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THE USE OF METHODS FOR OPTIMIZING THE GENETIC ALGORITHM FOR THE COLORS OF A FRACTAL STRUCTURE PATTERN IN CARPET DESIGN

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Abstract. Customer satisfaction can be enhanced by reducing the gap between what the customer really needs (customer requirements) and what the manufacturer can provide (product specifications). The carpet industry's customer design approach, in which products are created by converting customer needs into product specifications (in a mass production system) or into product diversity (in a mass customization system), cannot provide optimal satisfaction to all customers. Some carpet buyers are still forced to soften their requirements and agree to a pre-determined product in the assortment. This study proposes a new carpet design concept and an optimal price per customer order to increase customer satisfaction by opening the maximum possible channel for customers so that they can participate in value creation, so that they are no longer only looking for goods, but can, if necessary, involve in the production cycle to specify their own design. To ensure the viability of the proposed concept, this article presents the integration of the point of separation of the participation of several customers, the analysis of product attributes, crowd screening and a new production strategy. Real resin-based desktop clock products are used as a practical example to test the applicability of the concept and demonstrate its advantages.

Keywords: genetic algorithm, fractal, Pascal triangle, fractal, mutation, optimization, fitness function.

Introduction

Optimization problems are problems in which it is required to find the best solution; at the same time, as a rule, there are various restrictions on the scope of changes in control a variable, which does not allow using the methods of classical mathematical analysis, but requires the use of various computational methods. In this article we will look at optimizing the colors of fractal patterns of carpet design. Optimizing carpet colors we used a genetic algorithm. The concept of design is different from the scientific research that we sometimes analyze, design is a design that consists not only of studying the essence of what exists, but of creating innovation. When designing carpet designs in the carpet industry, the choice of color is of great importance.

General customization and automation in the carpet industry, this method of creating a bar mat for the buyer is considered in quality. The genetic algorithm is the direction of optimizing those stimulated by an environment that works in addition, such as interrelated; mutation and the survival of the most suitable one's work for machine learning. This method is widely used in optimization and classification work.

This method used two databases; one with basic patterns and the other with colors. This work developed software to optimize the selection of paints in carpet design in the production of complex images of fractal carpets based on a genetic algorithm. As parameters of the genetic algorithm, crossover and mutation probabilities are used. They can be from 0 to 1. Thus, they are considered probability. If the operator is assigned a value of "0", it means that as a result of this operator, no individual will change in this population. Likewise, if "1" is indicated as a parameter, it means that all individuals, in other words, all populations, change. Both of these values are usually not specified, since they do not contribute to the efficiency of the algorithm. So, in this study, we will select a value from 0 to 1 for the crossover and the probability of mutation.

Literature Review

This method was also considered in the textile industry. This article will discuss the application of genetic algorithms in the textile industry. The genetic algorithm allows you to contain a large number of answers and select perfect designs from them by receiving feedback from assignments. However, many patterns are unpleasant and may not be suitable for customer demand. According to the customer, it is not easy to choose interesting and stylish models from such a variety of designs. To find the optimal price, an interactive genetic algorithm can be used to optimize colors and select ideal patterns based on the user's necessary feedback. We can use it to optimize color in the manufacture of carpets of complex designs (Nuraliev F. M. N.A., Narzulloev O. M., 2019). Attempts to eliminate these problems led to the creation of a theory of genetic algorithms. The founder of the theory of genetic algorithms is rightfully considered the American researcher John Holland, who in the late 1960s, it proposed the use of methods and models of the mechanism for the development of the organic world on earth as the principles of combinatorial registration of options for solving optimization problems. In 1975, John Holland published his most famous work "adaptation in natural and artificial systems" (Panchenko T. V., 2007). In it, he first introduced the term" genetic algorithm". John Holland's Students Kenneth De Yong and David Goldberg continued his career in the field of genetic algorithm. Goldberg's most famous work is "search optimization and genetic algorithms. in machine learning" (Gladkov L. A., 2006). In the carpet industry, several carpet designs of different colors can be created in a complex fractal image system. However, given the time, many patterns may not be attractive and beautiful enough, and choosing patterns among a wide range of customer tastes can be a big problem. To solve such a problem, an optimization and design scheme based on artificial intelligence can be used. This method develops a design system that is consistent with the requirements of customers and is based on market demand, which gradually connects with users, collects feedback and gives optimal results for users. In the carpet weaving system, several designs of different colors can be made. Also, many patterns may not be unpleasant and in demand. According to the buyer, it is not easy to choose interesting and stylish models from such a variety of designs. With the help of an interactive genetic algorithm, it is possible to optimize colors by price and select ideal images, taking into account the necessary feedback from the user. We can use the genetic algorithm to optimize the color of fractals in carpet production with complex image carpet designs (Dariush S., Mehdi H., Hamed A. and Mohammad Sh., 2014). To create an optimal color selection plan, a genetic algorithm is used in the design of carpet production. The interactive genetic algorithm was also used to optimize the color detection of carpet products, and was used in a similar way to previous research databases that included initial reserves to begin the optimization process.

