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Retraction

Retracted: Training Strategy of Music Expression in Piano Teaching and Performance by Intelligent Multimedia Technology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Zheng, T. Tian, and A. Zhang, "Training Strategy of Music Expression in Piano Teaching and Performance by Intelligent Multimedia Technology," *International Transactions on Electrical Energy Systems*, vol. 2022, Article ID 7266492, 14 pages, 2022.

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Research Article

Training Strategy of Music Expression in Piano Teaching and Performance by Intelligent Multimedia Technology

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Teaching using a multimedia technology in the 21st century affords the possibility of developing novel instructional strategies and paves the way for the all-around extension of musical educational functions. The importance of multimedia teaching technology in piano instruction has started to emerge in our country and society due to the ongoing development of this kind of technology in music educational institutions here. The conventional method of teaching piano has several drawbacks that may be mitigated by using one of the several alternative methods of instruction for the instrument, especially in light of the ongoing advancements in science and technology. A pianist's methods of expression are the tools they use to convey their thoughts and emotions about a piece of music to the audience. Teachers may demonstrate their musical skills to students and they must immediately focus on a musical expression which is vital for performers. In this paper, the Multimedia-based Piano Teaching Model (MPTM) has been proposed to improve the piano teaching quality. Traditional piano instruction is improved and developed using multimedia technology in this article. The Internet education model is used for teacher assessment, and the systematic way representing piano teaching combines different music educational materials. It begins building a sufficiently broad music network infrastructure resource sharing framework and benefits society's amateur music literacy. The use of machine learning in students' concrete piano instruction has the potential to thoroughly promote contemporary piano instruction and enhance the overall quality of instruction. To begin, an explanation of the intelligent piano's features and capabilities is provided. The neural network is used to suggest a technique for detecting a piano note on a set. The network can assess the input piano music signal's time frequency by translating the original time-domain waveform into the time-varying frequency distribution. Intelligent piano instruction analysis can effectively achieve the overall optimization of piano performance. The test results show that MPTM has a significant role in boosting the desire to learn to play the instrument. The experimental results show that the proposed MPTM achieves a learning skills ratio of 97.6%, a learning activity ratio of 98.5%, a student performance ratio of 93.8%, a teaching evaluation ratio of 90.3%, and a learning behavior ratio of 94.2% when compared to other methods.

1. Overview of Multimedia-Based Piano Teaching Model (MPTM)

The demand for piano instruction is increasing, and the number of piano instructors is increasing [1]. People's eyes are being opened to a new generation of multimedia piano instruction resources like technology and the Internet, which continue to advance [2]. Multimedia piano instruction is widely disseminated through the Internet in several methods. This rich and diversified teaching method is becoming more popular [3]. Internet-connected intelligent pianos may be used to educate online students on how to play the piano, gradually allowing them to realize its intelligence [4].

As a result of inefficient and chaotic management practices, the growth of piano teaching activities is severely hampered by the conventional manual techniques used in traditional piano education management [5]. Lessons in the traditional "teacher with piano content" method fall short of student expectations. Developing piano instruction will be more effective if multimedia technology is used [6]. Learners are provided less time to play the piano and cannot obtain sufficient practice, making it difficult for students to apply the information they have gained from their professors to actual piano playing [7]. Teachers' energy and time are limited and because they cannot identify the challenges that every student faces, it is difficult for a teacher to offer a lesson that is individualized for each student's level of proficiency [8]. In addition, because students in big classes have varying levels of competence, learning process of pupils is made more difficult by the teaching environment [9].

The use of multimedia technology in piano instruction at universities and colleges represents a significant revolution in music teaching and educational method in colleges and universities, indicating that music education has entered a new age [10]. The use of multimedia technology in college and university piano instruction helps change abstraction into concreteness, which is important for boosting students' capacity to enjoy music [11]. The use of multimedia technology in piano instruction accomplishes the union of technology and science which can realize all-dimensional high-efficiency education [12]. It helps increase the piano's attractiveness to pupils which is important for increasing students' interest [13].

Machine learning is used to analyze multimedia piano instruction performance information which offers decision assistance for teaching managers and is most important for improving multimedia piano teacher performance [14]. In the functional design of the piano teaching operating system, neural network (NN) music visualizations are a crucial contribution [15]. Students can watch their piano performances, allowing them to fully comprehend the information in the song they play. Machine learning techniques and NN representation learning are widely utilized in the age of information processing jobs [16]. For advising the student in playing practice, a music assessment system based on the NN model is determined [17].

Students' capacity to enjoy music may be improved via multimedia technologies in college and university piano instruction. MPTM emphasizes practical and deliberate difficulties that may not occur in smaller classes. A range of supervised, unsupervised, and semisupervised machine learning algorithms have attracted much interest in this domain. This study proposes a specific machine learning approach for evaluating the possible association of piano instruction. This study examined two major components of piano music learning. Machine learning methods may improve piano music courses for various learning styles and audiences. The automatic creation of lesson plans that may instruct music fans to play their favourite instruments provides access to distinct learning styles, diverse musical backgrounds, and talents. Machine learning is used in music automated recording technology to determine the implementation principle and legislation of a piano automatic recording system. Music, rhythm, and instruction may all benefit from the integration of piano music technology, which is the focus of this course.

1.1. *The Main Contribution of the Study*

(i) This study presents an evaluation technique based on the NN model for students' playing practice.

(ii) Piano instructors and students worked together to develop an assessment index for the neural networks used in this model.

(iii) The NN's training has been completed and the piano teaching procedure has been verified using piano performance data.

The overall organization is as follows: Section 1 discusses the introduction of piano teaching, Section 2 deliberates the related works, Section 3 explores the proposed MPTM with machine learning techniques, Section 4 explores the results and discussion, and Section 5 demonstrates the conclusion of the paper.

2. Related Works

JAVA-based Piano Teaching Management System (JAVA-PTMS) for analysis of the status quo and problems of piano teaching informatization was described by Nie [18]. By analyzing the current reasonably mature technological framework and programming language, this study chose to implement a *B*/*S* system architecture and an SSH framework for the major body of the system. JAVA was used to build and construct the system based on the structural design idea. There has been a successful implementation of the finished piano instruction administration system. As a result, the school's limited piano teaching resources cannot fulfil the growing demand from students with such inadequate piano foundations, distinct understandings, and preferences for the piano. The findings of the experiments reveal that a more stable system has a quicker reaction time.

Digital Piano Training System based on Technological Pedagogical Content Knowledge (TPACK) for analyzing preschool students' piano performance was discussed by Changhan et al. [19]. 30 of the university's preschool students were randomly chosen and offered a one-month trial of the Digital Piano Training System (DPTS) technology at a public institution in Northeast China, which provides digital piano lessons and has 360 students enrolled. Therefore, it was established and validated that the DPTS has been the most effective piano teaching instrument for preschool pupils. As a consequence, institutions should consider using DPTS as one of their piano teaching methods.

Blended Piano Teaching Model (BPTM) for students at the University of Hunan City who are not majoring in Filipino music should take this course deliberated by Zhu [20]. Regarding sight-reading, scales and arpeggios, etudes and piano pieces, the experimental group utilizing the BPTM model outperformed the control group statistically. It was inferred and proven that the BPTM was an effective teaching instrument in piano instruction for nonpiano majors.

Piano Teaching Strategy (PTS) for teaching organic concepts was expressed by Yonathan [21]. In-depth interviews with students and participant observation were the main modalities of data gathering. Setting objectives, modelling, listening, visualization, breakdown of the musical structure, and subdivision assistance are among Arens' teaching tactics. Arens teaches that procedures and creative interpretation are the same rather than taught separately which is a huge difference.

