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Deep Learning Technology in Computer Aided Industrial Layout Design Platform

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Abstract. Design embodies important significance in the stage of economic and cultural development. The gradual use of CAD in the stage of industrial plan has greatly promoted the growth of industrial plan and industrial network informatization. Traditional product design pays attention to the realization of design goals, and pays little attention to the relationship between products, people and environment, resulting in the disconnection between products, environment and users. In this article, the relationship between computer-aided design (CAD) and industrial design will be analyzed. When classifying 3D models, the classifier will be selected according to this algorithm to classify the models, thus realizing the construction of computer-aided industrial layout design platform. The results show that the recall and error of the improved CNN are obviously superior to those of the comparison method in both the early and late operation stages, and the response speed is more than 20% higher than that of the traditional CNN. The proposed method can effectively use the pose information of 3D models and improve the accuracy of 3D model classification.

Keywords: Industrial Design; Computer Aided Design; Deep Learning; Convolutional Neural Network.
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1 INTRODUCTION

Due to the increasing growth of market economy and technology, all enterprises in the world are participating in the market competition, and the new products that are developed and successfully entered into the market every year are the key for all enterprises to win in the competition [1]. The important link of product innovation is a new concept with market competitiveness and realization possibility, which is produced in the product conceptual design stage. This process needs the support of knowledge. The idea of component reuse is that users put forward modeling concepts, and the system extracts available components from the model database for users to combine models [2]. The combined modeling method based on this idea is simple, easy to use and powerful, so it has attracted wide attention. The commonality of these modeling methods is that they regard 3D modeling as a technological process, and require users to have a clear modeling goal before modeling [3]. Traditional product design focuses on the realization of the design goal, and pays little attention to the relationship between products and people and the environment, resulting in the disconnection between products and the environment and users [4]. Being in the 3D space, the information obtained is all three-dimensional. How to obtain 3D space information is an important problem in the field of computer vision. Computer Aided Industrial Design (CAID) is the sublimation of computer application, and it is also research characterized by the use of computer 3D technology, which has important practical value for industrial design and product design [5]. 3D reconstruction based on depth map is also called 3D reconstruction based on RGBD data. The data object processed by this technology is different from other image reconstructions. It uses RGB images and their corresponding depth images as input, and the input depth map has the vertical distance between each spatial coordinate and the position of the depth camera, which reduces the difficulty of 3D reconstruction. This article will analyze the relationship between CAD and industrial design, and propose a 3D modeling algorithm based on improved CNN, so as to realize the construction of computer-aided industrial layout design platform.

The goal of computer-aided 3D creative modeling technology is to provide inspiration for users' modeling and help them get innovative modeling results [5]. The research shows that in actual product R&D, completely redesigned products only account for 1/5 of all products, and the rest products are designed by using mature product cases accumulated in the past R&D process to make minor modifications. Incremental design by designers can effectively save design time and reduce design workload. Using CAID, designers can collect design information through the Internet, collaborate in product development activities, and conveniently build high-quality 2D and 3D models of products through various computer software, so as to obtain realistic renderings of products [6]. The existing computer-aided 3D creative modeling system is limited to modeling. Simply taking skin and 3D printing-oriented model analysis as the subsequent steps of modeling can't solve the problem. This article presents a 3D modeling algorithm of computer-aided industrial layout design based on CNN, and its main innovations and contributions are as follows:

⊖ Aiming at the insufficiency of existing methods in image recognition, this article proposes a computer-aided industrial layout design scheme based on CNN.

⊜ By using CNN's ability of automatic characteristic learning and accurate target identification, this scheme transforms the problem of multi-object classification into the problem of tampering area location.

