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Localisation and Pre-calculation for Anti-missile Defence Shield System

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ABSTRACT

One of the most important problems in anti-missile systems is localisation ambulatory missiles' defence sites along with fixed missiles' defence sites in best positions to destroy enemy's missiles. For localisation, there are lots of constraints and consumptions, which should be considered to making predictions in missiles behaviours. An optimum algorithm for localisation of the missiles' defence sites is provided. Predictions of attackers' missiles behaviors for assisting real-time defending operations in the defender sites is also provided. One simulator for finding the best places to locate ambulatory missiles' defence sites presented. This simulator considers fixed and ambulatory missiles' defence sites along with their parameters to provide best solutions by relying on modified genetic algorithm.

Key words: Anti-missile systems, missile, genetic algorithm, localisation, prediction

1. INTRODUCTION

Nowadays missile attacks are one of the impressive elements in wars. There exist many different types of missiles belonging to different categories which they can be evaluated in terms of the missile's range, the amount of destruction and the way of conduction. Recently, various countries confronting with missile's attacks have studied a system called anti-missile shield system. Anti-missile shield systems can perform a complicated detection operation by tracing enemy's missiles, using their radar equipment and using fixed or ambulatory defence missile sites. These operations include predicting a missile's movement path, and then targeting and destroying them. To target and destroy a missile, a large number of factors must be taken into account. An important factor is to determine a place to locate defence sites in a geographical environment or a country to protect important places and sites. Furthermore, whenever a missile is traced, there is only a very limited time to perform subsequent processing to target and destroy the missile. Hence, decisions made in this limited time should be accelerated by performing a number of pre calculation steps. In this article the first goal is to find the best possible places to locate the ambulatory defence sites based on our knowledge about the important places, which we need to protect them. The second goal is to choose the best possible site among several existing defence sites, where they can be used to destroy the missiles at the attacking time. The second goal achieved by performing some preprocessing steps and using supporting data from results of first goal.

The problem of locating defence sites in anti-missile defence shield is an active research topic which is NP-complete due to a large number of elements that should be considered[1]. Brown[2], *et al.*, proposed a method for anti-missile defence shield system to defend against ballistic missiles. They assume that both attacker and defender sites have quite complete information about each other's equipment and targets. They have considered various assumptions in their work. They can obtain positions and abilities of defence sites with arithmetic calculations and greedy methods for ballistic missiles attacks. By doing some experiments with general algebraic modelling system (GAMS), they have shown that in a very short time, about half an hour with 1 per cent tolerance by 12000 variables that have been defined in their method's framework, a nearly optimised answer has been obtained[2]. Jun[3], *et al.* proposed a system to defend war ships against air missile attacks that can detect multiple air attacks and attack to all of them simultaneously by presenting a connected genetic algorithm (GA) whom they have connected by simulating annealing (SA). Their proposed method is a hybrid version of GA in which SA is performed at each generation to improve the fitness of current solutions locally. In fact, they have performed only the second stage of localisation; that is, detection and destroying the attackers, and manually localisation of the sites. Then, they concluded that their proposed hybrid algorithm has better solutions in comparison to GA. Genetic programming was used to compute the best time for exploding the defending missile without even hitting to the target missile[4]. Eckler[5], *et al.*, have proposed a computational method for most game versions like missile defend shields for defending and covering targets and allocating fired missiles.

The main problem of the proposed methods is that none of the studied methods have considered the localisation to defend against attacker's missile. Also evolutionary algorithms is not used in most of them, therefore it is obvious that in the large state spaces there is the possibility of stocking into local optimum solutions. Carlisle[6], *et al.*, proposed automated load balancing of a missile defence

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simulation using domain knowledge, which considered large number of objects by parallelisation and two new algorithms for static load balancing. Theater ballistic missiles can deliver high-explosive, chemical, biological, or nuclear warheads over long distances. A standard game theoretic model for defence would assume that the attacker does not observe the positioning of defensive assets before launching the attack, and the defender is far from allocation of attacking missiles to targets[7]. Eckler[5], *et al.* discuss solutions for many versions of such games. Bracken[8], *et al*. discuss solutions that are robust with respect to uncertain numbers of attacking assets. For other researches about optimisation by GA and GP below works can be mentioned. Zenghua[9], *et al*. used genetic algorithm to analyze the weapon-target assignment problem. Moore[10] applied GP to improve aircraft survivability in an environment with surface-air missile. Sommerer[11], *et al.* explored the principles of application of these principles to air and missile defence.

