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The Weapon Target Assignment Strategy Research on Genetic Algorithm

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Abstract. The weapon target assignment is an important problem in modern air defense combat with multi-objects and fighters. The weapons units arrange is a dynamic and complex process, for saving weapons resources and attacking target effectively, the weapon target assignment model satisfies expected damage probability, the performance analysis such as target threat degree, the weapon attack priority and the target attack cost must be took into consideration. The optimization strategy and efficient formula for weapon target assignment are presented in surface to air missile defense system here, the mathematical model search for the optimization solution by genetic algorithm and obtain optimal efficiency in target attack. An illustration verifies the superior model and the effective algorithm.

Keywords: Target Assignment; Threat Assessment; Priority Exponent; Optimization Strategy; Intercept Time

1. Introduction

The multi-fighter operation gets more and more common in modern information warfare, the advantage of all weapon units is utilized fully to intercepts targets effectively. Therefore, weapon target assignment (WTA) will complete the data fusion and efficiency calculation in air defense command system. According to battlefield situation, the target assignment scheme is calculated rationally for play attack performance of the fighter fully, which is provided to commander for decision-making such as avoiding repetitive attacks and cooperating each other.

The research shown, most fighters are shot down by medium-range missile within super eyesight distance in modern air combat. The air attack target adopted many means such as large fleet, multi-fighter and electronic interference. If the manual assignment is adopted in the confrontation, not only the fight time is too late but also the target assignment capacity is limit in whole system, which are all reduce combat efficiency. Therefore, in the multi-platform air defense system, the target assignment is important, which coordinate the combat action of weapon launch platform, for example, which and when the weapons attack the targets selected.

There has many types of missile weapon system, the target treats degree and operation performances in all kinds of weapon are different, which results in the target assignment become more complex. If the target assignment is completed by hand in combat, both the fight time and target assignment capacity are limited, which will reduce operational efficiency greatly. The classical combat way on experience and intuition can not be competent for modern air defense, the weapon target assignment strategy research is essential.

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2. Genetic Algorithm for Optimization Problem

The genetic algorithm with global optimization is proposed by professor Holland in 1962 at first, which received wide attention in intelligent computation fields widely. In fittest survival view in bio-genetics, the individual adaptability is raised through natural selection, genetic and mutation, this algorithm has obvious advantage in resolving difficult problem on large space, nonlinear, global optimization. Therefore, genetic algorithm is quickly extended to optimization, searching, machine learning and other research areas.

Genetic algorithm represent the problem solving as chromosome, thus a group of chromosomes is constituted and placed in problem environment, starting from an initialization group, selecting the chromosomes with good adaptation to environment for replicating and regeneration, a new generation of chromosomes group can be produced by two genetic manipulation such as crossover and mutation, which evolved to and converge to one of the most adaptable individuals eventually, the optimal solution is obtained. Research shows that if search time is long enough and the optimal solution of each generation can retain, the global optimal solution can always be searched.

As the strategy and method on overall searching only affect search direction of objective function and corresponding fitness function in calculation, therefore, genetic algorithm has versatility and robustness for solving optimization problems in complex systems, it is applied in engineering applications widely. The implementation principle of genetic algorithm showed in figure 1.

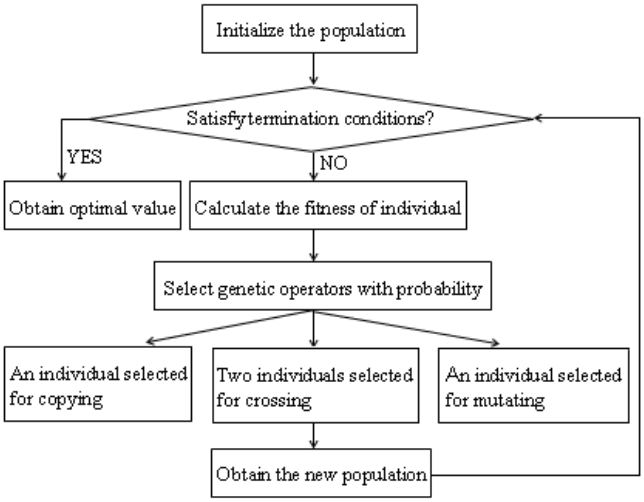

Figure 1. The work flow chart of genetic algorithm

Essentially, modern target assignment is a dynamic search process of best efficiency in mathematics model and lowest cost in target interception. Therefore, target assignment strategy and optimization decision-making based on genetic algorithm is researched here.

3. The Mathmatic Model for Target Assignment

3.1 Air missile defense system

Missiles are regarded as major weapon in modern warfare, and missile defense technology becomes hot research topic for military and information expert. The reasonable target assignment strategy and optimization algorithm for weapon target assignment improve operational effectiveness greatly. According to target threat degree and air combat priority index of target intercepted, the relative weigh for weapon unit of target attack is definite, the combined effect on target assignment result is weighed, which ensure high target interception as far as possible.

