2011 International Conference on Telecommunication Technology and Applications
Proc .of CSIT vol.5 (2011) © (2011) IACSIT Press, Singapore

Optimal Sensor Deployment for Object Recognition using Artificial Intelligence Methods

Abdolhossein Alipoor [1, a)], Mehdi Fesharaki[2, b)]

[1]CE Department, Islamic Azad University, Babol Branch, Iran

[2]CE Department, Maleke Ashtar University, Tehran, Iran

[a)] hosseinalipoor@srbiau.ac.ir

[b)] fesharaki@mut.ac.ir

Abstract. In this era of rapid intelligent sensor systems, one practical goal of sensor deployment in the design of distributed sensor systems is to achieve an optimal monitoring and surveillance of a target region. Since environmental condition and target characteristic are two parameters which can change sensors values in target recognition so for achieving highest target recognition rate, sensors must be deployed intelligently. The intelligent sensor deployment for monitoring operations and target detection is one of the serious subjects to reduce information processing time and increasing information fusion accuracy. This paper attempts to design an intelligent sensor deployment service to detect the presence or absence of a target in a region with obstacles by using optimization algorithms and neural network. This service specifies the best sensory configuration having highest recognition rate in each situation. We propose two different optimization algorithms including genetic algorithm and simulated annealing to help accessing the best sensors positions in a definite environment. Since there is no assessment function for acquiring the best configuration of sensors group on the basis of problem space variation, Neural Network is used to perform as a fitness function estimator in the optimization approaches. We define 500 different scenarios for 9 sensors in different conditions for neural networks training process. By defining new scenario and run optimization algorithms in this scenario we find sensors in which placement must be used to reach the highest recognition rate.

Keywords: Intelligent Sensor Deployment, Objects Recognition Rate, Optimization Algorithms, Neural Network.

1. Introduction

Sensor deployment is a fundamental issue in sensor networks. Studies on the deployment problem are concentrated on deploying sensors to cover assigned areas or set of points efficiently [1]. The sensor deployment operation determines the best configuration in every situation and Not only should the sensors be informative, Processing information in sensor fusion is done more precisely and with lower noise, which leads to product more accurate information and Processing is performed on less information so the time of information processing for target detection is decreased. It is important to realize that, although the deterministic detection model is considered frequently in literature, the detection process is in fact stochastic in nature. Target is more likely to be present at certain points of the surveillance region than in others. Moreover, this probability may even change in time. Sensors are also non-deterministic. The probability that a sensor actually detects a target is, in general, a function of distance between them, but it also depends on other factors, such are environmental conditions and measurement noise. Therefore utilizing artificial intelligence methods help to find optimal sensor deployment in indecisive problems.

2. Sensor deployment optimization service

Due to different efficiency of sensors and also many effects of environmental conditions on sensors' performance, optimized sensor deployment is so important. Many techniques have been developed for general optimized solution searching for sensor deployment. These techniques range from applying strategy based on Target Involved Virtual Force Algorithm (TIVFA) and sensor protecting strategy [1] to applying advanced artificial analysis techniques such as genetic algorithms and simulated annealing algorithms [2]. Unique optimization techniques have been proposed such as particle swarm optimization [3] and cutting and surrogate constraint analysis [4]. The point of this section is not to review each search solution or optimization technique but to identify the variety of algorithms available. Genetic algorithm uses a set of chromosomes to present possible solutions for solving problems. Each chromosome contains substrings called genes, expressing variants of the problem space. In this paper, genetic algorithm is one of optimization methods used for finding the optimal sensor deployment for target detection. Figure 1(a) illustrates a chromosome that is a set of sensors defined as one possible solution. In this problem since 9 sensors use for environmental monitoring and every sensor locate in two dimensional ranges X, Y. Therefore each chromosome has 18 genes which every two genes depict each sensor's geographical position. For Example the solution is shown in the Figure 1(a) placed sensor 1 in X1 = 5, Y1 = 5 and sensor 2 in X2 = 7, Y2 = 96 and sensor 3 in X3 = 107, Y3 = 103 and …, sensor 9 in X9 = 94, Y9 = 69 respectively. Figure 1(b) illustrates the whole process of sensor deployment using genetic algorithm. The contribution of this paper is the use of neural network as an estimator to evaluate the fitness value of each optimization algorithm chromosomes but In all previous methods at first made a fitness function and then use optimization approach to find the optimal solution so this method is the first utilizing fitness function estimator for sensor deployment in environmental monitoring or target recognition [3, 6 and 7].