2 RELATED WORK

Due to the rapid growth of deep learning (DL) in recent years, various end-to-end neural network structures have emerged for different 3D representations in image 3D reconstruction technology, but different 3D representations have different development trends. A very important part of DL method is data set, which determines what kind of task to complete. Computer aided industrial design is a creative activity in the field of industrial design supported by computers and their corresponding computer aided industrial design systems. Through model making, information exchange, design drawing, optimization effect and other steps to analyze. The early software system of 2D aided industrial design of design plane is gradually excluded from the category of CAD. At present, CAD has undergone qualitative changes in design methods, design processes, design quality and efficiency [7]. Tsukanov et al. [8] Computer 3D modeling has made outstanding achievements in the performance of design software. It can get a complete model design result through model editing, surface construction and artistic rendering. At the same time, it has a very powerful plug-in function. This can be a good design creation analysis in industrial design. Some students have no clear direction or different plans for their future development and employment, plus they are afraid of learning many basic modeling commands. It leads to lack of learning motivation and no interest in software courses. Wang and Qin [9] design the process, after the model design and analysis of important points, lines, surfaces and bodies, we start from the reality and demonstrate the typical entity operation. The dull and astringent commands are vividly expressed to make the previously insipid theoretical concepts come alive. Deepen stereoscopic sensory impression and stimulate interest. At the same time, propose targeted design problems, so that students can think about and solve them with the knowledge they have received and mastered. In the form of answering questions, discussing, self-study after class, and submitting reports, students can firmly integrate existing knowledge. Deeply operate and remember, and deeply understand why it is necessary to "separate" and "connect" in modeling design and modeling steps, so as to make them step by step and learn from each other. Yuan and Niu [10] summarized a set of methods for preliminary estimation of basic parameters by referring to relevant aircraft overall design documents and theoretical derivation. This method can estimate the main basic parameters with less input parameters. A set of preliminary design methods for wing and tail shapes are summarized by consulting relevant aircraft overall design documents, which can be used for rapid shape design. By comparing different technical routes, a general parameter sensitivity analysis method is determined. Computer aided design technology has been widely used in the field of dental prosthetics. Embedment is a common type of restoration to reconstruct partially damaged teeth and restore occlusal function. Zhang et al. [11] proposed a robust two factor constrained deformation framework for dental inlay modeling. The proposed method is proved to be effective and robust by sampling ray tracing collision for tooth surface segmentation and occlusion surface reconstruction based on two factor constrained deformation. Computer aided CAD should include the design purpose and meaning in the design content, more vividly and fully convey and reflect the product concept and creativity, and create more realistic and aesthetic product models. Make students master various commands and special effect tools, divide and merge, and adjust multiple parameters and control points. In the teaching of computer aided industrial design Rhinoceros software, we should adhere to the combination of theoretical knowledge teaching and students' independent practice. Seeing the phenomena that are hard to think of or see at ordinary times, enrich the three-dimensional thinking, so that Zhang [12] can be inspired and inspired, and then cultivate students to establish the overall design concept and innovative concept. It emphasizes the diversified teaching of heuristic discussion, a large number of practical exercises from simple to deep, and teaches students in accordance with their aptitude.

This article presents an industrial design image recognition model based on CNN. This model makes use of CNN's automatic characteristic learning ability and accurate target identification ability, enhance the generalization ability of the network, and uses batch normalization to speed up network training.

3 METHODOLOGY

3.1 Overview of CAID

Today, with the growth of information technology (IT), IT has become an indispensable part of social life and has been applied in various fields of society. Under this background, CAID has also developed rapidly. Computer industrial design is a digital and visual industrial design method based on information technology. Many manufacturing enterprises began to introduce IT into the field of industrial plan and computer application, providing users with personalized, diversified and interesting industrial design and production products. With the help of IT, industrial design can not only greatly improve work efficiency, but also keep the novelty and uniqueness of products. In addition, while improving the appearance of products, it also makes a series of improvements and optimizations on the performance and operation mode of industrial products. The core of industrial development is to constantly innovate and improve technology. In today's increasingly fierce market competition environment, if products are not to be eliminated, we must innovate and reform the appearance, structure and material of products to make them more attractive.

Due to the continuous satisfaction of people's material life, people's requirements for industrial products are getting higher and higher. They are no longer satisfied with the practicality and functions of the products themselves, and their requirements for humanized and emotional design outside the industrial products are improved. Therefore, the use of CAD software is of great significance in the industrial design process. The CAID improves the precision and efficiency of assembly tool design, and makes up for the deficiency of traditional tooling. By observing the renderings of computer design, industrial designers make advance design, which makes industrial product design look more intuitive and natural. CAD must have modern design ideas and ways of thinking, and then understand the characteristics of modeling design from the perspective of 3D modeling. For industrial designers, the basic principles and general rules of 3D modeling of industrial products through CAD software, and then they have the ability to skillfully use various modeling techniques to realize specific 3D modeling.