Methodology

The genetic algorithm is similar to an interactive genetic algorithm; however, there is a slight difference where there is primarily a fitness function (target function) and the user sees the level of compatibility for each chromosome. The interactive genetic algorithm can communicate with users and therefore affect the user's emotions and is used in the arts and design fields and is used in production. In the carpet manufacturing industry, the application in color optimization is blurred in accordance with the purpose. For this, too, a program was developed by the Python programming language to express design through complex fractal images. The developed software consists of the following main section. Complex fractal image patterns and colors created by the program are displayed to the user in the main part, which is evaluated by the user. In other parts, the user can view existing carpet design samples from the carpet design sample base and create, edit or delete the desired design samples and place them in the database. The user can do the same for the colors in the software component and finally enter the knitting machine pattern and color boundaries. Using the method of binomial polynomial theory, methods and algorithms for visualizing images in fractal form have been developed, taking into account algebraic structures based on the Pascal triangle and The Theory of prime numbers based on Mod p (Nuraliev F. M. N.A., Narzulloev O. M., 2019). Each pattern is shaped on the basis of a Pascal triangle, in which each component is taken into account, the number of rows indicates the number of rows and the number of columns indicates the number of rows in the pattern. For example, the first size in the Pascal triangle indicates the amount of red, the second – green, the third – blue. Genetic algorithm parameters such as population number, number of parents transferred to the next generation, intersection coefficient, mutation rate, number of generations, and time limit are shown. There is no time limit for the algorithm to work, and the chromosome population is considered as a vector, that is, all chromosomes are sent to the fitness function through a matrix, where the number of rows is equal to the number of chromosomes. The number of columns is equal to the number of chromosomes genes. Thus, the fitness function is called only once for each generation, and the speed of execution of the algorithm increases. After determining the required parameters, the task of the genetic algorithm is performed. In the recorded function, the number of genes, the upper and lower limits and previous parameters of each gene are used as inputs, and the final population of chromosomes and their assumptions are used as the final product. Since in the final population some chromosomes may be the same as other chromosomes, samples of a similar design need to be eliminated and a new population with different chromosomes formed, and the best samples are installed on the user. After optimizing the carpet design, the color is optimized in the selected carpet designs.

Genetic method of color optimization of fractal structure images

Like chromosomes, which change in nature due to changes in genes, in the genetic algorithm these elements are constantly changing, turning into full and strong populations. The size of the chromosomes and the number of genes depend on the type of problem. Genes are actually a true determinant of the variables needed to optimize the problem. The suitability of chromosomes determines their effectiveness and the function of solving the problem. Such tasks related to the tastes and feelings of people use a direct definition of fitness instead of its function by a user called an interactive genetic algorithm. The choice of color options for paints for the manufacture of a particular carpet product is a complex issue, since it is necessary, on the one hand, to ensure the established accuracy of painting, and on the other, to be able to produce carpets. The main goal is to maintain the minimum cost and at the same time the highest productivity. To solve these problems, in general, methods of mathematical programming and optimization are used.

In real problems, a connection between objective functions, criteria inevitably arises:

1. criteria can match each other;
2. criteria may contradict each other;
3. criteria can be independent.

