Semiautomatic 3D Virtual Fish Modeling based on 2D Texture

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Abstract

In the field of Virtual Reality, many studies have been reported. Especially, there are many studies on generating virtual creatures on computer systems. In this paper, we propose an algorithm to automatically generate 3D fish models from 2D images which are printed in illustrated books, pictures or handwritings. At first, 2D fish images are captured by means of image scanner. Next, the fish image is separated from background and segmented to several parts such as body, anal fin, dorsal fin, ectoral fin and ventral fin using the proposed method "Active Balloon model". After that, users choose front view model and top view model among six samples, respectively. 3D model is automatically generated from separated body, fins and the above two view models. The number of patches is decreased without any influence on the accuracy of the generated 3D model to reduce the time cost when texture mapping is applied. Finally, we can get any kinds of 3D fish models.

1 Introduction

In this paper, a semiautomatic 3D modeling algorithm based on 2D texture is proposed. There are many studies about hardware for virtual reality, construction of virtual world, representation of virtual creatures[1]-[5] and so on. Generally, in the field of CG(Computer Graphics) and virtual reality, 3D models are generated by means of drawable tools, CAD(Computer Aided Design), 3D digitizer and so on. It is necessary to have a talent of art and knowledge of computer technology for generating 3D models. The main purpose proposed in our research is a simple and automatic generation algorithm for 3D models.

In this paper, we propose semiautomatic 3D virtual fish generating system using 2D textures which are handwritings, pictures and so on. The flowchat of proposed 3D model generating system is illustrated in Fig.1. At first, an illustrated image is captured by means of image scanner and transformed into gray-scale in order to separate fish region from background easily. And the fish image is separated from background and segmented to several parts such as body, anal fin, dorsal fin, pectoral fin and ventral fin. A new algorithm "Active balloon model" is proposed to segment these fins region from the body. After that, users choose font view model and top view model The 3D body model is generated based on the selected front and top view model. And the 3D fin models, whoes thickness is proportional to the distance between a pixel and contour, are generated. A wireframe model is constructed by the body model and these fin models. The wireframe model has, however, a large number of triangle patches. Therefore, the number of patches is reduced without any debasement on the accuracy of the generated 3D model, because that it saves the processing time when texture mapping is applied. Finally, the original image is mapped to the 3D model as a texture. We can get any kinds of 3D fish models from 2D printed images.

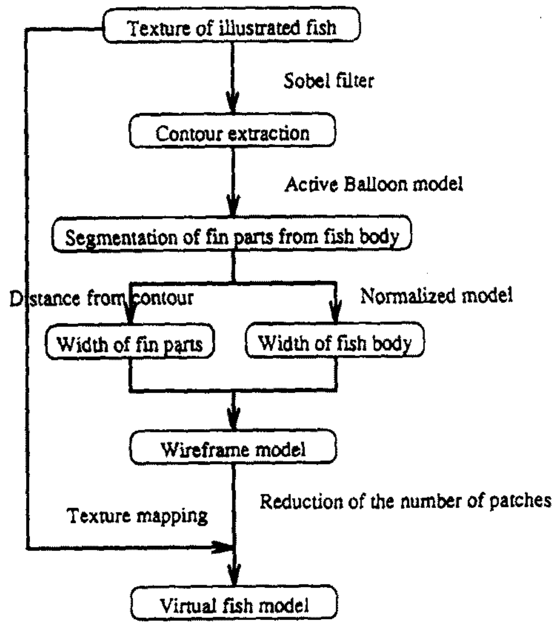

Fig. 1 Schematic representation of automatic generation of virtual fish

2 Contour extraction of fish

An original image is taken by an image scanner from an illustrated book. In this paper, we select fish to generate 3D model because it is easy to generate 3D models since almost all fish shapes are similar to ellipsoid. The image is 24 bits full color image and used as a texture after generating 3D model. In order to separate the fish from background, the image is translated from 24 bits full color to 8 bits gray scale image. The gray scale image is illustrated in Fig.2.

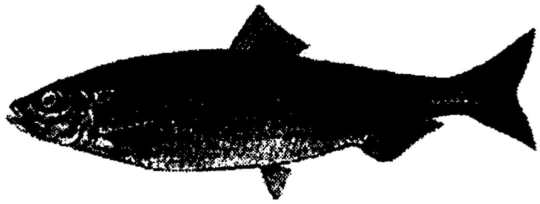

Fig. 2 An example of gray scale image (herring).

The contour of fish is emphasized using Sobel filters in order to extract the contour line. After emphasizing the fish contour, the image is binarized. And then, the contour line is extracted as Fig.3.

Fig. 3 Contour extraction of fish image

3 Segmentation of fin regions from the body of the fish

In this section, a new method "Active Balloon model" which separates fin regions from the body of fish is described.