CAD needs fast network and perfect data to support it. Only perfect data and fast network can make the products produced have functions and brand effects that other products do not have, thus laying a solid foundation for the design of the whole computer-aided process. It not only greatly surpasses the restriction of traditional technology in the past, but also reasonably solves the risks and injuries caused by some manual operations, and plays a very important role in the whole industrial design. CAD can well reduce the cost of industrial production and manufacturing. It is more intuitive and convenient to know about product design through the form of CAD renderings. At the same time, it can evaluate the possible problems in industrial product design and some defects of products, so as to make improvements to achieve a good design process.

3.2 Improved 3D Modeling Algorithm Based on CNN

The estimation of image depth can also be realized by constructing neural network. The deeper the network, the stronger the expression, and the more complex tasks can be accomplished. However, the deeper the neural network is, many problems may arise, such as the network is difficult to train, the training speed is slow, the convergence is difficult, and the network parameters are too many. If the number of network layers is small, the network capability it can express is limited. The structure of color image recognition model based on CNN in this article is shown in Figure 1.

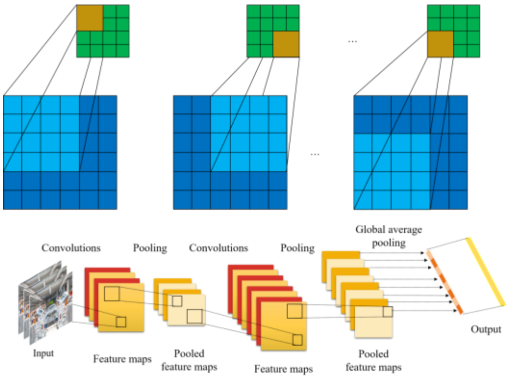

Figure 1: Structure of color image recognition model based on CNN.

The schematic of constructive learning algorithm is shown in Figure 2. All model classifiers share a CNN feature extraction network, but they have different classification networks. In the training stage, all training data are used to train the feature extraction network. Each model classifier is trained by the view under the corresponding viewpoint group. In the most representative view selection, the linear regression model of single view and its classification accuracy is established. Then the output of regression model is used as the basis of view representativeness.

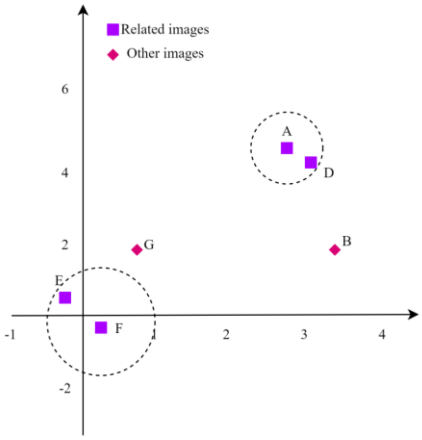

Figure 2: Schematic diagram of constructive learning algorithm.

The CNN function is defined as:

$$x_j^l = f\left(\sum_{i \in M_j} x_i^{l-1} \times k_{ij}^l + b_j^l\right) \tag{1}$$

$$F_j^{(n)} = \sum_i w_{ij}^{(n)} * F_i^{(n-1)} + b_j^{(n)} \tag{2}$$

$$F_j^{(n+1)} = f\left(F_j^n\right) \tag{3}$$

Where: f is the pointwise activation function. Convert each data item x_i to y_i in a mini-batch $B = \{x_1, x_2, x_3, \ldots, x_m\}$ of size m :

$$y_i = \gamma \widehat{x}_i + \beta \tag{4}$$

$$\widehat{x}_i = \frac{x_i - E_M(x_i)}{\sqrt{Var_M(x_i) + \varepsilon}} \tag{5}$$

$$\bigcup_{i=1}^{N} R_i = R \tag{6}$$

For all i and j, $i \neq j$, there are:

$$R_i \cap R_j = \varnothing \tag{7}$$

For $i = 1,2,\ldots,N$, there are:

$$P(R_i) = TRUE \tag{8}$$

For $i \neq j$, there are:

$$P(R_i \cup R_j) = FALSE \tag{9}$$

Where $P(R_i)$ is a logical predicate over all elements in set R_i, and $\varnothing$ represents the empty set.