2. ASSUMPTIONS AND FORMULATION

Since anti-missile defence shield system has various and complicated parts. Authors has considered assumptions and primary limitations to perform experiments to find the best places to locate ambulatory missile sites along with fixed missile sites.

- First, a geographical territory such as a territory of a country is defined as the region where anti-missile defence shield system should defend it.
- In the territory where Anti-missile defence shield system should defend it, a set of radars are located and by default they have the ability of detection, tracing and defining movement speed of missiles just in the defined defence range (such as interior border of one country).
- There is N fixed missile defence sites and n ambulatory missile defence sites to defend and also fire to enemy's missiles.
- Each of the missile defence sites have M kinds of missiles with various ranges, error coefficients, speed of missiles and control ability. All the fixed and ambulatory missile defence sites are considered homogenous in missiles. Ranges are gleaned from the open literature[12-14].
- Each of missile defence sites have the ability of firing one to three missiles to the target simultaneously or non-simultaneously.
- Anti-missile defence shield system considers attacker missiles in two ballistic and non-ballistic categories. In fact, all non-ballistic missiles such as average range, short range and long range are considered in one category.
- The attacks of enemy are categorised, and the probable regions of missile attacks are already entered into the simulator.
- Vital and important regions of defence range are divided manually and by defining the importance coefficient. These divisions start from regions with importance coefficient of one that is the most important region, and are graded to the regions with importance coefficient of ten that is the lowest region. (the regions with no defence importance are defined with zero degree)
- The regions where installing and placing ambulatory Anti-missile defence shield systems is impossible are considered in the defined defence territory.
- Weather condition of the environment is considered as a variable of error efficiency in targeting and destroying the missiles of enemy.

3. GENETIC ALGORITHM

Genetic algorithms are suitable algorithms to search in large state spaces considered as a search heuristic[15], and it is mainly used in optimisation problems. Genetic algorithms uses Darvin's natural selection principles to find an optimised equation for prediction or pattern matching. Genetic algorithm is a programming method using genetic evolutionary as a problem solving pattern. Genetic algorithms are a specific kind of algorithms using biology methods such as inheritance and mutation[15].

3.1 The Specific Chromosome Instruction of the Problem

In the proposed method, each chromosome depicts a set of answers in terms of translocation coordination of the ambulatory anti-missile defence shield sites along with fixed sites (in geographical latitude and longitude). In each chromosome, there are $(N + n)$ numbers of coordination to translocate ambulatory and fixed anti-missile defence shield sites as shown in Table 1.

In Table 1, each of the ambulatory and fixed anti-missile defence shield sites has a two dimensional array for the features of attacker and defender missiles which are indexed with attacker and defender detail ID. These IDs refer to another two dimensional array related to each of them. The referred 2 dimensional array shown in the Table 1 is depicted in Table 2. In this indexed array, the information about attacker missile and the method of defender site to defend is recorded (registered) with the following content.

(1) The average speed of each attacker and defender missiles.
(2) Movement coordination of each of the missiles.
(3) Predicting the type of missile in the attack. (Ballistic or no ballistic).
(4) Recording the type of used defence missile to destruction.

