# Research on Genetic Algorithm Model for Organizational Capability Evolution Based on CAS Theory

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Abstract: Genetic algorithm model research plays a crucial role in the evolution of enterprise organizational capabilities, however, the traditional ant colony algorithm has certain limitations for solving the problem of model research, and its effect is not ideal. This paper explores the evolutionary mechanism of organizational capability under the theory of Complex Adaptive System (CAS), and introduces a genetic algorithm model to simulate and optimize this process. By analyzing the application of genetic algorithms in the evolution of organizational capabilities, it aims to provide a persuasive framework for enterprises to promote their adaptability and competitiveness. The simulation results based on MATLAB show that under certain evaluation criteria, the genetic algorithm model research scheme based on CAS theory shows obvious advantages in the accuracy of genetic algorithm model research and the processing time of influencing factors of genetic algorithm model research, which can achieve ideal results comprised with the traditional ant colony algorithm.

## 1 INTRODUCTION

Genetic algorithm model research plays an important role in the evolution of enterprise organizational capabilities (Ji and Huang, et al. 2023), which can realize the precise positioning and real-time control of genetic algorithm model research (Ren and Wu, et al. 2021). However, the traditional genetic algorithm model research scheme has the of poor accuracy (Ji and Chen, 2023), which has an adverse impact on the research effect of the genetic algorithm model (Gu, 2022). In an ever-changing market environment, the capabilities of business organizations need to evolve to adapt to external challenges (Zeng and Zhu, et al. 2021). Complex Adaptive Systems (CAS) theory provides a theoretical basis for understanding how firms adapt to environmental changes as an organic whole (Ren and Wu, et al. 2021). The CAS theory views the enterprise as a system of interacting individuals who are able to learn, evolve, and adapt to each other. In such a system, the genetic algorithm model can be used as an effective tool to simulate the evolution process of enterprise capabilities (Xue and Lin, et al. 2021).

## 2 RELATED CONCEPTS

### 2.1 Mathematical Description of the CAS Theory

Genetic algorithms (GAs) are search heuristics that mimic natural selection and genetics. It simulates the genetics, mutations, selection, and crossover of biological evolutionary processes to find the optimal solution or the most adaptable solution (Zhou, 2023). In the evolution of organizational capabilities, genetic algorithms can help enterprises find the most effective capability allocation among many possible capability combinations.

$$\lim_{x\to\infty}(y_i \cdot t_{ij}) = \lim_{x\to\infty} y_{ij} \geq \max(t_{ij} \div 2)\mathrm{K} \quad (1)$$

The judgment of outliers is shown in Equation (2).

$$\max(t_{ij}) = \partial(t_{ij}{}^2 + 2 \cdot t_{ij}) \succ \frac{1}{2}(\sum t_{ij} + 4) \quad (2)$$



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First of all, we need to define the "genes" of the organization's capabilities. These can be a business's key business processes, management practices, technological innovations, or anything that can impact the performance of the business (Cheng and Shao, et al. 2023). The different combinations of these genes represent the different capabilities of the enterprise.

$$F(d_i)=\frac{n!}{r!(n-r)!}\sum t_i\bigcap\xi\cdot\sqrt{2}\to\oint y_i\cdot 7 \tag{3}$$

## 2.2 Selection of Genetic Algorithm Model Research Scheme

Next, the genetic algorithm simulates the evolution of enterprise capabilities through the following steps: Initialize Populations – Create a random set of enterprise capability configurations as the initial populations.

$$g(t_i)=\ddot{x}\cdot z_i\prod F(d_i)\frac{dy}{dx}-w_i\mathrm{K}\Phi \tag{4}$$

Assess Fitness – Assess the fitness or performance of each capability configuration based on the market environment and internal conditions of the enterprise.

$$\lim_{x\to\infty} g(t_i)+F(d_i)\le\frac{\Delta y}{\Delta x}\max(t_{ij}) \tag{5}$$

Selection – Select the best competency profile based on fitness scores as the foundation for the next generation.

$$\overline{g(t_i)}+F(d_i)\leftrightarrow mean(\sum t_{ij}+4) \tag{6}$$

## 2.3 Analysis of the Genetic Algorithm Model Research Scheme

Crossover & Mutation – Cross and recombine selected configurations, as well as random variations, to generate new diversity. Repeat – Iterate over and over again until you find the optimal enterprise capability configuration or reach a preset number of iterations.

$$No(t_i)=\frac{\overline{g(t_i)}+F(d_i)}{mean(\sum t_{ij}+4)}\frac{\partial^2\Omega}{\partial u\partial v} \tag{7}$$

In this way, genetic algorithms can not only help companies identify and develop the most appropriate capability configuration for the current environment, but also be able to anticipate possible future changes and prepare in advance (Liu and Ma, et al. 2023). This forward-looking capability adjustment is the key for enterprises to maintain a leading position in the fierce market competition.

