In order to solve the problem that violin performance evaluation is too subjective, this paper proposes a violin performance evaluation system based on mobile terminal technology. Violin sound evaluation mainly includes two indicators such as pronunciation quality and distance transmission ability. LabVIEW 8.2 is used to collect data, and fast Fourier transform (FFT) is used to analyze the time-domain signal in frequency domain, and the pronunciation process of violin is discussed in depth. Using statistical methods to process the test data of pronunciation distance transmission, a parameter model representing the pronunciation distance transmission ability is proposed, and finally the WeChat applet is used to control the recording and display. The results show that the process of violin sound production is accompanied by the weakening of octave peaks and the development of overtone peaks. The stable stage is marked by the stability of each octave peak and overtone peak. The sound head initially presents a simple excitation response, with only one near octave overtone and three cycles. Its maximum overtone peak/dominant frequency peak ratio coefficient is $k = 0.36$; the back entry complex excitation response has about nine cycles, with $k = 0.735$. Then enter the quasi-stable excitation response, whose waveform is similar to the typical A-string empty string pull waveform in the later stage, with $k = 0.36$; the maximum overtone peak/main frequency peak proportional coefficient is $k = 0.39$ in the rising section of the start, $k = 0.2$ in the loudest section, and $k = 0.26$ in the stable section.

1. Introduction

With the development of the Internet, the transmission cost of information has dropped sharply. Because the education industry can be highly informationized due to its knowledge attribute, online education has developed rapidly. In the first half of 2020, due to the impact of the epidemic, all primary and secondary schools and colleges and universities could not start school normally, and online education became an important basis for nonstop classes because of its noncontact characteristics [1]. With so many advantages, online education has developed rapidly in China, and many excellent products have emerged in the field of music education. Traditional education needs space and small class teaching. The Internet attribute of online education can greatly reduce the cost of education, reduce the cost of education, and even provide free online classes. The wide audience of Internet products has led to a rapid increase in the concentration of the industry. Excellent textbooks and teachers can be quickly and widely disseminated. The quality of education people receive is also higher than the traditional education model [2]. With the development of artificial intelligence technology, various intelligent functions are also embedded in music education software, such as practice music recommendation and intelligent music level rating, and some intelligent software are connected with the electronic piano, realizing the combination of software and hardware. It can intelligently correct errors and intelligently follow music according to the players’ piano keys, greatly improving the learners’ learning enthusiasm and efficiency.

With the popularity of smart phones, a large number of music education mobile software has entered our vision.
Through market research, we found that most of the musical instrument education software in the market focuses on providing learners with musical instrument teaching videos, or through the video function of mobile phones, real-time transmission of the fingering, and instrument pronunciation of the practitioners to the musical instrument teachers, so as to realize the accompaniment and remote guidance of musical instrument learning [3].

2. Literature Review

Gliga proposed a multitone detection system, in which two notes are input, and the system can detect the original note from the audio superimposed by two notes [4]. Waltham adopted the heuristic signal processing method, and his system can recognize polyphonic music played by eight organ ensembles. However, the problem of multitone detection has not been solved. Although the system proposed by them can recognize more notes, in fact, the effect it achieves is the recognized notes which are consistent with the sensory effect of the input audio instead of pursuing the accuracy of note results [5]. At the same time, if the fundamental frequencies of polyphonic music with multitone superposition overlap each other, they will affect each other in time-domain and frequency domain, which will bring greater difficulties to recognition. Elmezayen proposed a piano multitone estimation algorithm based on spectral envelope non-negative matrix decomposition, and its performance has been greatly improved on the international universal dataset maps in MIREX (Music Information Retrieval Evaluation eXchange) [6]. Mastellone used a new spectrum analysis method to realize the non-negative matrix decomposition system, which currently performs well on maps datasets [7]. Chen proposed the hidden Markov/semi-Markov model to solve the location problem. However, the HMM algorithm needs careful design and training, and the DTW algorithm only needs simple model without training to obtain good results. In recent years, the characteristic value selected by dynamic time warping algorithm is the pitch information of audio. The recorded audio information is serialized into numbers for fuzzy string matching. The music score following system based on DTW has the characteristics of high efficiency, accuracy, and simple model. It can occupy a small amount of resources to get accurate results. It is very suitable for a lightweight piano performance evaluation system [8]. In the system proposed by Zhang, the system based on non-negative matrix decomposition is used in piano teaching [9]. Otomański and others implemented a piano transcription interface device based on non-negative matrix decomposition [10]. In the system proposed by Rajpar, the system based on non-negative matrix decomposition is used in piano teaching [11].