3.2 The Proposed Method using Genetic Algorithm

Based on assumptions in the section 2, one chromosome structure is created. Some modifications are performed in the stages of common GA to solve the problem. Indeed, in each stage of generation production, attacker missiles attack about c times to each generation of chromosomes with various values. Actually the attacks are performed in different states instead of running fitness function once on each of chromosomes. Consequently, the success/failure rate in defence is obtained by different implementations, and is recorded in an array called *fitness* (i,c). In the Fig. 1, flowchart of proposed algorithm provided. In addition to genetic algorithm steps the flowchart shows attacking to each generation of chromosomes. In the flowchart, *End of Attacking* conditional block determines

Table 1. The created chromosome instruction to anti-missile defence shield system

Missiles		Static defence site 1		...	Static defence site 1		Dynamic defence site 1		…	Dynamic defence site n	
Chromosome (1)	**Defenders**	**Latitude (N)** Attacker detail	**Longitude (E)** Defender detail		**Latitude (N)** Attacker detail	**Longitude (E)** Defender detail	**Latitude (N)** Attacker detail	**Longitude (E)** Defender detail		**Latitude (N)** Attacker detail	**Longitude (E)** Defender detail
	Attacker (1)	ID 1	ID 1		ID 1	ID 1	ID 1	ID 1		ID 1	ID 1
	Attacker (2)	ID 2	ID 2		ID 2	ID 2	ID 2	ID 2		ID 2	ID 2
	…	…	…		…	…	…	…		…	…
	Attacker (L)	ID L	ID L		ID L	ID L	ID L	ID L		ID L	ID L
⋮	⋮	⋮			⋮	⋮	⋮	⋮		⋮	⋮
Chromosome (i)	Attacker (1)	ID 1	ID 1		ID 1	ID 1	ID 1	ID 1		ID 1	ID 1
	Attacker (2)	ID 2	ID 2		ID 2	ID 2	ID 2	ID 2		ID 2	ID 2
	…	…	…		…	…	…	…		…	…
	Attacker (L)	ID L	ID L		ID L	ID L	ID L	ID L		ID L	ID L

the number of the attackers attacks to each generation. Also for each number of attacking to each generations fitness value calculated separately. So in the next generation of this algorithm, genetic operators will be applied on chromosomes according to determined operators' rates. Consequently average value of fitness function calculated (Phase 1). Finally and after finishing the proposed modified GA steps, the creation of pre-calculated results begin to run (Phase 2).

3.3 Initialisation

Since selecting initial population is impressive on the results of the proposed algorithm, initialisation is considered semi randomly. Firstly producing initial chromosomes in a way that the probability of selecting geographical coordination to locate defence sites in defence region by considering information of important locations (assumptions of section 2). Secondly grading the coordination of enemy attacks that is set manually, and is as follows.

