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Using the Hybrid GA-TOPSIS Algorithm to Solving the Site Selection Problem in Passive Defense

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ABSTRACT

One of the main principles of the passive defense is the principle of site selection. In this paper, we propose a multiple objective nonlinear programming model that considers the principle of the site selection in terms of two qualitative and quantitative aspects. The purpose of the proposed model is selection of the place of key production facilities of a system in which not only it observes the dispersion principle but also reduces the system transportation costs. Moreover, the proposed model tries to select the sites that can fulfill other elements of site selection as well as dispersion in a way that it increases the trustworthiness of the selected network. For solving the proposed model we used the Genetic Algorithm integrated with TOPSIS method

1. Introduction

Facility location or site selection is a kind of spatial planning during which the place of establishment will be determined. In the usual spatial planning, first the features of the zones is determined and then depending on their features and specifications, the activity or the activities that are suitable for each zone is determined. But in site selection, first the features of a particular activity is determined and then the places and zones that are more suitable for the determined activities will be assigned (Drezner, 1995).

Site selection is vital to the efficiency and profitability of industrial activities. Industrial location presents a comprehensive introduction to and critical review of this field of growing academic and business interest.

The industrial site selection theories intend to explain the structure of the site selection of the industrial activities based on the factors and variables that are efficient in site selection and try to find the best sites for establishment of industrial centers. Most of these theories originate from economic thoughts formulated by the economists. They have tried to create these theories so that they relate the site variable to the main body of the economic theories. Generally, the industrial site selection theories can be divided into three methods (Church and Murray, 2009).

a) Minimum cost method in which, in the process of site selection, the attempt is made to minimize the production costs.
b) The analysis of the available commercial area in which the main focus is on the demand and market and also maximizing the available area.
c) Earning the maximum advantages that is, in fact, the logical result of the above methods.

The ideas made by Lan Hard, Houver and Weber are mostly related to minimizing the costs. In 1890s, Lan Hard tried to show how it is possible to show a optimum site selection in simple conditions of two primary sources and one market in a triangle (Wesolowski, 1993).

The beginning of the industrial site selection goes back to 1909 when Weber published his book Weber Standortder Industrien in this regard. In this book, he presented his paper findings on factorial industries. He took the fallowing three factors as the influential elements in industrial site selection: (Weber, 1965)

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- Workforce costs
- Transportation costs
- Association forces or non association of the transportation costs.

In recent years, the principle of site selection has been more emphasized and the scientists have proposed many theories on this domain (Hamacher et.al, 2004). In traditional microeconomic theory, the firm is defined as a productive unit which seeks to maximize profit through production and sales, so most of researchers in this context only focus on the system costs. Their results can not solely be applied in passive defense issues because they do not pay attention to the security of facilities places, limitation of their distances, their dispersion to increase the covered areas and reduce their recognizability by the enemy and avoid impairment of production network because of being closeness. If the facilities be placed near each other, they may be attacked in an inroad.

One of the defining objectives in location science is to maximize dispersion. Facilities can be dispersed for a wide variety of purposes, including keeping competitors of the same franchise system apart, dispersing criminal rehabilitation facilities from population centers, and locating nuclear power plants in such a way as to maximize security (Curtin and Church, 2006).

Dispersion models can be applied over a spectrum of scales: macroscale applications include such things as the location of radio transmitters or defense installations over a large geographic region; mesoscale applications include the location of schools, housing developments, landfills, or incinerators within a smaller, well-defined geographic region; and microscale applications of dispersion can include such things as product shelf location and factory or classroom layout studies (Alçada-Almedia et.al, 2009, Rakas et.al, 2004)

By far the most common use of dispersion models is for the location of undesirable facilities (see Church and Garfinkel, 1978; Drezner and Wesolowsky, 1985; Erkut and Neuman, 1989; Drezner and Wesolowsky, 1996). This literature is further divided into the location of noxious and obnoxious facilities. Noxious facilities are those that present some health risk to any population that would be exposed to either the damaging repercussions of an accident at the facility or the damaging consequences of long-term exposure to the facility. Examples of noxious facilities include coal-fired power stations, nuclear power plants, hazardous waste storage sites, oil storage tanks, ammunition dumps, landfills, and incinerators. Obnoxious facilities are not expected to cause health risks to populations, but they may have (or be perceived to have) deleterious social or economic consequences associated with their location and operation. Examples of obnoxious facilities include prisons, activities that generate excessive noise, social service centers, and rehabilitation (e.g., drug treatment) centers (Murray et al. 1998). Obnoxiousness may result in disagreements between the facility operator and the local population that are based on ideological or attitudinal conflict (Sorensen, et.al, 1984). Facilities that are considered undesirable may have attributes that are both noxious and obnoxious (Berman and Wang, 2008).

