Design and Implementation of Piano Performance Grading System Based on Data Analysis

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Abstract. In order to meet the needs of piano learners to get feedback on their performance accuracy, this paper designs and implements a piano performance scoring system based on wechat. In the audio preprocessing part, the user's uploaded playing audio can be converted into a file format that is easy to analyze, and the music name can be detected by the music detection algorithm; in the performance scoring part, the music fingerprint based localization algorithm and the non negative matrix factorization based multi pitch detection algorithm are used to detect the correctness of the user's uploaded music. Based on the test data, the system scores the accuracy and the accuracy of the whole play for the subsection. The final result is presented in the form of images. The WeChat interactive part, which develops a public official account through the WeChat public platform development technology, can check the music contained in the system library by passing the official account. And upload their own playing audio, get graphical feedback and get some related services.

Keywords: Piano score · WeChat official account · Multi pitch detection · Music fingerprint location

1 Introduction

As a branch of the Internet, mobile Internet can provide people with high-quality network services through mobile terminals. In mobile Internet products, instant messaging applications have a large number of users. Among the instant messaging applications, the most outstanding one is the wechat released by Tencent in 2011. According to the statistics of professional market research companies, the market share of wechat in mainland China is as high as 93% 0. By June 2015, wechat had 600 million active users worldwide. In August 2012, WeChat launched the official account function, and enterprises and organizations can provide corresponding services to users through developing official account numbers. According to statistics, the official account number of WeChat has exceeded 12 million in 2016, an increase of 46.2% over the same period. In China, 523% of Internet users have the habit of using official account numbers. All this shows the attraction of the official account and the huge market hidden behind it. After a large number of questionnaires, we found that most piano learners want to have the function

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of piano performance evaluation in piano education products, but the current evaluation methods are very scarce [1]. Therefore, taking the accuracy of piano playing as the breakthrough point, this set up is designed to design a WeChat official account that can evaluate the piano playing audio of users.

2 Introduction of Related Technologies

Including the introduction of sound signal spectrum analysis method and multi pitch detection algorithm based on non negative matrix factorization. Then it introduces the music fingerprint algorithm used in the system, and then introduces the development technology of WeChat official account platform access technology and background development framework Codeigniter.

2.1 Basic Principle of Ant Colony Algorithm

The pitch information of sound signal is reflected in its frequency domain, and the spectrum analysis is the basis of frequency domain research. Most of the spectrum analysis is based on STFT (short time for short Fourier transform). Fourier transform can be applied to stationary random process and periodic transient signal, but sound signal is not a stationary process, so Fourier transform cannot be used to analyze it directly. However, the sound signal after short-time processing can be approximately regarded as a stationary random process, so it can be analyzed by short-time Fourier transform. The spectrum analysis of sound signal can be realized by two steps: windowing and fast Fourier transform.

2.2 Calculation Method

The traditional FFT spectrum generation algorithm is discrete Fourier transform (DFT), DFT is difficult to be widely used in practical applications because of its time complexity of N, and FFT algorithm is an improvement of DFT. FFT decomposes the DFT matrix into the product of sparse factors to achieve the purpose of fast calculation, thus reducing the computational time complexity to the order of nlogn. The definition of DFT is shown in Formula 1. Where x is the plural. If we calculate directly according to this definition, we need to do o (n) operations in total. Among them, XK has n outputs in total, and each output needs.

$$x_k = \sum_{n=0}^{N-1} x_n e, k = 0, \ldots, N-1 \tag{1}$$

Foot (k) and feel (k) are the odd and even numbers of the sequence {xn −) respectively. So far, the first N2 points of YK can be calculated. For the last N2 points, because both fodd (k) and fven (k) are functions with period N2, and the unit root is symmetric, we can get formulas (2) and (3).

$$y_{k+\frac{N}{2}} = F_{even}(k) - W_N^K F_{odd}(K) \tag{2}$$

$$y_k = F_{even}(k) - W_N^K F_{odd}(K) \tag{3}$$

In this way, a Fourier transform of length n is decomposed into two Fourier transforms of length N2. Decomposition can continue in the same way. By using the method of the main theorem, it can be concluded that the time complexity of the algorithm is O (nlogn).

3 Multi Pitch Detection Algorithm Based on Non Negative Matrix Factorization

3.1 Introduction of Multi Pitch Detection Algorithm

In 1999, hsseung and ddle proposed a new matrix decomposition method in nature. This method is nonnegative matrix factorization (QMF) algorithm, which is a matrix factorization method when all elements in the matrix are nonnegative. This paper has attracted great attention of scholars in various fields, because in scientific research, there are many analysis methods with huge data that need to be processed by matrix, The method of non negative matrix factorization opens up a new direction for dealing with a large number of data. In addition, compared with the traditional algorithm, NMF algorithm is more simple in implementation, its decomposition form is easy to explain, and it occupies less storage space. There are many ways to realize NMF algorithm, among which NMF decomposition based on Euclidean distance and NMF decomposition based on dispersion are the most widely used [2]. The NMF algorithm based on dispersion can be described as decomposing the input matrix V into v wh (the elements of matrix V, W and H are not negative), so as to minimize the dispersion D. In the calculation, two multipliers are generated according to some new rules. When the dispersion of the product of V, W and H satisfies the set size limit, the iteration is stopped.

