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Study on Traditional Flower Design Based on Genetic Algorithm Optimized by K-medoids Algorithm

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Abstract

With the continuous improvement of the economic level, people pay more and more attention to the appreciation of art. Art of flower arranging is an art following certain laws of creation and it has a long history. At present, the flower shape depends mainly on the arrangements' experience and personal preferences. This paper attempts to use genetic algorithm optimized by the K-medoids algorithm for its research, through the replacement of the genetic algorithm to get more design solutions, so as to broaden the designer's ideas, to achieve the innovation of art design. Experiments show that the beauty of floral works produced by the optimized genetic algorithm is better than that produced by traditional genetic algorithm.

Keywords*: K-medoids algorithm; genetic algorithm; traditional flower arrangement art*

1. Introduction

Floral art and design is a kind of art form utilizing the materials of flowers, including roots, leaves, seeds, fruit, branches, flowers and other fresh and dried floral materials and by different arrangements, different display method to show the different art, technology and natural beauty, as shown in Figure 1 [1]. Floral art and design has its unique charm. With the progress of social economy and rapid development of flower industry, flower arrangement art design has also been rapidly developed [2].

Figure 1. Floral Art

Floral arrangement works, in the aspect of visual sense, firstly need to immediately arouse a natural sense of view and emotion. if it fails to make immediate react, then the flower materials placed in front of the viewers will not be able to attract their attention [3]. In the flower arrangement works, the elements arouse the viewers' emotional reaction mainly consist of three part. The first one is a creation (or conception), referring to the theme expressed and corresponding selection of flower material; the second is the idea (or composition) [4]. That is how to skillfully configure the modeling of these flower

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materials so as to fully demonstrate their beauty in the work; the last one is the container [5]. That means the floral containers matched with the creation. These three organically coordinate promotes that the work gives people the enjoyment of beauty.

Now the flower shape and the sense of art is mainly handled down based on the long-term experience of works [6]. In order to realize the innovation of art design, the designer must open the train of thought, and try to excavate the creative inspiration. How to excavate the creative inspiration and make innovation become the key to art design. This paper attempts to use the genetic algorithm to study on it, through the replacement of the genetic algorithm to get more design solutions, so as to broaden the designer's ideas and eventually realize the innovation of art design.

2. Flower Clustering Method Based on K-medoids Algorithm and Genetic Algorithm

Floral art design is the process of selection and combination of various flowers. It is obviously that different flowers may bring different results. While some flowers are similar, as a result, the effect is similar. For these kinds of similar flowers, in the flower arrangement, choose one category as much as possible. Don't repeatedly choose. Therefore, it is necessary to have a division of the flowers. Cluster analysis is the process of dividing data set into a number of different categories by comparing the similarity between the data, requiring a higher similarity within a class of data while a low similarity of different types of data [7]. Similar or not similar metric is usually described by distance. Therefore, this article intends to use the method of combining genetic algorithm and k-medoids algorithm to do a clustering research on the original material of floral art and design -- flower, so as to distinguish different kinds of flowers.

2.1. Feature Extraction and Evaluation of Flowers

Clustering is to group data into multiple clusters. In the same class, there is a high degree of similarity between the same category, while objects in the different categories have an obvious difference.

Flowers are the reproductive organs of angiosperm to reproduce the offspring. The typical flower, in the short axis of a limited growth, produces the calyx, corolla and stamens and pistil of germ cells. A single complete flower consists of six basic parts, namely pedicel, receptacle, calyx, corolla, androecium and gynoecium, in which the pedicel and receptacle equivalent to the branch part, the other four parts equivalent to the branches of abnormal leaf, often referred to as the flower parts. A single flowers with the complete four parts is called complete flower. If any one of the parts is lacked, then it is called incomplete flower.

According to the above description and the actual needs of the arrangement, this paper will select the following characteristics as the characteristic of the flower arrangement material-- flower.

(1) Pedicel. In floral art design, the pedicel is an important component. Pedicels have different lengths, diameters and colors, which constitute the main features of the pedicel.

(2) Leaves. Floral leaves are the important part playing the role of foiling, which will be usually seen in the art of flower arranging. Leaf length, width, color, and quantity constitute the important characteristics of leaves.

