Design of Interactive Music Teaching System for Wireless Communication Application by Convolutional Neural Network Optimization and Edge-Cloud Computing

Nani Zeng (znani569@163.com)
Hunan University of Arts and Science

Research Article

Keywords: edge-cloud computing, interactive system, Convolutional Neural Network, wireless communication, Softmax Convolutional Neural Network-Long Term Evolution

Posted Date: November 3rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2221492/v1

Abstract

This study aims to improve the effectiveness of online music teaching and optimize the current interactive system of online teaching. Firstly, the basic connotation of Convolutional Neural Network (CNN), edge-cloud computing and their application principles are discussed. Then, the basic principles of wireless communication and its comprehensive optimization methods are discussed. Finally, the Softmax Convolutional Neural Network-Long Term Evolution (SCNN-LTE) model based on CNN to optimize wireless communication technology is designed. Model skills are comprehensively assessed. The results show that, compared with other models, the comprehensive performance of the designed CNN model has been greatly improved. The evaluation found that the recall value of the Softmax Convolutional Neural Network (SCNN) model is around 0.9-1.0, and the precision value is around 0.8–0.9. Additionally, CNN models are applied to wireless communication technologies for performance evaluation. The accuracy of the SCNN-LTE model is generally between 0.7 and 0.9. The designed model not only optimizes the CNN model to a certain extent but also deeply optimizes the wireless communication technology. Therefore, the model can be better applied to the online music teaching interactive system, providing important technical support for its effect optimization. This study not only provides a technical reference for the optimization of wireless communication technology but also contributes to the performance enhancement of the online music teaching interactive system.

Introduction

With the development of science and technology, the traditional classroom teaching mode can no longer satisfy the desire of students to acquire knowledge. It limits the pioneering thinking of students to a certain extent so that their thinking can only follow the direction of the teacher. Students' learning patterns are largely the same, limiting autonomous agency. Furthermore, the place to listen to the class is limited to the classroom. A dull learning environment, fixed teaching mode, and fixed teaching content make students lose interest in exploring knowledge. Therefore, the establishment of an interactive teaching system is imperative [1]. Wireless communication technology is the main technical support. How to improve the efficiency of the teaching process is also very necessary research. Convolutional Neural Network (CNN) is a relatively advanced deep learning technology. Wireless communication technology is optimized and applied to the music teaching interactive system, which plays an important role in improving the current teaching interactive system [2]. Although the research on this technology is not perfect, many existing theories provide technical support for it.

At present, Ivanytska et al. (2021) pointed out that online teaching has become an important aspect of modern education, and it has received more and more attention. It is not limited by time, space, and personnel and can extend education to all corners of society through computer networks. Learners can learn autonomously at appropriate times and places and obtain higher-quality educational effects at a lower cost. However, the current Web-based distance teaching system has certain deficiencies. It is a system-centered education model, which requires people to adapt to the system rather than the system to serve learners actively. It does not fully reflect the dominant position of teachers in organizing courses, especially the teachers' experience, strategies, and emotions cannot be expressed. The system lacks intelligence when instructing learners and cannot dynamically adjust teaching strategies according to the changes in learners' emotional states. Therefore, in a sense, the current Web-based distance teaching system lacks a "people-oriented" atmosphere [3]. Juneja et al. (2021) pointed out that with the development of society, modern educational and electronic information technology is more and more closely integrated. Auxiliary teaching products based on computer, multimedia, and network technology emerge in an endless stream. How to combine modern electronic communication and modern educational technology organically has become one of the hotspots in the field of modern teaching research. Based on the lack of teacher-student communication and student learning records in traditional classroom teaching, a clicker-type interactive teaching response system is designed. This system is used for teaching and can significantly improve students' interest in learning [4]. Sony et al. (2021) pointed out that with the development of communication technology, the real-time and accurate monitoring of the external electromagnetic spectrum environment has become an increasingly urgent requirement. Spectrum monitoring technology has more extensive application prospects in both military and civilian fields. At present, machine learning technology has become the development trend of a new generation of information technology. It has been deeply integrated with many fields and has achieved a series of development results, which has greatly promoted the transformation and upgrading of traditional industries. The CNN algorithm in machine learning has been widely used in the fields of image detection, speech recognition, and radar signal recognition due to its excellent performance in accurate feature extraction from high-dimensional data. Combining the CNN algorithm with spectrum monitoring technology, a spectrum monitoring system based on CNN is proposed. Finally, the hardware development platform completes the realization of the system. Firstly, the forward and back-propagation processes of the artificial neural network (ANN) algorithm are analyzed theoretically in detail. Then, the structure and function of CNN are systematically discussed. Each layer in the network, such as convolutional, pooling, activation function, and fully connected layer, has an in-depth study of the structure and calculation method. According to the forward propagation process of CNN and the specific calculation method of each network layer, four parallel computing methods suitable for CNN forward propagation are proposed, which realize the deep optimization of wireless communication technology through CNN technology [5].

Based on this, firstly, the basic connotation of CNN technology is discussed. Then, wireless communication technology is discussed in depth. Finally, an optimization model of wireless communication technology based on CNN technology is designed. Models are evaluated. This study not only provides a reference for the development of online teaching but also contributes to the development of wireless communication technology.

Research Theories And Methods

Convolutional Neural Network

With the continuous change in human needs, artificial intelligence technology has become an important carrier of scientific and social development [6], and the machine learning technology supporting its development has become a social hotspot. Machine learning is a multi-field interdisciplinary subject involving probability theory, statistics, approximation theory, convex analysis, algorithm complexity theory, and other disciplines. It studies computer simulation or realization of human learning behavior to acquire new knowledge or skills, reorganize existing knowledge structures, and continuously improve its performance. As a branch of machine learning, deep learning is unique in current scientific and technological research and has made extraordinary achievements [7]. Deep learning is a technology that simulates the human brain based on machine learning. At present, the development of deep learning technology not only provides an important impetus for the sublimation of machine learning technology but also makes important contributions to the development of various fields [8]. The source and structure of deep learning techniques are shown in Fig. 1.

