Application of Superpixel Clustering Algorithm to Hip Joint Image Segmentation Registration

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Abstract. Hip fracture is the most common and serious type of fracture in the elderly. The traditional orthopedic disease diagnosis method lacks sufficient information to assist doctors in making a diagnosis, which may easily lead to missed diagnosis and misdiagnosis, delay patient treatment, and may even cause medical accidents. By introducing computer-aided diagnosis technology, this research is mainly divided into the medical image preprocessing process of hip joint diseases, the image segmentation method of superpixel clustering algorithm, the image registration method based on volume feature point selection in the diagnosis of auxiliary ribs of hip joint diseases, and the visualization technology-based method. There are four parts in the evaluation method of auxiliary diagnosis and evaluation of hip joint diseases based on the calculation of quantitative indicators. Segment abdominal CT images through superpixel clustering image processing algorithm to provide auxiliary diagnosis and evaluation of hip joint diseases.

Keywords: Hip Fracture · Image Processing · Clustering Algorithm

1 Introduction

Hip fractures are the most common and serious type of fracture in the elderly. Surgical treatment of two-row acetabular fractures has proven challenging due to the complex acetabular fracture pattern and curved surface of the acetabulum [1]. In the U.S., women are as likely to suffer hip fractures as they are from breast, ovarian, and uterine cancers combined, while men are more likely to suffer hip fractures than prostate cancer. With the intensification of population aging, the incidence of hip fractures in the global elderly is increasing at a rate of 1% to 3% per year. It is estimated that the number of hip fractures in the world will rise to 6.26 million in 2050, and more than half of them will occur in Asia. The incidence of hip fractures in China is also increasing year by year: from 1990 to 1992, the incidence of hip fractures over the age of 50 was 83/100,000 for males and 80/100,000 for females, and increased to 129/100,000 for males during 2002–2006,

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women 229/100,000, and medical expenses have also increased sharply. It is estimated that the total medical expenses for hip fractures in 2020 will be close to 100 billion yuan. Therefore, hip fracture in the elderly has become one of the most important public health problems in the world [2, 3].

With the aging of my country's population, the proportion of osteoporosis in the elderly has increased, leading to an increase in the number of hip fracture patients year by year. At present, there are non-surgical treatment and surgical treatment for the clinical treatment of elderly patients with hip fractures. However, due to the poor resistance of elderly patients and many underlying diseases, non-surgical treatment requires long-term bed rest, which is prone to pressure sores, pulmonary Complications such as infection and deep vein thrombosis seriously affect the quality of life of patients and even endanger their lives. Therefore, surgery is the best treatment for hip fractures in the elderly. However, elderly patients are complicated with multiple complex medical diseases and organ decline in various systems, which increases the risk of surgery, and the incidence of postoperative complications and mortality are also extremely high [4].

2 Research Status

With the rapid development of social and economic life, the number of patients with orthopedic diseases is increasing day by day. There are many kinds of orthopedic diseases, and some symptoms are similar and may occur at the same time. The traditional orthopedic disease diagnosis method lacks sufficient information to assist doctors in making a diagnosis, which may easily lead to missed diagnosis and misdiagnosis, delay the treatment of patients, and may even cause medical accidents [5, 6]. According to statistics, the misdiagnosis rate of diagnosis directly based on medical images can reach 10%–30%. Guobanfa [2021] No. 18 "Opinions of the General Office of the State Council on Promoting the High-quality Development of Public Hospitals" In order to promote the high-quality development of public hospitals, better meet the people's growing needs for medical and health services, promote medical technology innovation, and promote originality New technologies for disease prevention, diagnosis and treatment. This study introduces computer-aided diagnosis technology, which includes computer science, medicine, mathematics, graphics and other multidisciplinary knowledge, covering numbers, images, 3D models and other aspects [7]. Its realization depends on medical image and its processing technology, such as computer tomography (Computed Tomography, CT), microscopic computer tomography (Micro Computed Tomography, Micro-CT), high-power microscope imaging (High-Power Microscope, HPM), etc. Combined with medical image processing technologies such as image segmentation, registration, and visualization, it can visually present useful information in the form of comprehensive index values, 2D images, and 3D models. Diagnosis by experience or spatial imagination provides a lot of scientific basis for diagnosis, reduces the rate of misdiagnosis, and improves the efficiency of diagnosis and follow-up treatment. Therefore, the use of computer-aided diagnostic technology for orthopedic disease diagnosis has great practical significance [8, 9].

