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APPLICATION OF MULTI-OBJECTIVE OPTIMIZATION ALGORITHM BASED ON ARTIFICIAL FISH SCHOOL ALGORITHM IN FINANCIAL INVESTMENT PORTFOLIO PROBLEMS

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Abstract. In order to comprehensively measure these two indicators and make reasonable portfolio investment decisions, the author proposes using swarm intelligence optimization algorithm - artificial fish swarm algorithm to solve multi-objective investment portfolio problems, and has achieved good results. In order to verify the effectiveness and superiority of the artificial fish school algorithm, the author used MATLAB programming to conduct simulation experiments using AFSA algorithm and genetic algorithm (GA), and compared the results obtained. The results show that compared to the GA algorithm, the artificial fish school algorithm can obtain better investment portfolio decision-making solutions for investing in five types of assets, making investment returns as large as possible while minimizing risks, indicating the efficiency and superiority of the algorithm in solving multi-objective investment portfolio problems.

Key words: Artificial fish school algorithm, Multi objective optimization algorithm, Financial investment, Combinatorial problem

1. Introduction. With the continuous development of the market economy in today's society and the increasingly fierce social competition, the competitive field of asset investment has gradually penetrated into various industries and even people's daily financial life. However, when investing, there will inevitably be complex multi-objective investment portfolio problems, which cannot avoid complex calculations, therefore, in the face of the difficulty that existing mathematical programming methods cannot directly solve multi-objective investment portfolio problems, the author considers solving this problem from the perspective of highly efficient swarm intelligence optimization algorithms that have emerged and developed in recent years, which involves handing over a large amount of complex computational work to computers to complete. The so-called optimization algorithm basically describes search or rule based strategy or specific process, and gets the solution which can achieve user expectation by some search rules and channels. The theoretical research and practical application of optimization algorithms have made great progress, and many scholars have attempted to apply them to solve various engineering optimization problems. Many studies have shown that their problem-solving ability is higher than other traditional algorithms, and they have achieved good results, especially in combinatorial optimization problems. Therefore, people insist on innovative research on the theory and application of optimization algorithms. The author chooses a new type of swarm intelligence optimization algorithm - artificial fish swarm algorithm for research and applies it to solve practical problems [1]. The artificial swarm algorithm adopts a new method which is different from other optimization algorithms. There are some differences between the specific implementation of algorithms and the overall design idea, compared to the design method and the solution. However, it can also be combined with other traditional methods. AFSA does not require the initial values, measurement values, or properties of the target function. It has the potential to overcome local weaknesses and globalization. It is precisely because of the excellent characteristics that artificial fish swarm algorithm has attracted great interest and extensive attention from researchers from all walks of life at home and abroad since it has been applied. At present, the research and application of artificial fish swarm algorithms have entered many disciplines and been used to solve practical problems. This conclusion has become a research topic with high research value.So far, although the artificial fish school algorithm has been studied and applied by many scholars in related fields, its application scope and improvement work on the algorithm itself still need further improvement and expansion. Therefore, the author's research on using

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artificial fish school algorithms to solve multi-objective investment portfolio problems has important theoretical significance and practical application value for both the field of economics and computer science [2]. At the same time, it is also a preliminary exploration of the application of artificial fish swarm algorithm in the field of multi-objective investment portfolio.

Artificial Fish Swarm Algorithm (AFSA) is an intelligent swarm algorithm based on the behavior of fish game, which simulates the basic behavior of animals.Since its proposal, AFSA has received widespread attention from domestic and foreign researchers, as well as in-depth research and practical applications. So far, there have been hundreds of relevant references on the research and application of AFSA, indicating the significant influence of this algorithm both domestically and internationally. Related studies have shown that although the artificial fish swarm algorithm has many superior characteristics, it still has some shortcomings, such as low solving accuracy, being trapped in local extremum and low efficiency, and slow convergence speed in the later stage. In response to these shortcomings, scholars have adopted different design methods for exploratory research and improvement, making the algorithm more effective in solving practical problems.

In the process of capital market, rational investors will decide how to allocate some risk factors which they hold in an appropriate way, in order to achieve the goal of increasing risk as much as possible and obtaining the maximum funds.How to comprehensively measure the two main factors that constrain capital investment, namely investment risk and investment return, and make reasonable portfolio investment decisions, this also leads to a multi-objective investment portfolio problem. And this problem belongs to a complex nonlinear programming problem, which is difficult to be effectively solved by traditional algorithms. Therefore, the author proposes to use swarm intelligence optimization algorithm - artificial fish swarm algorithm to solve multi-objective investment portfolio problems, and has achieved good results [3].