G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16	G17	G18
S1		S2		S3		S4		S5		S6		S7		S8		S9	
X1	Y1	X2	Y2	X3	Y3	X4	Y4	X5	Y5	X6	Y6	X7	Y7	X8	Y8	X9	Y9
5	5	7	96	107	103	3	196	97	102	108	197	200	1	193	104	199	196

Fig.1. (a): Chromosome Structure.

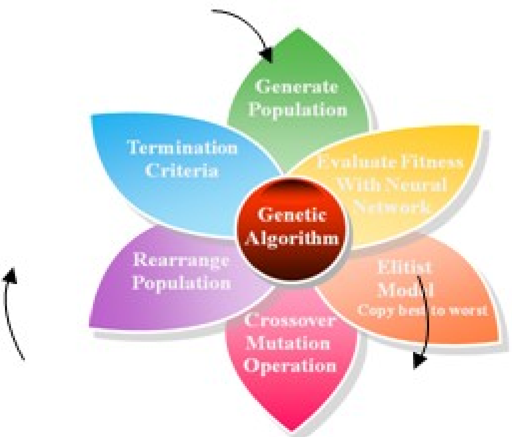

Fig.1. (b): Genetic Algorithm Process.

```
Procedure simulated annealing
Begin
t←0
Initialize temperature T
Select a current string VC at random
Evaluate VC
Repeat
Repeat
Select a new string VN
In the neighborhood of VC
By flipping a single bit of VC
If f (VC) < f (VN)
Then VC ← VN
Else if random [0, 1) < exp {(f (VN) - f (VC))/T}
Then VC ← VN
Until (termination-condition)
T←g (T, t)
t←t+1
Until (stop-criterion)
End
```

Fig.1. (c): Pseudo Code of Simulated Annealing [5]

For implementing optimization algorithms and showing their results use MATLAB Optimization tools. In genetic algorithm, stochastic uniform method is used for deployment function. For scaling, function rank method is used and two point functions with 0.8 crossover fraction is used for crossover function. Constraint dependent function is also used for mutation with 0.2 mutation fraction [5, 6]. In Simulated annealing method for annealing function, Boltzmann annealing function is used. After that Exponential temperature update is used for temperature update function and used [0, 0, 0, 0, 0, 0] point for start point of simulated annealing algorithm.

3. Evaluating fitness value with neural network

The most important part of optimization problem is to evaluate fitness of any solution which showing every selected solution to what extend optimized. Since there is no assessment function for acquiring the best configuration of sensors on the basis of problem space variation and there is no function to specify every sensory deployment in each situation has what target recognition rate, we use neural network as a targets recognition rate estimator and utilize one of its methods term Multilayer perceptron neural network (MLPNN) for fitness value estimation. The reason of using this method refers to our previous research [9], which depicted that MLP method is one of the best methods for evaluating fitness function in optimization algorithm for sensor deployment. Every sensory position is one of MLP input, therefore MLP has 9 inputs and has 3 layers to estimate target recognition rate of every sensory deployment. The first layer has 50 neurons; the second one has 20 neurons and the last one has 1 neuron. The first and second layer take advantage of Tansig activation function and the third layer use pure line activation function. Error back propagation training algorithm with 0.1 learning rate and The Levenberg- Marquart function is used for the training part. Besides, the network training stop criteria is specified as the 1e-05 mean square error. Supervised learning model is used for neural networks training by using MATLAB toolbox [8, 9 and 10].