Assuming that the input and output functions of industrial layout design image feature information are expressed as R and R' respectively, the bilateral filtering discrete form expression of industrial layout design image feature information is as follows:

$$R'=[k,j]=\sum_{m=-p}^{p}\sum_{n=-p}^{p}B[m,n,k,j]R[k-m,j-n] \tag{10}$$

Where p represents a pixel of industrial layout design image feature information; m represents the variance of industrial layout design image feature information; n represents the standard deviation of industrial layout design image feature information; $B[m,n,k,j]$ represents Gaussian kernel function of industrial layout design image feature information, and its calculation expression is as follows:

$$B[m,n,k,j]=\frac{\exp\left(-\frac{m^2+n^2}{2\sigma_\delta^2}-\frac{R[k-m,j-n]}{2\sigma_\xi^2}\right)}{R(k,j)} \tag{11}$$

Where σ represents the scale parameter of industrial layout design image feature information. The above equation is used to smooth the feature information of industrial layout design images from geometric and photometric domains, eliminate the influence of noise, and keep the feature details of industrial layout design images.

In this article, the introduced visual expression sensitivity difference method is used to process image data. The equation is:

$$(x-x_1)+\Delta x=-f\left(\frac{a_1(x-x_1)+b_1(y-y_1)+c_1(z-z_1)}{a_3(x-x_2)+b_2(y-y_2)+c_3(z-z_2)}\right) \tag{12}$$

Where $f(x)$ represents validity, and the validity in general is a range value. x, y, z are digitization of length, width and height of scanned image data. The equation is:

$$(y-y_0)+\Delta y=-f\left(\frac{a_2(x-x_1)+b_2(y-y_1)+c_2(z-z_1)}{a_3(x-x_2)+b_2(y-y_2)+c_3(z-z_2)}\right) \tag{13}$$

Where x, y, z are the special function values of valid data, and the matching effect can be directly calculated through the transformation of the equation. The matching value represents the corresponding attribute feature, and the attribute feature coefficient equation is:

$$\begin{cases}\Delta X=X\left(r^2k_1+r^4k_2\right)+\left(r^2+2x^2\right)P_1+2xyB\\ \Delta Y=Y\left(r^2k_1+r^4k_2\right)+\left(r^2+2x^2\right)P_2+2xyB\end{cases} \tag{14}$$

Type, r said integration coefficient; k represents the attribute extraction coefficient; P is a deployment function; B is an order-changing function. Non-uniform image interpolation method arranges the image data orderly, and then tracks the data. In order to ensure that the data can be reflected to the greatest extent, sequence sorting is required, as follows:

$$M = \begin{bmatrix} L_{xx}(x,y,\sigma) & L_{xy}(x,y,\sigma) \\ L_{xy}(x,y,\sigma) & L_{yy}(x,y,\sigma) \end{bmatrix} \tag{15}$$

Where M is the statistical value of the sequence, the image attributes after the sequence sorting are regular, and the imaging stage of images is not revised.

4 RESULT ANALYSIS AND DISCUSSION

This data set is applied to the training of the CNN structure with the task of depth completion, and finally the prediction of the pixel values not returned by the depth sensor is completed, and a complete depth image prediction network with RGB images and depth images as inputs is realized. The points in the 3D point cloud obtained by the 3D reconstruction network are independent, unrelated and lack of envelope structure, which is different from the closed 3D model in real life. Therefore, it is necessary to further process the point cloud, connect the points in the point cloud, reconstruct the surface and form a solid 3D model. The system inputs the blank background image, extracts the image data features through the image feature extraction network, and then reconstructs the 3D point cloud to obtain the 3D coordinates of the reconstructed target. Finally, the surface of the point cloud data output by the network is reconstructed into a solid model. In order to avoid the loss of important information caused by the rejection of special data, the quantitative data with large differences in data distribution interval can be discretized. Data outlier removal processing is shown in Figure 3.

