IMPLEMENTATION OF INTELLIGENT CONTROL FOR OPTIMIZATION OF FLEET PLACEMENT TNI-AL SHIPS USING GENETIC ALGORITHM

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ABSTRACT

Limited number of KRI and provided by the state budget and the needs of Homeland Security resulted in the territorial sea to the demands of thinking about optimizing the assignment of patrol boats in the sector OPSKAMLA and placement into the base of supporters, taking into account the ship type, speed, radar range, sailing abilities (endurance) and Human Resources so that the obtained results of the optimization of the composition of the assignment of 27 patrol boats to the 7 sectors ARMATIM KAMLA operations by maximizing the coverage area and minimize operational costs. Genetic Algorithm (GA) is a searching algorithm , based on the workings through the mechanism of natural selection and genetics. GA is not the result of the global optimum technique but it is not easily trapped in local optimum.

From the results of optimization with GA conducted on a variety of crossover and mutation probability, which is conducted on populations 10-100, 10,000 and 500 generations, there are some of the best fitness value. Having done some experiments with different values obtained the best result so obtained acceptable results. One of the best results is a probability of crossover 60% and mutation 0.1%, showed a wide coverage area, 942, 929 Mil^2 and operating costs IDR 2, 853, 447, 000, thus the optimization model is able to save the State Budget of approximately 48% of the purse budget IDR. 5 million.

Keywords: Genetic Algorithms, Coverage Area, Minimum Cost

INTRODUCTION

Republic of Indonesia is a country that has the largest area is the island with the sea and the rest is a vast area of land consisting of pooled with cluster of islands that Indonesia should consequently be able to control and secure all of its ocean territory in accordance with the provisions of the United Nations Convention On The Law Of The Sea (UNCLOS, 1982) (Subroto S, Wahyono, 1983). Given Indonesia as an archipelagic nation with 17 499 islands and vast ocean that reaches 5.8 million km^2, a coastline of approximately 81,000 km and covering a land area of 2.2, million km^2 and a cross position located between two continents and two oceans, allowing the vulnerability of such violations, taking property without the permission of the sea, smuggling, piracy and sabotage (Hamzah, 1984). The number of cases of violation of a violation of territory by a foreign country ships, illegal fishing and illegal logging that occurred in Indonesia showed that the territorial sea area of Indonesia has not fully covered by warships of the Republic of Indonesia (Ariansyah, Achmad, 2008).

As a major component of national defense at sea, the TNI-AL shall carry out the policy of national defense, namely: maintaining state sovereignty and territorial integrity, protecting the honor and safety of the nation, carrying out military operations. TNI-AL base as one integral component of the SSAT is spearheading force in carrying out the task of supporting the operation of KRI. The role of the TNI-AL base as the development of naval forces to the area of operations or "position deployment forces" will have significance in supporting task force operations as the TNI-AL NKRI security operations at sea.

Limited number of KRI and provided by the state budget and the demands of NKRI Security on the assignment of marine vessels in the sectors of Maritime Security Operations (MSO) to lead the eastern region of the demands of thinking about the distribution of the optimum assignment of patrol boats, so the exact type and the number and selection of the appropriate base which will be developed as a major base in the sectors of security in security operations north eastern region (Ariansyah, Achmad, 2008).

MATERIALS AND METHODS

Intelligent Control

Intelligent control is a discipline in which the control method was developed to emulate the characteristics - an important characteristic of human intelligence. Characteristics include adaptability and learning, with planning under situations of high uncertainty (planning under large uncertainly) and the ability to handle huge amounts of data (Kuswadi, 2007).

Characteristic that distinguishes Intelligent System with other systems are:

a) Able to act appropriately in an uncertain environment system.

b) Least able to detect the environment and can make decisions and control.

c) With a higher level, may have the ability to recognize an object and event, presents a model of knowledge in the world as well as provide proper reasons about future planning.

d) More sophisticated then the system will be able to feel and understand, and choose something wisely, and act in a successful despite many changes in the environment, so the system is capable of self-reliance

Genetic Algorithm (GA)

Genetic algorithm as a branch of Evolutionary Algorithms are adaptive methods used to solve a search value in an optimization problem. The algorithm is based on the genetic processes that exist in living things, namely the development of generation in a natural population, were gradually following the principle of natural selection or "who is strong, he is to survive (survive)." By mimicking the theory of evolution, the Genetic Algorithm can be used to find solutions to problems-problems in the real world (Michalewics Z, 1996).

High defense of the individual providing the opportunity to reproduce through cross-breeding with other individuals in the population. The new individuals are generated in this case is called heredity, which carries some properties of its parent. While individuals in the population who are not selected in the reproduction will die by itself. In this way, several generations with good characteristics will emerge in the population, to then be mixed and exchanged with other characters. With a growing number of individuals to marry, the more likely it will be the best that can be obtained.

Before the GA can be executed, then an appropriate code (representative) for the problem to be designed. This is a point solution for the problem space is encoded in the form of chromo some consisting of the smallest genetic component genes. With the theory of evolution and theories of genetics, in the application of GAwill involve some operators are:

1. The evolution operator involving the selection process (selection) in it.

2. Genetic operators that involve the crossing operator (crossover) and mutation (mutation).

To check the results of the optimization, we need a fitness function, which indicates an overview of results (solutions) that have been encoded. During walking, the parent should be used for reproduction, crossover and mutation to create offspring. If properly designed GA, the population will experience convergence and we will get an optimum solution.

