Zooming and Rotational Effects of Metamorphic Animation On Circle-like Fractal Image based on Multi-transitional IFS Code

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ABSTRACT
The metamorphic technology is very important to make an animation exhibits the gradually changes from the source image into the target images. If the source and target image that represent the same circle-like fractal object are slightly different, then the metamorphic animation can exhibits the rotational and zooming effects. If the order of functions in the 2D IFS code of circle-like fractal as a node in the multi-transitional IFS code differ compared to the next node by shifting one function, then the rotational effect is occurred. But if the order of functions in the 2D IFS code of circle-like fractal as a node in the multi-transitional IFS code differ compared to the next node by shifting more than one function, then the rotational and zooming effects are occurred.

Categories and Subject Descriptors
I.3.7. Fractals

General terms
Experimentations

Keywords
Zooming and rotational effects, metamorphic animation, circle-like fractal, multi-transitional IFS code

1. INTRODUCTION
In this paper, the metamorphic animation of circle-like fractal is presented. Usually rotational animation around a center as a fix point can be done by executing a rotational component of Affine transformation. A circle-like fractal object can be constructed from a number of transformation functions at least eight functions. To have the rotational effect of the circle-like fractals object is not only obtained by the rotational component of transformation process, but also it can be obtained by metamorphic animation of multi-transitional IFS code [15] base on round robin-like scheduling to alter the order of transformation functions from one node to the next node of multi-transitional IFS code in circular way. The drawback of rotational animation through the rotational component of transformation process is the IFS code of fractal object should be normalized so the center of the object is a fix point. In the other hand the rotational effect through the metamorphic animation mentioned above does not depend on the IFS code whether is already normalized or not. Interestingly there is also discovered a zooming effect, if the order of transformation functions is changed not by a single function at a time, but by every power of two and the power can be increased, so the number of functions is decreased until only a pair of transformation function as an extreme condition is left. This paper consists of eight sections, there is an introductory section at the beginning and there are acknowledgements and references sections at the end. In the middle there are five other sections, those are Related Works, Fractal and IFS Code, Simulations, Future Work, and Conclusions sections.

2. RELATED WORKS
There are many fractal studies which are conducted since 1980's; some of the fractal studies are dealing with IFS fractal. What is fractal and what is IFS will be explained later in the next section. 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. 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. Barnsley and Hutchinson [6] 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 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. 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. In their paper, Zhang and Liu [9] 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. 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.

3. FRACTALS AND IFS CODE

3.1. Fractal

Fractals object that has fractional dimension is studied for the first time by Mandelbrot [11] as the father of fractals. The fractal geometry that can represent many amorphous or formless objects in the nature is the extent of the ordinary geometry. The enlargement part of a fractal object exhibits the similarity of the whole fractal object, because the fractal object has the self-similarity property iteratively in the way of enlargement [12].

3.2. 2D 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 [13][14] is the set of the affine transformation of each contractive function that according to the collage theorem and the self-similarity property can be decoded to be a fractal image. The 2D IFS code, mathematically can be represented by the affine transformation equation with the '**a**', '**b**', '**c**', '**d**', '**e**' and '**f**' as the coefficients of an affine transformation function as displayed below:

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

Figure 1. Affine transformation equation

3.3. Circle-like Fractals

The circle-like fractals can be built by at least eight affine transformation functions. In this paper, the 16 affine transformation functions of 2D IFS circle-like fractal is used as described in the table-1 below, that has the centric at a fix point (0, 0) and has the radius of 1.0. The thickness of circle-like object is around a half of the radius that can be seen in figure 2 and 3 below. There are 16 holes around the circle-like fractal that cannot be full covered by the 16 contractive functions around