In the international violin-making competition in Mittenwald, Germany, all musical instruments are evaluated by the judges in terms of timbre and technology. The scoring system of the judges is based on the following characteristics: (a) the quality of the process; (b) dimensions and specifications; (c) paint and paint treatment; (d) general impression, including material selection; (e) pronunciation; (f) sound transmission capacity; (g) performance feeling; and (h) overall impression of sound quality. Almost all evaluation means are based on people’s subjective feelings and require music experts with considerable professional knowledge, and the evaluation means are not easy to popularize. On the other hand, because people have different feelings and cannot form specific data to save, this evaluation method has certain subjectivity, and there are some deficiencies in inheritance, which is not convenient for further development and improvement. Based on LabVIEW 8.2, this paper proposes a new instrumented evaluation method and displays the results through WeChat applet, aiming to establish a quantifiable data evaluation system, which is of great significance to the quantitative evaluation of violin sound.

3. Research Methods

3.1. Pronunciation Quality Evaluation System. Pronunciation quality is an important indicator of system evaluation. The violin sound is transmitted to the computer through the microphone and analog-to-digital converter by the manual playing method, and then the time-domain diagram of playing waveform is given through the analysis and calculation of relevant programs, and then the frequency-domain analysis diagram is obtained through FFT processing of waveform, as shown in Figure 1.

3.2. Evaluation System of Pronunciation and Telepathy Ability. The ability to pronounce far is another important index in the systematic evaluation. The system uses computer as the core and LabVIEW 8.2 as the working platform to establish the secondary application program. Through the audio sampling card of Dell core dual core computer, the dual channel synchronous sampling at the distance of 1 m and 10 m is realized. At the same time, a number of general-purpose software are combined to establish the analysis program block for sampling data, forming the prototype system of “quantitative analysis of violin pronunciation transmission performance” [12].

3.3. Evaluation Software System. The virtual sampling instrument system for violin sound is designed by LabVIEW 8.2. This system, together with the Dell dual channel sampling card, can achieve those as follows:

(1) 11/22 kps sampling rate
(2) 12 bit sampling accuracy
(3) Sampling time not less than 20 seconds
(4) Synchronous storage capacity of not less than 60000 data in each channel
(5) The sampling results are displayed in real time and can also be played back or postprocessed by other software [13].

Due to the particularity of the data structure of LabVIEW 8.2, effective data text, curve group diagram, and analysis curve group diagram can be formed through the
connection of Microsoft office software and origin data processing software.

3.4. Implementation of the WeChat Applet Module. The WeChat applet module is the main part of interaction with users. The system uses the function of applet front-end module to meet the needs of users in the actual use process. The WeChat applet module in this system is mainly divided into four functions, namely, displaying music score content, adding/deleting music score, uploading recording, and displaying evaluation results [14]. The two functions of displaying music score content and adding/deleting music score are relatively simple, which can be completed through image size adaptation display and database related operations. Here, we will focus on the recording upload function and the evaluation result display function.

The recording upload module mainly completes the function of recording the user’s performance content and uploading it to the background server. The recording module directly calls the relevant interfaces of WeChat applet to realize. After the “recording” button is pressed, the applet calls the recording manager wx.getrecordmanager() to start recording [15].