In multi-fighter air combat, the weapon target assignment problem is a challenge in information warfare, the air defense command system can assign weapon reasonably for eliminating the threat from enemy targets in time. The weapon target assignment research is focus on model and algorithm [1]. The selection rules of target function include the facts such as less resource and energy loss for fighter, the minimum threat degree and the minimum number of targets remaining, different selection rule reflect different decision intention,

which decided different target function form and combat strategy [2]. AS a NP-complete problem, with the number increasing in weapon units and targets, the solution space show the trend of combined explosion [3].

Before 80's in 20th century, the solution research on weapon target assignment is limit to classical algorithm such as the implicit enumeration, branch and bound methods, cutting plane method, dynamic programming, etc [4]. Then, the WTA problem is resolved by some intelligent optimization algorithms such as genetic algorithm, taboo search, neural networks, simulated annealing, ant colony algorithms and hybrid optimization strategies [5].

The linear programming optimization method is adopted to resolve the target assignment problem, the target function selection include the smash target function, defense target function and miss target function, which directly affects on target assignment and combat result. The classical target assignment method on linear programming only considers the kill probability of different weapons attacking different goals. the characteristics in dynamic system-self is ignored in battle, which results in workload saturation on launch platform, the fatal case such as easy penetration will occur once the important target appear.

These optimization targets function always only pursuit for quantitative index but neglect for essential performance index such as target treat degree and target interception efficiency. The task for missile intercepting enemy is abstracted as optimization problem on target assignment, and the target assignment strategy is realized by genetic algorithm here [6].

3.2 Weapon Target assignment model

When many types of weapons combat on lots of incoming targets, the weapon assignment is a dynamic process, which includes not only appropriate type and weapon unit numbers but also planning the ideal shooting time for each weapon unit, the attack corridor is established for satisfactory combat results. The model in weapon target assignment is shown in figure 2.

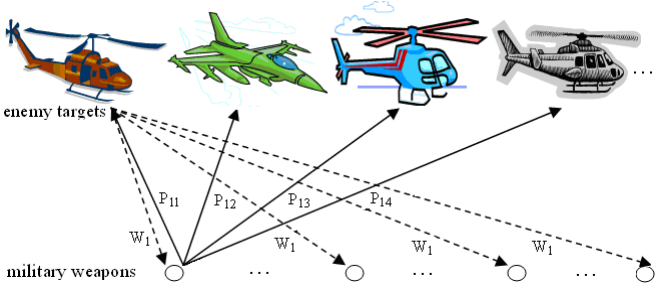

Figure 2. Target assignment illustration

Target assignment is a continuous and dynamic process, which generally described as: if there are M fire units $H_1, H_2, \cdots, H_M$ in air defense combat, which attack N group of air fighter $T_1, T_2, \cdots, T_N$, all target is arranged in strict order according to threat degree. The threat degree evaluation value of the j th target as w_j, The advantaged degree evaluation value which is related i th fire unit to the j th target as p_{ij}, the attack efficiency of all target denoted as $c_{ij} = w_j * p_{ij}$, here, c_{ij} stands for the profit degree from some targets. If the basic principles on target assigned request is satisfied, the optimal value can be searched by $\max(\sum_{j=1}^{n} c_{ij})$.

3.3 Genetic Algorithm realization

If the chromosome coding and fitness function are defined, the optimization process of target assignment based on genetic algorithm is realized as the following steps:

The chromosome scale is defined as X, there are X possible solution generated to compose initial solution chromosome at random way. The fitness value is calculated for each individual, new chromosome is generated by genetic operation such as selection, crossover and mutation. Above step is repeated until the genetic generation is satisfied.

4. Illustration and Result Analysis G

The solving problems on optimal effectiveness can convert into optimal solution to function, so, the genetic algorithm competes for it.

The matrix scale as 40×15 is generated as an initial population in genetic algorithm, Chromosome is processed for many times operation such as selection, crossover, mutation by here, and the optimal solution for target assignment function can be obtained. If there are 8 fire units and 15 enemy targets, in function body, p_{ij} defined as the advantage degree of weapons, w_j defined as threat degree assessment of targets, the w_j for 15 targets are [0.47, 0.97, 0.76, 0.62, 0.48, 0.77, 0.33, 0.74, 0.54, 0.65, 0.43, 0.35, 0.63, 0.66, 0.57] respectively. The individual numbers and the largest genetic generation selected as 40 and 80 respectively, the chromosome length and generation gap set as 15 and 0.9.

The fitness inserted technology is adopted, and the individuals with most fitness can be extended to next generation. When an initial population is created, the Chrom add ones (NIND, 15) matrix, which ensure the sequence number is not as 0 during matrix process. Population mean curve is used to track objective function performance.