2. Methods.

2.1. Multi-objective investment portfolio problem and its model. Assuming there are n assets Si (i=1,.., n) available for investors to choose from in the market, with an existing amount of M of funds used for a period of investment. The average return on purchasing Si during this investment period is ri, and the expected risk loss rate is qi. There is a certain level of risk in the investment process. Consider using the largest risk among n assets to measure overall risk. Assuming that a certain transaction fee needs to be paid when purchasing an asset, let the transaction rate paid for purchasing Si be pi. When the purchase amount does not exceed the given value ui, the transaction fee will be calculated based on ui; Furthermore, assuming that the deposit interest rate deposited into the bank is fixed [4]. Establish the following multi-objective investment portfolio model, assuming that the proportion of funds for purchasing asset Si to the total M is xi, the required transaction cost is:

$$T(x_i) = \begin{cases} 0, x_i = 0 \\ u_i p_i, 0 < Mx_i \leqslant u_i \\ (Mx_i)p_i, Mx_i > u_i \end{cases} \tag{2.1}$$

The total net income during an investment period is recorded as V:

$$V = \sum_{i=1}^{n}(Mx_i r_i - T(x_i)) \tag{2.2}$$

For an investment period, the overall risk (taking the maximum risk) is recorded as R:

$$R = \max_{1\leqslant i\leqslant n}\{Mx_i q_i\} \tag{2.3}$$

In order to maximize returns and minimize risks, the mathematical model for the multi-objective investment portfolio problem is:

$$\begin{aligned} max \quad v &= max\{\sum_{i=1}^{N}(Mx_i r_i - T(x_i))\} \\ min \quad R &= min\{1 \leqslant i \leqslant n\{Mx_i q_i\}\} \end{aligned} \tag{2.4}$$

2.2. The principle of artificial fish school algorithm . The main idea of the Artificial Fish Swarm (AFSA) algorithm is that in the body of water, the area where fish are most abundant is usually the area with the most nutrients. This decision is based on these characteristics to simulate the food, crowd, end-to-end collisions, and behavior of fish schools, in order to achieve global development.

(1) Individual definitions of artificial fish. The individual state of artificial fish can be represented as a vector $X = (x_1, x_2, ..., x_n)$, where xi (i=1, 2, n) is the variable to be optimized; The food concentration at the current location of the artificial fish is expressed as Y=f (X); The distance between artificial fish individuals is expressed as $d_{ij} = ||X_i - X_j||$; The maximum number of attempts per foraging for artificial fish is trynumber, the perceived distance for artificial fish is visual, the maximum movement step for artificial fish is step, and the crowding factor is δ[5,6].

(2) Description of artificial fish behavior.

Foraging behavior: Set the current state of the artificial fish to X_i, and randomly select a state X_j within its perceptual range (visual), if the food concentration in this state is better than its current state, the artificial fish will move one step forward in that direction; On the contrary, randomly select state X_j again to determine whether the forward condition is met. After repeated attempts at trynumber, if the condition is still not met, randomly move one step.

Crowding behavior: Set the current state of artificial fish to X_i, explore the number of $(d_{ij} < visual)$ partners nf and their central position Xc in the current field, if $Y_{cnf} < \delta Y_i$, it indicates that the food concentration at the center position is better than the current state and not too crowded, and the artificial fish moves forward towards the Xc position. Otherwise, they perform foraging behavior [7].

Tail chasing behavior: Set the current state of the artificial fish to X_i, and explore the optimal partner X_{max} in the current field, if $Y_{max}mf < \delta Y_i$, it indicates that the food concentration at the partner's location is better than the current state and the surrounding area is not too crowded. If not, the artificial fish will move forward towards the X_{max} position. Otherwise, they will engage in behavioral activities.

Random behavior: This behavior is easy to execute and is the original behavior for the behavior.

Report board: used to record the status of the best fishermen. During the refining process, each artificial fish compares itself with the status of the reports. If the status of the news report itself is improved, it will be adjusted to its own status so that the news report can record the best events in history.

2.3. Multi-objective investment portfolio problem based on AFSA algorithm.

(1) Model optimization. For the solution of the multi-objective investment portfolio problem described by the author, the following method can be used to first transform it into a single objective problem, and then solve it: Set weights ρ for the weight of the total net investment return, then $1 - \rho$ weighting the overall investment risk $(0 \leqslant \rho \leqslant 1)$, so the above multi-objective investment portfolio model can be transformed into a single objective model as follows:

$$\begin{gathered} max \quad F(x) = \rho \times V + (1-\rho)(-R) \\ max \quad F(x) = \rho \times \sum_{i=1}^{N}(rMx_i - T(x)) + (1-\rho) \times (\max_{1\leqslant i\leqslant n}\{Mx_iq_i\}) \\ s.t. \begin{cases} \sum_{i=1}^{N} x_j = 1, 0 \leqslant x_i \leqslant 1 (i = 1, 2, ..., n) \\ 0 \leqslant \rho \leqslant 1 \end{cases} \end{gathered} \tag{2.5}$$

For the model ρ investors can make appropriate adjustments based on their own situation to obtain appropriate investment portfolio decisions [8].

