Packaging Design of IFS Algorithm Based on Fractal Theory

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Abstract

The implementation of IFS algorithm based on fractal theory is described by irregular geometry. We will apply it to packaging design especially in packaging and decoration design and we will achieve unexpected results. It not only can produce unpredictable, colorful and beautiful patterns, but also can produce good anti-counterfeiting effect on the packaging graphics. In the packaging design, based on the anti-counterfeiting consideration, we often need to design more arbitrary graphics. Sometimes we need some abstract and realistic 3D graphics to meet the aesthetic needs of consumers. The software that focuses on graphic image processing and structure design cannot accomplish this task well. Based on the characteristics of packaging and decoration graphics, this paper studies the IFS algorithm of fractal generation algorithm, which uses Visual C++ to generate fractal graphics, and changes IFS parameters to generate new graphics, so as to realize the practical application of IFS algorithm based on fractal theory.

Keywords: Packaging design, Fractal theory, IFS algorithm, Graphic processing.

1. INTRODUCTION

Nowadays, the packaging design of various products in the market is endless and various. But the general purpose is always that all kinds of product packaging design should strive to give people a visual impact. Two, the anti-counterfeiting requirement of packaging design is also the key point to consider (Wang et al., 2015). As a category of nonlinear fractal mathematics and its application in packaging design, has the following four characteristics: first, has strong decorative effect, high color purity; second, self-similarity of image elements, although it is self-similar, but not dull and stereotyped feeling; third, flexibility; fourth that is abstract.

2. A BRIEF INTRODUCTION OF FRACTAL THEORY AND IFS ALGORITHM

The fractal theory, which is known as the geometry of nature, is a new branch of modern mathematics. In 1973, B.B.Mandelbrot proposed the idea of fractal dimension and fractal geometry for the first time. Compared with the traditional geometry, the fractal geometry has the following characteristics: on the whole, fractal geometry is irregular everywhere. For example, the shape of the coastline and mountain is extremely irregular in shape from a long distance (Ullah et al., 2015). In different scales, the regularity of the graphics is the same. The above coastline and mountain shape are observed from the close range, and the local shape is similar to the whole form. The IFS algorithm is one of the most common and important fractal algorithms, which is a typical method of drawing fractal graphics. The basic idea of IFS is that it considers the whole appearance and part of the set object. In the sense of affine transformation, it has a self similar structure (Aaron et al., 2017). In this way, after the definition of the geometric object as a whole, some affine transformations are selected to transform the whole form to the local part, and this process can be carried on iteratively until satisfactory shape is obtained (Omori et al., 2013). The iterated function system (IFS) is a self similar fractal structure by the transformation of the original graphics (generators) such as contraction, rotation and translation. The affine transformation set is called IFS. With the complex plane $f(z) = z^2 + c$, fractal iteration of the inherent connection, but the complex plane belongs to non linear transform, and the IFS is a linear transformation. The theory and method of IFS system is the theoretical basis of fractal natural landscape simulation and fractal image compression (Yang, 2015). Its basic idea is that the global and local parts of objects have self similar structure in the sense of affine transformation, which forms the famous stitching theorem. The charm of the IFS method is that it is the inverse problem generated by fractal iteration (Thamizhchelvy and Geetha, 2014). According to the splicing theorem,
we can get a lot of information for a given graph, such as a picture, by finding several generation rules. The basic principle of generating graphics in IFS system:

Linear transform two-dimensional space $\mathbb{R}^2$ has the following form:

$$
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
= \begin{bmatrix}
  a & b \\
  e & f
\end{bmatrix}
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
+ \begin{bmatrix}
  c \\
  g
\end{bmatrix},
a, b, c, d, e, f \in \mathbb{R}
$$

(1)

For $x, y \in \mathbb{R}^2$, if there is a compression factor $s$ that satisfies $0 < s < 1$, the next form is set up:

$$
\| \mathbf{w}(x) - \mathbf{w}(y) \| \leq s \| x - y \|
$$

(2)

$\mathbf{w}$ is called a contractile affine transformation. The transformation can also be expressed as:

$$
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
= \begin{bmatrix}
  r \cos \theta & s \sin \varphi \\
  r \sin \theta & -s \cos \varphi
\end{bmatrix}
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
+ \begin{bmatrix}
  T_x \\
  T_y
\end{bmatrix}
$$

(3)

The iterative function system consists of a set of contractive affine transformations of $\{w_1, w_2, w_3, \ldots, w_n\}$ and two-dimensional IFS can be expressed as:

$$
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
= \begin{bmatrix}
  a_i & b_i \\
  e_i & f_i
\end{bmatrix}
\begin{bmatrix}
  x \\
  y
\end{bmatrix}
+ \begin{bmatrix}
  c_i \\
  g_i
\end{bmatrix},
i = 1, 2, \ldots, N
$$

(4)

When generating a graph, the probability of each transformation is called:

$$
P_i = \frac{|a_i f_i - b_i e_i|}{\sum_{k=1}^{n} |a_k f_k - b_k e_k|}, \quad P_i > 0, \quad \sum_{i=1}^{n} P_i = 1
$$

(5)

The formula (4) can generate a number of points that constitute the fractal graph; the formula (5) is mainly generated by the probability control of the rules.