In Fig. 1, the main idea of deep learning technology is to learn the activity mechanism of the human brain, convert it into an algorithm model that can be calculated and run on a computer, and operate the model and solve problems. Typically, such neural network techniques are highly capable of learning and can solve various problems. Therefore, deep learning techniques are widely used in various fields [9]. At present, deep learning technology is mainly used in various fields such as face recognition, image recognition, image classification, image segmentation, speech recognition, and scene recognition and has made great progress and development. Deep learning technology includes many branch technologies. Among them, the achievements of CNN technology are more remarkable [10]. The calculation of deep learning technology is shown in Eq. (1):

$$y = f(\sum_{i=0}^{N} w_i x_i + b)$$

1

In Eq. (1), *w* represents the weight, *b* represents the bias, and *f* represents the activation function. The calculation of each level of the neural network is shown in Eq. (2):

$$x^{(k)} = f^{(k)}(w^{(k)}x^{(k-1)} + b^{(k)})$$

2

In Eq. (2), *k* represents the level. The calculation of the learning state of the neural network is shown in Eq. (3):

$$x' = x - \epsilon \nabla_x f(x)$$

3

The information transfer is shown in Eqs. (4) and (5):

$$z^{(k)} = w^{(k)}x^{(k-1)} + b^{(k)}$$

4

$$x^{(k)} = f^{(k)}\left(z^{(k)}\right)$$

5

The derivation is shown in Eq. (6):

$$\frac{\partial \mathscr{L}(y\hat{;}y)}{\partial w^{(k)}} = \frac{\partial \mathscr{L}(y\hat{;}y)}{\partial z^{(k)}} \cdot \frac{\partial z^{(k)}}{\partial w^{(k)}}$$

6

$$\frac{\partial \mathscr{L}(y\hat{;}y)}{\partial b^{(k)}} = \frac{\partial \mathscr{L}(y\hat{;}y)}{\partial z^{(k)}} \cdot \frac{\partial z^{(k)}}{\partial b^{(k)}}$$

7

After optimization, Eq. (8) is obtained:

$$\delta^{(k)} = \delta^{(k+1)} \cdot \frac{\partial z^{(k+1)}}{\partial x^{(k)}} \cdot \frac{\partial x^{(k)}}{\partial z^{(k)}}$$

8

Eq. (8) can obtain not only the result of the forward conduction of the neural network but also the error of the backward propagation.

CNN technology originated around the 1960s. The design of this neural network is inspired by the exploration of the cat's primary visual cortex [11]. CNN for image recognition and classification is the most used in research. CNN mainly includes input, convolution, pooling, fully connected, and output layer structure. The multi-level structure makes the CNN technology very versatile [12]. The main structure of the CNN technology is shown in Fig. 2.

In Fig. 2, CNN has a multi-level structure, and each level includes many neural network layers. The two most important processes in CNN are convolution and pooling, as shown in Fig. 3.

Figure 3 shows the important working layers of CNN with convolutional and pooling layers. Among them, the main function of the convolutional layer is to scale the input parameters, reduce the proportion of input parameters, and improve the computational efficiency of the model. The main role in this process is the convolution kernel in the convolutional layer [13]. The function of the pooling layer is to pool the input parameters; that is, to perform local random screening of the parameters, to eliminate some data in some parameters, to reduce the calculation amount of the parameters, and to reduce the calculation amount of the model as much as possible. Common pooling operations include max pooling and average pooling [14]. These random pools also need to be trained to improve computational performance. The computation of random pooling training is shown in Eq. (9):

$$p_i = \frac{a_i}{\sum_{k \in R_j} (a_k)}$$

9

In Eq. (9), p represents the probability of element pooling; R_j represents the set of input elements; a represents the input elements; i and k represent the sequence of input elements. Then, the elements of the probability are calculated and subjected to a multinomial distribution sampling operation, as shown in Eq. (10):

$$s_i = a_i$$

10

The Softmax classifier is used to optimize the CNN model. The principle is to optimize the model by minimizing the negative log-likelihood function, as shown in Eq. (11):

$$f_\theta(x) = \frac{1}{1 + \exp(-\theta^T x)}$$

11

In Eq. (11), x represents the sample; T represents the training sample sequence; θ is the parameter model. During the training process, θ is trained separately, reducing the computational cost of the model. The calculation of the cost is shown in Eq. (12):

$$C(\theta) = -\frac{1}{m}[(1 - y^i)\log(1 - h_\theta(x^i)) + \sum_{i=1}^{m} y^i \log h_\theta(x^i)]$$

12

In Eq. (12), *x* and *y* represent the sample value; *m* and *h* represent the value parameter of the sample. The calculation of *x* and *y* is shown in Eq. (13):

$$f_\theta(x_i) = \begin{bmatrix} p(y_i = 1 \mid x_i; \theta) \\ p(y_i = 2 \mid x_i; \theta) \\ \cdots \\ p(y_i = n \mid x_i; \theta) \end{bmatrix}$$

13

Then, based on this, the calculation of the cost is optimized as shown in Eq. (14):

$$c(\theta) = -\frac{1}{m}\left[\sum_{i=1}^{m}\sum_{j=1}^{k} 1\left\{ y_i = j\right\} \log \frac{e^{\theta_v^T x_i}}{\sum_{v=1}^{k} e^{\theta_v^T x_i}}\right]$$

14

Eq. (14) uses gradient descent to minimize $c\left(\theta\right)$ and improve the computational effect of the classifier. Then, Eq. (6) is optimized, as shown in Eq. (15):

$$\theta_k=\theta_k-a\nabla_{\theta_k}c\left(\theta\right)$$

15

The parameters have the same meaning as Eq. (15) [15]. After the classifier is used to optimize the CNN, the performance of the Softmax Convolutional Neural Network (SCNN) will be greatly improved. The design uses the optimized deep CNN model SCNN for wireless communication. The efficiency of wireless communication is improved by optimizing the task processing mechanism of wireless communication.

Wireless communication

At present, wireless communication technology has become one of the mainstream technologies in society. Due to the rapid development of information technology, the traffic of wireless transmission has greatly increased. Mobile communication has changed the way people communicate, exchange information, and entertainment [16]. Mobile wireless communication has revolutionized people's daily life. The official estimates of the International Telecommunication Union show that in the next development, the traffic growth of mobile users will reach an unprecedented rapid growth rate of more than 50% per year. Therefore, the capacity and various resources of the wireless network will become the bottleneck restricting the wireless service from dealing with massive users [17, 18]. The main principle of wireless communication is shown in Fig. 4.