(3) Flower parts. Calyx, corolla, stamen and pistil, these four parts constitute the complete flower, which can be evaluated from floral size and color.

According to the above introduction, the characteristics and evaluation are listed in table 1.

Table 1. Characteristics and Evaluation of Flowers

Characteristics	Evaluation Criterion	Evaluation Score
Pedicel length	From short to long	1~10
Pedicel diameter	From thin to thick	1~10
Pedicel color	From light to dark	1~10
Leaves length	From short to long	1~10
Leaves width	From narrow to wide	1~10
Leaves color	From light to dark	1~10
Leaves quantity	From little to many	1~10
Size of flower parts	From small to large	1~10
Color of flower parts	From light to dark	1~10

2.2. Flower Clustering Method of Genetic Algorithm Based on K-medoids Algorithm Optimization

The basic idea of k-medoids method is mainly randomly selecting a data on behalf of a class of data, then it is possible to find K cluster centers from the N clustering data, for which repeated cycle is necessary. According to the distance from the cluster center, other objects are respectively classified into the corresponding categories based on the principle of the minimum distance. If replacing a clustering center can get a better clustering results, it proves that the new clustering center is better, and then it can replace the original clustering center. Whether the clustering quality is good or not will be evaluated by the use of a cost function, which can represent the size of the distance from the various data to the clustering center. At present, whether a cluster center (medoids) Oj can be replaced by a non cluster center Orandom or not can be got by checking non cluster center T based on the following 4 kinds of situations, as shown in Figure 2.

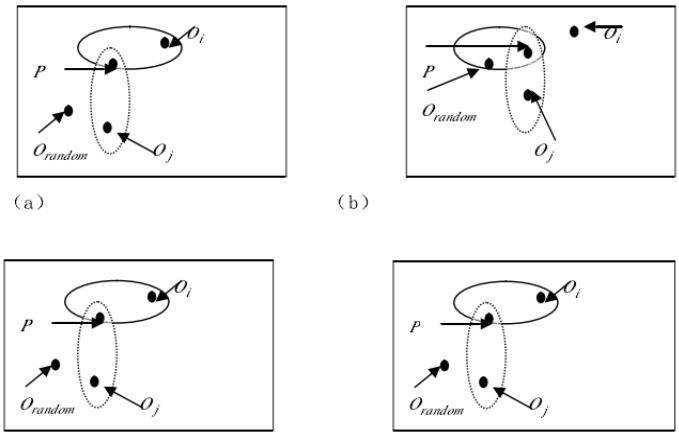

Figure 2. Schematic Diagram of Clustering Process of K-medoids Algorithm

Figure 2 is a schematic description of the 4 cases of the above k-medoids clustering algorithm. The variance E consisting of the cost function will be changed because of the classification of the data objects. It can be seen that the cost function is mainly used to calculate the different variance brought about by the different cluster centers. The output of the cost function is generated by replacing the original and inappropriate cluster representative to make the distance variance change and accumulate. If the value R of the cost function is negative, it means the replacement is effective and Oj can be replaced by Orandom, which can reduce the actual variance E. Otherwise, it is considered that the current clustering center is appropriate that it is unnecessary to be transformed, so this cycle can keep unchangeable.

The processing flow of K-medoids algorithm is shown in Figure 3.

