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Three Dimensional Visualization Modeling Algorithm for Medical Images Based on Machine Learning

Xiaojuan Wang, Yuntao Wei*

College of Electronic Information Technology, Jiamusi University, Jiamusi 154007, China
wangxiaojuanwxj@163.com, weiyuntao3@163.com

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Abstract. Aiming at the poor effect of medical image feature recognition and detail judgment, three-dimensional visualization modeling of medical image is needed. A three-dimensional (3D) visualization modeling algorithm of medical image based on machine learning and edge contour feature detection is proposed. Firstly, the distribution matrix of three-dimensional visual gray-scale pixels is constructed for medical images. According to the distribution of pixels, the blurred areas in medical images are de-noised and separated to extract their edge contour features and avoid noise interference. Secondly, the image edge contour features are visually decomposed to construct the three-dimensional contour of medical images. Finally, the machine learning method is used to reconstruct the three-dimensional contour visually, and the three-dimensional visualization model of medical images is established to realize the three-dimensional visualization modeling algorithm design of medical images based on machine learning. The simulation results show that the method has better feature resolution, higher accuracy of detail feature extraction and better effect of three-dimensional reconstruction, and improves the effect of feature recognition and detail judgment of medical images.

Keywords: machine learning, medical image, 3D visualization modeling, image reconstruction

1 Introduction

3D reconstruction of medical image is an advanced medical image processing technology. With the development of medical image processing technology, 3D reconstruction of medical image using image processing technology can not only reconstruct the 3D surface of the object, but also reflect its internal structure, providing realistic display for doctors. Using medical images to judge pathological features can improve the ability of identification and diagnosis of pathological features, which plays a very important auxiliary role in disease diagnosis and treatment [1-2]. It can be seen from this. Combining the three-dimensional visual feature reconstruction method to realize the three-dimensional feature detection of medical images, and researching the three-dimensional visual reconstruction methods of medical images is of great significance in the analysis and processing of medical images [3].

The existing medical image reconstruction technology is often a knowledge-based expert system, which is subjective to a certain extent. Machine learning is a widely used image processing technology, which is highly active in the field of artificial intelligence and has become a hot topic in medical image processing. In Literature[4], machine learning algorithm is applied to neuromuscular disease image recognition research, and four machine learning algorithms are used to test the subjects respectively. The results show that deep neural network has better image processing technology. In Literature [5], image segmentation is based on machine learning, convolution neural network is analyzed, and network model is constructed for image segmentation, and the results show that the effect is better good.

In this paper, machine learning is used for 3D visualization modeling of medical images, and the performance of the algorithm is verified by experiments. The results show that the proposed algorithm has good 3D reconstruction effect. The main contributions are as follows:

(1) The method of region feature reconstruction is used to decompose the 3D visualization features of medical images, and the 3D contour distribution model of medical images is constructed to provide the basis for medical

* Corresponding Author

image processing; (2) According to the pixel distribution, the fuzzy areas in the medical image are denoised and separated, and the edge contour features are extracted to avoid noise interference; (3) The machine learning method is used to detect and reconstruct the 3D visualization of medical images. Combined with the block feature matching method, the 3D visualization reconstruction and modeling of medical images are realized. The superiority of the algorithm is verified by multiple indexes.

2 Related Work

At present, the research on 3D visualization modeling technology of medical images has been carried out by a lot of related scholars. Deng Jianquan [6] et al. studied the three-dimensional visualization modeling of renal blood vessels in small pigs. A pair of fresh, normal in vitro piglet kidneys were infused into the abdominal aorta (red) and "titanium oxide epoxy" fillers, and the vena cava (yellow, right renal vein ligation) was infused. Two-dimensional images were acquired with a 128-slice spiral CT thin-layer scan. The 3D visualization model was successfully reconstructed with the software MIMICS19.0. Cai [7] et al. used a medical image three-dimensional visualization system to accurately predict liver volume after liver resection. Between January 2010 and June 2016, 69 patients with liver cancer underwent MI-3DVS-based liver resection, and all patients underwent CT scans 5 days before and 5 days after surgery. CT images were reconstructed with MI-3DVS and assisted hepatectomy. Simple linear regression, intra-class correlation coefficient (ICC), and Bland-Altman analysis were used to evaluate the relationship and consistency between actual liver resection volumes (AELV) and predicted liver resection volume (PELV). Peng et al [8] discussed a highly dynamic image algorithm based on the layering of the guide filter image. First, the image of the guide filter was decomposed into two parts of infrared images. Then the image details are preserved and re-synthesized, which improves the calculation efficiency and maintains the detail enhancement ability in the subjective and objective evaluation of the human eye. However, the limitation of the above algorithm lies in the uncertainty of the degree of detail retention when decomposing the infrared image, which causes a slight error in the image synthesis.

