ANIMATING CYCLING EVENT SIMULATION BY IFS FRACTAL MODEL

Based on Cloning and Scaling Techniques

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ABSTRACT

There is a tricky way to animate rotational effect of two different fractal objects as parts of a single multi-object of fractal. From the multi-object point of view, both the individual events are looked like as a single simultaneous event such as in the rotational simulation of two rotating wheels as the front and rear wheels and a rotated wheel of the pedal wheel in a bicycle. The above rotational effect can be created by metamorphic animation methods on the fractal object which has IFS code in rotational IFS code family. The identical but differ in position object can be constructed by means of cloning technique and the identical but differ in size and position can be constructed by means of the cloning and scaling techniques. To accomplish the simulation of cycling event of a bicycle in the fractal model, a combination method between metamorphic animation on multi-object and object is proposed.

Keywords: IFS fractal animation model, rotational IFS code, cloning and scaling techniques, metamorphic animation, multi-object

1. INTRODUCTION

The Fractal animation model has advantages over the non-fractal model. One of the advantages is the animation algorithm in fractal animation model is more simple than in the traditional way, so the hybrid of non-metamorphic and metamorphic animation can be realized with the same algorithm. The only difference is there is the coefficient interpolation of IFS code set in the metamorphic animation, but not in the non-metamorphic animation. The other advantage of fractal model which is relevant to this topic is the ability to create a synchronization among each rotation effect in objects as part of a single multi-object, so it looked like as rotation of a new object by means of metamorphic animation method on IFS fractal objects which have IFS code sets in a family of rotational IFS code. The above new method is completely different from rotational operation used in reference [14]. The use of multi-object of fractal in a fractal animation model is already accomplished by and described in reference [12,13]. A special effect such as the weaving effect of tree-like fractal which will be used in this paper as a windy effect can be realized partially or totally by means of metamorphic animation method as described in reference [15]. This paper is the expansion research of the previous research [17].

2. FRACTAL MODELS

Fractal

Fractal as a new terminology is proposed for the first time by the father of fractal, named Mandelbrot [2] and as an honor to his contribution, his name became and cannot be separated from the name of the famous fractal set, the Mandelbrot set beside the other famous fractal set, the Julia set in the early time of the emerging fractals as a new field of science especially in mathematics and computer science. In general, there are at least two major fractal models are emerged as the applicative models, i.e. the L-system fractal model and the IFS fractal model, as described in the next subsections.

L-System Fractal

The other applicative fractal model is the L-system which is introduced for the first time by Lindenmayer, so the letter-‘L’ can be interrelated as the initial name of him. The L-system model is most suitable to model and reconstruct plant-like objects governed by turtle-like rules iteratively in such a way so the appearance of plant-like objects becomes natural [5].

IFS Fractal

The IFS code model is the fractal model which is proposed for the first time by Barnsley and Demko [3] based on the self-similarity property proposed by Hutchinson, [1] and is becoming popular when in his book entitled: “Fractals Everywhere”, Barnsley modeled the famous fern fractal [6]. Basically, the 2D IFS fractal model is based on the affine transformation function which is self-contractive, so is called as the self-affine function. The 2D self-affine function has six coefficients (**a, b, c, d, e,** and **f**) and can be expressed as the combination of a matrix and a vector in mathematical expression as described by Equation (1) as follow.

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

The coefficients in IFS code set as expressed in Equation (1) above are the affine transformation coefficients that can be classified into two kinds of transformation, the linear and the rotational transformations as described in the next section. The linear transformation is needed such as in animation of the bicycle to move forward while the front and rear wheels rotating by means of metamorphic animation on multi-object which are explained later in the next section. The linear transformation actually consists of a collection of several primitive functions, such as move in X and Y-directions (2D), zoom-in and zoom-out (scaled up and down) and mirror relative to the X, and Y. In this paper, only the move functions are explained in the subsections inside of the next section.

