Current Status of Bio-medical Imaging Technology and Method in China: A Review

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Abstract-**Medicine imaging plays a more and more important role in illness detection and treatment. Various imaging skills, including CT imaging, MR imaging, ultrasound imaging and so on are in application and under research nowadays, and those images could be got from medicine databases in hospitals, clinical cases or volunteers. Since the biomedical researches are attracting more and more attention in China, our group investigated papers on biomedical published in the last 3 years in China and referenced 35 papers here. From different views, we investigated methods applied in image resources, image preprocessing, image registration, image segmentation, and their application fields. By reviewing those papers, we aim at getting a brief view of the current biomedical research trend in China.**

Keywords- Bio-Medical Imaging; Image Resource; Image Preprocessing; Image Segmentation; Image Registration

I. INTRODUCTION

Biomedical image processing is a new interdisciplinary field that combines mathematics, computer science, medical imaging and many other areas. It takes advantage of mathematical theory, and with the help of the recent highly-developed information technology, biomedical image processing technique is gaining much attention. The medical science relies much more heavily on medical images produced by different advanced equipment nowadays to acquire information in order to make accurate diagnosis and offer appropriate diagnosis. Since medical images can reflect the condition of a patient more directly, thus increasing the accuracy of diagnosis. It's estimated that more than 70% of information is acquired through those images. And because of its importance, we focus our attention on medical image processing to gain a look of the development in China.

The contribution of medical imaging is conspicuous, so many hospitals and academic institutions take it seriously. Various studies are based on the medical imaging to achieve accuracy, efficiency and evaluation. And technical papers spring up to compete for a position in academic magazines. In clinical diagnosis, medicine imaging could help to detect the abnormal movement, organs and even cells, like the cancer organs and breath movement, and early detection could really be of great help to lower the death rate. Besides, medical imaging could be used directly to conduct the diagnosis, the response given by those images offer valuable advices for doctors. And hospitals and academic institutions usually use medical imaging to evaluate the diagnosis performance.

Medical imaging has many profound methods to support the accuracy and robustness of the whole system. Recent studies are devoted to making new method as well as revising the old ones to compete for efficiency and guarantee the accuracy. Many methods, like ACM (Active Contour Model) segmentation, intensity-based image registration, etc. are widely applied in clinical diagnosis and have good results.

This article is a review of medical imaging technologies of the paper published in the last three years in China. In this paper, we began our investigation based on papers from the proceedings of the 2nd International Conference on Biomedical Engineering and Biotechnology (iCBEB 2013), then we expand our review to other references. In this article, the review is divided into 6 parts: image resources are elaborately investigated and classified into groups by different dimensions at part II; studying methods are also meticulously investigated, and classified these methods into image preprocess in part III, image registration in part IV and image segmentation in part V; finally we checked out the image application fields in part VI.

II. IMAGE ACQUISITION AND STORAGE

With the development of social economy and the increasing population, the efficiency and reliability of medical diagnosis is more significant. The traditional way of storing image information in film is no longer fast or accuracy enough, while film takes up a large amount of place as well as it's not convenient to move. As a result, digital imaging techniques changed the traditional way of image access. Meanwhile, with the development of digital imaging technique, computer technique and network technique, an efficient picture processing system-PACS (Picture Archiving and Communication System) was born, which solved the difficulties of medical image acquisition, image digitalize, image storage and image management greatly. Speeding up of digital medical image acquisition is very important to the diagnosis of disease.

A. *Digital Imaging Technique*

Medical images can be divided into analog images and digital images by storage means. Analog image refers to the degree of spatial coordinates, which computer will not deal directly with. Digital image is stored, processed and used by computers, which belongs to the invisible image. Film is the only carrier of analog images. The image record once produced, it's not possible to improve the quality, and it's also not easy to store and transmit. The traditional way already cannot adapt to the needs of the development of modern medicine. Digital images are acquired from medical devices. Vast amounts of images are stored digitally, and they can be checked and used through computer at any time. The most frequently-used medical digital imaging techniques in China are X-ray, CT (Computed Tomography), magnetic resonance, ultrasound, and DSA (Digital subtraction angiography). A brief description of the techniques is showed in Table 1.

