

Calligraphic Design in Fractal Model Based on Rectangle Collage Decomposition

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Abstract

A fractal model can deliver the beauty of self-similarity feature to be used in designing artistic things such as calligraphic characters. The fractal model can deliver the power of mathematics to be used in modeling the complex things that can be handled by computer programs. This paper delivers the short-cut way to design the artistic calligraphic characters based on the modification of the existing form of the simple rectangle fractal object to construct the stroke form of the calligraphic character as the simple solution of the inverse problem. The upright collage component design of rectangle fractal object can be decomposed into many cells of collage component of a calligraphic character with equal size in the right position of the cells according to the stroke of calligraphic character designed. The short-cut way to encode the fractal object is by copy-editing the representative IFS code based on the position of the cells according to the position of each component of the stroke. The calligraphic characters in fractal form as the collection of IFS code set are the representation of the affine coefficient functions, so they can be easily modified by means of the affine transformation function to any desired form.

Keywords: calligraphic design, fractal model, collage decomposition, IFS (iterated function system) code



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INTRODUCTION

In their book entitled "The Colours of Infinity – The Beauty and Power of Fractals" edited by Gordon, N.L. featuring Clarke, A.C., Mandelbrot, B. and Stewart, I., there is a paper in the last chapter written by Clarke, A.C. that presents "The Colors of Infinity – the film script". There are so many small but fascinating color pictures presented and commented by the fractal's experts. In the preamble of the last chapter, there is a quotation quoted by Einstein. He says that "The most beautiful thing we can experience is the mysterious. It is the source of all true and science". All things presented in the paper are about the beauty and power of fractals especially the Julia set fractal in correlation with the Mandelbrot set fractal as the most famous fractal. (Gordon, N.L., 2010). In this paper, the calligraphic design in the fractal model can be generated by means of the IFS code modification of fractal rectangle object based on the rectangle collage decomposition, instead of by graphically composing collage in the fractal inverse problem. A calligraphic character can be designed as the collection of cells in grid composition. Each cell exhibits the structure of a whole calligraphic character in miniature fashion as the fractal self-similarity property as the beauty calligraphic appearance. The form of calligraphic character can be manipulated by means of affine transform functions, especially the shear and scale functions to create the desired designs. The number of cells is set according to the dimension of the calligraphic character designed.

LITERATURE REVIEW

There are two clusters of related work papers correlated with the topic of this paper. The first cluster is corresponding to the graphical calligraphic model topic and the second one is corresponding to the fractal design model and fractal pattern art topic.

Graphical Calligraphic Model

In this cluster at least there are eight papers picked to discussing on how to model graphical calligraphic design in general. Mash'al, M., and Sadri, J. proposed an evolutionary process of the Genetic algorithm to create the composition of calligraphic artwork that allows the user to create art without requiring any technical or artistic training (Mash'al, M., and Sadri, J., 2013). Pengcheng, G. and Jiangqin, W. presented an approach for the recognition of calligraphic characters using spectral hashing (SH) to dynamically reduce the whole training set. The experiments showed that their approach reduces the training time of the classifier but does not lower the accuracies of recognition much (Pengcheng, G. and Jiangqin, W., 2014). Yang, Y.C., et al. presented a new model for simulating a virtual Chinese hairbrush using Camshaft Curve, a novel analytic curve to define the shape of the brush stroke. The software developed based on this model can be used for creating Chinese calligraphic artwork (Yang, Y.C., et al., 2015). Du, X., et al. proposed a novel calligraphy synthesis framework that is designed to support the generation of calligraphic characters in a particular style based on relevant feedback and Bayes classifier (Du, X., et al., 2016). Murata, K., et al. used the utility of onomatopoeias and proposed a design supporting system of Japanese Kanji-calligraphic "Shodo" font using onomatopoeias utterance based on the correspondence between onomatopoeias and the scratched and blurred look (Murata, K., et al., 2016). Doshi, A.A., and Rout, B.K. developed and used a program manipulator to trace the vowels of the alphabet calligraphically with help of control points by describing the path. They claimed this work can bring the industrial manipulator one step closer to performing free form motion (Doshi, A.A., and Rout, B.K., 2018). Kobayashi, M., et al. used Leap Motion as a writing instrument to write something very similar to the handwriting of the actual writing brush. The questionnaire results of the texture of handwriting showed many people with respect to (Kobayashi, M., et al, 2018). Hu, Y., and Chen, M., by taking ultra-fractal software as an example the characteristics of Chinese Yi nationality's traditional pattern lacquerware as a calligraphic pattern can be generated by using the Klein transform algorithm through several iterations (Hu, Y., and Chen, M., 2019).