If the generation gap set as 0.9, the change trend of population mean is stable, the convergence performance of target function is better. The individual number and the maximum genetic population selected as 80 and 400 respectively. The simulation results shown in figure 3, so, the horizontal and vertical coordinates represent the genetic iterations number and the optimal profit value, accompanied with the increasing of iterative optimal solution, the optimal value in objective function curves gradually converge to a stable value. When the iterations numbers is closed to 20, the optimal solution kept at 6.4404. In a conclusion, the overall function performance is close to stable value accompany with the increasing of function iterations number continuously, but the mean of population changes more frequently.

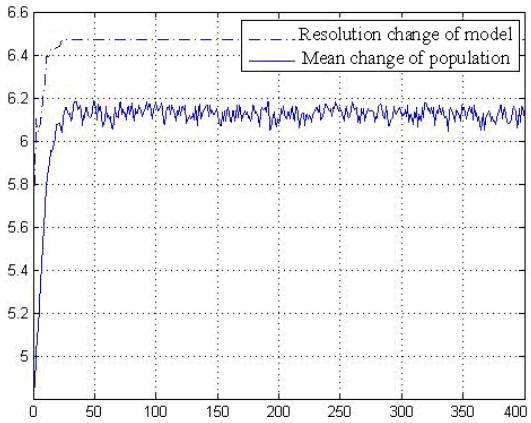

Figure 3. The solution optimization process

When the individual number increased to 100, the iterations number increasing to 800, the objective function of the optimal solution becomes as 6.4719, the population individual is more stable and the function performance is more perfect, the simulation results shown in figure 4. From that, the optimal solution of target function keep unchanged even if the iterations number increasing continuously.

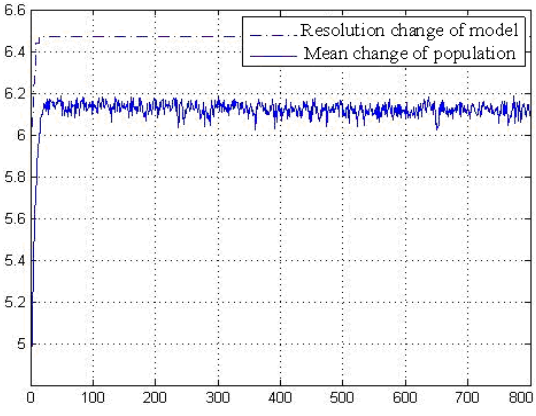

Figure 4. The solution optimization process

If the generation gap set as 0.9, in case of individual number and the largest iterations number selected as 80, 400 and 100, 800 respectively, the target assignment result shown in table 1.

Table 1 The target assignment result

Target number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Optimal Solution
Assignment NO.1	1	7	7	1	7	4	1	7	2	7	3	1	1	1	8	6.4404
Assignment NO.2	2	7	7	1	7	1	1	7	1	7	1	1	8	4	8	6.4719

Simulation result analysis: when the iterations number reached to 400, the optimal solution keep up with 6.4719, which shows the optimization solution can be obtained, if the optimization iterations number obtained. The generation gap has important influence on function solution, and the optimization performance is in proportion with the generation gap value.

5. Conclusion

The optimal solution of target assignment model is resolved by genetic algorithm here, which realizes the weapon unit assignment in multi-fighter combat dynamically. It ensures attack the threat target with desired damage probability in the target assignment, and it gives priority to consider the weapon units with larger threat weight for the target. That is, which not only consider the residual targets but also shot the target with inferior threat degree, there is enough weapons unit for followed target to assign, as far as possible to shoot more targets effectively. As a whole, the method can take into account not only crucial target but also total combat, the target assignment and decision-making are realized, the genetic algorithm have a great advantage in weapon target assignment optimization.

6. Acknowledgment

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7. References

[1] H.P. Cai, Y.W. Chen, the research and developtment of weapon target assignment,the fire and opration control.,2006 ,31 (12) :11-15.

[2] H.P. Cai, J.X. Liu,Y.W. Chen, et al. Survey of The research on dynamic weapon target assignment problem. Journal of Systems Engineering and Electronics, 2006, 17(3):559-565.

[3] S.P. Lloyd, H.S. Witsenhausen. Weapons allocation is NP completes[C] Proceedings of the IEEE Summer Simulation Conference Reno, Nevada, 1986.

[4] J. M. Rosenberger, H Su , H.A.Y Wang, et al. The generalized weapon target assignment problem[C] the 10th International Command and Control Research and Technology Symposium on the Future of C2, McLean, VA, 2005:2-11.

[5] D. Khosla. Hybrid genetic approach for the dynamic weapon target allocation problem[C] Proceedings of SPIE ,2001,4396 :248-263.

[6] Z.J. Lee,C.Y. Lee. Parallel ant colonies with Heuristics applied to weapon2target assignment problems[R]. 2002 TAAI: 201-206.