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Efficient CT Image Volume Rendering for Diagnosis

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***Abstract*—**Volume rendering is widely used in medical CT image visualization. Applying 3D image visualization to diagnosis application can require accurate volume rendering with high resolution. Interpolation is important in medical image processing applications such as image compression or volume resampling. However, it can distort the original image data because of edge blurring or blocking effects when image enhancement procedures were applied. In this paper, we proposed adaptive tension control method exploiting gradient information to achieve high resolution medical image enhancement in volume visualization, where restored images are similar to original images as much as possible. The experimental results show that the proposed method can improve image quality associated with the adaptive tension control efficacy.

***Keywords*—**Tension control, Interpolation, Ray-casting, Medical imaging analysis.

I. Introduction

VOLUME visualization is widely used in diverse medical imaging applications. Image analysis, by means of three-dimensional imaging representation, can help clinicians diagnose accurately from a large number of volumetric sectional images generated from sectional imaging modalities [1]. So, it is important to depict volumetric medical images accurately by volume visualization with high resolution. Direct volume rendering displays the volume data using opacity transfer function relating to the voxel's illumination scalar values in a range of opacity decision level [2]. One of the typical methods for volume rendering is ray-casting. This method can generate high quality rendered image. However, visual artifacts can be indispensable if the number of sampled data is insufficient. It is because medical devices (e.g., computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET)) can generate the finite number of discrete sampled signal from continuous domain of human body. That is, it is the artifact called aliasing in case of three-dimensional volume visualization using ray-casting [3]. To solve this problem, ray-casing incorporates the increment of the sampling rate along a ray. According to Nyquist-Shannon sampling theorem, the sampling frequency must be greater than twice to original signal. Because aliasing artifacts are occurred when the sampling rate is low, the sampled data can be supplemented by interpolation. The most popular interpolation functions are nearest neighbor, B-spline, Catmull-rom spline methods. First, nearest neighbor is easy to compute but it makes ringing artifact. Secondly, B-spline is third order polynomial and it generates more accurate images than nearest neighbor interpolation but it has highly computing cost and it doesn't pass through the control points. So, it can't interpolate edge smoothly since interpolated scalar values generate error. Finally, Catmull-rom spline computes accuracy interpolated values cause pass through the control points.

However, this method makes difference value of the input data ('overshoot' or 'undershoot') [4], [12]. In Medical imaging has large data set to detailed diagnosis. Also, it has Gaussian distribution due to large amounts of data. In this paper, we proposed a high quality interpolation algorithm. This proposed method increases the sampling rate by gradient adaptive tension control interpolation. Besides, proposed method maintains curve tension on gentle gradient and adjusts interpolation curve tension on steep gradient.

II. Interpolation in Medical Imaging

A. Super-sampling

High quality volume visualization is active research for accurate in medicine and science. In proceeding of volume rendering, if the sampling rate is not enough, aliasing artifacts are introduced [4]. To avoid aliasing artifacts in volume visualization, it needs to increase the sampling rate along a ray. If a large distance between samples (i.e., a low sampling rate), it has occurred under-sampling and Moire pattern like wood grain artifacts [5]. According to Nyquist-Shannon sampling theorem, interpolated samples can be reconstructed if it is sampled at least higher than twice the highest frequency of the original signal. To increase the sampling rate (supersampling), volume data is using interpolation method. Because a various of imaging is required that it be able to display images without aliasing artifacts [6]. And also, in two-dimensional images, interpolation is required various medical image processing applications [7]. Namely, interpolation can solve the aliasing artifacts and there is required in medical imaging applications. Interpolation is a various type of methods.

