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Deformation and Construction of 3-D Medical Image

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Abstract

Using the computer-aided device, the images of the inside organ of human body can be gained. These images are much helpful for the physician's diagnosis. However, the image is in 2-D, so it can only present the partial information of the organ, instead of whole. Furthermore, in order to simulate surgical procedure, the deformation of the organ is quite necessary. In this paper, we describe one new method about deformation and reconstruction of 3-D medical image. The deformation is performed on the 2-D image. Then using these deformed 2-D images, the 3-D image can be reconstructed. This method is easy to execute. And the result is satisfying.

Keywords: DICOM、Template、Metamorphosis、Image Processing、OpenGL

1. Instruction for DICOM

Before we introduce the algorithm of the deformation and construction, we would like to introduce some knowledge of DICOM, because we use this kind of medical image to perform our work. The image data we treated come from DICOM files. And the result images after processing are stored into DICOM file, too. In the future, we will also use this kind of files to communicate with other devices.

In the actual application, the data of patient should be transferred from one department to another department in one hospital or in different hospitals frequently. It is very inconvenient if the patient's data written on the paper and the image printed on the film. It costs much time during transmission, and needs many persons to take part in, therefore, the standard used for communication is established. It is DICOM, the abbreviation of Digital Imaging and Communication in Medicine [1]. DICOM stands for Digital Imaging and Communications in Medicine. It is the industry standard for transfers of digital images and other medical information between computers. Patterned after the Open System Interconnection of the International Standards Organization, DICOM enables digital communication between diagnostic and therapeutic equipment and systems from various manufacturers.

DICOM defines the format of the medical files. It is that every file has a header, which includes many attributes describing the related image. Then the image data follows. In order to operate the image, our application reads the file by the DICOM standard firstly. And the medical image can be displayed. After the processing the file will be stored as DICOM by the standard.

2. Algorithm description

The deformation is performed on 2D image. Then using these deformed images we construct 3D image. There are many different methods to warp an image. Traditional filmmaking techniques include clever cuts and optical cross- dissolve [2]. They can give the powerful illusion of continuous metamorphosis, but require much skill and are very tedious work. The cross-discover is also used for changing one digital image to another. The color value is interpolated from the correspond position of the first image to the second one. One method uses “particle system” to map pixels from one image to another [3]. The image can be also mapped to regular shapes, such as plane or cylinder [4].

Our method is based on the work of Thaddeus [5]. It is local morphing for that the morphing is based upon fields of influence surrounding the control elements.

2.1 Single control line pair

There are two methods to warp an image. One method scans through the source image pixel by pixel, and copies them to the appropriate place in the destination image. If there are some pixels not painted in the destination image, they should be interpolated. The other method is reversed, which goes through the destination image pixel by pixel, then samples from the source image. In this paper, we use the second one.

Single line pair approach uses two lines to warp the image. One line is drawn in the source image. The other one is in the destination image. They are used for calibrate the warped area. After the deformation, the area surrounding the line in the source image is warped to the place where the line lies in the destination image.

The value sampling procedure is illustrated in the figure 1 (on next page). The value u is the position along the line. It is the ratio on the line that the distance between the perpendicular point of X on the line and the point P, to the length of the PQ. The value v is the distance from X to line PQ. Using these u and v to find the corresponding position in the source image. Then we sample the X’ from the source image as the value of X in the destination image. Scanning the destination image pixel by pixel and sampling every

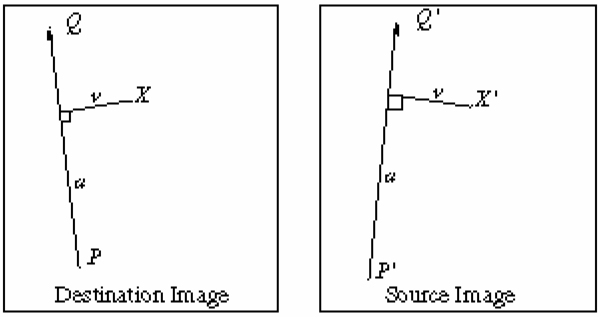

Figure 1: Single line pair

pixel's value from the source image, then we get the warped image.

By this method, we can realize the translation, rotation and scaling of the image. Because the length of the line normalizes the value of u, while the value of v is not (it is always distance in pixels), the image is scaled along the direction of the lines by the ratio of the lengths of the lines. The scale is only along the direction of the line. If the length of the pair lines is same, only the rotation and the translation are performed, without the scaling.

2.2 Multiple line pairs

It is obvious that the single line pair can only realize the simple deformation. If we want to perform some complex deformation, we should find an alternative. It is multiple line pairs.

