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Research Article

IoT Networks-Aided Perception Vocal Music Singing Learning System and Piano Teaching with Edge Computing

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The research on Internet of Things (IoT) network and edge computing has been a research hotspot in both industry and academia in recent years, especially for the ambient intelligence and massive communication. As a typical form of IoT network and edge computing, the intelligent perception vocal music singing learning system has attracted the attention of researchers in education and academia. Piano teaching is an important course for music majors in higher education. Strengthening piano teaching can cultivate outstanding piano talents for the country and promote the development of music art. This paper applies IoT perception technology to piano teaching, constructs an intelligent piano teaching system, and uses edge computing algorithms to accurately deploy sensors into the system by exploiting the ambient intelligence and massive communication. The system includes data acquisition, data perception, data monitoring, and other modules, making piano teaching more humanized and intelligent. Experiments show that the research in this paper provides important guidance for the application of IoT networks and edge computing, especially for the ambient intelligence and massive communication.

1. Introduction

The research on IoT network and edge computing has been a research hotspot in both industry and academia in recent years, especially for the ambient intelligence and massive communication. As a typical form of IoT network and edge computing, the intelligent perception vocal music singing learning system has attracted the attention of researchers in education and academia. This paper applies IoT perception technology to piano teaching, constructs an intelligent piano teaching system, and uses edge computing algorithms to accurately deploy sensors into the system. The system includes data acquisition, data perception, data monitoring, and other modules, making piano teaching more humanized and intelligent, through the ambient intelligence and massive communication. It is an attempt and an innovation to apply IoT technology and edge computing to piano teaching.

Based on the IoT network technology and edge computing, many scholars have carried out research work. Rao made a comprehensive analysis of piano teaching by using the fuzzy comprehensive evaluation method. The results have shown that the idea based on fuzzy mathematics promotes the progress of piano teaching [1]. Demrayak and Temel applied sensor technology to the piano teaching system, which effectively evaluated the arm movements of piano students [2]. Hamond et al. introduced automatic information technology into piano teaching, making piano teaching more vivid [3]. Zhao discussed the development status of piano teaching in the context of "micro-era". Practice has shown that the teaching method under the "micro era" has realized the upgrading of piano professional teaching from teaching concept to evaluation system [4]. Ryu analyzed the problems existing in today's piano teaching classroom and proposes corresponding solutions to these problems [5]. These studies on the application of the IoT network in piano teaching are rich, but lack pertinence.

With the progress of the times, there are more and more application scenarios of edge computing. Kouziokas and Perakis proposed a collaboration-based industrial intelligent perception framework that realizes intelligent and efficient industrial production services [6]. Liang et al. designed an intelligent perception system for battlefield intelligence, which can accurately analyze the military requirements, combat operations and mission requirements of the joint battlefield [7]. Akinsunmade and Ejieji applied the Bluetooth sensor and Bluetooth adapter to the intelligent perception recognition system. The experimental results have shown that the system has strong stability and fast sensing speed [8]. Yan et al. proposed a crowdsourcing-based industrial intelligent perception system, using which factories improved productivity and workplace safety [9]. Liang et al. applied IntelliSense technology to home sleep monitoring. Experimental results have shown that this technique is effective in detecting irregular sleep [10]. Xiao et al. proposed an edge detection algorithm based on IntelliSense. Experiments show that the algorithm is effective for edge detection of color remote sensing images [11]. Du et al. developed a distributed cooperative spectrum sensing algorithm based on IntelliSense. Simulation results have shown that the algorithm improves the detection efficiency to a certain extent [12]. The above research on edge computing is relatively detailed, but less related to the IoT.

IoT networks have come a long way in recent years. As an important part of the Internet of Things, edge computing has also attracted the attention of many researchers. This paper applies the IoT network to the piano teaching system, and then uses the edge computing algorithm to accurately deploy the sensors into the system. The research found that the new piano teaching system proposed in this paper has important reference significance for the next development of the Internet of Things and edge computing, especially for the ambient intelligence and massive communication.

2. IoT-Based Intelligent Perception and Vocal Singing

2.1. IoT-Based Intelligent Perception Technology. Based on the IoT network and edge computing, this paper studies the intelligent sensing technology. Intelligent perception is the process of acquiring and processing external information using sensors and network technology. The specific content of intelligent perception is shown in Figure 1. "Sense" refers to sensing technology, and "knowledge" refers to recognition technology. Among them, sensing technologies include sensor sensing, radar sensing, and satellite sensing, and recognition technologies include image processing, image analysis, and image understanding. At present, the intelligent sensing technology is quite mature, and the applications in enterprises include intelligent access control and intelligent front desk [13]. Smart access control is to enable the machine to have the ability to perceive, to capture the face through the camera for perceptual recognition, and to compare with the database face image, so as to perform attendance access control check-in. The smart front desk mainly uses face recognition for appointment registration.