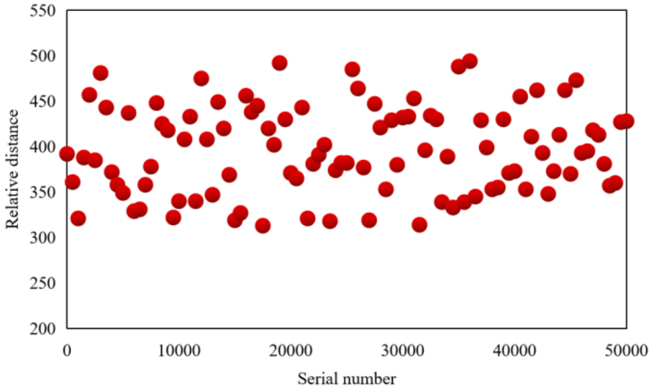

Figure 3: Data outlier removal processing.

Using these data to train the designed CNN can get better network weights. Then, substituting the obtained network weights into CNN can become the basic model of urban circular economy development evaluation. Compare CNN output data with real economic development data, as shown in Figure 4.

Improved CNN is a variable structure system, which can obtain the weight and structure of the network through learning and training. It shows strong self-learning ability and adaptability to the environment, and can complete the ability to adapt to the environment and learn from external things.

The current feature extraction methods do not consider the pose of 3D models, which reduces the performance of the classifier. The pose of 3D model is closely coupled with the model category. When you only see a certain surface of the 3D model, and determine which viewpoint the surface was acquired from, you can judge the pose of the model, so it is easy to infer the type of the model. Each index was tested 20 times, and 4 of them were selected. The experimental results were drawn into a table as shown in Table 1.

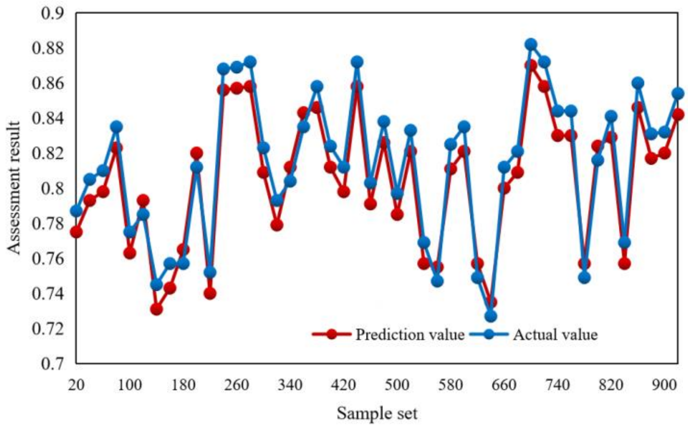

Figure 4: Learning results of machine learning.

Index	*1*	*2*	*3*	*4*
Regional similarity	0.945	0.964	1.952	0.971
Accuracy of contour	0.976	0.977	0.968	0.992
Time stability	0.979	0.985	0.974	0.963

Table 1: Experimental results of indicators.

Each model classifier corresponds to a viewpoint group. Therefore, the input of training each model classifier is the view under each viewpoint group, and finally the 3D model classification based on pose under different viewpoints is realized. In order to make full use of the features extracted by the baseline system and mine the pose information of views in different viewpoints, the convolution pool layer parameters of all feature extraction parts are fixed, and the full connection layer of the model classifier is trained by using the two-dimensional views in different viewpoint groups. Table 2 shows the change of the accuracy of the evaluation model of economic and environmental coordination degree when different iterations are set.

Iterations	*Accuracy*
2000	30.8%-67.9%
4000	40.5%-70.8%
6000	62.5%-72.8%
8000	71.7%-81.4%
10000	80.8%-90.4%
12000	81.8%-91.6%

Table 2: Model accuracy of different iterations.

It can be seen that after many iterations, the accuracy of the improved CNN has gradually increased and stabilized. In pattern classification, only when the data of the same category have certain similarity can a classifier with high recognition rate be trained. However, when classifying views, the traditional method considers that all views of each model belong to the same category. In fact, the views of the same model in different viewpoints are very different, so it will be difficult for the classifier to learn a reasonable classification surface if it is placed in one category. Table 3 shows the precision comparison results on data sets.

Proposed method	*Color*	*Modelling*	*Typesetting*	*Layout*
VOE	5.1E+03	6.1E+03	4.1E+04	1.3E+03
EPOR	5.2E+03	5.2E+04	3.1E+04	7.4E+04
RCC	5.4E+03	5.2E+04	3.4E+04	4.6E+04
VIBE	5.9E+03	7.6E+03	3.3E+04	4.3E+04
FASTSEG	2.5E+04	6.2E+04	3.5E+04	4.7E+04
Proposed method	3.3E+03	5.7E+04	7.1E+03	1.3E+04

Table 3: Accuracy comparison results.

