Metamorphic Animation of Plant-like Fractal Images Based on a Family of Transitional IFS Code Sets Approach

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ABSTRACT

To have the interpolation of metamorphic animation between a pair of objects as the source and target of fractal images in IFS model looked natural, the IFS code form of fractal attractors should be in a family of transitional IFS code with the correct order and the same number of transformation functions and relatively with the same size of attractors. The metamorphic animation of fractal images can be constructed on more than two fractal images. The multi-transitional IFS code can represent the multiple fractal images as the iteration nodes of the cyclical animation. There is a solution needed to have the metamorphic animation of fractal images in IFS model with different number of transformation functions.

Keywords

Animation, Fractal, IFS model, metamorphic, multi-transitional IFS code, natural

1. INTRODUCTION

In this paper, the method of the metamorphic animation of plant-like fractal images based on a family of multi-transitional IFS code sets approach is presented. IFS code is the representation of the form, size and orientation of an IFS fractal. 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 sets as the multi-transitional nodes. The challenge and the contribution of this paper are the solutions of many problems to be resolved, such as the size of the IFS attractors in the consecutive nodes are not always the same. The number of iterated function of each IFS code set in the transitional nodes also is not always the same. The probability value composition of each IFS code set is changed variously. 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 seven sections, including this introductory section at the beginning and references sections at the end. In the middle there are five others section, those are Related Works, IFS Code and Transitional Nodes, Simulations and Results, Future Work, and Conclusions sections

2. 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 [4] 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 [6] 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 [14] 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 [10] 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 [3] 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 [5] 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 [12] 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. In their paper, Zhang and Liu [13] 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 [8] 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 [15] 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. The transitional and multi-transitional IFS code approaches are explained in the conference version paper [7], but there are no comparisons of both approaches to the non-transitional one compared to this extension paper which has more simulations

3. IFS CODE AND TRANSITIONAL NODES

3.1 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 [9] in an iteratively way, so the enlargement part of it still exhibits the similarity of the whole

3.2 3.2. IFS Code

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 [1] [2] 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 as equation (1) below. The 'a', 'b', 'c', 'd', 'e' and 'f' are the coefficients of a single function.

$$w\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}a & b\\c & d\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}e\\f\end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

3.3 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 the 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 through a random number generator [1]. A pair of random numbers represents the position of a point in the space according to each contractive function and its probability coefficient for the part of the fractal object represented by in a set of IFS code.

3.4 A Family of IFS Code

According to the Collage theorem [1], 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 [7]. 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 and table-2 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 2D IFS code are 'a' and 'b'). In table-1 (not in a family of transitional IFS code) below, the sequence order of the second and third function (in bold) of the first set is swapped compared to the sequence order of the second set in table-2 (in a family of transitional IFS code).

Table 1: Comparison of the two types of fern fractal (not in a family)

2D IFS code of Fern (type-1): Not in a family							2D IFS code of Fern (type-2)						
A	b	c	d	e	f	p	a	B	c	d	e	f	p
0,85	-0,1	0,1	0,85	0	0,1	0,72	0,74	-0,11	0,11	0,74	0	0,2	0,72
-0,15	**0,14**	**0,14**	**0,15**	**0**	**0,2**	**0,12**	0,23	-0,11	0,11	0,23	0	0,1	0,12
0,15	**-0,14**	**0,14**	**0,15**	**0**	**0,15**	**0,12**	-0,23	0,11	0,11	0,23	0	0,15	0,12
0,01	0	0	0,2	0	0	0,04	0,01	0	0	0,3	0	0	0,04

Table 2: Comparison of the two types of fern fractal (in a family)

2D IFS code of Fern (type-1): In a family							2D IFS code of Fern (type-2)						
A	b	c	d	e	f	p	a	B	c	d	e	f	p
0,85	-0,1	0,1	0,85	0	0,1	0,72	0,74	-0,11	0,11	0,74	0	0,2	0,72
0,15	-0,14	0,14	0,15	0	0,15	0,12	0,23	-0,11	0,11	0,23	0	0,1	0,12
-0,15	0,14	0,14	0,15	0	0,2	0,12	-0,23	0,11	0,11	0,23	0	0,15	0,12
0,01	0	0	0,2	0	0	0,04	0,01	0	0	0,3	0	0	0,04

3.5 Normalization Size of IFS Attractor

In the case of plant-like fractal such as fern and tree fractals, the size of an IFS attractor not only depends on the values of coefficient-'e' and 'f' as the representation of the farthest points relatively from the origin of the space, but also on the values of coefficient- 'a' or 'd' of their 2D IFS code as the representation of the size in x and y directions. In order the visualization of the interpolation images between the two extreme IFS attractors is presented appropriately, the values of the normalization scale especially on coefficient-'f' should be set accordingly [7]. In the table-3 below as an example, the maximum value of coefficient-'f' of both IFS code sets are 2.0, but the coefficient-'a' to 'd' of the first IFS code set has around 25% bigger than the second IFS code set (in bold), so the appearance of the first object is slightly bigger than the second one as can be seen in the figure-1 and figure-2 below.