Table-1: Circle-like fractal

16 functions of 2D IFS code of circle-like fractal						
a	b	c	d	e	f	p
0.371	0.094	-.150	0.232	0.375	0.927	0,6
0.283	0.177	-.283	0.177	0.707	0.707	0,6
0.156	0.230	-.368	0.098	0.921	0.391	0,6
0.000	0.250	-.400	0.000	1.000	0.000	0,6
-.150	0.232	-.371	-.094	0.927	-.375	0,6
-.283	0.177	-.283	-.177	0.707	-.707	0,6
-.368	0.098	-.156	-.230	0.391	-.921	0,6
-.400	0.000	0.000	-.250	0.000	-1.000	0,6
-.371	-.094	0.150	-.232	-.375	-.927	0,6
-.283	-.177	0.283	-.177	-.707	-.707	0,6
-.156	-.230	0.368	-.098	-.921	-.391	0,6
0.000	-.250	0.400	0.000	-1.000	0.000	0,6
0.150	-.232	0.371	0.094	-.927	0.375	0,6
0.283	-.177	0.283	0.177	-.707	0.707	0,6
0.368	-.098	0.156	0.230	-.391	0.921	0,6
0.400	0.000	0.000	0.250	0.000	1.000	0,6

3.4. Round Robin-like Schedule

The duplications of 2D IFS code of circle-like fractal can be made by copying the original one to the other 15 duplications of it for the 16 functions version, or to the other 7 duplications of it for the 8 functions version, etc. To make the duplications of 2D IFS are slightly different from the original one, shift the first affine function to be the last affine function in a set of 2D IFS code for the 16 functions version or shift the first and second affine functions to be the last and last one affine functions in a set of 2D IFS code for the 8 functions version as can be seen in the table-2 below as an illustration, etc. The other version is the 5 functions version (every 3 functions is shifted, except the last function). The way of shifting a fix number of functions is like the round robin scheduling.

Table-2 : Comparison of coefficient-‘a’ of eight multi-transitional IFS code of circle-like fractal with the different for every 2 functions

Coefficient-‘a’ of eight transitional 2D IFS code of circle-like fractal images							
a1	a2	a3	a4	a5	a6	a7	a8
0.371	0.368	0.150	-.156	-.371	-.368	-.150	0.156
0.283	0.400	0.283	0.000	-.283	-.400	-.283	0.000
0.156	**0.371**	0.368	0.150	-.156	-.371	-.368	-.150
0.000	0.283	0.400	0.283	0.000	-.283	-.400	-.283
-.150	0.156	**0.371**	0.368	0.150	-.156	-.371	-.368
-.283	0.000	0.283	0.400	0.283	0.000	-.283	-.400
-.368	-.150	0.156	**0.371**	0.368	0.150	-.156	-.371
-.400	-.283	0.000	0.283	0.400	0.283	0.000	-.283
-.371	-.368	-.150	0.156	**0.371**	0.368	0.150	-.156
-.283	-.400	-.283	0.000	0.283	0.400	0.283	0.000
-.156	-.371	-.368	-.150	0.156	**0.371**	0.368	0.150
0.000	-.283	-.400	-.283	0.000	0.283	0.400	0.283
0.150	-.156	-.371	-.368	-.150	0.156	**0.371**	0.368
0.283	0.000	-.283	-.400	-.283	0.000	0.283	0.400
0.368	0.150	-.156	-.371	-.368	-.150	0.156	**0.371**
0.400	0.283	0.000	-.283	-.400	-.283	0.000	0.283

3.5. Multi-transitional IFS Code

In general, the cyclical metamorphic animation of fractal images in between several pairs of the start and target IFS code that are different can be accomplished based on the multi-transitional IFS code in pair by means of the random iteration algorithm sequentially and cyclically [15]. In this paper, for each pair, the start and the target IFS code sets in the multi-transitional IFS code are the same, both represent the same circle-like object, but with the different in the order of affine transformation functions in each of IFS code set as a node as described in the previous section.

4. SIMULATIONS

There are two kinds of simulations conducted in this paper as a comparison example. The first simulation dealing with the metamorphic animation of the 16 transitional 2D IFS codes of circle-like fractal with different order of transformation functions for every a single function of each transitional node (the 16 functions version). The second simulation dealing with the metamorphic animation of transitional 2D IFS code of circle-like fractal with different order of transformation functions for every 3 functions of each transitional node (the 5 functions version) through the round robin-like schedule as described in the previous section. The first simulation exhibits a rotational effect and the second simulation exhibits a zooming effect as illustrated in figure-2 and figure-3 below. The rotational effect through metamorphic animation can be obtained from any kind of circle-like that has the centric not at a fixed point (0,0) as illustrated in figure-4 below. In the other hand, the rotation animation of the circle-like fractal that has the centric not at a fixed point (0,0) through the rotation component of affine transformation exhibits the revolution effect around a fix point (0,0) as illustrated in figure-5 below.

