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Framework of music Controller Based on Brain Computer Interface

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Abstract
the study of Brain-Computer interface provides theoretical and practical basis for many brain electrical applications; for human, music can adjust mood, strengthen the immune ability, and improve the work efficiency. The existing music playback systems mainly focus on the convenience of control and simple music recommendation, but pay little attention to the mood of real-time users. Based on music control and recommendation, the paper designed one Brain-Computer interface system, which can intelligently control music; music control includes active control and passive recommendation, and passive recommendation is to automatically adjust music based on the physiological status of the users. Through the study on the recommendation accuracy, response time and comfort degree of the system, the system was proved to be feasible.
Key words: ELECTRO ENCEPHALO GRAPH, BRAIN-COMPUTER INTERFACE, MUSIC CONTROL , MUSIC RECOMMENDATION

1. Introduction

In recent 10 years, people have made lots of study on the influence of music, and the study results have been applied in various industries, such as health, education, sports training, etc. Music can not only influence people's mind, but also physiology. Music can adjust mood, and calm you down; music is good for easing your pain. What's more, music can promote the intellectual development.

Many researchers have applied music therapy in various aspects, such as intervention on anxiety symptoms[1], research on the treatment of patients with depression, the study on improving sleep by music[2], etc. Researchers used music for the treatment of some special children, such as cerebral palsy, autism, behavior disorders. The Children Welfare Association of Zhengzhou invited music therapists for the treatment of mentally disabled children at the age of 3 to 15 in 2010, and those children had more interaction and communication with teachers after seven-month treatment[3].

The research results showed that appropriate music can adjust mood, improve memory and thinking ability, so as to improve the work efficiency. For example, Li Xue in Shenyang made special study on the characteristics and application category of music for mood adjustment, and the results showed that different music had different effects on mood modification, and the effects were also affected by the individual's own peculiarity[4]. Sun Chang'an of Suzhou University of Science and Technology found[5] that music could promote the working memory, which was probably related with the activation of the parietal lobe of the brain found through ERP. Bilhartz and others found that music stimulation can change the production of part of neurotransmitters and polypeptide hormone so as to promote people's memory. [5] Shaw and others drew the response area of brain to the music through fMRI technology, and the research found that music training promoted the ability of spatial reasoning. [6] Li Donglan found music can improve people's ability of divergent thinking through empirical study.

The positive regulation of music to the work and life is based on the right time, right emotional status and right music. If you choose the inappropriate music, it would be counterproductive, however, the current study on music control and regulation system haven't noticed this. The present music control system studies mainly focus on the control of music sound, the convenience of the control and the control of the interface. For example, in the paper of [5], one music control system that was controlled by gestures was introduced that vibrotactile feedback for digital musical instruments (DMIs) that are controlled with open air hand motion. The hand motion was captured with infrared marker based motion capture technology. The final research results showed that the synthesized vibrotactile stimuli can provide useful feedback on how the performer is playing the instrument, as well as enhancing the experience of playing the given DMIs. Similarly, various input methods were used to achieve the music playback control in [7, 8, 9]. These researches make it convenient for people to achieve music control in daily life, but there is no in-depth research on the depth choice of music. Reid oda studied how to automatically choose music in the paper [10], and introduced in detail the music recommend system, by which users can automatically hear their favorite music. The mood and state of people change constantly, so the right music may not be the right if the environment is changed.

This paper introduced a new music recommender system; through the monitoring of EEG and calculation of different frequency in EEG to detect the emotional state of users in real time, based on the collected learning and training results, the system will recommend appropriate music band in order to adjust the mood, eliminate the effect of all kinds of bad mood, regulate mind and body, relieve stress and improve the efficiency.

2.System structure and design

This article described a simple system that can control and recommend music by using brain wave, and the overall system structure is shown in figure 1. The whole system was established on the basis of brain wave, the personal information security system is to ensure that the EEG characteristics of the users won't be stolen; the personal preference of related brain-electrical system is to record the personal music recommendation history so as to gradually optimize the recommendation. The main body contains the music playback system, which is established on the music control system and music recommendation system. In the music recommendation system, the active and passive recommendation are contained; active recommendation means to automatically recommend according to history preference, and passive recommendation is to achieve music recommendation by real-time EEG characteristics. Recommendation system is established on the management of music library; according to the different uses, the music library can be divided into local music library and passive music library, the overall frame of this system can described as Figure 1.