The recording and uploading module of the applet mainly controls the transformation of different states by two buttons. When the system is initialized, the status of the two buttons are “record” and “upload.” At this time, the “upload” button is disabled, and audio cannot be uploaded without recording files. When the user clicks the recording button, the recording starts, and the state of the first button is switched to “stop.” After the user finishes recording, click the “stop” button to end recording. Then the WeChat applet will record the user’s performance content during this period and store it as an MP3 format audio file. At this time, the “upload” button can be used. The user clicks the “upload” button to upload the audio file to the background server. At this time, the status of button 2 changes from “upload” to “evaluation.” After clicking button 2 to obtain the evaluation, this button is disabled. The status in button 2 can only be enabled after recording and ending recording in button 1, and the recording in button 1 can start and end recording at any time. In the actual use, users may record repeatedly until they are satisfied, so the state change design meets the actual use needs of users.

The superposition and display of performance evaluation results in this system are realized in the WeChat applet front-end module. In order to intuitively present the performance evaluation results to users, the system displays errors by directly superimposing error information on the music score pictures. The wrong note played by the user will be directly marked in the corresponding position in the music score picture, and the bar rhythm that may be too fast or too slow will also be displayed in the corresponding position. Drawing in the WeChat applet is similar to other programming languages, and corresponding data drawing operations need to be performed on canvas [16]. In this system, some preset data are first required for small program drawing, and these data are encapsulated into render property objects in small programs.

4. Result Analysis

4.1. Sound Quality Evaluation Test Equipment. Computer, Dell dual channel sound card (12 bits, 22050 cps), LabVIEW 8.2 secondary development software, Origin 7.51 Stradivarius Guqin in 1741 and Stradivarius Guqin in 1692, and short-range and remote microphones are the equipment used for the sound quality evaluation test.

4.2. Analysis of the Violin Sounding Process. In 1741, the waveform of Stradivarius Guqin was obtained after LabVIEW 8.2 data acquisition. The sampling time was 3 seconds. Analyze the sound head and intercept the waveform between 0.3 s and 0.33 s of representative time nodes. Due to the fact that the effect of the bow on the string cannot be stabilized instantaneously, and the resonant cavity lags behind the vibration of the string, there will be a transition period before the resonant cavity stabilizes the vibration, that is, the sound head. It is not difficult to see from the waveform that the waveform of the sound head can be divided into four stages: starting, simple excitation response, complex excitation response, and quasi-stable excitation response [17].

After the start, the sound head initially presents a simple excitation response, with only one near octave overtone and three cycles. Its maximum overtone peak/dominant frequency peak ratio coefficient $k = 0.36$, and then enters the complex excitation response, about nine cycles, with $k = 0.735$, and then enters the quasi-stable excitation response. Its waveform is similar to the later typical A-string empty string playing waveform, with $k = 0.36$.

4.3. FFT Analysis and Comparison of Each Stage of Violin Sound Production. By comparing and analyzing Figures 2 to 5, the first dominant frequency is around 438 Hz, which is related to the natural frequency of the violin. At the beginning of the start, as shown in Figure 2, the dominant frequency is not very obvious, and there is a phenomenon of

![Figure 1: Pronunciation quality hardware system.](image-url)
multiple frequencies and the peak value is not much different from the dominant frequency. This is related to the asynchronous vibration of the resonant cavity and the string, that is, the so-called “uncoordinated period.” At this time, the sound generated is very irregular, and the start time should be shortened as far as possible. Then enter the quasi-stable excitation response, the first dominant frequency peak of the curve is sharpened and strengthened, the maximum overtone peak/dominant frequency peak ratio coefficient \( k = 0.36 \), while other octaves are gradually reduced and weakened, and there is overtone peak development between octaves [18, 19]. As shown in Figure 3, in the rising stage of the start, in addition to the main frequency, there are seven octave peaks, and there are three overtone peaks between the two adjacent octave peaks. In the loudest stage of the start, as shown in Figure 4, the main frequency peak is further sharpened and strengthened, \( k = 0.2 \), the frequency doubling peak is further reduced, and only five frequency doubling peaks are left. At the same time, the overtone peaks between frequency doubling are further developed and the number becomes more. In the stable playing stage, \( k = 0.26 \), and the peak value of each octave peak has little difference, and the development of overtone peak tends to be stable; that is, it enters the stable pronunciation stage [20].