$$Zh(t_i)=\bigcap\ [\sum\overline{g(t_i)}+F(d_i)] \tag{8}$$

As a powerful optimization tool, the application of genetic algorithm in the evolution of enterprise organizational capability based on CAS theory provides a methodology for enterprises to dynamically adapt to environmental changes (Cheng and Liu, et al. 2023). By simulating the process of biological evolution, companies can continuously explore and optimize their own capabilities to gain an advantage over the competition.

$$accur(t_i)=\frac{\min[\sum\overline{g(t_i)}+F(d_i)]}{\mathbf{R}\sum\overline{g(t_i)}+F(d_i)}\times 100\% \tag{9}$$

The application of genetic algorithms not only enhances the adaptability of enterprises, but also promotes their continuous innovation and development (Xie and Zhao, et al. 2021). With the increasing complexity of the business environment, mastering advanced tools such as genetic algorithms has become an indispensable core competitiveness for enterprises.

$$accur(t_i)=\frac{\min[\sum\overline{g(t_i)}+F(d_i)]}{\sum\overline{g(t_i)}+F(d_i)} \tag{10}$$

Within the theoretical framework of Complex Adaptive Systems (CAS), a company is seen as an organism that is constantly evolving, learning, and adapting to its environment. In such a system, the evolution of organizational capabilities is the key to the survival and development of enterprises. Genetic algorithms (GA), as an optimization technology that simulates the evolutionary process in nature, have been proven to have unique advantages in promoting the evolution of organizational capabilities.

# 3 OPTIMIZATION STRATEGIES FOR GENETIC ALGORITHM MODEL RESEARCH

In this paper, we will discuss how genetic algorithm can promote the evolution of enterprise organizational capabilities under CAS theory, and analyze its application and challenges in practical operation. Genetic algorithms enable firms to discover optimal or near-optimal solutions in their set of organizational capabilities by simulating variation, crossover, and selection mechanisms in the process of natural selection.

## 3.1 Introduction to the Research of Genetic Algorithm Model

From the perspective of CAS theory, the evolution of enterprise organizational capabilities is not only an optimal allocation of existing resources, but also a dynamic process involving innovation, learning, and adaptation. Genetic algorithms provide a framework that enables companies to find the most adaptable combination of capabilities in an ever-changing market environment in Table 1.

Table I. Genetic algorithm model research requirements

| Scope of application | Grade | Accuracy | Genetic algorithm model research |
|---|---|---|---|
| Small business | I | 91.39 | 90.41 |
| | II | 88.81 | 88.14 |
| Medium-sized businesses | I | 88.90 | 86.69 |
| | II | 92.59 | 89.12 |
| Large | I | 90.88 | 90.29 |
| | II | 91.62 | 88.93 |

The genetic algorithm model research process in Table 1 is shown in Figure 1.

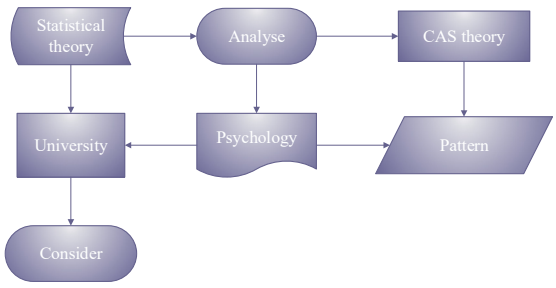


Figure 1: The analysis process of a genetic algorithm model study

First of all, the core of genetic algorithms lies in their ability to handle complex search spaces, which means being able to find the best combination of multi-dimensional organizational capabilities. For example, enterprises need to continuously optimize in many aspects such as technological innovation, market development, and human resource management. Genetic algorithms are able to take these dimensions into account and progressively approximate the optimal solution through an iterative process.

## 3.2 Research on Genetic Algorithm Models

Second, genetic algorithms emphasize population-level evolution rather than individual evolution. In the evolution of organizational capabilities, this means that the entire organization needs to evolve as a collective, rather than relying on the optimization of individual departments or individuals. The accumulation and inheritance of collective wisdom is the key to maintaining the competitiveness of enterprises in the fierce market competition.as shown in Table 2.

Table 2: The overall situation of the genetic algorithm model research scheme

| Category | Random data | Reliability | Analysis rate |
|---|---|---|---|
| Small business | 89.55 | 89.66 | 91.77 |
| Medium-sized businesses | 87.95 | 91.54 | 91.65 |
| Large | 90.60 | 89.82 | 91.70 |
| Mean | 91.73 | 92.95 | 90.93 |
| X6 | 91.90 | 88.05 P=1.249 | 92.17 |

## 3.3 Genetic Algorithm Model Research and Stability

Furthermore, the mutation manipulation in genetic algorithms provides innovative possibilities for the evolution of organizational capabilities. in Figure 2.