2.2. IoT Based Intelligent Perception Vocal Music Singing Learning System. Based on the IoT network and edge computing, this paper builds an intelligent perception vocal learning system as shown in Figure 2. In this system, learning resources refer to all available teaching resources related to vocal music learning. It includes vocal data, PPT courseware, audio, and video, and each resource is set with a corresponding identification keyword. Learning feeling refers to the use of mobile positioning technology to build a virtualized resource navigation map of cyberspace, to perceive, locate, and extract relevant vocal music learning information of an application, so as to provide effective intelligent perception application services. Learning feeling is to use intelligent perception technology to acquire and locate vocal music learning information, and then provide corresponding services for learners.

With the help of the IoT network and edge computing, vocal music learning resources can also form a three-dimensional personalized knowledge perception map. Among them, the first dimension is the resource-aware navigation for learners entering the learning resource platform, the second dimension is to accurately locate the learning content and related information, and the third dimension is to complete the matching between learners' learning needs and potential resources.

3. IoT Network and Edge Computing-Based Piano Teaching Model

Assisted by the IoT networks and edge computing, vocal singing and piano accompaniment are interrelated, and a good piano accompaniment can make vocal singing more musical. In this paper, the application of the intelligent perception vocal music singing learning system to the piano teaching mode can also be said to complement each other.

3.1. IoT-Based Intelligent Piano Teaching System. Combined with the IoT network and edge computing, this paper draws the architecture diagram of the piano teaching system shown in Figure 3. First, establish the connection between the vocal music singing learning system and piano teaching, so that students can play with a purpose. Piano accompaniment music itself and vocal singing are interdependent in melody, and the fusion of the two can complete a more beautiful melody. Then, there is the realization of the perception function. In order to realize the perception function, there must be certain software and hardware to support it. Therefore, sensors are arranged in the learning process of piano teaching, and the learner wears an intelligent induction bracelet. The bracelet can monitor the learner's technique and playing process in real time, and record the whole process. Finally, according to the piano teaching data on the bracelet, piano teachers and students can make an assessment of the piano learning efficiency.

3.2. IoT-Based Realization Process of Intelligent Perception. Combined with the IoT network, this paper constructs the realization process of intelligent perception as shown in Figure 4, including three parts: sensing unit, computing unit, and interface unit.

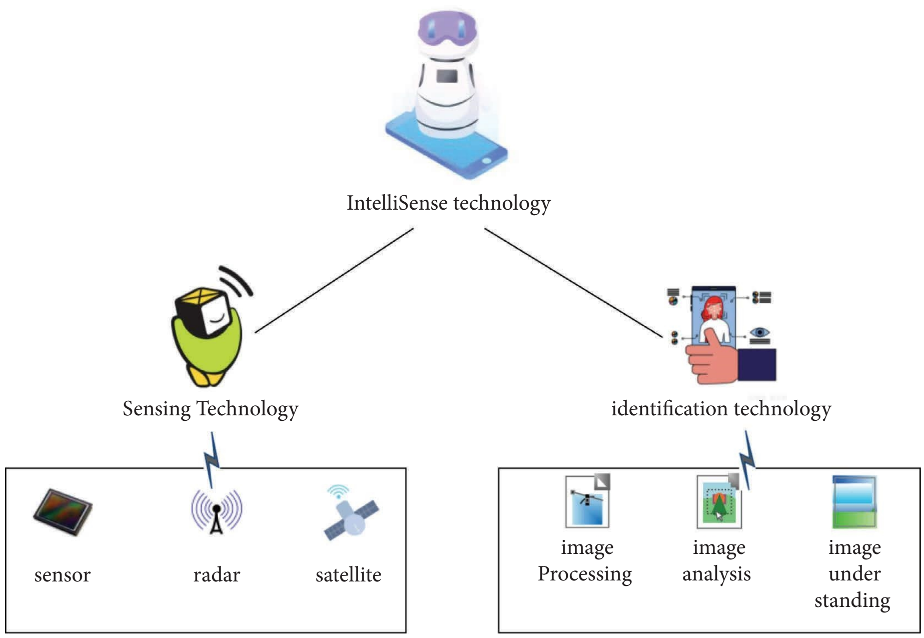

FIGURE 1: IoT-based intelligent technology framework.

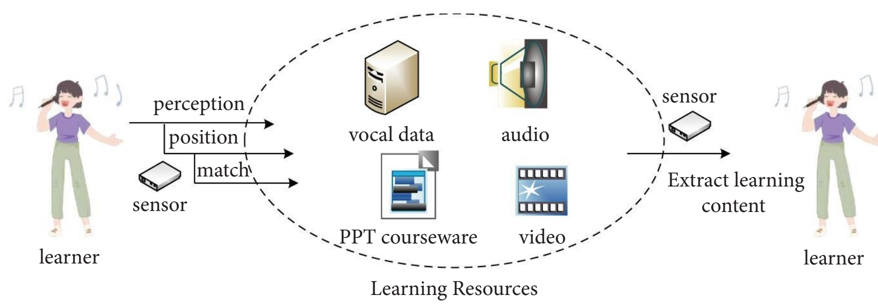

FIGURE 2: IoT network and edge computing based intelligent perception vocal learning system based on.