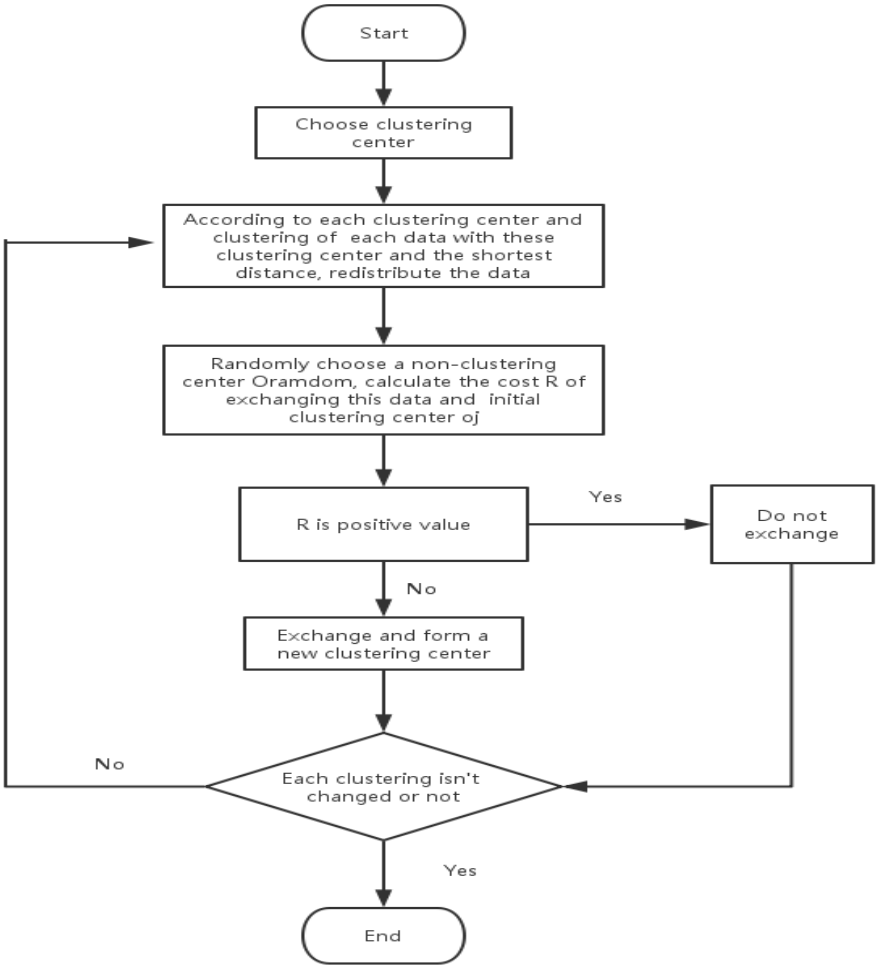

Figure 3. Flow Chart of K-medoids Algorithm

The above content has done the selection of characteristics of flowers. For each flower needed by floral art design, the feature evaluation can be done according to the characters described before. if there are K branch flowers, then a matrix of k lines and 9 columns can be got.

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} & a_{17} & a_{18} & a_{19} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{k1} & a_{k2} & a_{k3} & a_{k4} & a_{k5} & a_{k6} & a_{k7} & a_{k8} & a_{k9} \end{pmatrix}$$

In the matrix, $1 \le a_{ij} \le 10, 1 \le i \le 9, 1 \le j \le k$ is the feature matrix selected for the flower arrangement art design. On the basis of this characteristic matrix, the clustering method of the genetic algorithm combined with k-medoids algorithm are used to proceed clustering. The specific steps are as follows.

(1) Real number coding. According to the practical problems of this paper, the coding method of real number coding is adopted. The number of genes in an individual

represents the number of clusters, each of which represents a data object that is needed to process in the data set, and the data object is a cluster center.

(2) Initial population generating. This paper uses random function to generate the initial population and the initial population matrix. In this matrix, each row represents an individual, and each element in each row means a cluster center. How many individuals are included in population is represented by the number of rows in the matrix and the number needed to be clustered is represented by the number of columns.

(3) The determination of fitness function. In this paper, the mean square deviation is used as the fitness function. The definition is as follows:

$$E = \sum_{i=1}^{k} \sum_{p \in C_i} |p - m_i|^2 \tag{1}$$

In the definition, E is the summation of all the data needed to be clustered and the mean square deviation of the corresponding clustering, P is one of the points in a class, and m_i is the mean value of c_i clustering.

(4) Roulette is used to realize the selection operator. The basic idea of roulette is that the probability of each individual being selected is in direct proportion to the value of the fitness function, and the basic process is as follows:

$$p(a_j) = \frac{f(a_j)}{\sum_{i=1}^{n} f(a_i)}, \qquad j = 1,2,\cdots,n \tag{2}$$

In the roulette, $p(a_j)$ indicates that the selected probability of the j individual, f(aj) indicates the fitness function value of the j individual, and n refers to the number of individuals. The specific algorithm process is shown in Figure 4.