Fractal Design Model and Pattern Art

In the second cluster, many researchers proposed fractals as a new tool to model artistic things such as calligraphic art or graphics and pattern design in general. In this cluster, there are at least eleven papers picked. Kharbanda, M., and Bajaj, N. reviewed a survey of significant advances on fractal art in fashion design that can be used to generate unimaginable patterns by which the creativity of designers can be increased (Kharbanda, M., and Bajaj, N., 2013). Heidarpour, M., and Hoseini, M.S. proposed a novel application that produces art tile patterns using a genetic algorithm based on the fitness function as the basic construction criteria (Heidarpour, M., and Hoseini, M.S., 2015). Day, N. described how an experimental fractal image generation tool can be used to create a self-similar pattern that resembles Celtic art such as spiral patterns with scaled repeating images from initial simple geometric object iteratively based on the extended Hata-Hutchinson fractal image generation method (Day, N., 2016). Gang, L., et al. provided a brief introduction to the basic concepts of a fractal with emphasis on fractal unit design principle as a new language for design and its application (Gang, L., et al., 2017). Zhang, W., et al. presented a novel single-image super-resolution procedure by which input image up-scaled to the high-resolution image while preserving the textural and structural information (Zhang, Y., et al., 2018). Kwun, Y.C. provided escape criterion and generated fractals of the Julia and Mandelbrot sets via CR iteration scheme with s-convexity to inspire those who are interested in generating automatically aesthetic patterns (Kwun, Y.C. et al., 2019). Malishevsky, A. gave a survey on some of the applications of the fractal theory and analysis to study the geography of Kyiv and Ukraine graphically (Malishevsky, A., 2020). Xue, W.R. explored an innovative intelligent artistic creation way and absorb digital fractal image technology through the continuous exploration to realize the automatic art design by adopting neural style transfer algorithm to transfer the artistic elements of other excellent works to fractal graphics (Xue, W.R., 2020).

Chen, Z. investigated the design of ceramic tiles by Iteration Function System (Chen, Z., 2020). Darmanto, T. proposed the way to generate a set of artistic characters by means of the inverse problem method in a fractal model based on the composition of the collage components in the grid (Darmanto, T., 2021). Fang, L. analyzed the value and importance of art in the computer graphic design of the artists and proposed a solution to enhance their aesthetic level (Fang, L., 2021).

METHODOLOGY

Based on the beauty and power of fractals features as explained above, there is a realistic opportunity to design the calligraphic characters of Arabic in IFS fractal model that can be accomplished by decomposing the collage of rectangle object in IFS code form into any form of the calligraphic collage in its IFS code form as the collection of unique strokes.

Collage of Rectangle Object

To begin with and for the sake of easiness in designing, the initial collage of the rectangle object can be composed of four collage components in an upright position as can be seen in the figure-1. The position of each local centroid relative to the absolute centroid at a point $[0.0, 0.0]$ at the middle bottom of each collage component in the Cartesian coordinate also can be seen in figure-1 and those are used in designing the representative affine transform function of the components. Actually, there is another way to design a rectangle fractal object by just consists of two collage components but not in the upright position (Darmanto, T., 2016), so the generated IFS code is not simple to be copy-edited and why is not used in decomposing the code into the IFS code of the calligraphic character.