TABLE 1 DIGITAL IMAGING TECHNIQUES IN CHINA

Technique	Description
X-ray	It's mainly used in detection of bone lesions and soft tissue lesions. Some common examples are Chest X-ray, which is used to diagnose lung diseases such as pneumonia, lung cancer or emphysema, and the abdominal X-ray is used to detect the intestinal infarction, free air and free fluid [1].
CT	It's based on X-ray source, using computed tomography way to obtain the image of body. It is widely applied to viscera check in areas such as head, chest, abdomen, and spine[2], [3].
SPECT(Single-Photon Emission Computed Tomography)/CT	It's one of the most advanced medical imaging equipment. It's the ideal research tool for living disease diagnosis, new drug research and development [4].
PET(Positron Emission Tomography)/CT	It solved the precision and location problem of PET, and greatly improves diagnostic accuracy [5].
TCT(Thermal Computed Tomography)	CT based on a radiation balance between adjacent infinitesimals used for structural reconstruction of optical-thin biological tissues [6].
Magnetic resonance imaging	It uses the signal generated by nucleus resonates in the magnetic field to reconstruct and imaging [7].
FMRI (Functional Magnetic Resonance Imaging)	It's based on activity on the brains of the change of the local brain blood oxygen level to observe a task when the so-called "brain activation" is widely used in brain imaging [8].
PMRI (parallel magnetic imaging)	It accelerates the acquisition of MRI scanners by skipping numerous phase-coding lines in the k-space while keeping the frequency-encoding direction fully sampled [9].
Ultrasound imaging	A process that ultrasonic wave is missioned to the body while it meets interface in the body and results in reflection and refraction, and may be absorbed or attenuated in the tissues. It's because the various morphology and structure of the tissues, the degree of reflection, refraction and absorb are different, doctors can identify them through the wave types, curves and characteristics of the images [10], [11], [12].
DSA (digital subtraction angiography)	Angiographic images that through digital processing and delete the images of the unneeded tissue, only keep vascular images [13].

Through different techniques, images of the same object have different features and effects, which will be compared and selected on different purposes. SPECT/CT, MRI and CT are compared from the images of skull base bone invasion in nasopharyngeal carcinoma, and the result MRI was the best while SPECT/CT had poorer specificity than MRI and CT, and CT exhibited low sensitivity, but high specificity [4]. In some experiments, images acquired by different imaging techniques are to obtain the combinative consequence. X-ray, CT and MR imaging features of recurrence in giant cell tumors of bone are combined to evaluate their risk factors [14].

B. *Picture Archiving and Communication Systems*

PACS (Picture Archiving and Communication Systems) is used in the hospital image department systems, and its main task is to make all kinds of medical imaging (including the MRI, CT, ultrasound, X-ray machines, all kinds of infrared instrument, the microscopic instrument equipment) through various interfaces (simulation, DICOM, network) stored as digital form, then store the vast amounts of images in database for later practical use.

PACS plays an important role in transmitting and organizing vast data. Currently, most first-class hospitals in China have completed information management equipped with network, implemented of basic condition of image information systems. According to the investigation of present PACS system application situation in China made by E-Health magazine joint Beijing Huatong Commercial Information Company, in 2009-2011, PACS market was growing rapidly in China, the average annual growth rate was over 25%. In 2011, 76.8% first-class hospitals had PACS implemented thoroughly [15].

PACS have a big marketing among first-class hospital and tertiary hospitals. PACS software brands used in First-class hospitals include domestic brands, which the top three are Huahai, Tianjian and Dongruan respectly, and international brands, GE, Carestream, Siemens, Philips, Fuji, etc. As for tertiary hospitals, half of them in developed areas of China were implemented the full PACS, most of these hospitals had using radiology PACS or mini PACS. The domestic brands huahai, Dongruan, and Lanyun won the top three major brands. Foreign manufacturers products were limited to price and cost of sale problem, they didn't appear too much. Community hospitals were in the early stages of medical informatization with outdated equipment. Most of them didn't have the DICOM interface, which was the difficulty of accessing to the PACS system. These hospitals were the new target of PACS in the future market competition, but the start of the market would also take time.

