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Design Method of Electric Bicycle Traffic Signs Using Particle Swarm Optimization with Convolutional Neural Network

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Abstract. In order to study the application of computer aided design (CAD) and virtual reality (VR) in the design of traffic signs for electric bicycles, this article combines particle swarm optimization (PSO) with convolutional neural network (CNN) to better understand and utilize the data and characteristics in VR modeling, so that designers can fully consider the effects of signs in the actual environment at the design stage. The article analyze the expressive ability and detection performance of the algorithm for traffic sign image processing, compare the classification accuracy of PSO-CNN, CNN and long-term and short-term memory (LSTM) models under different types of traffic signs, test the processing time of traffic sign features by different methods, and test the user satisfaction. The experimental results show that PSO-CNN model has higher accuracy and shorter processing time in traffic sign image classification, and users have higher evaluation on its interactive ability and user experience. This article verifies the superior performance of PSO-CNN model in traffic sign image processing through experiments.

Keywords: CAD; Virtual Reality; Traffic Sign Design; Degree of Satisfaction; Virtual Reality; Traffic Sign Design; Satisfaction
DOI: https://doi.org/10.14733/cadaps.2024.S12.145-158

1 INTRODUCTION

Due to the growth of science and technology and the progress of society, electric bicycles, as a green and environmentally friendly means of transportation, are increasingly favored by people. However, with the popularity of electric bicycles, traffic safety problems have become increasingly prominent. Correct and clear traffic signs are of great significance to guide and standardize the driving behavior of electric bicycles. Intelligent vehicles are an important development direction for future transportation systems, and one of their core technologies. However, due to the complexity and diversity of the actual traffic environment. Cao et al. [1] proposed an improved feature pyramid model, AF-FPN, aimed at improving the detection performance and accuracy of traffic signs while meeting real-time requirements. Different traffic signs are generally recognized through visual features such as color and shape. For example, directly segment all pixels of the image in the RGB color space and determine whether there are traffic signs in the target area through corner detection. However, this method has poor performance in solving lighting changes and occlusion issues. The target has a close relationship with its surrounding contextual environment, and utilizing this relationship can improve the accuracy of detection. For example, a person's position in the picture may indicate whether they are running or standing. The AF-FPN model reduces information loss during feature map generation through adaptive attention module (AAM). Traffic signs are one of the important means of road traffic management, and the quality of their design directly affects traffic safety and traffic efficiency. There are mainly two types of lane detection algorithms: traditional lane algorithms are usually based on image processing technology, identifying lane lines by analyzing features such as pixel values, colors, and textures. The deep learning algorithm utilizes neural network models for feature learning and classification, which can more accurately and efficiently detect lane lines. With the continuous development of technology, intelligent vehicles have become one of the research hotspots. In autonomous driving and intelligent transportation systems, intelligent vehicles need to be able to accurately and quickly detect lanes in order to safely and effectively drive. The lane detection algorithm is a key technology for achieving this goal, and therefore has received widespread attention. Cao et al. [2] analyzed the use of color transformation and gradients to generate a binary image with filtering thresholds. The experiment shows that in the three-color spaces of HSL, LAB, and LUA, the B channel of LAB and the L channel of LUV are the best combination for identifying lane lines. You can also experiment with Sobel gradient filters, where image gradients measure the directional intensity of color changes. The traditional traffic sign design method mainly depends on the designer's hand-drawing and model making, and the design process is cumbersome and requires a lot of manpower and material resources. Among them, CNN is suitable for extracting features from images, so it is particularly effective for the image processing part of traffic flow detection tasks. RNN is suitable for sequential data processing, such as time series and text, and can therefore be applied to tasks such as traffic flow prediction and anomaly detection. With the acceleration of urbanization and the rapid development of technology. Intelligent transportation systems aim to improve road traffic safety, alleviate traffic congestion, and reduce environmental pollution through various advanced technological means. Using the above information, the position and radius of the vehicle in the lane can be calculated through geometric relationships. This requires estimation of the vehicle's attitude, which can be achieved through the vehicle's sensors or computer vision algorithms. Chen et al. [3] introduced a deep learning-based edge traffic flow detection scheme and elaborated on it in detail. Moreover, it is often difficult for designers to accurately predict the effect of the logo in the actual environment due to the limitations of the actual use scene. This design method is not only inefficient, but also easy to lead to the disconnection between the design results and the actual needs, resulting in a waste of resources. In recent years, the continuous growth of CAD and VR provides a new solution for traffic sign design.