The Internet with Piano Intelligent Network Teaching System Model (IPINTSM) for using Internet technology was explored by Shuo [22]. The acoustic and multinote models of the HMM with many tones were created with the aid of the Internet. An IPINTSM is created after determining the match between the testing audio and the multinote models. The most accurate multinote identification rate was found when the multistate recognition system included seven states. When the IPINTSM multinote recognition state is 7, the IPINTSM has generated fresh inspiration that is more accurate.

Students' perspectives on distance piano education were qualitatively analyzed by Ünlü [23]. The research explores how university students who get piano instruction through distance education are influenced favorably or adversely. Qualitative research was conducted utilizing the phenomenological design technique to achieve the results. The study's findings indicated that students did not find piano lessons through distance learning advantageous in general and that students' overall performance suffered as a consequence.

Microlecture Flipped Classroom Piano Teaching Model (MFCPTM) for analysis of piano teaching mood was initialized by Fu [24]. This essay delves deeply into the theory of the microlecture flipped classroom and explores the benefits of incorporating it into the practice of piano instruction. The excellent method of MFCPTM to optimize piano teaching in the microclass flipped classroom can benefit colleges and institutions and provide a useful reference for strengthening the piano teaching in the micro-class flipped classroom in colleges and universities.

Linna et al. [25] expressed the Wireless Network in Piano Music Teaching based on artificial intelligence. Artificial intelligence (AI) advancement offers a new path for the old educational approach. In the opinion of piano majors, a smart piano benefits novices and those with limited piano skills. On the other hand, high-level students will not benefit from smart pianos. Teachers should use various techniques to meet students' needs at various skill levels in the classroom. Finally, based on the existing state of the smart piano, countermeasures and proposals for the future development of the smart piano in piano music instruction are proposed.

Based on the analysis of existing methods, piano teaching needs to be improved more effectively. The proposed method, MPTM, utilizes the neural network to analyze the student's performance and predicts the teaching quality to deliver the desired outcome.

3. Multimedia-Based Piano Teaching Model (MPTM)

With the advent of multimedia network teaching as a contemporary teaching mode, new educational techniques may be developed and educational functions can be expanded in all directions. With piano education and performance, complicated networks and multimedia technology have been studied extensively. This article aims to identify, examine, investigate, and assess current piano training techniques to maintain only those that comply with contemporary theories of learning, educational standards, and the distinctive qualities of the piano discipline. Before introducing various network training instances for piano instructors to use and investigate, the pros and disadvantages are considered. Switching to a more student-centred teaching style will improve the initial single-class teaching method. The innovative teaching approach allows students to learn the piano at their speed via multimedia and network technology. In this study, the course material is digitized and represented using machine learning algorithms, and the systems that allow access and availability of the produced content are maintained using the NN and machine learning technologies with or without Internet assistance. When these two technologies are used with piano instruction, higher music education on machine learning may be more effective.

Offline instruction is face-to-face piano teaching in a smart classroom shown in Figure 1. Online teaching complements offline teaching using microlecture videos, distant education, and smart partner training technologies. Eyestrain is likely to develop when there is a significant contrast in brightness between the musical notation and the surroundings, such as when the instrumental music is darker and the environments are light (similar to using a smartphone in the dark). A piano light such as the LED piano light is required to correctly illuminate the sheet music and the piano keys. Light Emitted Diode (LED) indications in the piano game mode motivate kids to practice. Students may study music in a pleasant and joyful setting, increasing their sensitivity to music and enthusiasm for learning and making piano instruction dull. With the introduction of piano teaching apps, the intelligent piano may be linked to the app software through smart devices to enable human-piano interaction. The Garage Band application program may create music without requiring professional Musical Instrument Digital Interface (MIDI) equipment, giving music enthusiasts more options. Synthesizers, samplers, and computers all can interact with one another via the use of MIDI signals. MIDI is a method for connecting devices that generate and control music. The MIDI controller or keyboard can also imitate a violin, flute, bagpipe, or any other instrument for which samples can be found. Familiarity with the controls will have a pleasant manner of playing them into the music. Built-in systems of intelligent pianos and network piano classrooms provide recorded or live video instruction courses. Teachers and students may communicate through network voice and video. Teachers and students interact via example, dialogue, and visuals.

Smart pianos give scores to students based on their pitch, rhythm, and strength. Each student understands their learning circumstances and inadequacies. Student assessment is three-staged. First, first-time intelligent piano users must examine their piano-learning level, interest, and future aspirations. Students without a piano basis should start with

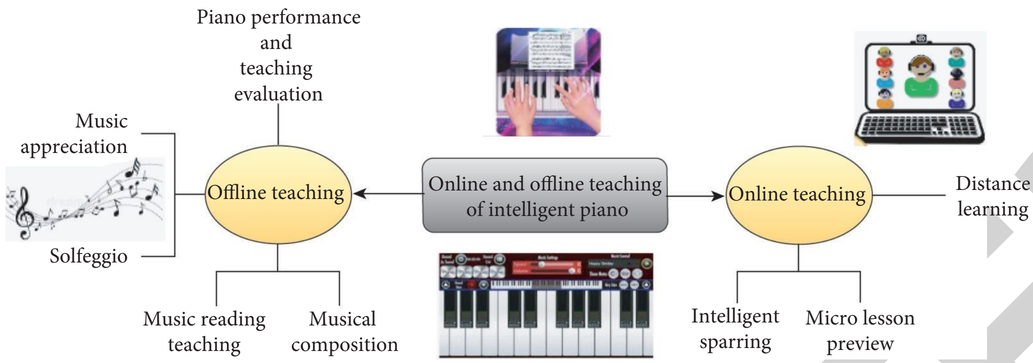

Figure 1: Hybrid teaching of offline and online piano teaching model.

the basics, while those with a foundation may pick the test's difficulty level. Second, the repertoire's song, rhythm, and power are rated. Third, students' results determine a learning plan for their present level. Smart piano assessment helps instructors train students according to their potential. Elementary learners benefit from one-to-many group education, whereas high-level learners prefer one-on-one. In each step of student learning, sensible assessments of their learning circumstances may drive learning passion via group competition. The smart assessment module may convey kids' music and class successes to parents through the network so they can monitor their students' development. Students may also self-evaluate and evaluate based on instructor feedback. Teachers may master students' learning and make modifications and innovations based on their suggestions.

Simulating real neurons is a complex task that takes more than mere easiness; it demands an understanding of the fundamental properties of biological neurons. As with real neurons, the "connection strength" of an artificial neuron may be determined by the weighted total of the input signals from other neural connections, each of which represents a possible output, and this sum defines the neuron's active state. The $Z_1, Z_2, \ldots, Z_m$ coupling weighting matrices correlate to the $y_1, y_2, \ldots, y_m$ feature vectors, which comprise the M inputs. Neurons are depicted by input and connection vectors Z and Y, respectively, which show the cumulative influence of the input signal on the neuron's output.

$$\text{snet} = \sum_{j=1}^{m} y_j z_j. \tag{1}$$

As found in equation (1) neuron input signal has been described. After receiving input from the network neurons should provide the desired results. Whenever the cumulative effect of its input signals hits this threshold, each neuron is in an excitation state. In this suppression state, the neuron does not respond to the input signal. $E(y)$: out Enet represents the transfer function for artificial neurons, and R the output of neurons. Linear, nonlinear ramp, step, and t-type transfer functions are all examples of typical governing equations, as shown in the following equations:

$$E(y) = ly,$$

$$E(y) = \sigma, k, \quad \text{when}\, y \geq \theta, \tag{2a}$$

$$E(y) = \sigma y, \quad \text{when}\, y - \theta < y < \theta,$$

$$\begin{aligned} E(y) &= -\sigma, k, \quad \text{when}\, y y \leq \theta, \\ E(y) &= \sigma, \quad \text{when}\, y \geq \theta, \end{aligned} \tag{2b}$$

$$E(y) = \phi, \quad \text{when } y \geq \theta, \tag{2c}$$

$$E(y) = \alpha + \frac{a}{1 + \exp(-\mathrm{d}y)}. \tag{2d}$$

As discussed in equations (2a), (2b), (2c), and (2d), transfer functions have been deliberated. Equation (2a) denotes the linear function, (2b) shows the nonlinear slope function, (2c) shows the step function, and (2d) represents the t-type function, where σ is a transfer function variable, θ is an angle, a is a transfer function variable, ϕ is a step function coefficient, and l is a slope function variable. A network's effectiveness might be severely affected by transfer functions that exponentially increase network input; hence, the selection of transfer functions for various application areas of the NN model is crucial. A lot of people are using the new feature. In general, the hidden layer employs a t-shaped function, and the output layer utilizes a linear one.