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 2, No. 3, May 2012

Covering Set Methods

The concept of Set Covering Methods is intended to minimize the number of hub ports / bases are needed to serve / cover other bases. Selected bases will provide cover / service on the ship to the other bases. So that will minimize the number of hub ports / bases that ultimately would save the budget as a base selected will be developed as the main base for supporting marine security operations.

Set covering up to a system that has provided each consumer can be reached by at least one facility (Huragu, 1999). Set covering is a way of determining the lowest cost of placing a facility in which each demand node can be reached by at least one facility (Daskin, 1995). From the second definition above, the general set covering can be interpreted as the choice of location of the existing alternatives in order to minimize all factors that affect the restriction that each demand can be reached by the selected location.

Set covering problem is to place the facilities in the minimum amount necessary to cover all locations to demand or if the research is put KRI bases in the minimum amount to cover the existing patrol sectors. The parameters used in the set covering location model in the form of distance and location of the base operating sectors KRI which is formulated to minimize the number of bases, as follows:

$$\text{MINIMIZE} \quad \sum_{j\in J}^{n} Xj \qquad (2.1)$$

$$\text{SUBJECT TO} \quad \sum_{j\in Ni}^{n} Xj \geq 1 \quad \forall I \in I \qquad (2.2)$$

$$Xi \in \{0,1\} \qquad \forall\, j \in J \qquad (2.3)$$

The objective function (2.1) to minimize the number of bases (Xj) are placed. The barrier function (2.2) ensures that every sector of the patrol on the cover by at least one base. Variables of decision (2.3) is a decision "Yes" or "No" is selected as a base cover at other bases in the sector.

Transport Model

Transport model is to determine the transportation plan a number of goods from source to destination. The data model includes the needs and budgets that will be used, the purpose of transportation is to determine the amount of goods to be sent and which tools are used so that the cost minimum.

In other words transport models attempt to determine what transportation plans a number of items from a source to a destination which includes:

1. Level of supply from each source and the number of requests in each destination.
2. Transportation cost per unit of goods from any source to any destination.

The following figure shows a transport model of a network with m sources and n destinations. The number of deals in resource i is m and the number of requests in the destination j is n. While the unit cost of transport between source i and destination j is the C_{ij}

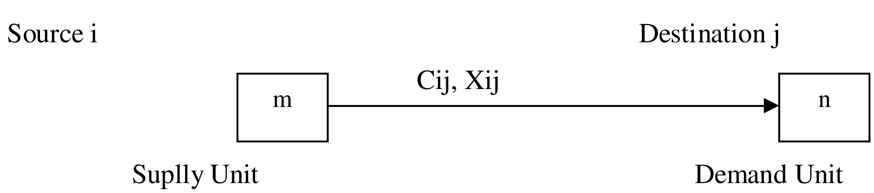

Figure 1.Transport Model

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 2, No. 3, May 2012

Figure 1shows a transport model of a network with m sources and n destinations. Unit cost of transport between source i and destination j is C_{ij}, assuming X_{ij} is the number of goods shipped from source i to destination j, then:

$$\text{Maksimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{n} Z = Cij\ Xij \qquad (2.4)$$

$$\sum_{i=1}^{m} Xij \leq ai \quad i = 1,2,...m \text{ (source)} \qquad (2.5)$$

$$\sum_{j=1}^{n} Xij \leq bj \quad j = 1,2,...n \text{ (destination)} \qquad (2.6)$$

$$Xj \geq 0$$

Marine Safety Operations (MSO)

MSO is the presence of daily operations at sea that have strategic value for the existence of the nation's sovereignty and maritime security in the national jurisdiction of Indonesia. MSO carried out by the patrol vessels TNI AL (Patrolling Forces). MSO aims to prevent, deter and secure a sea of Indonesia's national jurisdiction of offenses and crimes at sea in the form of piracy, illegal logging, illegal fishing by foreign vessels and other marine natural resources. MSO conducted by KRI in the form:

a. MSO throughout the year are carried by ships of the TNI- AL routinely patrol the MSO sectors.

b. Special operations are conducted by the TNI-AL Operational Command integrated with the operating area, time and target specific operations. MSO in the eastern region NKRI carried by ships TNI AL patrol in the eastern fleet throughout the year.

HOW TO RESEARCH

Genetic Algorithm (GA)

Genetic algorithm is a search algorithm based on the workings through the mechanism of natural selection and genetics. The goal is to determine the structures of the so-called high-quality individuals in a domain called the population to obtain the solution of a problem. John Holland developed the genetic algorithm through an iterative procedure to adjust the population of individuals who are potential solutions.

Genetic algorithm is different from a conventional search algorithm because it starts with an initial set of known populations. Each individual in the population is called chromosome. Chromosome is defined as a string of symbols, usually a single bit . Genetic algorithms use two basic principles of biological systems, namely:

a. Selection of species (evolution)

b. Increased diversity (genes with genetic operations)

Evolution is a process or a continuous change toward a perfection or balance. In the presence of species that have a fitness value (the level of compatibility with the environment), then the selection is based on its fitness value.

Genes are important properties to be brought by the next generation. Genes can be operated to obtain genetic diversity through the process of reproduction, crossover, and mutation. Selection occurs in every generation, while the increase in diversity occurred in each new generation.