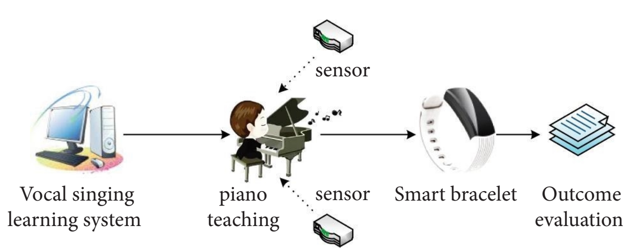

FIGURE 3: IoT network and edge computing-based architecture of piano teaching system.

Several sensors are arranged in the sensing unit to monitor and record the entire teaching process. The data in the sensor will be transmitted to the computing unit in time, and the computing process of the unit includes signal acquisition, data processing, and data storage. The signal collection is divided into image collection and audio collection. The image collection collects the position, depth, and foot movement of the fingers pressing the piano keys through multiple cameras, and the audio collection collects the piano playing sound through the omnidirectional microphone. Data processing is the modeling of piano temperament and piano score, and the processing and analysis of audio. Data storage is to save all the data generated in the process of piano teaching. Both ends of the interface unit are connected with intelligent sensors and external network systems to ensure the smooth operation of the entire intelligent sensing work.

3.3. IoT Networks-Based Application Demonstration of Intelligent Piano Teaching System. Combined with the IoT network and edge computing, this paper constructs the application process of the intelligent piano teaching system as shown in Figure 5, which mainly includes three parts: acquisition module, perception module, and processing center. In piano teaching, playing technique and audio output are the two most important links [14], so the acquisition module also focuses on these two when collecting data. Through the network server, the acquisition module transmits the relevant data to the perception module, and then the processing center compares the fingering images and audio information in the data, and finally forms a new piano teaching mode.

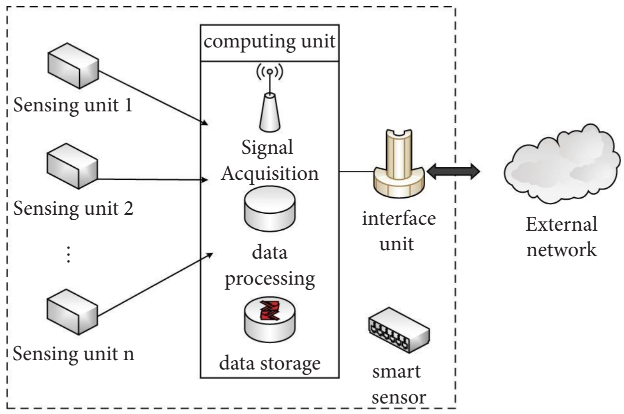

Figure 4: IoT network and edge computing-based realization process of intelligent perception in piano teaching system.

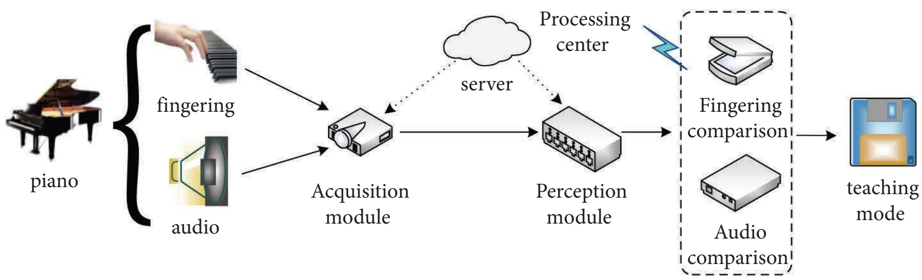

Figure 5: IoT network and edge computing-based application process of intelligent piano teaching system.

3.4. IoT-Based Organic Combination of Vocal Singing and Piano Teaching. Based on the IoT networks, in order to promote the better cooperation between vocal singing and piano teaching, this paper improves the teaching mode in the piano teaching classroom, that is, let the piano learners accompany the vocal singers to strengthen their cooperation consciousness. The specific content is as follows: first, the piano accompaniment and vocal singers analyze and understand the background and style of the work together under the guidance of the teacher, and the two must reach a consensus on understanding the work. Then, the piano accompanist also needs to understand the singing style of the singer. The more comprehensive he knows about the singer, the more he will be able to control the overall situation with certainty, and put into practice without accident, so that the processing of the work can achieve better results. Finally, the accompanist and the singer must be emotionally consistent, and the two must have a common purpose in their hearts, which is to finally express the emotion of the work correctly and jointly create a perfect musical image.