Let us assume that the neural network has m nodes in the input layer, that the hidden layer has p nodes, that the output layer has m nodes, and that there is a weighted correlation between the weights of U_{jl} and Z_{jl} between the input and hidden layers. Its transfer functions are $E_1(y)$ and $E_2(y)$, and the output of the node that is on the buried layer is represented in $E_1(y)$.

$$W_l = E_1\left(\sum_{j=0}^{m} U_{\mathrm{jl}} y_j\right). \tag{3}$$

As shown in equation (3) hidden layer node has been demonstrated. The output layer node's outcome is represented by the following expression:

$$x_j = E_2\left(\sum_{j=0}^{m} Z_{jl} W_l\right). \quad (4)$$

In equation (4), output layer node outcome is calculated for teaching evaluation ratio, as well as student performance. The rhythm quality is extracted from the music score bar by bar, using each musical section. Each performance segment may be precisely pinpointed using the score split into music subsections. The current bar's rhythm and beat may be determined based on the performance time's placement. It is the relationship between the length of a given note, also known as the time point, and the duration of the pronouncing of each note; as shown in the picture, its scoring with four quarters sounds as one measure. By isolating the tempo from the current bar, rhythm will be able to evaluate the player's capacity to keep up with a moderate beat. Note the times at which the player depresses and releases each of the four notations while maintaining alignment with the first note played at the beginning of each bar. Following notes are dependent on how long the preceding note has been spoken, according to the rhythm's qualities. As previously stated, subsequent notes would have mistakes if the prior note was improperly handled. Various weights must be given to different notes to assess the level of rhythm mastery. To determine how well the rhythm of this portion of music is understood, divide the standard value by the pronunciation point for each note and multiply the result by the weight of that note.

$$E(y) = \sum\left|\left(T_j - A_j\right)\right| + \sum P_j\left|\left(F_j - C_j\right)\right|P_j. \quad (5)$$

As obtained in equation (5), rhythm music has been determined. This measure's note sequence number is j. The number of notes in this measure time the player pushes releases a key t and standard release time is all included in this measure's notes list; C is the usual release time and P is the amount of weight that corresponds to the different notes. For each measure, the note volume is quantified and recorded. In terms of rhythm, the first note of each bar is critical. The beat characteristic of this bar may be extracted using the same procedure and various weights for different notes as shown by the following:

$$E(y) = \sum\left|\left(B_j - A_j\right)\right|P_j. \quad (6)$$

Beat feature function is given in equation (6). These variables are note count j, note volume (B), bar length (A), weighted value (P), and chord volume (A) with j being the number of notes in each bar.

The structure of CiP is shown in Figure 2. The "Coloring-in Piano" (CiP) is a novel musical instrument in which traditional pianos do not require their players to reproduce the melody line meticulously. Using CiP enables them to focus directly on the musical expression crucial for the performers, allowing the instructor to demonstrate their musical understanding to the student. There are a series of trials to compare the performance of Coloring-in Piano with that of a regular piano. It is clear from these findings that a pianist using CiP can play just as well as one using a traditional piano.

Furthermore, we found that CiP may help the instructor execute even an unprepared piece to their delight. As a result, they are free to focus their full attention on musically expressing themselves. This output information is being recorded by the piano that is attached. Before beginning to play it is important to input into the computer the sequence of pitches that will be used in the composition that will be played. The MIDI note numbers are what are used to specify the pitches. During the performance, the computer will replace the note numbers that were fed into it with the note numbers that are being played.

At last, the computer will output the note numbers that have been replaced and then feed those numbers into the tone generator. In light of this, the CiP can always output sound at the correct pitch, even if the performer touches the wrong keys. At this time, CiP is capable of handling monophony. CiP will not react to any key-down events within the first fifty milliseconds after a previous key-down event. This is done to account for accidental touches.

On the other hand, note-on velocity (when the key is pressed down), note-off velocity (when the key is pressed up), and pedal messages are generated while the player performs. The different parts of the instructor's musical knowledge are represented in the same way the instructor conveys them. This is the first system developed to learn and predict polyphonic expression in piano music with various performing styles. Polyhymnia can generate expressive polyphonic piano performances using music scores, so that it may be utilized as a computer-based tool for expressive performance. Polyhymnia can completely computerize an expressive performance on the piano. The fundamental structure of an expressive performance may be deduced from musical symbols, and these symbols themselves can be interpreted in several different ways. Polyhymnia is an automated piano performance system that can learn and anticipate polyphonic expressiveness and interpret musical symbols mechanically. According to the results of experiments involving produced performances, the system produced performances with polyphonic expressiveness and dynamic sound, and human listeners could discern between the various performance styles. Machine-rendered piano performance might benefit by modelling the hierarchical structures of a specific composition. Interactive performance may be achieved by extending Polyhymnia model parameters via an interface. The use of adaptable parametric models for their automated interpretation is advocated. Since piano music is often polyphonic, emotive piano performances must include polyphonic characteristics. This study refers to musical expression with such characteristics as polyphonic expression. The suggested statistical modelling of polyphony piano renditions demonstrated that performance produced with polyphonic expression looked better than presentations without it. This has been accomplished by demonstrating that polyphonic expression can be modelled statistically. The results of experiments conducted on performances created by Polyhymnia using a variety of compositions suggest that they had polyphonic expressiveness and sounded expressive. The majority of these systems focus on discussing different interpretations of

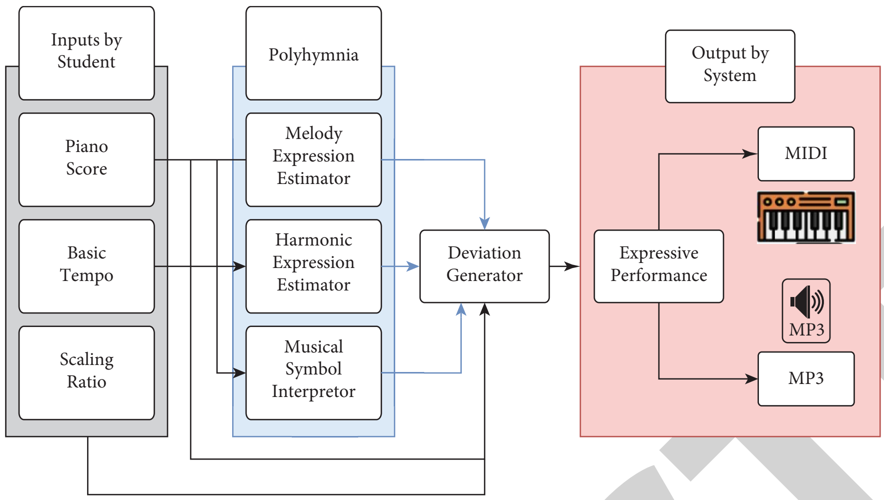

Figure 2: Tune generating.

monophonic tunes. Still, polyphonic interpretations have received less attention owing to the computational complexity and enormous quantity of required data.