Thus, the basic idea is to maintain the structure of the genetic algorithm or set of species populations that maintain the structure of populations or set of species representing a candidate solution of a problem. By using or utilizing the properties - the properties of biological systems, genetic algorithms can provide satisfactory results in the optimization process. Genetic Algorithm Cycle is shown in figure 2.

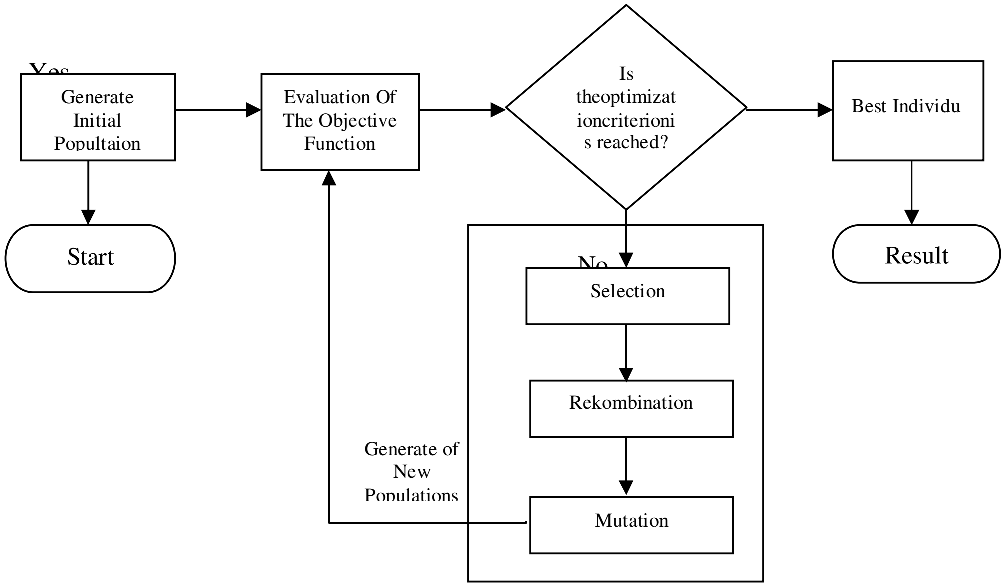

Figure 2.The Cycle of Genetic Algorithm (Haupt, S.E., Haupt, Randy L, 2004)

Several steps should be taken in the Genetic Algorithmis:

Defines the Individuals

Individu represents one of the solutions of the problem to be solved. The number of genes is based on the number of ships. Since there are 28 ships, the number of genes in each individual is created chromosome 28 genes that contain numbers that put the ship at the base. Numbers 0 indicates no vessel placement and number 1 stated there was a ship stationed at the base.

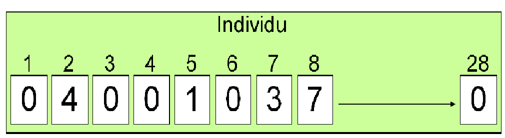

Figure 3.Representation of Individual

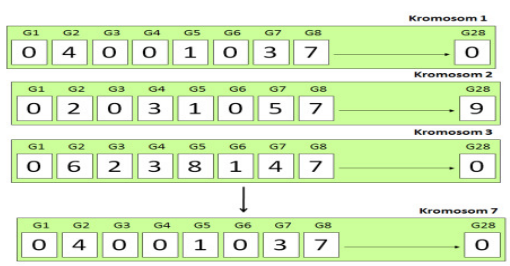

Figure 4. Representation of Genes and Chromosomes

Description:

- G1 ... G28 = Gen (Total Bases)
- 0 or 1 = allele (Number Ship, there were 27 boats)
- Chromosome 1..7 = combination of genes that form a certain value (Sector)
- Individual 1.2 ... = Formation placement of patrol boats

Defining value fitness

An individual is evaluated based on a particular function as a measure of performance. In the natural evolution, individuals of high fitness value will survive. At this optimization problem, if a solution is sought is to maximize a function h (known as the maximization problem), then the fitness value used is the value of the function h is:

$$\text{Fitness} = h \qquad (3.1)$$

But if the problem is to minimize h, then the h function cannot be used. This is due to the rule that individuals with high fitness values are better able to survive the next generation. Therefore, the fitness value is used as follows:

$$\text{Fitness} = \frac{1}{(h)} \qquad (3.2)$$

That is, the smaller the value of h, the greater the value of fitness. But this would be a problem if the bias h is 0, the resulting fitness value infinity. For that h need to be added a number that is considered so small that the fitness value becomes:

$$\text{Fitness} = \frac{1}{(h+a)} \qquad (3.3)$$

Where a is a number that is considered very small and varies according to the problem to be solved.

Patrol boats for the placement problem, there are two values that optimized the maximum coverage area (C) and minimum operating cost (B). Because the genetic algorithm uses the logic of maximum fitness value for the coverage area is defined as follows:

$$\text{Fitness} = C \qquad (3.4)$$

And for the operational cost as follows:

$$\text{Fitness} = \frac{1}{(B+a)} \qquad (3.5)$$

Initial population generation

Generating the initial population is randomly generating a number of individuals. Population size depends on the problem to be solved and the type of operator to be used. Once the population size is determined, then made the generation of initial population. Conditions that must be met to demonstrate a solution must be fully considered in the generation of each individual.