This paper proposes a 3D visualization modeling algorithm for medical images based on machine learning. First, the edge contour features of medical images are taken to construct a three-dimensional contour line visualization distribution model, and machine learning methods are used to visually reconstruct the three-dimensional contour. The results show that the proposed algorithm feature resolution is good, the detailed features can be accurately extracted, and the medical image reconstruction effect is good.

3 Three Dimensional Contour Distribution of Medical Images

3.1 Extract Edge Contour Features of Medical Images

Construct a three-dimensional visual gray-scale pixel distribution matrix for medical images, and perform noise reduction and separation processing on blurred areas in medical images based on the pixel distribution to extract the edge contour feature amounts to avoid noise interference. In order to realize the three-dimensional visualization modeling of medical images, the visual distribution analysis of edge contour features of medical images needs to be performed first, and the extraction of edge contour features is the basis of visual analysis [9]. Therefore, let the spatial matrix of the gray pixel distribution sequence D of the three-dimensional medical image be:

$$D=\begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} \tag{1}$$

Where, I_x and I_y represent gray pixels of medical image.

According to the pixel distribution, the blurred area in the medical image is extracted, and the blurred area $E(\mathbf{T}_n)$ can be expressed as:

$$E(\mathbf{T}_n)=\frac{1}{N}\sum_{i=0}^{N-1}\left\|p_i-\mathbf{T}_n(g_i')\right\|^2+\tau\cdot\Phi(\mathbf{T}_n)I_x I_y \tag{2}$$

Where, $\Phi(\mathbf{T}_n)$ is the fuzzy pixel integration vector. p_i is the pixel blur vector of medical imag. N is the pixel sequence value. τ is the blur coefficients of gray pixels in medical image [10-11]. Combine the fuzzy information fusion method to obtain the fuzzy weighting function of medical image $f(g_i)$ as:

$$f(g_i) = c_1 E(\mathbf{T}_n)\tilde{\lambda}_i \sum_{j=0}^{N_{np}} \frac{\rho_j \vec{\upsilon}_{ij}}{\left|\vec{\upsilon}_{ij}\right|^{\sigma_1} + \varepsilon} \Bigg/ \sum_{j=0}^{N_{np}} \frac{\rho_j}{\left|\vec{\upsilon}_{ij}\right|^{\sigma_1} + \varepsilon} \tag{3}$$

Where, $c_1 E$ is the specific fuzzy area, and $\left|\vec{\upsilon}_{ij}\right|$ is the image information's absolute value from i to j. $\tilde{\lambda}_i$ is the fusion coefficient, ρ_j is the weight matrix, ε is the pixel variance. In order to avoid noise interference in the process of extracting features of medical images, noise reduction and separation processing is performed on the blurred areas of medical image images [12]. The processing conditions are as follows.

$$\delta(\cdot) \tag{4}$$

Where, H is the confusion area's noise reduction threshold range, and θ is the specific value. Based on the noise reduction process, the edge contour features of the medical image are extracted as follows:

$$\begin{aligned} f(\mathbf{G}_n) &= a_1 + a_2 x + a_3 y + a_4 z + \sum_{i=0}^{n} \gamma_i U(g_i', p_i) \\ g(\mathbf{G}_n) &= b_1 + b_2 x + b_3 y + b_4 z + \sum_{i=0}^{n} \theta_i U(g_i', p_i) \end{aligned} \tag{5}$$

Where, $f(G_n)$ and $g(G_n)$ represent the overall edge contour and internal contour of the medical image, respectively. a and b represent different pixel noise reduction coefficients, respectively.

According to the above model construction, the 3D visual decomposition of medical images is performed using the envelope contour detection method, and the 3D visual modeling of medical images is performed to improve the 3D visual reconstruction and feature resolution capabilities of medical images [13-14].

