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# Research and Application of the Three Elements of Music Teaching Sound Based on Bayesian Network

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***Abstract***

*As a key element of music teaching, this paper focuses on the use of Bayesian network techniques with the characteristics of the three elements of sound in music for music teaching. The Bayesian harmonic model of audio is introduced in the analysis of music signals, and a Bayesian harmonic model is proposed on this basis, and then the fundamental frequency parameters and harmonic amplitudes in this model are estimated using a reversible hopping Monte Carlo sampling algorithm. The accuracy of the Bayesian harmonic model is studied and the error between the actual signal and the test signal is found to be less than 2%. The average score of the experimental class after the assessment of students' professional music ability with the help of Bayesian network technology and the tutorial teaching of the three elements of sound characteristics was 86, and the average score of the control class using traditional teaching was 79.8, with a score difference of more than 6 points. Therefore, the music signals synthesized by using Bayesian harmonic model analysis reproduced the original signals better, and the performance of the students subjected to model-assisted teaching improved significantly, which led to the improvement of the teaching quality of music majors.*

***Keywords:*** *Bayesian algorithm; music teaching; three elements of sound; Monte Carlo algorithm.*

## Introduction

Tone is produced by the vibration of objects and is the basic material that makes up music. Music belongs to the art of time, and the flow of sound reflects the continuity of time; without sound there is no music (VanWeelden, 2012). Tone has four attributes: height, length, intensity, and timbre. The number of vibrations in a certain period of time determines the height of a tone, and the number of vibrations is also called frequency (Liang et al., 2016). If the number of vibrations is high, the tone is high, and vice versa, the tone is low. The length of the sound is determined by the duration of the sounding body. If the duration is long, the tone is long, and vice versa, the tone is short. The size of the amplitude determines the strength of the sound. If the amplitude is large, the sound is strong, and vice versa, the sound is weak (Klonari, Pastiadis, Papadelis, & Papanikolaou, 2011). The nature, shape, structure and amount of overtones of the sounding body determine the timbre. The more overtones there are in the same instrument or in the same voice, the more

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beautiful the tone will be, while on the other hand, the tone will be very weak (Siedenburg, Jones-Mollerup, & McAdams, 2016; Yao, Li, & Ma, 2021).

Tones are divided into two categories: musical tones and noise, both of which are essential elements in music. Musical tones are produced by objects that vibrate regularly and periodically and have a fixed pitch, and they are the main material for structuring musical works (G. D. A., 2021; Yang, 2022). Noise is a sound made by an object that vibrates irregularly and non-periodically and has no fixed pitch (Baral & Torlak, 2019). The instruments that play musical tones are mainly piano, violin, flute, erhu, bamboo flute, guzheng, guitar, etc. The role played by noise is also difficult to replace by musical tones, and the purpose of using noise in music is mainly to render emotions or cause contrasts in timbre (Yan, 2021; Zhang H. W, 2018).

Literature (Richerme, 2022) music education can be divided into broad and narrow dimensions. Music education is distinguished at the broad and narrow level. Music education in the former sense means that people's thoughts, thinking qualities and emotions will be influenced by music to improve their knowledge and skills. The latter music education means that music education is carried out in an orderly manner with a certain purpose, with the school as the main body and with the knowledge of certain social needs. The literature (Li & Xu, 2015) Yale University held a symposium on the problems arising from contemporary music education and suggestions to solve them in two ways.

On the one hand, it encouraged the expansion of the curricular repertoire in terms of musical material, including non-Western, jazz, popular and ethnic music and called for an enhanced introduction to the life and works of composers. On the other hand, it is suggested that although the performance standards in American music education are currently high, the curriculum is mostly focused on training in musical skills, neglecting curriculum training for a comprehensive understanding of music, so that the performance aspect advocates a more complete musical experience through composing, performing and listening.

The core concept of the integrated music sense approach in the literature (W. A., 2014) is that the learning of music should be a merging of all aspects of music into a whole. It is guided by the idea of developing students' creative thinking and adapting to the new wave of industrial revolution, and requires the integration of music history and music theory in the teaching selection by merging various types of musical materials, using analysis, performance, and composition. The literature (Paynter J, 2018) suggests that teachers are the key to basic music education, and that the teaching goal of enhancing students' musical aesthetics can be truly implemented only if teachers give conceptual importance to teaching basic music knowledge and promote students' mastery of it through reasonably designed teaching sessions.

Literature (Wang, 2021) mentions that traditional music teaching methods stereotypically teach music theory knowledge, ignoring the main position of students and making them lose interest in learning music theory knowledge. It should follow the great development of the times, adopt novel teaching methods, stimulate students' learning enthusiasm, combine music theory with music practice, and develop a complete theoretical system of basic music knowledge in order to improve the classroom efficiency of music teaching.

Although the three major music teaching methods share a common philosophy and teaching methods, each has its own advantages and characteristics due to the different historical and cultural backgrounds. In the literature (Good-Perkins, 2019), the Dalcroze method is based on the sense of "hearing", so that students can use their own bodies as musical instruments and reproduce the music they hear with body rhythms, thus training improvisation, performance, and creativity through music and body rhythms. The literature (Xin X U, 2019) Kodaj method of music teaching, on the other hand, focuses on the role of singing, arguing that the human voice is an innate instrument and should be used to its advantage to learn music.