There is little discussion over the automated interpretation of musical symbols based on extremely basic principles, since they enter a MIDI-like score. A music expressive performance may be provided by certain commercial notation software. It is not known how they likely come up with musical expressions that they use basic criteria to understand musical signals. Polyhymnia users must enter a piano score in MusicXML format to get an expression piano performance. MusicXML, unlike MIDI, can digitally encode almost all musical symbols. A mathematical model is used to analyze encoded musical signals and create a variety of possible interpretations for each symbol. Conditional Random Fields (CRFs) are used to teach and produce polyphonic expressiveness for polyphonic piano renditions. Scaling ratios influence the expressiveness of the resulting music. In addition to MIDI and MP3 files, the system enables expressive performances.

To determine gap value using the performance data in Musical Instrument Digital Interface (MIDI) format, the interonset interval (IOI) may be calculated as follows:

$$\mathrm{IoI}_j = S_{\mathrm{non}\,(j+1)} - S_{\mathrm{non}\,(j)}. \quad (7)$$

As described in equation (7), IOI has been deliberated, where IoI_j refers to the j-th information output indicator, $S_{\mathrm{non}\,(j)}$ refers to the emitted time of the j-th note-on message $S_{\mathrm{non}\,(j)}$, and $S_{\mathrm{non}\,(j+1)}$ refers to the emitted time of the $(j+1)$-th note-on message non$(j+1)$. The value of the gap may be found by doing the following:

$$\mathrm{gap}_j = S_{\mathrm{non}\,(j+1)} - S_{\mathrm{noff}\,(j)}. \quad (8)$$

As found in equation (8) gap value has been identified, where $S_{\mathrm{noff}\,(j)}$ is the note-off message's emission time and $S_{\mathrm{non}\,(j+1)}$ is the $(j+1)$ note-on message's emission time having $\mathrm{gap}_j = S_{\mathrm{non}\,(j+1)} - S_{\mathrm{noff}\,(j)}$. As a result, if the j-th note has a positive gap performer has shortened it. In addition, the MIDI note-on message's velocity data are retrieved. The speed at which a note-on message descends a key is almost identical to the note's volume.

The piano's control flow diagram shows a subtemplate for control in Figure 3. There are three distinct sorts of piano playing: the piano itself, the piano's white key, and the piano's black key. The piano type is responsible for managing all aspects of piano performance, including the instrument's startup, playing, and sound. The piano white key and the piano black key may be used as a single white or black piano key, respectively. The piano-playing module, the pianist audio processing module, and the piano screen and controller make up the piano teaching system. Figure 3 depicts how the system's piano display and control module completes its tasks. The process begins with the activation of the virtual piano and then moves on to the initialization of the piano's variables, the showcase of the piano interaction, and finally the tracking of the piano audio input operations. The piano interface will be redisplayed once the operation is processed and detected while using the piano interface.

Following the activation and initialization of the analogue piano, the piano disk interface will be shown and playing will be observed. After the detection of playing actions variety of playing events will be handled to bring about an update to the piano's user interface that will show the final effects. The piano audio processor module is responsible for simulating the sound of a piano and improving such a sound. Applying certain treatments to the sound will become richer and more pleasant, significantly increasing the auditory experience that the instructor and the students have. The addition of a module that generates a soft sound source will contribute to the production of a better voice effect.

An observation of understanding has been made and is particularly true when compared to an investigator to aid comprehension. A central location provides a great position; a disadvantageous location offers an important comparison point. After learning about scribe searches learner adopts a new point of view on the world and records that perspective in the dataset $\sin(\gamma) = n_1/n_j$ and $\sin(\beta) = n_2/n_j$.

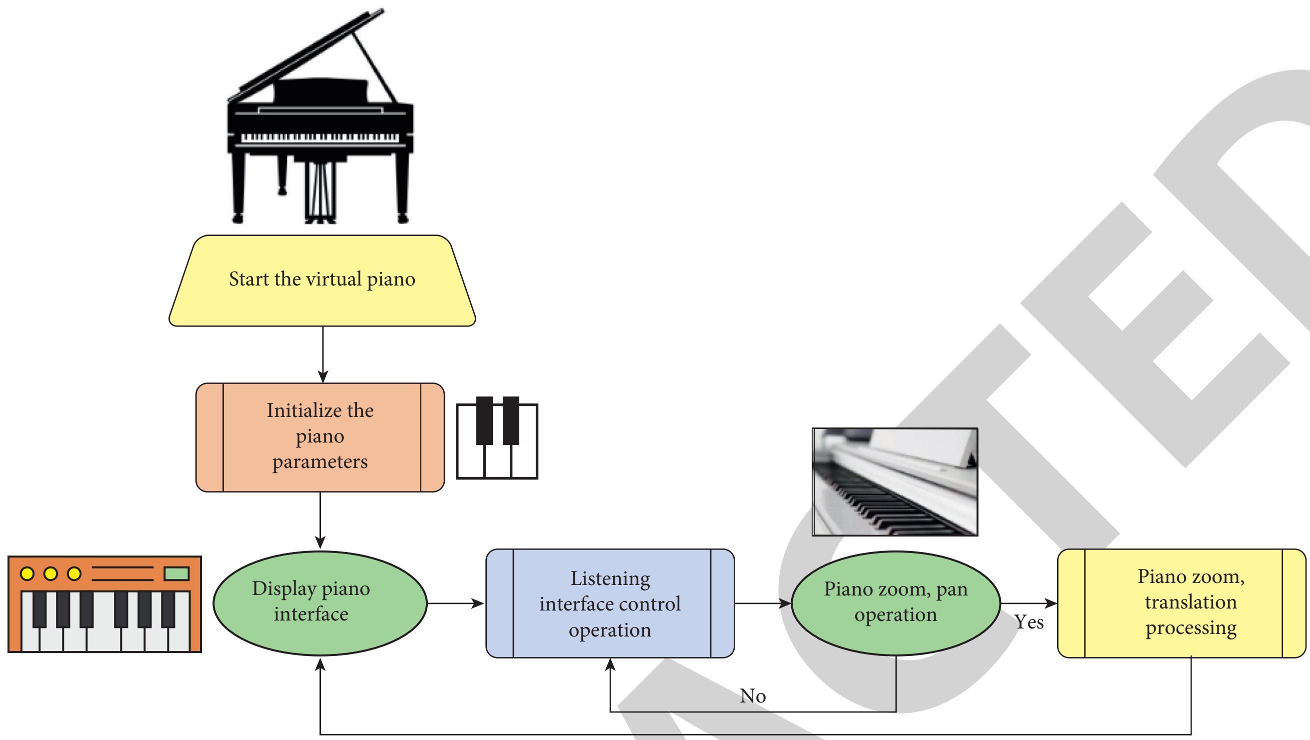

Figure 3: Piano control flow chart for controlling subtemplates.