4. Specification of neural network input and output in the current problem

To estimate the fitness value of each chromosome accurately, at first the neural network should be trained with a set of real data. In this problem, the neural network is trained with 500 samples. When neural network accomplish the accurate estimation on real data, it presents suitable response per each input. In this research surveillance operations performed in the geographical ranges of 200Km * 200Km and All of sensors mentioned in this paper are homogenous placed in definite geographical area. In order to get real data, sensors in 500 different scenarios with different conditions are run and get target existence recognition accuracy rate of each sensors deployment. We use them as real data in neural networks training stage and after that, the neural networks will be able to estimate the output of sensors in new scenario as fitness function of optimization algorithms.

5. Experimental result

In this paper, optimization algorithms are used for sensor deployment. Neural network is utilized for the purpose of estimating fitness function of each optimization algorithms: genetic algorithm and simulated annealing and compared their results. By using 500 different scenarios, the training task of neural networks is done. Consequently, the neural network approach obtained the efficiency with error accuracy of 1.85e-05. New scenarios are defined and optimization methods are run in new situation. To found which algorithm can obtain the optimal sensors deployment, every optimization method runs 10 times and earned run averages. The genetic algorithm approach obtains % 96.6 recognition rates in 46 seconds average times. Figure 2(a) shows the result of one genetic algorithm running and obtained % 96.256 recognition rates in 50 second. This method proposed sensors deployed in these positions: sensor 1 in $X1 = 5$, $Y1 = 5$ and sensor 2 in $X2 = 7$, $Y2 = 96$ and sensor 3 in $X3 = 107$, $Y3 = 103$ and …, sensor 9 in $X9 =199$, $Y9 =196$ respectively. Simulated annealing approach obtains % 94.70 recognition rates in 53 second average times. Figure 2(d) shows the result of one simulated annealing running and obtained % 96.170 recognition rates in 50 seconds. This method expressed sensors placed in these positions: sensor 1 in $X1 = 1$, $Y1 = 9$ and sensor 2 in $X2 = 61$, $Y2 = 47$ and sensor 3 in $X3 = 111$, $Y3 = 98$ and …, sensor 9 in $X9 = 94$, $Y9 = 69$ respectively. Figure 2(b), (c) show the deference between these two approaches by computation of their time consuming and recognition rates and indicated that the genetic algorithm is the best method for optimal sensor deployment.