5. FUTURE WORK

For the related future work of this study, the research can be extended to study whether the zooming and rotational effects of metamorphic animation of circle-like fractal images based on the multi-transition 3D IFS code version are also occurred

6. CONCLUSIONS

To make the order of the transformation functions in the start of a transitional IFS code as a node slightly differs compared to the order of the transformation functions in the target of another transitional IFS code as the next node, the round robin-like schedule can be used based on shifting a fix number of functions from one node to the next nodes.

In general cyclical metamorphic animation of circle-like fractal images that generated by decoding the multi-transitional IFS code sets as nodes by means of the random iterated algorithm can exhibit the rotational effect with or without the zooming effect, depends on the shifting number of functions from one node to the next nodes.

The rotational effect of metamorphic animation on circle-like fractal does not depend on whether the 2D IFS code of circle-like fractal has the centric in a fixed point (0,0) or not

7. ACKNOWLEDGMENTS

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8. REFERENCES

[1] Chang, H.T., Chang, T.C., Wen, K.L.1999. Hierarchical fixed-point Searching Method for Resizing Binary Fractal Image with IFS Code Modification. *Image Processing International Conference 1999*

[2] Chu, Hsueh-Ting and Chen, Chaur-Chin. 2000. A Fast Algorithm for Generating Fractals. *Pattern Recognition 15th International Conference* 2000

[3] Zhang, Yi-Shun and Yang, Yang. 2001. Displaying IFS Attractor Based on Fixed Point. *Info-tech and Info-net International Conference 2001*

[4] Lai, Cheng-Ming, Lam, Kin-Man, Chan, Yuk-Hee, Siu, Wan-Chi. 2004. An Efficient Fractal-based Algorithm for Image Magnification. *Intelligent Multimedia, Video and Speech Processing International Symposium 2004*

[5] Chen, Chuan-Bo, Zheng, Yun-Pin, Sarem, Mudar. 2006. A Fractal-based Algorithm for the Metamorphic Animation. *Information and Communication Technologies International Conference 2006*

[6] Barnsley, M.F. and Hutchinson, J. 2006. New Methods in Fractal Imaging. *Computer Graphics, Imaging and Visualization International Conference 2006*

[7] Wang, Yan, Zeng, Lan-Ling, Qi, Yan. 2008. Golden Section in 3D Plants IFS Reconstruction. *Young Computer Scientists International Conference 2008*

[8] Fu, Chong and Chen, Ying. 2009. Study on Fractal Images Construction with Topology Invariance IFS Attractor. *Computer Science-technology and Applications International Forum 2009*

[9] Zhang, Huai-Qing and Liu, Min. 2009. Tree Growth Simulation Method Based on Improved IFS Algorithm. *Computational Intelligence and Software Engineering International Conference 2009*

[10] Zhuang, Yi-Xin, Xiong, Yue-Shan, Liu, Fa-Yau. 2011. IFS Fractal Morphing based on Coarse Convex-Hull. *Information Technology and Artificial Intelligence Conference IEEE Joint International 2011*

[11] Mandelbrot, Benoit B. 1982. The Fractal Geometry of Nature. W.H. Freeman and Company.

[12] Hutchinson, John E. 1979. Fractals Self-similarity. *Indiana University Mathematics Journal 30*

[13] Barnsley, M. F., and Demko, S. 1985. Iterated Function Systems and the Global Construction of Fractals. *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences, Vol. 399, No. 1817 (Jun. 8, 1985), pp. 243-275*

[14] Barnsley, Michael F. 1993. Fractals Everywhere. 2nd edition. Morgan Kaufmann,. Academic Press

[15] Darmanto, T., Suwardi, I.S., and Munir, R. 2012. Cyclical Metamorphic Animation of Fractal Images Based on a Family of Multi-transitional IFS Code Approach. *IEEE Conference on Control, Systems & Industrial Informatics 2012*

