music characteristics are normalized, the indicator AL_{mc} is calculated by the following formula:

$$[AL_{mc}] = \frac{1}{N_f} \times \sum_{i=1}^{N_f}([C_f]_i - [C_a]) \tag{10}$$

Among them:　　N_f:Number of artist A's followers;　　C_{f_i}:Music eigenvector of the ith follower; C_a:Music eigenvector of Artist A

6.3　Model Solution

Considering dimension 1, it is easy to find that when influencers and followers correspond in a correct relationship, the "universal influence of influencers on music created by their followers " IF is 3.343, which is identified as IF_r and omitted in the calculation process. After I have held several reordering of followers in the column, makes the impact error, the corresponding relationship between followers get multiple IF value of the error, as $[IF_e]$, part of IF_e value is: 2.846, 2.827, 2.824, 2.829, 2.835, 2.828, 2.830.

The IF_e value generally varies within (2.82-2.85). According to Equation (5), the significant multiple $K \approx 80$ is calculated.From the above analysis results, we can conclude

that influencers have a general influence on the music produced by their followers, which is roughly two orders of magnitude greater than the influence of other factors on the music produced by their followers.

Combined with dimension 2, the consistency between the genre of the influencer and the genre of the follower is 76.57%. From the results of these two dimensions, we are very confident that influencers do have a great influence on the music that their followers create.

We also evaluated the 'contagious' of music Characteristics. The parameter L_{mc} reflects the 'contagious' of music Characteristics to the whole body of the artist. The solution results are as follows.

Table 8: Contagious of Musical Characteristics

con	L_{mc}	con	L_{mc}	con	L_{mc}
danceability	0.10	acoustic	0.17	instrumental	0.26
tempo	0.11	duration	0.18	mode	0.31
loudness	0.13	live	0.20	key	0.34
valence	0.16	speech	0.21		
energy	0.17	Count	0.24		

The results indicate that the three musical characteristics of 'danceability', 'tempo' and 'loudness' are more "contagious " than other musical characteristics. Take danceability for example. The danceability of a piece of music is a combination based on musical elements, including rhythm, rhythmic stability, beat strength, and overall regularity. The dance performance of music makes the whole music full of artistic vitality, so that the listener can feel the emotional attitude contained in it psychologically and in action, thus having a profound 'contagious'.Schubert's Army March, for example, can lift people's spirits, while Chopin's Funeral March can bring anyone to tears.

7   Problem 5: Major Meaps and "Revolutionary Artists "

7.1   Problem Analysis

In a period of time, after the stability of a musical genre, there will inevitably be reformers or changes in the social environment. In the future, the musical genre will also change, and then enter a new period of stability. This' major leap 'could be the emergence of a new genre of music, or the re-emergence of an existing genre.For the emergence of new music genres, we can understand that the musical characteristics of each genre have changed significantly in the time series. The re-emergence of existing streams can be understood as a significant change in the popularity of each genre over time series.

When looking for artist revolutionaries, we use the "music influence " model established in Question 1 as a search tool. By adjusting the attribute type weight and index type weight of the model, we can find the one or several artists with the largest comprehensive impact factor CF in the genre.

7.2 Model Solution

Using the data set Data by Year provided by The ICM, on the one hand, we normalized the music characteristics, and then drew the figure below with time as the horizontal axis. In the figure, we can intuitively see that some of the music Character-
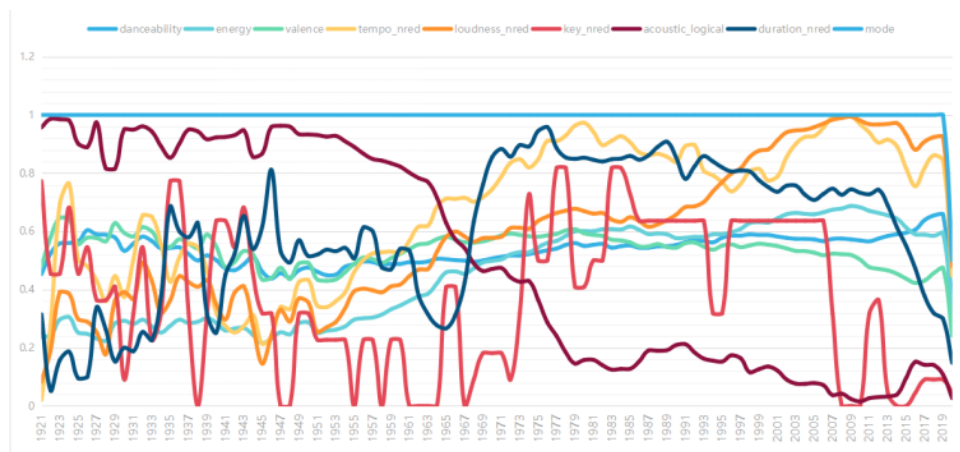