It includes various forms of methods such as first-tone chanting, Corwin gestures, rhythm reading, and alphabetic notation so that students can learn rhythm, pitch, and melody from singing, guide them to learn complete songs in an effective way, and enhance the development of musical sensitivity. Literature (Chun-Ying M. A, 2017) Orff music teaching method is used throughout the forms of language skills, singing performance, body rhythm, and instrument playing, transitioning from children's song recitation to word substitution, gradually adding song singing and vocal gestures, and finally using Orff instruments appropriate for young children to achieve the purpose of teaching activities.

The Bayesian harmonic model is proposed based on Bayesian network techniques because of the transient nature of the music signal, the inclusions of noise, and the complex structure of its fundamental frequency in the frequency domain. The model is then simplified by making the variables to be estimated in the model as fundamental frequency, number of harmonics, amplitude and noise variance. The statistical characteristics of the requested parameters are computed using a reversible jump Monte Carlo sampling algorithm by creating a stochastic process, an observation of the model or process or a sample test. Finally, the concept of the three elements of sound is introduced in detail and its characteristics are used to propose a music teaching method based on Bayesian network techniques. In addition to this the accuracy of the Bayesian harmonic model is determined and the improvement of students' musical ability by the music teaching method based on the new model is investigated.

## Bayesian Harmonic Model and Probabilistic Framework

Bayesian approach provides a class of rigorous solution framework for the estimation problem of dynamic systems, which uses known information to establish the probability density function of the system, i.e., the prior distribution, and then estimates the parameters according to some estimation criteria such as maximum posterior probability estimation, posterior mean estimation, and minimum mean square error estimation. Then the reversible jump Monte Carlo sampling (RJMCMC) algorithm is used to obtain the parameters, and the block diagram of the analysis and

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synthesis of the music signal is shown in Figure 1.

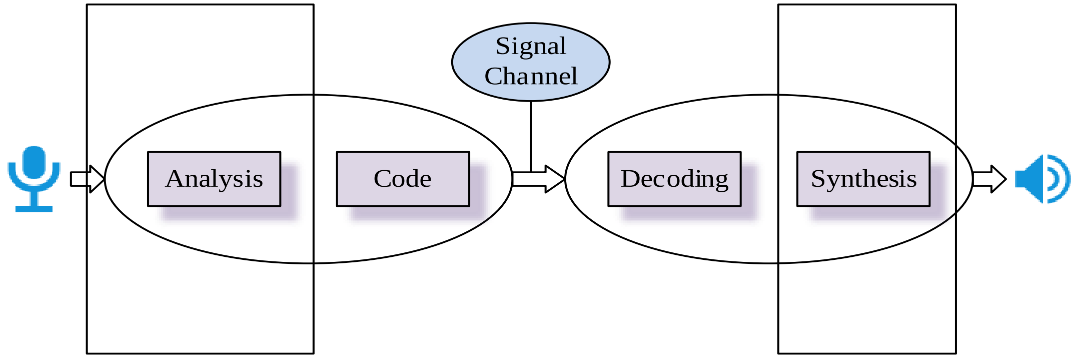


**Figure 1** Block diagram of music signal analysis and synthesis

At the transmitter side, the signal is first analyzed and parameters are obtained. Then the parameters are encoded and the stream is transmitted in the channel and reaches the receiver, where it is decoded and synthesized, thus completing the restoration of the music signal. The work done in this paper is to analyze the music signal to obtain the parameters and synthesize them, i.e., to implement the module in the box.

***Bayesian Harmonic Model***

In general, a music signal can be considered as a series of sine waves superimposed on each other. Consider a short time frame music signal, denoted as $y[t], t=1,2,\ldots,N$, containing $K$ notes, each containing $M_k$ harmonics, with a frequency of $\omega_{k,m}$ and a sampling rate of $\omega_s$. The polyphonic signal can be represented by the following equation:

$$y[t]=\sum_{k=1}^{K}\sum_{m=1}^{M_k}\left\{a_{m,k}[t]\cos\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right)+b_{m,k}[t]\sin\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right)\right\}+v[t] \quad (1)$$

The amplitude $a_{m,k}[t], b_{m,k}[t]$ of each harmonic is time-varying and consists of a series of basis functions $\phi_i$, $i=0,\ldots,I$ denoted as:

$$a_{m,k}[t]=\sum_{i=0}^{I}a_{k,m,i}\phi_i[t] \quad (2)$$

$$b_{m,k}[t]=\sum_{i=0}^{I}b_{k,m,i}\phi_i[t] \quad (3)$$

where $\phi_i[t]$ is the basis function, which can be any form of non-oscillatory function such as the

Hanning window. In this paper, the Hanning window is used. The initialization function is $\phi_i[t]$, and the other basis functions are:

$$\phi_i[t] = \phi[t - i\Delta t] \quad i = 0,\ldots,I \tag{4}$$

where interval $\Delta t = (N-1)/I$.