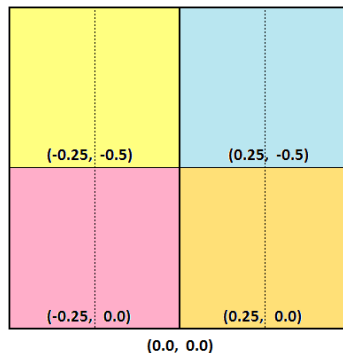


Figure 1. Fractal object of filled rectangles

In the iterated function system (IFS) fractal model, as the representation of the inverse problem result, the IFS code of rectangle object can be generated as can be seen in table-1. Each component is represented by a row in the IFS code that consists of six coefficients of the affine transformation and another coefficient as the probability factor. Coefficient-**a** represents the dimension in a horizontal direction determined by the horizontal component and the coefficient-**d** represents the dimension in a vertical direction determined by the vertical component, which is **0.5** for both coefficients. As long as there are no influents from vertical to horizontal and from horizontal to vertical directions, so the values of both coefficient-**b** and **c** are **zeroes** for all components. The coefficient-**e** and **f** as the representation of the position of local centroid in each component have the values as the same as the annotated local centroid in figure-1 for both horizontal and vertical coordinates accordingly. The IFS code of the rectangle object can be seen in table-1 with the same probability factor for each component.

Table 1. IFS Code of rectangle object

Cel l	Coefficient -a	Coefficient -b	Coefficient -c	Coefficient -d	Coefficient -e	Coefficient -f	Probabilit y
1	0.5	0.0	0.0	0.5	-0.25	-0.5	0.25
2	0.5	0.0	0.0	0.5	0.25	-0.5	0.25
3	0.5	0.0	0.0	0.5	-0.25	0.0	0.25
4	0.5	0.0	0.0	0.5	0.25	0.0	0.25

Calligraphic Design in Collage Component

In this paper, there are 8 calligraphic models are designed as examples grouped into two groups to represent two kinds of the Arabic calligraphic character. Each character consists of four models. Model-**A** to **D** for the first calligraphic character (“Allah”) as can be seen in figure-2, and model-**E** to **H** for the second calligraphic character (“Akbar”) as can be seen in figure-3. Each cell is represented by a number of columns and the number of rows consecutively in two digits, so the last row and column number-0 are used instead of 10. The column number represents the horizontal position and the row number represents the vertical position of the cells relative to the leftmost and topmost cell (11).

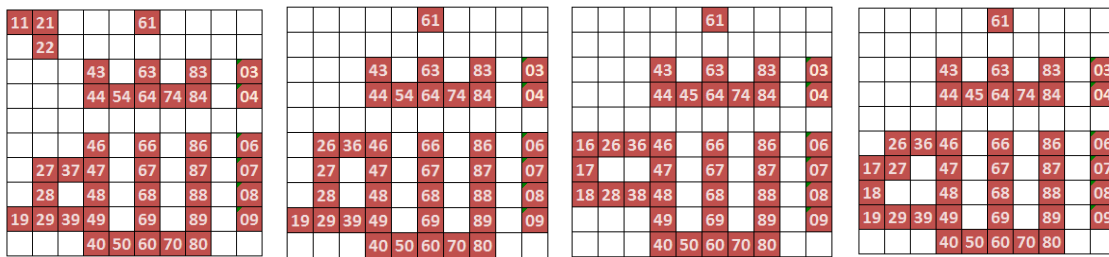


Figure 2. Collage design of Calligraphic-A, B, C and D (left to right)