Figure 7: Relation Curve between Music characteristics and Age

istics have changed significantly during a certain period of time. For example, music tempo accelerated steadily from the 1950s to the 1980s, indicating that the pace of life of human society accelerated during this period, which was closely related to the historical conditions at that time. Because music tempo is the expression form of the amount of time and intensity of musical movement. Rhythm of life is the prototype of music Tempo, and music Tempo is the artistic transformation and utilization of rhythm of life, as well as the element of reflecting life and expressing emotions.

On the other hand, given the "genre/active decade curve " in question 1, we can visually see the significant changes in the popularity of certain music genres over a period of time. For example, gray polyline R&B continued to rise in the 1940s and 1950s. This is because the end of the Second World War, to some extent stimulated the development of the United States, sustained rapid economic growth, social political situation is relatively stable. The living conditions of black Americans also changed rapidly, which created a good cultural space for the emergence of black R&B. After analyzing the causes of the music revolution in combination with data and history, we have reason to think that the characteristics that mark the music revolution may include: a significant change in one or more musical characteristics, and a significant change in the popularity of one or more music genres.

Finally, in order to find an artist revolutionary within a genre with a larger capacity, we increased the weight ratio of genre attribute from 0.6 to 0.7 on the basis of the weight setting in question 1. Taking the top 40 artists, the important revolutionaries of each genre (in part) are obtained in the table below.

Table 9: "Revolutionary Artists " of Various Genres

Pop/Rock	The Beatles, Bob Dylan, The Rolling Stones, Aerosmith
Country	Hank Williams
R&B	Marvin Gaye, James Brown, Stevie Wonder, Ray Charles
Jazz	Miles Davis, Charlie Parker
Blues	Howlin, Wolf, Muddy Waters
Electronic	Kraftwerk
Vocal	Billie Holiday
Folk	Woody, Guthrie, Pete Seeger
Classical	John Cage
Comedy/Spoken	Spike Jones

8　Problem 6: The Evolution of Music Genres

8.1　Problem Analysis

Question 6: Following on from Question 1, we study the evolution process of different music genres on the basis of the "relationship curve between genres and active years " drawn in 4.3.1. Since this problem is mainly the analysis of some "trends ", we use more charts to intuitively show these "trends " in the process of model building and solving, but relatively less explanation of specific parameters. In Question 6, an important parameter "the degree of generation's influence on genre development ", L_{yg}, proposed in Question 1, was considered to reveal the dynamic influence index.

8.2　Model Building

"Genre and active s curve " ordinate are different genres of different s in the number of active artists, by in some genres, such as Pop/Rock, mass is very outstanding, if use the curve will not be able to directly intuitive show the evolution of different genres, also not intuitive to show a certain genre's impact on other genres evolution process.Taking genres as units, we normalized the number of active artists in different eras within the same genre, and thus drew the normalized "relationship curve between genres and active eras ".

8.3　Model Solution

In discussing the evolution of genre, we choose genre R&B as an example. To explore whether the evolution process of R&B can be reflected in our network, we draw the "relationship curve between genre and active years " after the normalization of the five genres of R&B, Country, Pop/Rock, Jazz and Blues.