Medical image segmentation is a hot field in the field of image segmentation. In recent years, experts and scholars have proposed many theories and methods [10]. There

are segmentation methods based on traditional algorithms such as threshold, region growing, etc. For example, Ilhan et al. proposed a method for segmenting brain tissue affected by cancer [11]. The method uses morphological operations, pixel subtraction, and threshold-based image segmentation techniques to obtain clear images of the skull, brain, and tumor. The recognition rate of this method is 94.28% for tumor-containing images, 100% for tumor-free images, and the overall success rate is 96%, which is better than other algorithms. Zhang et al. proposed a bidirectional region growing segmentation algorithm for medical images [12]. This algorithm solves the problem that the traditional region growing algorithm is sensitive to noise and the order of pixel growth. At the same time, the concept of neighborhood difference transformation is proposed, and the threshold value is selected by using the minimum value optimization through the neighborhood difference transformation matrix. This method can obtain satisfactory segmentation results for medical images with a lot of noise. Although the above medical image segmentation methods based on traditional segmentation algorithms can obtain satisfactory results, they have certain limitations at the application level, and there are problems such as low operating efficiency and time-consuming. With the improvement of computer performance, machine learning methods are also widely used in the processing of medical images. He et al. proposed a three-layer automatic Adaboost-guided active contour model (ASM) based on CT images [13–15]. Three-level active contour modeling was automatically guided by the AdaBoost voxel classifier and AdaBoost contour classifier. A robust, accurate and fast 3D liver segmentation is achieved. Experimental results on three publicly available datasets show that the method achieves sufficient accuracy and significantly reduces segmentation time.

Aruna et al. proposed an improved intuitive fuzzy clustering (IFCM) medical image segmentation algorithm. Intuitive Fuzzy Sets IFCM uses a new Intuitive Fuzzy Theory (IFS) method to generate functions to compute non-membership values [16–18]. The method is extensively experimented on standard datasets of brain, lung, liver and breast images, compared with other IFS-based methods, and outperforms other methods. Criminisi et al. proposed an algorithm for efficient automatic detection and positioning of 3D CT anatomical structures. Efficiently Solving Anatomical Localization Problems Using Multiclass Random Regression Forests. The results of quantitative experiments on 400 high-variable CT databases show that compared with multi-atlas registration and template-based nearest neighbor detection techniques, this method has higher segmentation accuracy and stronger robustness to data [19–21].

In view of the above background, the research on the hip joint CT image segmentation method aims to solve the problems existing in the hip joint CT image segmentation process, optimize and improve it with the help of image processing technology, and obtain more accurate hip joint segmentation results. Realize effective segmentation and provide theoretical reference and technical support for image processing and clinical development of orthopedic medicine.

3 Research Content

Medical imaging methods for hip joint diseases mainly include CT, MRI, and X-ray. Among them, CT scanning has the advantages of high resolution, fast imaging, good display of the contrast between bony structure and surrounding soft tissue, the spatial relationship between the lesion and adjacent tissues, and bone joints with complex anatomical structures. Preferred means. In this paper, the superpixel clustering algorithm is applied to the research process of hip joint image segmentation and registration, and the auxiliary diagnosis and evaluation are carried out, and the medical image processing technology issues involved in image segmentation, image registration, and visualization are researched and analyzed.