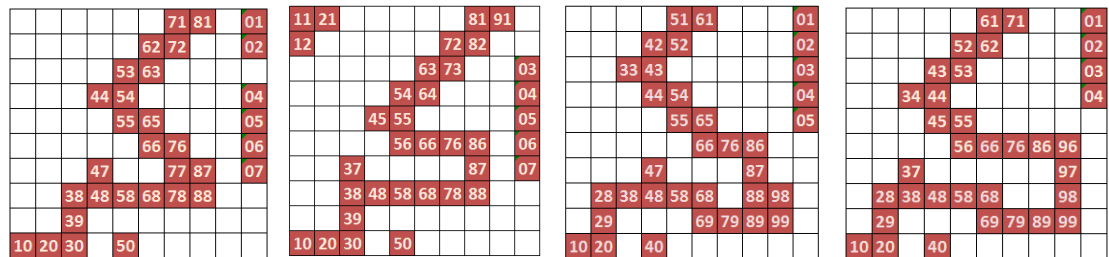


Figure 3. Collage design of Calligraphic-E, F, G and H (left to right)

IFS Code based on Equal Size of Collage Component

There are two kinds of stroke of character that can be generated by means of decomposing the collage of rectangle object, a stroke represented by four rows of the cell and another stroke represented by just one row of the cell as the result of merging the four rows of the first stroke type. To generate the IFS code of the stroke of the calligraphic character represented by four rows, the IFS code of rectangle fractal object (in table-1) is modified by editing the coefficient-**a** and **d** according to the dimension size of the collage component and the coefficient-**e** and **f** according to the local centroid position of each collage component. As an example, the first 12 rows of the IFS code set of calligraphic-**A** type-1 with 4 rows for each stroke are displayed in table-2. To generate IFS code of the stroke of the calligraphic character represented by a collage component, the IFS code of the type-1 of calligraphic-**A** (in table-2) is modified by editing the

coefficient-**a** and **d** according to the dimension size and the coefficient **e** and **f** according to the local centroid position of each new stroke. As an example, the first 3 rows of the IFS code set of calligraphic-**A** model-2 with one row for each stroke is displayed in table-3. As long as the collage component is an upright fashion, the values of the coefficient-**a** and **d** are equal to the size of the collage component which is **0.05** in table-2 and **0.1** in table-3 and the values of the coefficient-**b** and **c** are **zeroes**.

Table 2.

The first 12 rows of IFS code set (calligraphic-a model-1) with 4 rows for each cell, N = number of cells (4 rows for each cell)

Cel l	Coefficient -a	Coefficient -b	Coefficient -c	Coefficient -d	Coefficient -e	Coefficient -f	Probabilit y
11	0.05	0.0	0.0	0.05	-0.425	-0.9	1.0/4N
11	0.05	0.0	0.0	0.05	-0.425	-0.95	1.0/4N
11	0.05	0.0	0.0	0.05	-0.475	-0.9	1.0/4N
11	0.05	0.0	0.0	0.05	-0.475	-0.95	1.0/4N
21	0.05	0.0	0.0	0.05	-0.325	-0.9	1.0/4N
21	0.05	0.0	0.0	0.05	-0.325	-0.95	1.0/4N
21	0.05	0.0	0.0	0.05	-0.375	-0.9	1.0/4N
21	0.05	0.0	0.0	0.05	-0.375	-0.95	1.0/4N
22	0.05	0.0	0.0	0.05	-0.325	-0.8	1.0/4N
22	0.05	0.0	0.0	0.05	-0.325	-0.85	1.0/4N
22	0.05	0.0	0.0	0.05	-0.375	-0.8	1.0/4N
22	0.05	0.0	0.0	0.05	-0.375	-0.85	1.0/4N
...	0.05	0.0	0.0	0.05	1.0/4N

Table 3.

