Design and Research of Plum-shaped Ceramic Tea Set Based on computer 3D Fractal Pattern

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Abstract. Traditional ceramic tea set enterprises old tea set design, single shape. Early research scholars have not established a systematic design method and process of ceramic tea set shape image. These factors have affected the healthy development of the ceramic tea set industry. With the arrival of the perceptual consumption era, the shape and image conveyed by the appearance of the ceramic tea set directly affects the user's perception of the ceramic tea set and becomes the key factor for people to buy the ceramic tea set. Based on computer 3D fractal model, this paper proposes and discusses the initial expression of the topological structure of plum blossom ceramic graphics based on fractal iteration and region iteration segmentation, and the iteration of the structure. Finally, the research results of this paper are applied to the making process of plum blossom ceramic pattern.

Keywords: Fractal, Plum-shaped Ceramic Pattern, Iteration, Composition Model, computer 3D Fractal Pattern

1. Introduction
As foreign research related to perceptual imagery has flowed into China, some domestic research institutes and universities in recent years have also begun to focus on related explorations of perceptual imagery theory. The research on ceramic tea set mainly focuses on tea set design, tea culture and historical evolution of tea set, innovative design theory of tea set shape, application research of different materials of tea set, and application of some principles to tea set. In addition to the basic function of tea drinking, the design of tea set should also meet the needs of users in pursuit of personalization, emotion, and diversity, in order to give users a sense of pleasure. Although there are many researches on perceptual imagery in other products, there are very few related researches on perceptual imagery specifically for ceramic tea sets, and there is no systematic research on the quantitative relationship between user's perceptual needs and the morphological design of ceramic tea sets.

Based on the theory of perceptual imagery, this paper uses a combination of qualitative and quantitative research methods to study the quantitative relationship between user's perceptual imagery and the morphological elements of ceramic tea sets. In order to facilitate the research, the examples and questionnaires are used to prove the teapot as the main body of the tea set, and the ceramic teapot as the main research object for perceptual image experiments. First, the morphological characteristics
of ceramic teapots were analyzed by morphological analysis, and the key characteristic factors that influenced the morphological design of ceramic teapots were summarized. Second, the Internet and related magazines and books were used to collect and screen the ceramic teapots. A plum-shaped ceramic tea set based on a graphic element and a fractal iterative rule as a pattern topology.

2. Plum-shaped Ceramic Tea Set Based on 3D Fractal Pattern

Since "tea is for drinking", tea sets have also emerged. Throughout the history of tea ware development, we can see that the design of tea wares has gone through the stages of simplicity, richness, and elegance, from large to small, rough to delicate, simple to complex, and back to utmost simplicity. With the rapid development of the economy and the improvement of people's living standards, the design of ceramic tea sets has continued to change. The ceramic tea set shapes studied in this paper are mainly the above tea set types.

The plum-shaped ceramic tea set based on 3D fractal pattern expresses the pattern (P) as a binary composed of the initial composition set (u for short) and the pattern topology (s for short) as follows:

\[ P = \{ U, S \} \] (1)

2.1. Topological structure of Fractal iterative pattern

Pattern topology s determines the organization and presentation of elements in a pattern. The topological structure s of the pattern consists of the affine transformation set w and the iterative mode F of the IFS system, which is denoted as follows:

\[ S = \{ W, f \} \] (2)

2.2. Affine transformation set W

The elements of affine transformation set w represent the transformation processing rules of graphic elements in the process of pattern fractal iterative composition.

\[ W = \{ w_1, w_2, \ldots, w_n \} \] (3)

The element w ( \( w \in W \) ) of the set w is referred to as code, \( w = \{ (a, b, c, d, e, f), p \} \), where P is the application probability of the code (it can be omitted under the assumption of equal probability). W plays a decisive role in the display position and the result of u in pattern P. In this paper, w (U) is used to represent this process.

3. Determination of research subjects of ceramic tea set image

With the advent of the experience economy, which is people-oriented, more attention is paid to whether the product meets the needs of users and whether the user experience is good. Today's Internet intelligence, sharing economy, and community economy all place great emphasis on user needs and experiences. For example, Didi Travel solves people's travel problems, provides convenience for people's travel, and wins users' love, OFO, Mobike and other shared bicycles solved the problem of people's last mile travel, shared charging treasures, shared umbrellas, etc. brought convenience to people's travel life, Meituan Takeaway and Baidu Takeaway solved people's inability to buy food and cook on time due to personal reasons such as work and laziness, these are redesigned according to the pain points people encounter in daily life to meet the needs of people's daily life, and truly start from the needs of people and from the comfort of people. The same is true for the design of ceramic tea sets. In order to meet the needs of the market and consumers, the designers of ceramic tea sets must better understand the customs and consumption needs of different nationalities, and start from the needs of people to design the shape, color, and quality of ceramic tea sets. Innovative design in various aspects such as texture, texture, and structure makes it suitable for different consumer groups and expands the scope of use of ceramic tea sets. As daily necessities for people, tea wares should not only have practical and economic functions, but also have artistic aesthetics. They should
know what kind of form and structure people prefer and use more comfortably. Therefore, the development trend of ceramic tea set design should be based on tea culture, while satisfying its tea drinking function, it should also meet the individual needs of consumers. No matter how innovative the shape of the tea set is, its design innovation concept must focus on the people-oriented design purpose, fully grasping the factors such as the shape, color, quality, function, aesthetics of the tea set, and design a man-machine, perfect proportion, and truly meet the user's emotional needs. Ceramics Tea set.