(5) Using k-medoids algorithm to optimize the individuals. In order to accelerate the convergence speed of genetic algorithm, using k-medoids algorithm to optimize the individuals with roulette selection and compared with the initial individual, the optimized individual has better properties. Therefore, using it to replace the original individual can accelerate the convergence speed of genetic algorithm.

(6) Using the single point to implement crossover operator. The crossover has a variety of ways. This paper, based on the characteristics of the actual problem, select the single point crossover. Randomly select two individuals, and randomly selected crossing points, then exchange some of the genes of the selected two individuals in the intersection. The crossover probability is generally 0.4-0.9.

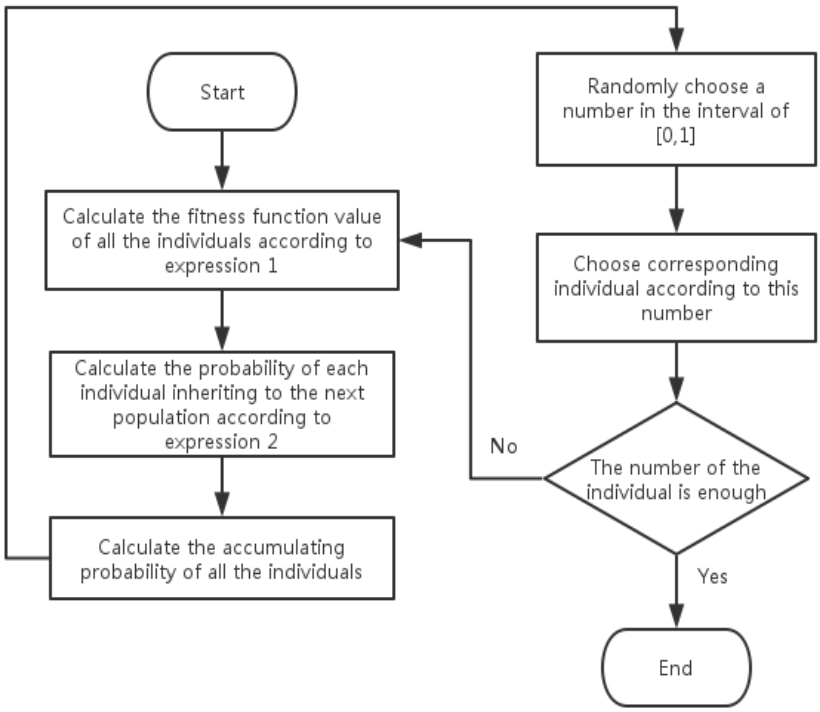

Figure 4. Flow Chart of Roulette Algorithm

3. Study on Floral Art Design Based on Genetic Algorithm Optimized by K-medoids Algorithm

Flower arrangement means arranging flowers in bottles, plates, pots and other containers. The floral material, no matter branches, or flowers, or leaves, are all without roots, and not casually arranged, but according to the conception of to choose material, follow certain rules of creation, arrange it into a beautiful form or shape, and take this opportunity to express a theme, transfer a feeling and sentiment, make the person pleased to both the eye and the mind, and get the spiritual beauty and pleasant. From the nature of the flower arrangement, it is a problem in combination of different flowers. Reaching the predetermined effect is a kind of optimization, so the flower arrangement is a combining optimization problem. While genetic algorithm is an effective method to solve combining optimization problems, and it has been widely used in combining optimization. This paper applies the genetic algorithm to the floral art design, in order to improve the efficiency and level of flower arrangement art.

3.1. Coding

This paper is to study the floral art design. The floral art design solution is a combination of a variety of different types, different kinds of flowers. Based on the practical problems, this paper uses the binary encoding method. In this encoding method, 0 and 1 are the symbols of composing the individual, and the individual is composed of a number symbol strings of 0, 1 composed by several 0 and 1.

The binary code is as follows: if it is needed to make a flower arrangement art design, the flowers can be selected are tulips (powder), Lily (white), carnation, chrysanthemum, rose (yellow), peony, Gypsophila paniculata, peach, cherry blossom, lotus and other 11

kinds. According to the serial number, it can be compiled as 1,2,3,4,5,6,7,8,9,10,11. The serial numbers are correspond to the flowers. For example, the number 5 represents the rose. The binary code is as follows:

0 0 0 1 0 1 0 0 1 1 0

The code represents that the 4, 6, 9, 10 flowers is selected, so the flower shape consists of the chrysanthemum, rose (yellow), peach, and cherry composition.