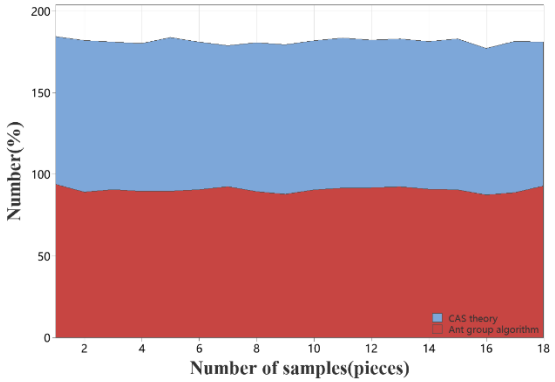


Figure 2: Study of genetic algorithm models for different algorithms

In practice, enterprises can simulate the mutation process by introducing new workflows, management methods or technological innovations, so as to jump out of the local optimal and find a new evolutionary path.

Table 3: Comparison of the research accuracy of genetic algorithm models of different methods

| Algorithm | Survey data | Genetic calculations Law model research | Magnitude of change | Error |
|---|---|---|---|---|
| CAS Theory | 90.46 | 92.52 | 87.30 | 90.47 |
| Ant colony algorithm | 90.39 | 91.02 | 89.06 | 89.06 |
| P | 92.35 | 90.65 | 91.71 | 88.71 |

However, genetic algorithms also face challenges in practical applications. The first is the selection of parameters, such as the rate of variation, crossover rate, and selection strategy, which directly affect the efficiency of the algorithm and the quality of the final result. The second is how to combine the abstract model of genetic algorithm with the actual operation of the enterprise, which requires a deep understanding of the business process and management mechanism. Finally, genetic algorithms require a sufficient number of iterations to ensure that the solution space is fully explored, which is a test of time and resource investment.and the specific results can be referred to Figure 3. These professional analysis data further verify the superiority of CAS theory in the study of genetic algorithm models.

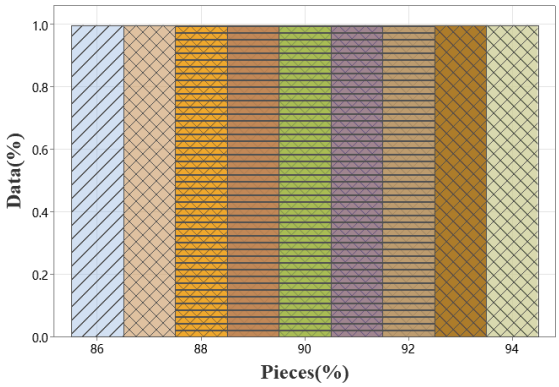


Figure 3: Research on the genetic algorithm model of CAS theory

In summary, genetic algorithm, as an optimization tool, plays an important role in the evolution of enterprise organizational capabilities under the guidance of CAS theory. By simulating the evolutionary mechanisms of nature, genetic algorithms can help companies find the most effective combination of organizational capabilities in a complex and volatile market environment. Despite some challenges, genetic algorithms will undoubtedly provide strong support for the continued growth and adaptability of enterprises as long as they are properly designed and applied.

## 3.4 Rationality of Genetic Algorithm Model Research

In order to verify the accuracy of the CAS theory, the genetic algorithm model research scheme is comprised with the ant colony algorithm, and the genetic algorithm model research scheme is shown in Figure 4.

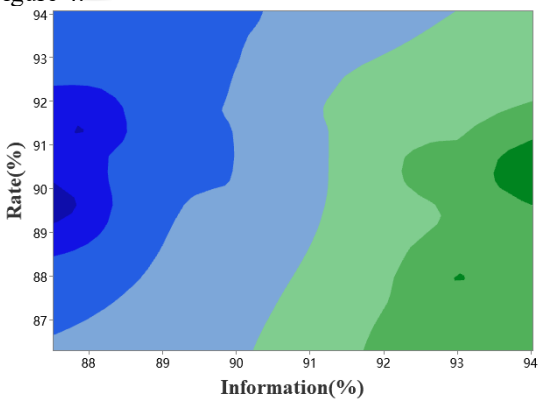


Figure 4: Study of genetic algorithm models for different algorithms

In complexity science, the Complex Adaptive System (CAS) theory reveals how systems in a constantly changing environment adapt and evolve through self-adjustment. Genetic Algorithms (GA) is an intelligent search optimization method that mimics the process of biological evolution. The combination of the two shows great potential to improve the organizational capacity of enterprises, like the double helix of DNA, intertwined with each other, and together promote the adaptability and innovation of enterprises to a new level.