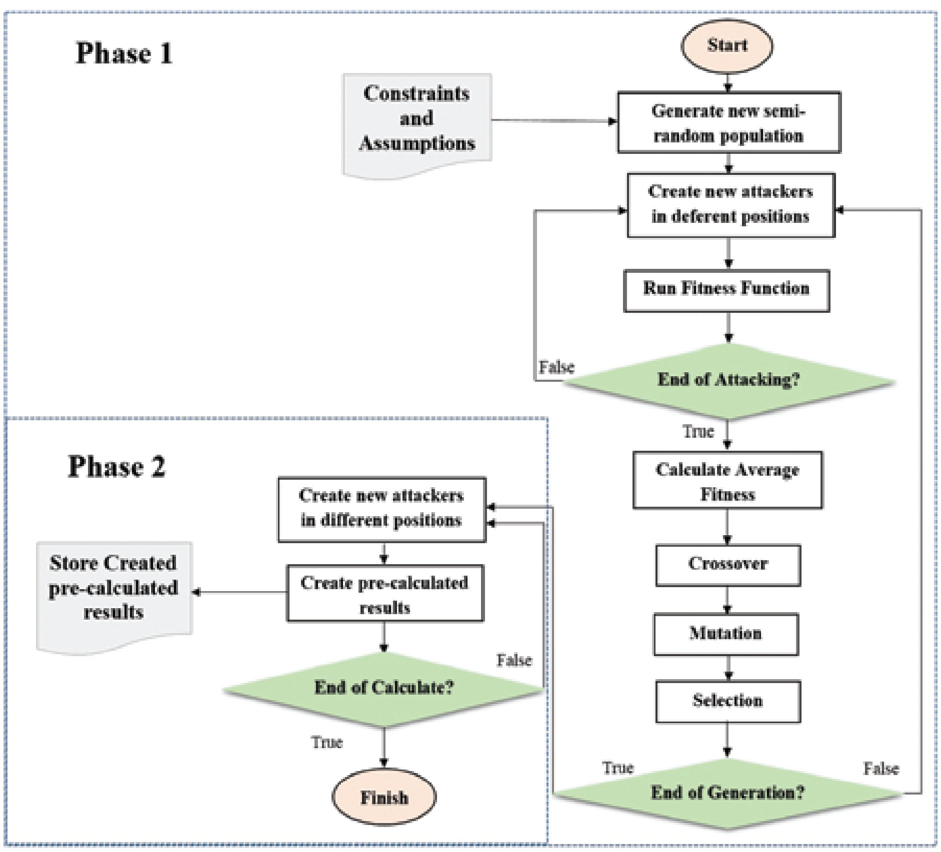

Figure 1. Flowchart of the proposed algorithm.

- First, a straight line is plotted from the center of each vital region of defence territory to possible attack centers by enemy shown by $Ax + By + C$.
- Then, we determine probability of selecting each point (geographical coordination to locate ambulatory missile sites) by using Eqn (1) and roulette wheel[16].

$$P_i = \sum_{k=1}^{N} \left(\frac{1}{\frac{|Ax_k + By_k + C|}{\sqrt{A^2 + B^2}}} \ Iff \ \frac{|Ax_k + By_k + C|}{\sqrt{A^2 + B^2}} \leq MaxRange\,Missile(M) \right) \quad (1)$$

where r determines the index of the number of randomly created points in the defence region. Variables x_k, y_k is the coordination of each randomly produced points. MaxRange Missile (M) is used for checking the range of defence missiles, so that if maximum range of defence missile could not reach to the plotted straight lines, then this value won't be impressive (because each site can destroy missile only in some plotted lines). Variable P_i is the probability of selecting each point in one uniaxial roulette wheel. The exact purpose of P_i is to calculate a coefficient to each randomly created point in the defence region in order to determine the number of points repetition in the roulette wheel to determine the probability of selecting each of them. From Eqn (1), if random defence sites are close to straight line between the location of attack and defence center, those points are more likely to be chosen.

3.4 Fitness Function

After creating chromosomes population, to measure the quality of chromosomes, attacking and defending operations should be performed first. To do this, the simulator simulates attack and missile defence operations, and then provided fitness function asses simulations results. Fitness function is the most important part of the proposed algorithm, as shown in Eqn. (2).

$$F_i = \frac{\sum_{j=1}^{N} \left(Fitness(i,j) \right) + \sum_{m=1}^{n} \left(Fitness(i,m) \right)}{c} \quad (2)$$

$$Fitness(i,j) = FSD_j, Fitness(i,m) = DSD_j$$

where variable C is the number of different attacks to one generation of chromosomes population. Variable FSD_j is the j^{th} fixed sites success or failure in destroying attackers' missiles in i^{th} chromosome. Variable DSD_j is the j^{th} ambulatory sites success or failure in destroying attackers' missiles in i^{th} chromosome. Therefore variable F_i calculate the fitness value of the i^{th} chromosome, which is the average value of the number of successfully defending process. Successfully defending process means each sites success in destroying enemy's missiles in different situations of attacks. In this equation, greater value of the F_i, shows that obtained chromosome has better performance in destroying enemy's missiles.

3.5 Crossover and Mutation Operators

According to various experiments done with different elements, the best result is obtained for operators in the following way.