To sum up, the following conclusions can be drawn:

(1) The process of violin sound production is accompanied by the weakening of octave peak and the development of overtone peak. The stable stage is marked by the stability of each octave peak and overtone peak.

(2) Excitation response: The sound head initially presents a simple excitation response, with only one near octave overtone and three cycles [21]. Its maximum overtone peak/dominant frequency peak ratio coefficient is \( k = 0.36 \); the back entry complex excitation response has about nine cycles, with \( k = 0.735 \). Then enter the quasi-stable excitation response, whose waveform is similar to the typical A-string empty string pull waveform in the later stage, with \( k = 0.36 \).

(3) maximum overtone peak/main frequency peak proportional coefficient is \( k = 0.39 \) in the rising section of the start, \( k = 0.2 \) in the loudest section, and \( k = 0.26 \) in the stable section;

(4) Generally speaking, the violin pronunciation can pass through the complex excitation response stage within 0.02 seconds, and the shorter the transition time, the better. The maximum overtone peak/dominant frequency peak proportional coefficient \( k \) is controlled at the level of 0.26, which can be used as a professional piano.

4.4. Performance Analysis of Violin Articulation with Time Amplitude Curve. Obviously, the amplitude of a short-range microphone is much larger than that of a remote microphone. Although it is required to play each string smoothly, it can be seen from the curve of the short-range microphone that the vibration development behavior of different strings is different, and it generally presents the phenomenon of
“high low higher,” in which a and e strings have more obvious characteristics. However, the waveform of the remote microphone is not a simple linear attenuation of the curve of the short-range microphone. Its waveform is obviously different from that of the short-range microphone, and the difference in the pronunciation of the four strings can be observed from its “macro” distribution.

The amplitude ratio of time amplitude curve of two microphones can be used to characterize the sound transmission performance of violin. Because the vibration signal is positive and negative distribution, it is necessary to carry out absolute value processing before the next step of statistical processing. Figure 6 is a comparison curve of the average of absolute values of 100 subsamples (the average of 100 data) for two microphones. Figure 7 is a comparison curve of the peak values (the maximum value of 100 data) of the absolute values of 100 subsamples adopted by the two microphones.

$K_c \text{ value is a parameter that uses absolute value average }$

value to characterize the sound transmission performance of violin, which is defined as follows:

$$K_c = \frac{\sum_{i=1}^{n} V_{1,i}}{\sum_{i=1}^{n} V_{2,i}}$$

(1)

where $i$ is the subsample serial number that changes with the sampling time; $n$ is the number of statistical subsamples, $n = 20$ and $n = 100$; $V_{1,i}$ is the transient value of the remote microphone; and $V_{2,i}$ is the transient value of the remote microphone [22].

$K_p$ value is a parameter that represents the sound transmission performance of the violin by using absolute value peak value, which is defined as follows:

$$K_p = \frac{V_{1p,i}}{V_{2p,i}} (i - n \sim i),$$

(2)

where $i$ is the subsample serial number that changes with the sampling time; $n$ is the number of peak statistical subsamples, $n = 100$; $V_{1p,i}$ is the transient peak of the remote microphone; and $V_{2p,i}$ is the transient peak of the remote microphone [23].

It is preliminarily believed those as follows:

(1) The KC value using the absolute value average method has high sensitivity, but the dispersion is also large.

(2) The absolute value peak method can obtain higher data amplitude (three times larger than the average value).

(3) Details of the loss waveform: The sensitivity of KP is slightly lower, but the dispersion is also relatively small.
(4) Increasing the number of statistical subsamples can reduce the dispersion: The statistical results of the 0.5 second time period for the teletransmission performance of Stradivarius 1692 show that string $a$ is the best, string $e$ is the second best, string $D$ is also the second best, and string $G$ is the worst. These results were obtained through five groups of 11,000 data in each group, including $Kc(G) = 0.1192$, $Kc(D) = 0.1320$, $Kc(A) = 0.2669$, and $Kc(E) = 0.156180.1262$.