The technique used in generating the initial population is random-walk by using some of the following parameter:

1. Number of vessels assigned and ready to ship data
2. The number of bases to be used and the data base that is ready

The essence of how the random-walk was to involve random numbers for each gene according to the chromosome representation is used.

$$\text{IPOP} = \text{round}\{\text{random}\ (N_{ipop}, N_{bits})\} \qquad (3.6)$$

Description

IPOP is a gene that will contain random rounding of numbers generated as much

N_{ipop} (Initial Population) X N_{bits} (number of genes in each chromosome).

Selection process

Selection is used to select which individuals will be selected for crossover and mutation. Selection is used to obtain the best individual candidates, assuming that either parent will generate offspring that well too.

The selection process used in the assignment system and the placement of these patrol boats are:

1. Roulette Wheel, to select individuals based on the influence of fitness values. Individuals with high fitness means an individual who will be more easily selected.
2. Rank, the process used to ensure no appearance of super-individuals who would undermine the process of evolution so caught up in the local-optima.
3. Elitism, the process used to ensure the fitness of a generation is always better or at least the same as the previous generation fitness by replacing worst individuals with the best individuals in previous generations.

Crossover and Mutation

Crossover is a very important component in the genetic algorithm as a chromosome that leads to a good solution to the derived from the process of moving the cross-two chromosomes. Crossover process is determined by the probability of crossover, which means not all chromosome pairs have crossover.

Gene mutation is done by random mutation, by selecting one gene value <> 0 and is changed to 0, then its value is placed in the gene that is 0. Mutation process is done by a specified mutation probability.

RESULTS AND DISCUSSION

Data Collecting and Processing

The collection of data on research activities conducted in the Eastern Fleet Command RI include Command and Control Center (PUSKODAL), Staff Operations (SOPs), Staff Logistics (SLOG), Staff Planner (SRENA) and Patrol Unit (SATROL) who carry out security operations the sea. The data obtained in the form of data that are qualitative and quantitative consisting of primary and secondary data obtained by direct interviews with relevant agencies and also with a journal and keep the ship in the field. Of SOPs and data obtained Armatim SATROL sector operations in eastern Indonesia and the ability of patrol boats in the form of speed, endurance sailing and compatibility range radar and patrol boats operating in the sector. Of SLOG and SRENA Armatim data obtained liquid logistics costs and logistics personnel patrol boats.

This fitness value is used as a reference in achieving optimum value in the genetic algorithm. . Because TSP aims to minimize the distance, then the fitness value is the inverse of the total distance of the line obtained. How to do inverse can use the formula 1 / x or 100000-x, where x is the total distance of the line obtained.

Data Types

Data Capabilities Patrol Boats

Data capabilities needed patrol boats in the study were included speed knots), endurance (days) and the radar range (miles).

Ability coverage area coverage patrol boats

Patrol boats data can be used to calculate a range of capabilities and range of coverage area during a patrol boat sailed carry out the operation. Patrol boats moving from one point to another during the operation has a variable speed capability and the ability of radar coverage.

A range of patrol boats is the ability of the distance range patrol boats that sail for 1 day. Coverage area is the area of the patrol boats that can covered patrol boats in the area of operation for 1 day sail. To calculate the distance and roaming wide range of patrol coverage per day for sailing ships depicted in Figure 5 and defined as follows. :

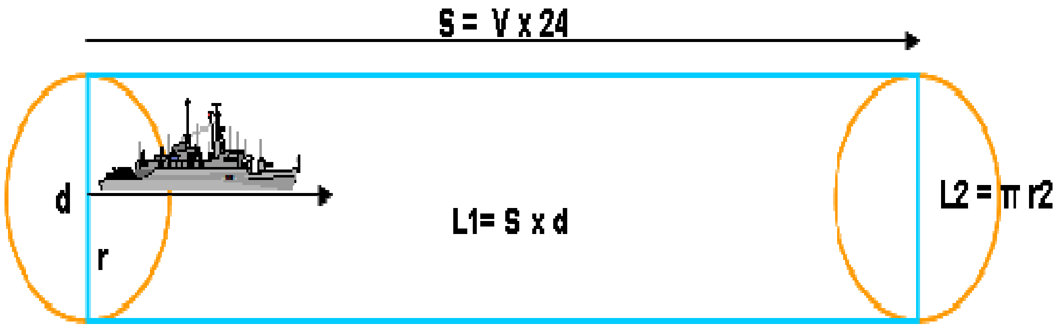

Figure 5. Wide range of coverage area patrol boat (Source: Okol Sri Suharyo, 2008)

Description

S = Distance cruising per day = Velocity x 24 hours = V x 24 (miles)

L1 = Area of rectangle = S x d (mil^2)

L2 = The area of a circle = πr^2 (mil^2)

d = Range radar (miles)

Wide range patrol vessel coverage is the rectangular area (L1) coupled with an area of a circle (L2)

Area Coverage = (L1 + L2) x Probability of detection radar

= (L1 + L2) x 0.9 (mil^2)

KRI UntungSuropati (USP) with a velocity V = 14 knots, the radar range d = 48 miles, then:

S = Distance Cruising per day = 14 miles / hour x 24 hours = 336 miles

L1 = S x d = 336 x 48 = 16 128 mil

L2 = 3.14 x r^2 = 3.14 x 24 2 = 1809 mil^2

Coverage Area KRI USP = (L1 + L2) x 0.9 = (16,128 + 1,809) x 0.9 = 16 143 mil^2 per day

???