The polyphonic signal can then be expressed as:

$$y[t] = \sum_{k=1}^{K}\sum_{m=1}^{M_k}\sum_{i=0}^{I}\phi[t - i\Delta t] \times \left\{ a_{m,k,i}\cos\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right) + b_{m,k,i}\sin\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right)\right\} + v[t] \tag{5}$$

***Simplified Model***

In this paper, only single-tone signals are analyzed, i.e., the number of notes is fixed at 1, and the harmonics and fundamental frequencies satisfy a strict multiplicative relationship, i.e., the detuning is 0. The variables to be estimated in the model are the fundamental frequency, the harmonic number amplitude, and the noise variance. The simplified model can be expressed as follows:

$$y[t] = \sum_{m=1}^{K}\sum_{i=0}^{I}\phi[t - i\Delta t] \times \left\{ a_{m,i}\cos\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right) + b_{m,i}\sin\left(\frac{2\pi\omega_{k,m}}{\omega_s}t\right)\right\} + v[t] \tag{6}$$

Let the magnitude matrix be $\beta$ and the specific elements of length $2M(I+1), m = 1,\ldots,M, i = 0,\ldots,I$ be:

$$\beta(2(Mi+m)-1) = a_{m,i} \tag{7}$$

$$\beta(2(Mi+m)) = b_{m,i} \tag{8}$$

The kernel matrix is $D, t = 1,\ldots,N$ The specific elements are:

$$D(t, 2(Mi+m)-1) = \phi(t - i\Delta t)\cos(m\omega t) \tag{9}$$

$$D(t, 2(Mi+m)) = \phi(t - i\Delta t)\sin(m\omega t) \tag{10}$$

The model can be simplified as:

$$y = D\beta + v \tag{11}$$

$v$ is the noise vector, which is white noise with a variance of $\sigma_v^2$.

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***Model Probabilistic Framework***

(1) Likelihood function of the model

The likelihood function of the model is:

$$p\left(y\mid\beta,\omega,M,\sigma_v^2\right)=\frac{1}{\left(2\pi\sigma_v^2\right)^{N/2}}\exp\left[-\frac{1}{2\sigma_v^2}\|y-D\beta\|^2\right] \tag{12}$$

(2) Model prior probability

The prior probability function of the model is:

$$P\left(\beta,\sigma_v^2,\omega,M\right)=p\left(\beta\mid\sigma_v^2,\omega,M\right)p\left(\omega\mid M\right)p\left(M\right)p\left(\sigma_v^2\right) \tag{13}$$

The prior probabilities of each parameter are:

In this paper, the zero-mean Gaussian distribution is chosen as the prior probability of the day, and the covariance matrix is $\sigma_v^2/\xi^2\sum I$ :

$$p\left(\beta\mid\sigma_v^2,\omega,M,K\right)=N\left(\beta;0_{2R(I+1)},\sigma_v^2/\xi^2\sum I\right) \tag{14}$$

$\omega$ obeys the mean distribution:

$$p2\left(\omega\mid M\right)=u\left(\omega_m;[0,\omega_s/2M]\right) \tag{15}$$

The noise variance $\sigma_v^2$ follows an inverse gamma distribution:

$$p\left(\sigma_v^2\right)=IG\left(\sigma_v^2;V_0,\gamma_0\right) \tag{16}$$

The prior probability of $M$ is modeled using a Poisson distribution and is expressed as follows:

$$p\left(M=m\mid\Lambda\right)=e^{-\Lambda}\frac{\Lambda^m}{m!} \tag{17}$$

(3) Posterior probability of the model

The posterior probability of the model can be obtained from the Bayesian formula:

$$p\left(\beta,\omega,M,\sigma_v^2\mid y\right)\propto p\left(y\mid\beta,\omega,M,\sigma_v^2\right)p\left(\beta,\omega,M,\sigma_v^2,M\right) \tag{18}$$

The representation of the posterior probability of each parameter is given below:

$$p\left(\omega,M\mid y\right)\propto\left(\gamma_0+y^tPy\right)^{\frac{-(N+v_0)}{2}}\det\left(S\right)^{\frac{1}{2}}p\left(\omega\mid M\right)\frac{\Lambda^M}{M!} \tag{19}$$

Of which $P = I - DSD^t, S = \left[D^t D + 1/\xi^2 I\right]^{-1}$.

The posterior probability of the noise variance $\sigma_v^2$ is:

$$p\left(\sigma_v^2 \mid \omega, M, y\right) = IG\left(\frac{N+v0}{2}, \frac{\gamma 0 + y^t P y}{2}\right) \quad (20)$$

The posterior probability of $\beta$ follows a Gaussian distribution, denoted by:

$$p\left(\beta \mid \sigma_v^2, \omega, M, y\right) = N\left(\mu, \sigma_v^2 S\right) \quad (21)$$

Among them $\mu = SD^t y$.