In Fig. 4, the development of wireless communication technology has established a huge guarantee for the communication industry. Long Term Evolution (LTE) in unlicensed bands can help utilize the resources of the wireless spectrum more efficiently, providing better services to users. Therefore, it has attracted great attention in wireless communication research. The field of wireless research has introduced several technologies to enable LTE to coexist harmoniously with other mature technologies in the unlicensed spectrum, such as Wi-Fi. However, the wireless environment is inherently uncertain and is an extremely complex heterogeneous network. It changes dynamically and continuously. Users of the network are changed frequently, new networks can be deployed, and running networks can be taken down immediately. In addition, the amount of data each wireless node must transmit and the load on the network vary [19]. The working principle of LTE is shown in Fig. 5.

Figure 5 is the working principle of LTE. Techniques for fair coexistence with different wireless technologies in unlicensed spectrum must consider potential changes in the wireless environment. At present, wireless network communication technology has been greatly developed. Therefore, its current online teaching process has become its main carrier, and its optimization can effectively improve the effectiveness of online teaching and promote the comprehensive development of the online teaching system. Then, activation functions are used to optimize the model further. The activation function layer is often referred to as a nonlinear mapping layer, which is used to improve the entire CNN function model and extract feature capabilities (i.e., nonlinear characteristics). Even if a deep neural network contains many linear operation layers, this deep neural network can still only be used to express linearly mapped functions. It cannot express complex functions [20]. In practical use, various activation functions can be selected. This work uses the Sigmoid activation function, as shown in Eq. (16):

$$\mathrm{Sigmoid}\left(x\right)=\frac{1}{1+\exp(-x)}$$

16

The activation function refers to the characteristics of biological neurons and simulates them mathematically. This function expression takes a set of data and outputs the corresponding result. In the field of neuroscience, biological neurons usually have a fixed value. When the neuron receives an input signal, and the effect of the signal exceeds the fixed value, the biological neuron is activated. Generally, it is called the active neuron state. If it is not activated, it is called the neuron's inhibitory state. Therefore, the role of the activation function is very important [21].

With the rapid development of deep learning, various algorithms of DNN have been gradually applied in the fields of wireless communication and the Internet of Things. In order to be able to adapt to changes in the wireless environment, the advantages of reinforcement learning have been fully demonstrated. LTE is enhanced with deep reinforcement learning techniques to provide reasonable coexistence between co-located LTE and Wi-Fi networks. The optimized wireless communication model is Softmax Convolutional Neural Network- Long Term Evolution (SCNN-LTE). CNN technology is used to optimize wireless communication technology. Then, it is used in the music teaching interactive system to improve the effectiveness of the current online music teaching.

Research design

1) Interactive system for music teaching

The basis of music teaching interaction is the construction of a system, and its concept is interactive teaching. Interactive teaching is an interactive teaching method based on the idea of scaffolding teaching and built on the background of teacher-student dialogue. In the network environment, interactive learning is the "human-machine-human" interaction based on computer multimedia technology and network communication technology. Interactive learning is a teaching system based on computer technology and using interactive teaching and learning methods. Interaction is originally a computer term that refers to the process in which the system receives input from the terminal, processes it, and returns the result to the terminal, that is, a human-machine dialogue. In communication, interaction is the exchange of information between the sender and the receiver. Therefore, there is interaction in various forms of teaching activities. Interaction is one of the most basic characteristics of teaching activities. It's just that in different teaching forms, the ways and characteristics of interaction are quite different. Therefore, it is breakthrough research to optimize the music teaching interactive system by strengthening the wireless communication technology.

2) Setup of research data

The design idea is to optimize the wireless communication technology through CNN to improve the performance of wireless communication and then apply it to the online music teaching interactive system to improve the interactive teaching efficiency between teachers and students. This study is mainly about designing and optimizing the teaching interaction system. Therefore, this study is mainly to optimize the wireless communication technology of CNN and then apply it to the music online teaching interactive system.

Firstly, the CNN model is evaluated for performance. Therefore, the dataset is used to train and evaluate the model. The datasets used are 1. Mixed National Institute of Standards and Technology (MNIST) is a large-scale handwritten digit database collected by the National Institute of Standards and Technology in the United States, containing a training set of 60,000 examples and a test set of 10,000. Each sample is a 28 × 28-pixel grayscale picture of handwritten digits [22]. 2. Canadian Institute for Advanced Research-10 (CIFAR-10) consists of 60,000 32x32 color images in 10 categories. Each class has 6,000 images, 50,000 training images, and 10,000 testing images. The dataset is divided into five training and one testing batch. Each batch has 10,000 images. The test batch contains 1,000 randomly selected images from each class. The training batch contains the remaining images in random order. However, some training batches may contain more images from one class than another. Overall, the sum of the five training sets contains exactly 5,000 images from each class [23]. 3. The Canadian Institute for Advanced Research-100 (CIFAR-100) has 100 categories. Each class has 600 color images of size 32×32. Among them, 500 images are used as the training set, and 100 images are used as the test set. Each image has fine_labels and coarse_labels, which represent the fine-grained and coarse-grained labels of the image, respectively. The CIFAR100 dataset is hierarchical [24].

During the test evaluation process, the model is evaluated by three indicators: recall, precision, and accuracy [25]. Among them, the calculation of recall and precision rate is shown in Eqs. (17), (18), and (19):

$$recall = \frac{tp}{tp + fn}$$

17

$$precision = \frac{tp}{tp + fp}$$

18

$$accuracy = \frac{tp + tn}{tp + fp + tn + fn}$$

19

The specific meanings of *tp*, *fp*, *tn*, *fn* are: 1) $tp + fn$ represents the actual number of correct samples. 2) $tp + fp$ represents the total number of correct samples for the prediction result. 3) $tp + tn$ represents the actual number of error samples. 4) $tn + fn$ represents the total number of wrong samples [26].