4. Application of Edge Computing Algorithm in Piano Teaching

Combined with the edge computing method of Gaussian mixture model, this paper deploys and locates the sensor equipment in piano teaching. According to the idea of Gaussian distribution [15], the distribution form of device nodes can be expressed as follows:

$$f(x, \alpha, \beta) = \frac{1}{\sqrt{2\pi\beta}} e^{-1/2(x-\alpha)^2 \beta^2}. \quad (1)$$

In formula (1), α is the mean value of the Gaussian distribution, which describes the center position of the Gaussian distribution and β^2 is the variance of the Gaussian distribution, which describes the degree of concentration of the data in the distribution. The larger the β^2, the more dispersed the distribution, the smaller the β^2, the more concentrated. It can be known from this formula that the closer the sample node is to the center, the higher the probability will be, and the smaller the β^2, the more concentrated the sample node will be.

Assuming that all sample nodes are generated by Gaussian component, the distribution of sensor devices in piano teaching can be regarded as the problem that the sample nodes obey the Gaussian mixture model distribution. The calculation method is $G = \{g_1, g_2, g_3, \ldots g_k\}$.

$$p(x_a, \alpha, \beta) = \sum_{b=1}^{k} \alpha_b * f(x_a, \alpha_b, \beta_b). \quad (2)$$

Where α_b represents the weight of each Gaussian model component and satisfies the following equation:

$$\sum_{b=1}^{k} \alpha_b = 1, \quad (3)$$

$$0 \le \alpha_b \le 1, \forall_b \in [1, k]. \quad (4)$$

After calculating the probability distribution of each sample node, the probability values of all sample distributions can be obtained by multiplying the probability of each sample node. The calculation method is as follows:

$$\max\prod_{a=1}^{N} = \sum_{b=1}^{k} \alpha_v * f\left(x_a, \alpha_b, \beta_b\right). \tag{5}$$

The previous Gaussian mixture model simply compares the probability to cluster the sample nodes, which often results in the imbalance between some Gaussian components [16]. In order to ensure that the load belonging to each Gaussian component is relatively balanced, the following mathematical model is established:

$$B_b = \sum_{a=1}^{N} p_{ab} * c_{ab} * y_{ab}. \tag{6}$$

In the formula, B_b represents the total load of the Gaussian component g_b, p_{ab} represents the probability of the node b on the Gaussian component g_b, c_{ab} represents the load required by the sensor device g_b to connect the terminal device x_a, and y_{ab} is a binary variable. The loading of the entire Gaussian mixture model can be written as follows:

$$B = \frac{1}{k}\sum_{b=1}^{k}\sum_{a=1}^{N} p_{ab} * c_{ab} * y_{ab}. \tag{7}$$

In order to ensure the load balancing of the entire Gaussian mixture model [17], the objective function is as follows:

$$\min\sqrt{\frac{1}{k-1}} = \sum_{b=1}^{k}\left(B_b - B\right)^2, \tag{8}$$

$$s.t\ y_{ab} \in \{0, 1\}, 1 \le a \le N, 1 \le b \le k, \tag{9}$$

$$\sum_{b=1}^{k} y_{ab} = 1, \quad \beta_{ab}^{t+1} = \frac{\sum_{a=1}^{N} \omega_{ab}^{t+1}}{N}, \tag{10}$$

$$\sum_{b=1}^{N} y_{ab} * c_{ab} \le c_b. \tag{11}$$

The restriction formula (9) represents the indicator variable of y_{ab}, which can only take values between 0 and 1. Formula (10) indicates that each sensor device can only be clustered into one gateway.

Generally, in the problem of parameter estimation of edge devices, variable selection is a primary problem to be solved, because the selection of variables is related to whether the subsequent model parameter estimation can be performed accurately. Variable selection must be performed when estimating parameters of edge devices. The selection of variables should be based on some information criteria. Commonly used information criteria include AIC (Akaike information criterion) criterion and BIC (Bayesian information criterion) criterion. The criterion expression is as follows:

$$AIC = -2 * \log H + 2K, \tag{12}$$

$$BIC = -2 * \log H + K * \log N. \tag{13}$$

In the formula, K represents the number of parameters to be estimated in the selected model, N represents the length of the selected model data sample, and H represents the maximum likelihood estimate of the model established with the sample node as a variable.

This paper uses the BIC criterion to solve the maximum likelihood estimate of the Gaussian mixture model, namely,

$$BIC = -2 * \max\sum_{a=1}^{N} \log\left(p\left(x_a, \alpha, \beta\right)\right) + K * \log N. \tag{14}$$

Firstly, different initial parameters are selected, and the maximum likelihood estimation value of Gaussian mixture model is obtained by the algorithm. Substituting into formula (14), the BIC value can be obtained, and then the smaller BIC value is selected as the number of Gaussian models in the Gaussian mixture model, so as to ensure the optimal number of edge sensor devices.