Using linear interpolation is increasing the sampling rate for eliminate noise. This method is commonly used because much calculates the amount of fast execution speed, but the error is larger defects that require precise calculations cannot be used. Therefore, you should try to use the proper order to obtain the interpolated value for using a third-order polynomial interpolation. Reconstruction techniques in different ways by Catmull-rom spline method is used to calculate whether the opacity to increase the sampling rate and the interpolated value from the maximum value. However this way, assume the

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interpolated curve always original voxel value given exceeds the extreme case; the value of deformation due to the falling value of efficiency can cause image distortion [8]. Increase the sampling rate in a different way when using Cubic B-spline interpolation does not exceed the original voxel value C. Method proposed by Zhang. Cubic B-spline interpolation to calculate the amount of time-consuming, not only given control points, because the inaccurate value can be generated. Varying degrees of control points using the interpolation of the curve, with the advantages of a B-spline passes through all the control points in this study Catmull-rom spline interpolation method and the overshoot, tension that are part of larger changes and maintain degrees a steep part of the overshoot free efficient interpolation curve method is proposed to adjust the tension.

B. Proposed Method

High quality image is determined by the reconstruction. Less error where you want to create a smooth curve scalar value can be obtained by using a higher order reconstruction filter. We proposed using Gaussian function on Catmull-rom spline polynomial. So, proposed method reduces the overshoot or undershoots in steep gradient.

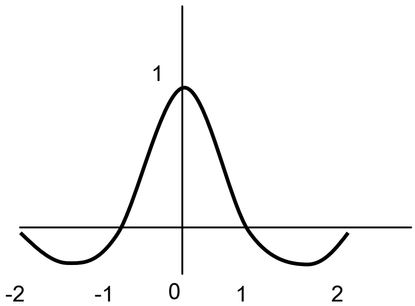

Fig. 1 Catmull-rom spline interpolation kernel

Catmull-rom spline is widely used and low computational cost. It is passed all of the control points and added or changed the control point in the segment, called local control. Therefore, it has advantage that able to predict accurate interpolated value even if the data is rapidly changing. Here, Catmull-rom spline is a third-order polynomial as follows [9]:

$$w_{crm} = \frac{1}{2} \cdot \begin{cases} 3|x|^3 - 5|x|^2 + 2 & 0 \le |x| < 1 \\ -|x|^3 + 5|x|^2 - 8|x| + 4 & 1 \le |x| < 2 \\ 0 & |x| \ge 2 \end{cases} \tag{1}$$

Catmull-rom spline polynomial occur the overshoot. In order to reduce the overshoot phenomenon, reduces the value of the variation of the weights, however, transition method not respond appropriately to the change, so the change not is able to obtain accurate interpolated values. Three-dimensional medical imaging has the amount of data. Also, CT image data have hundreds of MB because it is needed for accurate diagnosis with high-resolution [10]. So the precise diagnoses of high quality images are required. Therefore, how to create an efficient interpolation curve by adjusting the tension of the curve according to the variation of the values given by the Gaussian function is performed according to the changes at each point of the tension adjustment.

III. Results

Experiment to determine the validity of the proposed interpolation method, comparing interpolation control points and each of the two-dimensional image interpolation method has been compared to the filtering processing.

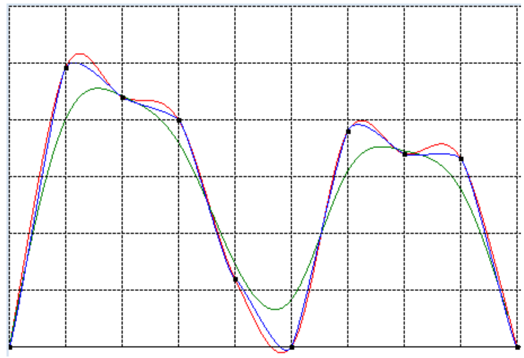

Fig. 2 comparing interpolation curves. Black points are control points. Red curve is Catmull-rom interpolation, green curve is cubic B-spline and blue curve is proposed interpolation curve