3.2 Construction of 3D Contour Visualization Model for Medical Imaging

Extract the edge contour features of medical images and construct the function of the edge contour features of medical images. It is shown in formula (6).

$$Accuracy = \frac{\sum_{i=1}^{m} \delta(f_i, r_i)}{n} \tag{6}$$

Where

$$n \tag{7}$$

Where, $\delta(\cdot)$ refers to the eigenvalue cardinality of medical images, k is the characteristic compensation coefficient. f_i refers to the edge grey feature value of the medical image at r_i, $L(x, y, \sigma)$ refers to the smoothing operator for medical images, and $G(x, y, \sigma)$ is the contour fitting coefficients for medical images, which is calculated as:

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}} \tag{8}$$

Where, e is the contour value of medical image, σ is the mapping value of 3D space feature. Determine the edge detail information of the medical image, perform image reconstruction and hierarchical decomposition according to the distribution distance $E(d(x, y))$ of the edge detail feature points of the medical image.

$$(a, b_m) \tag{9}$$

Where, F_d is the edge feature of 3D visualization F_{d_x} and F_{d_y} are the edge scale of the damaged medical image at (x, y). The distribution feature quantity of the edge detail grid surface of medical images is $d(x, y)$. Suppose noise of hypothetical medical images N_l and η are the three-dimensional contour threshold value. The 3D contour line visualization distribution model of the medical image is:

$$N_l = \begin{cases} 1 & l = 0, L \\ \left[2\pi \times \frac{F_d}{3} \times \sin \eta \Big/ l_t \right] & l = 1, ..., L-1 \end{cases} \tag{10}$$

Where, l is the sequence combination of contour points.

Based on the above analysis, a visual distribution model of the three-dimensional contour lines of medical images is constructed, and the three-dimensional contours are visually reconstructed using machine learning methods, and the three-dimensional visual imaging processing of medical image images is performed [15]. According to the image reconstruction results, 3D visualization is performed to construct a 3D visualization modeling analysis of medical images.

4 Three Dimensional Visualization Modeling of Medical Images

4.1 Three Dimensional Visualization Reconstruction of Medical Images

Based on the fuzzy filtering and noise reduction of the adaptive filtering detection method for the 3D reconstructed image of medical images [14], the 3D visualization modeling of medical images is proposed. This paper proposes a 3D visualization modeling method of medical images based on machine learning and edge contour feature detection. The method based on machine learning is used to reconstruct features of 3D reconstructed images of medical images from algorithms, models and evaluations. Machine learning methods use feature selection and feature item weight calculation to extract the edge contour features of medical images [16-17]. A three-dimensional contour line distribution model of a medical image is constructed, and the edge information feature components of the medical image are:

$$\tilde{p}(x, y) = \frac{k(x, y)}{v(x)} \tag{11}$$

Where, M_i is the fuzzy operator for 3D visualization reconstruction of medical images, and C_j refers to the featured component of the image edge information in C_i.

The continuous reconstruction feature components at the (a, b_m) point of the reconstructed medical image surface are:

$$L(a, b_m) = \log\left(\frac{|M||M_i \cap C_j|}{|M_i||C_j|} \right) \tag{12}$$

Assume that the 3D visual feature distribution pixel set of the medical image is $I(x, y)$, in high-resolution imaging areas, the edge contour feature distribution of medical image images satisfies the Jacobian matrix $J(x, y, \sigma)$. Perform continuous feature extraction on medical images, that is:

$$L(a, b_m) = \sum_{M_i \in P^{res}} \sum_{C_j \in P^{true}} \frac{|M_i \cap C_j|}{|M|} \log\left(\frac{|M||M_i \cap C_j|}{|M_i||C_j|} \right) \tag{13}$$

The three-dimensional visual feature reconstruction method is used to reconstruct the medical image, and the fuzzy information enhancement method is used to perform feature enhancement processing on the blurred point information of the medical image, thereby obtaining an approximate solution of the differential feature quantity of the medical image:

$$\nabla \phi \tag{14}$$

Where, $x_1, x_2, x_3, ..., x_T$ is the feature sub-sample of each sub-block, S is the time window function for 3D visualization reconstruction of medical images. The statistical shape model of the medical image is established, and the adjacent pixel set of 3D visualization reconstruction of the medical image is obtained as:

$$F = \tilde{p}(x, y) = p(x, y)\left(\frac{v(x)}{v(y)}\right)^{1/2} \times \overline{x_T} \tag{15}$$

