Construction and Application of Interactive Teaching Platform for Landscape Architecture Design based on Computer-Aided Virtual Reality Technology

Yijie Deng[1*] and Lei Zhou[2]

[1]College of Design, Zhoukou Normal University, Zhoukou 466000, China, 20102008@zknu.edu.cn
[2]College of Design, Zhoukou Normal University, Zhoukou 466000, China, 20061046@zknu.edu.cn

Corresponding author: Yijie Deng, 20102008@zknu.edu.cn

Abstract. The teaching mode of landscape architecture is different from the teaching method of traditional subjects, it mainly needs to reflect the concept of landscape architecture content. The computer-aided design (CAD) method has been widely used in many disciplines, and it can display the courseware content vividly. It is also a way to increase student's interest in learning and classroom interactivity. Virtual reality (VR) methods can also be a good way to present the content of landscape architecture to students and teachers. The teaching content of landscape architecture is a teaching method that contains more pattern information and color information, which is very different from traditional subjects. The traditional teaching methods can no longer be applied to the teaching of landscape architecture. This research uses CAD technology and VR method to carry out systematic design and related research on the teaching interactive classroom of landscape architecture. In order to improve the interactivity of landscape architecture classroom, this study effectively combines neural network method with CAD technology. The research results show that CAD technology and VR method can improve the efficiency and interactivity of landscape architecture teaching classroom. The neural network method also has good feasibility and accuracy in the teaching classroom of landscape architecture.

Keywords: Landscape Architecture Design; Computer-Aided Design; Deep Learning; Virtual Reality
DOI: https://doi.org/10.14733/cadaps.2023.S1.35-45

1 INTRODUCTION

The teaching content of landscape architecture will include characteristic information such as the pattern, color and layout of the landscape, which is very different from the content of traditional Chinese mathematics. There is also a big difference between the teaching mode of landscape architecture and the traditional discipline. The teaching of traditional subjects will be taught in the way of courseware or blackboard, which requires students to memorize and understand knowledge. However, the classroom of landscape architecture requires less theoretical knowledge to memorize, and it mainly requires students to understand the connotative knowledge of landscape architecture. If the traditional teaching methods are used to teach students the knowledge of landscape architecture, the students will only learn the theoretical knowledge of landscape architecture better. This is also not a good guide for students in the layout and design of landscape gardens. The design of landscape architecture has a great relationship with the layout of the city and economic factors. At the same time, the patterns and colors of landscape architecture teaching content cannot be understood through traditional teaching methods. Courseware is a popular teaching method, but it can only teach the knowledge process of landscape architecture in the form of pictures or videos. This approach also limits students' interest in learning and the interactivity of the classroom. This makes it difficult to ensure that students truly understand the content of landscape architecture teaching.

With the improvement of computer performance and the continuous progress of hardware equipment, CAD technology has been widely used in teaching classrooms [1]. CAD technology can display the courseware content in the form of pictures or videos, and the teaching content can come from information on the Internet. This method can solve the learning of pattern information and color information in landscape architecture teaching classroom. However, the teaching of landscape architecture is also a three-dimensional teaching mode. Landscape architecture is not only a separate art, it also has a relatively large relationship with the surrounding environment layout [2]. VR technology is a teaching mode that can convert the knowledge of landscape architecture into three-dimensional mode. VR technology allows students to perceive the real environment, and it can also achieve interaction with students. VR technology is a method that integrates computer graphics technology, human-machine interface technology and sensing technology. It can integrate the content of landscape architecture and environmental factors, and it will be displayed to students in a three-dimensional way. This way enhances the authenticity and fidelity of the content, and it also allows students to interact with the VR interface. The application of VR technology in the teaching field is relatively small, which mainly depends on the small necessity of expensive cost. However, VR technology is a necessary technology in the teaching mode of landscape architecture, which can improve students' learning interest and classroom feedback. At the same time, in order to solve the problem of the interactive nature of landscape architecture classroom and the real-time nature of teaching content, this study uses neural network method to study the relevant characteristics of landscape architecture teaching content. This research will use CAD technology and VR technology to display the teaching content of landscape architecture in a three-dimensional real environment for learning. This method can realize the interaction between landscape architecture teaching and students. At the same time, the neural network method is used to learn more real-time landscape architecture related content, which is then fed back to the landscape architecture teaching classroom.