***Reversible Jump Monte Carlo Sampling Algorithm***

In Bayesian filtering problems, for general multivariate distributions, the integral result cannot be obtained, so the integral must be approximated. Monte Carlo method is a statistical experiment method, and its basic idea is to first build a probability model or stochastic process. Then the statistical characteristics of the sought parameters are calculated by observation or sampling tests of the model or process, and the arithmetic mean is used as the approximation of the sought solution.

When calculating integrals of the form $I(f) = \int f(\theta) p(\theta \mid x) d\theta$, it is not really feasible to use a computer for this calculation when the forms $f(\theta)$ and $p(\theta \mid x)$ are more complex. Suppose we generate a series of particles as follows:

$$\left\{\theta^l\right\}_{l=1,\ldots,L} \quad (22)$$

These particles are generated by sampling from the posterior probability $p(\theta \mid x)$. Thus $I(f)$ can be approximated as the following weighted sum:

$$I(f) \approx \frac{1}{L} \sum_{l=1}^{L} f\left(\theta^l\right) \quad (23)$$

The RJMCMC algorithm is an application of the Monte Carlo sampling algorithm. In this paper the number of harmonics of the signal is not fixed, which will cause a variation of the dimensionality. RJMCMC allows to construct a Markov chain of jumping dimensions, which defines a series of motions that are reversible and can jump back to the original state in the latter, i.e. jumping reversible. The first step of the RJMCMC algorithm is to select one of a series of

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movement methods, which is usually done by homogenized sampling. Then the proposed values are generated from the proposed probability distribution $q(z,z')$, then the permittivity $a(z,z')$ is calculated, and finally the proposed or previous values are added to the Markov chain. The formula for $a(z,z')$ is:

$$a(z,z') = \min\left[1, \frac{\pi(z')q(z',z)}{\pi(z)q(z,z')}\right] \tag{24}$$

where $\pi(z)$ is the target probability distribution, i.e., the posterior probability distribution of the previous section.

The algorithm can be described as follows:

First the initial value (generally the value at the previous moment) is determined and the type of motion is selected from the possible motion modes, generally the mean distribution. Loop again (from 1 to $M$) to generate the proposed value from the proposed probability density function. The permission rate $a$ is calculated and if the permission rate is greater than 1, the new predicted value is the suggested value, and if the permission rate is less than 1, the suggested value is assigned to the new predicted value with the probability of permission rate $a$. Finally, $M$ predicted values are returned. The posterior probabilities of each parameter are given in the previous section, and the next flow chart for estimating the parameters using the RJMCMC algorithm is shown in Figure 2:

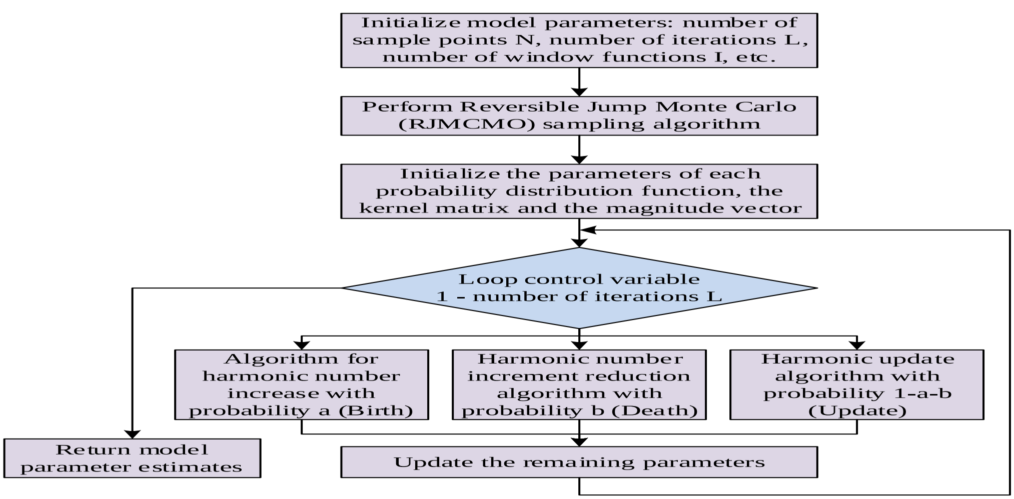


**Figure 2** Program flow diagram

First, the model parameters are initialized, and then it is time to perform the RJMCMC iterative algorithm. There are three cases in the iterative process, corresponding to the cases of increasing, decreasing and constant number of harmonics, and the parameters are updated at each iteration. In this way, after several iterations, each parameter is stabilized and the estimation criterion is chosen to obtain the estimated values of the parameters.