The last step of edge computing is to solve the objective function. The objective function expression above can be expressed as follows:

$$\max\sum_{a=1}^{N}\log\sum_{b=1}^{k}\alpha_b * f\left(x_a, \alpha_b, \beta_b\right). \tag{15}$$

Because of the Gaussian mixture model involved, it is very troublesome to directly find the derivative of the objective function, so this paper adopts the expectation-maximum iterative algorithm (EM) for calculation [18]. According to the above, the iteration expression can be expressed as follows:

$$\omega_{ab}^{t+1} = \frac{\alpha_b^t * f\left(x_a, \alpha_b^t, \beta_b^t\right)}{\sum_{b=1}^{K}\alpha_b^t * f\left(x_a, \alpha_b^t, \beta_b^t\right)}. \tag{16}$$

In the formula, t represents the number of iterations. The parameters of each Gaussian model component can be estimated from the probability data. The specific process is as follows:

$$\alpha_b^{t+1} = \frac{\sum_{a=1}^{N}\omega_{ab}^{t+1} * x_a}{\sum_{a=1}^{N}\omega_{ab}^{t+1}}, \tag{17}$$

$$\beta_b^{t+1} = \frac{\sum_{i=1}^{N}\omega_{ab}^{t+1}\left(x_a - \alpha_b^t\right)\left(x_a - \alpha_b^t\right)^T}{\sum_{i=1}^{N}\omega_{ab}^{t+1}}, \tag{18}$$

$$\alpha_{ab}^{t+1} = \frac{\sum_{a=1}^{N}\omega_{ab}^{t+1}}{N}. \tag{19}$$

The parameters of each Gaussian model are denoted as $\theta = \{\theta_1, \theta_2, \theta_3, \ldots\theta_k\}$, and each model as $\theta_b = (\alpha_b, \beta_b)$, according to the number of iterations, the parameters of

Table 1: IoT network and edge computing-based adaptability of teachers and students in the piano teaching model.

Degree of adaptation	Teacher		Student	
	Number of people	Proportion	Number of people	Proportion
Cannot adapt	4	1.3%	8	2.7%
Not very suitable	7	2.4%	13	4.3%
General adaptation	23	7.7%	46	15.3%
Well adapted	96	32%	103	34.4%

each Gaussian model component can be expressed as follows:

$$\theta_b^{T+1} = \left(\alpha_b^{t+1}, \beta_b^{t+1}\right). \quad (20)$$

By multiplying the parameter values of each Gaussian component, and then calculating the sample node value of each Gaussian component, the sensor device can be arranged at the edge of the path of the piano teaching system.

5. IoT Network and Edge Computing-Based Practice Results and Analysis of Piano Teaching Mode

Combining the IoT network and edge computing, this paper proposes a new piano teaching model. In order to analyze whether the new piano teaching mode can make students and piano teachers adapt, this paper investigates the degree of adaptation of 300 teachers and students in a certain college to the new piano teaching mode. The survey results are shown in Table 1.

From IoT networks as well as the number and proportion of the adaptation level in Table 1, it can be clearly seen that there are very few people who cannot adapt to this model. Generally, there are relatively more people who adapt, and the number of teachers and students accounts for 23% of the total number. People accounted for the majority, and the number of teachers and students accounted for 66.4% of the total number, which also shows from the side that it is relatively successful to apply the IoT network and edge computing to piano teaching.

The most important thing in the IoT based piano teaching is students' autonomy. In addition to the teaching content in the classroom, it is also very necessary for students to practice piano after class. In order to verify whether the new piano teaching mode can improve students' autonomy, the time spent practicing piano after class under the traditional piano teaching mode and the new piano teaching mode was investigated. The specific period is five weeks, and the survey results are shown in Figure 6.

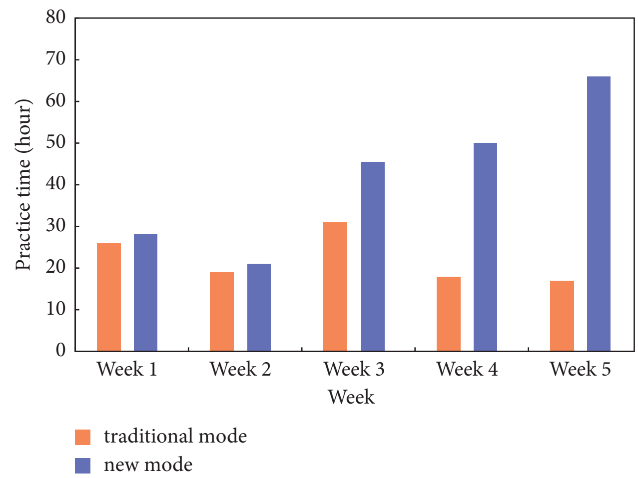

Figure 6: IoT network and edge computing-based after-class piano practice time under the traditional piano teaching mode and the piano teaching mode.