## 3.5 Effectiveness of Genetic Algorithm Model Research

First, let's examine the core elements of CAS theory – adaptability, nonlinearity, and emergence. As a typical complex adaptation system, the structure and function of an enterprise organization are constantly adjusted according to changes in the external environment. This bottom-up, self-organizing structure gives businesses the flexibility and resilience they need in the face of uncertainty. in Figure 5 shows below.

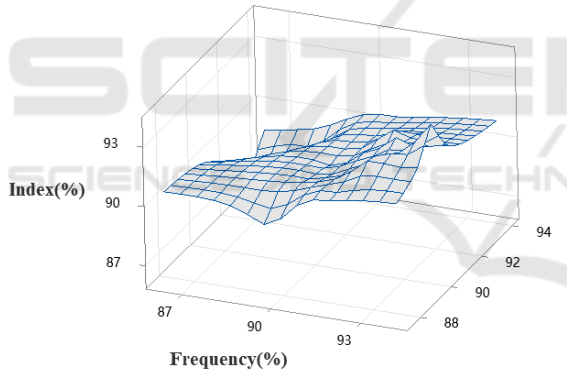


Figure 5: Research on genetic algorithm models for different algorithms

At the same time, the nonlinear characteristics suggest that small input changes can trigger unpredictable large outcomes, emphasizing the development characteristics of firms that are sensitive to initial conditions and dependent paths. The emergent phenomenon explains how new macro-level attributes or functions arise through interactions between individuals, which is the source of innovation in Table 4.

Table 4. Comparison of the effectiveness of genetic algorithm model research of different methods

| Algorithm | Survey data | Genetic algorithm model research | Magnitude of change | Error |
|---|---|---|---|---|
| CAS Theory | 89.70 | 87.52 | 91.35 | 87.54 |
| Ant colony algorithm | 92.58 | 88.94 | 88.58 | 93.26 |
| P | 88.05 | 93.03 | 90.70 | 91.09 |

It is in this theoretical context that genetic algorithms come into play. As a computational model of natural selection, it draws on the mechanisms of crossover, variation, and selection in biological genetics to solve optimization problems. In the construction of enterprise organizational capabilities, we can regard various business strategies and management models as different "genes", which finally form the most suitable corporate strategy for the current environment by simulating the genetic process in nature, through a series of iterations and screenings. In this process, the principle of "survival of the fittest" is applied to business management practices in order to achieve the optimal organizational state. Figure 6 shows below.

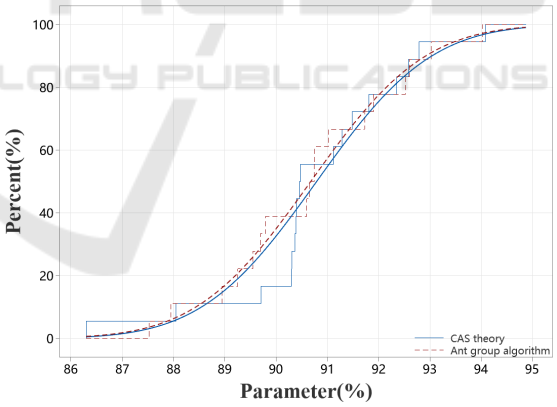


Figure 6: Research on the genetic algorithm model of CAS theory

Combining CAS theory and genetic algorithms, we realize that the improvement of organizational capabilities is not an overnight result, but a continuous evolutionary process. In this process, various factors within the enterprise – such as employee skills, management processes, corporate culture, etc. – are like various genes in the genetic material, they interact with each other, influence each other, and promote the evolution and maturity of the

entire organization through continuous trial and error, learning, and adaptation.

In practice, the use of genetic algorithms for organizational capacity optimization can be manifested in a variety of ways. For example, in the development of new products, companies can efficiently find the product solution that best meets the needs of the market by simulating the combination of different product designs (gene combinations), market feedback (natural selection), and design improvements (variation). Or in human resource management, by simulating the "genetic" process of employee training programs, the training model that best enhances team performance is selected.

# 4 CONCLUSIONS

In addition, the combination of CAS theory and genetic algorithm also provides a new perspective for enterprises to understand internal conflicts and contradictions. These seemingly negative factors may actually be important drivers of enterprise evolution. Just as mutations in biological evolution can sometimes lead to greater adaptability, some "non-traditional" thinking and approaches in a business can be the key to breaking new ground.

In conclusion, the combination of CAS theory and genetic algorithm provides us with a powerful set of tools and frameworks to understand and guide the construction of organizational capabilities. This is not only a revolution in enterprise management theory, but also a useful attempt to practice business. When we broaden our vision to the global level of complex systems, we can more clearly capture the context of organizational development, so as to take advantage of the fierce market competition.

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