Table 3: Comparison of fern (type-2) and tree (type-1) fractal

2D IFS code of Fern (type-2)							2D IFS code of Tree (type-1)						
a	b	c	d	e	f	p	a	b	c	d	e	f	p
0,74	**-0,11**	**0,11**	**0,74**	0	2,0	0,72	**0,49**	**-,075**	**0,075**	**0,49**	0	2,0	0,5
0,23	-0,11	0,11	0,23	0	1,0	0,12	0,45	-,217	0,217	0,45	0	1,0	0,24
-0,23	0,11	0,11	0,23	0	1,5	0,12	-0,45	0,217	0,217	0,45	0	1,5	0,24
0,01	0	0	0,3	0	0	0,04	0,05	-,003	0,003	0,6	0	0	0,02

3.6 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 of transitional IFS code. The value of probability coefficient of the dummy contractive function is set initially to zero [7]. 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-4 below (in **bold** with p = 0)

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Table 4: Comparison of the two types of tree fractal (with and without dummy code)

2D IFS code of Tree (1): With dummy code (p=0)							2D IFS code of Tree (type-2)						
a	b	c	d	e	f	p	a	b	c	d	e	f	p
0,49	-,075	0,075	0,49	0	2,0	0,5	0,48	-,124	0,124	0,48	0	2,0	0,25
0,45	-,217	0,217	0,45	0	1,0	0,24	0,45	-,217	0,217	0,45	0	1,0	0,24
-0,45	0,217	0,217	0,45	0	1,5	0,24	-0,45	0,217	0,217	0,45	0	0,8	0,24
-0,49	**0,075**	**0,075**	**0,49**	**0**	**1,8**	**0**	-0,48	0,124	0,124	0,48	0	1,8	0,24
0,05	-,003	0,003	0,6	0	0	0,02	0,05	-,003	0,003	0,6	0	0	0,03

3.7 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 several pairs of the iteration nodes 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 especially the ‘e’ and ‘f’ coefficients of their 2D IFS code according to a preferred size of fractal image [7].

4. SIMULATIONS AND RESULTS

There are four kinds of simulation conducted in this paper as an example comparison. The first simulation dealing with the sets of the 2D IFS code which are not in a family (fern-type-1 and fern-type-2 fractals). The second simulation dealing with the same sets of the 2D IFS code which are in a family of transitional IFS-code. The third simulation dealing with the sets of the 2D IFS code of plant-like fractal (fern and tree), and those are in a family of transitional IFS-code. The forth simulation dealing with the sets of the 2D IFS code of tree fractal, and those are also in a family of transitional IFS-code but with the different contractive functions number of their 2D IFS code, to accommodate the metamorphic animation between two kinds of tree fractal with the different branches number. Both figure-1 and figure-2 below illustrate the appearance of the transitional images in between the fern (type-1) and fern (type-2) fractals as a comparison example of two pair of IFS code (not in a family and in a family of transitional IFS code). The second simulation also shows a growing effect. Figure-3 below illustrates the appearance of the transitional images in between the two kinds of plant-like (fern and tree) fractals as an illustration of the third simulation that shows a mutation effect. Figure-4 below illustrates the appearance of the transitional images in between the two kinds of tree fractal as an illustration of the forth simulation that shows an extension effect from an object with four parts becomes an object with five parts. As a collection, the four IFS code sets as the representation of four fractal objects mentioned above (two types of both fern and tree ftractals) is the example of the IFS code sets which are in a family of multi-transitional IFS code. A cyclical morphing animation for example can be conducted from object-1 to object-4 through object-2 and object-3, then in the opposite direction from object-4 to object-1 through object-3 and object-2, or vice versa. As the results the natural metamorphic animation can be constructed through both transitional (a pair of objects) and multi-transitional (many pairs of objects) IFS code sets approach.