In traditional safety assisted driving road vehicle recognition algorithms, image processing technology is often used to detect and recognize vehicles. These algorithms usually preprocess the image first, such as filtering, edge detection, etc. to reduce interference noise, then use feature extraction technology to extract vehicle features, and finally classify the vehicles through a classifier. However, these traditional methods often have certain limitations, such as poor adaptability to complex backgrounds and lighting conditions, and susceptibility to interference noise. In order to overcome these limitations, safety assisted driving road vehicle recognition algorithms based on artificial intelligence have gradually become a new research trend. This algorithm utilizes machine learning technology to learn a large amount of training data, automatically extracting vehicle features and classifying them. In machine learning, deep learning is the most popular method, which utilizes neural network models to extract layer by layer features from data, resulting in more abstract and effective feature representations. Chen [4] introduced a safety assisted driving road vehicle recognition algorithm based on artificial intelligence, which combines image processing and machine learning technology to accurately and real-time recognize vehicles in complex road environments. CAD technology makes the design of traffic signs more accurate and efficient. CAD software can help designers to do graphic design, dimension marking and material statistics on the computer, which greatly improves the accuracy and efficiency of design. Moreover, through CAD technology, designers can modify and optimize the design more conveniently to meet the design requirements in different environments and conditions. However, CAD technology also has some limitations. Intelligent connected vehicles have significant advantages in improving traffic safety and efficiency, and improved real-time detection methods for traffic signs are of great significance for enhancing the intelligence level of intelligent connected vehicles. Du et al. [5] explored the application of improved real-time traffic sign detection methods in intelligent connected vehicles. In traffic scenes, traffic signs are important elements that guide traffic participants such as vehicles and pedestrians. However, due to various factors such as lighting conditions, sign fouling, angle changes, etc., the detection and recognition of traffic signs has become a challenging problem. Therefore, researching and developing an accurate and efficient real-time detection method for traffic signs is crucial for the application of intelligent connected vehicles. Some studies utilize deep learning methods such as YOLO, SSD, etc. for traffic sign detection and recognition. These methods have good performance in processing complex backgrounds and multi-scale targets, but may be limited by the quality and quantity of the training dataset. Although CAD software can provide accurate design and simulation, the results are often based on preset conditions and static scene simulation. It is impossible to fully simulate the dynamic changes and user behavior in the real environment, which makes there still exist a certain gap between the design results and the actual use results. The rise of VR provides a new way to solve this problem. VR can create a highly realistic virtual environment, allowing designers to simulate and evaluate the design effect in the real environment. Through VR, designers can observe the performance of the logo in the actual environment, as well as the user's feedback and behavioral response to the logo. In this way, we can fully understand and evaluate the actual effect of the logo in the design stage, reduce the errors in the design and improve the efficiency and practicability of the design. This method combines the accuracy of CAD with the immersive experience of VR, so that designers can fully consider the effect of signs in the actual environment at the design stage.

The main idea of FastVGG is to reduce the number of parameters and computational complexity by introducing binary convolution into the network. Binarized convolution refers to limiting the weight of the convolutional kernel to+1 or -1, which can convert 32-bit floating point numbers (float32) in CNN into 1-bit binary numbers (bits), greatly reducing the amount of parameters and computation. In addition, FastVGG also uses Model Pruning technology to further optimize the network structure. By removing some neurons or network layers that have little impact on output, the model size can be reduced and the inference time of the model can be accelerated. Both of which adopt a combination structure of multi-layer convolutional layers and fully connected layers. In automatic traffic sign recognition, the FastVGG network can be used to extract image features and classify them. Firstly, convolution and pooling operations are performed on the input image through the network. The FastVGG network can extract feature representations of input images through operations such as convolution and pooling, and use these features for classification and recognition. Due to its efficient and lightweight characteristics, FastVGG networks can be applied in scenarios with high real-time requirements. And it can handle various traffic signs and complex backgrounds. Traffic signs are important indicators of road traffic rules and safe driving. For autonomous vehicle, accurate identification of traffic signs is the key to ensure driving safety. With the acceleration of urbanization, the complexity of transportation scenarios is also constantly increasing. In this context, detecting small targets in traffic scenes is particularly important. Small targets usually refer to pedestrians, cyclists, vehicles, etc. in traffic scenarios, and their presence is of great significance in areas such as traffic monitoring and autonomous driving. However, due to the small size, variable shape and posture of small targets, detection is difficult. To address this issue, He et al. [6] proposed a small target detection method for traffic scenes based on YOLO MXANEt. Hou et al. [7] through experimental verification, we found that these methods have good effects and advantages, which can greatly improve the accuracy and efficiency of road surface monitoring, and provide scientific basis for road maintenance and safety management. However, these methods also have some shortcomings that require further research and improvement. In future research, we will continue to explore and research more efficient and accurate pavement monitoring and analysis methods, providing more reliable technical support for road maintenance and safety management. Nevertheless, the existing methods still have some limitations, such as easy to fall into local optimal solution and weak robustness. Therefore, this article proposes an optimization method of VR modeling based on PSO-CNN, aiming at further improving the efficiency and accuracy of VR modeling. In this article, PSO and CNN are combined, and the global search ability of PSO is used to find the optimal parameters of CNN model, so as to overcome the problem that CNN is easy to fall into local optimal solution and improve the robustness of the model. Through this optimization method, the data and features in VR modeling can be better understood and utilized, so as to realize more efficient and accurate model training and prediction. The innovations of this study are as follows:

(1) This article combines PSO algorithm with CNN. PSO algorithm improve the robustness of the model. This combination is a novel idea and provides a new solution for VR modeling optimization.

(2) This method combines the accuracy of CAD with the immersive experience of VR, so that designers can fully consider the effect of the logo in the actual environment in the design stage. Through this combination, the design of traffic signs for electric bicycles can be optimized and evaluated more effectively.

(3) The proposed method adopts a new design process. First, the basic graphic design and dimensioning are carried out by using CAD, and then the designed logo is put into the actual use scene for simulation test by using VR. Through the simulation test, we can evaluate the feasibility of the design and user satisfaction, and find and correct the problems in the design in time.