## The significance of the three elements of sound in music teaching and technology development

### *The Three Elements of Sound*

Of the three elements of sound, volume refers to the strength of a tone and is relatively easy to grasp both figuratively and technically. The common intensity notation on the score has six basic volume levels from Fortissimo (ff) to Pianissimo (pp), plus more layers with less common volume notations such as piu f. The shaping of the volume levels is horizontally the control of phrasing, section direction and ebb and flow. Vertically it is a sharp distinction between voices and a strict control of the independence between fingers. Tone is determined by a variety of factors such as the number of overtones and the order and strength of their arrangement when the articulator vibrates. In many music instruments and dictionaries, tone and timbre are often equated as one concept or as a fusion of concepts. However, from the point of view of piano performance, tone and timbre are two different categories of sound. Tone is variable, tone quality is constant. Tone is the sound produced by the player's use of many technical factors, such as depth, length, speed, angle, strength, etc., and the blend of them, which makes the listener feel different emotions and colors, thus distinguishing it from the quality of the sound, which is clear and pleasant or muddy and unreal. The sound quality refers to the quality of the sound produced by the player using the key touch technique, not the mechanical and acoustic principles of the sounding material.

### *Technical Development of the three Elements of Sound*

The first key to producing a quality sound from the very beginning of one's studies is to develop a correct concept of sound quality at the aural level; the ear is the player's best teacher. The second key is to have solid basic skills related to sound quality. While addressing the most basic requirements of sound quality, we need to further address other issues related to sound such as evenness, clarity, accuracy, neatness, granularity, power, etc. and thus continue with various basic technical training such as long/short scales, long/short arpeggios, chords, chromatic scales, toccata, finger rotation, alternating hands, crossed hands, etc. Of course, the deeper techniques include the training of vocal level distinction and balance control, rhythmic training, pedal training, advanced techniques such as double octave, double third, long-distance jump, etc., as well as the training of playing persistence. All of these techniques are inseparable from the consideration of sound, and the perfect combination of technique and music can be achieved by taking into account the sound quality and emphasizing musicality while completing various techniques.

Volume is influenced and conditioned by strength, speed, height and other factors, and strength is

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divided into two kinds: self-gravity (own weight) and artificial force (muscle explosive force). In playing the piano, self-gravity is mainly used to make sound, specifically through the self-gravity of the fingertips, palms, wrists, forearms, big arms and even back muscles, waist and other parts of the body, which can be used only with the weight of the fingertips and the first joint at the minimum volume, and the weight of the shoulders, back and waist at the maximum volume. Different body parts emit different weights, and the volume level will be different. Although the main use of gravity is to produce sound, it does not mean that artificial force cannot or does not need to be used. Human force can be used to augment the lack of self-gravity and the lack of speed and height of the keys, but it is not possible to play purely by human force, but by a combination of both. The combination of both must be used, with self-gravity as the primary force and human force as the secondary force, in order to satisfy the requirement of "pleasing to the ear" and to enrich the volume level.

The ten points that influence the change of tone are summarized as "six degrees and four elements". The "six degrees" refer to the six "degrees" of key touch: the speed of the key, the angle of the key touch, the strength of the implementation (self-gravity and artificial force), the height from the key, the depth of the key touch, and the hardness of the support. The four elements are: level, pedal, timing, tonality and harmony. In these "six degrees and four elements", students usually only consider the force, but ignore the other points. It is easy to imagine how many different tones can be played by combining these ten elements and blending them in a variety of ways.

According to the characteristics of the three elements of sound, the Bayesian harmonic model proposed in this paper can be used to analyze the correct music to extract the characteristic signals of volume, tone quality and timbre. Then the sound of one's own practice is processed, and the comparison of the two can reveal one's error points. And students can then quickly and purposefully adjust their practice to the error points.

## Research on Music Teaching Based on Bayesian Harmonic Model

Music learners are often not easily able to hear the gap between their own and correct tunes. With the help of Bayesian harmonic modeling, the musical signals in the learner's own played tune and the correct tune can be extracted in terms of the three elements of sound, and comparing the signal characteristics with each other makes it easier for the learner to quickly find out where he or she is wrong.

To verify the recognition accuracy of Bayesian harmonic model, different musical instruments were selected to be analyzed according to their timbral characteristics in this paper. A total of 3051 music clips reflecting the performance of different main instruments were included in 8 categories of listening sensation. 8 categories of instrument styles were: 4 categories of Chinese folk instruments, including guzheng, pipa, erhu and flute. The four categories of Western instruments are: saxophone, guitar, piano and violin. Except for the piano, all other instrument songs are songs with a certain type of instrument as the main instrument in the listening sense.

***Model Analysis***

In this paper, we first process the music signal for one frame and finally obtain the synthesized signal for multiple frames. The number of sample points of each frame is 1000, i.e. $N = 1000$, and the number of basis functions is $I = 13, v_0 = \gamma_0 = 0$. The number of iterations set is 500, and convergence is reached smoothly after less than 200 iterations. In this paper, the last 100 sample points are selected as the simulation sampling points, and the maximum posterior probability criterion is used for the estimation of M, and the minimum mean square error estimation criterion is used for the estimation of $\omega$ and $\beta$, and the following are the simulation results. Figure 3 shows the actual signal and Figure 4 shows the test signal. Comparing the synthesized sound signal and the original sound signal, it is found that the melody and pitch of the synthesized sound are very close to the original sound with an error rate lower than 0.02.