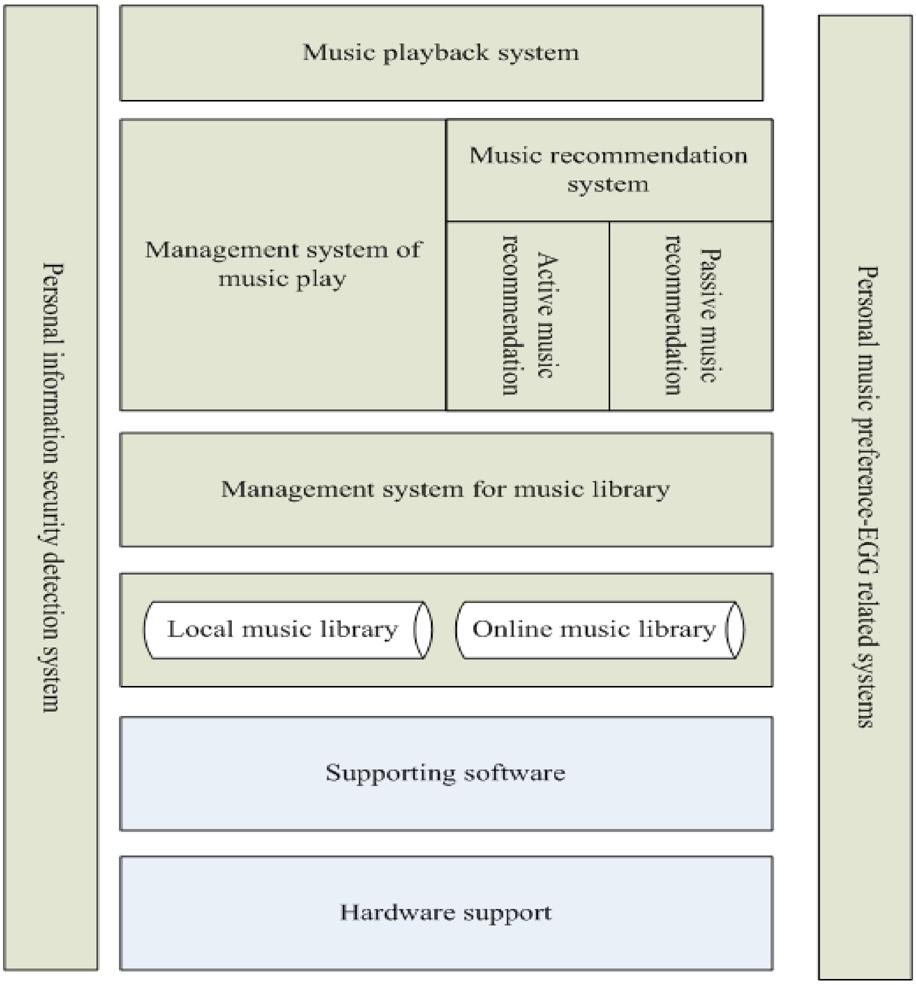

Figure 1. Overall frame chart of System

The simple testing system is divided into seven modules: interface, local playback, network playback, music recommendation, database management, music download and network support. The relation of each module is shown in Figure 2 as show of Figure 2, interface , database management and music download is designed by classical method. So, In the paper, the EEG application mainly reflects in playback control and music recommendation.

