Efficient CT Image Segmentation Algorithm Using both Spatial and Temporal Information

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요약

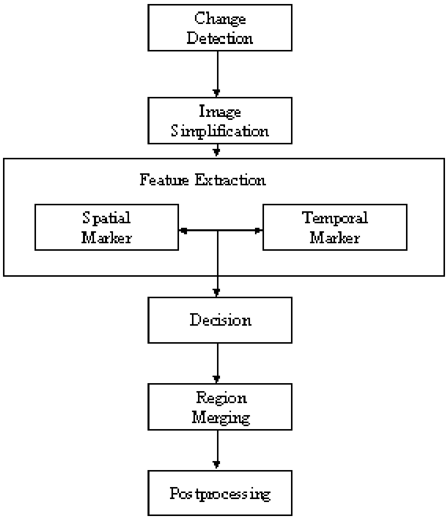
This paper suggests a new CT-image segmentation algorithm. This algorithm uses morphological filters and the watershed algorithms. The proposed CT-image segmentation algorithm consists of six parts: preprocessing, image simplification, feature extraction, decision making, region merging, and postprocessing. By combining spatial and temporal information, we can get more accurate segmentation results. The simulation results illustrate not only the segmentation results of the conventional scheme but also the results of the proposed scheme; this comparison illustrates the efficacy of the proposed technique. Furthermore, we compare the various medical images of the structuring elements. Indeed, to illustrate the improvement of coding efficiency in postprocessing, we use differential chain coding for the shape coding of results.

I. Introduction

The basic concept of object-based coding is to extract similar brightness objects and express them as similar brightness object, contour, or color variable representing their similar brightness. Each object's information is expressed as a set of actual variables of similar brightness object, contour, and color. One of the basic problems of object-based coding is the process of abstracting similar brightness object regions and anticipating their brightness. Since it influences the performance of object-based coding, the process of efficient image analysis needs to be utilized[1].

The conventional segmentation methods may produce an inaccurate object contour or even a merging of the general view and the background because of the misuse of spatial or temporal information and the inadequate use of each type of information. For such reasons, an attempt to use both spatial and temporal information in order to obtain better results is a sound procedure. To obtain more accurate information, this paper proposes the efficient segmentation algorithm using both spatial and temporal information. The proposed algorithm consists of six parts: preprocessing, image simplification, feature extraction, decision making, region merging, and postprocessing. In the simulation results, we show the efficiency of the proposed technique in the segmentation results for both the conventional scheme and the proposed scheme.

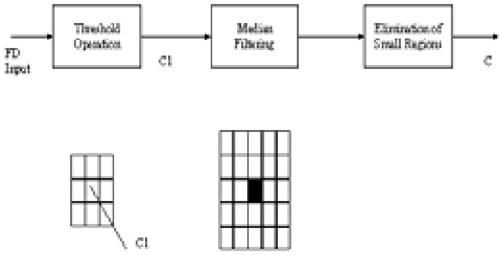
II. Simulation method



▶▶ Fig. 1 Proposed segmentation algorithm

The proposed segmentation algorithm is shown in Fig. 1. Similar brightness regions maintain a contour and are made even inside through the application of morphological filters. The inside of similar brightness regions have the process of feature abstraction applied to them and the process of merging many non-decided pixels with adjacent feature regions using the watershed algorithm. As long as the results obtained via this process are divided excessively into segmentation regions and the similar brightness regions are segmented into smaller regions by merging, the final segmentation results can be obtained when postprocessing is finished.

1. Abstraction of similar brightness regions



▶▶ Fig. 2 Similar brightness region abstracter

Since previous segmentation methods have used either temporal or spatial region information, they have produced inaccurate contours in objects. Since there was a possibility of segmentation in the conventional algorithm, preprocessing was proposed to protect against this the possibility. The similar brightness region algorithm used in this paper follows the Hotter method.

2. Image simplification

Image simplification using morphological filters maintains contours and allows inside regions to be segmented easily. Simplification by morphological filters, that is, open-close by reconstruction, are suitable to keep information in a contour and to make intensity within a region even. Many morphological tools consist of two basic transformations: dilation and erosion.

Erosion: $\varepsilon_n(f)(x) = Max\{f(x+y), y \in M_n\}$

Dilation: $\delta_n(f)(x) = Min\{f(x-y), y \in M_n\}$

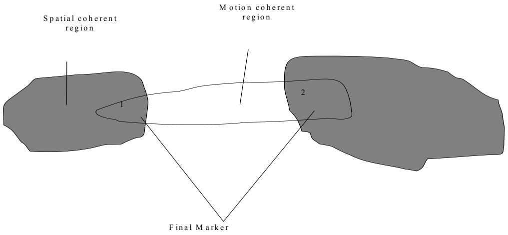
where f(x) is an input signal and Mn is an even morpheme of size Mn. To maintain the regional contours and at the same time simplify the image, the process of image reconstruction should be carried out. The open-close method that reconstructs and preserves contours and simplifies the image is given by[7]:

Open-close by reconstruction:

$$\varphi^{(rec)}(\delta_n(\gamma^{(rec)}(\varepsilon_n(f), f)), \gamma^{(rec)}(\varepsilon_n(f), f))$$

This paper experimently selected 11 as morpheme size.