- Crossover operator is n point crossover in which two chromosomes will be selected randomly from created chromosome population, and three random points of chromosomes will be combined. Here, the value of n is considered to be 3.
- Mutation operator in genetic algorithm is an operator to prevent the problem of staying on local optimum results. In the proposed method, mutation performed in two ways. Firstly, some genes from each chromosome is selected randomly in $1/n$ number of ambulatory defence sites. So a new random geographical coordination will be replaced by existing geographical coordination in that gene depicting the coordination of ambulatory missile defence site. Secondly, if $M > 1$ that is, if there is more than one type of missiles in a site, then $i/n + N$ number of missiles will be replaced by the related genes by considering range of each missile. (Third column of Table 2, (a)).

3.6 Selection Function

Selection function in genetic algorithm is a step, which considered after performing genetic operators. In the selection

Table 2. (a) The construction and saved information for defence missiles and (b) attacker missile

Chromosome ID	Detail	Defender (1)	…	Defender (L)
Chromosome (1)	Average speed			
	Movement position array ID			
	Defence missile type			
. . .	. . .		…	
Chromosome (i)	Average speed			
	Movement position array ID			
	Defence missile type			

(a)

Chromosome ID	Detail	Attacker (1)	…	Attacker (L)
Chromosome (1)	Average speed			
	Movement position array ID			
	Attacker missile type			
. . .	. . .		…	
Chromosome (i)	Average speed			
	Movement position array ID			
	Attacker missile type			

(b)

function chromosomes will be selected and transferred to other generation. According to carried out experiments from running genetic algorithm and considering the obtained fitness function in each chromosome is as follow. Firstly 20 per cent of population will be transferred to next generation by elitism[17]. 20 per cent of chromosomes that have higher fitness value in comparison to other chromosomes will be directly transferred to other generation. The main reason of using elitism is to preserve the best chromosomes in the next generations. In the remaining part of this function, 80 per cent remained chromosomes will be selected with uniaxial roulette wheel. In the each step of selecting chromosomes by using roulette wheel, selection probability is defined by value of fitness function.

4. SUPPORT SELECTION OF THE DEFENCE SITE TO FIRE AT THE TIME OF MISSILE ATTACK

As it is clear, determining the time to fire through the missile of the enemy and selecting or scheduling sites of defender to fire through missile of the enemy are key characteristic of Anti-missile defence shield systems. This situation occurs mostly when more than one defence site have the ability or required range to fire through missile of the attacker. In this stage, after determining the best place to locate missile defence sites and by using hypothetical missile sites of the enemy, they attack to different and important points of defence region for z times. In this situation, located fixed and ambulatory sites in different states will defend and save this information in a data set.

(i) Segmentation of covered regions in each defence site according to their success in destroying attacker missiles in each region by using different simulators (in the proposed method, 0 to 10 region are considered to determine the possible availability of destroying the missile). This is to decide that two defence sites have jointly covered one region, and have required a range to fire through attacker's missile.

(ii) Finding the best time for each defence site to fire through missiles of the enemy by estimating movement path of the enemy missile and considering their movement path to determine relative appropriate time to fire through attacker's missile by doing experiments and surveying the obtained results.

Recorded information in data set makes it possible to defence sites to accelerate two mentioned important points determining segmentation of the success rate of destruction of each site and scheduling firing through the target.

5. SIMULATION RESULTS

To test and evaluate the results, C#.Net 2013 programming language and DirectX 10 are used to design and implement a two dimensional simulator. Figure 2 is an indicative of main part of the simulator. In this simulator, after entering the required information and determining the value of some elements, the simulator starts its operation. Determining these elements are as:

- Number of attacker missile sites
- Number of defender missile sites
- Maximum number of simultaneous attacks of the attackers