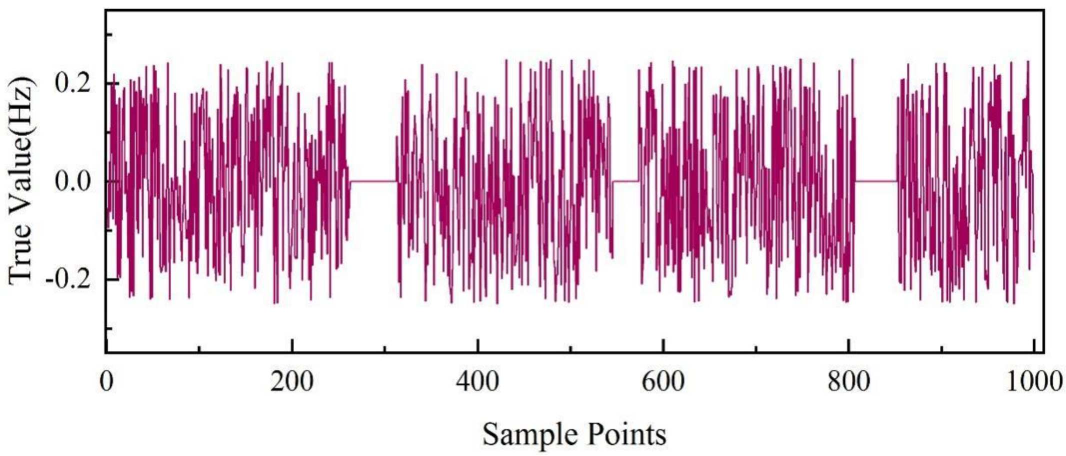


**Figure 3** Actual signal

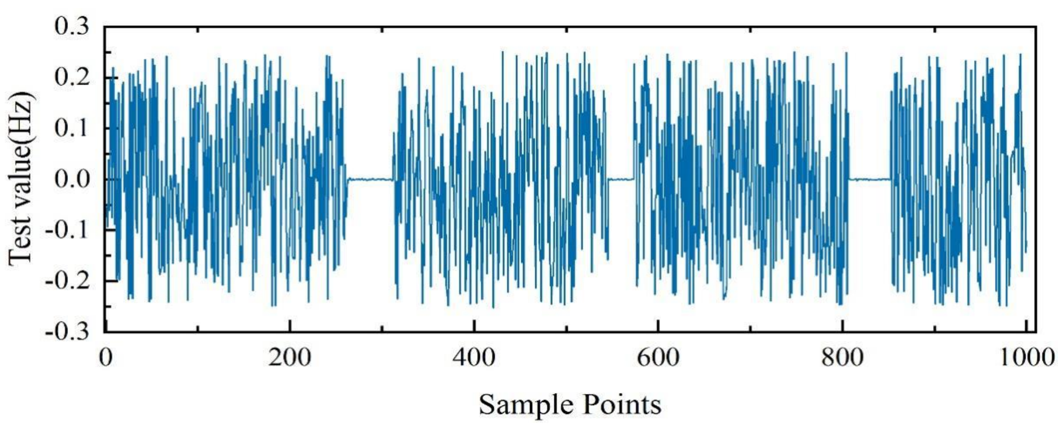


**Figure 4** Test signal

***Analysis of Teaching Results***

The teaching results are evaluated through three directions: skills assessment, competency growth assessment, and objective analysis of audio technology. In order to better understand the students' practical training and skills mastery, the author collects all students' practical training audio records every week in the practical training as a reference basis for the competence assessment. The assessment steps are as follows:

(1) Students will be tested in groups for live skills demonstration, and the test will be held in the college's music hall. 7 music performance teachers will be invited to score the students' live skills test one by one. And record the students' examinations through audio recording for archiving.

(2) The assessment location is the audio training room, where the instructor scores the students' growth ability based on the previously stored audio of the students' stage practical training. Both the live skills demonstration scoring and the growth ability scoring are calculated according to a full score of 100.

(3) The assessment location was the audio training room, where the teacher opened the audio files of the students' examinations and counted the students' failure rate of the repertoire by Bayesian harmonic model analysis (there were 15 repertoire points).

(4) After obtaining the scores of the three achievements, the scores of the digital and traditional groups were counted separately.

(5) The scores of the experimental and control groups were compared horizontally, and then the scores were compared longitudinally within the experimental and control groups. The longitudinal and cross-sectional comparisons were used to determine the effect of the Bayesian harmonic model-based teaching model on students' skill acquisition.

Table 1 shows the students' scores in music performance, and the analysis shows that the overall scores of students in the three sections remain stable, with "excellent", "good" and "poor" grades. The grades did not change. It means that the use of Bayesian network technology in teaching and practice in a short period of time did not lead to significant improvement in teaching results, and the students with better foundation could still achieve good results through traditional teaching mode and their own efforts to maintain their professional level at a certain level, although they were not taught with the aid of Bayesian network technology.

However, the comparison between the experimental group and the control group revealed that the scores of the experimental group were slightly higher than the control group in the same level comparison, and the average score of the experimental group was 1.7 points higher than that of the control group in the skill demonstration. The experimental group scored 7 points higher than the control group. The experimental group 3 scored 5.8 points higher than the control group 3. The data showed that the experimental group had a certain advantage over the control group in the skill demonstration test, and their final scores were slightly higher than each other.