Where

$$\tilde{p}(x, y) = \frac{k(x, y)}{v(x)} \tag{16}$$

Where, $v(x) = \sum_y k(x, y)$, $v(x)$ and $L_x(x, y, \sigma)$ represent the adjacent number of 3D visualization reconstruction of medical image at x and y respectively. $p(x, y)$ is the statistical shape model. $M(x, y, \sigma)$ is the visual optimization model of statistical shape model. The neighborhood search method is used to enhance the information of medical images, and the 3D visualization reconstruction of medical images is obtained.

$$E_{(vi)} = \frac{1}{2} F(\left|d - |v_i - v_{i-1}|\right|^2 + |v_{i-1} + 2v_i + v_{i+1}|^2) \tag{17}$$

Where, $d = \frac{1}{n}\sum_{i=0}^{n-1} |v_i - v_{i-1}|$, v_i refers to the feature number in the image, and v_{i-1} refers to the neighborhood values of characteristic values in the image. According to the above processing, 3D visualization detection and reconstruction of medical images are performed, and 3D visualization modeling and analysis of medical images are performed according to feature detection and reconstruction results.

4.2 Three Dimensional Visualization Model of Medical Image

Machine learning is used for 3D visual reconstruction and visualization modeling of medical images, and area feature reconstruction methods are used for 3D visual feature decomposition of medical images. Set the medical image vector quantization feature [18-19], and extract the gray pheromone of the medical image, and the pre k dimensional feature module of the medical image is described as:

$$k(\phi) = \int \frac{1}{2} k\left(|\nabla \phi|\right)^2 dx - E_{(vi)} \tag{18}$$

Where, $\nabla \phi$ is the local template matches for medical images. The sparse linear segmentation method is used to enhance the details of the medical image. The reference template matching function of the medical image is:

$$P(x, y, d(x, y)) = k(\phi)\left|u(x - d(x), y) - \tilde{u}(x, y)\right|^2 \tag{19}$$

Where, $\tilde{u}$ is the module function of the medical image, and u refers to the image to be reconstructed. $d(x, y)$ is the contour feature components of medical imaging images.

Machine learning algorithms are used to perform 3D visualization modeling and adaptive optimization of medical images. The 3D visual feature distribution model of medical images is:

$$J(x,y,\sigma)=\begin{pmatrix}\frac{\partial P}{\partial x}\\ \frac{\partial P}{\partial y}\end{pmatrix}=\begin{pmatrix}1 & 0 & L_x(x,y,\sigma)\\ 0 & 1 & L_y(x,y,\sigma)\end{pmatrix} \tag{20}$$

Multiple feature decomposition is performed on the medical image $L_x(x,y,\sigma)$, and the three-dimensional visual feature set of the output medical image is:

$$H(x,y,\sigma)=J(x,y,\sigma)\begin{pmatrix}1+L_x^2(x,y,\sigma) & L_x(x,y,\sigma)L_y(x,y,\sigma)\\ L_x(x,y,\sigma)L_y(x,y,\sigma) & 1+L_y^2(x,y,\sigma)\end{pmatrix} \tag{21}$$

Template matching for medical images with morphological segmentation [20]. In summary, the 3D visualization modeling output of medical image $M(x,y,\ \sigma)$ can be expressed as:

$$\begin{aligned}M&=\begin{pmatrix}\frac{\partial^2 P}{\partial x^2}\vec{N} & \frac{\partial^2 P}{\partial x\partial y}\vec{N}\\ \frac{\partial^2 P}{\partial x\partial y}\vec{N} & \frac{\partial^2 P}{\partial y^2}\vec{N}\end{pmatrix}=\begin{pmatrix}\left(0,0,L_{xx}(x,y,\sigma)\right)\cdot\vec{N} & \left(0,0,L_{xy}(x,y,\sigma)\right)\cdot\vec{N}\\ \left(0,0,L_{xy}(x,y,\sigma)\cdot\vec{N}\right) & \left(0,0,L_{yy}(x,y,\sigma)\right)\cdot\vec{N}\end{pmatrix}\\ &=\begin{pmatrix}L_{xx}(x,y,\sigma) & L_{xy}(x,y,\sigma)\\ L_{xy}(x,y,\sigma) & L_{yy}(x,y,\sigma)\end{pmatrix}\end{aligned} \tag{22}$$