3. AFFINE TRANSFORMATION AND COLLAGE THEOREM

Linear Transformation

By moving fractal object in **X**-direction by a unit distance **dx**,the new coefficient-**e’** and **f’** of the 2D IFS code are recalculated iteratively based on the new coefficient-**a’** and **c’** which depend on the previous coefficient-**a** and **c** as described in equation (2.a) to (2.d) as follow [4,16].

$$a = 1.0 - a * dx \quad (2.a)$$
$$c' = c * dx \quad (2.b)$$
$$e' = e + (1.0 - a * dx) \quad (2.c)$$
$$f' = f - c * dx \quad (2.d)$$

By moving fractal object in **Y-**direction by a unit distance **dy**, the new coefficient-**e’** and **f’** of the 2D IFS code are recalculated iteratively based on the new coefficient-**b’** and **d’** which depend on the previous coefficient-**b** and **d** as described in equation (3.a) to (3.d) as follow [4,16].

$$b' = b * dy \quad (3.a)$$
$$d' = 1.0 - d * dy \quad (3.b)$$
$$e' = e - b * dy \quad (3.c)$$
$$f' = f + (1.0 - d * dy) \quad (3.d)$$

Moving procedure in X-direction will be used to animate bicycle moving forward as explained above and in the corresponding section below for more detail.

Linear Deformational Transformation

To have the size fractal object is changed horizontally (in X direction), or vertically (in Y direction) or both can be achieved by applying the deformational transformation procedure. There are two kinds of linear deformational transformation procedure, the dilation or contraction in X-direction and the dilation or contraction in Y-direction as described in the six equations: (4.a) to (4.c) for dilation in X-direction and (5.a) to (5.c) for dilation in Y-direction [16].

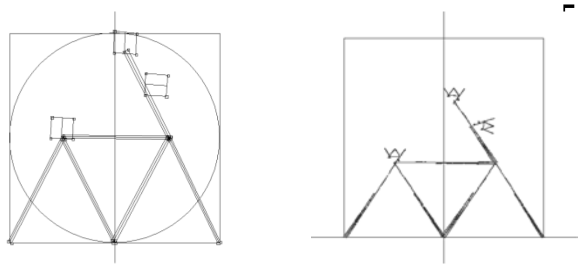
$$b' = b * (1.0 - df) \quad (4.a)$$
$$c' = c \,/\, (1.0 - df) \quad (4.b)$$
$$e' = e * (1.0 - df) \quad (4.c)$$

$$b' = b \,/\, (1.0 - df) \quad (5.a)$$
$$c' = c * (1.0 - df) \quad (5.b)$$
$$f' = f * (1.0 - df) \quad (5.c)$$

The dilation procedure in Y-direction will be used in preparing frame-like of bicycle as illustrated in Figure-1 (b) at the next section.

Collage Theorem

The collage theorem is explained concisely by Barnsley and with the self-similarity property of fractal are became the foundation of the IFS model [6]. The best way to explain what is collage theorem is by giving an example such as illustrated in Figure-1(a) and (b), which will be used in the simulation. Each region in collage layout is as part of and resembles the form of the whole, the correlated IFS code set is displayed in Table-1.There are nine affine functions with probability factor represented by rows. The first six rows represent the six rods of the bicycle frame.The last three rows represent the front lamp of bicycle which has 90 degrees counter clockwisely different orientation from the orientation of object as a whole and two other parts of bicycle which are the vertically mirrored version of the orientation of object as a whole.



(a) 9 regions of collage layout of (b)

(b) bicycle frame-like fractal (After dilation in Y-direction)

Figure 1. Implementation example of collage theorem

TABLE-1 IFS CODE OF BICYCLE FRAME-LIKE AS AN EXAMPLE

a	b	c	d	e	f	p
0.01	0.330	0.0	0.494	0.0	0.0	0.12
0.018	-0.35	0.009	0.498	0.0	0.0	0.12
0.014	-0.33	0.007	0.498	-0.49	0.0	0.12
0.012	0.316	0.0	0.497	0.5	0.001	0.12
0.0	0.670	-0.01	0.006	0.26	-0.37	0.12
0.018	0.276	0.0	0.410	0.26	-0.37	0.12
0.106	0.002	0.009	-0.10	0.051	-0.75	0.08
0.104	0.007	0.004	-0.1	-0.24	-0.44	0.08
0.007	0.135	-0.07	0.005	0.252	-0.56	0.