The research content is mainly divided into the medical image preprocessing process of hip joint diseases, the image segmentation method of superpixel clustering algorithm, the image registration method based on volume feature point selection in the diagnosis of auxiliary ribs of hip joint diseases, and the hip joint disease based on visualization technology and quantitative index calculation. There are four parts in the evaluation method of auxiliary diagnosis of diseases.

3.1 Medical Image Preprocessing

Image noise is an important factor affecting image quality. However, the contrast of some tissue details in the CT image is very low, and the noise will affect the resolution of the CT image and reduce the quality of the CT image. During the imaging process of medical images, they are often disturbed by the detection equipment and the noise in the environment to generate noise, which makes the CT value of the image fluctuate randomly and seriously affects the image information.

In order to improve the speed and analysis ability of computer processing CT images, improve the image quality in the acquired original CT images, remove redundant noise, and improve the contrast of images, it is necessary to preprocess the original CT images. This paper studies the CT images of hip joints. There are many irrelevant factors in the images, including tissues and muscles. Due to the particularity of the research objectives, image preprocessing is particularly important. Before the 3D reconstruction of abdominal CT images, preprocessing is performed to remove redundant noise and enhance the region of interest, which can make the reconstructed 3D images more accurate.

Perform preprocessing on the abdominal CT image, aiming at the low contrast and high noise of the original hip joint CT image, choose a suitable image preprocessing method to perform image filtering, image sharpening and histogram on the hip joint image Image equalization and other operations complete the image preprocessing work. The flow of the entire image preprocessing operation is shown in Fig. 1.

Fig. 1. The overall process of hip joint CT image preprocessing

Image Filtering, CT images of the hip joint contain a lot of noise, and the function of image filtering is to eliminate the noise in the original image, which is the so-called image denoising. Most CT images of hip joints contain additive noise. Traditional filtering algorithms have a good inhibitory effect on additive noise, and the processing speed of traditional algorithms is fast and simple. This study mainly uses the Gaussian filter algorithm for preprocessing. See Fig. 2.

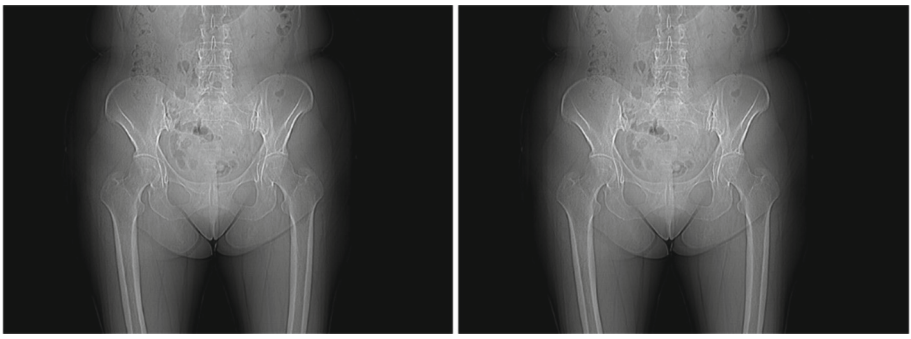


Fig. 2. Comparison chart of image filtering and processing of CT image of hip joint

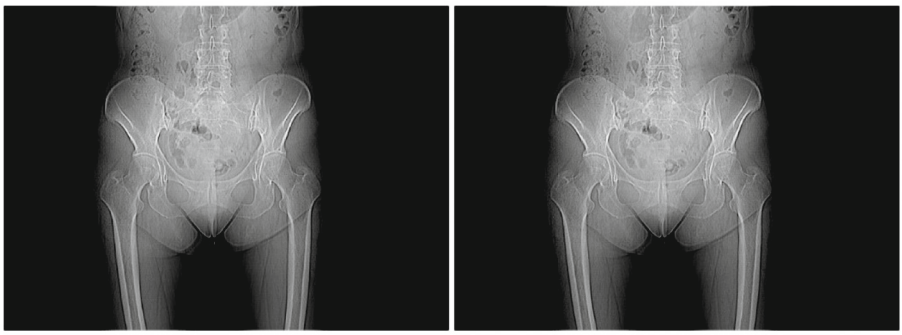
Aiming at the disadvantage that the image contrast is reduced after Gaussian filtering, effective image sharpening and enhancement processing will be performed to make the CT image of the hip joint clearer.