2 RELATED STUDIES

The teaching mode of landscape architecture is also one of the research hotspots, and many researchers have done a lot of research. Huang [3] believed that the advent of the digital age has changed the paradigm of landscape design and planning, it can help designers provide more imagination. This paper uses CAD technology and VR technology to conduct related research on

urban landscape design and planning, which can help landscape designers to conduct in-depth inspection of design schemes. VR technology can assist designers to adjust the scheme. The results of the study show that CAD technology and VR technology can improve the scheme and imagination in the field of landscape design. Li et al. [4] has found that computer virtual reality technology can improve efficiency in the teaching of landscape design. It uses SketchUp virtual modeling software and virtual reality technology to investigate and analyze the relevant factors of landscape design in teaching. It has introduced the application status and feasibility of computer-aided systems and VR technology in college teaching. The research results show that CAD technology and VR technology can improve the teaching efficiency of landscape design, it can enhance students understanding of building and vegetation layout and design. Luo et al. [5] has applied computer stereoscopic simulation software to urban landscape design tasks. It uses the surface calculation method and texture resource calculation method of the computer system to complete the modeling task of urban landscape design. It also verifies the accuracy of the 3D model based on the landscape percentage, patch index, etc. of the urban landscape layout. The results show that the accuracy and convergence speed of the computer system and model can meet the design task of urban landscape. Li and Xu [6] has designed a three-dimensional imaging technology of landscape architecture according to the problems existing in the process of landscape architecture simulation design, which is completed based on virtual reality technology. This method ensures that the coordinates of the landscape garden and features such as layout and imagery are well correlated. The research results show that VR technology and computer three-dimensional imaging technology can better complete the reconstruction task of landscape architecture, and it also has certain advantages. Zhao [7] applies computer VR technology to landscape design tasks, and it also analyzes the difference between VR and VR-GIS in landscape design. Research has found that the application of computer and VR technology has good stability in landscape design, and the modeling error is basically between 1-3%.

The landscape architecture teaching system will involve features such as pattern features, color features, and layout. The traditional teaching mode is difficult for students to learn the concepts of these features. However, through the above literature review, it can be seen that very few studies use CAD technology and VR technology to design landscape architecture teaching interactive system. This research uses CAD technology and VR technology to design a landscape architecture teaching interactive system, and it also uses neural network method to study the relevant factors of landscape architecture teaching. This research is mainly divided into 5 sections. Section 1 mainly introduces the defects of landscape architecture teaching mode and the advantages of CAD technology in the teaching system. The research status of landscape architecture teaching mode is introduced in Section 2. The third section mainly introduces the application of CAD technology in landscape architecture teaching interactive system, it also introduces the application of neural network method in landscape architecture teaching system. The fourth section mainly analyzes the predictability and accuracy of the relevant factors of landscape architecture teaching, which is also a key part of the entire landscape architecture teaching interactive system. The fifth part summarizes the full text.

3 APPLICATION DESIGN OF CAD AND VR TECHNOLOGY IN LANDSCAPE ARCHITECTURE TEACHING SYSTEM

3.1 Introduction to the Design of Teaching Interactive System

CAD technology has been widely used in teaching tasks in many disciplines. It can well display the teaching content, and it can also improve students' interest and enthusiasm in learning [8]. VR technology is a three-dimensional interactive method. If VR technology is applied in the teaching system, it will allow students to experience the teaching content more realistically. This research combines CAD technology and VR technology, which will be applied in the landscape architecture teaching interactive system [9]. The landscape architecture teaching interactive system will

include two processes. In the first process, it needs to use the neural network method to effectively extract the pattern features, color features and layout features of landscape architecture [10]. CAD technology and VR technology will make full use of these features to reconstruct the three-dimensional teaching model. After VR technology reconstructs the relevant features in the landscape architecture teaching classroom, these three-dimensional landscape architecture teaching contents will be displayed to students or teachers through CAD technology. This landscape architecture teaching interactive system will make full use of the advantages of CAD technology and VR technology, and it also makes use of the advantages of neural network methods in extracting features.