III. IMAGING PREPROCESSING

The clinical images are usually of low quality due to damages in the process of forming, transmission and storage. The main goal in the preprocess step is to clear the noises which caused the low quality, enhance useful information, and reconstruct the image to get the internal connections. Therefore, we focus our investigation on denoising, enhancement and reconstruction.

A. Denoising

Denoising, also known as noise reduction, is the process of removing the noises in the images picked up from a variety of sources. The medical images are full of noises since the environment can't be free of interference. To gain the accuracy of the imaging processing, denoising is an indispensable step of image pre-processing.

The method SRAD (Speckle Reducing Anisotropic Diffusion) is applied to reduce speckle noise in ultrasound images [16]. Speckle noise is the grainy white and black texture in an image, which makes it hard to detect the edges of an object accurately. So it is very important to eliminate those noises to get the correct segmentation. This nonlinear anisotropic diffusion method uses a multiscale approach, and as the scale increases, the noise will be eliminated gradually.

In order to reduce Gibbs oscillation and severe frequency aliasing, a new denoising method is proposed based on the dual-tree complex wavelet transform (DTCWT) [17]. This algorithm overcomes the shortcomings like redundant frequencies. The main idea is to employ two DWTs with filters in each of them, and by joining them, the analytical transformation is achieved. This new method showed effective results compared with traditional ones.

A filter based method for processing veterinary ultrasound was proposed [18]. Since this kind of images is often affected by interference of echoes from sub-resolvable, some filters are used separately and then form a compound so that the speckle can be reduced.

B. Enhancing

Image enhancing is the process of strengthening useful information to refine the vision effect. By clarifying the whole image or a region, the part of image of interest can be clarified to make further process easier.

The target of recognizing cytoplasm is to distinguish multiple cells from the image, and because the special chemical used, the color of the cell is different from the background [19]. So the idea to make the contrast of the background and cells more outstanding is to stretch the color to a wider range, thus making it easier to distinguish according to the color.

The mathematical morphology is a popular method for the image processing because of its efficiency. Based mainly on a fully developed mathematical theory, it is easily accepted and improved by researchers. Though it was intended to process binary images at first, its usability has now extended to almost any kind of image analysis and process, making it one of the most powerful methods for image segmentation. The basic idea behind this concept is to measure and extract the corresponding shape in an image by using a structure element with certain morphology. Additionally, there are four basic operations, namely erosion, dilation, opening and closing. In the mammogram images, the enhance stage is achieved by mathematical morphology (MM). The main task of MM algorithm is the construction of structural elements, and in this literature, this algorithms is implemented by gamma correction and a dual-structural element, thus enhancing the microcalcifications, which makes it more efficient to detect.

C. Reconstruction

Image reconstruction is a technique according to the data that acquired from the detection of object to reconstruct images. The significant meaning of reconstruction is that people can gain the images of internal structure of the detected objects without causing physical damages to these objects. Nowadays, image reconstruction is used universally in the biomedical image processing field. The common reconstruction methods in the biomedical image processing field are back-projection algorithm, Fourier transformation, etc.

Simple back projection algorithm is an approach that backprojects a sample by setting the same value of every image pixel along the ray pointing to it. It reconstructs an image by smearing each view along the direction it was acquired originally and then a resulting image is gained. Moreover, filter back-projection algorithm is regarded as an improvement of the simple

back-projection algorithm. It corrects the blurring in the simple back-projection algorithm. In this algorithm, every view is filtered before backprojecting to counteract the blurring point spread function, then these filtered views are backprojected to offer the reconstruction image.

Additionally, Fourier transformation is also widely used in the reconstruction of CT images. The process of Fourier transformation can be described as follow. First, each view takes the 1D fast Fourier transformation. Second, these view spectra was used to calculate the 2D frequency spectrum of the image by applying the Fourier slice theorem and use the interpolation routine to make the conversion. Finally, the inverse fast Fourier transformation of the image spectrum is used to gain the image which is reconstructed.

Furthermore, some advanced and improved methods for image reconstruction are proposed during these years as well. An in-line phase contrast micro-CT reconstruction for biomedical specimen method has been proposed [20]. This method includes a projection extraction method implemented by using the Fourier transform to the forward projections of in-line phase contrast micro-CT and the filter back-projection algorithm which is widely used for reconstruction.