### 3. APPLICATION OF IFS ALGORITHM BASED ON FRACTAL THEORY IN PACKAGING DESIGN

#### 3.1 Overall design of algorithm

When packaging designers are designing packaging patterns, software that focuses on graphic and image processing and structural design has been unable to meet people's requirements for product design. The 3D fractal graph level of rich and profound connotation, fractal, magnificent change unpredictably just to meet the people of this need (Meng et al., 2013). Fractal patterns generated by computers are very sensitive to parameters. Small errors can cause huge differences in results, which makes it difficult to copy and imitate (Iovane, 2015). Therefore, fractal algorithm based on IFS algorithm can be superimposed on the product's anti-counterfeiting trademark or logo, and even can be used as part of the logo, so as to achieve a good anti-counterfeiting effect (Quirce et al., 2017). The IFS algorithm is used to generate fractal graphics, mainly using similar transformation and affine transformation. The key to determining the shape of a graph is an IFS code consisting of an affine transform coefficient and a probability value (JÓZSEF, 2014). This topic realizes the use of IFS algorithm to generate fractal graphics, and can change the IFS parameters, which generate the function of new fractal graphics and realize the operation interface of dialog box. The specific operation steps are shown in Figure 1.
IFS parameter initialization
Drawing fractal graphics
Change the IFS parameters
Redrawing the graphics

Figure 1. Running steps

(1) Initialize the IFS parameter module: the initial IFS code value of a given program can generate sierpinski gasket so that it can be generated in the initial demonstration of the program. (2) Drawing the graphics module: the realization part of the IFS algorithm is the main part of drawing fractal graphics. (3) The input parameter i dialog module: This module is mainly based on the needs of the generated graphics, and changes the i value of the line number in the input of IFS parameters. At the same time, the IFS parameter input dialog also determines the number of editable and non editable lines based on the i value. (4) IFS input parameters dialog module: this part is mainly to the input dialog box for the IFS parameter is initialized to 5 rows and 7 columns, and according to the i value of the input dialog box will enter the editable or not editable, to facilitate the IFS input parameters. (5) Call the dialog module: This module is mainly set up for two dialogs. After the i value is executed, which is judged and stored. After the IFS parameter is input, the input IFS parameter is assigned to the variable in the drawing module to facilitate the generation of the new graphics.

Figure 2. Drawing flow chart

The specific program flow chart is shown in Figure 2. The flow chart of the dialog box is shown in Figure 3
3.2 Program operation

After explaining the IFS algorithm and the design ideas of the subject and the implementation of the related algorithms, the results of the application of the program interface are introduced at last. Here is a demonstration of the results of the program running.

Figure 3. Dialog flow chart

Figure 4. Triangle shape

1) click create the Sierpinski gasket option under the demo menu.
2) Click to generate the Sierpinski gasket option to generate the graphics. As shown in Figure 4.

3) select screen option in the menu, will generate QtEmbedded blank.

4) select the input parameter option under the operation menu and the input I value dialog box will appear.

5) when the input I value is 2, the input IFS parameter dialog box appears. According to i=2, only two behavior can be editable in the dialog box. In the input IFS parameter dialog, input the parameter of the tree shape. As shown in Figure 5.

6) the shape of a tree, as shown in Figure 5.

4. CONCLUSIONS

Iterated function system is one of the generating methods of fractal patterns. Its progress in fractal reconstruction has led to the innovation of image compression technology, reaching the high compression ratio which cannot be achieved by conventional compression methods. The main idea is to store the IFS system that generates the image without storing the generated image, and the image is generated by the special hardware of the IFS system in the recovery time. For the IFS system to generate fractal images, the random iterative algorithm is an efficient algorithm. In view of this, a random iterative algorithm is used in the process of program implementation. The random iterative algorithm produces many points that constitute the entire image, which are generated by a continuous and random loop. Therefore, in programming, the method of thread can be used to control the speed of point production, and when and when the control points are finished. As one of the ways to generate fractal, iterated function system has unique characteristics in natural scenery simulation and image compression. It is a feasible and valuable research area. It is believed that the application of three-dimensional fractal technology in the field of packaging has considerable practical value and broad prospects for development.

REFERENCES