The edge contour information of the medical image is reset, and the contour features of the medical image are extracted and reconstructed. The 3D visualization modeling expression of the medical image is:

$$Q_{ij}=\frac{\begin{pmatrix}\sum_{j\in N^-(i)}\left(M\frac{i+j}{2}+(1-M)\frac{k(\phi)}{2}\right)\\ +\sum_{j\in N^+(i)}\left(M\frac{i+j}{2}+(1-M)\frac{k(\phi)}{2}\right)\end{pmatrix}}{\sum_{j\in N(i)}\left(M\frac{i+j}{2}+(1-M)\frac{k(\phi)}{2}\right)} \tag{23}$$

The machine learning method is used for 3D visualization detection and reconstruction of medical images, and the block feature matching method is used to realize 3D visualization reconstruction and modeling of medical images.

4.3 Steps of 3D Visualization Modeling Algorithm

In summary, the specific steps of visual modeling are as follows:

(1) Perform reconstruction of 3D reconstructed images of medical images;

(2) Perform 3D visualization reconstruction of medical image features, extract edge contour feature quantities of medical images, and output edge information feature components of medical images;

(3) Decompose the 3D visualization features of medical images, enhance the details of medical images, and obtain the reference template matching function of medical images; input the corresponding functions for 3D visualization modeling and adaptive optimization of medical images, and output 3D visualization feature sets;

(4) Template matching for medical images combined with morphological segmentation methods;

(5) Extract and reconstruct the contour features of the medical image in the 3D visualization feature set, and obtain the 3D visualization modeling expression of the medical image;

(6) Realize 3D visualization reconstruction and modeling of medical images.

Through the above process, three-dimensional visualization modeling of medical images is realized, which provides effective image support for medical diagnosis.

5 Experiment and Result Analysis

In order to verify whether the method can accurately judge the details of the picture, the application performance in realizing the three-dimensional visual modeling of medical images is tested experimentally.

5.1 Experimental Environment

The simulation tool for 3D visualization modeling of medical images in the experiment is Matlab Simulink, and the graphics processing software for 3D visualization modeling is 3DStudio MAX. The spatial distribution frequency of medical image visual information sampling is 24KHz, and the fusion vector distribution set of spatial pixels is 300 * 300.

5.2 Experimental Indicators

5.2.1 Feature Resolution Accuracy

The visual distribution analysis of the edge contour features of medical images is a key part of 3D visualization of medical images, and the extraction of edge contour features is the basis of visual analysis. Among them, extracting detailed features requires testing the feature resolution accuracy, so the feature resolution accuracy is set as one of the indicators, and the specific calculation formula is as follows:

$$Acc = \frac{F_d}{3} \times \sin\varsigma \Big/ l' \times 100\% \tag{24}$$

Where, ς is the overall edge of the feature and l' is detail feature resolution angle.

5.2.2 Feature Matching Accuracy

Feature matching is one of the basic principles of information retrieval. It compares and matches the differences between the two parties and outputs completely or partially matching information. The accuracy of feature matching reflects the degree of matching of medical images, so it is used as the second evaluation indicator.

5.2.3 Three Dimensional Reconstruction Effect

The medical image feature recognition ability and detail processing effect are finally reflected in the reconstruction of medical images. The specific formula is shown below.

(25)

Where, Rec is the overall effect of medical image reconstruction, Ext is the feature matching degree, and mat is the reconstruction error. The error coefficient of the formed image is scaled according to Wiener filtering, and whether the final effect is optimized by judging the value of the three-dimensional matrix and the scale strength is verified.

5.3 Experiment Datasets

Select the type of page in FOVIA (http://fovia.com/) for 3D visualization of medical image data entry. The cross-compilation method is used for medical image feature recognition and visual reconstruction to obtain the original medical image sampling results. It is shown in Fig. 1.

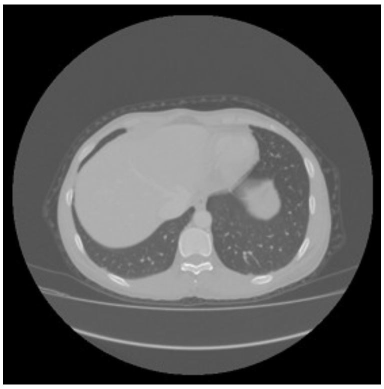


Fig. 1. CT image of original medical image

5.4 Results

5.4.1 Comparison of Feature Resolution Accuracy

The adaptive filtering detection method is used for medical image 3D reconstructed image to perform fuzzy noise reduction and separation, to extract the edge contour features of medical image, to achieve information enhancement, and obtain enhanced results. It is shown in Fig. 2.