3.2 Form of Expression

First, Moreover, if the weight coefficient of a note changes from lower than the threshold value to higher than the threshold value in a certain period of time, it means that the piano key corresponding to the note has just been pressed; if the weight coefficient of a note changes from higher than the threshold value to lower than the threshold value, it means that the piano key corresponding to the note has just been released. We need to extract the spectrum template for each single note. For each audio containing a single note, first of all, it needs to detect the silent area, and get the playing section of the note through the detection of the silent area. Then, FFT transform is performed on the playing section of the note to extract the spectrum information, and then nm algorithm is used to extract the spectrum template which can represent the note in the spectrum information. The spectrum templates of each single note are assembled into w matrix. For the performance audio, after frame division and preprocessing, the frequency spectrum V of each frame is obtained by short-time Fourier transform. NMF algorithm is used to decompose h from V so that v = wh, and H is the weight coefficient of each note. After further thresholding, the results of multi pitch detection can be obtained. The principle of multi pitch detection algorithm based on NMF is shown in Fig. 1.

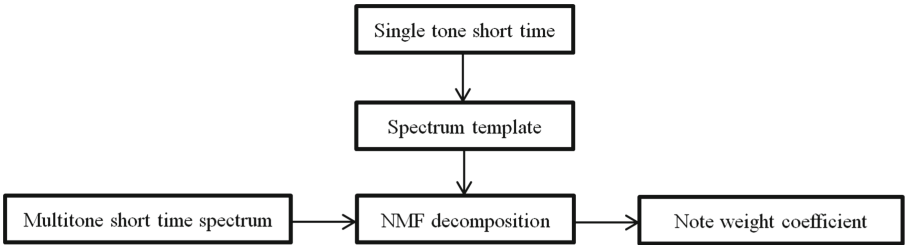

Fig. 1. Schematic diagram of multi pitch detection algorithm

4 Evaluation Index System and Evaluation Strategy

4.1 Main Introduction

Multimedia work evaluation is an important means to measure the practical teaching value and teaching effect of multimedia courses. The evaluation of multimedia works not only involves the teaching design thought, teaching content arrangement, design intention of teaching scheme, but also involves the application of multimedia technology and artistic experience of students. Student multimedia work is a multimedia assignment that students make and complete by using the technology and methods they learn in multimedia courses according to the requirements of teachers' proposition [3]. The evaluation of multimedia works should be multi-objective and individual, which should have mathematical statistics of formative evaluation and language description of summary evaluation. Each index item should be refined as much as possible.

4.2 Index System

According to various teaching evaluation methods at home and abroad, we think that the evaluation index of multimedia teaching can be divided into four levels. The first level is technical evaluation; the second level is artistic evaluation; the third level is content evaluation; the fourth level is creative evaluation.

(1) Technical evaluation. Mainly through the evaluation of the technical content and expression effect of multimedia works to evaluate students' mastery of multimedia technology.
(2) Artistic evaluation. It is mainly to evaluate the interface layout, frame structure and color collocation of multimedia works to evaluate the students' feelings on the rational use of multimedia elements in the works.
(3) Content evaluation. Content evaluation is mainly to judge the integrity, logic and expression effect of students' multimedia works.
(4) Creative evaluation. It is mainly about the evaluation of students' conception of multimedia works and their personality expression.

4.3 Evaluation Strategy

In order to realize the computer automatic evaluation of multimedia works, it is necessary to formulate specific evaluation strategies and methods on the constructed evaluation

index system of multimedia works. The important goal of using computer to evaluate multimedia works is to reduce the workload of teachers' evaluation and enhance the objectivity of the evaluation results.

The automatic evaluation of computer is similar to the evaluation results given by experts under specific evaluation indexes and standards. Computer automatic evaluation is mainly to complete the technical evaluation of multimedia works, and solve part of the content involved in artistic and content evaluation. The main method is to give the specific problems and objectives of the corresponding multimedia works with the participation of teachers, and give the technical key points, art, content evaluation points and the final reference effect documents that need to be evaluated. According to the corresponding information provided by teachers, the multimedia works automatic evaluation system gives the specific score of each item according to the scoring standard, and finally summarizes into a final evaluation.