Image Sharpening, in order to effectively suppress the noise in the hip joint image, this paper uses Gaussian filter for preprocessing, the image quality has been effectively improved, but the contrast will be reduced, which will affect the edge information, so image sharpening is used The preprocessing method of the image is used to enhance the edge information features of the image and improve the image contrast. Next, the image Laplacian sharpening algorithm is analyzed experimentally.

Laplace sharpening is a second-order differential sharpening, which is based on the degree of change of image pixels and is an isotropic filter. See Fig. 3.

The above images (A) and (B) respectively represent the images of the hip joint image after Laplace sharpening. By comparing the above experimental results, it can be concluded that the hip joint image sharpened by Laplace can effectively highlight the edge information, the image outline can be effectively displayed, and the internal details of the image sharpened by Laplace are more preserved. it is good.

Histogram Equalization, histogram equalization is a kind of image enhancement. Because the CT images of the hip joint obtained by CT machines are often low in brightness and contrast, which will have a great impact on the results of the later 3D reconstruction work, so the method of histogram equalization is used to enhance the image quality. Histogram equalization is to use the histogram correction method to redistribute the gray value of the original image by using the nonlinear stretching method to expand the gray value range of the image.



(A) (B)

Fig. 3. Comparison chart of image sharpening processing of CT image of hip joint

In this paper, the preprocessing method of histogram equalization is used to test the CT image of the hip joint. The specific results and the simulation results of the gray histogram are shown in Fig. 4 below.

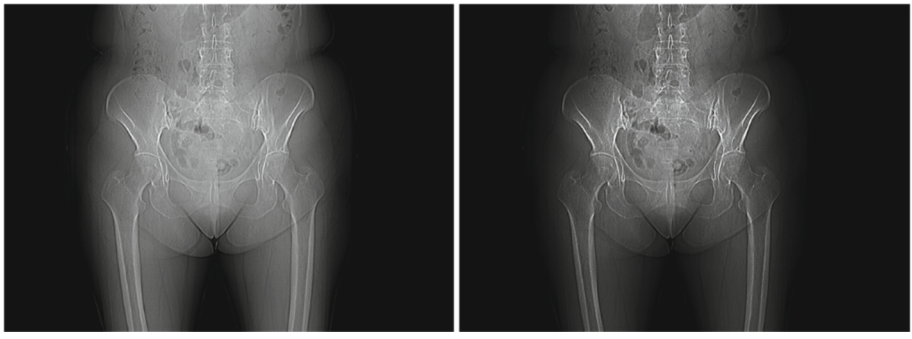


Fig. 4. Comparison chart of image histogram processing of CT image of hip joint

The experimental results are shown in the Fig. 5:

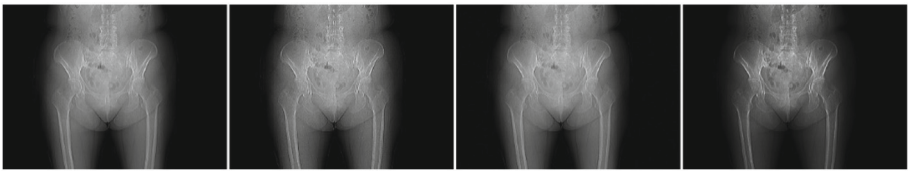


Fig. 5. Process diagram of hip joint CT image preprocessing

3.2 Superpixel Clustering and Segmentation

After the improved SNIC algorithm is used to segment the CT image of the hip joint and generate superpixels, we need to cluster and fuse the obtained superpixel blocks to obtain a complete segmentation result, so this article will use the fuzzy C-means clustering algorithm (FuzzyC-meansclustering, FCM is used to cluster the characteristics of superpixels, and the superpixels with high similarity are divided into several categories, so as to realize the aggregation of superpixels.