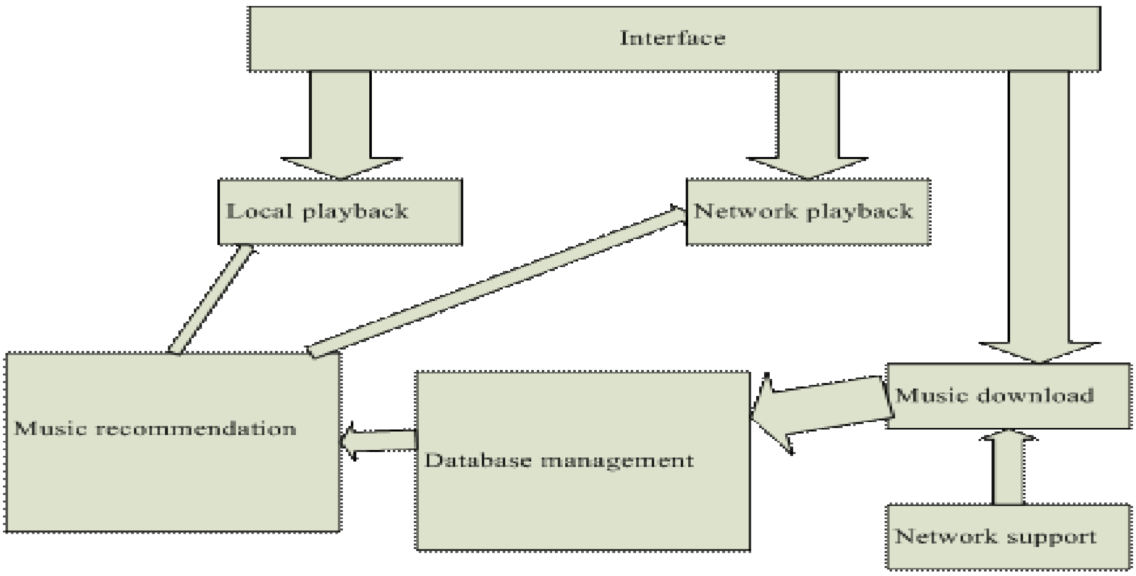

Figure 2. Module divided of system design

The main function of music recommendation system is to calculate the EEG features according to the existing EEG, and calculate the mental state of the users according to the EEG feature library, so as to select the songs for recommendation; the data flow chart of the whole system is shown in Figure 3.

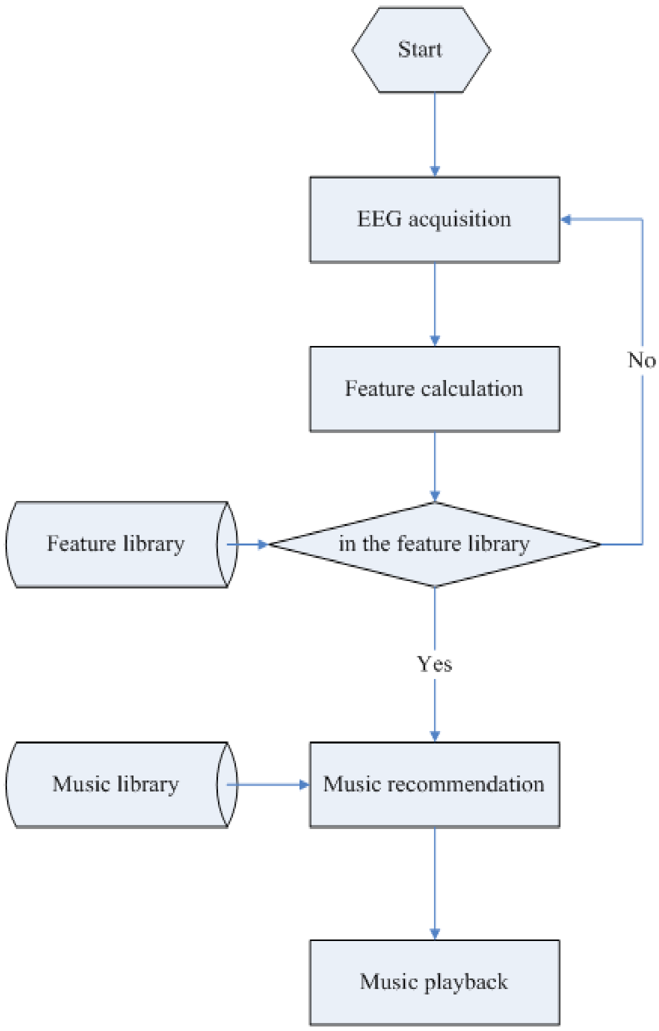

Figure 3. Recommendation flow chart

3.Method

3.1 Collection of EEG

The music control BCI designed in the paper includes active music control and passive music recommendation. The active control is mainly reflected in the choice of music while passive music recommendation is mainly reflected in the recommendation of most suitable music for the users at that time based on the real-time EEG characteristics of the users.

The EEG used in the paper was collected in the Brain-Computer interface lab from the college students of the Jiangxi University of Technology. The relaxed participants sat in one soft chair without arms in one quiet shielded room, looked at the computer screens in the front, and did the brain-electrical experiment according to the arrangement of the laboratory technicians and screen instructions. In the test, the 40 guide Neuroscan amplifier was used, and the data were collected by using the scan4.3 software. The reference electrode adopted the right mastoid, the sampling rate was 1000Hz, the band acquisition used 200Hz low-pass, 0.05Hz high-pass and 50Hz notch.