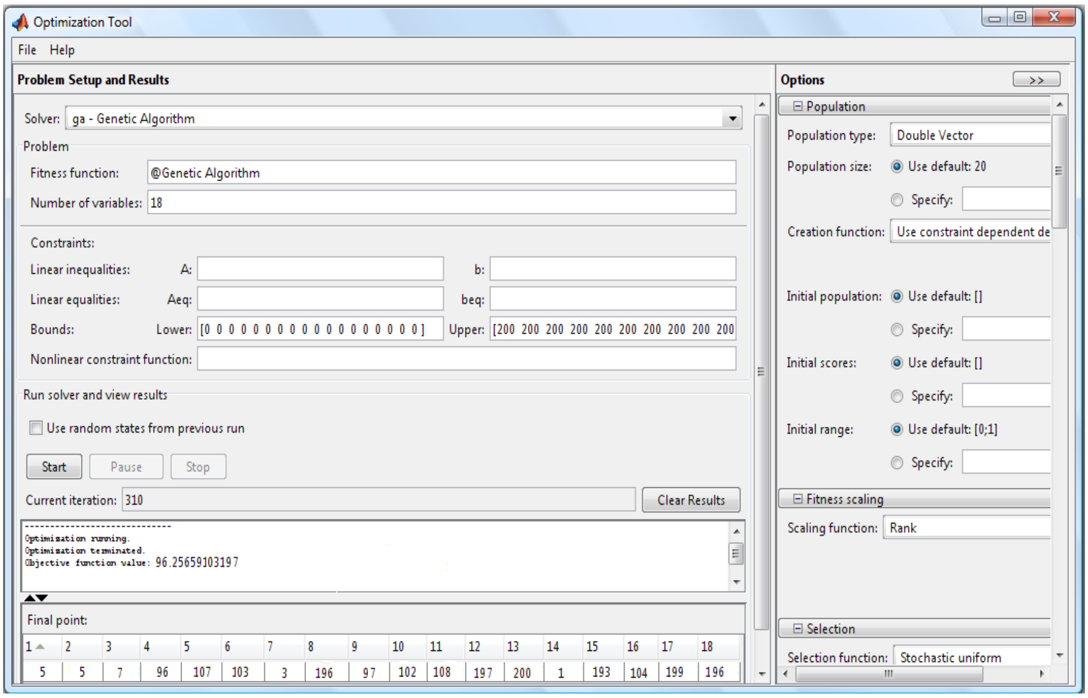

Figure. 2. (a): The Result of Genetic Algorithm Running

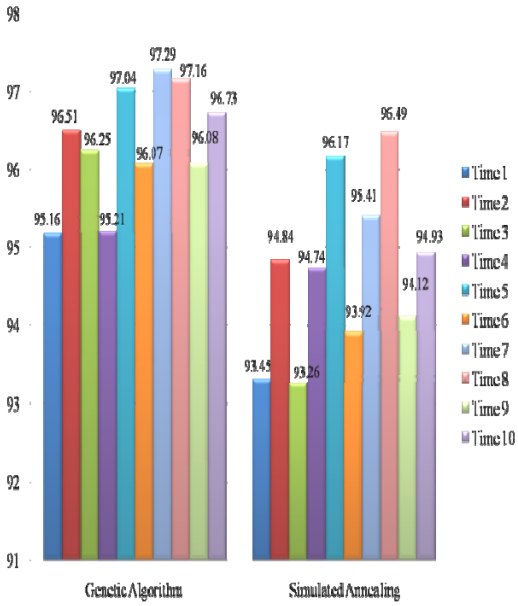

Figure. 2. (b): Recognition Rate Comparison between two methods.

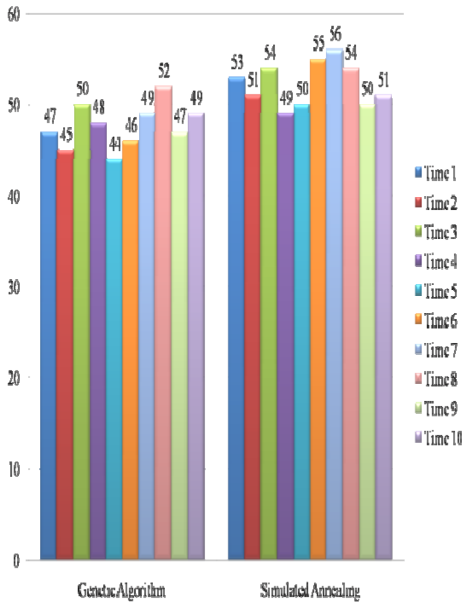

Figure. 2. (c): Time Consuming Comparison between two methods.

