Segmentation algorithm of Mouse brain Magnetic Resonance Microimaging based on 3D texture feature Simulation and brain Map

Sun Rui

Department of Radiology, Henan Province Hospital of Traditional Chinese Medicine (The Second Affiliated Hospital of Henan University of Traditional Chinese Medicine), Henan 450002, China

sunruihn@126.com

Keywords: Magnetic resonance microscopic imaging. Mouse brain. Three-dimensional texture simulation. Brain image segmentation

Abstract: Automatic segmentation of mouse brain MRI images is a typical work used in medicine by computer technology. Mouse's brain segmentation technology is of great significance for the study of brain diseases in human beings. With the deepening of brain science, brain science based on mouse magnetic resonance microscopic imaging (Magnetic Resonance Microscopy, MRM) has gradually become a hot research topic in this field. At present, the segmentation of MRM region of interest in mouse brain mainly depends on manual division, which is time-consuming and labor consuming. Automatic segmentation of mouse MRM brain image is important to automatic analysis of mouse MRM. It's of great significance. In this study, a 3D texture synthesis algorithm for MRM brain images based on mouse brain map is proposed, and the region of interest of mouse MRM segmented by this method. The results show that the algorithm can used for automatic segmentation of mouse brain MRM images.

1. Introduction

The brain science analysis of mouse brain by high-resolution magnetic resonance micro imaging (Magnetic Resonance Microscopy, MRM) has become a hot research topic in brain science. Similar to human brain MRI image processing, non-uniform field correction, image registration and brain segmentation are the key steps of mouse brain MRM image processing, and its accuracy will directly affect the results of subsequent analysis. Image segmentation is the technique and process of dividing the image into several specific regions with unique properties and extracting the objects of interest. The brain image of mice segmented according to the anatomical structure of the mouse brain divides the mouse brain into several regions of interest. In the morphological analysis of mouse brain, the accuracy of segmentation is often required.

In the process of human understanding of the brain structure of mice, the brain has divided into many functional areas; each area plays a different role in mouse language, movement, memory and so on. MRI because of its clear image, Because of its high resolution, it is widely recognized by medical researchers and doctors, especially in the automatic segmentation of medical brain and subsequent volume measurement.

The development of medical image segmentation to automatic processing has gone through a long process. Medical staff complete the initial medical image segmentation manually, when the number of image scanning layers is small, the feasibility of manual completion is higher. However, with the development of medical imaging technology, the number of scanning layers has increased greatly, and manual segmentation has become more and more difficult to achieve. The objective reason is that in most cases, the scanning image reaches tens or hundreds of layers, so it is almost difficult to implement the artificial segmentation method for each layer. The subjective factor is because of human knowledge and judgment, because the contrast of MRI image is not high, the organizational boundary blurred and so on. The boundary judgment of each region is vague, so very accurate segmentation needs to complete by professional medical personnel with many years of anatomical experience. Semi-automatic segmentation is a combination of human knowledge and the

  DOI: 10.25236/mmmce.2019.002

advantages of computer fast operation for image segmentation, but human experience still plays a major role in this process [1]. Therefore, automatic brain segmentation has become a hot topic in the field of computer technology. Only automatic segmentation can eliminate the subjective judgment error of artificial intervention.

Automatic brain segmentation based on graph method is a relatively complete system framework, which integrates a lot of knowledge. The principle is that the image that needs to segment mapped to the segmented template by registration, and then mathematical inverse transformation operator, to obtain the segmentation result of the original input image, transforms the segmentation result into the original image space. The problems involved in this process include prior knowledge utilization, registration, and template fusion and so on, such as the establishment of segmented templates, which is an application of global prior knowledge. The key of the graph-based segmentation algorithm is the accuracy of the mapping process, and the mapping determines the quality of the segmentation largely, so this kind of calculation the core of the method usually based on accurate registration algorithm. The establishment of atlas also has a single map or multiple atlas strategy. When the researcher's only study a single pathology, the geometric average of multiple cases of a disease is used as a unified segmentation template, but when studying a variety of different diseases, Because of the different shapes of the brain, the establishment of a unified template cannot meet the requirements of segmentation accuracy.

The realization of graph spectrum segmentation carried out with the development of registration algorithm. Only after the accuracy of registration, method reaches a certain extent can used for segmentation. The research of registration algorithm has a long history. The early registration is mainly the basic direction or angle registration, and there is no deformation, which is also a common rigid registration method in natural image registration. The typical rigid registration algorithm is stereotactic frame algorithm, which uses stereotactic marker (Stereotactic Fiducially Marker) as reference [2], but artificial marking can easily introduce error. Therefore, there are some computers that mention Operators or models with marked features are introduced [3]. Later, there were many full pixel registration methods.