3.2. Generation of the Initial Population

Initial population is generated by random function, and an initial population matrix is formed. Each row represents an individual, and each element in each row represents a flower. The matrix rows represent the number of the population, number of columns represent the number of flowers for flower design.

3.3. Determination of Fitness Function

Floral art design itself is not only a combining optimization problem of a variety of different types of flowers, but also contains a human aesthetics and values, so the fitness function must take aesthetic view inside. There are nine factors that influence floral art design value. As shown in Table 2, they are pedicel length; pedicel diameter; pedicel color; leaves length; leaves width; leaves color; leaves quantity; size of flower parts; color of flower parts. Different combinations of these 9 factors decide the aesthetic of the floral art design. Based on this, this paper designs the form as follows.

Table 2. Flower Feature Combination Score Chart

Characteristics	L1	L2	L3	L4
Pedicel length	2	3	3	2
Pedicel diameter	2	3	3	2
Pedicel color	2	3	3	2
Leaves length	2	3	3	2
Leaves width	2	3	3	2
Leaves color	2	3	3	2
Leaves quantity	2	3	3	2
Size of flower parts	2	3	3	2
Color of flower parts	2	3	3	2

The meaning of L1 can be explained: when representing length, it means long-long-long; when representing degree of thickness, it is thick-thick-thick; when representing color, it is dark-dark-dark; when representing size it is large-large-large; the meaning of L2 can be explained: when representing length, it means long-long-short; when representing the degree of thickness, it means thick-thick-thick, when representing color, it means dark-dark-shallow; when representing size, it is large-large-small; the meaning of L3 can be explained: when representing length, it is long-short-short; when representing the degree of thickness, it is thick-thin-thin; when representing color, it is dark-shallow-shallow; when representing size, it is large-small- small.

Many flowers are involved in floral art design. Before every flower arrangement design, classification of selected flowers for floral art design can be can be done. This paper argues that it can be divided into three categories. More than three categories are too much and confused, and if it is less, then it will be too simple. The 9 characteristics of the 3 kinds of flowers can be combined as it is shown previously. The number in the table is the scoring of different combination, and the total value of it is 10. According to the above table, the design of the fitness function is as follows:

$$F = \sum_{i=1}^{9} \partial_i \beta_i \qquad \sum_{\mathrm{i}=1}^{9} \partial_{\mathrm{i}} = 1 \tag{3}$$

In the fitness function, ∂_{i} indicates the weight of the factor of number i, and the summation of the weights is 1; βi represents the scoring of the characteristic of number i, and its order is shown in the above table. This characteristic function fully consider the influence of people's subjective factors on floral art design.

3.4. Implementation of the Selection Operator

In the genetic algorithm, using the operator to do the survival of the fittest operation in allusion to the individual in the population. In this paper, we use selection tournament, in which the parameters selected is for the scale of competition Tour. Tournament selection method is similar to the sports competition. The selection of the individual is selecting the highest value of the fitness function of the individual from a few individuals. In this method, only compare the fitness function value without doing arithmetic operation of the fitness function value. Therefore, whether the fitness function value is positive or negative has no influence on the method.

The specific process of the operation of the method is shown in figure 5.