For the evolution process of R&B itself, it shows the change trend of the gray broken line corresponding to the above figure and R&B. It can be clearly seen from the figure that R&B showed a rapid development trend from the 1940s to the 1960s (1940-1960), due to the continuous rapid economic growth and relatively stable social and political situation of the United States after the Second World War. The living conditions of
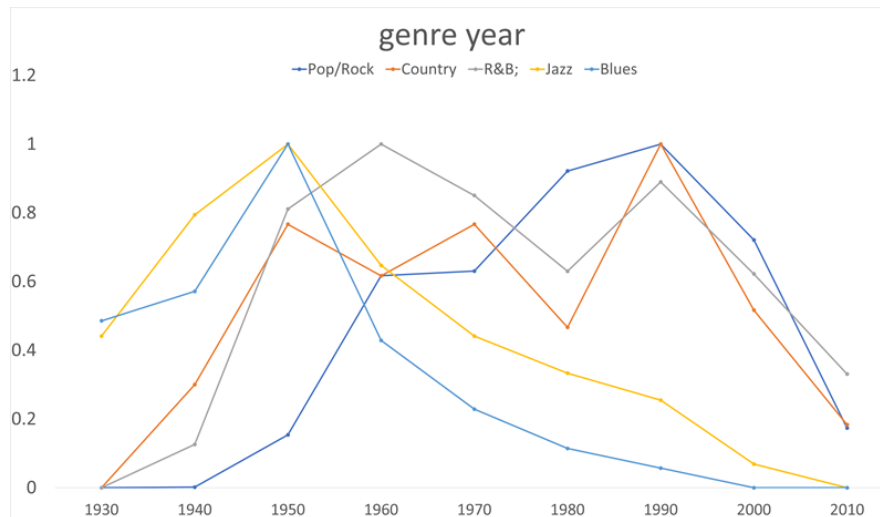
Figure 8: "Relation Curve between Genre and Active Era " of R&B Genres and Related Genres

black Americans also changed rapidly, creating a good cultural space for the generation of black R&B music. The new development of society culture at all levels is not only the necessary condition for the rise of R&B, but also the objective requirement of society.

The impact of R&B on the evolution of other genres is shown in the chart above comparing the development trends of R&B with those of other genres. When we look at country music, there are obvious similarities with R&B trends.To some extent, this shows that R&B and country music have some relationship and mixed relationship; If you look at rock music, its high growth period followed that of R&B, and it's believable that it was driven by R&B; When we look at jazz and blues, after the rapid growth of R&B, R&B combined the characteristics of the two genres and gave a new blood to other genres (rock and roll), jazz and blues began to decline. It can be said that R&B, taking the mantle of jazz and blues pop music, is the first of rock music, and has its own style, continuous innovation and development, and has been occupying an important position in the European and American pop music world for 50 years.

"The degree of influence of age on the development of genre"L_{yg} reveals that certain ages of different genres are particularly important for the development of this genre, and these ages mark the emergence of a revolutionary "revolutionaries " or a major historical change on a certain probability. The following table presents the influence degree indicator L_{yg} of different genres and different eras on the development of this genre.

Table 10: Degree of Influence of Decade on Genre Development L_{yg}

	1930	1940	1950	1960	1970	1980	1990	2000	2010
Pop/Rock	3.64	6.54	0.43	0.02	0.03	-0.13	-0.34	-0.61	-0.76
Country	0.20	0.10	-0.01	0.02	-0.03	0.07	-0.27	-0.36	-0.44
R&B;	2.12	0.64	0.01	-0.05	-0.06	-0.01	-0.25	-0.37	-0.46
Electronic	0.00	0.00	0.00	0.57	0.63	0.19	-0.37	-0.55	-0.69
Latin	0.12	0.11	0.05	-0.02	0.13	-0.17	-0.54	-0.75	-0.93
Religious	0.14	0.25	0.56	0.11	0.14	-0.21	-0.50	-0.72	-0.90

Some of the conclusions that can be drawn from the table above are that Pop/Rock peaked in the 1940s and had a long period of rapid growth after that. Electronic music

began to emerge in the 1960s, and the 1970s are of great significance to its development. Religious had been stable during the years 1930-1970, and the 1950s brought about a period of upsurge in its development, probably caused by the 'reassuring' reversal of the decline in church statistics' during the Second World War.