Firstly, this article introduces the demand of electric bicycle traffic sign design and the significance of modern technology application; Then the design method of traffic signs based on CAD and VR is proposed. Finally, the performance of this method is verified, and the user satisfaction is analyzed, which proves the effectiveness of this method for the design of traffic signs for electric bicycles.

2 RELATED WORK

Virtual reality (VR) technology provides a new environment for product design, allowing product designers to conduct product design in simulated real environments. In this environment, conceptual modeling plays a crucial role. Lorusso et al. [8] provided a detailed introduction to the definition, role, process, tools. Conceptual modeling refers to the process of establishing a model to express the product designer's understanding, planning, imagination, and concepts of the product. In virtual reality environments, conceptual modeling can help product designers identify and solve potential design problems in the early stages, thereby improving the quality and efficiency of product design. In addition, conceptual modeling can also help optimize the functionality and user experience of the product. Lu et al. [9] utilize shape detection algorithms to extract features from preprocessed images. Specifically, a shape detection algorithm based on Gradient Vector Flow (GVF) can be applied to detect shape features in images. Firstly, the input image is preprocessed using a shape detection algorithm to extract areas that may contain traffic signs. Then, for each possible area, image classification algorithms are used for classification and recognition to determine which type of traffic sign it belongs to. Finally, the recognition results are output in layers, including information such as the position, size, and rotation angle of different types of traffic signs. In the experiment, it was tested using publicly available datasets, including the IPSC2016 and GTSRB datasets. Compared with traditional single shape detection or image classification methods more than 10% and also has faster processing speed.

Through XR technology, designers can obtain real-time feedback during the design process. For example, through MR technology, Matthys et al. [10] modified and adjusted the design in real space through gestures or body movements. This not only improves the efficiency of design, but also enables designers to better understand the needs and expectations of users. XR technology can provide an immersive design experience. Through VR or MR technology, designers can simulate the effects of a design in the real world, which can help them better predict its performance in practical use. At the same time, this sense of realism and immersion can also be used for public participation in the design process, allowing the public to have a deeper understanding and participation in the design process. With the help of XR technology, designers can optimize the performance of their designs early on. For example, by simulating the thermodynamic and optical properties of buildings, designers can identify and fix potential problems during the design phase. Traffic sign recognition is a key link in autonomous driving and intelligent transportation systems. Accurate traffic sign recognition can help autonomous vehicle make correct decisions in complex traffic environments, thus improving road safety and driving efficiency. Wang et al. [11] explored a fast and high-precision traffic sign recognition method and applied it in conjunction with neural computing technology. The current traffic sign recognition methods mainly rely on image processing and machine learning technology. However, in practical applications, these methods face many challenges, such as changes in lighting conditions, occlusion of markers, and complex backgrounds. In addition, existing methods undoubtedly increases computational costs and time. It is necessary to develop a traffic sign recognition method with high accuracy, fast recognition, and adaptive ability. Wu et al. [12] designed a series of experiments and tested them using public datasets. The experimental results show that this method outperforms traditional detection methods in terms of accuracy and recall, while also improving processing speed. Specifically, this method has improved accuracy by over 10%, recall rate by over 8%, and processing speed by over 20%. In summary, attention feature fusion networks have broad application prospects in small traffic sign detection. Future research directions can include: 1) researching more effective feature fusion methods to improve detection accuracy and recall; 2) Explore the application of attention feature fusion networks in other fields, such as object detection, face recognition, etc.; 3) Research how to apply this technology to real-time traffic sign detection systems to promote the further development of autonomous driving and intelligent transportation.

In the field of traffic sign recognition, many researchers are committed to improving existing algorithms to improve recognition accuracy and robustness. Among them, some research focuses on the image preprocessing stage, such as filtering, edge detection, etc., to improve image quality. Other studies focus on feature extraction and classifier design, such as using deep learning algorithms to extract features and train classifiers. There are also studies dedicated to combining multiple methods to achieve more comprehensive traffic sign recognition schemes. However, various factors in the actual traffic environment, such as changes in lighting, obstruction, pollution, etc., pose certain challenges to traffic sign recognition. Xing et al. [13] proposed an interior design is a design activity carried out by people to create a good indoor environment. With the continuous development of technology, three-dimensional computer-aided simulation technology is gradually applied in interior design, providing designers with more accurate and convenient design tools. Yang [14] launched a discussion on "Indoor Design Optimization Teaching Based on 3D Computer Aided Simulation". Its aim is to explore how to improve the quality of interior design teaching through 3D computer-aided simulation technology, and cultivate students' innovation and practical abilities. Using a renderer to provide realistic rendering of virtual scenes allows designers to present the effects of indoor spaces in a more realistic manner. At the same time, rendering can also help designers optimize materials, lighting, colors, and other aspects to achieve better design results. Accurately and efficiently detecting and recognizing traffic signs is of great significance for ensuring driving safety and improving traffic efficiency. Yao et al. [15] adopted a method called "self-attention mechanism" in deep learning. By training a deep neural network to learn the self-attention weight of the input feature map, an enhanced representation of the input feature map is obtained. This enhanced representation can better capture microscale features, thereby improving the detection performance of small targets. Next, combine this microscale feature extraction with the YOLOv3 framework. YOLOv3 is a widely used real-time object detection algorithm, and its efficiency and accuracy make it popular in many practical applications. In our method, we modified the network structure of YOLOv3 to accept and process microscale features. To this end, we added a self-attention module after the convolutional part of YOLOv3 and before the fully connected layer, which can learn and apply self-attention weights to enhance feature representation. And other features for target matching, but these methods have poor performance in dealing with complex backgrounds and changes in lighting. In addition, when the size of traffic signs is too small, that is, small-scale targets, traditional methods often find it difficult to accurately detect and recognize them. Therefore, we need a method that can extract microscale features to solve existing problems.