The Figure 1 shows the design method of landscape architecture teaching interactive system. In the daily teaching tasks of landscape architecture, teachers will directly use the training interactive system. Teachers can directly input the courseware content into the CAD teaching interactive system, and it will automatically complete the feature extraction process of the landscape architecture courseware content, which will display the corresponding content to the students through CAD technology. In the design stage of the landscape architecture teaching interactive system, many parameters and data issues need to be considered. As can be seen from Figure 1, the first step in the design of an instructional interaction system is to collect many data sets. The corresponding software of the CAD teaching interaction system will learn the relationship between these data sets using the neural network method, which is also preparation for the VR technology to reconstruct the three-dimensional content of the landscape. More data-sets will improve the accuracy of VR reconstruction of 3D content of landscape architecture, because it can provide more feature support for VR technology.

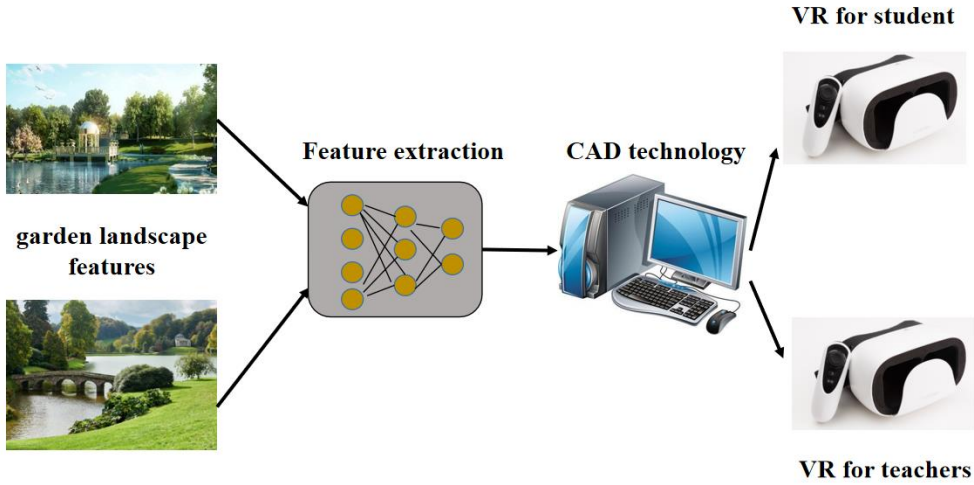

Figure 1: The design method of landscape architecture teaching interactive system.

As shown in Figure 1, this study selects the relevant data of a variety of different types of landscape architecture, which can ensure the accuracy of VR technology to reconstruct the teaching content of landscape architecture. If the amount of data is small, this leads to the poor generalization ability of VR technology reconstruction. After the neural network technology has extracted the pattern, color and layout features of the teaching content of landscape architecture, the data will be entered into the computer processing terminal of VR technology to carry out the reconstruction task. After the VR technology completes the reconstruction task of the landscape architecture teaching content, the CAD system will receive the three-dimensional landscape architecture teaching content. Students or teachers will learn related content of landscape architecture through CAD technology, and students or teachers can also achieve interactive

learning with VR technology. This kind of landscape architecture teaching interactive system will improve students' interest in learning, which can also ensure the richness of the teaching content of landscape architecture courses.

3.2 The Introduction of Neural Network Algorithms in Landscape Architecture Teaching System

The first link of the landscape architecture teaching interactive system is to use the neural network method to extract the pattern, color and layout features of the landscape architecture teaching content. Landscape architecture is not only related to these three factors, this study only selected three more important correlations to study. The patterns and color characteristics of landscape gardens will change greatly with the change of time and the changes of people's aesthetic ability. Similarly, the layout characteristics of landscape gardens will vary greatly with changes in policies. When performing the feature extraction task of landscape architecture teaching content, it can not only extract the spatial features of landscape architecture, it also needs to extract the temporal features of landscape architecture. Only in this way can the accuracy of landscape feature extraction be ensured. Therefore, this study selected the ConvLSTM algorithm to extract the spatial and temporal features of landscape architecture after comprehensive consideration.

There are many types of neural network methods, which can deal with both spatial and temporal features. With the rapid development of computer algorithms, it has also appeared algorithms that can deal with environmental factors. Long short-term memory recurrent neural network has relatively good advantages in dealing with temporal features, but it has certain defects in dealing with spatial features. The ConvLSTM algorithm combines the advantages of the convolutional neural network and the LSTM algorithm well, and it can handle the spatiotemporal characteristics of the research object well. The difference between the ConvLSYM method and the LSTM method is that it can perform convolution operations, so it can simultaneously process the temporal and spatial features of the research object.