3. Feature abstraction



▶▶ Fig. 3 Feature abstraction

It is the process to identify homogeneous regions within a simplified image from ones having uniform intensity. These regions become the initial fiducial points of the regions to be segmented. While homogeneous regions consisting of fewer pixel numbers than simplified morphemes and non-homogeneous regions leave uncertainties, homogeneous regions consisting of larger pixel numbers than the morphemes are divided into feature regions. Also, homogeneous regions in a temporal region are independently featured, and the common part between homogeneous spatial and similar brightness regions mark the final feature abstraction result.

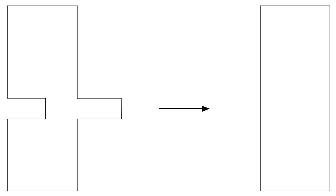
4. Decision

As the number of pixels remain uncertain. The watershed algorithm was used on the pixels in the adjacent region. The watershed algorithm is one of the tools which decide a contour in a morphology application. The algorithm used in this paper was applied to the simplified image instead of the morphological gradient image and consisted of the initialization of the homogeneous region and the flooding of uncertain pixels. To decide each pixel's region, hierarchical queue was used. Each queue had FIFO data structure[6].

5. Region merging.

Since the results obtained via decision making are divided into more segmentation regions than needed, they must be segmented into smaller regions through merging the similar brightness moving regions. The process to search for regions to be merged refers to the process of computing the optimal parameters and related errors. First of all, the largest region and its adjacent region are merged and their optimal similar brightness parameters are searched. If the merged region is smaller than the specific error, it will be regarded as a new region to be segmented. As this process is repeated, we can obtain segmentation of a smaller number of regions.

6. Postprocessing



▶▶ Fig. 4 Postprocessing

Although segmentation results obtained in this way have as much contour information as shown in Fig. 4, some parts may have little texture information. This paper proposes postprocessing, and morphological opening and closing to further reduce such parts.

III. Simulation and discussion

To analyze the performance of the proposed technique, this paper conducted a simulation using CT image in the form of JPEG.

1. Simulation for different kinds of morpheme sizes

In the simulation, it was found that if the morpheme size was larger than 11 in a JPEG format, there was no significant change in segmentation results. As morpheme sizes increase, computation increases and image information decreases. On the contrary, when morpheme sizes decrease, the number of segmentation regions will increase. Thus morpheme sizes that are suitable to image formats need to be selected. This paper experimentally selected 11 as the morpheme size.

2. Comparative simulations of contour coding of segmentation results

Coding efficiency after postprocessing is shown in Table 1. The chain coding method was used for the contour coding of segmentation results. Originally 3 bits per pixel were needed, but differential chain coding was used to realize a realistic environment which reduced the coding of bits. Coded bit string included a start point, an end point, and a differential chain code string. Differential chain coding was defined as follows and its range was from -4 to 3.

$$d=\begin{cases} c_n - c_{n-1} + 8 & if \quad c_n - c_{n-1} < -3 \\ c_n - c_{n-1} - 8 & if \quad c_n - c_{n-1} > 4 \\ c_n - c_{n-1} & otherwise \end{cases}$$

where d is differential chain code, Cn is present code, and Cn-1 is the previous chain code. To code d, Huffmann coding was used and Huffmann header information was ignored. In conclusion, the image segmentation technique proposed herein provides efficient algorithms that exactly abstract the contour information of objects which decide coding efficiency. This is an important issue for object-based coding, and removes unnecessary contour information. In this way, it could reduce data greatly and obtain a much higher compression effect.

[Table 1] Amount of Encoding Bit

	# of Coding Points	# of Bits
Hotter's Result	487	832
After Merging	422	736
Final Result	406	618

IV. Conclusion

This paper describes an image segmentation technique which is very important in an object-based encoder. To realize efficient image segmentation, morphological filters and the watershed algorithm were used for similar brightness regions. Furthermore, information from both spatial and temporal regions was used to derive more accurate results.

▶▶ Fig. 5 Result of Simulation

▌Reference ▌

[1] H.G.Musmann, M.Hotter and J.Ostermann, Object-Oriented Analysis-Synthesis Coding of Moving Images" Signal Processing Image Comm., Vol.1, pp.117-138, 1989.

[2] H.M.Hang, J.W.Woods, Handbook of Visual Communications" Academic Press, 1995.

[3] K.R.Rao, J.J.Hwang. Techniques and Standards for Image Video and Audio Coding" Prentice Hall, 1996.

[4] J.G.Choi, S.W.Lee and S.D.Kim, "Spatio-Temporal Video Segmentation Using a Joint Similarity Measure" IEEE Trans. Circuits and Systems for Video Tech., Vol.7, No.2, April 1997.

[5] M.Rabbani, P.W.Jones, Digital Image Compression Techniques" SPIE PRESS, 1991.

[6] L.Vincent and P.Soille, Watersheds in Digital Spaces: An Efficient Algorithm Based on Immersion Simulations" IEEE Trans. PAMI, Vol.13, No.6, June 1991.

[7] P.Salembier, "Morphological Multiscale Segmentation for Image Coding" Signal Processing, vol.38, pp.359-386, 1994.