On active music control, this paper adopted the visual stimulus mode. At the top left corner of the UI interface, there is one resident control, which is shown in figure 4. The red arrows is placed on each side of the box with blue background, marking the direction of the users to control the music. When the users move the mouse to the music control needed to be controlled by the control, the confirmation of the mouse can be achieved by blink. In this way, the four-direction control and confirmation function of the mouse can be realized by the control in figure 4 and blink.

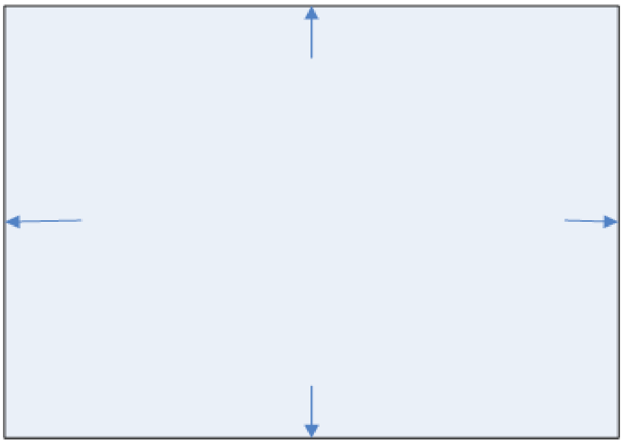

Figure 4. Control for visual control

The main purpose of designing passive music recommendation module is to recommend music to users according to their different emotional states. In order to achieve the accuracy of the passive recommendation, the users need to be trained. At first, the users will receive preliminary experiment, and the EEG of the users under different emotional states will be collected; meanwhile, users choose their own music under these emotional states, then the EEG of the users will be analyzed; in order to quantify the emotional states of the users, they will fill in the emotional state quantitative table before the experiment. This paper emotional state quantitative conclude : Angry, Downhearted, Cheerless, Light-hearted, Rattled, Perplexedly, Upset, Loopy, Toilsome, Sorrowful, Energetic, Distracted, Confident, Restless, Annoyed, Exhausted, Depressed, Proactive, Flurried, Abstracted, Confused, Tired, Blue, Cheerful , Forgetful, Capable, Excitable, Wrathful, Debilitated, Dirt-cheap, Full of activity, Uncertain feeling, Approving, Worried, Furious Complaining, Helpless, Of great drive, Proud.

As describe of above, grade each state under the five cases; the full mark of each case is five, and there will be a state-score corresponding relation. There are a number of redundant projects in the questionnaire ; in order to batter analyses this data, this paper reduce the emotion state to six state:Nervous, Angry, Depressed, Relaxed, Flurried, Work. And each state divided into five level: Barely, A bit, Moderate, Quite a bit, Extremely.

3.2 data analysis

According to the difference in practice, the EEG analysis can be divided into active way and passive way. On this two analysis methods, there are common EEG preprocessing methods, which can be described as follows:

1.Select EEG

In the process of test, especially when the subjects are very tired, there will be unconscious movement of the body; the myoelectricity will interfere the EEG, so the good EEG should be selected at first.

2. Filtering

The paper mainly analyzed the brain-electricity with the wave distribution from 1 to 50Hz; before data analysis, the paper firstly filtered the selected EEG.

3. Hjort data conversion

In order to reduce the interference to real signal from surrounding electrodes, the original data should receive Hjort conversion before data analysis, and the conversion methods are as follows:

$$c_i^H = c_i - \frac{1}{8}\sum c_j \quad (1)$$

C_i^H stands for EEG data, ci is the original EEG data, S stands for the surrounding eight electrodes of ci, and cj stands for the original EEG data of the eight electrodes.

Active EEG is from the visual evoked potentials. According to four different arrow flashing, the EEG with strong direction demand of the users can be produced. Due to the flashing frequency, the EEG with same direction can be collected several times in a short time; after superposition of these EEG, the ERP characteristics of different directions can be received.

Passive EGG is from the EEG sample analysis of users under different states. Construct state-feature corresponding relation matrix, and correspond music recommendation according to the matrix. EEG analysis includes offline feature extraction and online feature match. The detailed data flow chart is shown in Figure 5.