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An Overview of the FCM Algorithm. Cluster analysis is a method of classifying a data set with several samples according to certain rules. Classification process. Dunn proposed the FCM algorithm in 1973, and it has been applied to data analysis and classification in various fields. At present, the FCM algorithm is widely used in machine learning, pattern recognition and computer vision, and has achieved good results. The main goal of the FCM algorithm is to divide the data set X into c categories, and by repeatedly calculating the cluster centers of each category, the intra-class similarity of each type of data can be maximized, and the similarity between different classes can be maximized. Small. At this time, the sum of the distances between each data and its cluster center is the smallest, so construct the objective function J_m of the similarity index and optimize the objective function to take the minimum value to obtain the membership of each data to each category degree matrix.

Superpixel Feature Selection. The features in the image represent the relationship between pixels in a certain area, reflecting the grayscale law inside the image. For superpixels, it is characterized by the characteristics of superpixels, that is, the overall gray scale range of the pixels contained inside and the similarity between pixels. The gray-scale mean and gray-scale standard deviation can reflect the gray-scale range interval and gray-scale consistency of the image. They are basic and very commonly used as feature quantities to represent the characteristics of an image or a certain local area. Superpixels are clustered by several pixels, so the gray mean and standard deviation can be used as the features representing superpixels.

As a Result of Clustering and Segmentation. After selecting the features suitable for characterizing superpixel characteristics in the previous section, three eigenvalues of gray value, standard deviation and average entropy are extracted for each superpixel one by one to form a three-dimensional feature vector that can express superpixel characteristics, by using the FCM clustering algorithm to calculate the Euclidean distance between all superpixel feature vectors and cluster centers, clustering all feature vectors into a set number of categories can complete the clustering and merging of superpixels.

For the Clustering of Superpixel Features. FCM mainly constructs the objective function according to the distance between the feature vector and the cluster center,

and optimizes the objective function to obtain the minimum value, so as to obtain the membership matrix of each feature vector for each category, and then complete the clustering. Classification for each feature vector. According to the clustering results of the feature vectors, the clustering and merging of the corresponding superpixels can be completed.

Image Registration. Image registration can align the spatial position between images, combined with image fusion, multiple data information can be presented on the same image to assist in diagnosis. Image registration requires the use of two objects, the floating image and the reference image, and is actually a one-to-one mapping process between the floating image and the reference image. The purpose is to make the pixels in the reference image correspond to the pixels in the floating image, and The overall spatial position of the image is consistent.

4 Discussion and Summary

For hip joint diseases, a superpixel clustering image processing algorithm is proposed to segment abdominal CT images and provide auxiliary diagnosis and evaluation of hip joint diseases. An image preprocessing method is proposed, which preprocesses the interference noise that affects image information, introduces Gaussian filtering algorithm for filtering, uses image Laplacian sharpening algorithm for sharpening, and uses histogram equalization for image enhancement. Preprocessing works to remove unwanted noise and enhance regions of interest. Improve segmentation registration accuracy. A superpixel aggregation algorithm is proposed to segment the image. An improved SNIC algorithm is proposed to segment the image and generate superpixels, and the obtained superpixel blocks are clustered and fused to obtain a complete segmentation result. It has the ability to avoid errors caused by external factors, and segment the target area more quickly and completely. An image registration technique is proposed. The spatial position between images can be aligned, and combined with image fusion, multi-data information fusion can be presented on the same image. Three-dimensional visualization visual assessment is proposed, which can well assist doctors in diagnosis and expand the way doctors obtain diagnostic information from two-dimensional to three-dimensional.

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