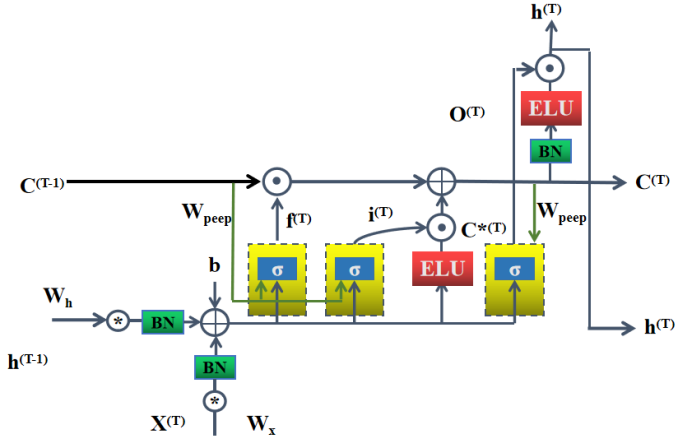

Figure 2: The ConvLSTM algorithm of Landscape Architecture Teaching System.

This study introduces the workflow of the ConvLSTM algorithm in order to more intuitively demonstrate its excellent performance in processing temporal and spatial features. The Figure 2 shows the ConvLSTM algorithm of landscape architecture teaching system. The ConvLSTM algorithm can memorize historical state information, and its input data will contain historical state data and current state data. It mainly includes four gate structures: forget gate, input gate, refresh gate and output gate. The forget gate will selectively forget historical information, and it will give greater weight to the data with more important information. However, the historical state

information with small weights is forgotten. The output gate also selectively outputs historical state information and current state information. The input form required by the ConvLSTM algorithm is a time series. However, the input form required by CNN requires data with labels, which is the difference between the two. Therefore, this study processes the pattern features, color features, and layout feature data of landscape architecture into the form of time series, which will be sent to the input layer of ConvLSTM.

3.3 The Processing Process of Landscape Architecture Teaching Data

In the design of CAD-assisted landscape architecture teaching interaction system, the output data of ConvLSTM algorithm is crucial. It directly affects the accuracy of VR technology to reconstruct the three-dimensional teaching content of landscape architecture, which can also be directly reflected to students or teachers through CAD technology. In the training phase of the ConvLSTM algorithm, data cleaning and data preprocessing are more important. There are relatively large differences in the numerical values of pattern characteristics, color characteristics and layout characteristics of landscape architecture teaching content. At the same time, in order to ensure the accuracy of the teaching content of landscape architecture reconstructed by VR technology, this research selects the data of various types of landscape architecture. This can easily lead to missing data. Data cleaning can solve the problem of missing data in the process of landscape architecture data collection. Figure 3 shows the workflow of data cleaning. It can supplement the missing data with 0, which can ensure that the convolution operation of the ConvLSTM algorithm will not generate errors. Similarly, the pattern features and layout features of landscape gardens are quite different, both in the magnitude of the value and the form of the value. This requires a data preprocessing workflow. The preprocessing of the data is to use the normalization algorithm to unify the related data of the pattern features, color features and layout features of the landscape garden in the same interval, and it will also conform to the same distribution.

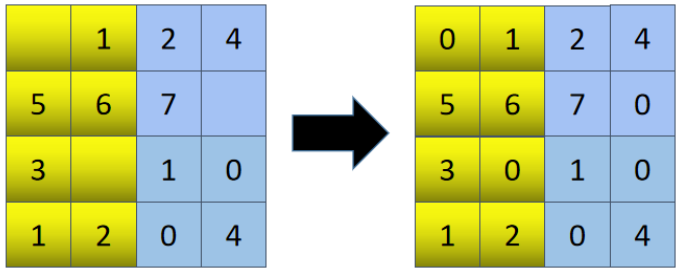

Figure 3: The schematic diagram of data cleaning.

4 RESULTS AND DISCUSSION

4.1 The Accuracy of Feature Prediction in Landscape Architecture Teaching

The accuracy of ConvLSTM in predicting the teaching content of landscape architecture will affect the effect of VR technology to reconstruct the 3D physical content of landscape architecture, which will also affect students experience of CAD-assisted teaching content. Only by accurately predicting the relevant characteristics of the teaching content of landscape architecture, students or teachers will have a better experience with the CAD-assisted teaching system.