The initial expert assessment of the selected criteria (Dariush S., Mehdi H., Hamed A. and Mohammad Sh., 2014) allows you to solve the problem of multi-criteria optimization in the simplest, but sometimes most effective ways. The genetic algorithm (Panchenko T. V., 2007) is based on the theoretical advances of synthetic evolutionary theory and C. Darwin uses the basic principles of evolution theory: heredity, variability, and natural selection. The genetic algorithm works with a set of individuals (population) with rows (chromosomes) that encode one of the solutions to the problem. This genetic algorithm differs from other optimization algorithms in that it only works with one solution and improves it. Each person is evaluated by a measure of his "suitability", depending on how "good" it is to solve the problem that suits him. For this, the fitness function (Gladkov L. A., 2006) (target function) is used, which highlights the most adapted solutions (which will continue to be used further) and the worst solutions (which will be removed from the population and will not affect the search for the optimal solution). So we strive to increase fitness, and therefore approach the desired solution and approach the desired decision. The operation of the genetic algorithm is an iterative process. Each new iteration over current individuals uses different genetic operators that give birth to new individuals. After that, all individuals are evaluated using the target function, and the most suitable ones are used in the subsequent iteration of the genetic algorithm. This process continues until the desired results are achieved, or the number of iterations exceeds the limit value (the limit of the number of iterations allows you to limit the time of operation of the algorithm from above). Also, one of the symptoms that must stop the iterative process is the approach of the population (the state of the population, all its individuals have been in a certain extreme region for several generations and are almost identical). The convergence of the population usually indicates that a solution closes to the optimal one has been found. Usually, the final solution to the problem is the most adapted person of the last generation. Genetic operators are a means of showing one set to another. They allow the application of the principles of heredity and variability to virtual populations. All genetic operators have probabilistic properties, which brings a certain degree of freedom to the work of the genetic algorithm. The most commonly used genetic operators are the crossing over (cross) operator and mutation operator. The transition Operator models the process of crossing individuals. This genetic operator leads to the creation of new individuals based on existing ones.

Results &Discussion

Currently, there are many different models and modifications of the genetic algorithm. In test functions, an experimental comparison of all their strengths and weaknesses with each other is impossible to construct within the framework of one article. The size of the chromosomal population is 6, the number of chromosomes transmitted to the next generation is 5, there is activity and 4 generations. The first generation of patterns was created from simple patterns stored in the database to run the genetic algorithm, but they could be modified by the user. The rating of users is from 1 to 9, the more attractive the design, the higher the rating. Subsequently, the first generation was evaluated, the next generations will be created on the basis of user ratings. Selection opera is an interactive operation performed by the user, the number of patterns in the database is the same for each generation, so patterns with a low compatibility value are excluded and will not be passed on to the next generation. The best design in each generation is the one with the highest fitness value or the best fitness value in this generation, and the average fitness value is the average value of all fitness values in this generation. With the production of new generations, the average fitness will be higher, which will show the well-being of the developed design samples and good user ratings.

Evolution algorithms use different evolution simulations in three stages of genes – chromosomes, human and generational. The genetic algorithm uses evolutionary modeling at the level of genes and chromosomes, in which the population consists of chromosomes with arguments of the same size. The emergence of a new generation is usually caused by chromosomal binding and partial mutation. In the genetic algorithm, the population of possible solutions in the search field, that is, the so-called individuals, the iterative evolution, becomes better solutions through the process. The population in each iteration is called the generation. Each generation assesses the physical fitness of individuals, which is usually the value of the target function in the optimization problem. Then a small set of individuals (parents) is selected and a transition mechanism is used to obtain a new generation of individuals (offspring). In addition, the mutation operator can be applied to maintain genetic diversity. The operation of any search algorithm depends on the balance between two opposing goals: using the best solutions found so far (local search) and at the same time studying the search field of other promising solutions (global search). Genetic algorithms have proven to be effective as a global search method, which means that they can quickly determine the area in which the optimal solution is available. Optimization problems over finite sets have a finite set of feasible solutions that can be enumerated and the best one can be selected from them, providing the extremum of the objective function (CF). The subject area of such tasks is the processes of operations research (IO), the theory of which has been formed for several decades. In our previous work, we used the symplex optimization method, but the result gave us one result. The simplex method has developed an algorithm for optimizing colors in the production of carpets of a given size, it is advisable to use mathematical programming methods to select the optimal set of colors, which can be done with the least cost and maximum benefit. In this paper, a genetic algorithm for optimizing the colors of the carpet industry is considered. One of the optimization methods is the genetic method. This method has also been considered in the textile and carpet industry. The genetic algorithm is a method for solving optimization problems based on the processes of natural selection (mutation, crossing, selection) and is part of a broader direction of artificial intelligence — evolutionary computing. In a genetic algorithm, each possible solution to an optimization problem is called an individual. Individuals form a population. The task is that in the process of evolution, each new generation of individuals (i.e. solutions to the optimization problem) becomes more perfect. In this work, with the help of a genetic algorithm, we got some of the best options.

