Analysis on the Research Approach and Trends of Medical Image Processing in China

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Abstract. In order to explore the research approach and hotspots in the field of medical image processing in China, the authors retrieved related literature in the field of medical image processing in China from 2009 to 2019 in CNKI database, and preprocessed the retrieved data. Then Citespace was used to analyze the retrieved data of 1363 documents from 2009 to 2019, the paper counted the basic situation of the article's publication time, subject, and analyzed the high frequency keywords, cited literatures with high frequency. The results show that the domestic medical image processing field has a high degree of attention to image segmentation, registration, and fusion. Deep learning, convolutional neural networks and transfer learning have been applied to medical image processing in recent years. This paper revealed domestic research trends in medical image processing, with a view to providing reference for research in medical image processing.

1. Introduction
Medical image processing is a multidisciplinary field that combines image theory and digital image processing. Since the middle of the 20th century, the imaging modalities have emerged endlessly. Medical imaging technologies such as CT, PET and MRI have been widely used in daily treatment[1]. In recent years, medical images have entered into the big data era, more and more medical image databases are available to researchers, and the full use of this information can provide a more comprehensive reference for clinical diagnosis and efficacy evaluation. The large number of medical images also brings many problems to researchers, such as traditional medical image processing mainly relies on manual operation of clinicians, this method is highly subjective, time-consuming, and inefficient. With the development of artificial intelligence, medical image processing technologies play an important role in medical teaching, clinical diagnosis, and efficacy evaluation. The authors used CiteSpace software for visual analysis in the field of medical image processing research domain, the data source is literature related to medical image processing in the CNKI database from 1999 to 2019.

2. Data sources and Research methods
2.1. Data source
The objective of the study is to analyze the research directions and trends of the related literature in the field of medical image processing in China. The data comes from the CNKI database, the resource type is journal, the search keyword is "medical image", and the search period of the data is 2009-2019. The source category is set to SCI, EI, core journals, and CSSCI. A total of 1,723 articles were retrieved. After screening, this paper finally selected 1363 articles as the main data source for this study.
2.2. Method
Visualizing the current trends in the research field can help researchers quickly grasp the research frontier. CiteSpace was developed by Professor Chen Chaomei using the Java language, focusing the evolution of the research field on one interface, this paper combines qualitative and quantitative methods to summarize the research progress in medical image processing, and uses the CiteSpace to analyze co-occurrence of keywords, emergent words, and clustering.

3. Results

3.1. Annual publication volume
Changes in the number of published publications each year help researchers understand trends in the field. Figure 1 shows the annual volume of papers in medical image processing in China from 1999 to 2019, it can be seen from the figure that the number of related literature publications remained below 20 in 1999. In 2003, the number of papers exceeded 100 for the first time, and the number of papers in 2009 reached its peak. After 2010, the number of papers began to decline and gradually stabilized. Through the above analysis, the development of the field of medical image processing can be divided into three stages.

①Rapid development stage(1999-2006). The volume of posts at this stage has been steadily increasing.

②Prosperity stage(2007-2010). The volume of posts in the field of medical image processing reached its peak at this stage.

③Stable development stage(2011-2019). The volume of post has dropped, but the development is stable, it has always remained at 100, and still has a high degree of attention.

![Figure 1. Annual publication volume of medical image processing from 1999 to 2019](image)

3.2. Keyword co-appearance analysis
Keyword co-appearance network can analyze the current research trends in the field of medical image processing. This network has two important indicators: centrality and frequency, centrality refers to the number of shortest paths through a node in the network, reflecting the connectivity of the nodes in this graph. Nodes with a centrality greater than 0.1 are called core nodes, another indicator is frequency, node size increases with frequency, the frequency reflects the degree of attention received. This paper used 1363 documents as the data source, sets the time slice to 2009-2019, Years Per Slice to 2, node type to Keyword, the keyword co-occurrence network shown in Figure 2 after combining the same keywords.
Figure 2. Keywords co-occurrence relationship of medical image processing from 2009 to 2019

Figure 2 shows that the most frequent keywords is image segmentation, the purpose of medical image segmentation algorithm is to automatically and accurately segment the required parts, combining centrality and frequency can better analyze the research status. ①The frequency of image fusion and mutual information is higher, but the centrality is lower. It showed that these two aspects of research have a high degree of attention, but the connectivity is low and needs further research. ②The frequency and centrality of image segmentation and image registration is very high. It showed that the connectivity of image segmentation and image registration is very good, and it is a current research hotspot. Table 1 lists top 5 keywords for frequency and centrality.

| Top 5 keywords for frequency | Top 5 keywords for centrality |
|-----------------------------|-----------------------------|
| frequency  | centrality  | keyword                | frequency  | centrality  | keyword                |
| 1       | 300        | 0.15        | image segmentation       | 1       | 69         | 0.25        | wavelet transform             |
| 2       | 198        | 0.22        | image registration        | 2       | 198        | 0.22        | image registration             |
| 3       | 140        | 0.12        | image fusion              | 3       | 300        | 0.15        | image segmentation             |
| 4       | 69         | 0.25        | wavelet transform         | 4       | 33         | 0.15        | edge detection                |
| 5       | 58         | 0.09        | mutual information        | 5       | 56         | 0.14        | image de-noising              |