3.1 Initial balloon model

We propose "active balloon model" in which a closed broken line swells up as a balloon until the broken line fits a body region of the fish. After that, the body region can be separated from fin regions easily. We use a closed broken line, which is an ellipse, since most of the fish bodies are similar to ellipsoids. An initial balloon is placed at the center of fish region shown in Fig.4. The initial balloon R has N connected control points.

3.2 Evaluation of the active balloon model

The active balloon energy E is defined by the equation (1). The energy E consists of two terms E_e and E_f which are defined by the following formula (2) and (3), respectively. E_e represents a degree of expansion of the active balloon. The energy $E_e(i)$ is equal to the area of a triangle made by control points W_i, W_{i+1} and the origin. The more the active balloon swells, the larger the value of energy $E_e(i)$ is. E_f represents a form factor of the active balloon. The value of energy E_f becomes large if the shape of active balloon is similar to a circle. The coefficient α defines the ratio of the energy E_e and the energy E_f.

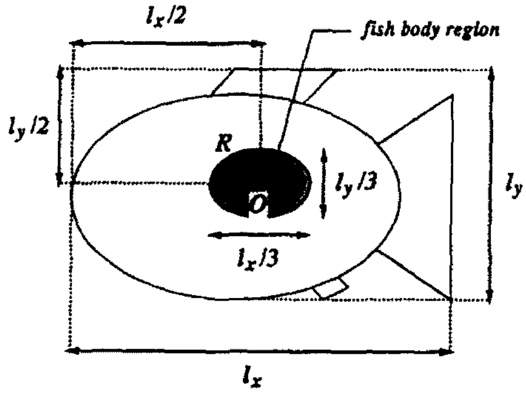

Fig. 4 Initial balloon of the active balloon model.

$$E = E_e + \alpha \cdot E_f \quad (1)$$

$$E_e = \sum_{i=1}^{N} E_e(i) = \frac{1}{2}\sum_{i=1}^{N} \sqrt{|\overrightarrow{OW_i}|^2|\overrightarrow{OW}_{i+1}|^2 - (\overrightarrow{OW_i} \cdot \overrightarrow{OW}_{i+1})^2} \quad (2)$$

$$E_f = -\frac{1}{2}\sum_{i=1}^{N} |\overrightarrow{W_iW}_{i+1} + \overrightarrow{W_iW}_{i-1}|^2 \quad (3)$$

The control point can expand toward eight neighborhood. The control point moves to the next pixel as it makes the largest value of the energy E. The expansion energy E_e has, however, no restriction for maximum value. So we define a restriction for the movement of the control point. The control point can move toward any directions in the internal fish contour, but the control point can not move to the external fish contour. If there is no pixel which enables the control point to move, the control point can not move any more.

In the initial expansion process, the energy E expands the balloon which becomes a like circle. The body region of fish is, however, similar to an ellipsoid. Therefore, the balloon does not fit to the contour of the body since the number of control points is not enough to be able to approximate the contour of the fish around the major principal axis. If the distance between W_i and W_{i+1} is larger than the threshold β, a new control point is generated.

3.3 Segmentation of the body region

We use the following parameters to separate the fin regions and the body region with active balloon model. α, β, N are set to 200. 10 and 40, respectively. N represents the number of control points at initial process. We show the expansion process in Fig.5, Fig.6 and Fig.7.

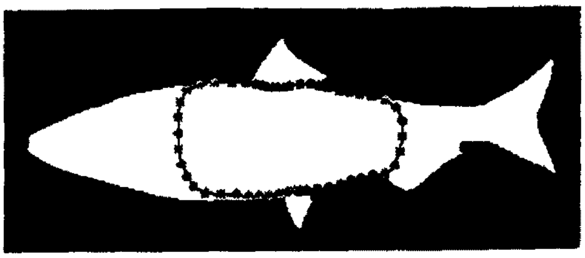

Fig. 5 The active balloon at 20 iterations.

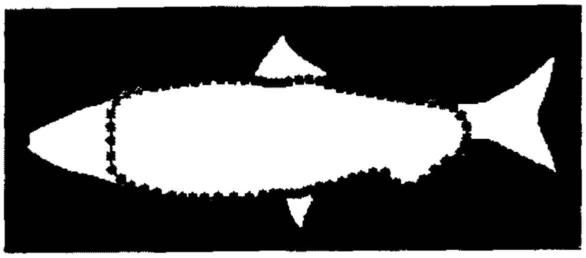

Fig. 6 The active balloon at 60 iterations.

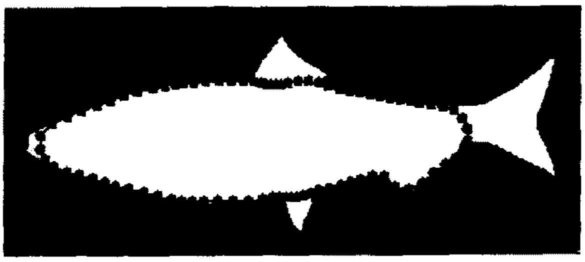

Fig. 7 The active balloon at final iterations.