The production of natural paints used in the production of carpets is an important environmental problem, the economic consequences of which are numerous and diverse. This article begins with the assumption that reducing greenhouse gas emissions is a necessary policy that must be developed in a cost-effective way. It is well known that market instruments are the best option in terms of economic efficiency. Customer satisfaction can be increased by reducing the gap between what customer really needs (customer requirements) and what manufacturer can provide (product specifications). The approach of Design for Customer where products are generated by translating customer needs into product specifications (in mass production system) or into product variety (in mass customization system) is not able to give optimum satisfaction to all customers. Some customers are still forced to relax their requirements and to accept predefined product in the assortment. This study proposes a new concept of Design by Customer to increase customer satisfaction by opening maximum possible channel for customers to involve in value creation so that they are no longer only searching for goods but they can also, when necessary, involve in production cycle to specify their own design. In order to ensure the viability of the proposed concept, the integration of multi customer involvement decoupling point, product attribute analysis, crowdscreening and new manufacturing strategy are introduced in this paper. Real products of resin-based table clocks are used as practical example to verify the concept applicability and to demonstrate its merit. Figure 1 presents the block scheme of the algorithm structure.

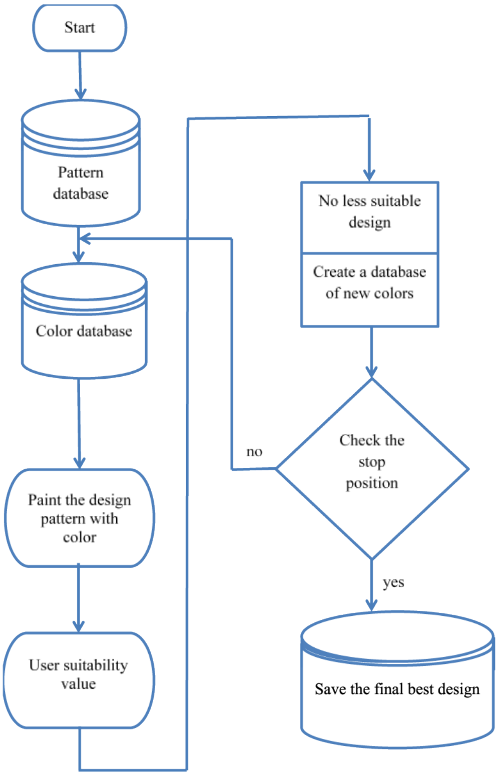

Figure 1 – Operation block scheme of the genetic algorithm

Unlike design chromosomes with the same number of genes, the number of colored chromosome genes can vary and is determined by the color variety of the selected designs. The number of genes is equal to the number of colors of the selected design. The color chromosome has an auxiliary gene that determines the number of colors, or in other words, the number of genes that are destroyed after the formation of the structure of the color chromosome. The genes of the main color chromosomes will have the desired value depending on the number of colors available in the color database. For example, if there are nineteen colors in the color database, the first gene will have a value from 1 to 19 after the auxiliary gene is excluded. The following genes cannot accept the values of the previous genes, since there may be undesirable changes in the design. In relation to the selected chromosome of the pattern, if the pattern was formed from a single pattern, the number of colors on the color chromosome is equal to the number of colors in the first pattern, if from two patterns, then the number of Colors is equal to the number of patterns. Wider color variety. After the auxiliary gene is removed, the limited color chromosomes are sent to the algorithm. The selected carpet design color chromosome and Color Matrix are sent to the coloring function of the selected design, and this feature paints the selected design in different colors and sends it to the fitness function to show the user when evaluating it. Similar to the automatic evaluation section in the design suitability function, similar colors from different generations of the selected design are included in the color suitability function. This function also imposes restrictions on color chromosome genes for painting images and edits them as needed.