Results

Performance Evaluation of CNN Models

At present, the performance of the CNN model has been greatly improved. Through the Softmax classifier, the CNN model has been optimized, further improving its performance of the CNN model. Then, the designed model is compared with the traditional CNN model and the Visual Geometry Group (VGG) Net model. The performance evaluation results of the SCNN model are shown in Fig. 6.

In Fig. 6, in the training and evaluation of the three datasets, the recall value of the CNN model is around 0.7–0.8; the precision is around 0.6–0.8; the recall value of the VGGNet model is around 0.8–0.9; the precision is around 0.7–0.8. Here, the recall value of the designed SCNN model is around 0.9-1.0, and the precision value is around 0.8–0.9. The comprehensive performance of the designed model has more advantages than other models and is more applicable.

Performance evaluation of the SCNN-LTE model

This study optimizes wireless communication technology based on designing the model of SCNN, thereby improving the comprehensive performance of wireless communication technology. Then, wireless communication technology is applied to the online music teaching interactive system to improve the interaction effect between teachers and students in the process of online music teaching. Therefore, the SCNN model is used to optimize the LTE in wireless communication technology, and the wireless communication SCNN-LTE model is designed. The evaluation results of the performance of the SCNN-LTE model are shown in Fig. 7.

In Fig. 7, the performance of the SCNN-LTE model during wireless communication is evaluated. The results show that the evaluation accuracy of the CNN-LTE model is generally between 0.7–0.8, and the accuracy of the LTE model is generally around 0.8. The accuracy of the designed SCNN-LTE model is generally between 0.7–0.9. Therefore, the designed model optimizes the wireless communication technology well and can effectively improve the performance of the wireless communication technology.

Conclusion

At present, a variety of science and technology has provided great impetus for social development. Due to the impact of COVID-19, online teaching has also become the current mainstream teaching method. Therefore, CNN technology and edge-cloud computing is used to optimize the wireless communication technology and apply it to the music online teaching interactive system to improve the efficiency of music online teaching. Firstly, the CNN technology is deeply analyzed, and the SCNN model is optimized. Then, the SCNN-LTE model for CNN optimization for wireless communication technology is designed. Finally, the SCNN-LTE model is applied to the online music teaching interactive system, and the model is evaluated comprehensively. The results show that, firstly, the recall value of the designed SCNN model is around 0.9-1.0, and the precision value is around 0.8–0.9. Secondly, the accuracy of the designed wireless communication SCNN-LTE model is generally between 0.7–0.9. The designed SCNN model not only optimizes the wireless communication technology but also applies it to the wireless communication technology. The overall performance of the model is very good. Therefore, the wireless communication model can better optimize the online music teaching interactive system. This study designs a better model and comprehensively evaluates the model. The effectiveness of the model in practical applications has not been evaluated. Therefore, in the future, the comprehensive effect of online music teaching will be improved.

Declarations

Ethical Approval

Not Applicable.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' contribution

NZ contributed to the data collection, and wrote the manuscript and manuscript edits.

Acknowledgements

This work was funded by "Family and country feelings" and "regional characteristics" blend "Hunan Music History" offline golden course construction (host) (research project on teaching reform in general colleges and universities in Hunan Province) (No. HNJG-2020-0726).

References

1. M. M. Khan, S. M. T. Rahman, S. T. A. Islam. “Online education system in Bangladesh during COVID-19 pandemic,” *Creative Education,* vol. 12, no. 2, pp. 441-452, 2021.
2. T. Kattenborn, J. Leitloff, F. Schiefer et al., “Review on Convolutional Neural Networks (CNN) in vegetation remote sensing,” *ISPRS Journal of Photogrammetry and Remote Sensing,* vol. 173, no. 2,

pp. 24-49, 2021.

3. N. Ivanytska, N. Tymoshchuk, L. Dovhan et al., “Effectiveness of digital resources in the learning management system within online education of future entrepreneurs,” *Journal of Entrepreneurship Education,* vol. 24, no. 4, pp. 1-8, 2021.
4. A. Juneja, S. Juneja, V. Bali et al., “Multi-criterion decision making for wireless communication technologies adoption in IoT,” *International Journal of System Dynamics Applications (IJSDA),* vol. 10, no. 1, pp. 1-15, 2021.
5. S. Sony, K. Dunphy, A. Sadhu et al., “A systematic review of convolutional neural network-based structural condition assessment techniques,” *Engineering Structures,* vol. 226, no. 3, pp. 111347, 2021.
6. M. Raghu, T. Unterthiner, S. Kornblith et al., “Do vision transformers see like convolutional neural networks?,” *Advances in Neural Information Processing Systems,* vol. 34, no. 12, pp. 12116-12128, 2021.
7. Y. D. Zhang, S. C. Satapathy, D. S. Guttery et al., “Improved breast cancer classification through combining graph convolutional network and convolutional neural network,” *Information Processing & Management,* vol. 58, no. 2, pp. 102439, 2021.
8. M. Tripathi. “Analysis of convolutional neural network based image classification techniques,” *Journal of Innovative Image Processing (JIIP),* vol. 3, no. 2, pp. 100-117, 2021.
9. M. Niu, Y. Lin, Q. Zou. “sgRNACNN: identifying sgRNA on-target activity in four crops using ensembles of convolutional neural networks,” *Plant molecular biology,* vol. 105, no. 4, pp. 483-495, 2021.
10. T. M. Ghazal. “Convolutional neural network based intelligent handwritten document recognition,” *Computers, Materials & Continua,* vol. 70, no. 3, pp. 4563-4581, 2022.
11. Y. Xu and T. T. Qiu. “Human activity recognition and embedded application based on convolutional neural network,” *Journal of Artificial Intelligence and Technology,* vol. 1, no. 1, pp. 51-60, 2021.
12. Z. Zhang, J. Tian, W. Huang et al., “A haze prediction method based on one-dimensional convolutional neural network,” *Atmosphere,* vol. 12, no. 10, pp. 1327, 2021.
13. H. Song and C. E. Montenegro-Marin. “Secure prediction and assessment of sports injuries using deep learning based convolutional neural network,” *Journal of Ambient Intelligence and Humanized Computing,* vol. 12, no. 3, pp. 3399-3410, 2021.
14. H. Yu, L. T. Yang, Q. Zhang et al., “Convolutional neural networks for medical image analysis: state-of-the-art, comparisons, improvement and perspectives,” *Neurocomputing,* vol. 444, no. 9, pp. 92-110, 2021.
15. A. Pesah, M. Cerezo, S. Wang et al., “Absence of barren plateaus in quantum convolutional neural networks,” *Physical Review X*, vol. 11, no. 4, pp. 041011, 2021.
16. W. Hong, Z. H. Jiang, C. Yu et al., “The role of millimeter-wave technologies in 5G/6G wireless communications,” *IEEE Journal of Microwaves,* vol. 1, no. 1, pp. 101-122, 2021.