To sum up, the following conclusions can be drawn:

(1) This paper studies the basic methods of evaluating the performance of violin pronunciation and telepathy and forms an experimental analysis scheme of $Kc$, $Kp$ parameter evaluation, and instantaneous FFT analysis [24].

(2) Based on the measured data of Stradivarius 1692 violin playing with four empty strings, the performance evaluation of violin pronunciation is carried out.

(3) $Kc$ and $Kp$ parameters can be easily obtained by software. Experiments show that they can accurately express the pronunciation and telepathy performance of each string. It further shows that it can be used for the comparison of pronunciation and telepathy performance of different violins [25].

5. Conclusion

On the basis of traditional violin evaluation methods, the concept of instrumented evaluation is proposed, and a relatively simple hardware system is established. Through sound acquisition and FFT analysis of violin pronunciation process, some characteristics and parameters representing violin sound quality are preliminarily obtained, which lays a good foundation for further discussion of violin sound evaluation methods. This paper puts forward a quantifiable evaluation method; that is, using the combination of software and hardware, through the data collection of LabVIEW 8.2 and the supporting use of Excel and Origin 7.5, the data and curves of violin pronunciation process and transmission ability are obtained, as well as the subsequent analysis conclusions.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] Y. Ran, D. Hu, Z. Xu et al., “Vertical-fluid-array induced optical microfiber long period grating (violin) refractometer,” *Journal of Lightwave Technology*, vol. 38, no. 8, pp. 2434–2440, 2020.

[2] S. Gonzalez, D. Salvi, F. Antonacci, and A. Sarti, “Eigenfrequency optimisation of free violin plates,” *Journal of the Acoustical Society of America*, vol. 149, no. 3, pp. 1400–1410, 2021.

[3] S. L. Lammlein, B. Van Damme, D. Mannes, F. W. M. R. Schwarze, and I. Burgert, “Violin varnish induced changes in the vibro-mechanical properties of spruce and maple wood,” *Holzforschung*, vol. 74, no. 8, pp. 765–776, 2020.

[4] V. G. Gliga, M. D. Stanciu, S. M. Nastac, and M. Campean, “Modal analysis of violin bodies with back plates made of different wood species,” *Bioresources*, vol. 15, no. 4, pp. 7687–7713, 2020.

[5] C. Waltham, “The violin: a social history of the world’s most versatile instrument,” *Journal of the Acoustical Society of America*, vol. 147, no. 1, pp. 381–382, 2020.

[6] A. Elmezayen and A. El-Rabbany, “Performance evaluation of real-time tightly-coupled gnss ppp/mems-based inertial integration using an improved robust adaptive kalman filter,” *Journal of Applied Geodesy*, vol. 14, no. 4, pp. 413–430, 2020.

[7] M. L. Mastellone, “Technical description and performance evaluation of different packaging plastic waste management’s systems in a circular economy perspective,” *The Science of the Total Environment*, vol. 718, Article ID 137233, 2020.

[8] H. Chen, S. Ye, T. Wang, X. Zheng, and T. Li, “Extraction of common-mode impedance of an induction motor by using all-phase fit with intermediate-frequency filtering,” *IEEE Transactions on Electromagnetic Compatibility*, vol. 63, no. 5, pp. 1593–1598, 2021.

[9] Z. Zhang, F. Wang, G. Xu, J. Jia, X. Liu, and Y. Cao, “Improved carrier frequency-shifting algorithm based on 2-fft for phase wrap reduction,” *Mathematical Problems in Engineering*, vol. 2021, pp. 1–10, Article ID 6664841, 2021.

[10] P. Otomański, E. Pawłowski, and A. Szlachta, “The evaluation of expanded uncertainty of dc voltages in the presence of electromagnetic interferences using the labview environment,” *Measurement Science Review*, vol. 21, no. 5, pp. 136–141, 2021.