Figure 4 shows the layout hotspot distribution of landscape architecture teaching content. In general, the layout distribution of landscape gardens is in good agreement with the actual layout distribution. This prediction effect is also more in line with the actual design scheme of landscape

garden layout. In the fringe areas of the landscape garden layout plan, more landscape settings are distributed here, while in the central area there are fewer landscapes. This shows that the ConvLSTM algorithm has well learned the basic characteristics of landscape architecture layout, which is also conducive to VR technology to complete the reconstruction of the three-dimensional effect of landscape architecture teaching content. A more accurate prediction effect will also ensure students experience of CAD-assisted landscape architecture teaching content. The distribution of the landscape garden layout in Figure 4 can illustrate that the ConvLSTM algorithm completes the prediction task of the basic layout.

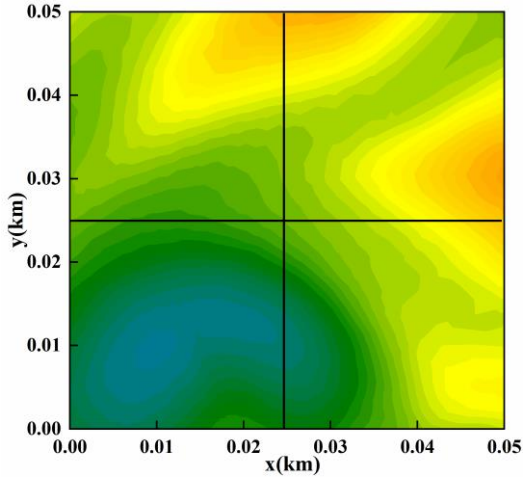

Figure 4: The hot spot distribution of landscape garden layout.

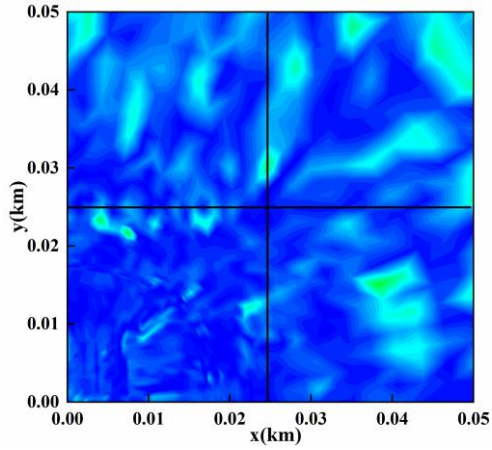

Figure 5: The error distribution of landscape architecture pattern features.

The prediction error distribution map can more intuitively display the error distribution and data values of each region. The Figure 5 shows the error distribution of landscape architecture pattern features. Dark blue areas represent prediction errors within 2%. It can be seen that the pattern prediction error of landscape gardens in most areas is within 2%. The prediction error of pattern features has a certain in-homogeneity, which may be caused by the in-homogeneous distribution of landscape gardens. Larger prediction errors appear in the edge areas of the landscape architecture layout, which may be due to the presence of more feature distributions in this part of

the area. This can also be seen through the hotspot distribution map of the landscape garden layout. Overall, all prediction errors of landscape garden patterns are within an acceptable range. This shows that the ConvLSTM method can effectively extract the pattern features of landscape architecture, which is also beneficial to the reconstruction task of VR technology. For the landscape architecture teaching classroom, the pattern feature is a key part of the feature. This part of the prediction error is convincing enough for the landscape architecture teaching classroom.

4.2 The Statistical Parameters of Landscape Architecture Teaching System

In this study, the pattern features, layout features and color features of the teaching content of landscape architecture were selected for prediction research. Figure 6 shows the predicted values of landscape architecture color features at different times. Among them, the black line represents the actual color feature value, and the blue line represents the predicted color feature value. In general, the predicted values of color eigenvalues in landscape architecture teaching are in good agreement with the actual color eigenvalues. Although there is a certain gradient of change in the color eigenvalues of landscape architecture at different times, the ConvLSTM method also predicts the change gradient of the color eigenvalues well. There are many errors in the fluctuations and troughs of the color eigenvalues of landscape architecture, but this error value is also acceptable for the teaching system of landscape architecture. For most of the color feature values of landscape gardens, the actual value will be greater than the predicted value, and only a few predicted values are greater than the actual color feature value. The prediction accuracy of the color feature value of landscape architecture enables VR technology to have enough information to complete the task of reconstructing the color feature of landscape architecture. For the CAD-assisted landscape architecture teaching system, color is a relatively intuitive feature for students. The prediction accuracy of color features will directly affect students' understanding of landscape architecture. This part of the error is sufficient for students to theorize landscape architecture.

