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Cyclical Metamorphic Animation of Fractal Images Based on a Family of Multi-transitional IFS Code Approach

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Abstract—**The metamorphic technology is very important and can make an animation more attractive. The cyclical metamorphic animation of fractal images can be constructed by more than two fractal images. The multi-transitional IFS code can represent the multiple fractal images as the nodes of the iteration of the cyclical animation. To have the interpolation between the source and target of fractal images looked natural, the IFS code form of fractal attractors should be in a family with the correct order and the same number of transformation functions and relatively with the same size of attractors.**

Keywords-component; Fractals, metamorphic animation, IFS attractor, multi-transitional IFS code

I. Introduction

In this paper, the method of the cyclical metamorphic animation of fractal images based on a family of multi-transitional IFS code approach is presented. Usually a morphing animation is done between the start and target images of fractals by interpolating the coefficient of IFS code. In general the metamorphic animation can be done cyclically through many IFS code as the transitional nodes. There are many problems, such as the size of the IFS attractor of each transitional node are not always the same. The number of iterated function of each IFS code set in the transitional nodes is not always the same. The probability value composition of each IFS code set is changed variously. The size of IFS attractors in the nodes is not the same. Another problem is the sequence order of contractive functions in each IFS code set usually is set randomly. The random sequence order of functions in IFS code affects the transitional visualization of morphing animation. So a kind of IFS code modification and decoding mechanism that depends on the probability values and the size of attractors are needed to overcome the problems. In this paper there are eight sections, including this introductory section at the beginning and acknowledgements and references sections at the end. In the middle there are five others section, those are Related Works, IFS Code and Transitional Nodes, Simulations, Future Work, and Conclusions sections.

II. Related Works

Most of IFS fractal studies are conducted on the area of fractal image compression methods. There are not many of IFS fractal research that conducted on the animation area, except the morphing animation. The other IFS fractal researchers study the algorithms of decoding fractal construction. Chang et.al [1] study an automatic mechanism to determine the original size and the coordinates of fractal image directly from its IFS code by hierarchical fixed-point searching method, so the desired fractal image size can be decoded later. Chu and Chen [2] propose a new algorithm called the recursion algorithm that can generate fractal images efficiently by applying a set of contraction mappings. In their paper, Zhang and Yang [3] present the principle and method of gradually displaying IFS attractor from one fixed point of an invertible affine transformation that effectively resolved some problems of random algorithm. Lai et.al [4] study an efficient image magnification algorithm based on the IFS that employs the self-similarity property instead of the conventional interpolation approach. The proposed method can increase the PSNR compared to other recent image magnification methods. Barnsley and Hutchinson [5] study the new discoveries as the top of the IFS attractor, the fractal homeomorphism theorem that sometimes provide a beautiful continuous transformation between a pairs of IFSs and the V variable fractals that provide a bridge from IFS attractors to random fractals. In their paper, Chen et.al [6] present a new fractal-based algorithm for the metamorphic animation. The objective of this study is to design a fractal-based algorithm and produce a metamorphic animation-based on a fractal idea by interpolating two weighted IFS codes between the start and the target objects. In their paper Wang et.al [7] propose a new method of drawing 3D plants. Through the observation, plants have the golden sections around 34.4 and 55.6 degrees of a branch angle 90 degree as a standard. The bamboo, herb and poplar tree as the examples of 3D plants IFS are reconstructed under OpenGL environment. In their paper, Zhang and Liu [8] propose the IFS fractal simplification algorithm based on a modified IFS iterative algorithm. The combination of the improved algorithm and the growth model makes simulation of natural tree growth more vividly. Fu and Chen [9] study various computer construction algorithms for generating fractal images based on IFS attractor, such as the deterministic algorithm, string substitution algorithm, escape time algorithm and inverse function iterated algorithm by comparing and discussing in detail. Zhuang et.al [10] study a morphing IFS fractal by calculating local attractor's coarse convex-hull and selecting rotation matching between IFSs. The morphing procedure of two IFS's fractal attractors is done by interpolating the parameters of the iterated function.

III. IFS CODE AND TRANSITIONAL NODES

A. Fractal

According to Mandelbrot [11], the father of fractals, the fractal object has fractional dimension, so the fractal geometry that can represent many amorphous or formless objects in the nature is an extended of the ordinary geometry. A fractal object has the self-similarity property [12] in an iteratively way, so the enlargement part of it still exhibits the similarity of the whole.