17. O. Elijah, S. K. A. Rahim, V. Sittakul et al., “Effect of weather condition on LoRa IoT communication technology in a tropical region: Malaysia,” *IEEE Access,* vol. 9, no. 4, pp. 72835-72843, 2021.
18. Rongrong Luo, Jing Wang, "Interactive Landscape Design and Application Effect Evaluation of Community Sports Park by Wireless Communication Technology", Wireless Communications and Mobile Computing, vol. 2022, Article ID 9334823, 11 pages, 2022. https://doi.org/10.1155/2022/9334823
19. P. Zhang, M. Peng, S. Cui et al., “Theory and techniques for “intellicise” wireless networks,” *Frontiers of Information Technology & Electronic Engineering,* vol. 23, no. 1, pp. 1-4, 2022.
20. S. Arai, M. Kinoshita, T. Yamazato. “Optical wireless communication: A candidate 6G technology?,” *IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences,* vol. 104, no. 1, pp. 227-234, 2021.
21. B. Liu, Z. Su, Q. Xu. “Game theoretical secure wireless communication for UAV-assisted vehicular Internet of Things,” *China Communications,* vol. 18, no. 7, pp. 147-157, 2021.
22. J. Nikolić, Z. Perić, D. Aleksić et al., “Whether the support region of three-bit uniform quantizer has a strong impact on post-training quantization for MNIST dataset?,” *Entropy,* vol. 23, no. 12, pp. 1699, 2021.
23. A. K. Sharma, A. Rana, K. K. Kim. “Lightweight image classifier for CIFAR-10,” *Journal of Sensor Science and Technology,* vol. 30, no. 5, pp. 286-289, 2021.
24. R. Fonseca, O. Guarnizo, D. Suntaxi et al., “Convolutional Neural Network Feature Extraction Using Covariance Tensor Decomposition,” *IEEE Access,* vol. 9, no. 4, pp. 66646-66660, 2021.
25. S. B. Larsen, C. J. Cowley, S. M. Sajjath et al., “Establishment, maintenance, and recall of inflammatory memory,” *Cell stem cell,* vol. 28, no. 10, pp. 1758-1774. e8, 2021.
26. M. T. Schenker, L. J. Ney, L. N. Miller et al., “Sleep and fear conditioning, extinction learning and extinction recall: a systematic review and meta-analysis of polysomnographic findings,” *Sleep medicine reviews,* vol. 59, no. 7, pp. 101501, 2021.