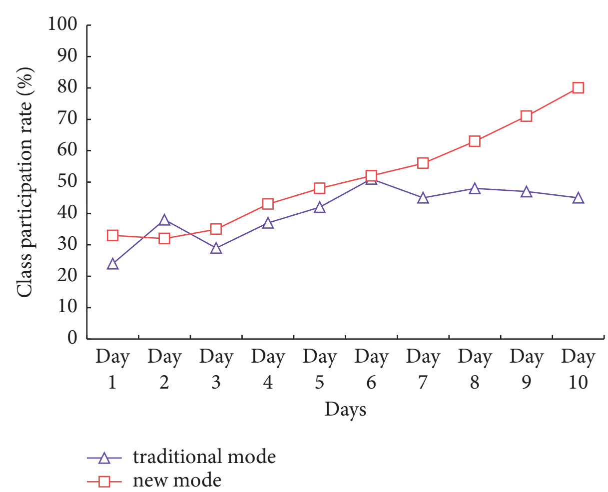

Figure 7: IoT network and edge computing-based classroom participation rate in traditional piano teaching mode and piano teaching mode.

As can be seen from the histogram in Figure 6, the practice time of the new mode in the first two weeks was only a little higher than that of the traditional mode, and there was a downward trend. This corresponds to the degree of adaptation mentioned above, and there must be a process for students to change between the two modes. From the third week, the students' piano practice time has increased significantly. The third week is nearly 15 hours longer than the second week, and the next two weeks have also maintained an upward trend. In contrast to the traditional model, although the duration of piano practice in the last three weeks has greatly increased in the third week, there has been a downward trend in the next two weeks. Generally speaking, the piano practice time under the new piano teaching mode is much longer than that in the traditional piano teaching mode, and as time goes by, the time is always on the rise.

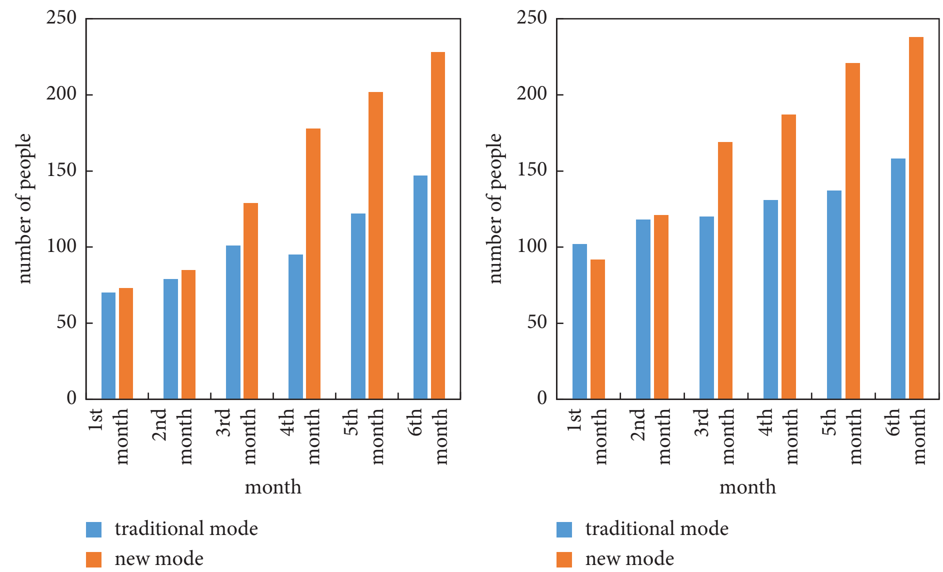

Figure 8: IoT network and edge computing-based status of piano grading under the piano teaching mode.

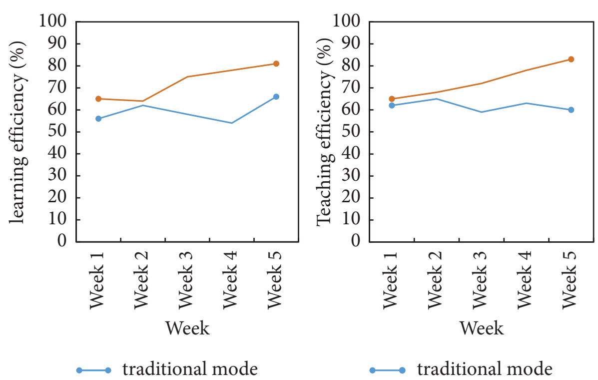

Figure 9: IoT network and edge computing-based learning efficiency and teaching efficiency under the traditional piano teaching mode and the piano teaching mode.