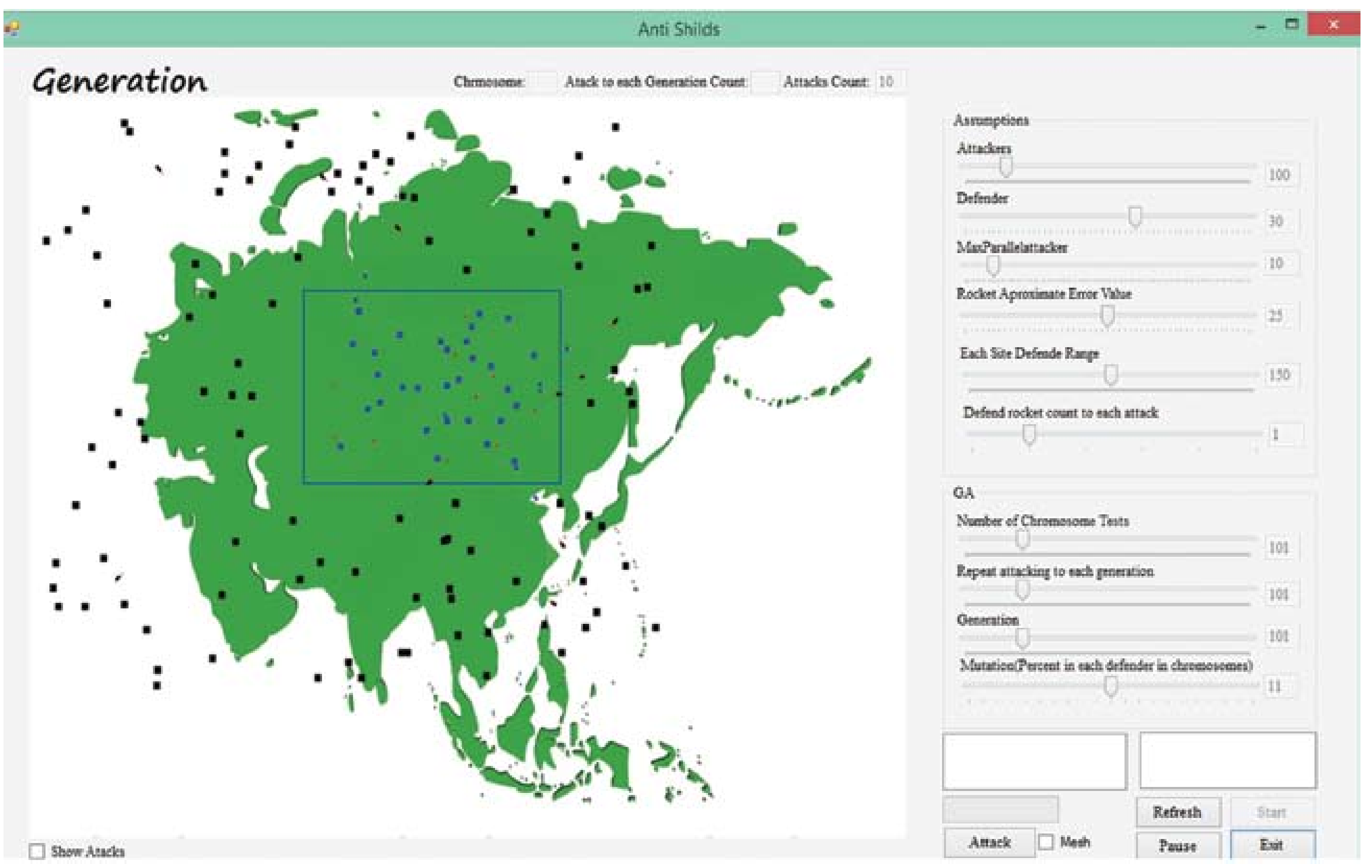

Figure 2. The main part of the designed 2-dimensional simulator, running randomly.