Figures

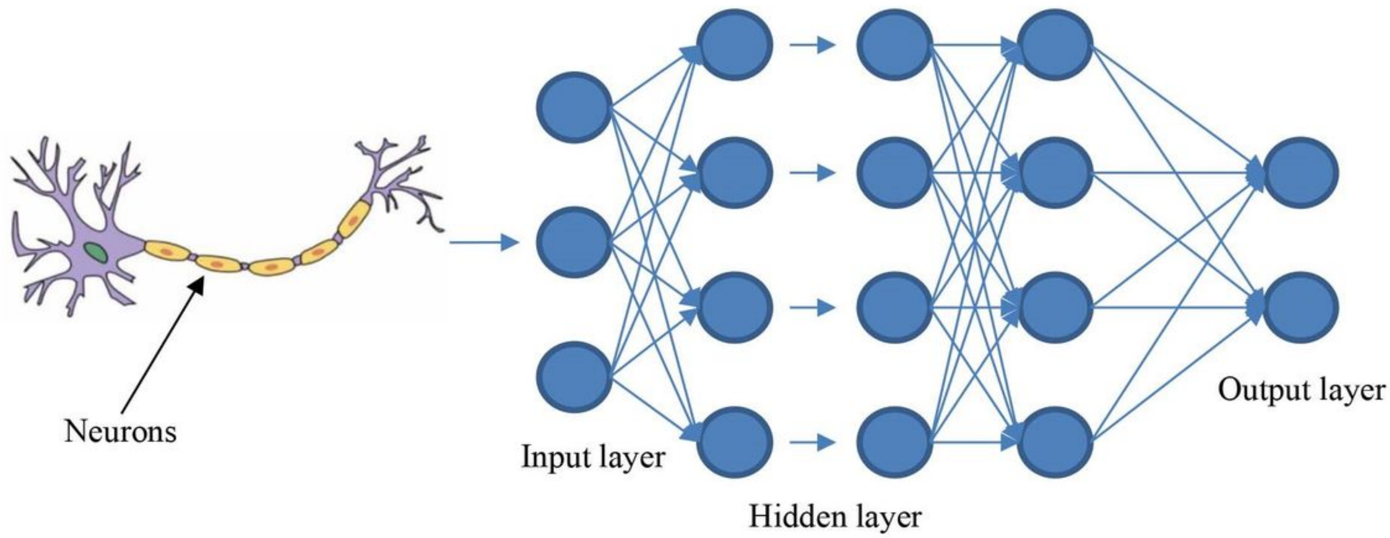

Figure 1

Source and structure of deep learning techniques

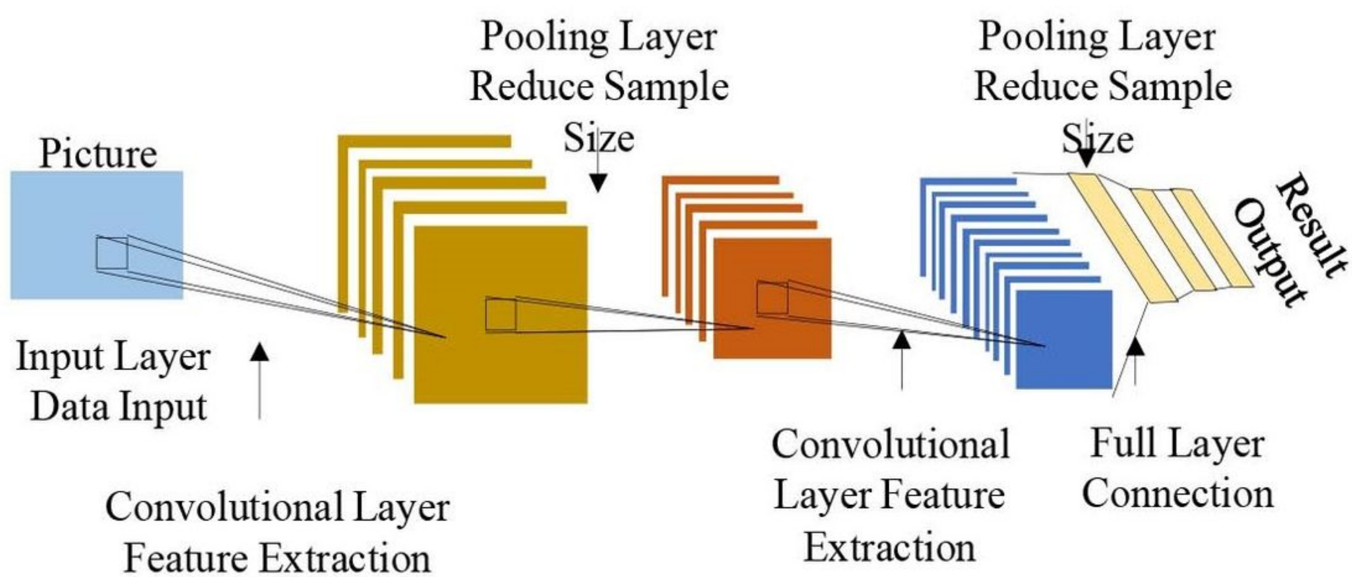

Figure 2

The main structure of CNN technology

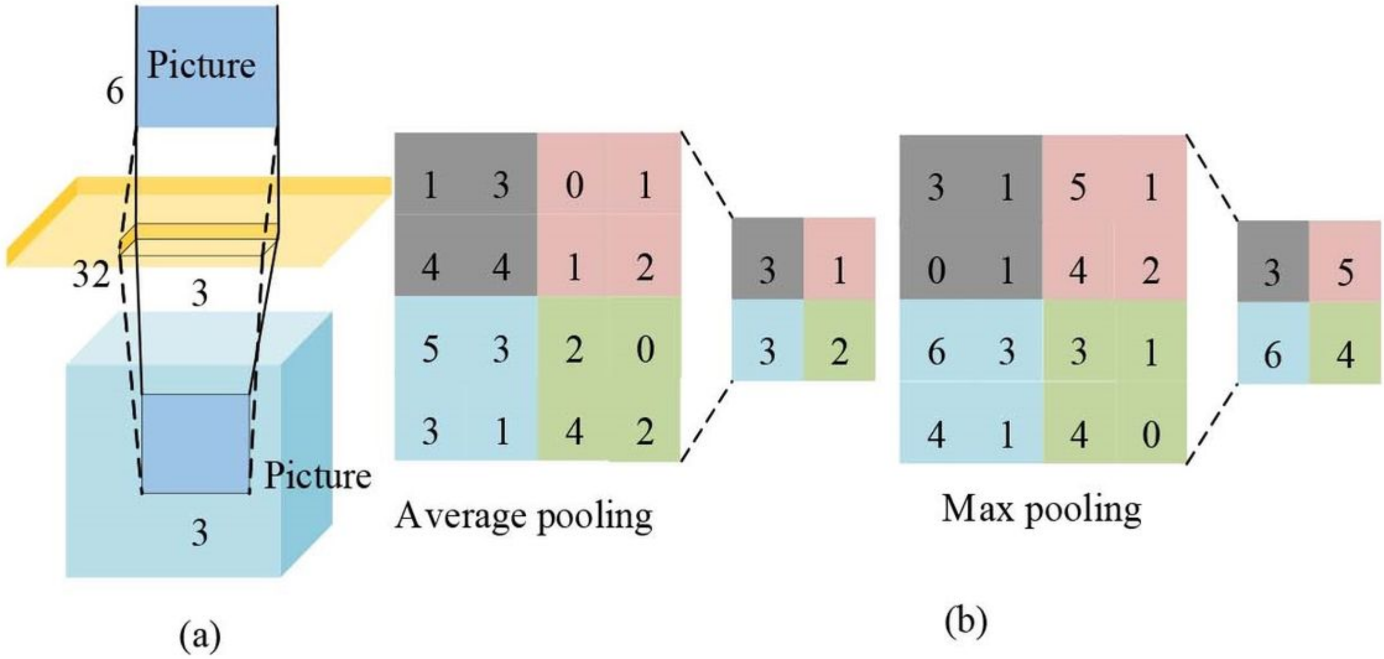

Figure 3

Convolution process and pooling process (a is the convolution process; b is the pooling process)