In the design of passive recommendation, EEG is divided into offline feature extraction and online feature match; offline feature extraction is to build feature library as different users correspond different features under different emotional states; online match is to match emotion based on the collected EEG and offline feature library. As shown in Figure 4, sample collection is to complete the collection of EEG according to the different states of the users; the sampling is conducted in laboratory environment; sampling frequency is 1000Hz, it takes 10 minutes for each experiment on 200 samples, and 3 seconds for each sample.

The main task of sample classification is to classify the received EEG according to the six emotion states and five cases in Table 2.

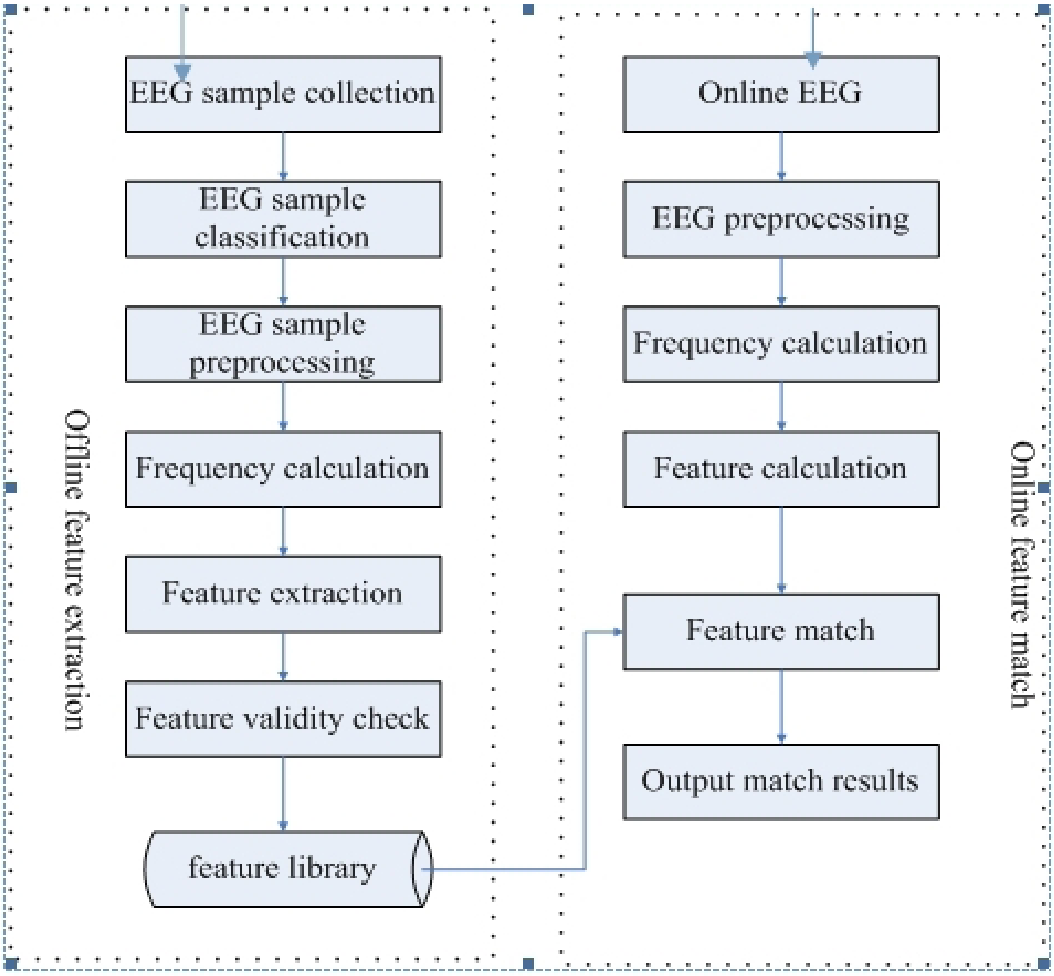

Figure 5. Flow chart of passive recommendation

The main task of EEG preprocessing is to select, remove the ocular-electron and filter the wave. The selection is to remove the excessive EEG samples caused by external emergency such as myoelectricity, movement, etc. To remove the ocular-electron is to remove the influence on EEG due to vertical blinking. To filter the wave is to achieve better feature extraction and filter out the wave band that would not be considered.