The first 3 rows of IFS code set (calligraphic-A model-2) with 1 row for each cell, N = number of cells

Cel l	Coefficient -a	Coefficient -b	Coefficient -c	Coefficient -d	Coefficient -e	Coefficient -f	Probabilit y
11	0.1	0.0	0.0	0.1	-0.45	-0.9	1.0/N
21	0.1	0.0	0.0	0.1	-0.35	-0.9	1.0/N
22	0.1	0.0	0.0	0.1	-0.35	-0.8	1.0/N
...	0.1	0.0	0.0	0.1	1.0/N

RESULT AND DISCUSSION

There are two types of strokes for each calligraphic character model in fractal form as the results. In general, the IFS code set of an object can be decoded by the random iteration algorithm and the IFS code set of multi-objects can be decoded by the partitioned-random iteration algorithm from each combination of the two or more representative IFS code sets (Darmanto, T., 2016). All of the IFS code sets are generated by decomposing the collage of the rectangle according to the dimension size and local centroid position of each stroke. In the first type, there are four duplicates of the self-similarity feature for each stroke and in the second type, there is only one self-similarity feature for each stroke. As the representative examples of the calligraphic fractal object, the model-**A** type-1 (left) and type-2 (right) are displayed in figure-4 and the model-**F** type-1 (left) and type-2 (right) are displayed in figure-5.

Monolithic Calligraphic Model

The monolithic calligraphic model which has only one type of stroke can be generated by the random iteration algorithm based on each IFS code set of calligraphic character. In figure-4 the calligraphic-A character for both types are displayed and in figure-5 the calligraphic-F character for both types is displayed. The type-1 with stroke in four duplicates of the self-similarity feature is displayed at the left side of each figure and the type-2 with stroke in single self-similarity feature is displayed at the right side of each figure.

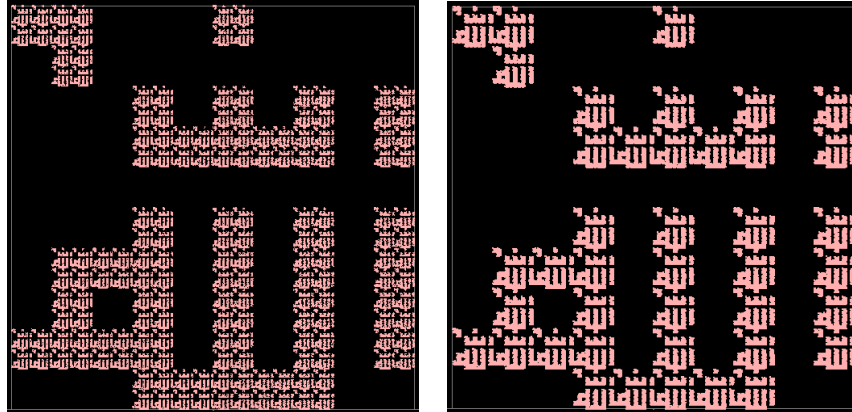


Figure 4. The fractal object of calligraphic-A in type-1 (left) and type-2 (right)

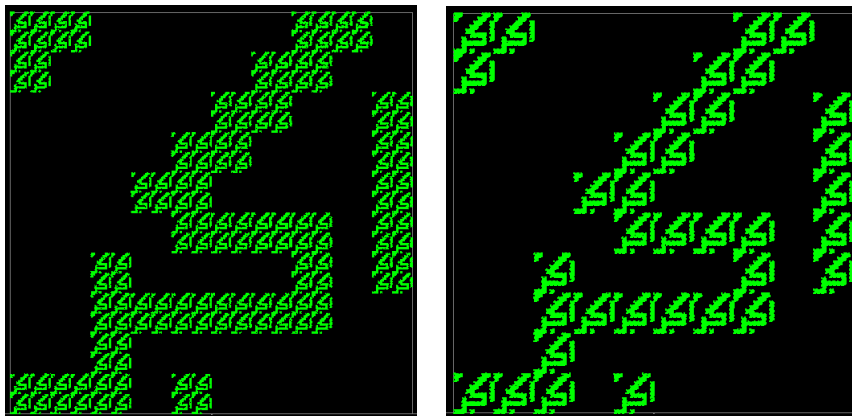


Figure 5. The fractal object of calligraphic-F in type-1 (left) and type-2 (right)

Multi-object of Calligraphic Model

The multi-object of a calligraphic model which has more than one type of stroke can be generated by the partitioned-random iteration algorithm based on each IFS code set for each calligraphic character. The combination of calligraphic characters of model-A and F for type-1 is displayed in figure-6 and for type-2 is displayed in figure-7. In the combination structure, each calligraphic character is still retained its characteristic of the stroke.