In order to improve the training efficiency and accuracy of the model, we also adopted a data augmentation method. This method can generate more training samples by randomly rotating, scaling, and other operations on the training data without adding additional computational burden, thereby improving the model's generalization ability. Finally, our proposed method was validated on a large number of experimental datasets, and the results showed that our method is more effective than traditional traffic sign detection methods in detecting small-sized traffic signs. Meanwhile, due to the combination of the YOLOv3 framework, our method can also achieve real-time detection, which is very important for practical applications. Yu et al. [16] integrates the outputs of the YOLO model and the VGG network. This fusion can be achieved in various ways, such as combining the boundary box coordinates output by the YOLO model with the feature maps output by the VGG network, and then outputting the final detection results through the fully connected layer. Image processing techniques, such as color space conversion and image enhancement, are used to improve the visual effect and feature extraction of traffic signs. Feature extraction distinguishes different traffic signs by selecting and extracting effective features from the image. Yu and Sinigh [17] discussed the application of green concept-based CAD in product packaging design. Taking the packaging design of a certain brand of chewing gum as an example, this article analyzes the application of green concept-based CAD in product packaging design. The traditional packaging of this brand of chewing gum is made of plastic bags, which has caused significant environmental pollution. In response to the concept of green environmental protection, the brand adopts CAD technology based on green concepts for packaging design. The designer's first consideration is to use sustainable materials to replace traditional plastic packaging. They chose biodegradable paper as packaging material to reduce its impact on the environment. At the same time, the designer also considered the appearance and structural design of the packaging to make it more attractive to consumers. Zhang et al. [18] conducted experimental verification on this. Traditional methods are usually based on image processing and machine learning techniques, but due to the complex traffic environment and various types of traffic signs, these methods often find it difficult to accurately recognize all types of traffic signs. Road traffic sign detection requires real-time processing, therefore the proposed method is required to have low computational complexity to achieve rapid detection. Zhao et al. [19] studied more accurate and efficient traffic signal status recognition. Traffic lights are an important component of urban traffic management systems, and their status has a significant impact on driving safety and traffic smoothness. Among them, YOLOv4 algorithm, as an advanced deep learning algorithm, has the advantages of fast speed and high accuracy, but there are still certain limitations in practical applications. The improved algorithm has high accuracy in traffic signal detection and recognition tasks, with an average recognition accuracy of 98.5% for red, green, and yellow traffic signal lights. Compared to the original YOLOv4 algorithm, the improved algorithm also has a significant improvement in running speed, with an average running speed increased by more than 25%.

3 METHODOLOGY

3.1 Feature Classification of Traffic Sign Images Based on PSO-CNN

In the field of graphic design and classification, many scholars have made relevant research and achieved results. The above research mainly focuses on the application and practice in specific fields, and lacks systematic and comprehensive research on related technologies. This article introduces a feature classification method of traffic sign images based on PSO-CNN. This method is a combination of PSO algorithm and CNN for feature classification of traffic sign images. Firstly, the method uses data preprocessing steps to clean, label and enhance the collected traffic sign images to prepare data sets for model training. These operations include denoising, image enhancement (rotation, cropping, flipping, etc.), data labeling, etc., aiming at improving the generalization ability and robustness of the model. Secondly, on the preprocessed data set, this method uses PSO algorithm to optimize the parameters of CNN model. In PSO-CNN, the parameters of CNN are regarded as "particles", and PSO algorithm is used to search the optimal parameter combination to improve the detection performance of the model. The process of optimizing CNN with PSO algorithm is shown in Figure 1.