**Table 1**: Statistical table of professional live skills in music Performance

| Group | Number of people | Average score | Ranking |
|---|---|---|---|
| Experiment 1 group | 15 | 93.5 | 1 |
| Experiment 2 group | 15 | 89.4 | 3 |
| Experiment 3 group | 15 | 76.3 | 5 |
| Control 1 group | 15 | 91.8 | 2 |
| Control 2 group | 15 | 82.4 | 4 |
| Control 3 group | 15 | 70.5 | 6 |

Table 2 shows the data of students' ability growth assessment, and the analysis shows that the ranking of ability growth breaks the original balance, and the experimental group is higher than the control group in ability growth across the board. The experimental group scored 2.6 points higher on average in growth ability compared to the control group. The average score of the experimental group was 9.8 points higher than that of the control group. The average score of growth ability in the experimental group 3 was 6.6 points higher compared to the control group 3. It can be seen that the application of Bayesian network technology made the students in the experimental group grow in their professional skills and improve their business ability to a higher degree compared to the control group. The intra-group comparison revealed that the experimental 2 group obtained the highest score of 92.3, indicating that the students with moderate professional performance obtained the greatest ability improvement with the application of digital audio technology. The comparison of growth competency values revealed that the Bayesian network technique was effective for the practical training and self-improvement aspects of the teaching process.

**Table 2**: Ability growth assessment statistics table

| Group | Number of people | Average score | Ranking |
|---|---|---|---|
| Experiment 1 group | 15 | 83.5 | 2 |
| Experiment 2 group | 15 | 92.3 | 1 |
| Experiment 3 group | 15 | 82.7 | 3 |
| Control 1 group | 15 | 80.9 | 4 |
| Control 2 group | 15 | 82.5 | 5 |
| Control 3 group | 15 | 76.1 | 6 |

Table 3 shows the data on the failure rate of the difficult points in music. The ranking of the failure rate of the difficult points from the objective assessment was found to be exactly the same as the ranking in Table 1, indicating that the students who were originally better in the traditional teaching mode had good performance as well. The experimental group had a slightly higher level of control over the error rate compared to the control group of students. The experimental group had a 3% lower error rate compared to the control group. Experimental group 2 had an 8% lower error rate compared to control group 2. Experiment 3 group had 6% lower error rate compared to control 3 group. It can be seen that the application of Bayesian network technology enabled the students in the digital group to grow in their professional skills and improve their business ability to a greater extent than the control group. On the other hand, the experimental group had a slightly better control of performance details. The students who performed under the concert hall sound field were more familiar with the sound feedback of the concert hall sound field after the Bayesian network technology to create the simulated sound field, so the students in the experimental group played more stably and well in the same environment. This shows that the practical training of Bayesian network technology application is helpful for students to improve their performance experience and grasp the details of sound.

**Table 3**: Music Difficulty Failure Rate Statistics

| Group | Number of people | Failure rate | Ranking |
|---|---|---|---|
| Experiment 1 group | 15 | 8 | 1 |
| Experiment 2 group | 15 | 12 | 3 |
| Experiment 3 group | 15 | 25 | 5 |
| Control 1 group | 15 | 11 | 2 |
| Control 2 group | 15 | 20 | 4 |
| Control 3 group | 15 | 31 | 6 |

The data from the three score tables were integrated to obtain a comparison of the assessment results of the instructional design, as shown in Figure 5. It was found that the students who applied audio technology in their instruction showed a more significant improvement in skill improvement, accuracy of learning, and control of error rate in the short term. The students' skills improvement, learning accuracy, and error rate control also improved in the traditional teaching mode, but slightly less compared to the experimental group. It indicates that the teaching curriculum designed by Bayesian network technology has a positive impact on the improvement of teaching quality.