Figure 6. The fractal multi-object of the combination calligraphic A and F in type-1

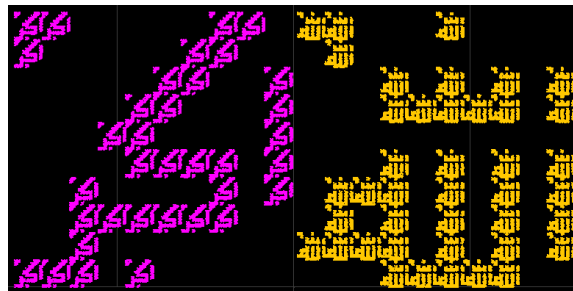


Figure 7. Fractal multi-object of the combination of calligraphic A and F in type-2

Freestyle Calligraphic Model

In the freestyle model, as long as the fractal multi-object has the feature of transformation affine functions, one character can be for example translated relative to the other character to have a more attractive appearance as represented by fractal multi-object in figure 8 as the combination of calligraphic character of model-**D** and **E** for type-2. The other two examples of freestyle calligraphic models are displayed in figure-9 and 10 respectively for the combination calligraphic character of model **B** and **G** and model **D** and **G** also for type-2. In figure-10 the form of both characters are deformed by the shear transformation in the horizontal direction to the right to form the italic style.



Figure 8. The fractal multi-object of the combination of calligraphic D and E in type-2

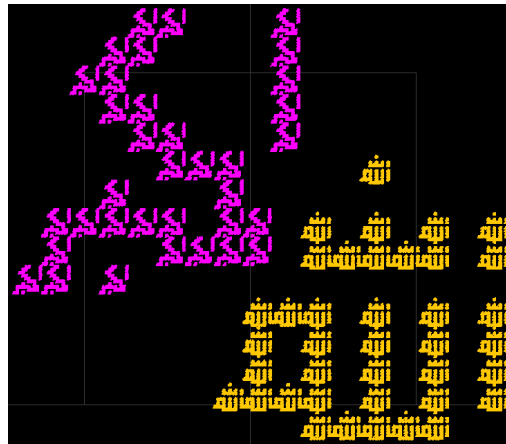


Figure 9. The fractal multi-object of aggregated calligraphic B-G in type-2

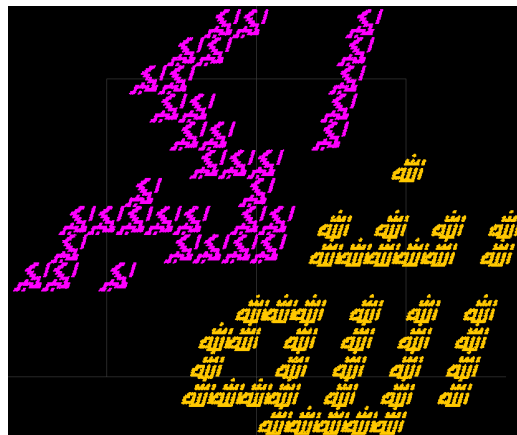


Figure 10. The fractal multi-object of aggregated calligraphic D-G in type-2 (italic style)

CONCLUSION

Based on two ways of designing the type of stroke, there are two types of stroke that exhibit self-similarity features in a more dense and “smooth” fashion that consists of four duplicates of self-similarity feature and another fashion in “strong” fashion that consists of only a single self-similarity feature. The combination of two calligraphic characters can exhibit the different appearance of the fractal self-similarity feature in freestyle and in a more attractive fashion, but the characteristic of the stroke in each character is still retained.

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