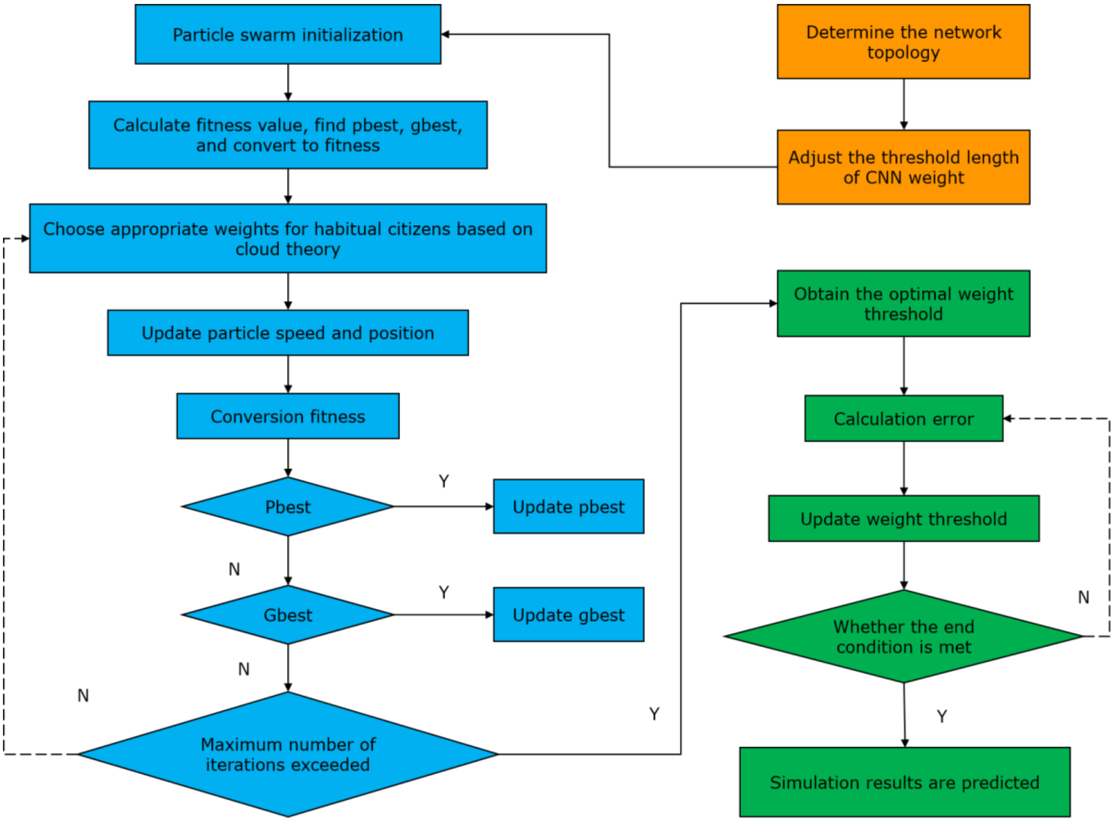

Figure 1: CNN optimization process.

In this process, PSO algorithm and CNN algorithm are very powerful tools, which can be used to process and classify complex image data. Combining these two algorithms can further improve the effect and efficiency of image processing. In this article, PSO algorithm is used to optimize the super-parameter of CNN model. In this process, scientists take the learning rate and batch size of

CNN model as variables of PSO algorithm, and the classification accuracy of CNN model as optimization goal, so as to use PSO algorithm to find the best combination of superparameters.

The dimension D of the initial search space range, the total quantity of population particles N, the quantity of iteration stops K, and the speed of particles n:

$$V_n \in [V_{\min}, V_{\max}] \tag{1}$$

The location of n particles:

$$S_n \in [S_{\min}, S_{\max}] \tag{2}$$

Define the fitness function and update the speed and position according to the following formula.

$$V_{nd}^{K+1} = WV_{nd}^{K} + r_1\zeta(P_{nd}^{K} - S_{nd}^{K}) + r_2\eta \tag{3}$$

$$S_{nd}^{K+1} = S_{nd}^{K} + V_{nd}^{K+1} \tag{4}$$

In the formula, K is the current iteration number.

Convolutional kernels are elements used in CNN to manipulate input images. They extract local features of the image by sliding on the input image and applying corresponding weights. The size of the convolutional kernel determines the scale of image features it can capture.

$$y = x * w \in R^{u\times v} \tag{5}$$

The size of the extracted features:

$$u = \left\lceil \frac{n - s + 2\cdot Zeropadding}{Stride} \right\rceil + 1 \tag{6}$$

$$v = \left\lceil \frac{m - k + 2\cdot Zeropadding}{Stride} \right\rceil + 1 \tag{7}$$

The traffic sign image feature classification method based on PSO-CNN combines PSO algorithm with CNN model, which realizes the efficient extraction and processing of traffic sign image features, and avoids the problem that traditional CNN method for traffic signs of electric bicycles, and provide useful reference for user satisfaction test.

3.2 Electric Bicycle Traffic Sign Modeling Optimization

The design of traffic signs for electric bicycles needs to pay attention to many factors, such as shape, size, color and contrast. The optimization of these elements can directly affect the visibility and readability of signs. Different from static signs, dynamic signs can be adjusted and changed in real time according to road traffic conditions and vehicle behavior. This can improve the adaptability and real-time of traffic signs, but it also increases the difficulty and complexity of sign design. In the actual traffic environment, traffic signs are often multi-level and multi-directional. For example, traffic signs on expressways include not only road signs and speed limit signs, but also traffic monitoring equipment and intelligent traffic indication systems.

On the basis of the previously introduced traffic sign image feature classification method based on PSO-CNN, this section will further explore the optimization method of traffic sign modeling for electric bicycles. A series of measures are taken to improve the classification accuracy of the model, reduce the processing time, and enhance its practicability and user experience. In this process, CAD software is mainly used to create and modify 3D models. Designers can accurately control the geometric shape, size, material and other properties of the model through CAD software, so as to meet the design requirements. At this stage, PSO algorithm can be used to optimize the parameters of 3D model, such as shape and size, to achieve the best visual effect or functional performance. In this case, PSO algorithm can search a solution space, which contains all possible combinations of shapes and sizes. PSO algorithm will search for an optimal solution in this solution space, which can make the visual effect or functional performance of the logo reach the best under the premise of meeting the design requirements. Once the CAD model is created and optimized, it can be imported into the VR environment for further adjustment and evaluation.