DPC-CB-SSRB algorithm for reconstruction is proposed [21]. This algorithm is used for helical cone-beam differential PC-CT and combines the CB-SSRB method of helical cone-beam absorption-contrast CT with the differential nature of DPC imaging. The way of performing this method is using 2D fan-beam FBP algorithm which is commonly used in this field with the Hilbert imaginary filter.

Additionally, the pulmonary average CT values can be used for the reconstruction of the 4D-CT of lung as well. Because the average CT values of the whole lung suggests cyclical variation while people are respiring, phases of CT images can be identified by computing the average CT values over time. The average CT values can be calculated by the following equations. The CT values $HU(x)$ of tissue x is:

$$HU(x) = 1000 \times (\mu_x - \mu_w) / \mu_w \qquad (1)$$

Where μx is the attenuation coefficient of the tissue X, and μw is the attenuation coefficient of water.

The ACV of each CT image is:

$$ACV(k) = \sum HU(i, j) / N \qquad (2)$$

Where k indicates the number of slice at a reconstruction of Cine scan, $HU(i, j)$ is the CT value of the pixel at row i and column j of a CT image that can be computed by the first equation, and N is the total number of the lung pixels.

By using such information, a reconstruction method based on pulmonary average CT values without any external respiratory monitoring device was introduced [22].

IV. IMAGING REGISTRATION

Image registration is the process of transforming different sets of data into one coordinate system. Data may be multiple photographs, data from different sensors, times, depths, or viewpoints. According to the nature of registration basis, methods of registration can be classified into two categories, intensity-based registration and feature-based registration. Based on the transformation models, image registration methods can be on the basis of linear transformation and non-rigid transformation. In addition, there are also some methods used to accelerate the process of registration and revise the results of registration.

A. Methods Based on the Nature of Images

The nature of images, such as the intensity information, point feature, line feature and so on, reflects the information about images. There are two classifications of the methods, intensity-based and feature-based registration, according to the source of images.

1) Intensity-based Method:

Intensity-based methods use the intensity information in images for registration. Among intensity-based methods, MI-based registration is one of the most widely-used methods. The mutual information of float image F and reference image R is:

$$MI(R, F) = H(R) + H(F) - H(R, F) \qquad (3)$$

Where $H(R)$ and $H(F)$ express the Shannon entropy of image F and image R, $H(R, F)$ represents the joint entropy of two images:

$$H(I) = -\int_I p(x) \log p(x) dx (I \in \{R, F\})$$

$$H(R, F) = -\int_R \int_F p(xy) \log p(xy) dxdy$$

(4)

The process of MI-based registration is showed in Fig. 1.

The process of MI registration:

Step1: input Referenced image R, Sensed image F

Step2: Interpolation

Step3: Doing affined transformation

Step4: Calculate the value of mutual information according to equation (3)

Step5: If the judgment of optimization is true go to Step6, else, go to Step3

Step6: Output the result of registration

Fig. 1 the process of MI-based registration

Although the MI method has advantages such as flexibility and accuracy, there are also some drawbacks especially the heavy computational load. As a result, some methods have been proposed to improve this method.

A medical image registration method using fuzzy theory was proposed [23]. This method mainly utilizes the fuzzy c-means clustering to get the rotation angles of the reference and float images. Basic algorithm is shown as Fig. 2. Additionally, a new similarity criterion of the quality of the results named fuzzy signal-to noise ratio is also used in this method.

The process of fuzzy c-means clustering:

Begin

    set threshold t

    Initiate membership matrix U= [u_{ij}], $U^{(0)}$

    while ($|| U^{(k+1)} - U^{(k)} ||<t$)

        calculate centroid vector: $C^{(k)}=[c_i]$ with $U^{(k)}$

        update membership matrix $U^{(k)}$, $U^{(k+1)}$

End

Fig. 2 Flowchart of MI registration

A new method used local linear embedding and hybrid entropy for multi-modality image registration was advanced [24]. This method improves the performance of MI-based registration method mentioned above by adding spatial information into it.