Computational experiment

A fractal pattern of 3 colors of a certain size was selected and the cost of painting the carpet was calculated. The number of each color in the Pascal triangle consists of three colors, for example 63, 78 and 30, here are these unknown price natural dyes our function is blurred in the resulting drawing:

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1. Constraints that task variables must satisfy:

$$x, y, z \geq 0$$

$$n = 18(32, 98, ...) \text{ line}$$

$$P = 3(m)(2, 3, 5, 7......) \text{ fuzzy numbers}$$

Target function of the task.

$$F = \sum_{i=1}^{p_1} x_i y_i \rightarrow \min.$$

Denote F - income from the sale of carpets, then the objective function of the problem is written as follows:

Thus, the task is to find

$$\min\ F = 63 * x + 78 * y + 30 * z \rightarrow \min,$$

under the constraints:

$$11 \leq x \leq 140$$
$$11 \leq y \leq 140$$
$$11 \leq z \leq 140$$

Using the genetic algorithm to solve this optimization problem, it get the following results:

Here we used mutations similar to reproduction, a certain number of individuals are selected from mutants and changed in accordance with predetermined operations.

A mutation was carried out to improve the generation. For each color in the process of solving the problem.

$$\text{Minimize } F = 63 * x + 78 * y + 30 * z$$

$$\text{over } \{0,1,2.....18\}$$

Representation: binary code e.g. 00111 for 7
Chromosome length is 5 (10010 is 18)
Population size 4
3 point crossover
Roulette wheel Selection
Randomly generated Initial Population: 1.

String No.	x	y	z	x(2)	y(2)	z(2)
1	15	17	18	01111	10001	10010
2	4	12	8	00100	01100	01000
3	4	9	19	00100	01001	10011
4	7	9	2	00111	01001	00010

Figure 2 – Randomly generated Initial Population

	Strin No.	x	y	z				Fi	Exp.Count
2	1	15	17	18	01111	10001	10010	17568	0,423887
3	2	4	12	8	00100	01100	01000	8349	0,201448
4	3	4	9	14	00100	01001	01110	8547	0,206225
5	4	7	9	2	00111	01001	00010	6981	0,16844
6	Sum							41445	1
7	Avarae							10361,25	0,25
8	Min							6981	0,16844

Color No.	Color price
0	11,00
1	24,00
2	26,50
3	35,00
4	37,00
5	37,00
6	39,00
7	40,00
8	42,00
9	47,00
10	50,00
11	50.5
12	61,00
13	78,00
14	85,00
15	89,00
16	102,00
17	99,50
18	140,00

*F=63*x+78*y+30*z*

0,00

Figure 3 – Computational experiment. Selection

1	String No.	Mating Pool X	Mating Pool Y	Mating Pool Z	Crossover point	Offspring After Crossover X	Offspring After Crossover Y	Offspring After Crossover Z	X Value	Y Value	Z Value	F	New No.
2	2	00100	01100	01000	4	00101	01101	01000	5	13	8	9675	1
3	4	00111	01001	00010	4	00110	01000	00010	6	8	2	6528	2
4	3	00100	01001	01110	2	00111	01001	01010	7	9	10	7686	3
5	4	00111	01001	00010	2	00100	01001	00110	4	9	6	7167	4
6	Sum											31056	
7	Avarage											7764	
8	Min											6528	

Figure 4 – Computational experiment. Crossover

10	2	00110	01000	00010	4	00111	01001	00010	7	9	2	6981	1
11	3	00111	01001	01010	4	00110	01000	01010	6	8	10	7233	2
12	2	00110	01000	00010	2	00100	01001	00110	4	9	6	7167	3
13	4	00100	01001	00110	2	00110	01000	00010	6	8	2	6528	4
14	Sum											27909	
15	Avarage											6977,25	
16	Min											6528	

Figure 5 – Computational experiment. Crossover

17												
18	1	00111	01001	00010	4	00110	01000	00010	6	8	2	6528
19	4	00110	01000	00010	4	00111	01001	00010	7	9	2	6981
20	3	00100	01001	00110	2	00110	01000	00010	6	8	2	6528
21	4	00110	01000	00010	2	00100	01001	00110	4	9	6	7167
22	Sum											27204
23	Avarage											6801
24	Min											6528