The higher the surface complexity of the view, the more information the view contains, and the more representative and distinctive it is. Therefore, when 3D models are classified using views with high surface complexity, the classification accuracy will be higher. Comparison of algorithm response speed is shown in Figure 5. The recall of the algorithm is shown in Figure 6. The accuracy of the algorithm is shown in Figure 7.

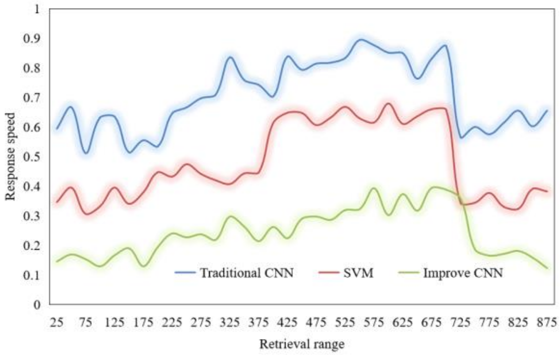

Figure 5: Comparison of response speed.

It can be seen that the recall and error of the improved CNN model are obviously superior to that of the comparison method in both the initial stage and the later stage, and the response speed is more than 20% higher than that of the traditional CNN. Therefore, it is feasible to apply this method to computer-aided industrial layout design. The reconstruction effect of 3D point cloud is better for network rules and simple objects, but slightly worse for complex objects. Moreover, each point in the point cloud exists independently, and there is no relationship information between points. Therefore, even if training is carried out under a large number of samples, there will be a big error between the reconstructed results and the real data. Compared with other detection methods. This research provides more basis for users' technological innovation in industrial design.

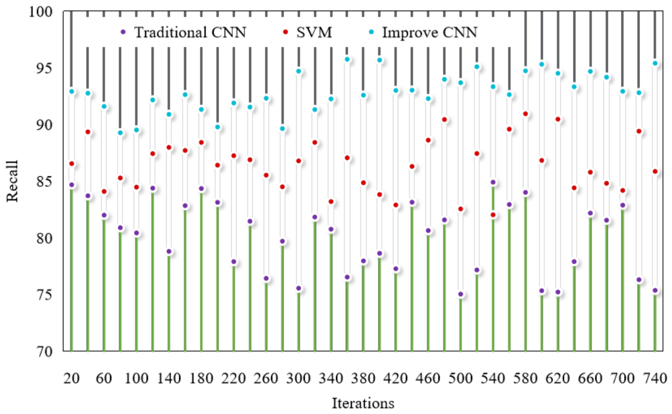

Figure 6: Recall of different algorithms.

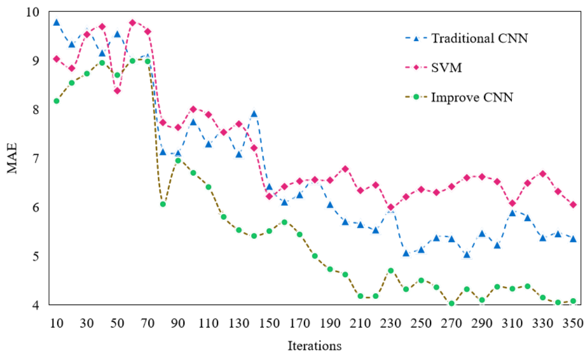

Figure 7: Errors of different algorithms.

5 CONCLUSIONS

This article presents an industrial design image recognition model based on CNN. This model makes use of CNN's automatic characteristic learning ability and accurate target identification ability, enhance the generalization ability of the network, and uses batch normalization to speed up network training. The recall and error of the improved CNN model are obviously superior to that of the comparison method in both the early and late operation stages, and the response speed is more than 20% higher than that of the traditional CNN. Therefore, it is feasible to apply this method to computer-aided industrial layout design. Compared with traditional methods, DL has great advantages in reconstruction efficiency and accuracy when applied to image 3D reconstruction technology, and 3D reconstruction technology can not only be used as the main body of application, but also assist other fields.

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