One notable thing in the table above is that all the years after 1990 have a negative impact on the genre, for which there are two possible explanations:

(1) The overall development of music after 1990 appears to be lacking in vitality, which, if true, should cause us some concern;

(2) Modern and contemporary artists are gradually "specialization and non-mainstream ". They gradually break away from the "music influence network " and are more willing to try to form a faction of their own. Therefore, most new artists do not have the relationship between influencer and follower. This also brings a severe challenge – the early music genre will face the situation of no successor, they flow in the body of excellent culture, need to be passed on urgently.

9 Problem 7: The Development of Musical Culture

Since its birth, music has been inseparable with culture. Music directly and centrally embodies the cultural spirit of a specific historical era.They blend and reinforce each other. From the regional point of view, music contains the cultural customs of different regions and different nationalities;From the point of time, music reflects the spirit and trend of different times.

In the long history of western development, the music of the 20th century is different from any other period in the past. It is a period of exploring innovative, deviant and colorful new music style.It breaks through the period of common writing since the Renaissance, and presents diversified music phenomenon in music genre and music expression form. The reasons for the change of music include social, political, technological and other factors, which have had a decisive impact on the characteristics of the development of western music.

In the late nineteenth century and early twentieth century, the outbreak of two world wars, which resulted in the loss of countless lives, caused great changes in social psychology. Music also began to reveal the ugliness of society instead of expressing beauty and harmony. Some artists show their treason to traditional music and a kind of personality publicity, soul catharsis and release. The destruction of the war also awakened the national consciousness, and music became an important tool for national salvation. A large number of anti-Japanese war themed music appeared and spread widely through necessary means.

The 20th century is a period of great development of science and technology. The rapid development of industrial revolution provides a realistic foundation for the development and innovation of music. The industrial peak of the first half of the 20th century, followed by the information society, accelerated the pace of musical diversification. A large number of composers began to use mathematics to calculate music, to conceive the structure and development of music in precise computational forms, and a large number of composers began to use the power of science and technology to explore new sound. With the advent of the Internet + era, the music industry structure is also in a period of great change, which has had a significant impact on the concept,

technology, production and cost of music creation. All these have injected fresh vitality into music creation and encouraged musicians to create more and better music works.

10 Conclusion

1. **Four "Music Influence" parameters can be captured in the Music Impact Network.** The number of followers of artists, the degree of influence of the decade on the development of the genre, the proportion of the number of followers of artists in the genre, and the ranking of the degree of influence of the decade on the development of the genre.

2. **The similarity of artists within genres is generally greater than that between genres.** According to the results of our model, the similarity between 18 music genres is less than that within the genre, and the similarity between the other two music genres (International and Blues) is greater than that within their respective genres.

3. **In the development of music, a genre will be influenced by another genre, and the similarity between the two will increase, while the similarity within the genre will decrease.** The similarity between music genres varies in different directions over time, which is related to the social environment at that time.

4. **Different music genres can be distinguished by their unique musical characteristics.** For example, the genre Reggae's most prominent music Characteristic is speechiness, while the genre Avant Garde's is duration.

5. **Influencers do have a very important influence on the music their followers create.** This effect is roughly two orders of magnitude greater than the effect of other factors on the music created by followers.

6. **Different music Characteristics do not have the same 'contagious'.** The three musical characteristics of danceability, tempo and loudness are more 'contagious' than other musical characteristics.

7. **The characteristics that may mark a musical revolution include a marked change in one or more musical characteristics, a marked change in the popularity of one or more musical genres.** A few "revolutionaries " from every genre of music also helped revolutionize music. The revolutionaries are mainly **The Beatles, Hank Wilianms, Howlin, Aerosmith, Krafwerk.**

8. Music is a kind of culture, which directly and intensively embodies the spirit of The Times culture in a specific historical period. The development of music is a process of constant change and innovation with society, politics and technology.

