Research on the application of computer-aided art image generation based fractal method

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Abstract

The purpose of this paper is to research on the application of computer-aided art image generation based fractal method. This paper discussed the method of generation fractal graphics. Various corresponding fractal graphics of drawing at microcomputer were given, which revealed clearly the close relation between Julia Set and Mandelbrot Set. The hardware consists of a host, a geometry processor and a pixel processor. The host supports operation system and the real-time control application program. The geometry processor includes two CPUs. The geometry processing velocity is 1 million quadrilaterals per second. The pixel rendering peak value rate is 260Mpixels per second. The system has multi-channel, multi-view-point functions. 128 moving objects can be controlled. Daytime, night fall, sun glow, night and cloud fog atmospheric effect can be generated according to the requirements.

Keywords: Application, Computer-aided art image generation, Method of generation fractal graphics

1. INTRODUCTION

With the development of computer and network technology, the information resources are growing rapidly. 3D geometric model becomes a new generation of data representation following the multimedia data model of sound, images, and video. The data of geometric model with high precision have a high requirement on network bandwidth when transmission on the network. The method of geometry images ignores the point connection of the original data, transforming the irregular three-dimensional geometry data into regular two-dimensional image data. It means that the geometric data can be processed with the aid of the image encoding method, which is more mature. When storing and processing the geometry image transformed from the three-dimensional model, it is very important to make geometry image optimal approximation to the original data, especially for the model with low-resolution. In the process of parameterization, part of the three-dimensional model is stretched greatly, then some features are not well maintained when regular sampling. This paper researches on the geometry images based on the related method at home and abroad, intends to combines the subdivision algorithm on the three-dimensional model and some error measure methods, adds the adjustment procedure to process the initial mesh, in order to improve the quality of reconstruction model. The method proposed in this paper is divided into two aspects:

(1) Resampling strategy based on subdivision. The regular resampling can’t deal with the area with tensile deformation and fail to capture the feature information, which will result in reconstruction error. Through subdividing the area locally and adding more points, the feature points on the parametric mesh will be also increased. The operation is equivalent to the local non-uniform sampling, which will improve the sampling accuracy on the region locally and obtain a new resampling result. Therefore, this paper introduces the interpolation subdivision algorithm to subdivide the original mesh locally and obtain an adaptive resampling. Experimental results show that compared with the traditional geometry image, the proposed method can provide better results on both PSNR values and reconstruction quality.

(2) Adaptive geometry image generating method. Geometry image offers a simple and compact way of encoding the geometry of a surface and its implicit connectivity in an image-like data structure. Unfortunately, part of the input model is stretched greatly in the parameterization process of geometry images generation. And the regular resampling fails to capture the features on the surface which will result in reconstruction error. This paper applies ICP algorithm, mean curvature and area stretching metric to determine the region to be processed. After dealing with the mesh locally, we can get a more accurate resampling result, which will produce higher quality reconstructions (Horsch et al., 2011; Kanarachos and Roeper, 1997).
2. MATERIALS AND METHODS

2.1 The derivative of form and culture connotation design in computer-aided image generation

The reason that many people have taken the trouble to depict a graphic repeatedly in the history is not only because it has significant aesthetic shape but because these symbols we see often have profound symbolic meaning. The graphic symbols are just the underlying meaning of the external expression it is the outer reification of the concept. These meanings mostly originate from the nature worship and religious worship and then derive into the auspicious symbolic meanings such as “life reproduction riches and honors well-being, removing disaster and dispelling evil”.

It is precisely the persistent pursuit of the connotation that leads to the hand down of the forms from generation to generation in this way; it has given rise to many branches. It can be said that the history of the meaning promotes the derivatives of the form. From the history extension and derivative of the meaning and form in the graphic symbols we can see that, the deduction of the shape in every history is not the totally denial to the original “mother theme” but to give it the new forms with the new aesthetic ideas which enriches and expands the “mother theme” continuously. Although the form in each period often changes with great difference from the former period we can still feel the unique spiritual ethos in the various kinds of the form.

