Oil painting Effect Simulation Based on Contour Extraction Gradient Sharpening Technique

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Abstract: Non-photorealistic rendering of computer graphics is one of the most active research topic, it is not like realistic graphics that pursue just like a picture's reality, but hope that it can highlight the image to express information through ignore some of the unimportant details, or to generate the image with artistic effect. In the study of non-photorealistic rendering technology, this paper proposes a contour extraction method based on gradient sharpening when extracting contour lines of images. The algorithm first sharpens the gradient of images, and then performs phase inversion and color removal to obtain the contour information of images.

1. Introduction

Computer graphics began to develop since the 1960s. People's pursuit of simulation world has been the goal of computer graphics development. Realistic graphics is a kind of research to reflect the realistic effect. It pursues realistic simulation of the scene, while non-realistic graphics pursues the effect of artistic style. With the development of computer graphics, more and more people find that there are many defects in the way of representing objects in the pursuit of realistic images like photos. Sometimes in order to better express the real and complex information, it is necessary to Abstract the image visually. Therefore, non-photorealistic graphics has become one of the hot issues in computer graphics research. Non-photorealistic graphics refers to the use of computers to generate hand-painted images with stylistic effects. Its purpose is not to pursue the authenticity of images, but to express the artistic style of images [1]. The appearance of non-photorealistic graphics makes up for the defects of traditional photorealistic graphics in architecture, medicine, machinery and other practical applications and arts.

In non-photorealistic rendering, what people pursue is not the photo-like sense of reality, but mainly to express the artistic characteristics of graphics and imitate the artistic works of painters. It usually only needs a set of curves to represent the shape information of the object in the process of non-photorealistic rendering. For example, when a painter paints an image in the style of pencil and pencil, he first makes a rough outline of the object. At present, many non-photorealistic rendering technologies use contour line extraction in the process of simulating the generation of artistic styles such as pencil, pen and cartoon. According to the mechanism of contour production, contour can be divided into five categories:

First class outline: the object contour. It refers to the public by the front and the back edge contour, which contains the edges of the objects and internal discontinuous [2]. The space of the object represents the edge of the contour information. The edge information is used to distinguish the object from its background, and the internal discontinuity shows the physical characteristics of the object.

The second type of contour: convex edges are also called sharp edges. Convex edges refer to the common edges of two adjacent faces when the included angle between the normal vectors of two adjacent faces is less than a certain value. There are only two states of convex edges, that is, visible or invisible. And as long as the convex edge is visible, then it needs to be drawn. So convex edges are also used as intrinsic feature lines on the surface of the object.

The third type of contour: concave edges are similar to sharp edges of the second type of contour. It is also considered as inherent feature lines. The difference is that the judgment condition is opposite

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to convex edges. The judgment of concave edges depends on whether the included angle between normal vectors of adjacent faces is greater than a certain value, so as to judge whether the common edge is concave [3].

The fourth kind of contour: boundary. Boundary is only an adjacent side. This kind of edge exists only in non-closed objects, and there is no such edge for closed objects. For example, an open box.

The fifth type of contour line: shadow contour line and material boundary contour line. The shadow generated by light on the surface of the dark areas produced by the boundary is called the shadow contour. And the shadow includes self-shadow and projected shadows on the object surface. A texture boundary is a boundary that represents the surface texture area or color area of different objects, The result of drawing with different materials will not produce geometric discontinuities, but will form obvious transitions depending on the materials or colors used. These obvious transitions can be used to enhance the artistic effect of the image in the non-photorealistic rendering process.

2. Contour Extraction Technology

Contour detection algorithm of image space. Contour detection algorithm based on image space is a simple and efficient method, which detects the edge contour and other contours of objects in the image cache by processing the scene image that has been drawn based on the observer's viewpoint. Although this method is affected by image accuracy, it is sufficient for general applications. Popular technologies fall into the following two categories:

The contours of objects are detected in depth image and vector image respectively, and then the results obtained by combining the two images are generated to a satisfactory result. Depth image by turning on the depth detection when rendering, the depth value of each pixel of the final drawn image can be obtained in the depth cache, that is, the depth image is obtained. This method assumes that for two adjacent pixel points, the depth of points belonging to the same object changes little, while the depth of points belonging to different objects changes greatly. The discontinuity of the surface is detected by analyzing the depth discontinuity of each pixel. In other words, it marks the points with large changes in depth as points on the contour line. Vector image is a method proposed by Decaudin to make up the deficiency of depth image. It is a specially drawn image in which each pixel holds a normal vector to the surface of the object. The method assumes that the normal vector of the object surface will change near the contour line. It mainly detected the contour line which is the fold contour line. Combining the two results, it can get a satisfactory object contour.

The effect of contour enhancement is achieved by drawing three scenes multiple times. This kind of algorithm is also called hybrid algorithm. This approach applies to the different caching techniques described above, such as environment mapping and hollow caching. The drawback is that you can not find all the contours at once. Like depth mapping, this method can only find the first kind of contour lines, but not the internal feature lines of the object. You can control the thickness of the contour by drawing it multiple times, but you will pay a high price.