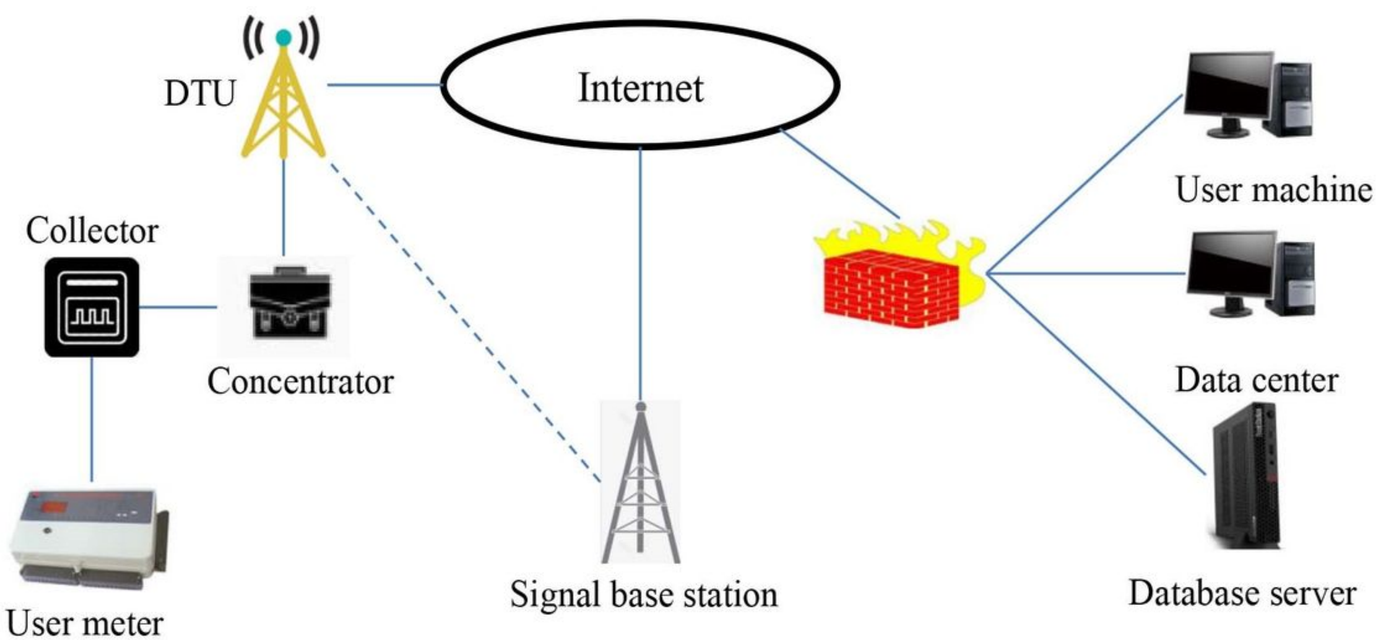

Figure 4

The principle of wireless communication

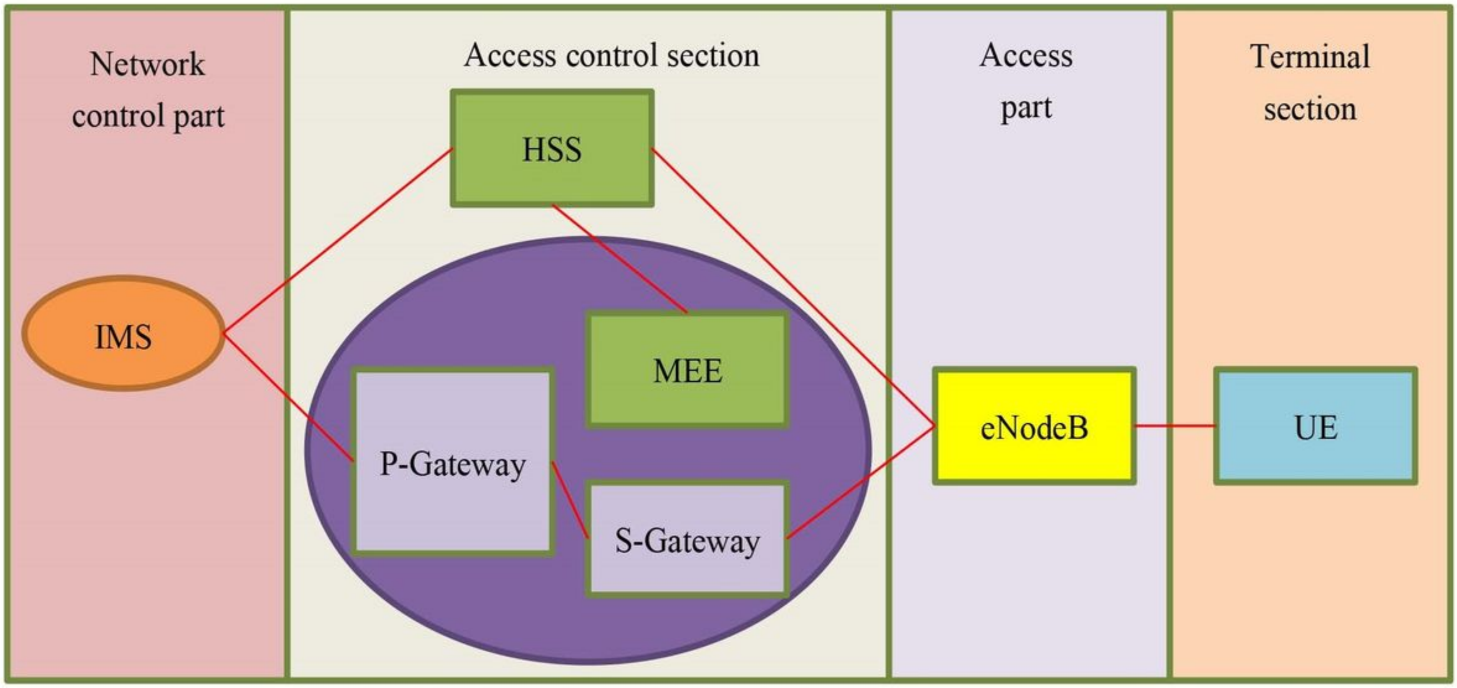

Figure 5

LTE working principle

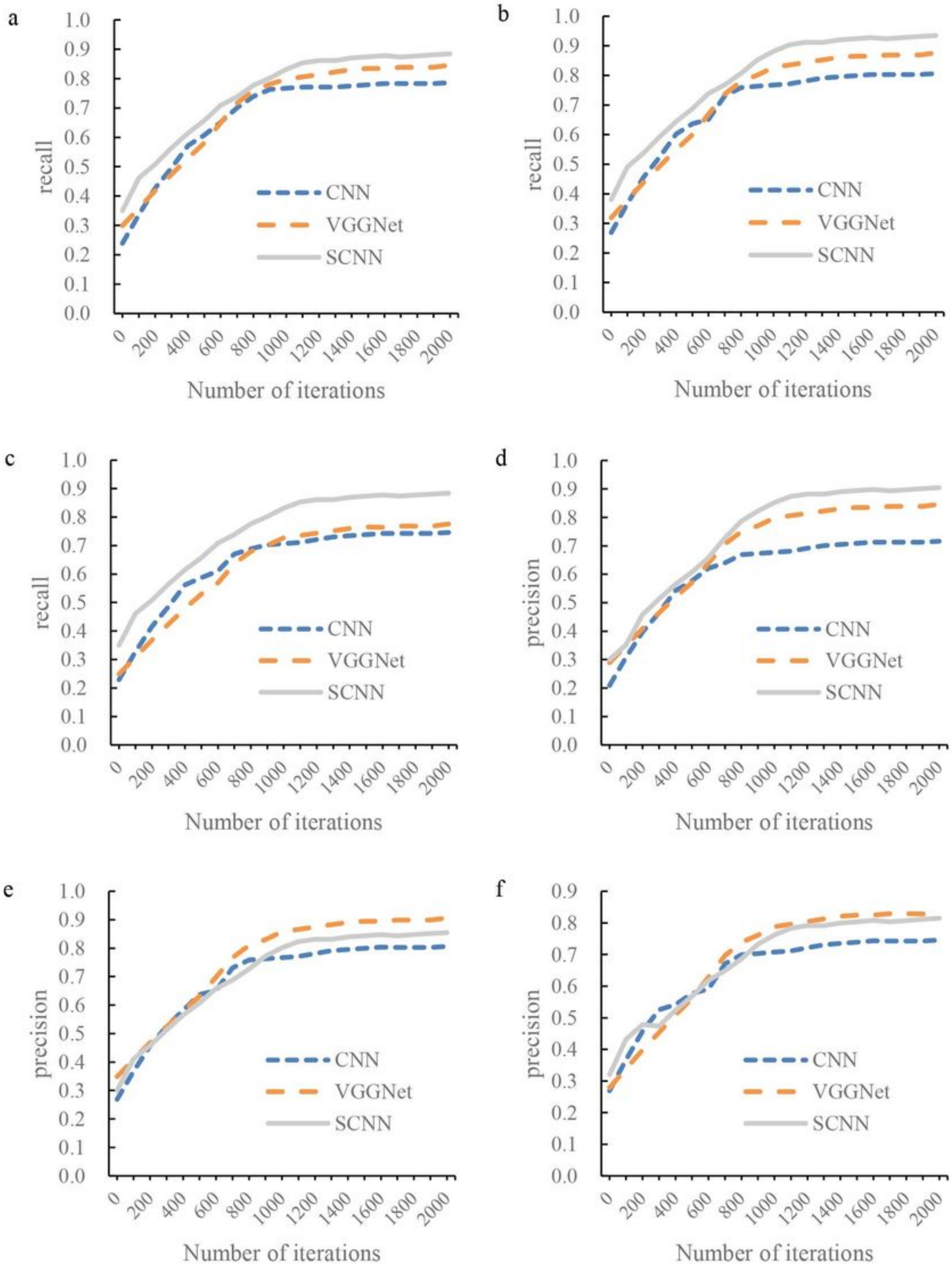

Figure 6

Evaluation results of the performance of the