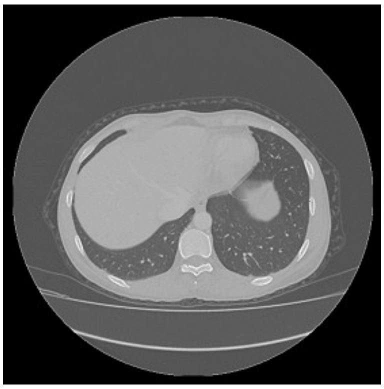


Fig. 2. Enhancement of medical image

A three-dimensional contour line distribution model of medical images is constructed, and machine learning methods are used to perform three-dimensional visual detection and reconstruction of medical images. Combining the block feature matching method to realize 3D visualization reconstruction and modeling of medical images, the methods in this paper and the methods in Literature [6], Literature [7] and Literature [8] were used to obtain the final 3D visualization modeling output. It is shown in Fig. 3.

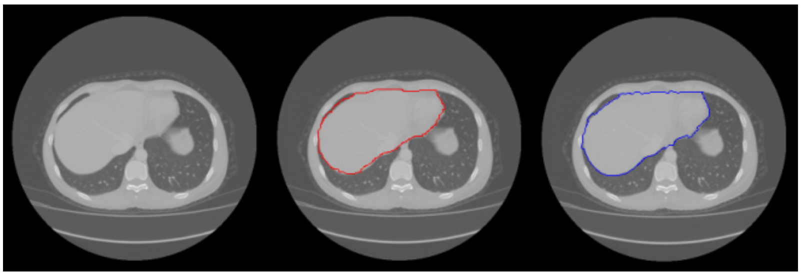


Fig. 3. 3D visual modeling output of medical image

Analysis of Fig. 3 and Fig. 4 shows that the method used in this paper for medical image 3D visualization modeling has strong feature resolution ability and high reconstruction accuracy.

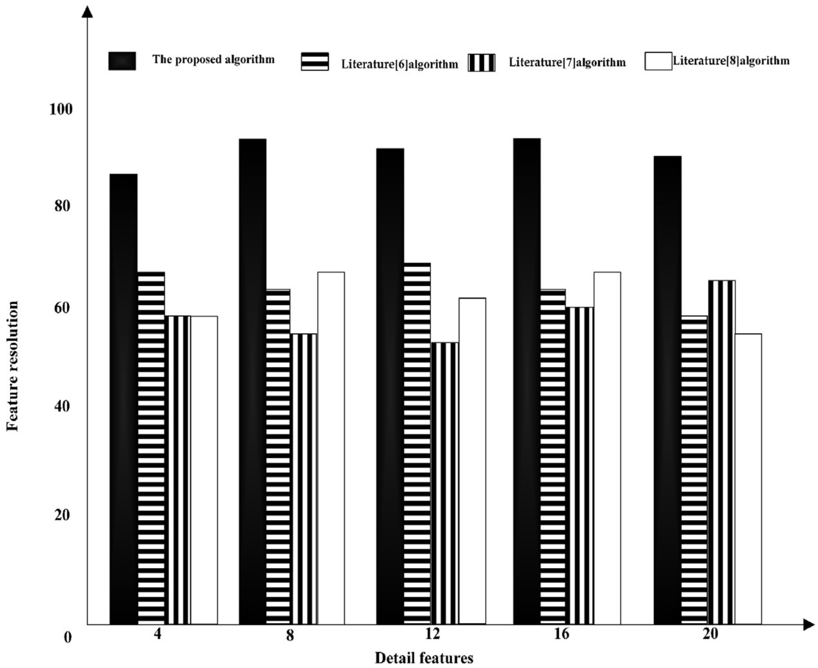


Fig. 4. Comparison results of visual resolution accuracy

5.4.2 Comparison of Feature Matching Accuracy

The method of this paper and the methods of Literature [6], Literature [7], and Literature [8] were used to perform a comparative test on the feature matching capabilities of 3D visualization modeling of medical images. It is shown in Table1.