The brain of mice can divided into hundreds of regions of interest. Compared with optical tissue slices, the resolution and contrast of MRM brain images collected in vivo are lower, the edges between the regions of interest are blurred, not only the division of brain regions is limited, but also the amount of data is also small. Markov random field model is one of the most important two-dimensional texture synthesis models at present, and its principle is that the texture of the points to fill only determined by its neighborhood in a certain range. Square based on Block composition the method can greatly improve the efficiency of synthesis. Efros et al proposed a two-dimensional texture synthesis algorithm. First, one of the samples randomly selected and placed in the upper left corner of the output image, and then the next texture block searched in the input sample. Two texture blocks need to achieve "best matching", but more repeated texture can cause mismatch. Liang also proposed a two-dimensional texture synthesis algorithm based on blocks. The algorithm calculates the correlation between the synthesized region and the overlapping region of the texture block in the sample graph, and finds the texture block whose correlation is higher than the set threshold in the sample graph. Here, the algorithm proposed by Liang put forward.

2. 3D texture Synthesis algorithm and Simulation based on Mouse MRM

The main steps of 3D texture synthesis algorithm based on mouse MRM are as follows: (1) image inversion used as sample image input. (2) in the sample image, a cube of a certain volume is randomly selected and placed in the upper left corner of the blank image to be synthesized as the first texture synthesis block. (3) Searching all the cubes of the same volume in the sample diagram, placing them in the position be synthesized, having a certain volume coincidence with the synthesized region on the edge, and then calculating the correlation of these coincidence regions. The cube above a certain threshold is placed in a collection, and finally. a three-dimensional block is randomly selected from the set as the texture of the region to be synthesized is synthesized. (4)

Repeat step 3 until the output image synthesized; (5) reverse the image again and output the texture image. The selection of stereo block size can adjusted according to the actual situation. If the selected stereo block is too small, it will increase the calculation time, and if it is too large, it may ignore the local texture features. The experimental results show that the algorithm can synthesize the texture features of the larger brain region of mice. In this paper, the three-dimensional texture synthesis algorithm proposed by us synthesizes the 21 larger brain regions divided in the anatomical map. Regions, including some white matter brain regions, such as corpus callous, In addition, because the texture features of cerebrospinal fluid are not obvious; we cannot synthesize the texture of ventricle. Therefore, the remaining 13 brain regions were synthesized smoothly by Monte Carlo method and Gao Si. The simulation flow based on the texture synthesis algorithm divided into three parts: texture synthesis, anatomical map processing and whole brain simulation. Texture synthesis part: First, 39 brain regions in the individual map merged and deleted, and the generation and anatomical maps divided into three parts: firstly, the 39 brain regions in the individual map are merged and deleted. Then, the 3D texture synthesis algorithm proposed by us used to generate the 3D texture of 21 larger brain regions. Finally, the gray distribution images of the remaining 13 brain regions are generated by Monte Carlo method, and then the Gao Si distribution images are smoothed by Gao Si smoothing. Anatomical map processing part: first, the division of 34 brain regions will be binary. Then, we need to resemble the divided anatomical map twice, the first time because of the different dimensions of the anatomical map and the original image. we need to use the anatomical map in the z-axis direction is interpolated and down-sampled in the x-axis and y-axis directions to obtain the same physical dimension as the MRM image in the study data. The whole brain simulation part: the texture image generated by the texture method and the random image generated by Monte Carlo method are used to fill each brain area in the spectrum to obtain a preliminary simulated whole brain image; Finally,the margin of 34 brain regions in the initial simulated whole brain was smoothed three-dimensionally.

3. Traditional Research and Clinical Application Prospect based on automatic brain Segmentation in mice

One important clinical application of brain MRI imaging in mice is the detection of human tumors and strokes, which usually cause significant anatomical changes. Besides these two types of disease diagnosis, MRI information utilization can use in many aspects. In particular, in the early detection of certain neuropathy, structural changes in the brain during this period are difficult to judge by eye and distinguished from age effects. As a result, many studies of brain disease are base on statistical analysis after automatic MRI segmentation. The traditional disease research model is very fixed. First, we need to collect images of the patient's brain. These include the control group and cases with a certain disease. Then the collected image input into the automatic segmentation system, and the system is output to different anatomical areas of each object. This pathological research model is a classical method, and so far, almost all medical researchers using automatic segmentation have used a single image source to study brain diseases in order to reduce the influence of non-anatomical factors. There are many sources of data in clinic. The method of disease analysis using homologous data can only used in scientific research. If the analysis method of medical researchers is applied to clinical diagnosis, it will face a great problem that the data are homologous, the clinical data may come from a variety of different devices, and its resolution, noise, scanning parameters and so on may have a variety of differences. At the same time, the different definitions of anatomical atlas provided by many segmentation systems also make it difficult for clinical application. Therefore, automatic segmentation is promising for future clinical diagnosis, which used to prevent multiple diseases such as Azhai in human beings. Silent disease has a very good preventive effect. In clinic, doctors have not made full use of existing knowledge to link the accurate relationship between anatomical structure and disease. In the future, based on big data treatment, the subtle changes of brain structure can detect by statistical analysis, which will play an important role in auxiliary doctor diagnosis.