Remove g from equation (9) to get the most basic knowledge of the item in the central library.

$$g_j = \sum_{j=1} \sin(\gamma) = \frac{n_1}{n_j} + \sum_{j=1} \sin(\gamma) = \frac{n_2}{n_j}. \tag{9}$$

As demonstrated in equation (9) central library has been described. A survey questionnaire, developed, integrated, and scored after the discovery of the teaching materials, will investigate the impact of distant location music piano education on machine learning and networked instructional methods on the unique educational capabilities of learners. Objectivity, efficiency, and quantifiable n_j/V_j analysis are all advantages of this approach. It is a common way to gauge a person's capacity for self-directed learning, as an alternative to specific learning activities, such as

$$\text{Learning activity} = \int_{j=1}^{m} n_j V_j \sin(\gamma). \tag{10}$$

As obtained in equation (10) learning activity has been discussed. Piano music learning $\sin(\theta)$ is a way of teaching $n(\gamma - \sigma)$ which includes an educational system to recognize the unjustified progression of $\sin\gamma$ to σ such a new economy that has finally lost its key function in continuous learning as proven by

$$\begin{aligned} \sin(\theta) &= \sum \sin(\gamma - \sigma) \\ &= \sin\gamma \sin\sigma + \tan\gamma \tan\sigma \\ &= \frac{n_1}{n_j}\frac{V_1}{V_j} + \frac{n_2}{n_j}\frac{V_2}{V_j} = \frac{n_1 V_1 + n_2 V_2}{nv}. \end{aligned} \tag{11}$$

As deliberated in equation (11) key function has been demonstrated. When deciding how to implement remote music education, the goal is to teach participants in an organized and simplified manner to integrate knowledgeable predefined attitudes and morality adapted for specific thoughts and actions. This goal $n_1 V_1 + n_2 V_2/nv$ is achieved by machine learning teaching techniques.

$$\begin{aligned} \text{Learning Behavior} &= \sum_{j}^{n} n_j V_j \frac{n_1 V_1 + n_2 V_2}{n_j V_j}, \\ &= \sum n_1 V_1 + n_2 V_2. \end{aligned} \tag{12}$$

As initialized in equation (12), learning behavior has been calculated. This belief is shared by educators who feel that learning $\sum_j^n n_j V_j$ is more than simply a means to an end.

$$\text{Learning skills Rate} = \sum_{j}^{n} n_j V_j + \frac{n_1 V_1 + n_2 V_2}{n_j V_j}. \tag{13}$$

As expressed in equation (13) learning skills rate has been formulated. Learning skills $|N(m)|$ such as notoriety, recognition, the capacity to grasp, and encouragement may be used by students to increase their skill set.

$$|N(m)| = \sum_{j} \text{observing}|n(N(m))| + \sum_{j}^{n} n_j V_j. \tag{14}$$

As shown in equation (14), to achieve the primary goal of piano music education based on machine learning and 5G network expansion, a socialist and optimization strategy must be underscored to break free of organizational limitations and identify an effective structure for the delivery of the indispensable university degree.

See Figure 4 for multimedia intelligent piano teaching system. Here, we provide a system for intelligently teaching piano using the multimedia with teaching system, which includes a system for teachers, one for students, and one for back-end administration (Figure 4). To assist students in improving their musical knowledge and their ability to play chords, piano teachers use clever methods of instruction. Instructors must devise instructional strategies that use students' strong sense of wonder, curiosity, and inventiveness to keep their students engaged and motivated to learn. Teachers may play an imported animation of piano lessons on the smart piano classroom's screen using the system's teaching feature as a second option. As a result, students can make notations on a smart music score shown through multimedia by their instructor. The instructor shows how to play a chord and teaches the proper technique. A standard performance video is also entered into the system so students can view it repeatedly after class. In addition, teachers must show and explain the fingering animation video and the associated knowledge points. The instructor checks whether each child's hand form and chord are correct throughout the playing process and encourages fingering. Sensible piano instruction may improve students' passion for piano practice and their capacity to study independently. Using their accounts in the intelligent piano application, students may log in and practice at their own pace under the guidance of their parents in the intelligent piano class.

By employing data acquired via research, an evaluation aims to enhance scientific methods and researcher decision-making. Edge-commuting can enhance this assessment. Data analysis will be more efficient as a result of the edge-enabled approach. The assessment information facts do not come into action by themselves. Proper processing of assessment data and feedback is required. The feedback assessment information plays a vital part in making the evaluation process successful and feasible. The development of multimedia-assisted piano education is a complicated and organized undertaking strongly tied to the relevant theoretical research, technical advancement, and teaching practice. Many factors influence its usefulness as a teaching tool, including the quantity and quality of information literacy teachers and students, as well as access to teaching support platforms. The MPTM team is now in the process of determining the best ways to teach students.

When designing multimedia-assisted piano instruction, employing massive machine learning technologies to study the factors that influence the effectiveness is a good place to start. The acquisition of useful knowledge is of the utmost importance to enhance the standard of multimedia instruction, with responses to questions concerning the evaluation, analysis, and prompt alteration of instructional methods. In today's information society, the swiftness with which feedback can be provided and the efficacy with which information can be transmitted both speed up the process of social evolution. During the assessment process, it is important to factor in the potential benefits of adopting data communications technology for data processing and the transmission of information. With machine learning, a method in which the processing unit is supplied with the network edges, the efficiency of the computer processing may be improved. The information must first be sorted and evaluated to determine how the data are distributed. Multimedia-assisted piano teaching and classroom management can be improved by using data characteristics, rules, and connection structure at the edges. According to the information provided by the evaluation feedback, it is necessary to find timely solutions to the various issues that have arisen in the teaching, further optimize the different aspects of multimedia-assisted piano teaching and give full play to the obvious benefits of multi-coal-assisted piano teaching, and establish the underpinnings for increasing the quality of piano instruction. Information literacy for educators and the promotion of educators' personal growth and development by teaching the piano with the assistance of multimedia combine the benefits of both conventional teaching and multimedia teaching and play a significant role in enhancing the quality of instruction. However, at the same time, more stringent standards should be put up about the qualifications and skills of instructors participating in multimedia piano instruction. With the assistance of edge computing priority to offer educators helpful information throughout evaluating students, this may be done via the evaluation system's orientation, diagnosis, and quick feedback. Analyzing assessment data, it is possible to identify instructors' obstacles and inadequacies in multimedia piano education. To assist teachers in enhancing their knowledge of multimedia information, emerging technology, and capacity for classroom integration to foster both the self-improvement and improved performance of piano players, Figure 5 displays the assessment index for the multimedia-assisted piano instruction approach.

The use of multimedia education as an additional tool for piano instruction has revolutionized and reshaped the way students learn the fundamentals of piano instruction. It may help students learn the fundamentals of piano theory and play more quickly and efficiently. An autonomous piano performance system should handle various unidentified piano compositions. There was evidence of polyphonic expressiveness and expressive sound in the performances made by Polyhymnia using diverse compositions. A piano piece may be played in a variety of different ways. It is possible to create a wide range of models by practicing various performance styles. Polyhymnia's experimental findings on various performances show that each trained model reflects the performance style in the training set. Taking piano solo lessons may be arranged to be one-on-one or in a group setting to integrate smart piano technology with more conventional piano instruction methods. As an experiment, a teacher and an intelligent piano may work together to collect data for six weeks to evaluate how well the class is progressing and the overall quality of the material taught. Lessons on the intelligent piano will be taught in groups during the first and second weeks, lessons on the intelligent piano will be taught to students individually during the third and fourth weeks, and lessons on the