4. RELATED WORKS

Through the work on the fractal-based algorithm for metamorphic animation that is studied by Chen et.al [7], the size of objects can be measured, for which the traditional way based on Euclidean geometry is failed. An image morphing based on pixel transformation approach that is proposed by Rahman et.al [8] depict the transformation of pixels with their neighborhoods; this method is organized with the replacement of the pixel values of a source image and convolving the neighbor with the help of a mask that is fast and efficient for image morphing. In their paper, Zhuang et.al [9] studied a morphing IFS fractal by calculating local attractor's coarse convex-hull and selecting rotation matching between IFS's. The morphing procedure of two IFS's fractal attractors is done by interpolating the parameters of the iterated function. Normally morphing animation is dealing with two different objects as the start and target objects, but if the morphing animation is dealing with more than two different objects, a new approach is needed such as the method which is based on a family of multi-transitional IFS code approach [10,11].

To generate multi-object of fractal, the partitioned-random iteration algorithm can be used, so the density of pixels population in an individual object as the part of multi-object can be controlled [12,13]. The hybrid animation model based on the metamorphic interpolation model and partitioned-random iteration algorithm model recently has been proposed to simulate the complicated multi-object of fractal [13].

5. TECHNIQUES

Two things need to be discussed in this section, as ready mentioned in the previous section, the new isualization techniques of the individual objects are eeded to create a single multi-object of fractal that onsists of the same form of certain objects as the part f its component.

Cloning Technique

To make the visualization process of fractal objects as the components of a single multi-object in efficient fashion, there is a tricky technique to be proposed called cloning technique. This kind of technique can be accomplished by redrawn the calculated position of an object as the original object to the new position of the second object as a duplication object at any certain distances from the position of the first one pixel by pixel.

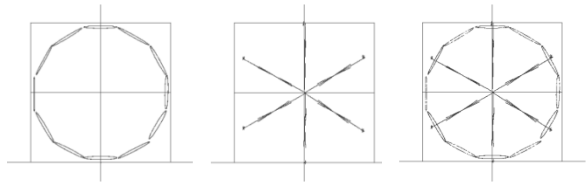
Cloning and Scaling Technique

For duplicating an object as a component of a single multi-object which is different in size and position from the original object as another component of the same multi-object, there is also a simple technique to be proposed by modifying the cloning technique as already explained above. The only modification is the size of the duplication object is changed by simply multiplied by a scaling factor.

To prepare the simulation of metamorphic animation which will be explained in the next section, both techniques are applied to produce a cycling event of bicycle-like fractal from left to right repeatedly as a continuous cycle. To simplify the appearance of bicycle-like fractal, there are at least four fractal objects as the components, the front and rear wheels with the same size as the first two objects, the pedal wheel in the middle is the third object and the frame of the bicycle is the last object. Actually, the wheels can be represented by two kinds of fractal objects, the circle-like and star-like objects. The rear wheel can be redrawn from the front wheel or vice versa by means of the cloning technique and to the new position and the pedal wheel can be redrawn from the front or rear wheel by means of the cloning and scaling technique with the new size and to the new position.

6. ANIMATION

The two objects, circle-like and star like objects are needed to be composed as a wheel-like as illustrated in Figure-2 (a), (b) and (c). The corresponding IFS code sets are displayed in Table-2 and 3.



a. Circle-like b. Star-like c. Wheel-like (a+b)

Figure 2. Composing wheel-like from circle-like and star-like fractals

By composing the front and rear wheels, pedal wheel (Figure-2) and frame of the bicycle (Figure-1) as part of a single multi-object of the bicycle, the new bicycle-like fractal can be created as illustrated in Figure-3. To have the background of cycling event, two types of tree-like fractal object is used as illustrated in Figure-4 (a) and (b), and the corresponding IFS code set is displayed in Table-4 and 5.

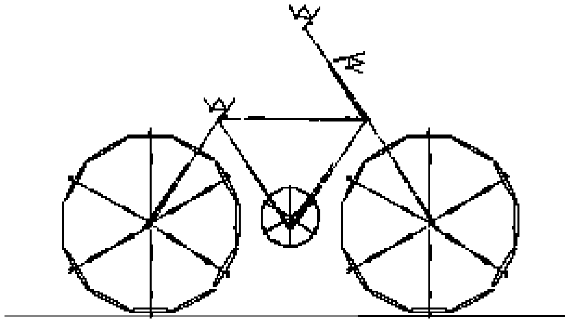


Figure 3. Multi-object of fractal as a bicycle object

a. Tree-like type-1 b. Tree-like type-2

Figure 4. Two types of tree-like fractal objects as a background

The background object is the interpolation image of the first and second tree-like objects created by metamorphic animation method on two IFS fractal objects.