VR provides an immersive and visual design environment for designers, so that designers can simulate and observe the effect of signs in the actual environment at the actual design stage. Through VR, designers can intuitively see the performance of signs in different scenes and different lighting conditions, so that possible problems can be found and corrected in the early design stage. See Figure 2 for the framework of VR system for traffic sign modeling of electric bicycles.

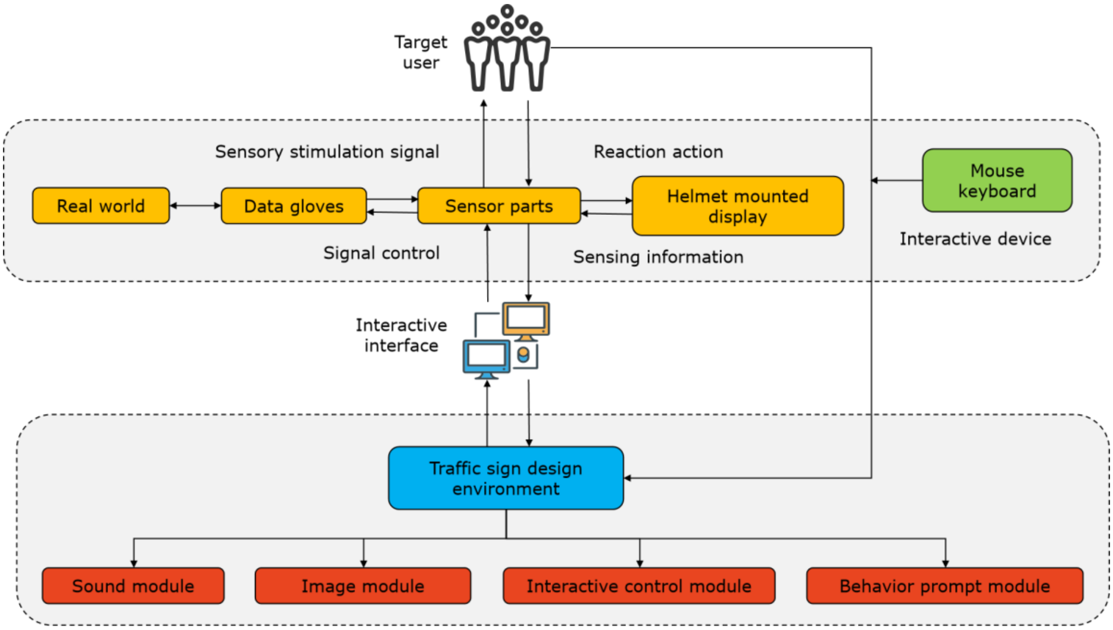

Figure 2: VR system framework.

$$R^{'}=[k,j]=\sum_{m=-p}^{p}\sum_{n=-p}^{p}B[m,n,k,j]R[k-m,j-n] \tag{8}$$

$$B[m,n,k,j]=\frac{\exp(-\frac{m^2+n^2}{2\sigma_{\delta}^2}-\frac{R[k-m,j-n]}{2\sigma_{\zeta}^2})}{R(k,j)} \tag{9}$$

Where σ represents the scale parameter of traffic sign image feature information.

In VR environment, CNN algorithm can be used to process and analyze visual information. The combination of CAD and VR enables designers to observe and adjust the effect of logo design in real time in virtual environment, and then optimize the design parameters through PSO algorithm. Moreover, CNN can be used to learn and predict the performance of signs in virtual environment, thus providing more reference information for designers.

4 RESULT ANALYSIS AND DISCUSSION

4.1 Performance Test of Modeling Algorithm

Collect various types of traffic sign images, including warning signs, prohibition signs and indication signs. Ensure that each type of logo has enough samples for training and testing. Clean, label and enhance the data for input into the model for training. Data enhancement includes operations such as rotation, cropping and flipping to increase the generalization ability of the model. PSO-CNN, CNN and LSTM are used to train the preprocessed data. When training, set appropriate hyperparameters to ensure the performance and stability of the model. Use the test set to evaluate the trained models and calculate the classification accuracy of each model under different types of traffic signs. Compare the performance of the three models and analyze their advantages and disadvantages. Tested the classification accuracy of traffic sign image processing algorithms, PSO-CNN, CNN, and LSTM under different types of traffic signs, as shown in Figure 3, Figure 4 and Figure 5.

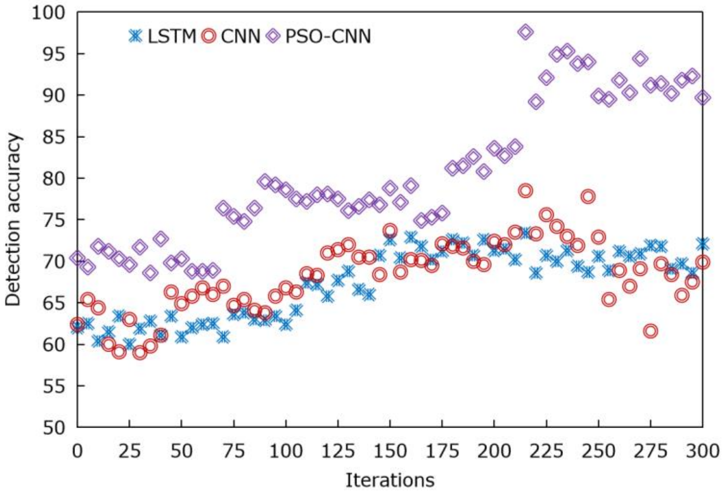

Figure 3: Detection performance of warning signs.