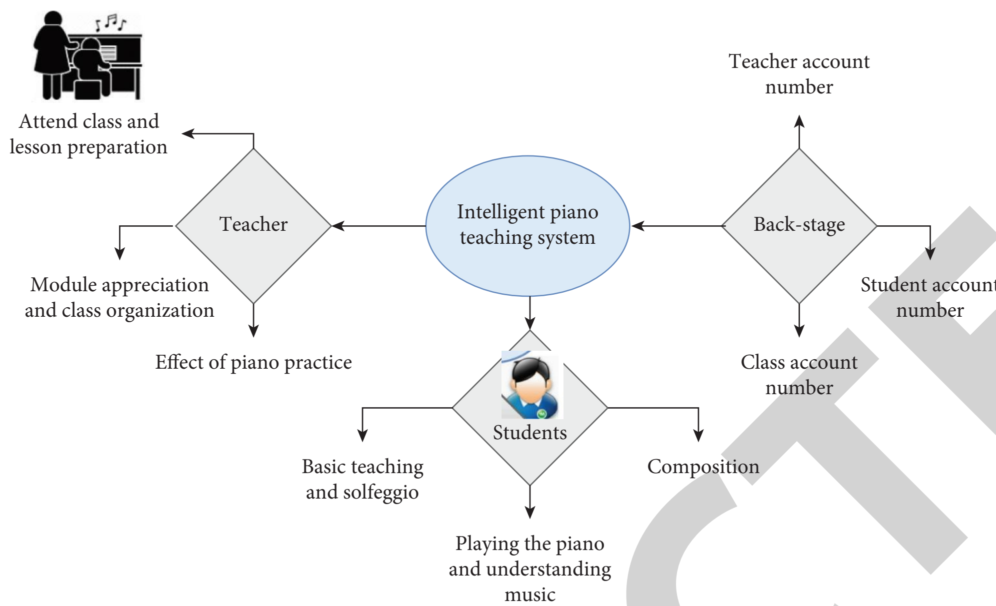

Figure 4: Piano display control subtemplate.

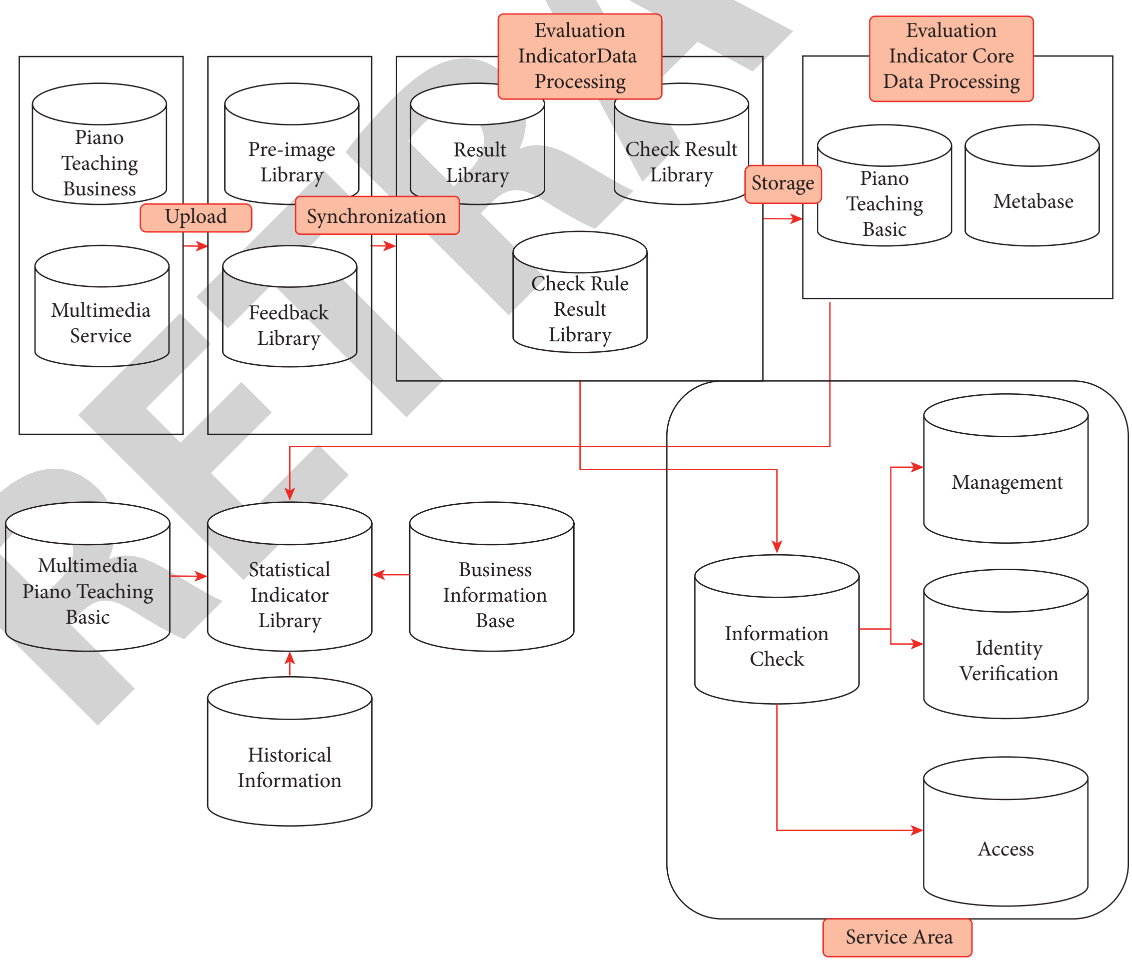

Figure 5: MPTM-based teaching evaluation.

traditional piano will be taught to students individually during the fifth and sixth weeks. The foundation is the regular stepwise and complementing instruction throughout the teaching process. The benefits of this new unified teaching approach will be reflected in the final evaluation of students' degrees of completion, which will be determined by combining the conclusions formed from the feedback from students weekly. Figure 6 depicts the intelligent piano lesson encounter process in which the students participate during the specific trial.

The performances of various piano compositions with different trained models showed polyphonic expressiveness and sounded expressive, according to experimental data. It was shown that human listeners could tell the difference between the models trained in different performance styles and the models taught in the same style.

4. Numerical Analysis

Analysis of the real dataset demonstrates that the suggested approach is feasible and effective. According to our findings, the potential usefulness of multimedia-aided piano instruction assessment data is by employing the degree of impact as the measure of association rules. According to the findings, it is out of the question to utilize the degree of impact as an association rule metric to uncover the potential use of multimedia piano instruction assessment data. Musicians now have a computer-based tool for crafting expressive, polyphonic piano performances to Polyhymnia, our automated piano performance system. Piano music may be created using digital symbol translations and simulation approaches of intellectual framework that account for polyphonic qualities. According to experiments, performances of different piano compositions with various training images showed polyphonic expressiveness and sounded expressive. To make things more interesting, the models were trained in different performance styles and were well distinguished by trained listeners.

4.1. Dataset 1 Description. When developing a Digital Signal Processing (DSP) project for a Virtual Studio Technology (VST) plug-in, we realized the advantages of digital technology in music teaching. The plan was to employ AI/ML to develop a product. 432 Wav files of piano triads over six octaves are included in this collection. A wave file represents the 12 major, minor, and diminished triad chords in its root and first inversion. 32 bits, 44 kHz mono, about 520 K size, and 3-second duration are the sample formats. Around 200 MB is the overall size of the wave files. Trios.csv is the CSV file containing the chords' names, octaves, and inversions. The notes that make up each chord are also included. Two underscore characters separate the chord names into four sections. Lowercase "*s*" indicates sharp notes and chords in musical notation. To denote flat notes or chords, *b* is used in lower case.

This document contains a list of chord placements and chords. It is organized into four columns: Chord, Note1, Note2, and Note3. A string that includes the name of the chord, whether it is sharp or flat, whether it is major or minor, and its location on the keyboard may be found in the Chord column of the table. The additional column labelled "Note" contains the individual notes that make up the triad, arranged in increasing order (https://www.kaggle.com/datasets/davidbroberts/piano-triads-wavset).