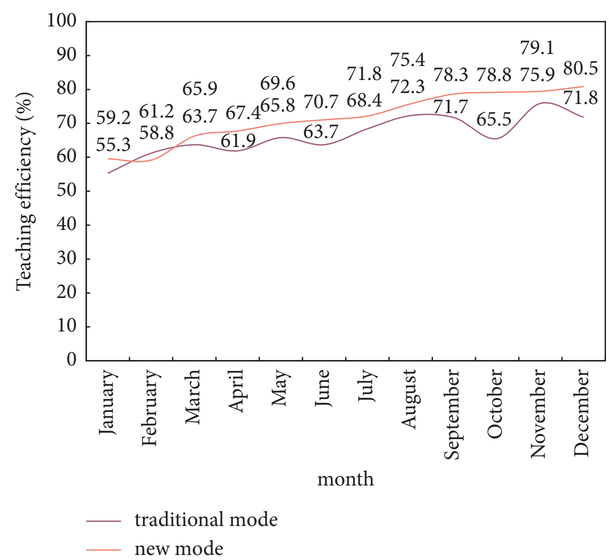

Figure 10: IoT network and edge computing-based teaching efficiency of traditional piano teaching mode and piano teaching mode within one year.

To measure the quality of an IoT based teaching model, the classroom participation rate is undoubtedly one of the best indicators. Figure 7 shows the classroom participation rate of the traditional piano teaching model and the new piano teaching model within 10 days.

It can be seen from the line chart in Figure 7 that the difference in the IoT based classroom participation rates between the two modes within 10 days is still relatively large. The first three days of classroom participation rates were relatively low, and on the second day, the participation rate under the traditional teaching model was even a little higher than that of the new teaching model. This is understandable, after all, it takes a certain process for students to accept the new teaching model. From the fourth day, the class participation rate in both modes started to rise, but the status of the rise was different in the following days. The classroom participation rate under the new teaching model has always been on the rise, while the participation rate of the classroom participation rate under the traditional teaching model fluctuates greatly and has a downward trend. Comparing the line charts, it is easy to draw that the classroom participation rate under the new teaching model is much higher than that of the traditional teaching model, and it is relatively stable.

In order to better demonstrate the practical effect of the new IoT based piano teaching mode, the students' piano grading test in the classroom was investigated. The specific period is the first 6 months, and the total number of people is 500. The survey results are shown in Figure 8.

From the perspective of edge computing, the first small histogram in Figure 8 represents the passing result of the piano teaching test based on the Internet of Things mode, and the second small histogram represents the passing result of the piano teaching test based on the edge computing mode. It can be seen that in the first two months, the number of people who passed the test under the two modes were not much different, and the number of people who passed the test did not even exceed 100 in the first two weeks. With the passage of time, from the third month onwards, the number of passing grades and the number of passing grades in both modes have increased, but the difference in the growth rate is still obvious. The growth rate under the new model can be said to be soaring. In the sixth month, the number of people who passed the exam and passed the grades reached more than 200. In contrast to the traditional model, its growth rate is relatively small, and there is still a decline in individual months.

From the basis of IoT networks and edge computing, the purpose of integrating intelligent perception technology and vocal singing in the piano teaching mode is to improve the learning efficiency of students on the one hand, and to improve the teaching efficiency of piano teachers on the other hand. Figure 9 presents the learning efficiency and teaching efficiency of the two modes over five weeks.

The first small line graph in Figure 9 shows the edge computing-based learning efficiency in the two modes over five weeks, and the second shows the teaching efficiency. The learning efficiency under the traditional piano teaching mode did not exceed 70% at the highest level within five weeks, and was basically between 50% and 60%, and fluctuated greatly. From the first week of the new piano teaching mode, the learning efficiency has reached about 65%, and in the second week, there was a slight decline, and then it has maintained a steady increase. In terms of teaching efficiency, the traditional model is relatively stable, and the efficiency is maintained at around 60%, while the new model has been on the rise, which is also due to the adaptability of piano teachers to the new model.

Unlike other teaching, the IoT based piano teaching is a relatively slow process, which requires that the teaching mode must be matched with teachers and students. In order to better verify the practical effect of the new piano teaching mode, the teaching efficiency of this mode within one year was analyzed, and compared with the traditional piano teaching mode. The specific comparison results are shown in Figure 10.

From the graph in Figure 10, it can be seen that there is still a large gap in the efficiency of IoT based piano teaching under the two modes within one year. In the first two months, due to the conversion and adaptation of the two modes, the teaching efficiency has shown a crossover trend. Since March, the teaching efficiency test under the new piano teaching mode has gradually increased, and it has maintained a trend of no decline until December. In contrast to the traditional piano teaching model, although there is an upward trend in the middle months, the overall fluctuation is too great. In contrast, it is easy to conclude that the teaching efficiency of the new piano teaching mode is 7.31% higher than that of the traditional piano teaching mode within one year.