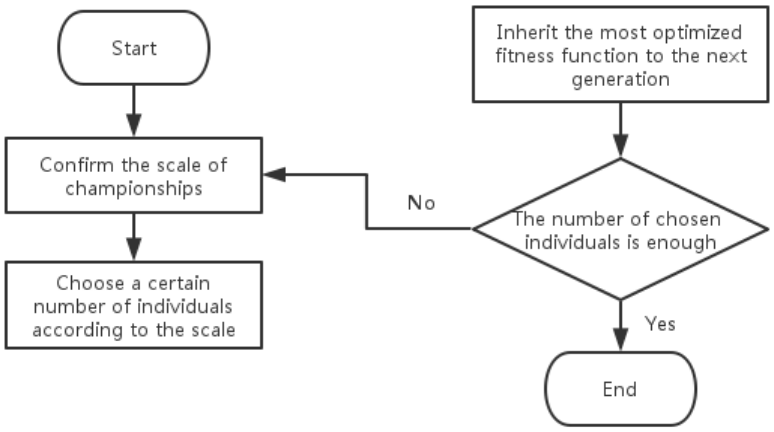

Figure 5. Algorithm Process of Championships

3.5. Implementation of the Crossover Operator

In order to better retain the new excellent individuals, and to produce more individuals, this paper adopt different cross strategies for different individuals. For the excellent individuals with higher fitness function value, this paper uses the single point crossover method to keep the best genes as many as possible. In the individuals with lower fitness function value, this paper uses three points to cross, to a large extent, to destroy the individuals. The general crossover rate is in the range of 0.4~0.9. In this paper, we consider that the fitness function value in the former 1/3 is the excellent individuals, and the individual in the latter 2/3 is the inferior individuals.

3.6. Implementation of Mutation Operator

The so-called mutation operator is to replace a certain or some gene values in the individual's coding string with other gene values, so as to generate a new individual. By

interaction of crossover operator and mutation operator interact can make genetic algorithm to complete the global search and local search.

In order to retain the individual as much as possible, this paper uses a new method of variation. First, two parameters are set: the individual mutation probability threshold α and genes variation threshold β. Before the variation of the selected individuals, first of all, randomly generate a random number by a uniformly distributed random number generator. If the random number is not greater than the individual mutation probability threshold value α, then it is considered that the individual needs no variation. If the random number is greater than the individual mutation probability threshold α, it is believed that the individual has the variation characteristic, and needs the variation.

Even if the individual has the characteristic of variation, whether its gene niche has the characteristic of variation needs to be measured by the gene mutation threshold β. If the randomly generated random number is not greater than the threshold of the gene mutation β, it is considered that the gene does not have the variation characteristics, and it needs no variation. Otherwise, it is necessary to carry out the variation. If it needs variation, this paper uses the single point mutation. That is, randomly select a certain gene point and use the value of other genes to replace the original gene value. The variation rate is generally valued from 0.001 to 0.1.

3.7. Algorithm Process in This Paper

The algorithm process is shown in figure 6.

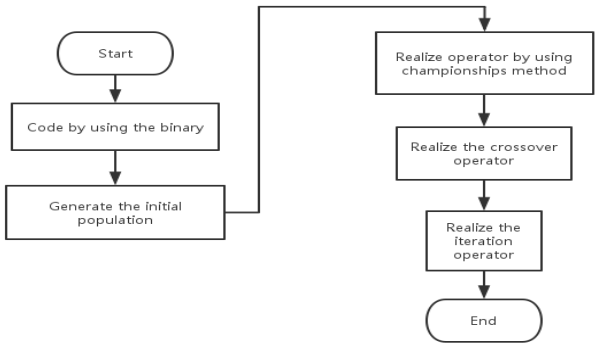

Figure 6. Algorithm Flow Chart in This Paper

4. Case Analysis

Select the following floral materials: anthurium, bird of paradise, VU bamboo, monstera, palm flower spike, air usnea, weng column cactus, brown branches, rhododendron flower, plum, autumn chrysanthemum flower and so on.

After using the standard genetic algorithm, the floral work produced is shown in figure 7. Based on the improved algorithm, the floral work is shown in figure 8. From the two paintings we can see, the floral art works generated by the improved genetic algorithm is superior to the standard genetic algorithm from the perspective of beauty and appreciation.

Figure 7. Floral Work Produced by Standard Genetic Algorithm

Figure 8. Floral Work Produced by Improved Genetic Algorithm

5. Conclusions

Floral art makes people obtain the good appreciation and get the spiritual beauty and pleasure. Whereas, the traditional floral art does flower arrangement mainly from the perspective of experience so that there are some limitations of its shape and art [8-10]. The flower art in essence is a combining optimization issue of a flower, so this paper uses the genetic algorithm to study on it. This paper designs the fitness function adaptable for floral art, and proposes the new crossover operator and mutation operator on the basis of the standard genetic algorithm. Verified by the experiment, the algorithm can produce better floral art works than that produced by traditional genetic algorithm.

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