No matter what is the childish bird or frog grain in the pottery or the elegant phoenix grain in the Han lacquer, after years of rinsing, they still can show the amazing vitality and touch the modern people. The hand- down of the meaning originate from Chinese traditional shape-sculpting concept that is the unique philosophy and aesthetic consciousness (Gabbay and Senturia, 2000; Hoffmann and opcroft, 1985; Estrada, 2003). Chinese traditional aesthetics put more emphasis on the overall sense of the unity of the object and the subject. It thinks that everything is a unified and harmonious set which follows one essential law therefore Chinese ancient artists had always dedicated to the creation of the integrated beauty and viewed the sky the ground the arts morality as a vibrant organic whale endowing the people's emotional feelings with the forms of the object using the forms to express the enjoy-able feeling having both the shape arid the charm. Under the overall outlook the sky and people are the same; the object and I are identical. The representation five format focuses on "vivid" not on "realist" centers on the "performance" nut on the "reproduction" attach importance to the overall formative vigor not to the minor detailed overall depiction of the objective target The selection of the shape of course is not a simple copy Irupt the recreation of the traditional form. This recreation is based on the understanding. The re-form extraction and use some elements in the traditional modeling with modern aesthetic concepts enrich the features of the times and apply the traditional modeling method and format to modern design for the ex-oppression of ideas which reflects the national character. In the extension of the front there are some outstanding examples. For example, the symbol of the Phoenix TV in Chinese adopts the phoenix graphics in the colorful pottery and uses a unique "Joyful Encounter" structural forms to reflect a solid cultural foundation. Phoenix's opposite rotated wings are very dynamic and embody the characteristics of the modern media.

The meaning behind Chinese traditional modeling is the key for people fascination on it. The ancient and modern people have the same longing for all good things. Therefore, the auspicious meaning behind the traditional modeling is suitable for the modern design and for the transmission of the ideas of the modern designer. For example, China Unicorn logo adopts the long and tortuous form derived from one of the 8 auspicious Buddhist tress- uses which symbolizes "far source and long stream reproduce permanently and the application of auspicious meaning decreases commercial aspects and increases the cultural flavor and affinity in our modern design.

The spread of the sprints is the followed use of the form and the meaning which is the development and promotion of the traditional modeling at a low level. The canon of a new nation form needs to get rid of the material appearance of aesthetic tradition anti to explore it deeply. Based on fully understanding of the traditional art spirits and modern design idea, we can absorb good ideas anti reject the bad ideas put it into practice in our daily life find the central point of the tradition and modernization only in this way can we create the nation forums fit for features of the new times only in this way can we find the modern design which belongs to our nation and is recognized by the international community (Shi and Tan, 2001). Through the extension of the traditional culture and figure in history we can see that art in itself, an open system which is updated and expanded under the impact of the new technology and modern idea, the connotation and spirits behind this are the result of the long-term accumulation of the history which are untitled to Chinese nation and the soul place of the nation form. If we want to extend and develop Chinese traditional art design to the modern design and create the new nation forms we should select the form external the arranging and spread the spirits.
2.2 Computer-aided image generation based on computer vision

The study of how designers work and think; the establishment of appropriate structures for the design process; the development and application of new design methods, techniques and procedures; and reflection on the nature and extent of design knowledge and its application to design problems are all the important problems to art design teaching (Chen and Ravani, 1987; Tomás and Leal, 2003; Benarieh and Ramer, 2004; Daniel and Joseph, 1999). The process of traditional product design and development is sequential, that is the outcome of previous stage is used as the input of the next stage. The conceptual design is normally optimized through iteration due to the lack of ideas at the early stage of design. For each interaction loop, it is very time-consuming and expensive to return to an earlier stage to modify designers' ideas, which often results in long leading time and high costs of new product introduction to the market. Moreover, the design philosophy of "form follows function" is no longer sufficient; the aesthetic aspect of a product has become more and more important key element for its success in today's market.

This conceptual design process is defined as Product Design from Nature, in short PDN, is the important consisting part for digital art design teaching. The inspiration from a natural system is called bio-inspiration. The bio-inspiration can be triggered either by direct observation of an art design professional or captured by engineering designer using 3D digitizing techniques to obtain surficial information. An art design professional often creates a conceptual design in the form of 2D sketch while engineering method leads to a point cloud in 3D. Both ways have limitation in that art design professional are lack of knowledge to build final physical product from his/her 2D sketch and engineering designer’s 3D point clouds are poor in aesthetic beauty. A traditional digital art design teaching system is shown in the figure 1.