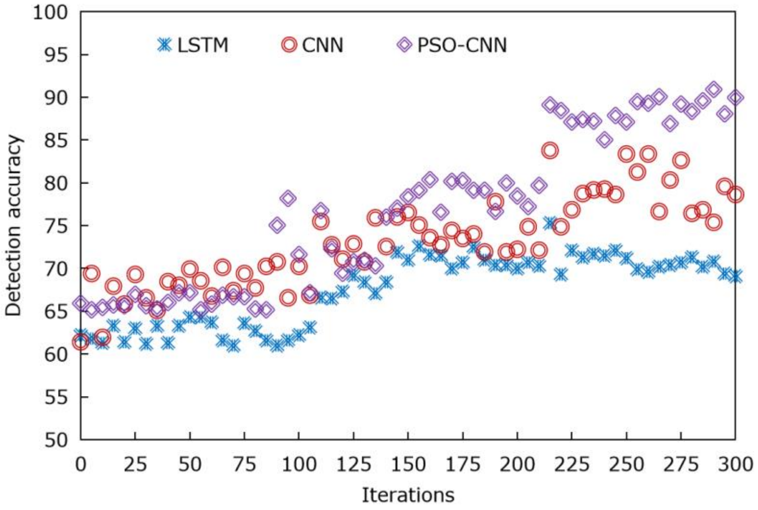

Figure 4: Detection performance of prohibition signs.

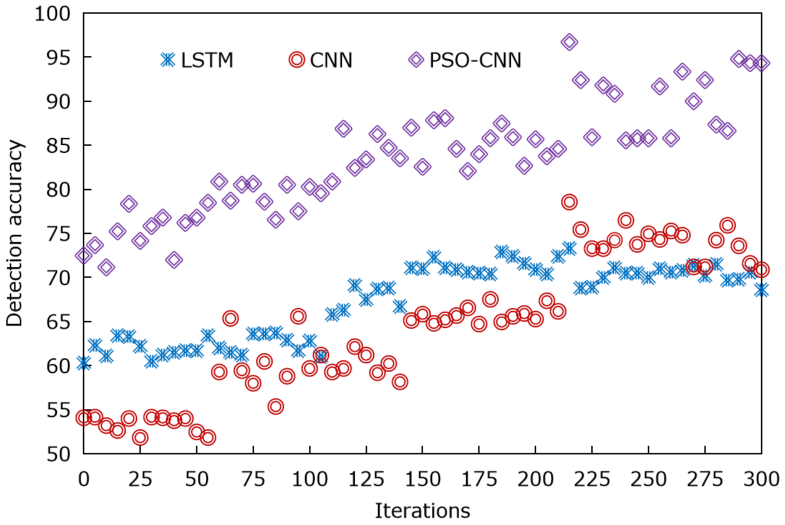

Figure 5: Detection performance of indicator signs.

It can be found that PSO-CNN improves the accuracy of traffic sign graphic classification. PSO-CNN shows high classification accuracy when dealing with different types of traffic signs. This shows that PSO-CNN algorithm has good expressive ability and detection performance in traffic sign image processing. In practical application, PSO-CNN is expected to provide more accurate and effective technical support for traffic sign recognition and traffic safety monitoring.

This method may adopt a more effective feature extraction and representation method, reducing unnecessary calculation and redundant operation, thus improving the processing efficiency. The processing time of traffic sign feature optimization by different methods is shown in Figure 6. From the experimental results, the traffic sign image processing method in this study shows excellent performance in processing time and efficiency. This may be because this method has certain optimization in implementation, which makes the processing process more efficient.

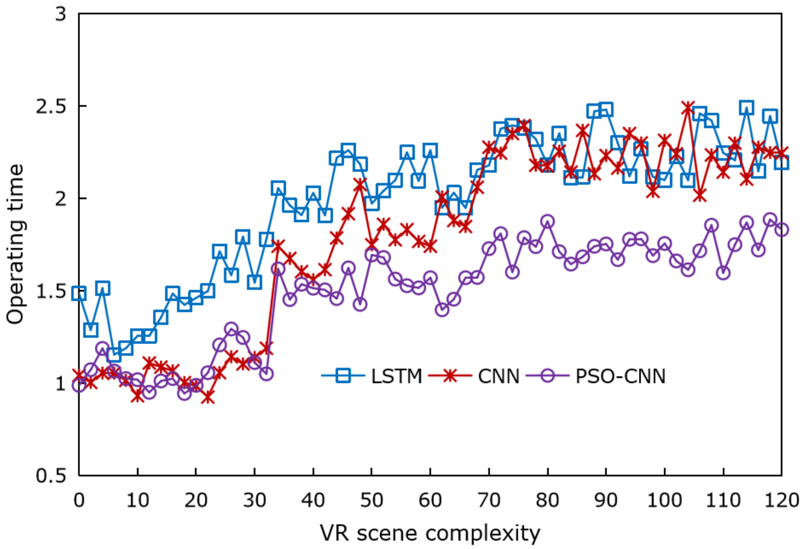

Figure 6: Comparison of optimization time for traffic sign features.