(2) Steps for solving the model. The steps to solve multi-objective investment problems using AFSA algorithm are as follows:

Step 1: Start the size of artificial fish stocks, automatically create N artificial fish stocks, set the requirement for the algorithm, including the quantity of simulation and simulation of artificial fish stocks movement, the detection by artificial fish stocks, the large-scale step artificial fish stocks movement, and the crowds are equal δ the maximum number of iterations to achieve the algorithm.

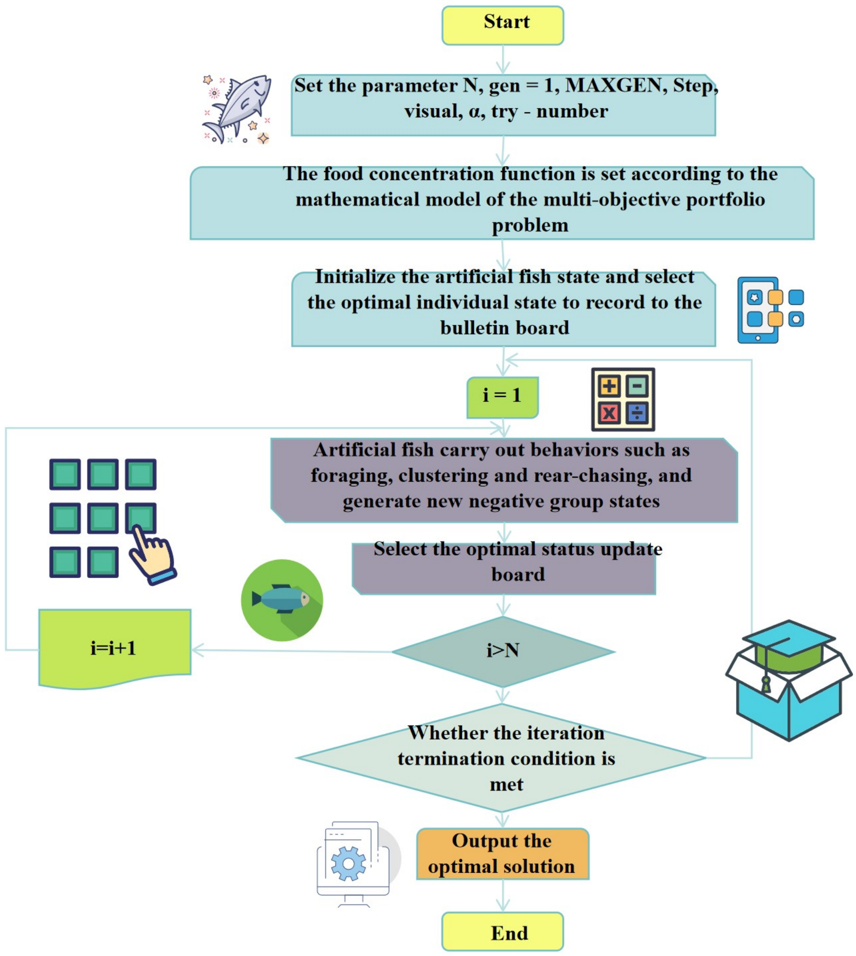

Fig. 2.1: Steps for solving multi-objective investment portfolio problems using AFSA algorithm

Step 2: According to the mathematical model of multi- objective investment problem, set up the food concentration function of the algorithm.
Step 3: Sample the current menu of all the fake fishermen and list the status of the best person on the poster.
Step 4: Each artificial fish acts as a laborer, crowded, and tailor -made, chooses the best practices, and modifies its own state.
Step 5: After the update, each fake fish will compare its status with the reports. If the effect is greater than the sign, the status of the sign will be adjusted.
Step 6: Determine the decision for the algorithm. If iteration termination condition is met, output the calculated result; output otherwise, continue with step 4.

Figure 2.1 shows the steps to solve a multi-objective investment portfolio problem using the AFSA algorithm.

3. Simulation experiments. In order to verify the effectiveness and efficiency of the artificial fish school algorithm, the author made a simulation of AFSA algorithm and genetic algorithm (GA) using MATLAB programming, and compared the results. There are five investment assets available for selection, with a total investment amount of M of 1000 yuan. The data on the return rate, risk loss rate, and other factors of each asset are shown in Table 3.1 [9].