SCNN model (a, d is the MNIST dataset; b, e is the CIFAR-10 dataset; c, f is the CIFAR-100 dataset)

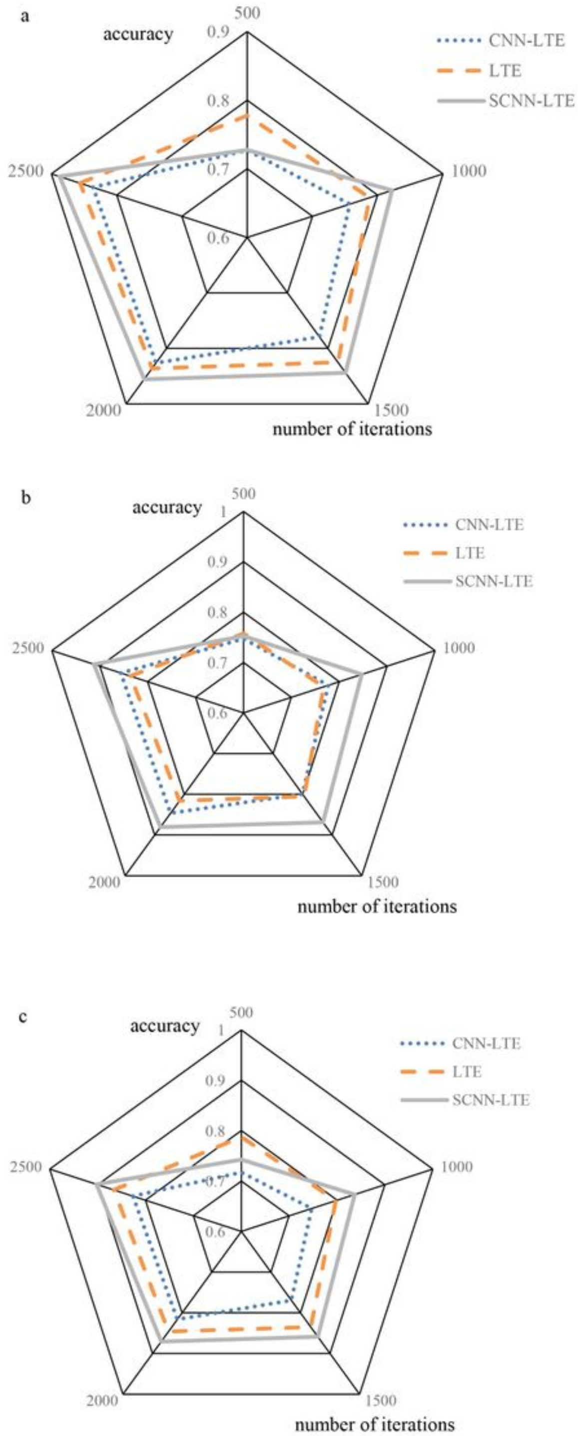

Figure 7

Evaluation results of SCNN-LTE model performance (a is MNIST dataset, b is CIFAR-10 dataset, c is CIFAR-100 dataset)