Table 1. Comparison of 3D visual modeling feature matching accuracy

Iteration number	improvement method	literature [6]	literature [7]	literature [8]
100	0.945	0.424	0.418	0.415
200	0.967	0.516	0.453	0.603
300	0.987	0.632	0.542	0.665
400	0.998	0.684	0.597	0.745

According to the analysis of Table 1, compared with the visual modeling in Literature [6], Literature [7], and Literature [8], the matching data of the feature matching ability of the improved method is much higher than the other three sets of data. This shows that the details of the image are accurately judged, and a better image effect can be presented. Therefore, the method used in this paper for 3D visualization modeling of medical images has good feature matching performance, strong visual expression ability, 3D visualization modeling with good overall performance and good quality.

5.4.3 Comparison of 3D Reconstruction Effects

To test the reconstruction effect of medical images, the methods in this paper and the methods in Literature [6], Literature [7], and Literature [8] were used to compare the image reconstruction effects of 3D visualization modeling of medical images.

From Fig. 5, the method in this paper has the least number of errors in the feature matching process. The comparison result of the 3D reconstruction effect is shown in Fig. 6.

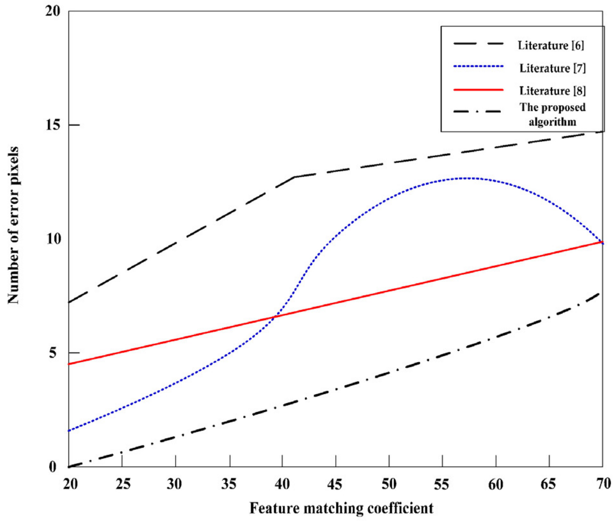
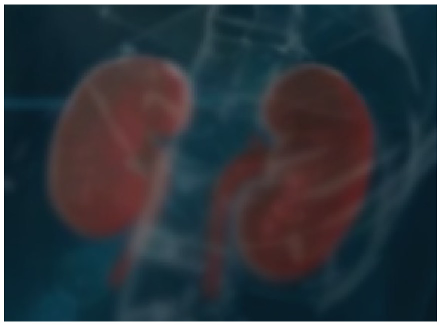


Fig. 5. Comparison of3D reconstruction error coefficients

(a) Literature [6]



(b) Literature [7]

(c) Literature [8]

(d) The proposed algorithm

Fig. 6. Comparison results of image reconstruction effects of 3D visual modeling

From Fig. 6, the image effect in Literature [6] has weak color contrast and low image quality; The image effect of Literature [7] does not highlight the bright spots, which is not conducive to interpretation, interpretation and recording; the image effect of the method of Literature [8] is fuzzy, and it is impossible to select the area in accordance with the actual situation of patients. Compared with the above three methods, the method in this paper has clear images with prominent highlights and good three-dimensional effects, which can achieve higher quality effects of three-dimensional visualized medical images.

6 Conclusions

In order to improve the ability of medical image feature recognition and detail processing, a three-dimensional visualization modeling algorithm for medical images based on machine learning is proposed. The image processing technology is used to reconstruct the three-dimensional medical image, and the three-dimensional feature recognition of medical images is performed to improve the recognition and detection capabilities of medical images. The 3D reconstructed image of medical image is separated by noise reduction, and the edge contour feature of medical image is extracted. Perform 3D visual feature reconstruction and 3D visual imaging processing on medical images, perform 3D visual detection and reconstruction of medical images, and realize 3D visual reconstruction and modeling of medical images.

The analysis shows that the method used in this paper for 3D visualization modeling of medical images has better feature resolution ability, strong feature recognition ability, good detail processing effect, and higher accuracy. The feature matching performance is good, and the quality of 3D visualization modeling is high. However, the research of machine learning in this study is not deep and specific enough. In the next step, we will analyze the image processing technology of different methods in machine learning in detail, and further improve the application of machine learning in medical imaging, so as to obtain more accurate reconstruction results, provide the basis for medical imaging research, and promote the progress of medical technology.

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