TABLE-2 IFS CODE OF CIRCLE-LIKE FRACTAL

a	b	c	d	e	f	prob
0.244	0.0	0.0	0.026	0.0	-0.02	0.8
0.221	-0.01	0.115	0.018	-0.23	-0.08	0.8
0.133	-0.02	0.228	0.006	-0.41	-0.25	0.8
-0.00	-0.01	0.258	0.0	-0.48	-0.49	0.8
-0.12	-0.01	0.221	-0.01	-0.41	-0.74	0.8
-0.22	0.0	0.133	-0.02	-0.24	-0.91	0.8
-0.25	0.0	0.0	-0.018	0.0	-0.98	0.8
-0.23	0.016	-0.13	-0.01	0.245	-0.91	0.8
-0.12	0.024	-0.22	0.0	0.426	-0.73	0.8
0.006	0.024	-0.25	0.009	0.484	-0.5	0.8
0.126	0.019	-0.21	0.02	0.418	-0.26	0.8
0.231	0.006	-0.12	0.018	0.242	-0.08	0.8

TABLE-3 IFS CODE OF STAR-LIKE FRACTAL

a	**b**	**c**	**d**	**e**	**f**	**prob**
0.02	-0.01	0.0	0.502	0.0	0.001	0.14
0.015	-0.01	0.005	0.032	0.0	0.016	0.02
0.01	-0.43	0.018	0.244	-0.43	-0.25	0.14
0.012	-0.01	0.016	0.019	-0.44	-0.24	0.02
0.0	-0.44	0.012	-0.24	-0.43	-0.74	0.14
0.013	-0.01	0.012	0.019	-0.44	-0.74	0.02
-0.01	0.006	0.0	-0.5	0.009	-0.99	0.14
0.002	-0.01	0.024	0.014	-0.01	-0.99	0.02
-0.01	0.426	-0.02	-0.25	0.428	-0.75	0.14
0.014	-0.01	0.02	0.018	0.418	-0.75	0.02
0.010	0.418	-0.02	0.27	0.420	-0.23	0.14
0.014	-0.01	0.017	0.022	0.414	-0.22	0.02

TABLE-4 IFS CODE OF TREE-LIKE FRACTAL TYPE-1

a	**b**	**c**	**d**	**e**	**f**	**prob**
0.036	0.002	0.0	0.197	0.007	0.0	0.08
0.022	0.108	-0.02	0.196	0.009	-0.2	0.09
0.02	-0.20	0.018	0.218	-0.04	-0.27	0.03
0.022	0.044	-0.01	0.146	0.053	-0.36	0.06
0.592	0.106	-0.2	0.402	-0.1	-0.39	0.23
-0.50	-0.10	-0.20	0.349	0.146	-0.45	0.20
-0.69	0.01	0.002	0.496	0.0	-0.49	0.[illegible]

TABLE-5 IFS CODE OF TREE-LIKE FRACTAL TYPE-2

a	**b**	**c**	**d**	**e**	**f**	**prob**
0.032	0.003	-0.00	0.197	0.003	0.0	0.08
0.028	0.097	-0.01	0.199	0.001	-0.2	0.09
0.018	-0.21	0.012	0.216	-0.05	-0.27	0.03
0.023	0.05	-0.01	0.136	0.057	-0.37	0.06
0.600	0.044	-0.09	0.382	-0.1	-0.39	0.23
-0.48	-0.14	-0.45	0.342	0.140	-0.48	0.20
-0.70	-0.03	-0.03	0.478	0.005	-0.48	0.27

7. SIMULATION

There are two kinds of animation method used in the simulation of cycling event animation, which is combining the metamorphic animation method on an object and the metamorphic animation method on multi-object. The metamorphic animation method on object as the first animation method is used for exhibiting the gradual changes from tree-like fractal type-1 form as a source into the tree-like fractal type-2 form as a target.