B. Iterated Function Systems

The two dimensional fractal objects can be encoded into two dimensional iterated function systems (2D IFS) code that represents the collection of transformation coefficients. The IFS code that proposed by Barnsley and Demko [13][14] is the set of the affine transformation of each contractive function that can be decoded to be a fractal image according to the collage theorem and the self-similarity property. Mathematically the 2D IFS code can be represented by the affine transformation equation with the **'a'**, **'b'**, **'c'**, **'d'**, **'e'** and **'f'** as the coefficients of a single transformation function:

$$w \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

Figure 1. Affine transformation equation

C. IFS Code with Probability

The set of IFS code as a fractal object representation can be converted to fractal image by means of the deterministic algorithm. The dense of part of image depends on the probability of contractive function as a representation of the image part. To construct a fractal image, the IFS code with probability coefficient can be decoded by means of the random iteration algorithm [14]

D. A Family of IFS Code

According to the Collage theorem [14], the decoding process of a single IFS fractal does not depend on the sequence of contractive functions of an IFS attractor, so the changing of the sequence order will not affect the result of the constructed fractal image. For a pair of the start and target of IFS attractors in morphing animation, the change of sequence order of the contractive functions in both IFS attractors will affect the interpolation result of the two original fractal images. The family of IFS code set with probability coefficient has the same sequence order of their contractive functions according to their probability values. For instance, the sequence order of the contractive functions in fern fractals (type-1 and type-2) is set based on the decreasing probability values (**p**) as illustrated in table-1 below. If the probability values is almost the same, the sequence order of the contractive functions of the second and third order in the below example is set based on the sign of the other coefficients (in this case the coefficients of the two-dimensions IFS code are **'a'** and **'b'**)

TABLE I. COMPARISON OF THE TWO TYPES OF FERN FRACTAL

2D IFS code of Fern (type-1)						
a	b	c	d	e	f	p
0,95	-0,01	0,01	0,95	0	0,10	0,89
0,05	-0,14	0,14	0,05	0	0,15	0,05
-0,05	0,14	0,14	0,05	0	0,20	0,05
0,01	0	0	0,20	0	0	0,01
2D IFS code of Fern (type-2)						
a	b	c	d	e	f	p
0,74	-0,11	0,11	0,74	0	0,20	0,75
0,23	-0,11	0,11	0,23	0	0,10	0,12
-0,23	0,11	0,11	0,23	0	0,15	0,12
0,01	0	0	0,30	0	0	0,01

E. Normalization Size of IFS Attractor

The size of an IFS attractor depends on the values of coefficient- **'e'** and **'f'** of their 2D IFS code. In order the visualization of the interpolation images between the two extreme IFS attractors is presented appropriately, the values of the normalization scale should be set accordingly.

F. IFS Code with Dummy Function

For the sake of simplicity of the random iteration algorithm, one or more dummy functions need to be inserted into one of the IFS code sets of the two original IFS attractors, so the number of the contractive functions is the same and still in a family. The value of probability coefficient of the dummy contractive function is set to zero. The IFS code with dummy function will not affect the form of the IFS fractal image individually, but will affect the forms of the interpolation images in between the two original IFS fractal images. As an example of IFS code with dummy function can be seen in the table-2 below (high-lighted)

TABLE II. COMPARISON OF THE TWO TYPES OF TREE FRACTAL

2D IFS code of Tree (type-1)						
a	b	c	d	e	f	p
0,49	-0,075	0,075	0,49	0	0,20	0,50
0,45	-0,217	0,217	0,45	0	0,10	0,24
-0,45	0,217	0,217	0,45	0	0,15	0,24
-0,49	0,075	0,075	0,49	0	0,18	0
0,05	-0,003	0,003	0,60	0	0	0.02
2D IFS code of Tree (type-2)						
a	b	c	d	e	f	p
0,48	-0,124	0,124	0,48	0	0,20	0,25
0,45	-0,217	0,217	0,45	0	0,10	0,25
-0,45	0,217	0,217	0,45	0	0,08	0,25
-0,48	0,124	0,124	0,48	0	0,18	0,24
0,05	-0,003	0,003	0,60	0	0	0.01