In this mode, each line has a weighting of the coordinate transformation. The position of sampling X_i' is effected by each pair of lines. The offset $D_i = X_i' - X$ is the difference that the pixel location is in the source and destination images. The weighted average is from the all offsets. The distance between the X and the line determines the weight. The current position X adding the weighted average offset is the position X' to sample in the source image. The single pair line is the special case of the multiple pair lines. The nearer the pixel to the line, the stronger the weight is. The equation is below:

$$weight = \left(\frac{length^p}{(a + dist)} \right)^b$$

Equation 1

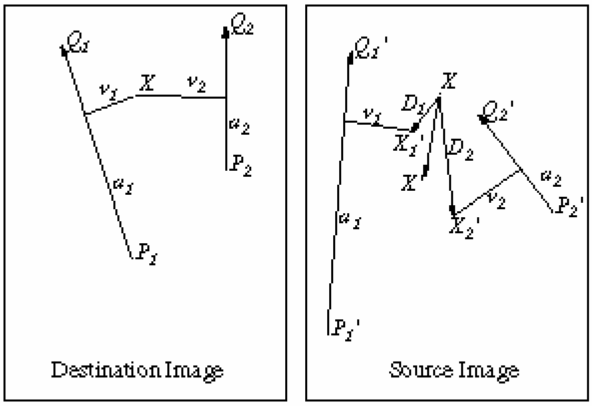

Figure 2: Multiple line pairs

Where length is the length of a line, dist is the distance from the pixel to the line. Because the line is just the segment PQ, the distance has three situations. The first is v, illustrated in figure 2, if 0<u<1; the second is the distance from P to the point, if u<0; the last is the distance from Q to the point, if u>1. Here, a, b and p are used to adjust the relative effect of the line [5].

The algorithm is as follows:

```
For each pixel X in the destination
        DSUM = (0,0)
        weightsum = 0
        For each line Pi Qi
                calculate u,v based on Pi Qi
                calculate X'i based on u,v and Pi'Qi'
                calculate displacement Di = Xi' - Xi for this line
                dist = shortest distance from X to Pi Qi
                weight = (lengthp / (a + dist))b    (refer to Equation 1)
                DSUM += Di *      weight
                weightsum += weight
        X' = X + DSUM / weightsum

        destinationImage(X) = sourceImage(X')
```

Figure 3. Psudocode of the algorithm

In figure 2, the X’ is the location sampled from source image corresponding the pixel X in the destination image. It is the weighted average of X1’ and X2’ coming from two pairs lines individually.

Using multiple pairs lines many complex transformation can be done, instead of simple transformation performed by single pair line such as translation or rotation. We can transact warping by this approach. Defining several pair lines according to what shape you want, the image can be transformed.

3. Display 3D image

Our aim is to deform the organ and show it on the screen. After the operation introduced above, the image has been deformed. The serial images sampled from the organ are deformed unified. Then using the deformed images builds the 3D image.

3.1 Construct 3D image

Constructing 3D image from 2D image is a big subject. It includes many complex procedures, such as image segment, image calibrate, shape reconstruct, and so on. In our system, we don’t perform so accurate construction. We just work out a sketchy result. Our method is that overlaying the image one by one as the correct order. We assume the distance between each image is one unit. If the distance is more than one unit, we can interpolate the nonexistent value. This method can’t get the shape of the organ. It just obtains the whole information.

3.2 Operate 3D image

The aim of construction of 3D image is to simulate the real organ in the computer. The user can observe the organ from difference directions and go into the object like operation. Using the display technique Open GL, we can reach it. The object can be rotated, translated and flied-through on the screen.

3.3 Result

Our system focuses on the deformation and construction 3D image. One application is in the dentistry. The shape of teethridge is arc. The dentist wants to change it to line, and construct the 3D teethridge. Our approach is to define an arched template, which consists of several lines, in the source image. In the destination image, there is a corresponding template that is line shape. Using the method introduced above, the teethridge is deformed to line illustrated in figure 4. This procedure is performed on every image unified. The deformed images make up the 3D teethridge model that is illustrated in figure 5.

4. Conclusion

3D medical image and its deformation are hot topic recently. In this paper we present one approach concerning this topic. The deformation is performed on 2D image. The aimed area is warped by the template that consists of multiply line pairs both in source image and in destination image. One serial 2D image constructs 3D image. Every image in the serial is warped in the same way. Assuming the distance between each image in the serial is one unit. We sort the serial image and overlap the images in the correct order. Then the 3D image can be displayed on the screen, furthermore, it can be also rotated, translated and flied through for observation.

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