2) Feature-based Method:

Feature-based methods establish a correspondence between the specified distinct features such as points, lines and contours in images. After feature extraction and analyzing the link between features in images, a transformation is determined to map the target image to the reference images, thereby establishing correspondence between them. The process of feature-based registration mainly contains four steps: images input, feature extraction, feature mapping and mapping result output.

A manifold-based feature point matching method for multi-modal image registration has been proposed [25]. This method advanced an idea of feature point mapping after manifold learning.

B. Methods Based on the Transformation Models

According to the transformation models used to correspond the target image space with the reference image space, there are two kinds of methods, rigid registration and non-rigid registration. Rigid registration refers to the transformations that does not change the distance between all points of the images, while non-rigid registration need not preserve the original relationship of all points in the images.

Because of the flexibility of non-rigid registration, more and more non-rigid registration methods have been proposed recently. Non-rigid image registration techniques normally either assume an initial rigid body or affine transformation, or run after a rigid-body or affine algorithm has provided a starting estimate.

A new non-rigid method based on normalized mapping through which any image can be transformed into an intermediate space is proposed by Q. Wang *et al* [26]. A new registration method based on nonlinear complex diffusion corner detection and

thin-plate spline model was proposed by W. Sun *et al* [27]. For DSA images, a registration method based on forward and inverse stretching has been put forward by B. Liu *et al* [13]. The basic non-rigid registration method is show as Fig. 3.

```
BEGIN
    Input source image A
    Applying spatial transformation to A to get TA
    Similarity measurement between target image B and TA
    Optimizing to get the best transformation parameters
    Doing transformation to get the resulted image
    Output resulted image
END
```

Fig. 3 Non-rigid Registration Method

C. Acceleration Processing

Problems such as heavy calculation and time consuming exist widely in medical image registration methods nowadays, leading image registration methods to be not as practical as expected in the clinical field. Consequently, some acceleration methods for image registration have been proposed nowadays.

Compute Unified Device Architecture to accelerate the process of 3D medical images registration is put forward by M. Lu *et al* [2]. This method makes use of one GPU parallel computing technology, CUDA made by NVIDA. Image maximum mutual information and multiple scales are also combined into it.

Powell algorithm is also a method to accelerate image registration. For example, B. Liu *et al* use this algorithm to accelerate the registration process.

D. Registration Revision

After registration, there are usually some mistakes in results or the results need to be refined. Therefore, there are some methods used to revise the registration.

An interactive multigrid refinement method used to revise deformable image registration was proposed. This method is on the basis of multilevel B-spline. It aims to revise the transformation in the regions which are overlapping between the transformed image and reference image interactively.

V. IMAGING SEGMENTATION

Segmentation of medical images is the process of figuring the contour of a certain organ of human or certain cells in the medical images. Traditionally, this process is carried out manually by human eyes. With the development of computer-aided image processing techniques recently, this tedious process can be done more quickly and accurately by computers. In this part, several common used methods for medical image segmentation are discussed. Since they all have advantages and disadvantages, they are combined to achieve efficiency and accuracy instead of implementing independently most of the time. The Basic procedure for segmentation is shown as Fig. 4.

```
Basic procedure for segmentation:
Input: the unprocessed medical image
Output: the extracted part
Procedure:
    Preprocessing of the original image
    Extract and select the features of each pixel
    For each pixel repeat
        Algorithm or process pre-knowledge
        Calculate feature and get res
        Compare res and make decision
    Select the pixels with same decision
```

Fig. 4 Basic procedures for segmentation

A. ACM (Active Contour Model)

The active contour model (ACM) method, which is also known as snakes among people, is an effective segmentation framework used to recognize the contours of noisy 2D/3D images. It uses the energy equation and a boundary which surrounds the contour to be determined. By shrinking and smoothing the boundary according to internal and external energies, the

contour of the images will be determined. Though this model is considered very successful, many problems still exist. One common drawback is boundary leakage. In the past years, some researchers have been focusing on this topic and did some improvements. The energy function of ACM is show as follow:

$$E_{snake}^* = \int_0^1 E_{snake}\big(v(s)\big)ds = \int_0^1 E_{int}\big(v(s)\big) + E_{image}\big(v(s)\big) + E_{con}(v(s))ds \tag{5}$$

where E_{image} represents the image forces acting on spline, E_{int} represents then internal energy, E_{con} denotes the external constraint forces introduced by user, and v(s) is the contour curve function in a (x,y) plane

By incorporating the fuzzy speed function into the ACM model, the scholars intend to make the segmentation of pulmonary nodules more accurate [3]. Using the fuzzy clustering algorithm, the value of the function will reach zero if the contour reaches the boundary of the nodules, which will make the program stop further evolution.