Table 3. Simulation results of the best defence sites localisation in different states

Test	Attackers	Defenders	M-P	Error	D-R(Km)	D-P-C	Population	A-Repeat	Mutation	Result (Success)
1	100	30	20	25%	150-250	2	100	100	5%	65.7%
2	100	30	20	30%	150-250	2	100	100	5%	61.2%
3	200	50	50	25%	150-250	3	1000	200	5%	75.1%
4	200	50	50	30%	150-250	3	1000	200	5%	73.2%
5	500	50	80	25%	150-250	3	5000	300	5%	80.6%
6	500	50	80	30%	150-250	3	5000	300	5%	80.2%
7	700	50	100	25%	150-250	4	10000	500	10%	93.7%
8	700	50	100	30%	150-250	4	10000	500	10%	93.3%

- Error rate in destruction of missiles of the attacker considering available hardware
- Defender missile sites range
- Amount of firing a rocket simultaneously from each of defence site
- The number of chromosomes in initial population
- Repeated attacks in each generation of chromosome population
- Mutation rate.

As shown in Fig. 2, this simulator created some geographical coordination in the determined defence regions to locate defence missile sites. In Fig. 2, blue points depict defence missile sites, while black points depict attacker missile sites, and black missiles are fired attacker missiles. Red points are targeting attacker missiles, and only attacker sites are aware of them. Blue missiles are fired missiles from defence sites.

Since war equipment or doing experiments in a real war needed to evaluate the results accurately, and as far as we have studied, in this method, there is no issue for comparison till now. Therefore, experiments are only performed by using simulator and different values whom the simulator has performed, and the results are presented in Table 3.

As shown in the Table 3, at first, experiment is performed in the best chromosome with the best obtained answer to locate defence sites. At initial experiment from left to right with 100 missile of attacker site (*Attackers*), 30 defence site (*Defenders*), mostly 20 simultaneously attacks at one time (*M-P*), 25 per cent error in firing through targets and destroying them (*Error*), 150-250 different defence sites operational ranges (*D-R(Km)*), the ability of mostly 2 defence sites to firing to one target simultaneously (*D-P-C*), 100 number of chromosomes in each generation (*Population*), 100 repetition of attacks to each generation (*A-repeat*) and 5 per cent mutation rate (*Mutation*). The obtained success rate in destroying attacker's missiles is 65.7 per cent (*Result (Success)*). We should mention generation value of GA in all of experiments considered for 100 times. As it is obvious, in the second experiment, the success rate in the best answer has decreased to 61.2 per cent by increasing the probability of firing error through target and destroying it. In further experiments, it is clear that we increased different parameters, such as the repetition of attacks to each generation. This increasing followed optimisation of the obtained results in which the result in the 8th experiment has increased to 93.7 per cent. We should mention here that because of the inevitability of the error in defender missiles, we considered high error rate in the experimental results. So if we decrease this error value, the proposed algorithm could achieve 100 per cent of success rate results.

6. CONCLUSION

In defence shield systems, one of the most important problems is to find a place for missile defence sites to locate and destroy attacker missiles. Since locating missile defence systems is a NP-Complete problem, therefore in this paper, a simulator is proposed to determine appropriate locations to locate defence missile sites by considering{T., 1996 #1}{T., 1996 #1}{T., 1996 #1}various elements and by using Genetic Algorithm and performing some modifications. In the proposed method, not only the place to locate missile defence sites was determined, but also we attempt to accelerate the real decisions at the time of attack by creating a data set from results of missile attacks simulations. In the designed simulator, in addition to simulating all stats automatically by using simulator, there is learning availability and optimising the performance of simulator by getting feedback from the real environment manually. For example, by getting feedback from the movement path of attacker missile and getting the performance result of the system after performing defence operation, the Anti-missile defence shield can create initial chromosomes semi randomly and gain the significant results.