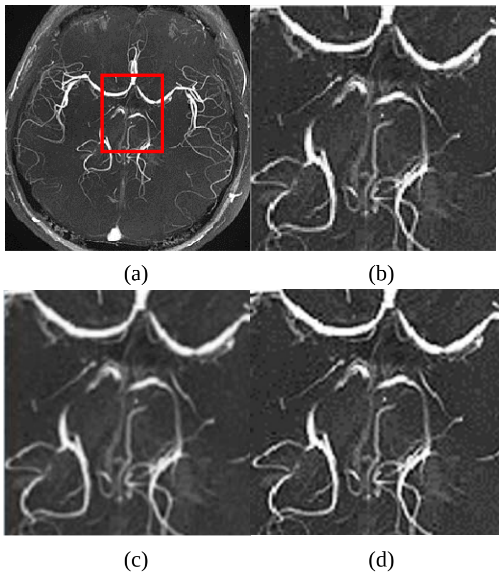

Fig. 3 Comparison of interpolated vessel images (a) original image (b) original image zoom in (c) B-spline (e) proposed method

Also, the rest of two original images and interpolated image PSNR (Peak Signal-to-Noise Ratio) compared.

TABLE I
PSNR COMPARISON

	Test Image Ⅰ	Test Image Ⅱ
Nearest Neighnor	29.9511	26.8330
Cubic Bspline	29.4317	26.2916
Proposed	34.3253	29.0615

Finally, brain volume data implement to the three-dimensional imaging using ray-casting [11] and comparing images.

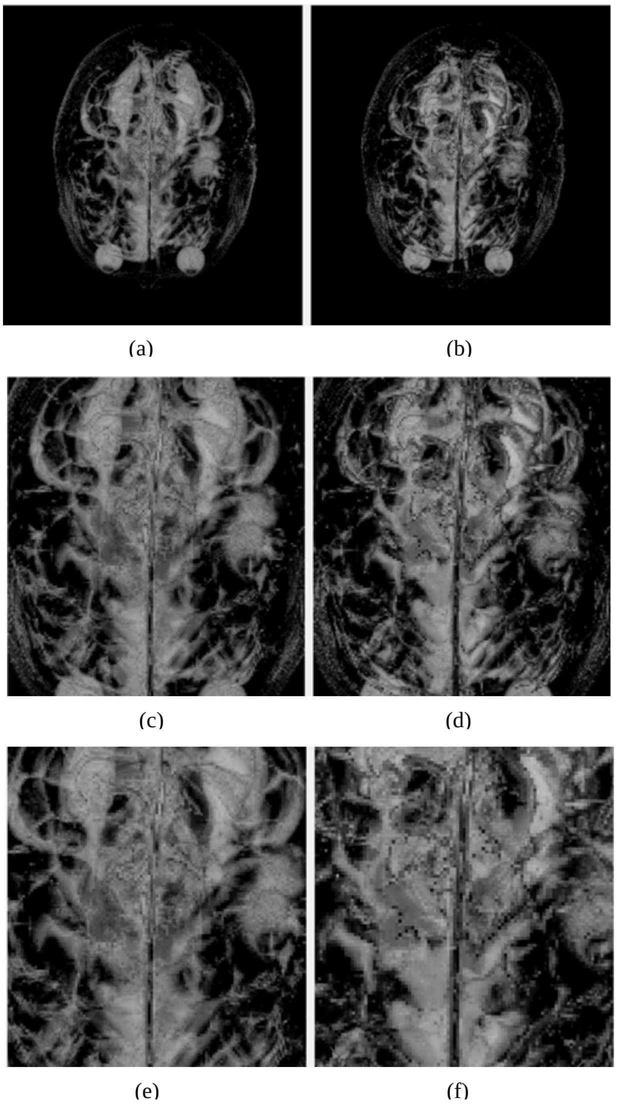

Fig. 4 Comparison of quadruple supersampling (a,c,e) proposed method (b,d,f) normal supersampling

IV. CONCLUSION

In this paper, we restored higher quality images than existing methods for generate interpolated value is close to the original signal that Varying degrees depending on the sample values of the error overshoot or undershoot phenomenon creates original image by adjusting the weights adaptively interpolation technique compared to conventional interpolation. Also showed that proposed method's PSNR results are higher than the conventional interpolation comes when the maximum signal-to-noise ratio compared Oversampling methods of the existing volume rendering volume data using the interpolation method proposed when it was more effective in improving the image quality that could be confirmed.

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