The number of students is on the *x*-axis and *y*-axis includes learning activity, learning behavior, learning skills, student performance, and teaching evaluation analysis based on comparative analysis of JAVA-PTMS [18], BPTM [20], PTS [21], and IPINTSM [22] with our proposed method MPTM.

4.1.1. Learning Skills Analysis (%). Students who get their piano instruction through multimedia have more opportunities to practice independently while following the teacher's explanations, enhancing their learning efficiency. Learning to play the piano aids in the development of previously undeveloped neural connections between the hands and the brain. Playing this instrument requires strong, flexible hands that can perform of their own will. Studying to play the first scale or chord on the piano is a crucial part of learning music theory. With one-on-one teaching, a teacher has the luxury of extra time to construct a lesson plan specific to each student's needs and abilities at the piano. Teachers may adjust their lesson plans depending on the progress and results of their students in real time. Figure 7 shows the learning skills ratio (%) based on the dataset.

As expressed in equation (13) learning skills rate has been formulated. The advancement of the educators' music playing skills will, in turn, enhance their capacity to recognize elegance, leading to a virtuous cycle that will encourage the students' piano learning. The improved performance of the educators' ability to enjoy beauty can drive the learners to build their playing skills.

4.1.2. Learning Activity Ratio (%). Individual instruction is widespread in the activities of college piano teaching. Most individual teachings need the students and the instructors to finish the instruction in a generally closed-off setting. Renouncing the space limitations of the traditional teaching model teaching activities and multimedia technology can help students understand the piano theory and practice ability. This is helpful for students to practice pertinence during the practice. All-dimensional audio-video impact may be used to increase students' emotional and knowledge experiences in the music classroom. Teaching in a more interactive approach like this necessitates that instructors begin with the facts and look forward to exploring new ideas. The use of multimedia technology does not make it simpler for students to locate a wide variety of high-quality resources and educational materials about the piano enhance the students' capacity for independent study. Figure 8 elaborates on the dataset's learning activity ratio (%) [26].

As obtained in equation (10) learning activity has been discussed. This paper presents the fundamental methodology of conventional piano instruction and investigates the use of multimedia technologies in the context of piano

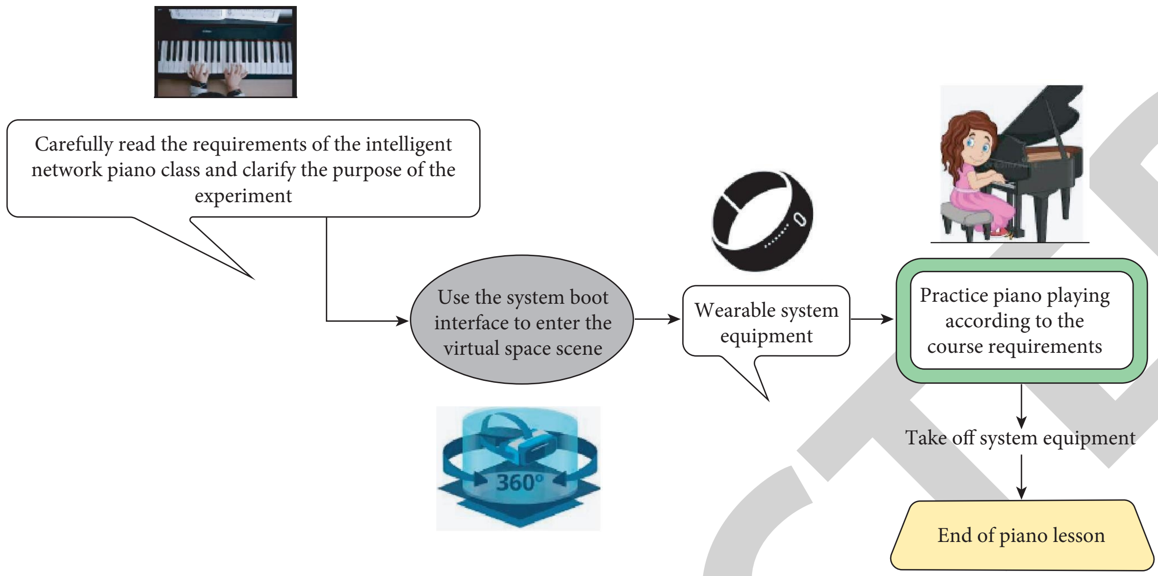

Figure 6: Student piano lesson for student learning performance analysis.

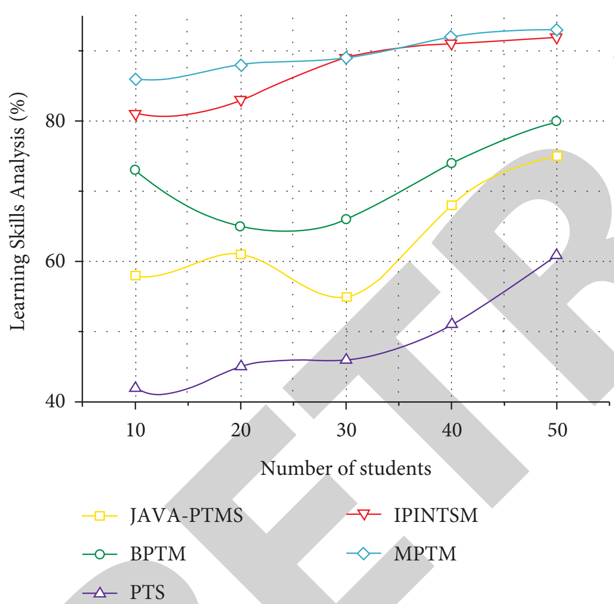

Figure 7: Learning skills analysis ratio (%).

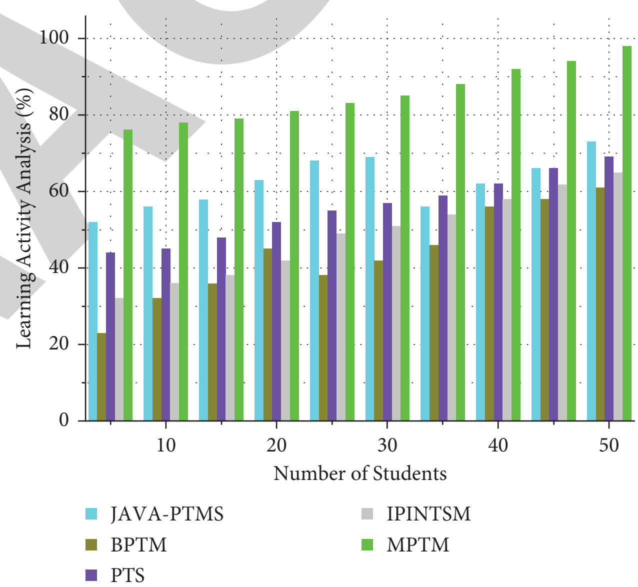

Figure 8: Learning activity ratio (%).

instruction. This article presents a design for integrating multimedia technologies into piano instruction. In conclusion, the research discusses the advancements that have been made in the field of multimedia piano instruction and expresses the hope that circumstances may be established to facilitate the seamless integration of multimedia technology and the activities involved in piano instruction.

4.1.3. Learning Behavior Analysis (%). Neural networks are widely used in piano playing and education. A neural network-based recommendation model is the focus of this study, which focuses on piano performance and training systems that are based on music content and user history. To build a user preference feature model, students often utilize the student modelling module to gather historical data on their music listening habits. Piano music education ideals and nonutilitarian music values influence people's behavior. Students' nonverbal cues are usually useful to piano instructors in gauging their level of commitment. The length of time students spend engaged in a task, the quality of the work they produce, and the way they communicate their feelings and ideas are all behavioral indications of motivation. Figure 9 depicts the dataset's learning behavior analysis ratio (%) based on dataset [26].