3.3. **Keyword burst analysis**

The analysis of burst words can help researchers grasp the research trends of different time periods. Figure 3 is the top ten burst words. The research hotspots in different time periods are volume rendering (2009-2011), genetic algorithm (2009-2011), wavelet transform (2009-2011), watershed algorithm (2013-2015), computer-assisted (2014-2016), compressed sensing (2014-2019), deep learning (2017-2019), sparse representation (2017-2019), CNN (2017-2019), transfer learning (2017-2019).

The burst intensity of deep learning and convolutional neural networks are above 10.0 in 2017-2019, it showed that researchers have applied deep learning and convolutional neural networks in medical image processing in recent years. Deep learning achieves the goal of improving classification or prediction accuracy by establishing a multi-layers neural network. In recent years, deep learning methods have been continuously applied to medical image processing and have achieved good results in accuracy.
3.4. **Keyword cluster analysis**

Cluster analysis can further reveal the relationship between keywords. This paper uses Log likelihood Ratio algorithm to cluster the keywords of 1363 articles, the index for evaluating the effect of clustering is Q value and S value. Q value measures the effect of the cluster structure, S value measures the homogeneity of the cluster. By general consent, Q>0.3, S>0.5 is reasonable. After clustering, six topics were calculated. The Q value is 0.651 and the S value is 0.5994, so the clustering in this paper is reasonable.

#0 Keywords included in image fusion clustering are wavelet transform, effect evaluation, sparse representation, etc. The problem of uncertain fusion effect often exists in image fusion, Lin et al. [2] proposed an image fusion method based on convolutional neural networks, which reduced the dependence on prior knowledge, strengthened the fusion effect, and compared it with traditional fusion algorithms.

#1 Keywords included in deep learning clustering are convolutional neural networks, computer-assisted, and machine learning, etc. Convolutional neural network is a research hotspot in machine learning. Convolutional neural network has complex structure and many models. Liang et al. [3] systematically summarized the structure of convolutional neural networks and their applications in medical image processing.

#2 Keywords included in image registration clustering are mutual information, partial volume interpolation, and similarity measurement, etc. Traditional non-rigid registration cannot meet the requirements of registration accuracy and registration time. Ji et al. [4] proposed an improved non-rigid registration method and tested different types of images.

#3 Keywords included in image de-noising clustering are anisotropic diffusion, partial differential equation, and histogram, etc. Medical spine images easily being interfered by noise in the process of imaging. Hui et al. [5] used bilateral filter to de-noise the spine image and preserve the edge features of the spine image.

#4 Keywords included in three-dimensional reconstruction clustering are volume rendering, volume cutting, and tissue engineering, etc. Rendering speed is slow during 3D reconstruction of medical images. Li et al. [6] proposed an improved ray projection algorithm that adjusts the sampling frequency according to the distance between the object and the viewpoint, which significantly enhances the image quality and speeds up the rendering rate.

#5 Keywords included in Image segmentation clustering are level set, snake model, and regional growth, etc. Ventricular image segmentation is one of the research hotspots of medical image segmentation. Li et al. [7] analyzed the advantages and disadvantages of four types of ventricular segmentation methods, summarized the existing ventricular segmentation algorithms, and discussed the evaluation indexes of ventricular segmentation.
4. Discussion
This paper uses CNKI database as the source and retrieves literatures in the domestic medical image processing field in the past twenty years, and pre-process the obtained data to calculate the publication time and subject of these documents.

(1) From the perspective of time, the domestic medical image processing field continues to receive high attention, and the development trend is basically synchronized with the international development trend. Chen et al.[8] analyzed the development of the international medical image field in the WoS database from 2003 to 2012, and concluded that it was the peak period of the development of the medical image field around 2010, and then has stabilized. This conclusion is the same as the domestic development trend.

(2) From the research hotspots, the research content in the field of medical image processing is distinctive. In the keyword co-occurrence analysis, this paper obtains a research network centered on image segmentation, image registration, and image fusion, different research topics have formed a research trend of cross fusion. The results of cluster analysis also show that segmentation, fusion, and registration in medical images have a high degree of attention.

(3) In terms of research trends, deep learning methods have been widely used in medical image processing in recent years. Continuously improving deep learning algorithms make the accuracy of processing results higher and higher, convolutional neural network has achieved good results in the processing of brain images, liver images and lung nodule images, medical image processing based on deep learning will become a future research trend.

Acknowledgments
This work was supported in part by the National Natural Science Foundation of China (81973981), Key Research and Development Program (Soft Science Project) of Shandong Province (2019RKB14090), Graduate Education Quality Improvement Project of Shandong Province (SDYY17119), and Traditional Chinese Medicine Science and Technology Development Program of Shandong Province (2019-0056).

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