The main purpose of frequency calculation is to calculate the EEG frequency feature of similar samples; the time-frequency domain analysis method is connected through Fourier transform, and their entirely separation is based on the invariant feature of signal frequency or smooth statistical property. In order to reflect the time history of frequency domain feature for non-stationary signal such as bio-medical signal, the engineering technology usually adopts two kinds of methods: time-window and frequency-window. But strictly speaking, time-window method and frequency-window method have the same problem, namely the "uncertainty principle" of resolution ratio for time-domain and frequency-domain. The more detailed resolution of time-domain, the more fuzzy resolution of frequency-domain, and vice versa. Therefore, the more reasonable approach is to combine the time and frequency to indicate the signal.

Short Time Fourier Transform(STFT) is the most commonly used linear transformation by far, and it is developed from Fourier Transform. FFT has the fastest calculation speed among the numerous time-frequency analysis method, and the analysis results have clear physical interpretation, which made it widely used in practice. Through fixed width of time-window sliding on the time shaft, the signal x(t) is divided into many segments of short-time signal with same length of time. In such time span, they are seen as smooth, and then they will have Fourier Transform, which will receive the signal spectrum. Windowed short-time signal strengthens the signal around the time t, and Fourier Transform reflects the frequency distribution around the time, namely:

$$X_t(\varpi) = \int_{-\infty}^{+\infty} x(t')\varpi(t-t')e^{-j\omega t}dt \quad (2)$$

Therefore, energy density spectrum at the time t is

$$P_{sp}(t,w) = |X_t(\varpi)|^2 \quad (3)$$

There is one different spectrum at different time, and the total of these spectra is time-frequency distribution.

The physical meaning of STFT is clear, and it gives the time-frequency structure consistent with our intuitive. However, due to the restrictions of "uncertainty principle" such as $\Delta t\Delta w \geq 1/2$ or $\Delta t\Delta f \geq 1/4\pi$ it is impossible to obtain high resolution in time domain and frequency domain at the same time. Therefore, in the process of practical application, there must be compromise between time-window and frequency-window, and the compromise depends on the time-frequency features of window and signal.

4. Results

To test the effectiveness of the system and avoid the interference of noise data, the system testing environment was arranged in the 40-channel EEG laboratory of Institute of Information Technology in Jiangxi University of Technology; 30 students of Jiangxi University of Technology were tested by this system. The main three aspects of the test is on the system usability, which include accuracy of recommending songs, the time for accurate music control and comfort of the users.

4.1 Average accuracy

The accuracy test in this paper mainly aimed at passive recommendation system. In view of the above six emotional states, the paper chose eight kinds of music from Baidu music such as sad, passion, quiet, comfortable, sweet, joy, romantic and nostalgic. There were 30 songs downloaded for each kind of music and there was no repetition. The 30 users were tested, and they would record whether the recommendation is correct.

Table 1 recorded the accuracy of recommending the local music to 30 users. According to the table 3, the highest accuracy of recommending music from the system is 89.86%, the lowest is 68.02%, and the average is 78.87%, which proves the effectiveness of the recommendation system.

Table 1. Accuracy of music recommendation(percentage)

	Nervous	Angry	Depressed	Work	Flurried	Relaxed
1	89.86	89.86	89.86	89.86	89.86	89.86
2	89.86	89.86	89.86	89.86	89.86	89.86
3	89.86	89.86	89.86	89.86	89.86	89.86
4	89.86	89.86	89.86	89.86	89.86	89.86
5	89.86	89.86	89.86	89.86	89.86	89.86
6	89.86	89.86	89.86	89.86	89.86	89.86
7	89.86	89.86	89.86	89.86	89.86	89.86
8	89.86	89.86	89.86	89.86	89.86	89.86
9	89.86	89.86	89.86	89.86	89.86	89.86
10	89.86	89.86	89.86	89.86	89.86	89.86
11	89.86	89.86	89.86	89.86	89.86	89.86
12	89.86	89.86	89.86	89.86	89.86	89.86
13	89.86	89.86	89.86	89.86	89.86	89.86
14	89.86	89.86	89.86	89.86	89.86	89.86
15	89.86	89.86	89.86	89.86	89.86	89.86
16	89.86	89.86	89.86	89.86	89.86	89.86
17	89.86	89.86	89.86	89.86	89.86	89.86
18	89.86	89.86	89.86	89.86	89.86	89.86
19	89.86	89.86	89.86	89.86	89.86	89.86
20	89.86	89.86	89.86	89.86	89.86	89.86
21	89.86	89.86	89.86	89.86	89.86	89.86
22	89.86	89.86	89.86	89.86	89.86	89.86
23	89.86	89.86	89.86	89.86	89.86	89.86
24	89.86	89.86	89.86	89.86	89.86	89.86
25	89.86	89.86	89.86	89.86	89.86	89.86
26	89.86	89.86	89.86	89.86	89.86	89.86
27	89.86	89.86	89.86	89.86	89.86	89.86
28	89.86	89.86	89.86	89.86	89.86	89.86
29	89.86	89.86	89.86	89.86	89.86	89.86
30	89.86	89.86	89.86	89.86	89.86	89.86

