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Automatic 3D Extraction of Internal Organ From Helical Scanning CT images

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1 Introduction

The helical scanning CT is a device which can takes CT images of cross sections along the human body shaft direction. The helical scanning CT spirally scans the body along the body shaft, so it is able to take images in short time and obtain 3D CT data with the extremely precision. However it is difficault for a doctor to specify the region of interest and to make a efficient diagnose using 3D CT data because the obtained data is a very large quantity. Therefore, the automatic extraction by computers is needed for the effective diagnose.

The usual region extraction methods of 3D CT data are divided broadly into two types. One is the two dimensional extraction that carries out the 2D region extraction on slice image sections, then to construct 3D shape piling up their results. The two dimensional extraction is executed on slice image section, so it can not use informations of three dimensional shape. For that reason, the exact extraction is difficult. The other is the three dimensional extraction. This type is directly extraction of 3D shape from volume data. As the three dimensional extraction, Region Growing and Deformable Model have been proposed. Because Region Growing is based on CT value only, it is difficult to extract an accurate shape of the region. Defomable Model is a method using the closed surface model. This model automatically changes the shape of themselves and fits to the contour of the region of interest. There are some problems that the result of the Defomable Model extraction is depend on an initial contour and parameters of the closed surface model, but it is able to extract with taking thought of the three dimensional information of CT data.

In this paper, we propose a method to extract the three dimensional region of an internal organ from CT data. This method is based on the Level Set Method proposed by Sethian et al., and can efficiently use the three dimensional informations included in 3D CT data. In Level Set Method, first, an initial propagating surface is set inside the internal organ region of interest, then the propagating surface expanded and fitted to the three dimensional shape of the internal organ. When the motion of the propagating surface is stopped, a shape of the surface is the extracted result. In the previous extraction methods using Level Set Method, there are some problems that an introduction form of a curvature is not obvious and the extraction results are depend on the location of the initial propagating surface. To address these problems, the curvatures based on the shapes of cross sections on the propagating surface and two step extracting process are proposed. In the first extracting step, expanding speed of the propagating surface depends on the gradients of image intensity. In the second step, the speed of the propagating surface depends on the image gradients and the surface curvature.

2 Definition of 3D Curvatures for Level Set Method

In order to extract the region of internal organs, we propose a method which effectively use the three dimensional informations included in the 3D CT data. The expanding speed on each x, y, z-axis is different at an each point on the propagating surface. First, curvatures at the intersection line between the propagating surface and each xy, yz, zx-plane are calculated, then expanding speeds on each axis are computed from the speed function, which is defined by curvatures on xy, yz, zx-plane and a gradient of CT value. So the propagating surface is expanded according to the speed reflecting the shape of cross sections of the propagating surface in each directions.

3 Two Step Expansion and Change of Curvature Coefficient

In the previous extraction methods based on Level Set Method, there is the problem that a result of the extraction depends on the location of the initial propagating surface.

To treat this problem the expanding process of the propagating surface is divided into two parts. In the first step, CT images are made vaguer than in second step. Therefore a rough shape of the region is extracted in the first step. In the second step, a detailed shape is extracted. The result in second step becomes independent on the location of the initial propagating surface.

In the first step, if the speed depends on curvatures from the beginning, the extraction result is influenced by the shape of the region of internal organ around the initial propagating surface. To avoid this influence in the first step, we also propose a new scheme. In the beginning of the expanding process, the coefficient of curvatures in the speed function is set to zero. After a volume of propagating surface becomes to a certain quantity, the

curvature coefficient is changed to a positive number. Therefore, the speed of surface expansion depends on the curvatures.

4 Experiments for Extraction of Internal Organ

The extraction of the liver region from 3D CT data was carried out. These experiments have two purposes. One is testing the two step expansion and the change of curvature coefficient for an effect to avoid the dependence of the location of the initial propagating surface. The other is making a comparison between two dimensional extraction and three dimensional extraction using this method.

As the result of the experiments, we could show that if we use the two step expansion and the change of curvature coefficient, the results of extraction did not depend on the initial location of the propagating surface. And the previous two dimensional extraction and the three dimensional extraction with this method were applied to CT data of three patients, and are compared about an accuracy of the extraction. In consequence, it was clear that the three dimensional extraction by this method prevents the propagating surface from protruding from the region of internal organ and it is possible to improve an accuracy of the extraction.

5 Conclusion

In this research, we proposed the new method to extract the three dimensional liver region from 3D CT images. In this method, the curvature in three dimensional space, two step expansion processes and the change of the curvature coefficient were introduced.

The results showed the three dimensional extraction using proposed method could achieve low dependence on the initial location of propagating surface, and prevent a protrusion in the part where a protrusion happened in two dimensional extraction.

The problems to be solved are the application of this method to other internal organs, and the examination of a method to change continuously the coefficient of the curvature in order to keep smoothness of the propagating surface.