For example, as shown in a) in Figure 1, the design of the Buddha's tea set comes from the Lushena Buddha in the Longmen Grottoes wearing a full shoulder coat. The elements of the Lushena Buddha's pleat are integrated into the design of the whole tea set, as shown in B) in Figures 3-4. The figures show the pleat, as the DNA line of the Buddha's tea set, permeates each part of the whole set of tea set. The shape of teapot is taken as the main body, the curve aesthetic feeling of pleats, body shape and handle of the teapot are extended to the public pouring cup, teacup and tool pot, creating a unified shape, simple and meaningful, in series, so that one can tell that they belong to the same tea set at a glance, with a high degree of identification. The symbol set of the fractal pattern shown in Fig. 1 is (see Table 1).

![Figure1. Buddha's clothes tea set and feature extraction](image)

**Figure1.** Buddha's clothes tea set and feature extraction

| s1   | s2   | θ    | a    | b    | c    | d    | φ    | e (tx) | f (ty) |
|------|------|------|------|------|------|------|------|--------|--------|
| w1   | 0    | 0.3  | 0    | 0    | 0    | 0    | 0    | 1      | 0      |
| w2   | 51.42| 0.187| 0.782| -0.782| 0.187| 0.3  | 0.3  | 0.623  | 0.782  |
| w3   | 102.86| -0.067| 0.975| -0.975| -0.067| 0.187| 0.3  | 1      | 0.623  |
| w4   | 0.3  | 0.3  | 154.29| -0.270| 0.434| -0.434| -0.270| 154.29 | -0.901 | 0.434  |
| w5   | 205.71| -0.270| -0.434| 0.434| -0.270| 205.71| -0.901| -0.223 | -0.975 |
| w6   | 257.14| -0.067| -0.975| 0.975| -0.067| 257.14| -0.901| -0.223 | -0.975 |
| w7   | 308.58| 0.187| -0.782| 0.782| 0.187| 308.58| 0.623| -0.782 |

### 4. Continuity of the Fractal Pattern

In the fractal iterative composition of the plum-shaped ceramic pattern, the topological structure of the pattern is expressed by both the primitive affine transformation set \( w \) and the fractal superposition mode \( F \). Among them, \( w \) focuses on the transformation and composition rules of elements in an iteration process, while \( f \) describes the iterative operation rules of patterns. The elements of \( W \) feature certainty and variability. Determinacy means that once the elements of \( W \) are determined, even if different elements are selected for composition, the pattern generated by the algorithm still has the same structure, as shown in A-B in Figure 2. Variability indicates that the number of elements in \( W \) and the value of each symbol are variable. Through any change of the above variable factors, patterns of different structures can be generated (as shown in Figure 2).
Figure 2. Example of fractal pattern

There are various types of ceramic tea wares. In terms of the shape of the tea wares, the shapes are all composed of the most basic elements, namely points, lines, surfaces, bodies, and space, such as the configuration of the pot body, pot handles, spouts, pot lids, etc. and the coordination of proportions, the smooth transition of the outline structure of the pot body, the technical treatment of light and shade of the shape, the contrast between the space and the entity, etc. [48]. Elements such as points, lines, faces, bodies, and spaces can also be embodied as harmony between the entirety and part of each form, outside-in, and the connection, turning, and ups and downs of each part of the form. Mastering the characteristics of these tea set elements, understanding the constitutional rules and mutual relations of each shape element of the tea set, and combining the basic forms to form different shapes are very important for the design of ceramic tea sets.

5. Conclusions
Based on the research on the shape design of ceramic tea sets, this paper constructs a shape design method of ceramic tea sets based on the user's perceptual imagery. According to this design method flow, the teapot is determined as the main body of the tea set through demonstration and questionnaires, and the teapot is the research object. Morphological decomposition of ceramic teapots was performed by morphological analysis, and representative image factors were determined using semantic difference and factor analysis methods. Based on the quantitative theory, the correspondence between the user's perceptual images of ceramic teapots and the morphological elements of ceramic teapots was quantified. Finally, three ceramic tea sets were designed based on the design elements suggested by the experimental results to evaluate and verify the experimental results. Based on the theory of perceptual imagery, a qualitative and quantitative method was used to construct a form design method of ceramic tea sets for users' perceptual imagery. Process. The morphological analysis method was used to decompose the ceramic teapot from the front and top to construct a linear feature library of ceramic teapots. Through the investigation and literature reading of ceramic tea sets, a large number of perceptual words related to ceramic teapots and samples of ceramic teapots have been collected, and a perceptual vocabulary and sample library for ceramic teapots have been created.

Acknowledgement
This paper comes from a project "the Research of Fashion Accessories Design "(the number of the project is IFA-2019-01). It belongs to the key project of the Research Center of Fashion Arts, which is the Key Research Base for Humanities and Social Sciences in Hubei in 2019.

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