REFERENCES

1. Tim, B. & Cooper, J.H.K. The complexity of timetable construction problems: *In* Computer Science, edited by E.K. Burke, Practice and Theory of Automated Timetabling, 2005, pp. 281-295.
2. Brown, G.; Carlyle, M.; Diehl, D.; Kline, J. & Wood, K. A two-sided optimisation for theater ballistic missile defence. *Oper. Res.,* 2005, **53**(5), 745-763. doi: 10.1287/opre.1050.0231.
3. Jian-jun, Z.; Yi, W. & Yue-ting, Y. Application of hybrid genetic algorithm in aerial defence target assignment. *Info. Eng. Appl.*, 2012, **154**, 1118-1123. doi: 10.1007/978-1-4471-2386-6.
4. Wiese, K. & Goodwin, S.D. The effect of genetic operator probabilities and selection strategies on the performance of a genetic algorithm. *Adv. Artif.l Intell.*, 2005, **1418**, 139-153. doi: 10.1007/3-540-64575-6_46.
5. Eckler, A.R. & Burr, S.A. Mathematical models of target

coverage and missile allocation. Military Operations Research Society, Alexandria, 1972. doi: 10.5711/morj.8.3.59.

6. Carlisle, M.C. & Merkle, L.D. Automated load balancing of a missile defence simulation using domain knowledge. *Soc. Model. Simul. Int.,* 2004, **1**(1), 59-68. doi: 10.1177/154851290400100105.
7. Matheson, J.D. Multidimensional preferential strategies. Analytic Services, Inc., report no. SDN 75-3, Arlington, VA. 1975.
8. Bracken, J.; Brooks, P.S. & Falk, J. E. Robust preallocated preferential defence. *Naval Res. Logistics*, 1987, **34**(1), 1-22. doi: 10.1002/1520-6750(198702)34:13.0.
9. Zenghua, L. & Jingye, W. Weapon-target assignment research based on genetic algorithm mixed with damage simulation. *In* Computer Application and System Modeling (ICCASM), 2010 International Conference on. Taiyuan, IEEE, 2010. doi: 10.1109/ICCASM.2010.5622555.
10. Moore, F. W., Genetic programming solves the three-dimensional missile counter-measures optimisation problem under uncertainty. *In* Genetic Programming, edited. Morgan Kaufmann, USA, 1998, pp. 242–245.
11. Sommerer, S.; Guevara, M.D.; Landis, M.A.; Jan M. Rizzuto; Sheppard, J.M. & Grant, C.J. Systems-of-systems engineering in air and missile defence. Johns Hopkins APL Technical Digest, 2012, **31**(1).
12. Lee, K.; Park, J.; Park, C.; Kim, S. & Oh, H.S. Simulation-based SAM (Surface-to-Air Missile) analysis in OpenSIM (Open Simulation Engine for Interoperable Models). Proceedings in Information and Communications Technology, 2012, **4**. doi: 10.1007/978-4-431-54216-2_38.
13. Gu, G.; Hu, J.; Zhang, L. & Zhang, H. Research on remote maintenance support system of surface-to-air missile equipment. *In* Quality, Reliability, Risk, Maintenance, and Safety Engineering (QR2MSE), 2013 International Conference on. Chengdu, IEEE, 2013. doi: 10.1109/QR2MSE.2013.6625823.
14. Wilkening, D.A. Ballistic-missile defence and strategic stability. Adelphi series. Taylor & Francis. 2014.
15. Man, Kim-Fung & Sam Kwong, K.S.T. Genetic algorithms: Concepts and designs: Advanced textbooks in control and signal processing. Springer Science & Business Media. Hong Kong, 2012, pp. 343.
16. Lipowskia, A. & Lipowska, D. Roulette-wheel selection via stochastic acceptance. *Phys. A: Stat. Mech. Appl.*, 2012, **391**(154). doi: 10.1016/j.physa.2011.12.004.
17. Zitzler, E.; Deb, K. & Thiele, L. Comparison of multiobjective evolutionary algorithms: Empirical results. *World Sci.*, 2000, **8**(2), 173-195. doi: 10.1162/106365600568202.

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In the current study, his contributions rely on the genetic algorithm implementation and making analyses of the achieved results.