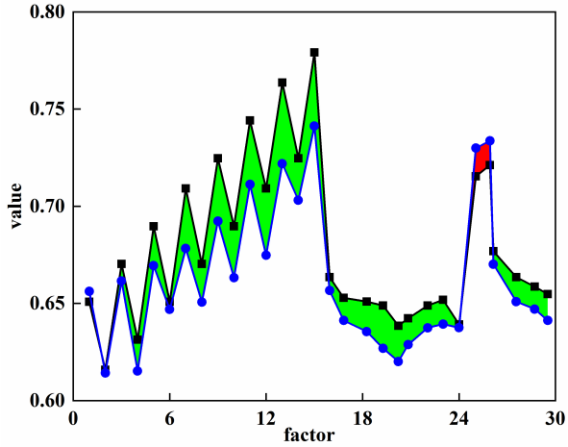

Figure 6: The prediction error distribution of landscape architecture color characteristics.

Figure 7 shows the predicted distributions of three eigenvalues of landscape architecture teaching content. In general, the prediction errors of the three characteristics of landscape architecture are all within 2.14%, which is a relatively good prediction error. The largest prediction error is only 2.14%, and this part of the prediction is mainly derived from the prediction of the pattern features of landscape architecture. There are many patterns in landscape architecture, which can easily lead to more prediction errors. The smallest prediction error is only 1.67%, and this part of the error comes from the prediction of the layout characteristics of landscape architecture teaching.

The prediction error of the color feature of landscape architecture teaching is only 1.93%. These three parts of the prediction error are sufficient for the CAD-assisted landscape architecture teaching system.

Figure 8 shows the linear correlation coefficient plot of the color features and pattern features of the landscape architecture teaching content. The blue part represents the predicted distribution of color features, and the red part represents the predicted situation of the pattern features of landscape architecture. In general, it has a good linear correlation whether it is the color characteristics or pattern characteristics of landscape architecture. The data points of the color feature of the landscape architecture are well distributed on both sides of the linear function. However, there are some data points far from the two sides of the linear function in the pattern features of landscape architecture teaching, which are relatively large data points. However, the error of the pattern features of landscape architecture teaching is also within an acceptable range.

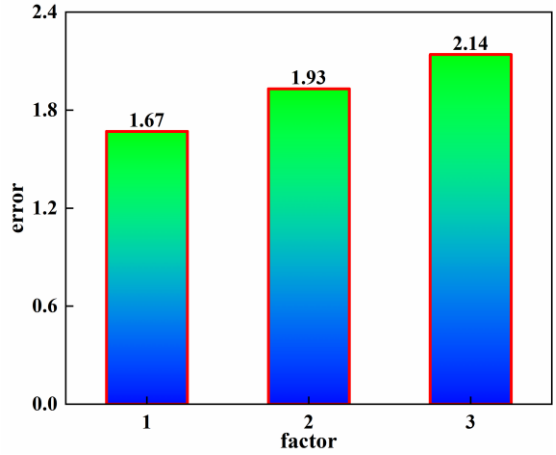

Figure 7: The prediction errors of three characteristics of landscape architecture teaching.

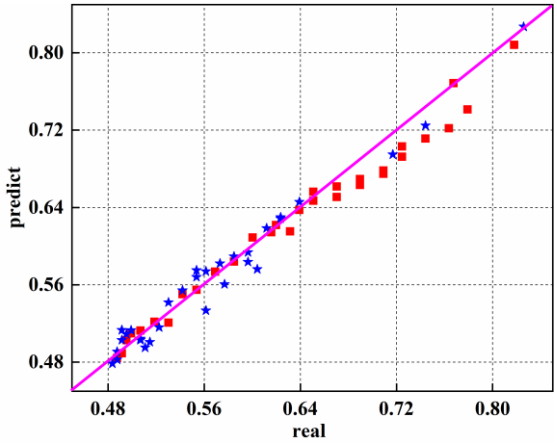

Figure 8: The linear correlation of predicted values of landscape architecture features.