This method is also used as a foundation to solve some image process problems like intensity inhomogeneity and low signal-to-noise ratio [17]. The researchers of this paper used a multi-scale method to do segmentations on ultrasound images. The first step is to use some algorithm to confine the boundary at a coarse scale. Then the ACM method is on stage, with the help of boundary shape similarity between those scales, the fined version of the boundary will be done.

B. Graph-based Segmentation

Just like the ACM method mentioned above, the GB (Graph-Based) segmentation method is also a very popular method for medical image segmentation. But different from ACM, which is a supervised method, the GB segmentation is a typical clustering method, which typifies the unsupervised learning method. To use the GB method, the original image will be transformed into an undirected graph, with each pixel having a corresponding vertical, and that vertical is connected to all its neighbors by weighted edges. Once the graph is completed, the rest of the task is to cluster the tiny verticals to form some sub graphs, along the path, local statistics and global image properties will be of great use in the process of clustering. Compared with ACM, one of the greatest advantages of GB algorithm is that GB doesn't have to set the original contour manually. Furthermore, since the graph theory is a fully developed discipline, many advanced knowledge can be applied. Some of the recent literatures have realized the advantages of this method and are based on it.

This method is also used to segment breast tumors in ultrasound images (US) [28]. The researchers added a new pair-wise region comparison predicate which takes advantage of the measures of SNR (Signal-to-Noise Ratio) of the ultrasound images to make it insensitive to some common encountered US image noises. These researchers later made some improvements to the method [10], because they realized the performance of their previous study, namely the RGB one, is heavily dependent on the parameters chosen, so they incorporated the PSO (Particle Swarm Optimization) algorithm to help them find the appropriate parameters.

To recognize the cytoplasm of cervical cells, a new method multi-way segmentation method is proposed by combining the graph-cut and thresholding [16]. Different from traditional graph based algorithm, the construction of graph by using this method uses the mean intensity values of 4 classes divided by thresholding.

C. SVM (Support Vector Machine)

```
Input:
    C= ( x⃗₁, x⃗₂, …, x⃗ₙ, y )    //training set
    y ∈ (ω₁, ω₂, … ωₘ)       //the classes
    θ = (x₁, x₂, …, xₖ)       //feature vector
Output:
    ŷ    //the class vector belongs
Algorithm:
    Read: training set C, feature vector θ
    For each ωᵢ  in set "y" repeat
        Calculate P(ωᵢ), P(θ|ωᵢ)
    Calculate postProbability for each class
    Compare the postProbabilities and output
the biggest probability ωₘₐₓ
```
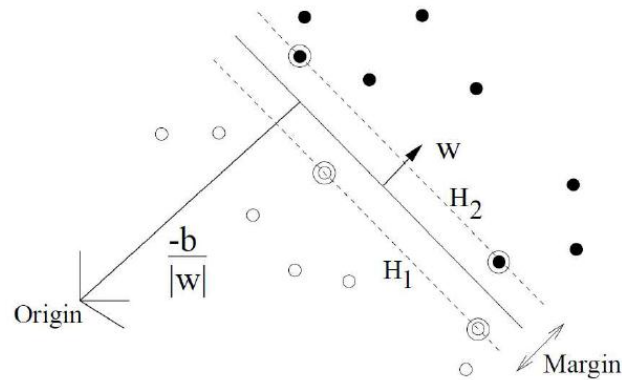
Fig. 5 Support vector machine algorithm

Fig. 6 linear separating hyperplanes for different objects

In the literature [29], they used the SVM method in a later phase of segmentation in order to reduce the chance of some deviations.

In the literature [30], the SVM classification method is used to make discrimination of the gastric cells and recognize those cancerous tissues. After preliminary classification, further optimization of the classification result is carried out by equivalent formulation, and the Lagrangian multipliers are used in the formulation by confining the local influence with a free parameter.