4. Summary

In this paper, the two-dimensional texture synthesis algorithm optimized and improved to three-dimensional mouse MRM texture synthesis algorithm, a complete set of mouse’s brain MRM simulation flow is proposed, and a good one-to-one correspondence between anatomical map and living MRM is established. It is of great significance to the further division of the region of interest. It can see from the results that our simulation of the virtual brain is more successful and has a high similarity with the real brain. The nonlinear registration algorithm improves the registration results to some extent compared with the linear registration algorithm. However, compared with our previous research, there are still some differences in varying degrees. We think, build The reasons for this difference are mainly divided into two parts: one is the error caused by the whole brain simulation of mouse MRM, the other is the error caused by registration. The errors caused by the whole brain simulation of mouse MRM are mainly divided into the following five factors: (1) the individual map of the data has 39 brain regions, while the anatomical map has hundreds of brain regions, which involves the problem of merging. Because the principle of data division does not specify which brain region the more than 100 brain regions belong to, there may be some differences in the principle of division. (2)MRM images sampled at equal intervals, while anatomical maps sampled at unequal intervals according to the thickness of optical tissue slices, and the interpolation of the images would bring some errors. (3) We use Monte Carlo method and Gao Si smooth way to synthesize gray feature distribution, which is still different from the actual texture. (4) The anatomical map divided by optical tissue sections of mouse brain, but the collapse of ventricle caused by cerebrospinal fluid loss, artificial fixation and the process of slicing will cause certain deformation of the brain. As a result, there are some differences in the local morphology between the anatomical structure and the images collected in vivo. There are also some errors in the division of individual atlas of the original image. The error caused by registration is mainly due to the graph of geodesic-SyN algorithm in the process of registration. The image is sensitive to different parameter settings, and the parameters we use are the optimization parameters for MRM image matching. However, the convergence caused by oscillations is more likely to occur in simulation image registration. Although we can prevent this by increasing the global smoothing coefficient, increasing the smoothing coefficient will lead to the decrease of the fineness of the deformation domain. The parameter setting of geodesic-SyN used by us is not necessarily global optimal for simulation image registration, and further optimization is needed in the later stage.

References

[1] Lin L, Fu Z, X X, et al. Mouse brain magnetic resonance microscopy: Applications in Alzheimer disease [J]. Microsc Res Techniq, 2015,78(5):416-424.

[2] Wei LY. Fast texture synthesis using tree-structured vector quantization[A].Conference on Computer Graphics and Interactive Techniques[C].Boston: ACM Press/Addison-Wesley Publishing Co., 2000:479-488.

[3] Fu Zhen r, Lin L, Zhang B w, et al. Research progress of mouse brain template creation based on MRM [J]. China Medical equipment, 2016, 31 (2): 25 / 30.

[4] Lin L, Wu S, Bin G, et al. Intensity in homogeneity correction using N3 on mouse brain magnetic resonance microscopy[J].J Brain science, 2013,23(4):502-507.

[5] B J, Trinh TL, Chuang KH, et al. Atlas-based automatic mouse brain image segmentation revisited: model complexity vs. image registration [J]. Magn Reson Imaging, 2012,30(6):789-798.

[6] Wu T, Min HB, Zhang M, et al. A prior feature SVM MRF based method for mouse brain segmentation [J]. Neuroimage, 2012,59(3):2298-306.

[7] Pagani M, Bifone A, Gozzi A. Structural covariance networks in the mouse brain[J]. Neuroimage, 2016,129:55.

[8] Franklin KBJ, Pains G. The mouse brain: in stereotaxic coordinates[A].The Mouse Brain in Stereotaxic Coordinates[C]. Pittsburgh: Academic Press, 2001:6.

[9] Ma Y, Smith D, Hof PR, et al. In vivo 3D digital atlas database of the adult mouse brain by magnetic resonance microscopy[J].Front Neuronal, 2008,2(2):1.

[10] Lin L, Chen K, Valla J, et al. MRI Template and atlas toolbox for the mouse brain[A].International IEEE Ebbs Conference on Neural Engineering, 2005. Conference Proceedings[C].New York: IEEE Xplore, 2005:6-8.

[11] Y Xiao j. Research and application of texture synthesis algorithm based on sample graph [D]. Xi'an: Northwestern University, 2010.

[12] Efros AA, Leung TK. Texture synthesis by non-parametric sampling[A].The Proceedings of the Seventh IEEE International Conference on Computer Vision[C].New York: IEEE, 1999:1033.