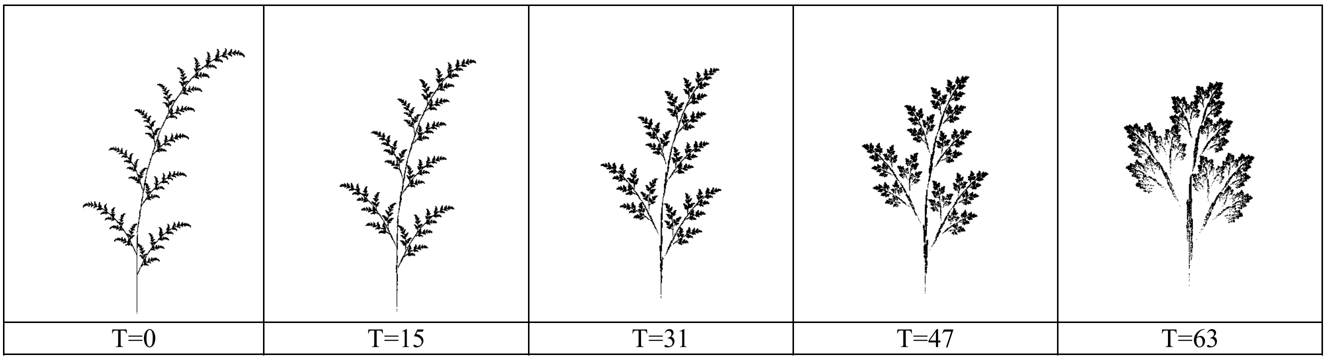

Figure 2. Sequence of metamorphic animation from fern to tree fractal

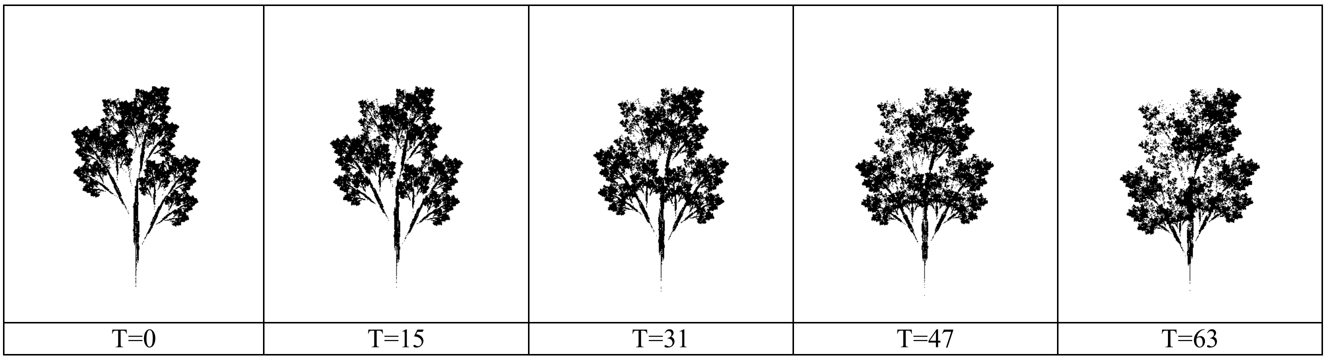

Figure 3. Sequence of metamorphic animation from tree (type-1) to tree (type-2) fractal

G. Multi-transitional Nodes IFS Code

In general, the cyclical metamorphic animation of fractal images in between several pairs of the start and target IFS code can be accomplished based on the multi-transitional IFS code in pair by means of the random iteration algorithm sequentially and cyclically. To have the visualization of metamorphic animation is looked natural, select sets of IFS code in a family and normalize the ‘e’ and ‘f’ coefficients of their 2D IFS code according to a preferred size of fractal image.

IV. SIMULATIONS

There are two kinds of simulation conducted in this paper as an example comparison. The first simulation dealing with the sets of the 2D IFS code in a family (grass, fern and tree fractals). The second simulation dealing with the sets of the 2D IFS code still in a family but with the various contractive functions number of their 2D IFS code (especially to accommodate the metamorphic animation between two kinds of tree fractals with the different branch number). Figure-1 below illustrates the appearance of the transitional images in between the fern and tree fractals as an example (for the first simulation illustration). Figure-2 below illustrates the appearance of the transitional images in between the two kinds of tree fractals (type-1 and type-2) as another example (for the second simulation illustration).

V. CONCLUSIONS

The selection of the IFS code sets in a family that have been normalized can make the metamorphic animation of fractal images is looked natural.

To generalize and accommodate the possibility of different number of the contractive functions of both the start and target IFS attractors, one or more dummy functions need to be inserted into one of the IFS code set that has a lack of the contractive function number.

In general cyclical metamorphic animation of fractal images can be generated by decoding the multi-transitional IFS code sets as nodes by means of the random iterated algorithm.

VI. FUTURE WORK

For the related future work of this study, the research can be extended to study the cyclical metamorphic animation of 3D fractal images based on the family of multi-transition 3D IFS code version.

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