4 Generation of 3D wireframe model

In this section, the generation of 3D wireframe model is described. In the previous section, a new method "active balloon model" is proposed to separate the fin regions form the body region. We employ different generation method to get 3D body and fins models. After generating each model, they are combined into one model.

At first, triangle patches are generated on the fish image as shown in Fig.8. Using spline method and distance model which are described in the following sections, thickness of the body and fins are calculated.

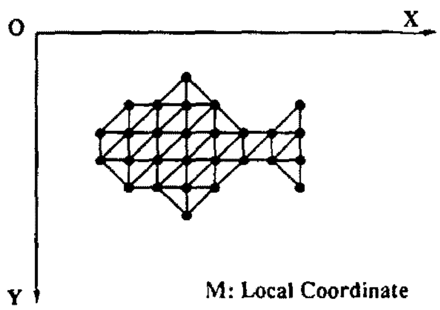

Fig. 8 2D model with triangle pathes.

4.1 Generation of 3D body model

The thickness of the body is calculated by spline model. It enables to generate many kinds of 3D models from a 2D image. Moreover, it is very difficult to determine the thickness of the model from 2D image. In this paper, model based method, therefore, is proposed to generate 3D model. We prepare front and top view model for default fish model. Each model has six kinds of shapes. Using two kinds of each side view model which are selected among the six models respectively, the thickness of the body is determined.

At first, the length and height of the fish are measured from balloon model illustrated in Fig.7. The selected front view model and top view model are magnified or reduced to fit the balloon model. An ellipsoid is generated as the body model using these two kinds of view model and the balloon model. We employ linear interpolation to generate the body model.

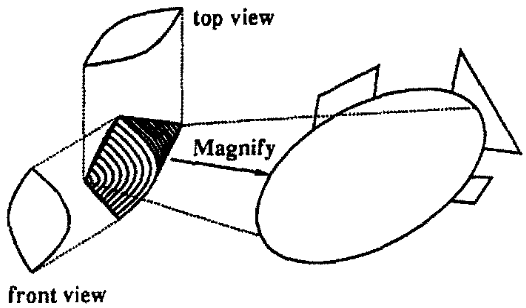

Fig. 9 Generation of fish model using spline model.

4.2 Generation of 3D fin models

Most of all kinds of fins are similar to a like boad and the thickness of the fins becomes gradually larger toward the fish body. Therefore, we generate the 3D fin model in which the thickness of the fin is proportional to the distance from the contour. The thickness of fin is defined by the following equation(4).

$$z(i,j) = \gamma\sqrt{d(i,j)} \tag{4}$$

where, γ is a positive coefficient and $d(i,j)$ is a distance to the contour from the pixel $p(i,j)$.

4.3 Optimization of triangle patches

There are a great number of patches in the initial patch generation process. We combine several patches into one triangle patch in order to reduce the number of patches. The following equation(5) is employed as an evaluation function for combining patches in case that $n \times n$ patches are combined into one patch.

$$e = \sum_{k=1}^{(n+1)(n+1)} (e_k)^2 \tag{5}$$

where, e_k is distance between a vertex of a triangle patch and combined new patch. If the error e is less than a threshold e_t, then these patches are combined. The threshold e_t is set to 50.

4.4 Generated 3D fish model

The generated body model and fin models are combined into fish wireframe model illustrated in Fig.10. The original image maps over the wireframe model as a texture. The results of virtual fish models are shown Fig.11.

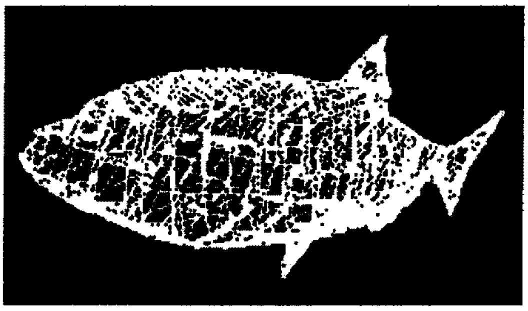

Fig. 10 3D virtual fish wireframe model. (herring)

Fig. 11 3D virtual fish model. (herring)

5 Conclusions

The 3D virtual fish model generation system based on 2D image is proposed. 3D model is generated automatically only scanning a texture and selecting two side view fish model. However, it is difficult to combine the body model and fin models smoothly. Moreover, the texture mapping does not work well around the contour of fish. We will concern these topics as further works. And we also study on non-interactive 3D model generation algorithm, using image processing and the knowledge about creatures or objects.

References

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