Operating Costs of Armatim Patrol Ship

Operating costs are defined as costs per day liquid logistics, logistics personnel and maintenance costs for operating the ship. The use of liquid logistics include Fuel (BBM) Solar, Freshwater and Lubricating oil. The use of logistics personnel include: Benefits screen, Lunch Money Operations and Leadership allowances

Ship maintenance during operation is the cost of maintaining the ship for sailing carry out the operation. There are 3 types of calculations carried out as follows:

1. Calculation of Liquid Logistics Use
   a. Cost of fuel = fuel use per day x price of fuel = A ltr x IDR 4300
   b. Freshwater cost (AT) = AT daily usage x price AT = B ltr x IDR 20
   c. Lubricating oils (ML) = Use Price ML x ML per day = C ltr x IDR 14 850
2. Use of Logistics Personnel Calculation
   a. Screen allowances; (IDR 5.000/hr/personnel) = IDR 5000 x Amount. Ship personnel
   b. Lunch Money Operations; (IDR 15.000/hr/personnel) = IDR 15,000 x Qty. Ship personnel
   c. Allowances Leader / Commander: (IDR 220 000 / E) = (IDR 220 000 / hr E)
3. Calculation of Ship Maintenance for sailing / Operations
   Parchim class = (Rp 1.200.000/hr E)
   Class = (IDR 1.500.000/hr E)
   Class PC = (Rp 800.000/hr E)

Process Optimization

In determining the model and optimization solution requires some parameters, the so-called parameter here is the control parameter of GA , namely:

a. Population size (pop_size)

b. Probability of crossover (Pc)

c. Probability of mutation (Pm)

This parameter value is determined also by the problems to be solved. There are several recommendations that could be used, among others:

a. For problems that have a large enough area of the solution, De Jong recommends to control parameter values: (Pop_size = 50, Pc = 0.6, Pm = 0.001)

b. If the average fitness of each generation is used as an indicator, then Grefenstette recommends: (Pop_size = 30, Pc = 0.95, Pm = 0.01)

c. When the fitness of the best individual is monitored at each generation, the proposal is: (Pop_size = 80, Pc = 0.45, Pm = 0.01)

Process optimization and visualization shown in Figure 6and 7 below:

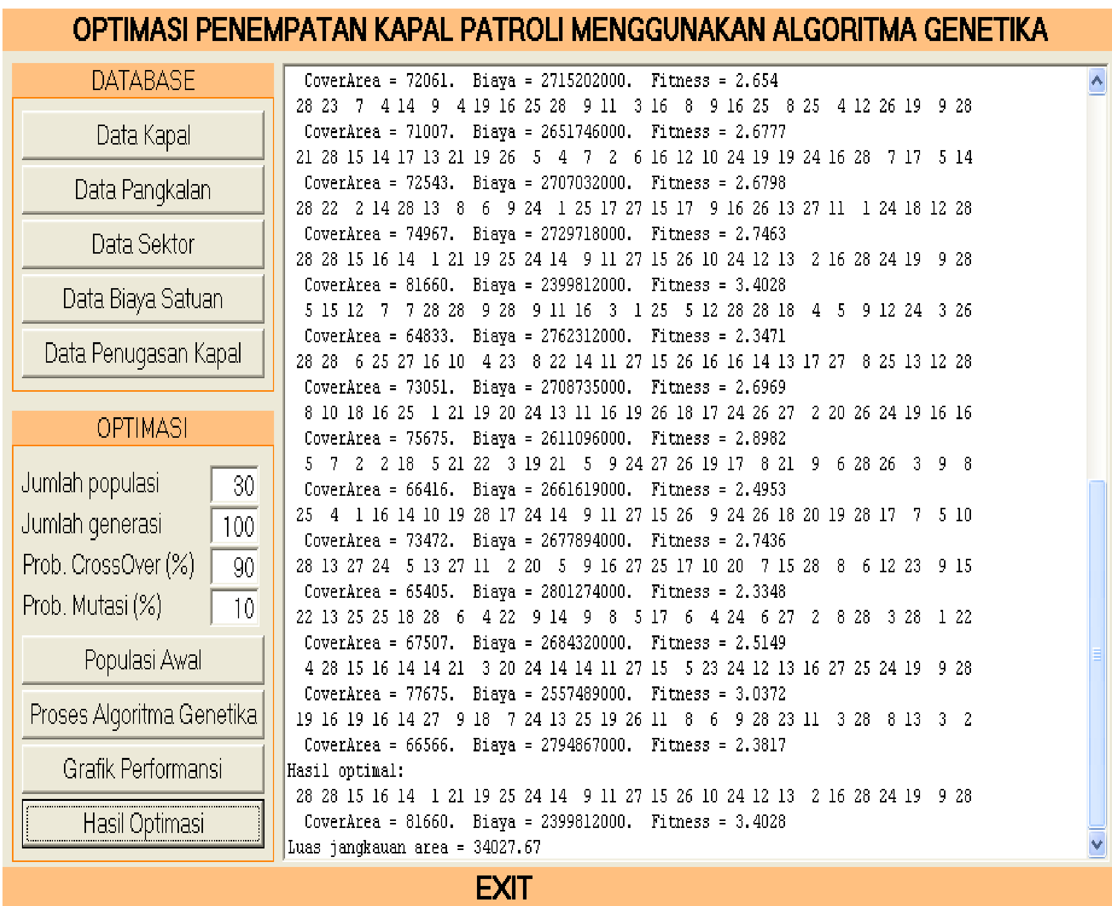

Figure 6. Optimization process using GA

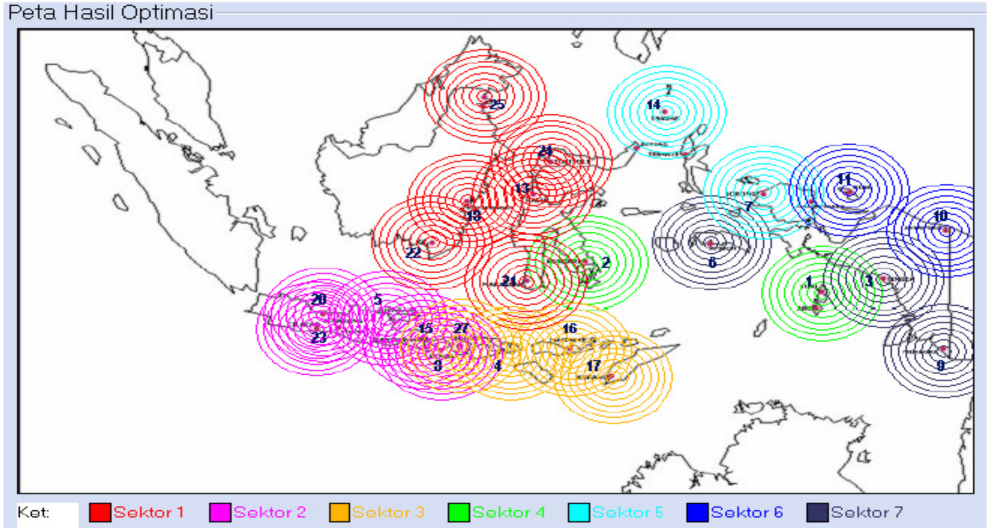

Figure 7. Visualization of TNI AL ship assignment in each sector

Scenario of Experiment

For the determine the population size, probability of crossover (Pc) and probability of mutation (Pm) refers to previous studies. Thus obtained two scenarios as follows:

a) The first scenario

Pc = 0.6, Pm = 0.001 size = 10-100 Pop-generation = 10,000

Pc = 0.45 Pm = 0.01 Pop-generation size = 10-100 = 10,000

Pc = 0.95 Pm = 0.01 Pop-generation size = 10-100 = 10,000

The experimental results of the first scenario can be seen in Table1.below:

Table 1. Result of 1's Scenario -the generation of 10,000

N	Pc = 0,6			Pc = 0,45			Pc = 0,95		
	Pm = 0,001			Pm = 0,01			Pm = 0,01		
	Coverage Area 1	Biaya Operasional 1	Nilai Fitness 1	Coverage Area 2	Biaya Operasional 2	Nilai Fitness 2	Coverage Area 3	Biaya Operasional 3	Nilai Fitness 3
10	1,944,551	3,046,043,000	6.1055	1,939,785	2,921,216,000	6.4631	1,977,021	2,906,698,000	6.5251
20	1,931,273	3,943,504,000	6.2880	1,949,642	2,844,263,000	6.5788	1,928,553	2,853,487,000	6.5824
30	1,932,916	2,989,462,000	6.2875	1,944,318	2,877,149,000	6.5814	1,936,263	2,934,228,000	6.4215
40	1,921,000	2,921,221,000	6.4014	1,929,140	2,899,437,000	6.4765	1,913,493	2,869,913,000	6.4907
50	1,936,110	2,948,781,000	6.3881	1,915,068	2,862,652,000	6.5133	1,938,394	2,921,216,000	6.4584
60	1,906,514	2,875,272,000	6.5539	1,923,851	2,895,566,000	6.4672	1,962,093	2,897,493,000	6.4951
70	1,903,560	3,031,521,000	6.1120	1,944,622	2,897,453,000	6.4347	1,948,374	2,897,520,000	6.5476
80	1,947,446	2,913,954,000	6.5062	1,926,257	2,853,417,000	6.5744	1,943,382	2,950,729,000	6.4085
90	1,942,929	2,853,447,000	6.6330	1,912,350	2,987,484,000	6.2227	1,927,558	2,888,280,000	6.4969
100	1,944,330	2,906,697,000	6.5122	1,948,631	2,897,538,000	6.5484	1,937,965	2,928,467,000	6.3404

b) Second scenarios

Pc = 0.6, Pm = 0.001 size = 10-100 Pop-generation = 5,000

Pc = 0.45 Pm = 0.01 Pop-generation size = 10-100 = 5,000

Pc = 0.95 Pm = 0.01 Pop-generation size = 10-100 = 5,000

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 2, No. 3, May 2012

The experimental results of the second scenario can be seen in Table 4.5 below:

Table 4.5 Result of 2's Scenario -the generation of 5000

N	Pc = 0,6			Pc = 0,45			Pc = 0,95		
	Pm = 0,001			Pm = 0,01			Pm = 0,01		
	Coverage Area 1	Biaya Operasional 1	Nilai Fitness 1	Coverage Area 2	Biaya Operasional 2	Nilai Fitness 2	Coverage Area 3	Biaya Operasional 3	Nilai Fitness 3
10	1,938,034	3,046,043,000	5.9834	1,927,059	2,921,216,000	6.4194	1,952,989	2,950,744,000	6.4411
20	1,944,259	2,978,279,000	6.2501	1,934,224	2,897,534,000	6.4985	1,893,653	2,906,678,000	6.4373
30	1,908,836	2,897,509,000	6.4107	1,935,514	2,897,478,000	6.4031	1,939,045	2,948,801,000	6.3981
40	1,953,246	2,939,607,000	6.3673	1,921,352	2,853,487,000	6.5570	1,963,458	2,913,949,000	6.3613
50	1,925,109	2,941,500,000	6.2670	1,901,653	2,881,058,000	6.4235	1,935,170	2,899,431,000	6.4974
60	1,921,581	2,934,243,000	6.3712	1,929,899	2,912,036,000	6.2502	1,937,411	2,943,448,000	6.3046
70	1,916,779	2,921,266,000	6.3841	1,935,785	2,950,724,000	6.2827	1,921,817	2,948,766,000	6.3395
80	1,913,220	3,018,498,000	6.1594	1,936,178	3,002,077,000	6.1710	1,909,557	2,913,929,000	6.3758
90	1,921,745	3,018,453,000	6.2875	1,932,765	2,897,464,000	6.2936	1,923,947	2,994,770,000	6.1459
100	1,913,774	2,853,432,000	6.5405	1,917,736	2,943,458,000	6.2375	1,928,025	3,046,048,000	6.2504

Comparison of Experimental Results From Two Scenarios

From the above experimental results by using multiple input parameter optimization results obtained are as follows:

1. The first scenario:

Experiment with population size = 10-100, Pc = 0.6, Pm = 0.001, L = 10,000

a. Coverage Area = 1942.929 Mil^2

b. Operating Costs = IDR 2.853.447.000

c. Fitness value = 6.6330

Experiment with population size = 10-100, Pc = 0.45, Pm = 0.01, L = 10,000

a. Coverage Area = 1,944,318 Mil^2

b. Operating Costs = IDR. 2.877.149.000

c. Fitness value = 6.5814

Experiment with population size = 10-100, Pc = 0.95, Pm = 0.01, L = 10,000

a. Coverage Area = 1,928,553 Mil^2

b. Operating Costs = IDR. 2.853.487.000

c. Fitness value = 6.5824

2. The second scenario

Experiment with population size = 10-100, Pc = 0.6, Pm = 0.001, L = 5000

a. Coverage Area = 1913.774 Mil^2

b. Operating Costs = IDR. 2.853.432.000

c. Fitness value = 6.5405

Experiment with population size = 10-100, Pc = 0.45, Pm = 0.01, L = 5000

a. Coverage Area = 1,934,224 Mil^2

b. Operating Costs = IDR. 2. 897.534.000

c. Fitness value = 6.4985

Experiment with population size = 10-100, Pc = 0.95, Pm = 0.01, L = 5000

a. Coverage Area = 1,935,170 Mil^2

b. Operating Costs = IDR. 2.899.431.000

c. Fitness value = 6.4974

Verification of Optimization Results

Verification of model results of the experiment aimed to check whether the model obtained from the optimization calculations are in accordance with the conditions on the ground, but it also as a comparison between the optimum conditions obtained from the model calculations with the real condition.

The verification results of the second scenario can be seen in Figure 4.4, 4.5 and 4.6 below:

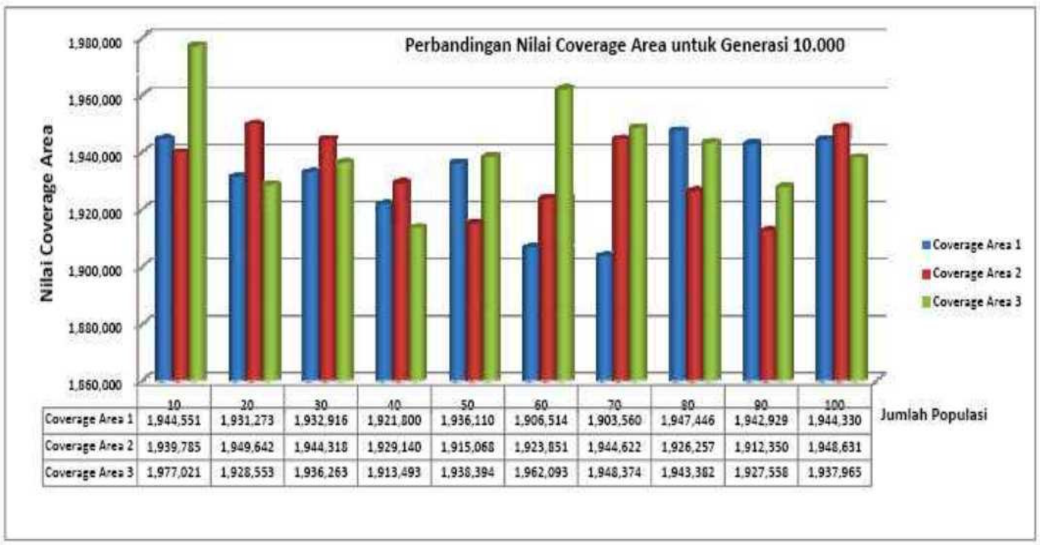

Figure 4.4 Result of Verification for 1's Experiment

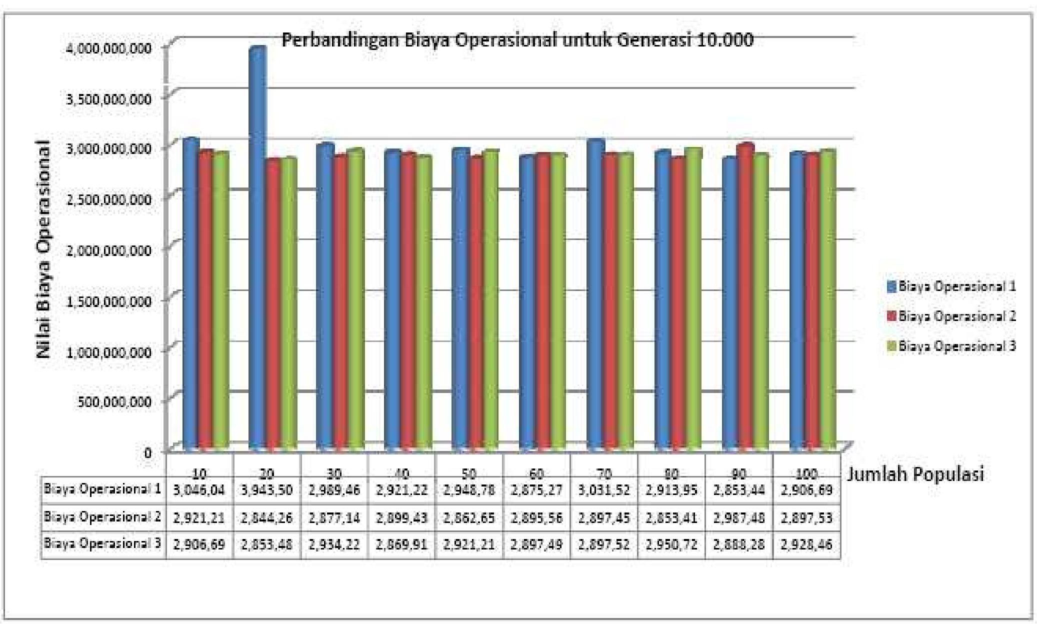

Figure 4.5 Result of Verification for 2'd Experiment

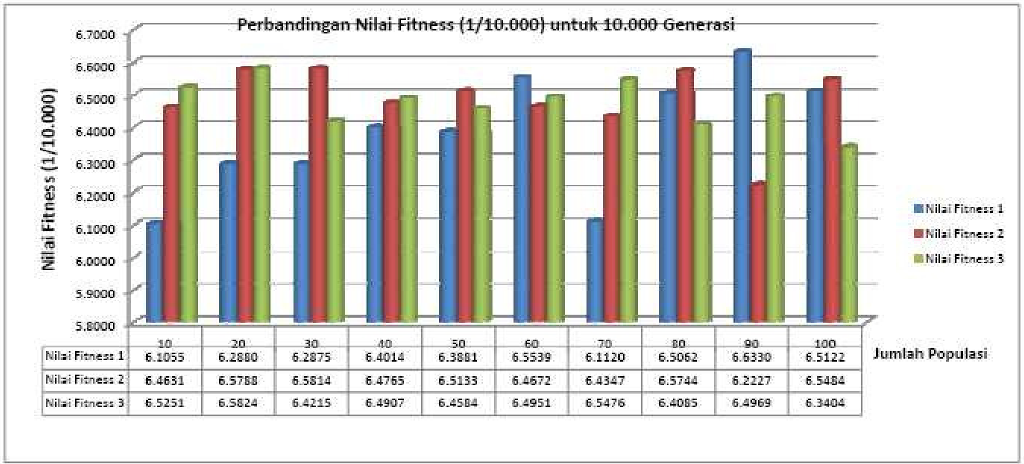

Figure 4.6 Result of Verification for 3'd Experiment

Based on data from field data that the eastern region comprising of 7 sectors has a total land area of about 1,688,765 Mil^2 be secured with a cost of IDR. 5.000.000.000, - while the optimization results generated from multiple experiments by using the GA a more optimum results obtained with several variations of input to get excellent results with the target area of coverage area of 1,942,929 Mil^2 only cost IDR. 2,853,447,000.

CONCLUSION

From a series of data processing and analysis carried out in the research / thesis can be drawn some conclusions as follows:

a. Results of optimization with the parameter number of 10000 generations, the population 10-100, the probability of mutation 0.1% and probability of crossover 60%. The results show the effect of running the program on population size to changes in the value of fitness. So we get coverage area 1,942,929 Mil^2, operating costs IDR 2,853,447,000 and the value of fitness 0.6633.

b. Results of optimization with the parameter number of 5000 generations, the population of 10-100, the probability of mutation 0.1% and probability of crossover 60%. The results show the effect of running the program on population size to changes in the value of fitness. So we get coverage area 1,913,774 Mil^2, operating costs IDR 2,853,432,000 and the value of fitness 0.65405.

c. From the results of several experiments using GA selected results using the parameter generation is between 10,000 and 500, the population was selected among 10-100, probability of mutation 0.1% and probability of crossover 60%

d. With a lot of the GA method proposed solution for the placement of the patrol fleet to every sector with respect to coverage area and operating costs.

RECOMMENDATIONS

The author recommends the development of this system in order to meet the needs of TNI-AL in particular ARMATIM are:

1. Provide additional input parameters such as (weather, waves, sector vulnerability, and weapons) in the placement optimization process using a fleet of patrol boats that approached the Genetic Algorithm actual field conditions.
2. Genetic Algorithm method could be developed to problems else in the world of marine and shipbuilding, for example, to determine the shortest route, the placement of containers of goods, and can also be combined with other methods to control the field.
3. Adding visualization assignment operations sector by providing on the size and a limit extent of the sector.

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