[11] A. H. Raijar, A. E. Eladwi, I. Ali, and M. B. Ali Bashir, “Reconfigurable articulated robot using android mobile device,” *Journal of Robotics*, vol. 2021, no. 3, pp. 1–8, Article ID 6695198, 2021.

[12] Y. Duan, Z. Yang, W. Ge, and Y. Sun, “Explosive thermal analysis monitoring system based on virtual instrument,” *Journal of Beijing Institute of Technology (Social Sciences Edition)*, vol. 30, pp. 218–224, 2021.

[13] J. Meng, M. Singh, M. Sharma, D. Singh, P. Kaur, and R. Kumar, “Online monitoring technology of power transformer based on vibration analysis,” *Journal of Intelligent Systems*, vol. 30, no. 1, pp. 554–563, 2021.

[14] M. Irfan, G. Cascante, D. Basu, and Z. Khan, “Novel evaluation of bender element transmitter response in transparent soil,” *Geotechnique*, vol. 70, no. 3, pp. 187–198, 2020.

[15] Y. Deng, G. Zhang, and X. Zhang, “A method to depress the transmitting voltage response fluctuation of a double excitation piezoelectric transducer,” *Applied Acoustics*, vol. 158, Article ID 107066, 2020.

[16] X. Zhang, L. Ma, G. Zhang, and G. S. Wang, “An integrated model of the antecedents and consequences of perceived information overload using wechat as an example,” *International Journal of Mobile Communications*, vol. 18, no. 1, pp. 19–40, 2020.
[17] A. Sharma and R. Kumar, “Performance Comparison and Detailed Study of AODV, DSDV, DSR, TORA and OLSR Routing Protocols in Ad Hoc Networks,” in Proceedings of the 2016 Fourth International Conference on Parallel, Distributed and Grid Computing (PDGC), December 2016.

[18] M. S. Pradeep Raj, P. Manimegalai, P. Ajay, and J. Amose, “Lipid data acquisition for devices treatment of coronary diseases health stuff on the Internet of medical things,” Journal of Physics: Conference Series, vol. 1937, no. 1, Article ID 012038, 2021.

[19] J. Liu, X. Liu, J. Chen, X. Li, and F. Zhong, “Plasma-catalytic oxidation of toluene on FeO2/sepiolite catalyst in DDBD reactor,” Journal of Physics D: Applied Physics, vol. 54, no. 47, Article ID 475201, 2021.

[20] R. Huang, P. Yan, and X. Yang, “Knowledge map visualization of technology hotspots and development trends in China’s textile manufacturing industry,” IET Collaborative Intelligent Manufacturing, vol. 3, no. 3, pp. 243–251, 2021.

[21] L. Yan, K. Cengiz, and A. Sharma, “An improved image processing algorithm for automatic defect inspection in TFT-LCD TCON,” Nonlinear Engineering, vol. 10, no. 1, pp. 293–303, 2021.

[22] P. Sheikhzadeh, H. Sabet, H. Ghadiri, P. Geramifar, P. Ghafarian, and M. R. Ay, “Design, optimization and performance evaluation of bm-pet: a simulation study,” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 940, pp. 274–282, 2019.

[23] J. A. Torres, C. A. Soto, and D. Torres-Torres, “Exploring design variations of the titian stradivari violin using a finite element model,” Journal of the Acoustical Society of America, vol. 148, no. 3, pp. 1496–1506, 2020.

[24] I. Issa, Z. Zhang, W. El-Kolaly, X. Yang, and H. Wang, “Design, ansys analysis and performance evaluation of potato digger harvester,” International Agricultural Engineering Journal, vol. 29, no. 1, pp. 60–73, 2020.

[25] C. N. Kumar and N. L. K. Chakravarthi, “Design, development and performance evaluation of manure spreader- a review,” International Journal of Current Microbiology and Applied Sciences, vol. 8, no. 09, pp. 2530–2539, 2019.