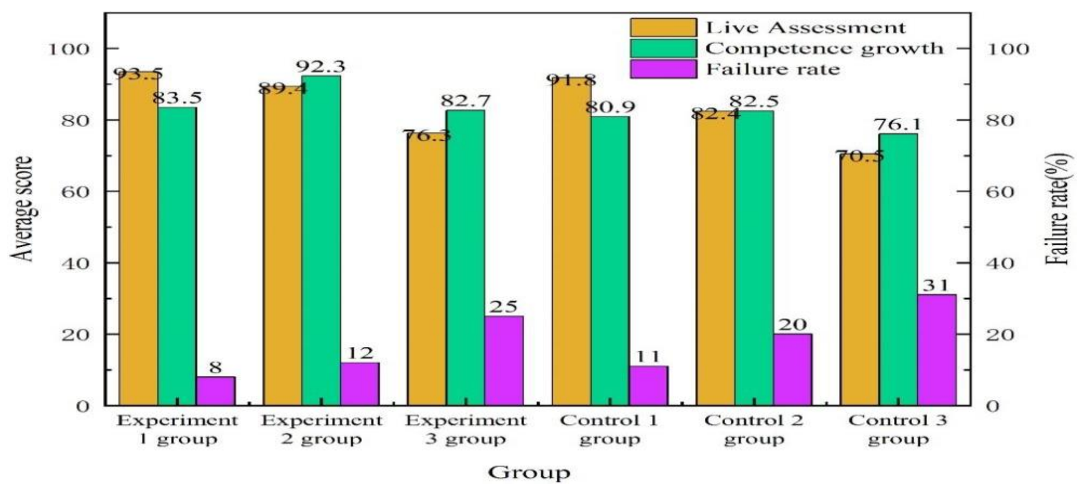


**Figure 5** Comparison chart of assessment results

In order to better analyze the impact of the teaching mode on the teaching results, the teacher also scored the students' recorded practical training of each stage of the target repertoire after each professional class, according to the technical level shown by the students in the practical training, and the fourth score was chosen as the score of the final assessment. The scores obtained were grouped together and averaged, and the results were analyzed as shown in Figure 6.

According to the graphs, the independent variable is the use of teaching methods (Bayesian network technology versus traditional teaching model) and the dependent variable is the effectiveness of teaching (change in students' professional skills). As the teaching progressed, the students' performance in the skills demonstration increased accordingly and exceeded the performance achieved in the traditional mode. This indicates that the application of Bayesian network technology has a catalytic effect on students' skills improvement.

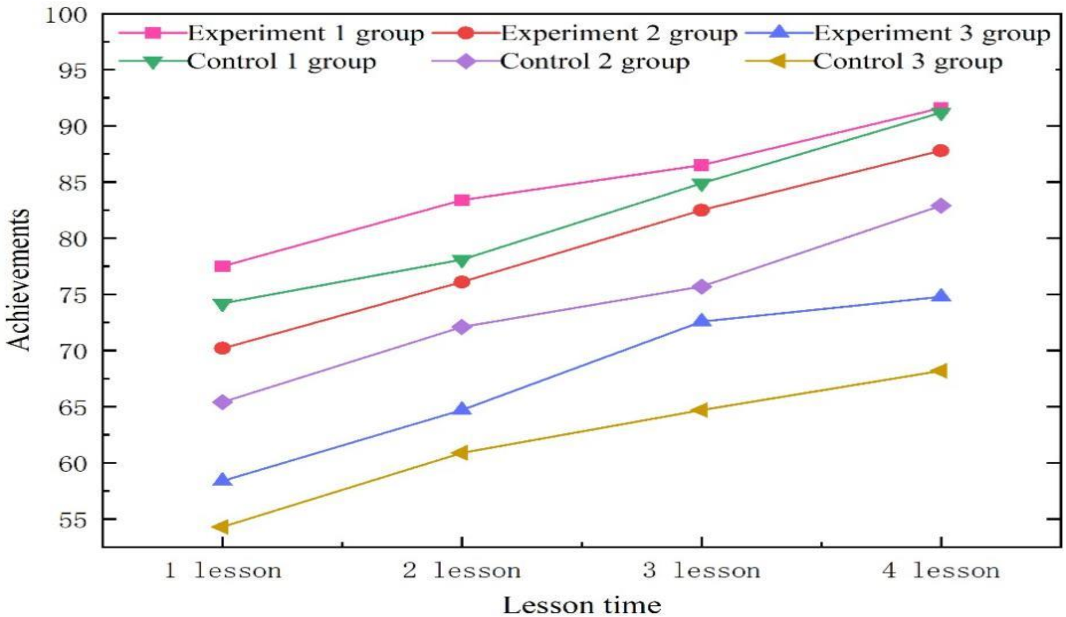


**Figure 6** Comparison chart of phased evaluation

## Conclusion

In this paper, a Bayesian harmonic model is proposed to analyze the music signal, and then the RJMCMC algorithm is applied to obtain the parameters. Based on the characteristics of the three elements of sound combined with the model's analysis of the music signal, students can quickly and accurately identify errors in learning music and make adjustments based on the correct music signal. In terms of professional skills, the scores of the experimental group using this model were slightly higher than those of the control group using the traditional teaching method, and the average score of the experimental group was 1.7 points higher than that of the control group. The experimental group scored 7 points higher than the control group. The experimental group 3 scored 5.8 points higher than the control group 3. In terms of musical ability growth, the experimental group scored 2.6 points higher on average compared to the control group growth ability. The experimental group 2 scored 9.8 points higher on average compared to the control group 2 for growth ability. The average score of growth ability in Experiment 3 group was 6.6 points higher compared to Control 3 group. This shows that the application of the study of the three elements of sound and Bayesian network technique led to the growth of the students' musical level in the experimental group.

Although the comparative data show that the application of Bayesian technology has brought some improvement to the teaching results, the new teaching model is based on the traditional teaching model and unfolds with the traditional teaching model as the core, and currently it only plays an auxiliary role in enhancing. Students end up with many uncertainties in the process of music performance, the state of singing, emotion, pitch and rhythm will have many unknown effects with the changes of objective factors such as environment, sound equipment and physical condition. Therefore, only by combining traditional teaching models, constantly trying to innovate and overcome various difficulties can we really make a qualitative leap in the teaching of music.

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