5 CONCLUSION

The teaching content of landscape architecture is quite different from that of traditional subjects. And the teaching content of landscape architecture is not only the content that needs to be memorized, it also has some design connotations that need to be understood. The traditional teaching mode can no longer satisfy the teaching method of landscape architecture. CAD technology has been widely used in teaching tasks in many disciplines. VR technology can reflect the teaching content in a more intuitive and vivid way. This research combines CAD technology and VR technology, it will realize the realization of CAD-assisted landscape architecture teaching interactive system. In order to better extract the pattern, color and layout features of landscape architecture, this study uses the ConvLSTM neural network technology to extract the features in landscape architecture teaching. In general, the ConvLSTM method can well extract the pattern, color and layout features of landscape architecture teaching. The largest prediction error is only 2.14%, and this part of the error comes from the predicted value of landscape garden pattern features. The prediction errors of the pattern features of landscape architecture teaching are mainly distributed in the edge areas of landscape architecture. The smallest prediction error is only 1.67%, and this part of the error comes from the prediction of the layout features of landscape architecture. The predicted values of pattern features and color features of landscape architecture teaching content also have a good linear correlation. In general, the ConvLSTM method can better help VR technology and CAD technology to realize the interactive system of landscape architecture teaching.

Yijie Deng, https://orcid.org/0000-0002-5026-4990
Lei Zhou, https://orcid.org/0000-0001-9179-7745

REFERENCES

[1] Wu, P.-Y.; Chen, S.-Y.: Innovation in Optimization of Virtual Space Experience Using Interactive Engine and Device-Example of a Song Dynasty Landscape Painting, sensors and materials, 32(10), 2020, 3419-3428. https://doi.org/10.18494/SAM.2020.2920

[2] Marcelo, F.; Ankur, G.: Estimating Pre-Test Probability of Coronary Artery Disease Battle of the Scores in an Evolving CAD Landscape, jacc-cardiovascular imaging, 12(7), 2019, 1401-1404. https://doi.org/10.1016/j.jcmg.2018.04.036

[3] Huang, Z.-K.: Research on Landscape Planning and Design Based on Computer Aided Desig, agro food industry hi-tech, 28(1), 2018, 1523-1527. https://doi.org/11.1203/AGRO.2018.01

[4] Li, Z.; Cheng, Y.-N.; Yuan, Y.-Y.: Research on the Application of Virtual Reality Technology in Landscape Design Teaching, educational sciences-theory & practice, 18(5), 2018, 1400-1410. https://doi.org/10.12738/estp.2018.5.037

[5] Luo, J.-L.; Guo, Y.-Z.; Wang, L.; Li, N.: Application of computer simulation and high-precision visual matching technology in green city garden landscape design, environmental technology & innovation, 24(8), 2021, 32-40. https://doi.org/10.1016/j.eti.2021.101801

[6] Li, R.-Y.; Xu, D.-W.: Distribution of Landscape Architecture Based on 3D Images and Virtual Reality Rationality Study, IEEE access, 8(1), 2020, 140161-140170. https://doi.org/10.1109/ACCESS.2020.3010097

[7] Zhao, X.: Application of 3D CAD in Landscape Architecture Design and Optimization of Hierarchical Details, Computer-Aided Design and Applications, 18(S1), 2020,120-132. https://doi.org/ 10.14733/cadaps.2021.S1.120-132

[8] Lu, X.: Three-Dimensional Visualized Urban Landscape Planning and Design Based on Virtual Reality Technology, IEEE access, 8(1), 2020, 149510-149521. https://doi.org/10.1109/ACCESS.2020.3016722

[9] Zhang, X.-F.; Yan, S.; Qi, Q.: Virtual Reality Design and Realization of Interactive Garden Landscape, complexity, 7(18), 2020, 11-20. https://doi.org/10.1155/2021/6083655

[10] [1] Luo, J.: Online design of green urban garden landscape based on machine learning and computer simulation technology, Environmental Technology & Innovation, 24(3), 2021, 101819. https://doi.org/10.1016/j.eti.2021.101819