11 Sensitivity Analysis

For the dimension of music characteristics, Model 2: Similarity measurement model is designed based on the 13 music characteristics given by The ICM to calculate the similarity between artists and all their own genres. 86.2% of artists have the highest similarity with their own genres. Eight music characteristics with the highest importance

were selected from the 13 music characteristics. When the eigenvectors and similarity were recalculated, the consistency was still 79.3%, indicating that Model 2: Similarity measurement model could still maintain a good measurement effect after the amount of data was reduced.

12   Strengths and Weaknesses

Strengths

1. Based on the idea of point sets in high-dimensional space, we propose a similarity measurement method, and mathematically complete the similarity between a single point, music eigenvectors, music eigenvector sets and itself. The similarity obtained by this method is dimensionless and comparable;

2. The measurement of similarity is completely based on the definition of distance between music eigenvectors. Therefore, when the data dimension is expanded, this method remains effective and the calculation amount will not increase geometrically;

3. We have inserted several visual charts in the paper, which is conducive to correctly and intuitively grasp the abstract concept of similarity;

4. The "Music Influence" Model is constrained by four different attributes of "Music Influence" parameters, which have global or genre attributes, dynamic or static characteristics respectively. Through different parameter weight setting methods, it is easy to obtain the comprehensive influence size and ranking of artists under different attributes by using this model, and the model has strong extensibility and robustness.

5. In the "influencers and followers model ", we use the thought of "mismatch ", the "similarity " music itself does not have reference, through the measure of right and wrong match case similarity mean this clever way to quantitatively measure the impact of followers to create music whether has a huge impact;

6. We have made a detailed analysis and explanation of the development history of music genre R&B by referring to a large number of literature materials and combining with the charts made by the data sets.

Weaknesses

1. The distance based on which the similarity measurement model is based is defined as Euclidean distance. As a kind of Minkowski distance, the dimensional scale difference of each component is ignored;

2. We generalize musical similarities to a certain extent, but the music itself contains extremely rich information, and the variety of musical characteristics presented is limited, which limits the resolution of musical factions. The study of music can be done by adding other musical characteristics and combinations;

3. The degree of influence of age on genre development L_{yg}, did not consider the impact of major changes in history on the development of music, the achievement of L_{yg} is not very rigorous.

One Page Document

To: ICM Society
From: Team 2117179
Date: February 9th, 2021
Subject: A report on 20th century music from Team 2117179

Thank you for providing us with several data sets. In this document, we introduce the value of using our approach to understanding the influence of music through networks. If you provide us with more sufficient data, our solution will change accordingly. In addition, we have further studied music and its influence on culture.

By studying musical influences, we can understand how a piece of music influences other artists and the music they make. Our research on the 20th century music can not only find out the great figures in the long history of music in the 20th century, but also provide a reasonable direction for future music creation to learn from, and promote the development of music.

The significance of constructing music influence network is that the object of music influence research should be the music culture structure, rather than the individual artist. Because the individual artist itself is very different and varied, and only its relationship is relatively stable. By studying network relations, it is helpful to combine artist relations, 'micro' network and 'macro ' structure of large-scale music system, so that we can better understand the relationship properties of different music and its influence on artists' creation.

For the data set provided to us, if the new data set contains other music Characteristics, such as lyric. We will extract the main feature words according to the occurrence times, and set a large weight. A reasonable music similarity evaluation model was constructed by selecting the best dimension through the normalization of singular value square histogram. If the new data set contains more time dimension information, our "music influence " model will still be applicable, but in the use of the model, we need to recognize the new emphasis of the research object, and adjust the weight of the parameters in the model based on this, so as to adapt to the change of the data set.

Culture occurs from ideas, ideas. The driving force of thoughts and ideas is people themselves. Music is a form of people's thoughts, feelings and hearts. It studies the relationship between music and people, and cares about the role, value and significance of music as a way of life for people.

Music is also an important way for us to study history. The formation, evolution and development of any culture are closely related to the development of history. The music culture passed down from generation to generation truly records the history and cultural development track of different periods and reflects the social life of human beings. With the deepening of the research, we deeply realize that pop music culture on the whole of the 20th century is a long history of symbiotic music culture, such as Blues, Country, Jazz, R&B music, such as both factions have unique music characteristic.

Sincerely,

Team 2117179

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