Figure 6 – Computational experiment. Crossover

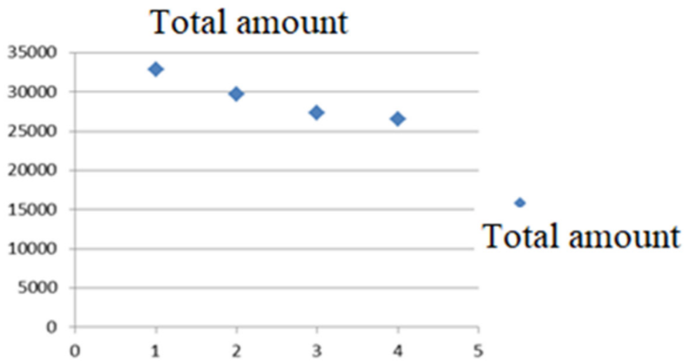

Figure 7 – The average adaptation situation of the generation and the best

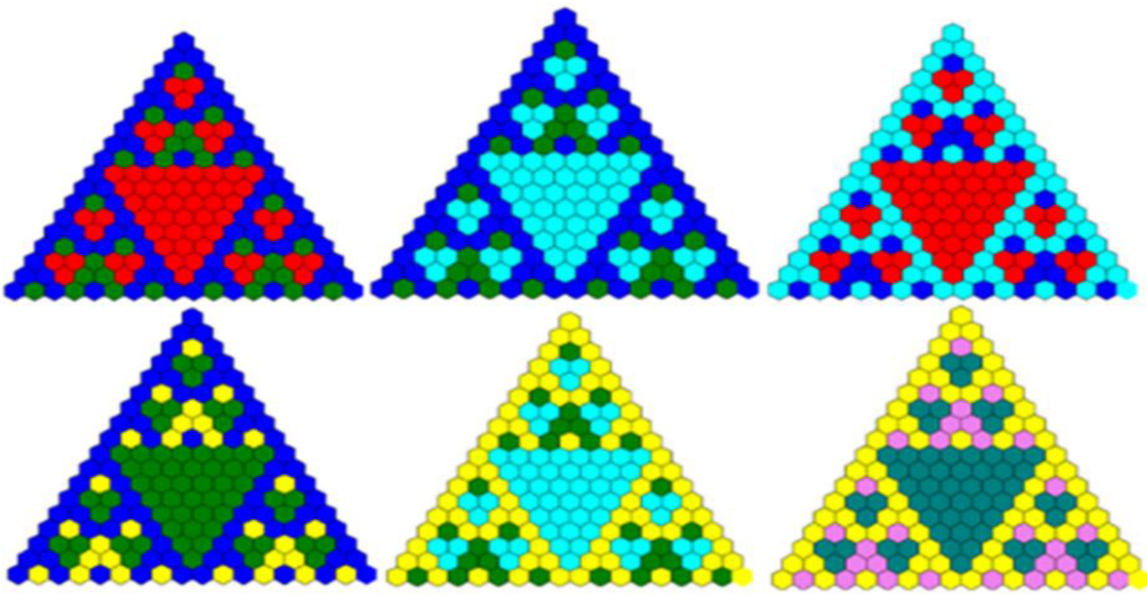

Figure 8 – Images of complex fractal structures based on Pascal's triangle Mod=3 for carpet obtained from genetic algorithm by optimization method

Conclusion

This article analyzes the basic principles of the functioning of search genetic algorithms, presents the most important genetic operators, models and strategies used in the genetic algorithm. Also, a positive experience of practical application of the genetic algorithm for optimizing multi-extreme functions is considered. Carpets are important both artistically and commercially. Research shows that the initial desire to buy a carpet is based on its design pattern and color composition. Therefore, the developed algorithm has optimal capabilities for design and color optimization. The user interface is a powerful application to extract data and tastes from the user, which can adapt to different postures and experiences. This program can create more beautiful and attractive designs and colors from the user's point of view when creating new generations, and will extract different variants of carpets on demand, reducing the cost based on the customer's demand. Compatibility charts also show improvements in color and design.

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