PSO-CNN model takes relatively short time to process traffic sign images, showing its superior performance. Compared with CNN and LSTM models, PSO-CNN has obvious advantages in processing efficiency. This may be because in PSO-CNN, and find the optimal solution more effectively and avoid the problem that CNN is easy to fall into the local optimal solution, thus shortening the processing time. Compared with the traditional VR modeling method, the method proposed in this article has obvious advantages in efficiency and accuracy. These results can provide effective support for the improvement of CAD design method of traffic signs for electric bicycles, making them more efficient and intelligent.

4.2 User Satisfaction Test

Through the simulation test, we can evaluate the feasibility of the design and user satisfaction, and find and correct the problems in the design in time. Using CAD software, designers can create virtual traffic sign models of electric bicycles. These models can contain various design details, such as shape, color, size, etc. Then, using VR, designers can put these models in the real road environment. In this way, the effect of electric bicycle in practical use can be simulated. Through the simulation test, designers can evaluate the feasibility of the design and user satisfaction. For example, if the simulation test results show that the visibility of the logo is poor in the actual situation, or it is difficult for the user to quickly identify the logo in some specific situations, then the designer can adjust and optimize the design according to this information. A simulation test was carried out in practical application. A series of traffic signs of electric bicycles are designed by using CAD software, and these signs are placed in the real road environment through VR. Then, some electric bicycle users are invited to participate in the simulation test to observe their reaction and operation to these signs.

The design method proposed in this article uses VR to allow designers and users to interact in virtual environment. This user-centered design method is more in line with the modern design concept and can improve the practicality and user satisfaction of the design. Through VR, designers can observe and evaluate the design effect of signs in a simulated real traffic environment. In this way, designers can intuitively understand the user's reaction and behavior to the logo, such as the focus of the user's line of sight, the speed of identifying the logo and the influence of the logo on the user's navigation. This information can help designers optimize the logo design and improve the interactive ability of the logo in practical use. Figure 7 shows the user satisfaction rating results of VR traffic sign design based on the CAD three-dimensional modeling algorithm in this article. As can be seen from the figure, the design method of VR traffic signs based on PSO-CNN shows strong advantages in interactive ability and user experience.

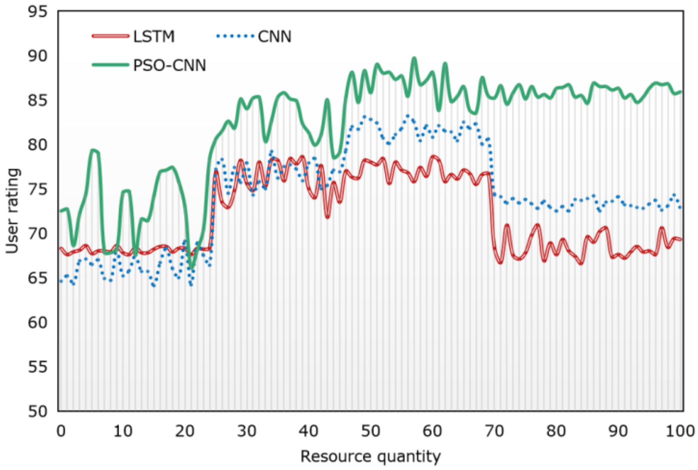

Figure 7: System user satisfaction score.

Through the simulation test, the feasibility and user satisfaction of the design are evaluated. This evaluation method can find and correct problems in time in the design stage, and avoid waste of resources and production errors. Moreover, through the user satisfaction score, designers can understand the user's acceptance and satisfaction with logo design, so as to optimize the design and improve the user experience. As can be seen from Figure 7, compared with the traditional traffic sign design method, the VR traffic sign design method based on PSO-CNN shows a higher rating level in terms of user satisfaction rating. This shows that users have high recognition and satisfaction with this design method, and think that it has better interactive ability and user experience in practical use.

Through this simulation test, we also found some places that need to be improved. For example, some design signs are difficult to be quickly recognized on fast electric bicycles. Moreover, it is also found that some signs are easy to confuse users in complex traffic environment. According to these feedbacks, the original design can be adjusted and optimized, and the reliability and user satisfaction of the logo can be improved. The application of this method can not only improve the efficiency and practicability of traffic sign design, but also help to promote the progress and growth of traffic sign design for electric bicycles.

5 CONCLUSIONS

With the popularity of electric bicycles, traffic safety problems have become increasingly prominent. Correct and clear traffic signs are of great significance to guide and standardize the driving behavior of electric bicycles. In this article, PSO and CNN are combined to better understand and use the data and features in VR modeling, so that designers can fully consider the effect of signs in the actual environment at the design stage. PSO-CNN method can automatically learn and extract image features, avoid the tedious process of manually designing features, and improve the efficiency and accuracy of feature extraction. The introduction of PSO algorithm can find the optimal parameter combination of CNN model and improve the detection performance and generalization ability of the model. This method can not only improve the efficiency and accuracy of design, but also help designers to better explore and understand the information and patterns in design data. By constantly optimizing and improving this method, we can better meet the needs of traffic sign design for electric bicycles and promote the development and innovation of traffic sign design for electric bicycles.

VR modeling optimization of traffic signs for electric bicycles is a multi-faceted process, involving data enhancement technology, model structure optimization, training strategy improvement and evaluation index selection. By comprehensively considering these factors, the performance and robustness of the traffic sign image feature classification method based on PSO-CNN can be further improved, which provides a useful reference for the improvement of the CAD design method of traffic signs for electric bicycles.

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