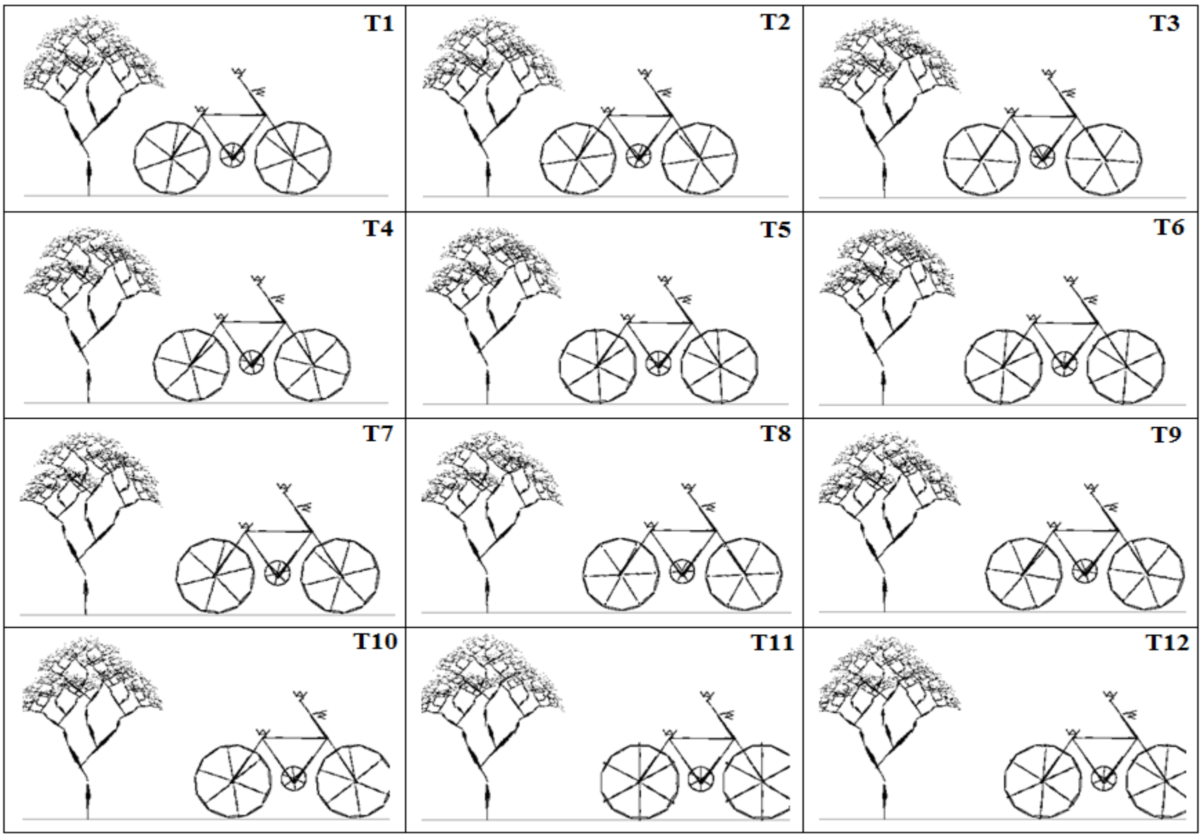


Figure 5. Sequence of images of cycling event as the combined result of metamorphic animation on multi-object and object

The metamorphic animation on multi-object method as the second animation method is used for exhibiting the rotational effect on three wheels, the front and rear wheels and the pedal wheel in the middle which have the same rotational speed by means of cloning and scaling techniques as described in the previous section. The interpolation images as the result of metamorphic animation combination of the tree-like fractal as an object and bicycle fractal as a multi-object can be seen in Figure-5. The movement of bicycle to the right while the wheels are rotating gradually also can be observed in Figure-5.

8. CONCLUSION

By applying cloning technique, one or many duplicated multi-object fractal can be reconstructed efficiently with the same rotational speed and the same size from a single set of multi-object of fractal, such as the front or rear wheel of the bicycle as the duplication of the other that consist of two different objects, the circle-like and star-like fractal objects.

By applying cloning and scaling techniques, one or many multi-object fractals can be reconstructed efficiently with the same rotational speed but with the different size from a single set of multi-object of fractal, such as the pedal wheel of bicycle as the modified duplication of the front or rear wheel that consist of two different objects as mentioned in the first conclusion above

By synchronizing the movement of two or more components of multi-object vertically or horizontally, such as the movement of the frame and the wheels of the bicycle to the right, the animation of moving bicycle can be realized.

By combining two different metamorphic animation methods between the metamorphic animation on an object and on multi-object, an attractive animation of an event can be accomplished, such as the combination of two different events, cycling event at the front and the windy effect event of the tree at the background as a single integrated event.

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