Weapon Target Assignment Based on Improved Artificial Fish Swarm Algorithm

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***Abstract*—Weapon-Target Assignment (WTA) problem is the key of air defense command and control. Therefore, it is an urgent problem to complete the assignment quickly and efficiently. In this paper, an improved artificial fish swarm algorithm is proposed to improve assignment rate. Based on artificial fish swarm algorithm (AFSA), particle swarm optimization (PSO) is introduced to change the individual visual of artificial fish, and genetic operator is added to avoid the local extremum trap. The proposed algorithm is validated by the concrete cooperative air defense examples. The simulation results show that the algorithm improved the computational accuracy and the rate of convergence in solving weapon-target assignment problem in air defense.**

Keywords—weapon-target assignment; artificial fish swarm algorithm; particle swarm optimization; genetic algorithm

I. INTRODUCTION

Weapon-target assignment is a process that maximizes the effectiveness of target attack. The primary concern is minimizing the total expected survivability of the targets [1,2]. Considering the real-time performance of air combat, the problem must be solved as fast as possible. The artificial fish swarm algorithm simulating the behavior of a fish inside water was proposed by Li et al [3]. It simulates the process of global optimization through the autonomous cooperation among fish swarm. The algorithm is simple and easy to implement, and has the characteristics of insensitive initial value and strong robustness [4,5]. However, artificial fish swarm algorithm has slow rate of convergence and is easy to fall into local optimal trap. Thus, some researchers have made improvements to these defects. Documents [6] and [7] improved the precision of optimization by changing the visual and step length of artificial fish adaptively, but it is easy to fall into the local extremum. Document [8] proposed an improved artificial fish swarm algorithm based on double chaos mapping , which makes use of ergodicity and initial value sensitivity of chaotic search , so that artificial fish groups trapped in local extreme values jump out of the trap , but the operation speed is slower. On this basis, the inertia weight of particle swarm optimization algorithm is introduced to change the visual of fish swarm to accelerate the rate of convergence, genetic algorithm is combined to prevent from falling into the trap of local optimum.

II. WTA PROBLEM FORMULATION

Suppose that there are M weapon platforms and N targets, weapons in a weapon platform have the same attack effect on the target and one target can be attacked by multiple weapon platforms synchronously. The threat degree of target j is $\omega_j\,(j=1,2,\cdots N)$, $\Sigma_{j=1}^{N}\omega_j=1(\omega_j\ge 0)$. The damage probability matrix can be written as $[p_{ij}]_{M\times N}(0\le p_{ij}\le 1)$ .Where p_{ij} is the damage probability of the target j by the weapon of the i .The assignment matrix is $[x_{ij}]_{M\times N}$, where x_{ij} represents that the weapon platform i attacks the target j and the detail of x_{ij} is as follows:

$$x_{ij}=\begin{cases}1, weapon\ i\ attack\ target\ j\\ 0, otherwise\end{cases}$$

Based on the above assumptions and the application background of WTA problem, the overall damage probability of the target f can be selected as the evaluate indexes. The mathematical model of WTA problem is as follows:

$$\max f=\sum_{j=1}^{N}\omega_j(1-\prod_{i=1}^{M}(1-p_{ij})^{x_{ij}}) \tag{1}$$

$$s.t.\begin{cases}\sum_{i=1}^{M}x_{ij}\ge 1, j=1,2,...,N\\ \sum_{j=1}^{N}x_{ij}=1, i=1,2,...,M\end{cases} \tag{2}$$

III. PROPOSED ARTIFICIAL FISH SWARM ALGORITHM

To improve the computational accuracy and the rate of convergence of the algorithm, several modifications were introduced into the AFSA. Concrete implementations are presented below.

Self-Adaptive Visual Procedure In this algorithm, the particle swarm algorithm of linear decreasing inertia weight strategy is fused with artificial fish swarm algorithm to form a new hybrid algorithm. This paper proposed an improved visual formulation as given in (3).

$$visual^{k}=visual^{k-1}\left(visual_{\min}+\left(rand(visual_{\max}-visual_{\min})\right)\right) \tag{3}$$

where $visual^{k}$ and $visual^{k-1}$ is the visual at current iteration k and previous iteration $k-1$. $visual_{\max}$ and $visual_{\min}$ represent the upper and lower bounds of the visual, respectively.

