Exploration of Design Methods Based on Bionic Functional Modules

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Abstract: Triz theory is the knowledge of heuristic methods to solve invention problems. The bionic model also has the effect of inspiring and solving invention problems. Both of them have been widely used in the engineering field. By consulting the existing bionic literature, analyzing the corresponding engineering problems to be solved, corresponding to the Triz conflict matrix, filling the bioengineering model into the conflict matrix, and establishing a conflict problem resolution matrix based on the bionic functional module, starting from the perspective of bionics a solution to the problem of engineering conflicts. In future design work, designers can quickly locate bionic objects, inspire design thinking, and greatly shorten the design cycle.

1. Introduction
In recent years, the rapid development of bionics and Triz innovation theory has attracted the attention of many scholars. The Triz theory is translated into the principle of innovative problem solving. It was summarized by the former Soviet Union scientist Altshuler and his team through analyzing a large number of patents and innovative cases[1]. Its problem-solving methods mainly include matter-field analysis, ARIZ algorithm, Conflict matrix, effect knowledge base, the method of determining the ideal solution[2], it has achieved full application and development in the fields of machinery, computer, agriculture and so on.

Since ancient times, nature has been the source of various innovative ideas for mankind. After hundreds of millions of years of evolution, the creatures on the earth have already mastered the optimal functional mechanism to adapt to the environment. Scientists use a variety of techniques to transform the abstract functions of selected templates into specific structures, so since the birth of bionics, bionic design has greatly promoted the development of modern science. Although Triz is a summary of many problem-solving methods, its methodology is abstract and difficult to understand[3], and the bionic model concrete visualization, However, the number of models is huge, it is difficult to choose the most suitable model. In daily design, it is difficult for designers to find the best solutions, an excellent bionic model corresponding to the problem.

At present, many outstanding scholars at home and abroad have combined Triz and bionics to carry out research. Among them, Baldussu[4], Vincent[5] and others, they match the biological model solution to the contradiction conflict solution, and provide the specific biological principle solution for designers to solve the contradiction problem. Man Li[6], Linqiang Li[7] and others, used the research method of combining the contradiction conflict matrix and the biological model to improve the performance of some products. It can be seen that the current combination of bionics theory and Triz theory, it is an interpretation of the principle of Triz's invention.
2. Theoretical basis

2.1. The establishment of Triz conflict matrix

Triz theory believes that the core essence of the solution of invention problems is to resolve contradictions. Through the analysis and research of a large number of patents, Altshuler summarized 39 general engineering parameters commonly used in the engineering field to express system functions and the contradiction matrix composed of them, which can effectively solve the technical contradictions in the system. This is Triz an important part of the theory. The 39 engineering parameters are arranged horizontally and vertically to form a 39×39 matrix. The vertical column represents the improved engineering parameter, and the horizontal column represents the deteriorated engineering parameter. Except for the engineering parameter itself, each parameter can form a contradictory relationship with another parameter. Conflict matrix is also one of the main research contents of Triz theory.

Each product is a system, which contains one or more functions. The product needs multiple interconnected parts to realize the corresponding function of the product. In order to improve the market competitiveness of the product, it is necessary to continuously improve the design of the product. When a part or component of a product is changed, the parts or components associated with the part or component may be changed, which may cause the product or system to be different. The performance of the aspect is affected. If these effects are negative, then there is a contradiction in the design[8].

In addition to 39 engineering parameters, Altshuler also summed up 40 invention principles to solve the conflicts of engineering parameters. Among these 40 invention principles, each principle corresponds to a contradiction that can be resolved. On the one hand, the invention principle has a positive effect that can achieve improved parameters, and on the other hand, it can also improve the negative effects brought about by deteriorating parameters. Therefore, the principle of invention was born on the basis of summarizing most of the principles of conflict resolution, and plays an important role in resolving technical conflicts.

2.2. The relationship between bionic theory and engineering parameters

Contradictions are universal. Contradictions exist in all things and run through the process of development of things. The continuous development of things is the process of constantly overcoming contradictions. After hundreds of millions of years of evolution, organisms on earth have formed functional structures and physiological institutions that perfectly adapt to the environment. In the process of adapting to the environment, organisms need to overcome their own systems, contradictions between themselves and environmental systems, this is the source of constant evolution, the biological function model has a method, a method that can solve the contradiction problem well.

In previous bionic designs, the bionics theory was well applied in the process of solving engineering problems. Altshuler summarized the engineering problems into 39 engineering parameters. Therefore, there is a natural connection between bionics and TRIZ conflict theory. Based on this, the author, by consulting and summarizing the existing bionic research literature, match biological function to engineering problem solving parameters, establishes a new conflict matrix based on the bionic functional module, and summarizes the existing excellent bionic engineering models through the Triz matrix, which is convenient in the future, design workers will consult, solve the problems encountered in the design process, inspire design thinking, and shorten the design cycle.
3. The establishment of conflict matrix of bionic functional modules

The establishment process is shown in Figure 2.
3.1. Acquisition of excellent bionic materials
Through hundreds of millions of years of evolution, the organisms in nature have evolved the most mechanism and physiological function to adapt to the environment. Since ancient times, human beings have begun to imitate the biological habits of nature and develop tools adapted to survive in nature. The reason why human beings can survive on earth for so many years is that they keep fighting with nature and "defeat" nature to a certain extent. Therefore, biological characteristics contain many tools and principles that can solve the problems encountered in human invention and creation, and their potential is huge. Altshuler created Triz conflict matrix by summarizing patent literature, this paper intends to use the same idea to establish, through reviewing and summarizing the existing bionic literature, integrating the biological models and engineering models obtained from the existing research in various literatures, establish, improve and enrich the conflict matrix based on bionic function module.