APPENDIX

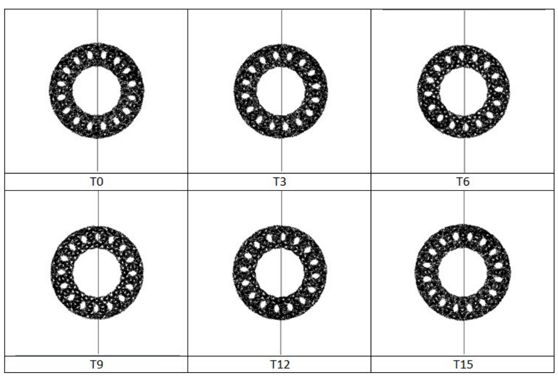

Figure-2. Sequence of metamorphic animation: exhibiting rotational effect

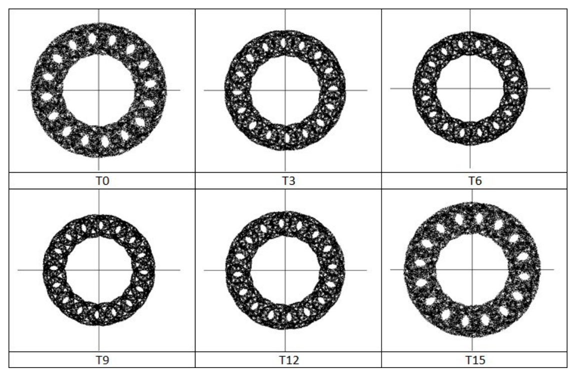

Figure-3. Sequence of metamorphic animation: exhibiting zooming effect

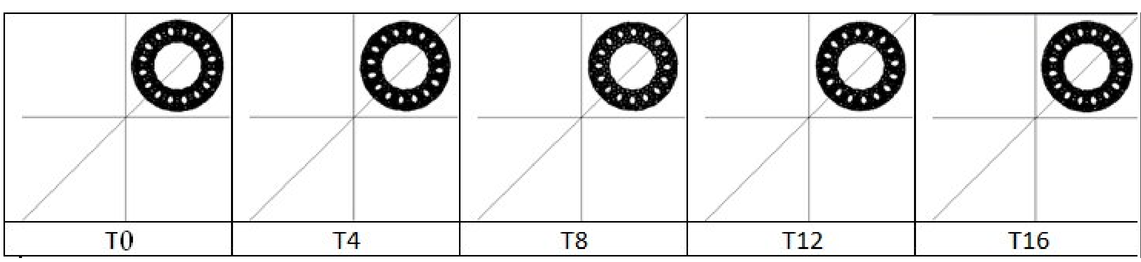

Figure-4. Sequence of metamorphic animation: Exhibiting rotational effect of shifted 2D IFS code of circle-like fractal

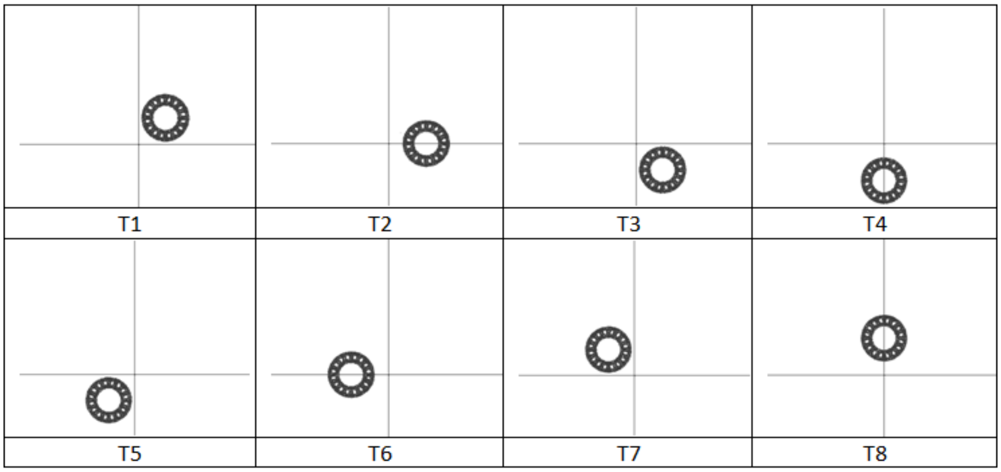

Figure-5. Sequence of rotation operation of shifted 2D IFS code of circle-like fractal around the centric (0,0) exhibiting revolutionary effect