6. Conclusion

The research on IoT network and edge computing has been a research hotspot in both industry and academia in recent years, especially for the ambient intelligence and massive communication. As a typical form of IoT network and edge computing, the intelligent perception vocal music singing learning system has attracted the attention of researchers in education and academia. This paper applies IoT perception technology to piano teaching, constructs an intelligent piano teaching system, and uses edge computing algorithms to accurately deploy sensors into the system, through exploiting the ambient intelligence and massive communication. The final results show that the research in this paper provides important guidance for the application of IoT network and edge computing, especially for the ambient intelligence and massive communication.

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 that they have no conflicts of interest.

References

[1] T. Rao, "The exploration of integrating piano teaching into ideological and political education from the perspective of morality building and people cultivating," *Region-Educational Research and Reviews*, vol. 3, no. 1, pp. 1–5, 2021.

[2] E. Demirayak and T. Temel, "An action research on the use of therapeutic stories as a new method of piano education," *Rast Müzikoloji Dergisi*, vol. 9, no. 1, pp. 2673–2706, 2021.

[3] L. Hamond, E. Himonides, and G. Welch, "The nature of feedback in higher education studio-based piano learning and teaching with the use of digital technology," *Orfeu*, vol. 6, no. 1, pp. 1–31, 2021.

[4] P. Zhao, "An optimized ability model construction of skill training in piano performance teaching," *Revista de la Facultad de Ingenieria*, vol. 32, no. 9, pp. 636–641, 2017.

[5] J. Y. Ryu, "I wish, I wonder, and everything I like: living stories of piano teaching and learning with young children," *LEARNing Landscapes*, vol. 11, no. 2, pp. 319–330, 2018.

[6] G. N. Kouziokas and K. Perakis, "Decision support system based on artificial intelligence, GIS and remote sensing for sustainable public and judicial management," *European Journal of Sustainable Development*, vol. 6, no. 3, pp. 397–404, 2017.

[7] X. Liang, R. Ghannam, and H. Heidari, "Wrist-worn gesture sensing with wearable intelligence," *IEEE Sensors Journal*, vol. 19, no. 3, pp. 1082–1090, 2019.

[8] A. E. Akinsunmade and C. N. Ejieji, "Land suitability and crop pattern model using integrated pollination intelligence algorithm and remote sensing," *Earthline Journal of Mathematical Sciences*, vol. 5, no. 1, pp. 1–15, 2020.

[9] R. Yan, A. Nandi, P. Wang, and W Li, "Guest editorial special issue on smart sensing and artificial intelligence-enabled data analytics for health monitoring of engineering systems," *IEEE Sensors Journal*, vol. 20, no. 15, p. 8203, 2020.

[10] Q. Liang, G. G. Yen, and T. S. Durrani, "Guest editorial: special issue on computational intelligence for communications and sensing," *IEEE Transactions on Emerging Topics in Computational Intelligence*, vol. 4, no. 1, pp. 1–4, 2020.

[11] F. Xiao, Z. Guo, Y. Ni, X. Xie, S. Maharjan, and Y. Zhang, "Artificial intelligence empowered mobile sensing for human flow detection," *IEEE Network*, vol. 33, no. 1, pp. 78–83, 2019.

[12] Y. Du, V. Issarny, and F. Sailhan, "When the power of the crowd meets the intelligence of the middleware: the mobile phone sensing case[J]," *ACM SIGOPS - Operating Systems Review*, vol. 53, no. 1, pp. 85–90, 2019.

[13] L. Li, "Study on the innovation of piano teaching in normal colleges and universities," *Creative Education*, vol. 09, no. 05, pp. 697–701, 2018.

[14] C. Liu and Q. Zhang, "Optimized application of network resources in college piano teaching reform under the background of innovation and entrepreneurship education," *Boletin Tecnico/Technical Bulletin*, vol. 55, no. 8, pp. 225–231, 2017.

[15] Y. Shao, "The influence of psychological factors on piano performance," *International Journal of Social Science and Education Research*, vol. 2, no. 12, pp. 83–87, 2020.

[16] D. A. Alexandrovna, L. S. Sergeevich, and P. M. Viktorovna, "Piano music of composers-minimalists in the teaching repertoire of higher music education," *Opción*, vol. 34, no. 17, pp. 149–162, 2018.

[17] A. M. Dudeque Pianovski Vieira, "Teaching in the history of education: a transdisciplinary perspective," *International Journal of Action Research*, vol. 13, no. 1, pp. 39–50, 2017.

[18] I. N. Okeke, "The ambiguity of musical expression marks and the challenges of teaching and learning keyboard instruments: the nnamdi azikiwe university experience," *UJAH Unizik Journal of Arts and Humanities*, vol. 18, no. 1, pp. 131–148, 1970.