In the literature [31], the authors proposed a new method based on the SVM method. Since there are some problems in traditional SVM and fuzzy SVM, a new algorithm is put forward by considering the fuzziness of training data, extending manifold regularization and maximizing margins. This algorithm is designed to solve imbalance problem and outliers/noise. It also takes the positive and negative data into consideration by assigning them different weight.

D. Bayesian

The Bayesian decision is a traditional pattern recognition method, and because of its simplicity, it is widely used in the segmentation of medical images, especially when the sample distributions have a probability associated with each class. According to different criterion, the Bayesian decision can be classified into several different types. But the basic principles behind them are the same, to calculate the posterior probability according to the known priori probability and compare them by different classes and thus making the most possible decision. Equation for calculating the posterior probability is showed as bellow:

$$P(\omega_i|x) = \frac{p(x|\omega_i)P(\omega_i)}{\sum_{j=1}^{c} p(x|\omega_j)P(\omega_j)} \tag{6}$$

An improved Bayesian decision for segmentation of diffusion tensor imaging is proposed [32]. In this algorithm, the eigenvectors span the spaces of different classes and associate an eigenvalue with each of them. But if the eigenvalue is too close to zero, this method will not be valid, so a threshold is introduced to substitute those eigenvalue that is smaller than the threshold.

The Bayesian can also be used to solve the problem of other segmentation method like ACM [33]. Since in the method ACM, the boundary areas are treated as mutation, some problems like boundary leakage may be encountered because of it. So the Bayesian principle can be applied in the weak boundaries as a stopping force to determine whether a pixel belongs to the outer or inner.

E. Threshold

Threshold is another popular method to distinguish the foreground from background. This method is the most common method, nearly every segmentation method have some part involved with it. However, since it is quite simple, there are inevitable many limitations. It can only be applied to images with certain characteristics, not accurate and besides, the value of the threshold is hard to define. The basic idea is to select one or several thresholds, and separate the foreground and background according to the gray value of each pixel, with adjacent values belonging to the same object. Since some kind of images have the characteristic that different objects have different gray value ranges, this method may prove easy to achieve and effective for those images. Because of its many characteristics, this method often plays a role in the preliminary steps of a segmentation process.

A novel method using the dual-threshold was put forward for extracting the potential microcalcification areas. Two advisable threshold values were calculated, and then the segmentation of the image can be carried out according to them. However, the authors were aware of the strengths and shortcoming of this method well, and they simply used this method to do

the coarse detection both to save time and not affect accuracy. A similar application of threshold method is used in the segmentation on cytoplasm of cervical cell images [16]. In this application, the multiple thresholding is intended for initial segments. The thresholding method can also be found in the initial segmentation step of the lung fields' recognition [34].

F. Others

Besides those segmentation methods mentioned above, some papers try to add some information to the medical images to make the segmentation process more accurate for some specific area of images.

In [34], the new proposed method tries to add the anatomical lung structure to guide the segmentation of lung area. And in [35], local phase information was added to detect the boundaries of abdominal.

VI. APPLICATION FIELDS

With the advanced facilities and the attributes of many studying methods, medical images have grown up to be sounder and more adaptable to our expanding demand for researches. Making a general survey of the studying papers within recent three years in China, we apply the medical imaging to a broad application fields, including the cancer identify, the brain activity, the breathing movement and lung's organization, etc.

A trending in applying this technology in medical area is in the cancer identification and diagnosis. A persuasive evidence of this trend is that 10 out of 47 studied the cancer diagnosis in the referenced papers published in the iCBEB last year. The mainly topic focused on detection of microcalcifications in the breast, magnetic resonance images implying in breast cancer chemotherapy, testing the nitric oxide delivery in breast cancer, segmentation and classification of the pulmonary nodules and locally advanced nasopharyngeal carcinoma, larynx carcinoma.

VII. CONCLUSION

In this paper, we investigated some medical imaging papers in last three years written by Chinese authors.

Based on the papers, we summarized the Image acquisition and storage method, gave an elaborated view of studying methods, mainly about the imaging preprocessing, image registration and image segmentation. Additionally, we took a brief look at the application field, whose main topic is cancer diagnosis.

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