As initialized in equation (12), learning behavior has been calculated. Using the preprocessed performance material and spectral properties extracted from the spectrum by the neural network may be trained to provide a regression model that can be used to predict piano performance

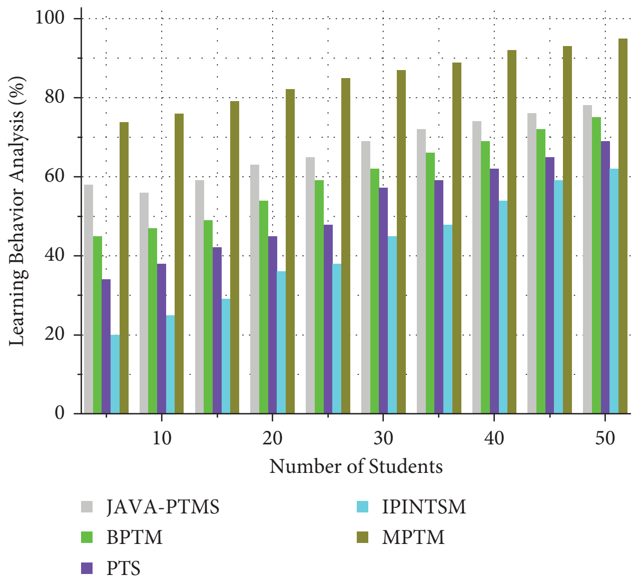

Figure 9: Learning behavior analysis ratio (%).

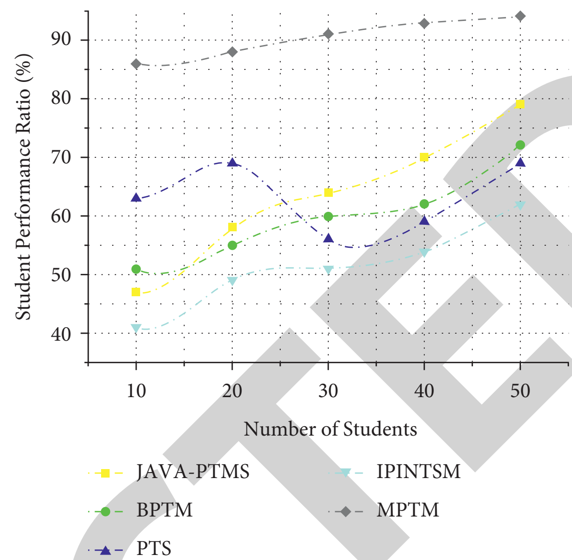

Figure 10: Student performance ratio (%).

characteristics. Recommended music items are generated by combining the regression model's predictions of piano performance attributes with a user's stated preferences and then using the recommendation algorithm module to build a list of music items in which the user would be interested.

4.1.4. Student Performance Analysis (%). Learning the piano is not a one-time activity, and it often demands students to have adequate knowledge and tracking complete recognition of the piano learners should need to have a specific skill play to achieve an overall performance level. The use of multimedia technology enables teachers to provide students with a reasonably open educational environment and space where students will thoroughly understand piano knowledge. This positively impacts the composition of emotional resonance and energy-boosting exchange, which in turn creates conditions for learners to enhance plenty of vitality for learning and performance ability. Figure 10 elaborates on the student performance ratio (%) based on dataset [26].

In Polyhymnia, a piano performance may be automated. An expressive performance may be guided by musical signals, which can be interpreted in many different ways. Because of this, we present adaptable parametric models that can be automatically interpreted. Expressive piano playing relies heavily on its polyphonic characteristics. Polyphony is common in piano compositions. This article will discuss them and refer to them as polyphonic expressiveness. Performances with polyphonic expressiveness were found to sound better than those without it, using a statistical model of polyphonic piano renditions. Based on the present state of multimedia technology application in the design of integration in piano instruction, this article focuses primarily on the application structure and general design of multimedia technologies in piano education. It concludes that multimedia piano education is innovative and groundbreaking, and the article intends to establish the circumstances for its smooth growth.

4.1.5. Teaching Evaluation Analysis (%). Traditional methods of instruction often result in students' lack of initiative when studying the piano. The students' lack of interest in studying leads to fewer attempts to master the piano and slows overall progress in their professional successes. Students' learning excitement may be considerably boosted by the incorporation and direction of multimedia technology and students' cognitive abilities can be improved while they are learning to play the piano. Figure 11 explores the dataset's teaching evaluation analysis (%) [26].

See equation (4) for output layer node outcome calculated for teaching evaluation ratio, as well as student's performance. Teaching can be made easier with the help of multimedia technology, which makes it possible to simplify the teaching process. Some of the more abstract aspects of piano playing and future technologies can be shown through the visual display provided by multimedia, which helps to prevent the issue of false cognition on the part of students as well as the preconceptions that can get in the way of improving the effectiveness of piano learning. Table 1 shows the results and discussion outcome.

5. Discussion

Using multimedia technology, this study explores the concepts and characteristics of multimedia network teaching technology, outlining the components, classifications, current state of development, and potential future applications. Two features of the teaching content structure and content delivery applications illustrate the key technologies employed in designing the network music education system. The many subsystems of the streaming teaching system are logically organized, and numerous sorts of technological challenges that must be overcome when using multimedia are examined. This paper proposes a system of networked multimedia instruction. To deliver educational services to faculty, students system uses existing campus network infrastructure software exclusively. This study's integration of

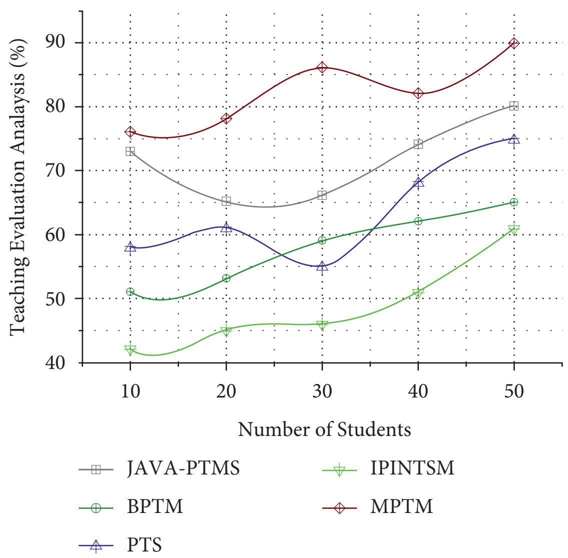

Figure 11: Teaching evaluation analysis (%).

Table 1: Results and discussion outcome.

Number of performance metrics	Outcome (%)
Learning skills ratio	97.6
Learning activity ratio	98.5
Learning behavior ratio	94.2
Student performance ratio	93.8
Teaching evaluation ratio	90.3

multimedia network technology and classroom instruction may increase the teaching impact and provide a pleasant teaching environment that encourages students to learn independently and collaborate. There are three levels in which this article's difficulties may be found: instructors, students, and school administration. As a first step, it is recommended that educators thoroughly understand how multimedia networks may be used to educate students and assemble a team capable of overseeing the implementation of these networks in the classroom. The use of multimedia technology in piano instruction may help students overcome limitations of time and distance, allowing them to get a deeper understanding of the art of piano playing and the information associated with it. The experimental results show that the proposed MPTM achieves the learning skills ratio of 97.6%, learning activity ratio of 98.5%, student performance ratio of 93.8%, teaching evaluation ratio of 90.3%, and learning behavior ratio of 94.2% when compared to other methods.

Data Availability

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

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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