3. Contour Detection Algorithm of Graphics Space

3.1 Contour detection algorithm based on polygon surface slice to describe object.

For a model described by a polygonal plane, its contour is composed of a part of a polygonal plane. The definition of contour includes the five types of contour mentioned above. The algorithms for detecting these five types of contour lines can be divided into direct detection algorithm and random detection algorithm. Direct detection algorithm means to directly traverse all edges in the image, and then judge whether the edge is a contour line according to the normal vector of the adjacent two faces of the edge. For example, if the angle between the normal vectors of two faces is less than the given threshold, it is a sharp edge marked as the second type of contour. It requires that there must be adjacent information of each edge, namely the normal vector of adjacent faces when using this method for detection. However, if the observer's viewpoint changes, all the contour lines must be

recalculated. This method is less efficient for contour detection. Literature [4] proposed an improved algorithm based on the edge cache structure. As the visibility of folded edges inside objects may change only when the position of the viewpoint changes greatly, such contour lines need to be redrawn. By default, we believe that such contour lines will not change, so when the position of viewpoint changes, we only need to judge the first type of contour lines. Therefore, this algorithm is very practical in contour detection. In the study of the algorithm, through the observation of the art and animation in the contour line, we found that the contour line generally has two characteristics. Firstly, there is no single contour edge in the image, the object contour is usually composed of many small contour edge connection. Secondly, if very small changes happened in the location of the view point, so in a frame on most of the contour line will also appear in the next frame. According to these two characteristics, a random detection algorithm is proposed. The algorithm does not need to detect all the edges in the image, but it needs to continue to determine whether its adjacent edges are contour edges when finding a small number of edges, and continue recursively until all the edges are found. Markosian proposed a real-time non-photorealistic rendering technology to improve the rendering speed of contour lines by sacrificing certain accuracy and details. The algorithm is applicable to polyhedral models with known adjacent information, which does not need to traverse the entire scene in the image. It is fast to draw. Moreover, the spatio-temporal consistency of contour lines is utilized, and the algorithm is also applicable to real-time interactive applications. Since the contour edge is marked separately, it can be used for drawing contour lines in many styles.

3.2 Contour detection algorithm based on the object of freeform surface description.

The object contour line described by freeform surface is a set of points composed of the normal vector of the object surface perpendicular to the line of sight vector. There are two kinds of common description of free surface: NURBS surface and subsurface. Generally, polygonal surfaces are used to approximate smooth surfaces. However, the use of polygons will choose the degree of existence. A small amount of polygons will lose the smoothness of the surface, while a large amount of polygons will cause too much data, thus these will make the algorithm be less efficient. The contour lines obtained by the detection algorithm of graphics space are based on geometric representation, which is different from the pixel representation of image space. Users can easily stylize the painting, including stroke simulation, changing the thickness of the line to get different styles. The detection algorithm based on graph space is also the detection algorithm based on geometric model information. For example, the algorithms mentioned above all use the adjacent relations between geometric sides, etc. More information needs to be obtained from the geometric model. However, when the algorithm is applied to large scenes or extremely complex model rendering, improving the processing speed of data will be a difficult problem worth cracking.

4. Contour Extraction

In the process of drawing pencil strokes, artists usually outline the general outline of the image, and then use more delicate strokes to further paint the colors of different parts of the image. Therefore, contour extraction technology becomes an important step in pencil drawing process. In many existing algorithms, edge detection algorithm is used to extract contour lines, and good experimental results can be obtained. Sun dandan et al. implemented the krisch edge detection algorithm, in which the tone was controlled by changing the attenuation factor to obtain contour lines with different effects. In this paper, the gradient sharpening method is used to get the contour line of the image.

Since the essence of image blurring is caused by the average or integral operation of the image, in order to make the edges and blurred contours stretched in any direction of the image be more clear, inverse operation can be carried out on the image such as differential operation, it so as to makes the image be clear.

In image processing, first order differentiation is realized by gradient method. For the function f(x,y) of an image application, the gradient vector of f(x,y) at the point (x,y) is defined as

$\vec{G}[f(x,y)] = \left[\frac{\partial f}{\partial x}\frac{\partial f}{\partial y}\right]$. The direction of the gradient is in the direction of the maximum rate of change of the function f(x,y), the magnitude of the gradient is expressed as G[f(x,y)], the value is $G[f(x,y)] = \sqrt{\left[\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2\right]}$.

It can be seen from this equation that the value of gradient is the unit distance increase of f(x,y) in the direction of its maximum rate of change. For the convenience of calculation, differential operation is usually replaced by difference. Therefore, for discrete digital images, the above equation can be rewritten as:

$$G[f(i,j)] \cong |f(i,j) - f(i+1,j)| + |f(i,j) - f(i,j+1)|$$

Through the above processing, the effect of figure 2 can be obtained, but there is still a big gap between it and the outline effect of pencil strokes. Through experiments, it is found that the sharpened results can be reversed and made a discoloration to produce similar outline effect of pencil strokes. Figure 3 is the processing result of reversed and discoloration.

Fig. 1 The Original Image

Fig. 2 The Result of Gradient Sharpening

Fig. 3 The Result of Phase Reversal and Color Removal

5. Summary

In this paper, a new method based on gradient sharpening is used to extract the contour line of the object in the image. The algorithm first sharpens the gradient of the image, and then performs phase inversion and color removal to get the contour line of the image

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