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2.3 The basic model and algorithm of fractional method

There are generally two ways for digital art design teaching: 1) design based on biological system functions through physical, chemical, engineering science and technology study to learn from nature, e.g. the design of bionic ploughs or bulldozers X51 or walking machines; 2) design based on biological geometric features. In this paper, the focus is placed on the second one-design based on biological geometric features. There are two methods for capturing geometric information for bio-inspiration. Method 1 is Art Design Method. In this method, the direct observation of a natural object is undertaken by art design professionals with their special knowledge and experiences and Method 2 is Engineering Method. In this method, the measurement of a natural object is carried out by engineers with engineering methods such as reverse engineering. Both methods have their advantages and disadvantages. To combine the advantages of both methods and overcome the disadvantages, a methodology for PDN is proposed as shown in Fig. 2. The procedure of the proposed methods is as follows (Akbulut, 2015):

Stage 1 Capturing surface geometrical information

As discussed above, there are two methods for capturing surface geometrical information. Method 1: by art design professionals and Method 2: by engineering professionals. In Method 1, art design professionals directly observe a biological object such as an apple, a lotus leave and a bird etc. to get bio-inspirations. Then with their expert knowledge, experiences and creation talent, they use their imaginary power to design either a pre-defined kind of product or any kind of product freely The outputs of the design are normally 2D sketch (free hand drawing). This 2D sketch can then be scanned using a normal 2D scanner to get digitized geometrical
information in the data format that is suitable for the late processing to generate the required geometrical information such as 3D models using various algorithms in Step 2.

For Method 2, engineering professionals employs advanced surface information capturing equipment to obtain geometrical and color data directly from a natural object. The outputs are normally various sets of points in x-, y- and z-coordinates for geometrical data and r, g and b for color information. They are together called point clouds which can be used for the late processing to generate useful information for geometrical design (such as 3D models) and aesthetics design using various algorithms in Step 2.

Stage 2 3D model build

This stage is consisting of the following main work: Filtering, segmentation, edge detection, and initial 3D modeling and aesthetics analysis/optimization for the final 3D models. Here, there should be sufficient collaboration between art design professionals and engineering design and 3D modeling professionals. The inputs from art design professionals should be effectively integrated into 3D modeling process to obtain aesthetical beauty product design. The inputs from engineering design and 3D modeling professional are used to build 3D models that are suitable for the production in Stage 3. In this stage, various algorithms have to be applied.

Stage 3 Prototype Manufacturing

The aim of any product design including PDN is to provide product description for manufacturing a physical product. This is equally important for Bionic Engineering to survive and to prosper. So, the natural stage of the proposed methodology should be the prototype manufacturing to build some prototypes of the design for test, quality control and production plan for late manufacture of the products for market. Here various rapid prototype techniques/methods are commercial available on market. The typical methods include Rapid Prototype, high-speed machining and laser cutting and processing etc.

Although computer support of form design will be rather moderate in the near future, especially when fast representation and alteration of early shape concepts are considered. The diverse tools, including free hand sketch, 2D digital images, and 3D modeling, applied by designers in the design process have been investigated separately.

The designer’s sketches and ideas are server as instantiations of ideas and the inspirations of designer process. In the conceptual development stage of a real design process, the different tools and media have been used: papers and pens, on-screen computer graphics, its equipment’s and scale models. Two-dimensional sketching is a continuous developing process made up of visual elements such as points, lines and planes. Meanwhile, they can get the feeling of how to construct a reasonable form, which can lay the foundation for the manipulation of 3D form in product design. Fig. 3 shows the designer choose one or more certain primitives, and through various operators and principles of aesthetic by observing a lotus plant. Especially, designers capture their ideas by sketching them on paper. Annotation helps identify key points so that their ideas can be communicated with other members of the design house or design studio. Since our human being peer to nature for inspiration from shell shape, human body, implements, and in art, design and architecture extend back to the ancient Greeks 5 BC years ago to the Renaissance today’s time. People have been concerning with the proportions of the parts of their works. Huntley’s listing of Fechner’s data is presented in Figure 4.

The algorithm can be expressed as following equation (1-2) (Frolkis and Cai, 2014; Kozaki et al., 2015; Gilkeson, 2016):

\[
\gamma_i(k_i, \omega) = \frac{1}{\rho_0 \omega^2} \left( \frac{e_{15}^0}{n_{11}^0} \right)^2 \frac{\beta_{\perp}^2}{k^2 - \beta_{\perp}^2} m_i
\]

\[
\mathbf{g}_i (k, \omega) = \frac{1}{n_{11}^0} \frac{1}{k^2} + \frac{1}{\rho_0 \omega^2} \left( \frac{e_{15}^0}{n_{11}^0} \right)^2 \frac{\beta_{\perp}^2}{k^2 - \beta_{\perp}^2}
\]
In which,

\[ \alpha^2 = \frac{\rho_0 \omega^3}{C_{11}} \]  

(2)

\[ \alpha^2 = \frac{\rho_0 \omega^2}{C_{66}}, \beta_\perp = \frac{\rho_0 \omega^2}{C_{44}} \]  

