Reduction of Triangles in Discretized Marching Cubes for 3D Rendering of Brain MR Images

Y. Han[1], M. Kwon[1], H. Park[1]

[1]Korea Institude of Science and Technology, Daejeon, Korea, Republic of

Synopsis

Surface rendering is a useful method in 3D visualization of brain MR images. Especially when the segmented result of MR images is given in advance, discretized marching cubes (DiscMC) algorithm can be easily utilized. However, the complexity of cerebral surface increases the number of triangles produced by DiscMC and thus, the computation time becomes an impediment to real-time 3D rendering. In order to speed up the 3D rendering, we propose a modified DiscMC table to reduce the number of triangles DiscMC. The proposed method reduces the number of triangles by 30% without loss in brain MR image quality.

Introduction

In order to create a functional brain map, 3D rendering of cerebrum has to be preceded. Generally, there are two methods in 3D visualization of an object, which are volume rendering and surface rendering. In this paper, surface rendering is efficiently employed because the white matter of brain MR image is segmented a priori. For surface rendering, marching cubes algorithm suggested by Lorensen and Cline is widely used because of its practical and simple nature [1]. However, standard marching cubes algorithm has some shortcomings such as topological inconsistency, computational inefficiency and excessive output data fragmentation [2]. For those reasons, Montani suggested the discretized marching cubes (DiscMC) which is especially efficient when applied to binary images because it does not require interpolation. DiscMC returns facets based on 13 incidences shown in Fig. 1. The facets are then used as basis of 3D object surfaces. However, the excess number of triangles produced by DiscMC causes deterioration in speed efficiency especially when the object has rough surfaces as brain. To overcome the problem, DiscMC uses a post processing to extract isosuface and reduce triangles. This needs additional computation, and the visualization of polygons produced as a result is more troublesome than visualization based on triangles. Therefore, this paper suggests a method which reduces the number of triangles without additional calculations and also without any image degradation.

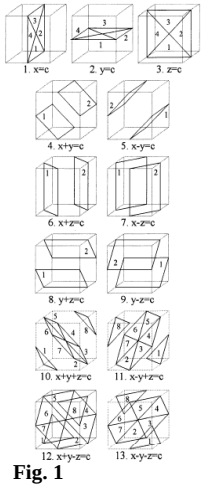


Fig. 1

Methods

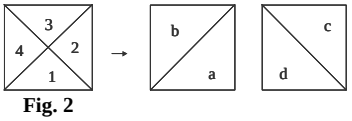


Fig. 2

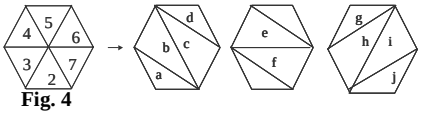


Fig. 4

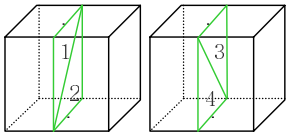


Fig. 3

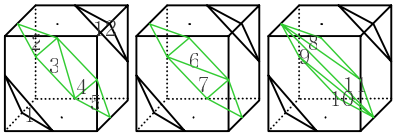


Fig. 5

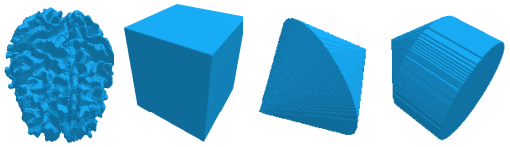
The proposed method simply adds 7 table entries to the DiscMC lookup table for cases 1, 2, 3, and 10, 11, 12, 13 shown in Fig. 1. These new entries represent all possible co-occurrences of neighboring triangles which can be merged to produce a larger triangle that could be visualized with less in number. For cases 1, 2 and 3, triangles are rearranged as shown in Fig. 2 and added to the lookup table as Fig. 3. For cases 10, 11, 12, and 13, the triangles are rearranged as Fig. 4 and added as Fig. 5. According to Fig. 2, the number of triangles in cases 1, 2 and 3 from Fig. 1 would be reduced to half when triangles 1 and 2 are produced as a result of DiscMC because new lookup table produces triangle a only. According to Fig. 4, the triangles in the center hexagon of cases 10, 11, 12 and 13 of Fig. 1 will be reduced when three or more neighboring triangles have to be visualized. If the proposed method is used, number of triangles is reduced compared to Marching Cubes or DiscMC while preserving the image quality because it does not modify the surface shape at all.

Results

Data 1, 2, 3 and 4 present the reconstructed 256×256×256 objects. Data 1 show the cerebrum which is segmented from brain MR image using HFCM [3], and rest of the data are arbitrarily prepared 3D binary objects. The number of triangles produced by DiscMC and by the suggested method is compared in Table 1. Table 1 shows that the number of triangles is reduced by 29.9% for brain MR data. The 3D rendered brain MR images from various viewpoints are shown in Fig. 6.

	DiscMC	Suggested MC	Reduction rate (%)
Data 1	790023	553149	29.9
Data 2	242408	122408	49.5
Data 3	86512	71172	17.7
Data 4	131072	91576	30.1

Table 1



Data 1 Data 2 Data 3 Data 4

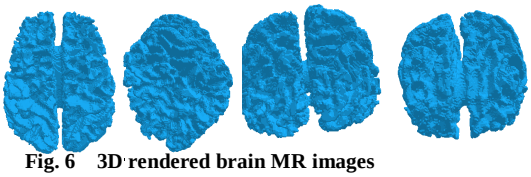


Fig. 6 3D rendered brain MR images

Conclusions

The proposed method modifies DiscMC lookup table and reduces the number of triangles produced by DiscMC. It remarkably speeds up the rendering process of brain MR images without degrading image quality.

Acknowledgement

This work was partly supported by the M1-0107-07-0001, the Ministry of Science and Technology, Korea.

Reference

[1] W. Lorensen and H. Cline. "Marching Cubes: a high resolution 3D surface construction algorithm," ACM Computer Graphics, 21(4):163-170, 1987

[2] C. Montani, R. Scateni, R. Scopigno, "Discretized Marching Cubes," in IEEE Proc. Visualization '94, pp. 281-287, 1994.

[3] M.J. Kwon, Y.J. Han, I.H. Shin, and H.W. Park. "Hierarchical Fuzzy Segmentation of Brain MR Images," submitted to IJIST, 2002