Genetic behavior In order to prevent from falling into local optimum, genetic operators are introduced to simulate the genetic behavior of fish populations. Let k be the number of genetic iterations for artificial fish populations. $\sum_i Y_{k,i}$ represents the total food concentration of the k generation artificial fish stock. The level of food concentration obtained by the K generation of artificial fish $X_{k,i}$ is $\overline{y_{k,i}} = Y_{k,i} / \sum_i Y_{k,i}$ 。 In order to reduce the amount of calculation, two copies of the first 20% of the food concentration level, one copy of the middle 40% portion, and 20% copies of the last 20% copies were selected from the artificial fish herd of generation k. This paper adopts single point crossing.

Algorithm process

Step 1: Initialize parameter: set the population size is of artificial fish n, visual initialization $visual_{\min}$ 、 $visual_{\max}$, congestion factor δ , the maximum try number N_{try} , the maximum number of iterations $T_{\max}$;

Step2: Perform swarm behavior and follow behavior, calculate objective functions, compare and record optimal solutions. If the two behaviors fail to change to step 3; If two behaviors fail, switch to step 4;

Step3: Execute the prey behavior, update the optimal solution;

Step4: Calculate and sort the total food concentration and the level of individual food concentration artificial fish.

Step5: Calculate the number of artificial fish that needs to be genetically duplicated is required in the artificial flock.

Step6: Inheritance, crossover, variation;

Step7: Changed the visual of artificial fish according to the inertia weight of particle swarm optimization;

Step8: Set the current number of iterations $k = k + 1$,if k reaches the maximum number of iterations or default precision, stop the algorithm, otherwise switch to Step2.

IV. SIMULATION RESULTS

Assume that there are three weapon platforms, the total number of the three weapon platforms is 12. The number of targets is 4 and the threat degree vector of targets is [0.15 0.36 0.18 0.31]. The damage probability matrix P is defined as follows:

$$P = [0.78\ 0.76\ 0.62\ 0.71; 0.92\ 0.68\ 0.59\ 0.59; 0.86\ 0.93\ 0.77\ 0.69]$$

In order to verify the convergence of our algorithm, the improved artificial fish swarm algorithm (IAFSA) is compared with genetic algorithm(GA) and artificial fish swarm algorithm(AFSA). The global average minimum, the global minimum and the average running time of each experiment are taken as the indexes to evaluate the performance of the algorithm. The results of 100 consecutive runs are shown in Fig 1, Table 1.

TABLE I. COMPARISON OF THREE ALGORITHMS

Algorithm	*IAFSA*	*GA*	*AFSA*
Gobal minimum	0.0065	0.0084	0.0073
Global average minimum[a]	0.101	0.0191	0.0104
Average running time(s)	0.977	0.426	0.661

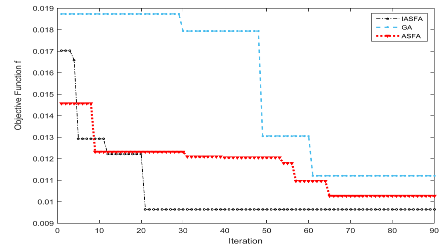

Fig. 1. Minimum Evolutionary Curve of three algorithms

It can be seen from Fig 1 and Table 1 that the convergence rate of IAFSA is faster than that of AFSA and GA. However, IAFSA adds food concentration ordering and genetic operators at each iteration, the average running time of a given number of iterations is probably longer than that of the other two algorithms. But the time of getting the optimum value is about 0.2 S. It is shorter time than other algorithms.

V. CONCLUSION AND FUTURE WORKS

In order to improve the computational accuracy and the rate of convergence of the artificial fish swarm algorithm, an improved AFSA in weapon-target assignment is proposed. The algorithm is tested by a concrete WTA problems in air defense; the results validate the superiority of the proposed approach.

ACKNOWLEDGMENT

The paper is funded by National Natural Science Foundation of China (Grant No. 61701134), the Natural Science Foundation of Heilongjiang Province China (Grant No. F2017004), the National key foundation for exploring scientific instrument of China (Grant No. 2016YFF0102806) and the International Exchange Program of Harbin Engineering University for Innovation-oriented Talents Cultivation.

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