The parameters of artificial fish school algorithm were set fish school size of 50%, the quantity of iterations

Table 3.1: Relevant data of various investment assets

S_i	r_i	q_i	p_i	u_i
S_1	29	2.6	1.1	104
S_2	24	5.6	4.6	53
S_3	22	1.6	2.1	199
S_4	6	0	0	0
S_5	26	2.7	6.6	41

Table 3.2: Different ρ optimal investment portfolio corresponding to the value

ρ	x_1	x_2	x_3	x_4	x_5	V(%)	R(%)	F(x)
0.0	0.000	0.000	0.000	1.000	0.000	5.00	0.00	0
0.1	0.2882	0.0825	0.3876	0.0029	0.2393	21.105	0.721	14.63
0.3	0.6786	0.3125	0.000	0.0092	0.000	24.146	1.697	60.57
0.5	0.8668	0.0094	0.0147	0.0136	0.0959	25.135	2.168	114.85
1.0	1.000	0.000	0.000	0.000	0.000	27.01	2.51	270.01

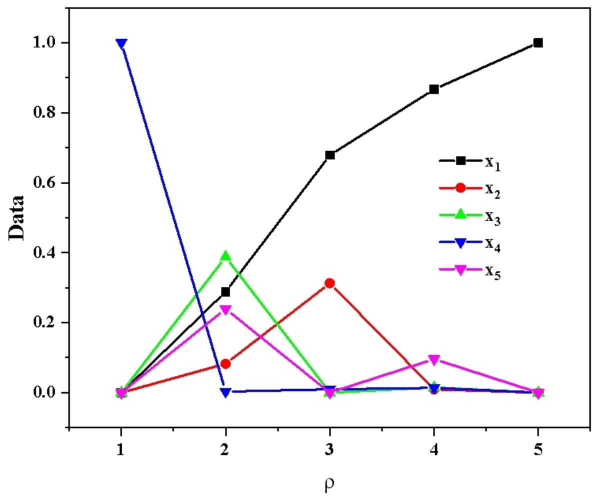

Fig. 3.1: Different ρ optimal investment portfolio corresponding to the value

of 100%, observed = 2.5%, moving step size = 0.4%, and population coefficient. respectively. δ=0.618, and detection calculation=100; Using MATLAB programming to adopt different risk ρ Resource allocation method is shown in table 3.2 and Figure 3.1.

From Table 3.2, it can be seen that for multi-objective investment portfolio problems, under different risk preferences, the artificial fish school algorithm can obtain better fund investment portfolio schemes. The simulation experiment results show the effectiveness and feasibility of AFSA algorithm to solve such problems. The range of iterations for genetic algorithm used for comparison is N=100,with a crossover probability of 0.8,a mutation rate of 0.01%,and a population size of P=100;The comparison of investment portfolio schemes based on the calculation results is shown in Table 3.3 and Figure 3.2 (assuming ρ= 0.5).

From Table 3.3, it is evident that for investing in five types of assets, compared to the GA algorithm, the

Table 3.3: Comparison of Investment Portfolio Plans

	x_1	x_2	x_3	x_4	x_5	V(%)	R(%)
GA	0.9073	0.0022	0.0008	0.0893	0.0009	25.008	2.269
AFSA	0.8668	0.0094	0.0147	0.0136	0.099	25.135	2.168

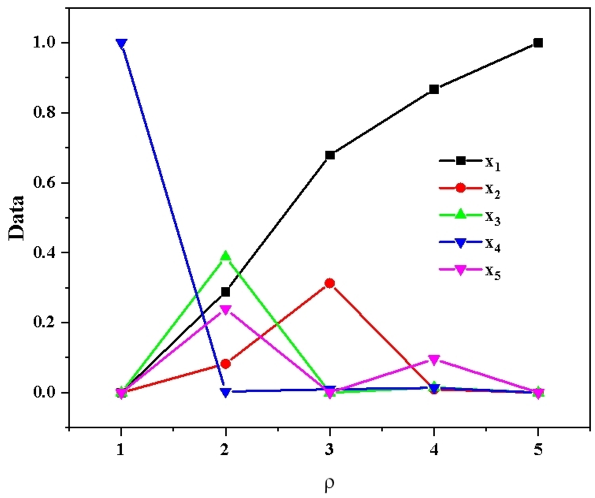

Fig. 3.2: Comparison of Investment Portfolio Plans

artificial fish school algorithm can obtain better investment portfolio decision-making solutions, maximizing investment returns while minimizing risks, indicating the efficiency and superiority of the algorithm in solving multi-objective investment portfolio problems [10].

4. Conclusion. The author proposed to study and apply the artificial fish school algorithm to multi-objective investment portfolio problems, and achieved good results through MATLAB programming. Experimental results show that this algorithm performs very well in solving such problems, but as a new type of optimization algorithm, there are still some shortcomings.Therefore, further research and improvement are needed to improve the performance of solving such problems when there are a large number of assets and investment funds.

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