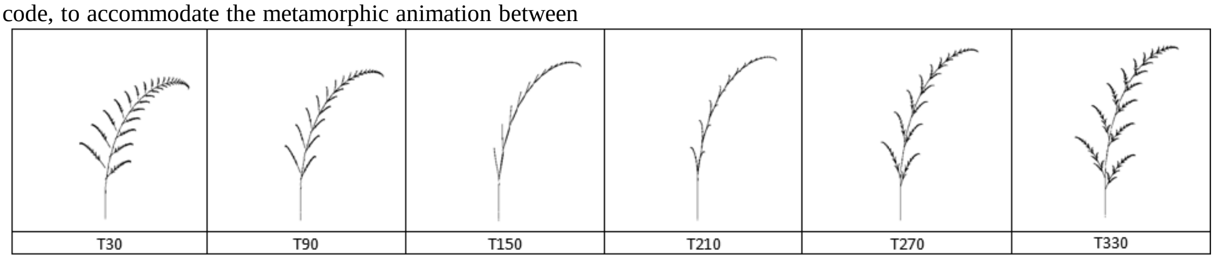

Figure 1. Metamorphic animation on fern fractals from (1) to (2) (non-natural effect)

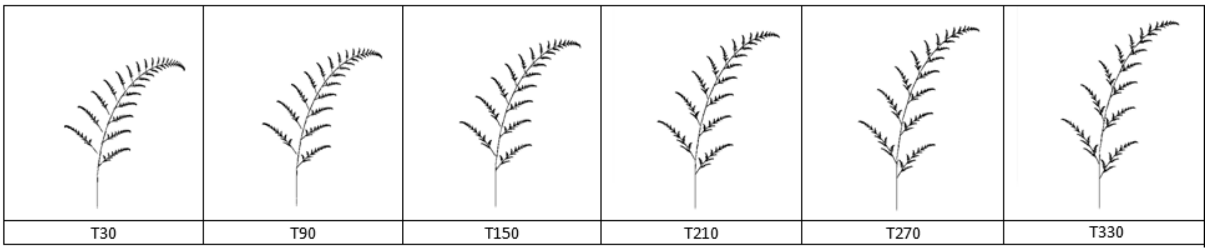

Figure 2. Metamorphic animation on fern fractals from type-1 to type-2 (shows a growing effect)

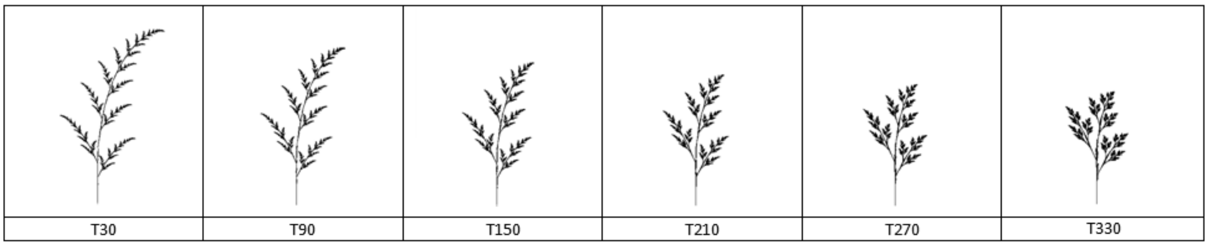

Figure 3. Metamorphic animation from fern (type-2) to tree (type-1) fractal (shows a mutation effect)

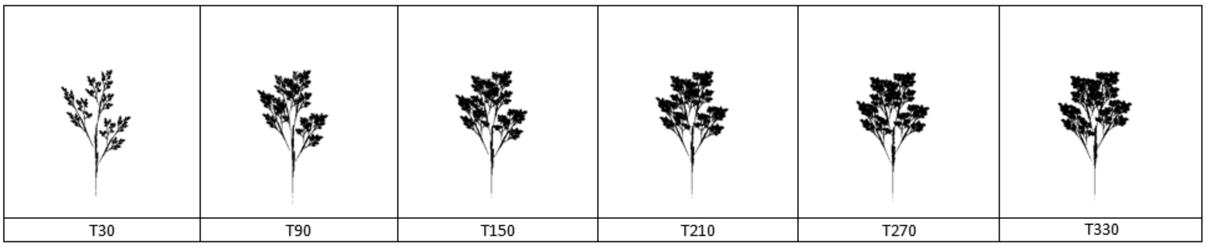

Figure 4. Metamorphic animation of two tree fractals from (1) to (2) (shows an extension effect)

5. FUTURE WORK

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

6. CONCLUSIONS

The selection of the IFS code sets in a family that have been normalized can make the transitional images of metamorphic animation of fractal images are looked natural or the appearance of those images are in between the appearance of the source and the target images, otherwise are not.

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 iteration algorithm.

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