3.2. Biometric extraction
The task of bionics is to study the principle of excellent biological function and apply its principle to the research and design of engineering. In addition, as research into bionics continues, scientists have found that the various functions of organisms due to the environmental impact are not only the effect of one factor or simply a combination of factors, but the result of the interaction and coupling of multiple factors. Therefore, in the analysis of biological characteristics, we should not only comprehensively analyze the factors that may affect biological functions, but also identify the main functional elements that affect biological functions. At present, the main method of bionics research is to conduct mathematical analysis on the data provided by biological models, express them into mathematical language, establish mathematical models available for research, and combine with practical engineering problems, establish a physical model, and finally evaluate and improve the program, in this way, it constitutes the whole process of problem solving.

3.3. Analysis function, corresponding parameters
The word of function is composed of verbs and nouns, which means that an object has properties that meet its needs. As a means of bionic design, functional bionics mainly studies the objective functional principles and characteristics of organisms, and obtains enlightenment from it to promote the improvement of product functions or the development of new product functions, which has played an important role in promoting the development and perfection of bionics theory.

The author believes that the biological function principle and the 40 invention principles have almost the same effect, as two common design guidance methods in the field of mechanical design, the biological function principle also has the function of resolving technical conflicts. When establishing a connection between the principle of Triz's invention and technical conflicts, one is to ensure that it can retain the positive effects brought about by the improved parameters, and the other is to solve or alleviate the negative effects brought about by the deteriorating parameters. Similarly, when establish relationships that biological functional model and conflicting parameters, the same guidelines should be followed. In addition, the biological function model should correspond to a priority problem, that is to find a corresponding improved parameter first, and then corresponding to the deterioration parameter to establish the contradiction problem solving matrix. This can prevent the phenomenon that the template appears repeatedly in the matrix, resulting in the matrix miscellaneous.
3.4. Case analysis
We take the Amazon royal water lily leaf as an example. The back of its leaf grows thick veins like chopsticks, which are criss-crossed and slab-shaped, forming large and small square grids, which can not only maintain the expansion of the leaf, but also increase the discharge water power and load capacity of the leaf. At the same time, there are many large cavities in the vein and the cavity is filled with air, so that the leaf can float on the water smoothly and bear dozens of kilograms of heavy objects without sinking.

![Fig.3 Amazon royal water lily](image)

In the field of engineering, the bionic application of the Amazon royal water lilies can not only improve the stability of the structure, but also reduce the weight of its own. Therefore, the functional model of Amazon royal water lilies, on the one hand, can correspond to the improvement of engineering parameter 13, the stability of the structure, and on the other hand, can correspond to the mitigation of deterioration parameter 2, the weight of the stationary object. The Amazon royal water lilies bionic template was filled into the conflict matrix, as shown in the figure, to establish the conflict matrix of bionic function modules for reference. In addition, the bionic engineering model of Amazon royal water lilies corresponds to the original invention principle to solve the conflict problem, namely the segmentation principle, which further proves the feasibility of this bionic example in solving the conflict.

![Fig.4 The process of establishing the conflict matrix of the Amazon Royal Water Lily bionic functional contradiction](image)

4. Application of bionic function module conflict matrix
The design of new products often encounter many problems. To solve the problems by Triz theory, it is necessary to first transform the problems into the standard problem model of Triz theory, and then obtain the solution model with the help of the corresponding Triz tools. The purpose of this paper is to classify, shrink and screen a large number of bionic objects by using Triz contradiction matrix, and organize them into engineering models, which are convenient for designers to refer to in the future and provide inspiration for problem solving.
4.1. Contradiction analysis method
Triz theory believes that the technical contradiction is caused by two factors in the system, which promote and restrict each other. The improvement of one element's parameters will inevitably lead to the deterioration of another element's parameters, which constitutes a contradiction. Therefore, using conflict matrix to solve the problem, we should first determine the contradictions in the functional system. At present, the main methods to determine conflicts include conflict detection based on material-field analysis, conflict detection based on quality engineering configuration (QFD), and conflict detection based on axiomatic design (AD).

4.2. Specific application process
The specific application method is similar to the traditional conflict matrix method, (1) Determine the technical system function; (2) decomposition technology system; (3) the system where the positioning problem is located; (4) Determine the improvement and deterioration characteristics of technical systems; (5) Find the corresponding bioengineering model solution in the matrix; (6) Referring to the bionic engineering model, combined with practical problems, the preliminary scheme is formed; (7) Scheme modeling, test scheme; (8) Problem solving. The specific process is shown in Figure 5.

5. Conclusion
(1) By Triz contradiction matrix, and the application of bionics theory in the field of engineering, the two connection, the bionic model replacement invention principle, through the establishment of mathematical model, the bionic model summarized as project template, and fill in the Triz contradiction matrix, establish the conflict matrix based on the bionic function module, inspired design ideas, the design period is shortened, and the establishment process is illustrated with the example of amazon royal water lilies bionic model.

(2) Explain the application process, analyze the designed product through the TRIZ contradiction analysis method, clarify the contradiction problems, find the matrix to find the appropriate bionic engineering model, establish the physical model based on the actual problems, and gradually form the best plan.

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