4.2 Control time

Music control time reflects the availability of system; when the music control time is too long, there will be no users to adopt it, although it can finally achieve music control. The paper tested the response time of the volume control (big/small), music selection (up/down) and player on-off. Table 2 recorded the response time of the six kinds of control from the 30 users. The results of table 2 show that the average music control time is 50 seconds to 100 seconds, which needs to be improved.

Table 2. Music control time (second)

	Volume up	Volume down	Choose up	Choose down	On	Off
1	56	75	93	94	63	60
2	78	82	71	60	98	54
3	55	57	58	81	79	52
4	97	87	87	53	93	97
5	100	93	90	76	59	70
6	56	51	97	65	65	66
7	73	83	51	92	78	93
8	67	72	52	59	83	66
9	95	56	100	77	86	100
10	64	71	73	88	91	55
11	59	68	52	76	67	58
12	60	96	84	73	96	55
13	88	87	78	59	80	65
14	56	60	95	53	62	52
15	72	50	95	60	54	65
16	73	55	100	66	65	53
17	65	52	75	88	82	54
18	54	89	96	77	55	92
19	67	64	88	50	52	84
20	80	76	87	86	89	64
21	85	78	70	53	89	67
22	81	87	55	56	78	74
23	95	90	87	52	53	54
24	90	98	84	56	86	55
25	55	82	66	83	88	79
26	87	61	87	99	94	54
27	68	68	84	80	90	68
28	60	54	89	60	69	78
29	61	82	74	57	89	55
30	64	62	77	54	70	55

4.3 Comfort level

At the end of the test, each user will have comfort survey, in which users score the test according to their own experience by hundred-mark system, and eventually the average score of the system comfort level is shown in Figure 6.

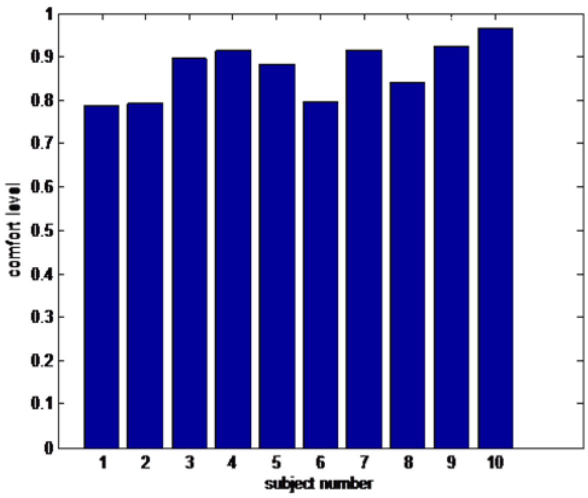

Figure 6. Statistical result of comfort level

5. Conclusion

Music can enrich people's life, so people have been studying to enjoy wonderful music. The study has made the control and choice of music much more easier, but how to give a full play to the music in order to improve working efficiency and living quality? Based on the music control of brain wave, the paper studied the active control and passive control of music, achieved the possibility of real-time music recommendation, established the corresponding relation between music and emotion, and verified the feasibility of the system through studying the recommendation accuracy, response time and comfort level.

Acknowledgments

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Duplicate Questions Removal Based on LDA in Q&A Community

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Abstract

There are a large number of similar or duplicate questions exist in Q&A community, resulting in poor efficiency retrieval and other issues. This paper puts forward a kind of removing duplicate questions method based on LDA, fully considering deep semantic knowledge of questions. First of all, we use LDA to model for question set, and execute parameter inference by Gibbs sampling of MCMC to calculate model parameters indirectly. Then through mining the hidden relationship between different