(3)

\[ C_{44} = C_{44}^0 + \frac{(e_{15})^2}{\eta^1_{11}} \]  

(4)

Rewrite again Eq. (1) as

\[ \hat{f}_H^\alpha(x) = \frac{1}{\Gamma(1+\alpha)} \int_{-\infty}^{+\infty} f(t) \left( t - x \right)^{\alpha} (dt)^\alpha \]

\[ = \frac{1}{\Gamma(1+\alpha)} \int_{-\infty}^{+\infty} f(t) g(x - t) (dt)^\alpha \]  

(5)

\[ = f(x) * g(x), \]

\[ \partial_j (C_{ijkl} \partial_k u_i + e_{ijkl} \partial_k \phi) - \rho \ddot{u}_i = 0 \]  

(6)

\[ \partial_j (e_{ijkl} \partial_k u_i - \eta_{ijkl} \partial_k \phi) = 0 \]  

(7)

The linear equation can be expressed into the following simplified forms:

\[ L(\nabla, \omega) f(x, \omega) = 0 \]

\[ L(\nabla, \omega) = T(\nabla) + \omega^2 \rho J \]  

(8)

So we get the PR value as the following:

\[ \mathcal{PR}(u) = \sum \frac{\mathcal{PR}(V)}{L(V)} \]  

(9)

\[ L_k = \frac{d_k}{\sum_{e=1}^{n} d_e} \]  

(10)

From the information security requirements, in the TOP-N algorithm, the construction of digital libraries is shown as the equation (11)-(12):
\[ d_i = \sqrt{\sum_{j=1}^{m} W(a_j - \hat{a}_j)} \quad (11) \]

\[ d_i(x_k) = \sum_{i=0}^{n} (x_{ij} - M_j)^2 \quad (12) \]

The data of geometric model with high precision have a high requirement on network bandwidth when transmission on the network. The method of geometry images ignores the point connection of the original data, transforming the irregular three-dimensional geometry data into regular two-dimensional image data. It means that the geometric data can be processed with the aid of the image encoding method, which is more mature. When storing and processing the geometry image transformed from the three-dimensional model, it is very important to make geometry image optimal approximation to the original data, especially for the model with low-resolution. In the process of parameterization, part of the three-dimensional model is stretched greatly, then some features are not well maintained when regular sampling. So, we have:

\[ R(C | X) = \frac{R(X | C)}{R(X)} \quad (13) \]

**Figure 1.** A traditional digital art design teaching system
Figure 2. A design process for digital art design teaching system

Figure 3. A hand sketch in digital art design teaching class

Figure 4. A hand sketch and digital sketch in digital art design teaching class
3. RESULTS AND DISCUSSION

The process of sharp edge detection is straightforward since the existence of tangency discontinuities can be easily checked along scan lines. But there are some errors here since the points on the true edge could be omitted during the scanning. This error is dependent on the resolution of the scanner. This is often found to be a barrier to the generation of a satisfactory 3D model.

The variation of curvature values can be used to detect the smooth edges. One characteristic provides a reasonable solution for detecting smooth edges in a curvature plot: 'spike'. These spikes in the curvature plot give a clear indication of the location at which the points are to be partitioned into different sets. Hence, the presence of spikes can then be used to detect the presence of smooth edges (Chhaya, 2015; Bangov, 2014; Pankratius, 2016; Yin and Shiodo, 2014).

The whole segmentation process needs to be successfully accomplished, since it is normally a prerequisite step to recognizing features from the discrete scanned data. It has been manually carried out by RE operators. The mouse is normally used to select appropriate points on the displayed image. The point data captured in the mouse “window” are ready to be mapped to a feature. Segmentation must be continued until the whole regions of a part are isolated completely. The level of subdivision depends upon the complexity of the surfaces. It is the trend that more work has been done for automatic segmentation though it is still in the early stage for the practical applications of fully automatic segmentation. It is especially true for the method based RE with normal industrial 3D digitizing scanners to scan a natural object. A case is shown in the figure 5.

4. CONCLUSIONS

In this paper, we research on the application of computer-aided image generation based fractal method. This paper discussed the method of generation fractal graphics. Various corresponding fractal graphics of drawing at microcomputer were given, which revealed clearly the close relation between Julia Set and Mandelbrot Set. The hardware consists of a host, a geometry processor and a pixel processor. The data of geometric model with high precision have a high requirement on network bandwidth when transmission on the network. The method of geometry images ignores the point connection of the original data, transforming the irregular three-dimensional...
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REFERENCES