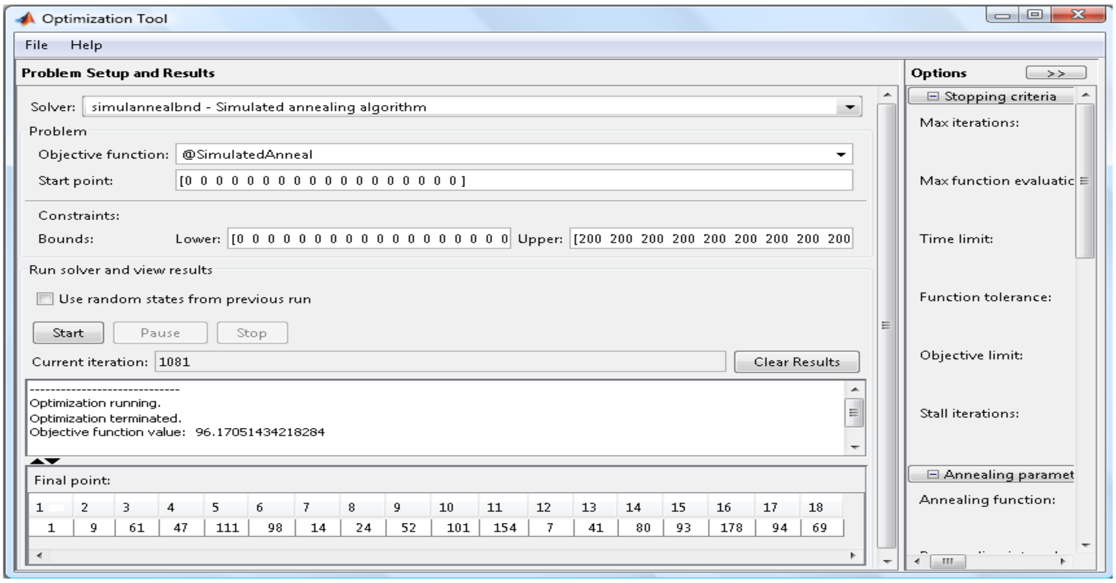

Figure. 2. (d): The Result of Simulated Annealing Running.

6. Conclusion and future work

We conclude that utilizing genetic algorithm with neural networks is a good approach for intelligent sensor deployment. With the use of genetic algorithm the most suitable configuration of sensor is obtained. The novelty of the proposed algorithm lies in the fact that the fitness is evaluated using neural networks to estimate the fitness value of each chromosome in the optimization algorithm. Using multi objective optimization to find the Pareto front between sensor numbers and recognition rate to found the highest recognition rate for every specific sensor numbers can be considered as future work.

7. Reference

[1] S. Li, C. Xu, W. Pan and Y. Pan, “Sensor Deployment Optimization for Detecting Maneuvering Targets”, *7th International Conference on Information Fusion*.2005.

[2] J. Deng, Y. S. Han, P.-N. Chen, and P. K. Varshney, “Optimal transmission range for wireless ad hoc networks based on energy efficiency,” *IEEE Trans. on Communications*, 2007.

[3] X. Xu, “Approximation for sensor deployment*,” IEEE Transactions on Computers*, 2007.

[4] D. B. Jourdan and O. L. de Weck, “Layout optimization for a wireless sensor network uses a multi-objective genetic algorithm,” *in IEEE Semiannual Vehicular Technology*, 2004.

[5] Thomas Weise, "Global Optimization Algorithms–Theory and Application", Version: 2008.

[6] J.W. Gardner, "Enhancing electronic nose performance by sensor selection using genetic algorithm approach," *Elsevier Sensors and Actuators journal*, Pages 114-121, 2005.

[7] H. Petersson and R. Klingvall, " Martin Sensor array optimization using variable selection and a Scanning Light Pulse Technique*," Elsevier Sensors and Actuators journal*, Volume 142, Issue 2, Pages 435-445, 5 November 2009.

[8] A. Konstantinidis, K. Yang, Q. Zhang and D. Zeinalipour, “A multi-objective evolutionary algorithm for the deployment and power assignment problem in wireless sensor networks”, *Elsevier Computer Network journal*.2009.

[9] A., Alipoor and M., Fesharaki, “Calculating the Impact Factor of Neural Networks on Optimization Algorithm for Sensor Selection”, IEEE *8th International Conference on High Performance Computing & Simulation*, NO 097, pp.650-655, France, 2010.