5 Design of Automatic Evaluation System for Works

5.1 System Design Objectives and Basic Ideas

The goal of this system is to explore a scientific and reasonable evaluation strategy, so that under the guidance of this strategy, the computer automatic evaluation of multimedia works can be realized. Therefore, the important criterion of system implementation is operability, which not only reflects the evaluation of each evaluation index to the work, but also enables the evaluation to be realized by computer. As a matter of fact, it is very difficult to form a unified evaluation standard for computer automatic evaluation because there are too many subjective elements in a work completed under an open topic without any constraints [4]. Therefore, it is necessary to have a suitable topic design as an important part of the system and have a suitable topic, In the process of computer automatic evaluation, we mainly solve the following problems: how to obtain the document information of multimedia works. how to use and analyze the obtained information to reflect the index components in the evaluation strategy. This part is mainly guaranteed by scoring strategy and logic.

5.2 System Composition

According to the above analysis and the actual environment and result requirements of the system, I divide the system into the following functional modules Block.

(1) Database module: the module mainly includes two parts, one is the question database, which is composed of examination document, standard answer and scoring strategy; the other is the result database, which stores the examinee information and evaluation results, which is the main data recording part of the evaluation system. Since there is no need for the original document in the evaluation process, the standard answers and scoring strategies in the question bank which affect the marking are called "multimedia works scoring standard management tool".
(2) Preprocessing module: This module is used to unpack and decrypt the recovered test paper, and get the legal marking document of the specified question type.

(3) Document recognition module: This module mainly completes the recognition of multimedia documents. That is to say, using the information export tool of multimedia works, the animation or image files can be converted into ordinary text with key information, which provides the basis for marking and matching. This module is the core module of the whole system.
(4) Marking module: the module extracts and analyzes the information of candidates' documents which have been parsed into text files, and gives the evaluation results according to the scoring strategy.

5.3 Design and Implementation of Evaluation System

The evaluation system consists of preprocessing module, document recognition module and marking module. The preprocessing and marking module are completed by the system platform. The document recognition module is implemented in the form of plug-in, which is the "multimedia work file information export tool" mentioned above. The implementation process of the evaluation is described as follows:

(1) The standard answer files of multimedia works produced by teachers are exported by using the "multimedia works file information export tool" to form the "multimedia works standard answer export information", and the score knowledge points are extracted from the information as the standard answers of system evaluation.
(2) The result file uploaded by the candidates is preprocessed, the result package is decrypted, the candidates' information is read, and the legitimacy of the results is verified. This process is completed by the preprocessing module.
(3) Thirdly, the document information identified in the examinee's multimedia file is stored in the temporary file by using the "multimedia work file information export tool".
(4) Compare the information of the designated knowledge points in the temporary file with the standard answers, and give the score according to the detailed rules.
(5) Record the score into the database.

Exactly speaking, the second step in the process is the beginning of batch review. The formation of standard answers in the first step should belong to the task of proposition stage, but because there is a process of multimedia document recognition here, it is regarded as a part of the evaluation execution [5]. It can be seen that the "multimedia works file information export tool" used for document recognition is useful in the process of extracting standard answers and batch review. Therefore, we design the script plug-in as a separate tool that can run, and call it where it needs to be used in large platforms.

6 Work Summary

In this paper, the multi pitch detection algorithm and music positioning algorithm are studied. According to the needs of piano learners to obtain the evaluation feedback of their own performance accuracy in practice, the investigation is carried out. After finishing, the demand of piano performance scoring is analyzed, and the system design and

implementation are carried out according to the functional requirements obtained from the analysis. The system finally adopts the NMF based multi pitch detection algorithm and music fingerprint based music localization algorithm as the core algorithm of the system, and implements a piano score system that can upload the playing audio to the user's score and overall score, and the system is finally presented in the form of WeChat official account. After testing, the system performs well in function and scoring accuracy.

References

1. Hou, Z.: Design and Implementation of Higher Vocational Learning Evaluation System Based on Web. Shanxi Normal University (2014)
2. Xing, M., Zhang, J., Wang, X., Zheng, Y., Li, M.: Design and implementation of provincial ambient air automatic monitoring system. In: Proceedings of 2013 Annual Meeting of Chinese Society of Environmental Sciences, vol. 5, p. 7. Chinese Society of Environmental Sciences: Chinese Society of Environmental Sciences (2013)
3. Wu, D.: Design and Implementation of Micro Auto Focusing System for Automatic Urine Sediment Analyzer. Wuhan University of Technology (2012)
4. Xiang, J.: Design and Implementation of Multimedia Works Automatic Evaluation System. Beijing University of Posts and Telecommunications (2010)
5. Yi, Q., Zhang, H., Wu, P., Lv, X., Luo, Q., Zeng, S.: Design and implementation of an optical microscope auto focusing system. Comput. Eng. Appl. **27**, 119-120+215 (2007)