The main theory in recent wars is the Five Strategic Rings of Warden. Col. John A. Warden III, a former USAF officer and theorist of air power, established a theory of strategic attack based on five levels of system attributes. They are:

- Leadership
- Organic/System Essentials
- Infrastructure
- Population
- Fielded Military Forces.

Each level of system or "ring" was considered one of the enemy's centers of gravity. The idea behind Warden's five rings was to attack each of the rings to paralyze their forces, an objective also known as physical paralysis. (Movahedniya, 2007)

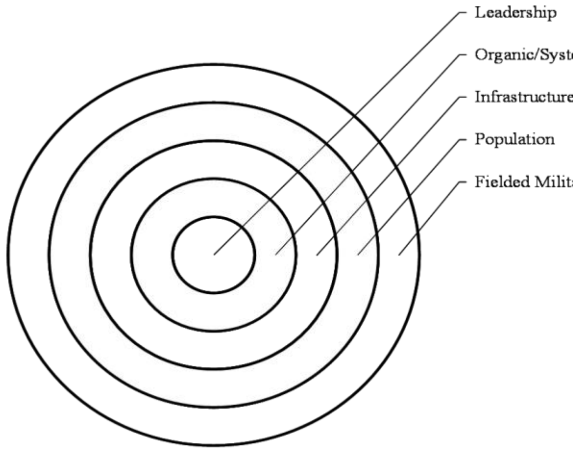

Fig. 1. Five Strategic Rings of Warden

The Purpose of this paper is to develop a model for facility location based on passive defense and a solution method for it that can be applicable against Wardens theory. So the proposed model tries to maximize the facilities dispersion measure. It can do so by maximization of the set of measured spatial (Euclidean) weighted distances. It should, also, select the sites that have reliability. This reliability refers to the ability to perform the duty and harmony with the environment. Additionally, we must minimize the transportation, location and production costs of the facilities.

The rest of this paper organized as follows: In the following section, we explain the necessity of site selection in the passive defense and then analyze the problem and its requirements and the way of fulfilling them. We also deal with the limitations of the problem and the reason of their existence. In section 4, we make the hypotheses, nomenclature and present the proposed model. In section 5, the conclusion of the proposed model will be offered in a unique unit and a numerical example will be solved. And then, the results and the model capabilities, in comparison with other models, will be analyzed.

2. Passive Defense and Site Selection Necessity

In the modern wars, it is inevitable to perform the passive defense steps in order to confront the enemy's attacks and reduce the damages due to air, land and naval attacks. It is a fundamental issue that covers all key substructures, crucial, hypersensitive and important military and non-military centers, like refineries, power plants, ports, airports, large industrial complexes, military and politic headquarters, tele-communication centers, strategic bridges, military industries, air bases, missile pads, populated centers and tactical quarters, support and defense seats, etc (Movahedniya, 2007).

The paper approach to statistics and recorded experiences in old wars shows that the technology gap between enemy's modern armaments and insider defensive armaments, vulnerability of air defense systems against electronic wars, unawareness of these systems against fighters and cruise and ballistic missiles, launching rockets far away the range of defensive air armaments, lack of anti missile arms will make the crucial points as some simple targets for a successful and quick aiming by enemy's fighters and armaments. Therefore, it seems necessary and inevitable to observe the principles of passive defense and execute them in the country. To do so, one of the main principles is site selection.

According to the proposed identification in the passive defense domain, site selection is: selecting the best and the most appropriate place for establishment in a way that it enables us to hide human force, facilities and activities appropriately. Thus, if site selection is done well, it minimizes the necessity to use artificial tools for camouflage (Movahedniya, 2007).

The experience has shown that an appropriate and suitable site selection can solve many problems related to camouflage and concealment and also reduce the possible threats and vulnerabilities. The advantages of an appropriate site selection are as follows:

The significant reduction of vulnerability.

Creation a suitable defensive situation.

Confronting the enemy with problems and limitations in his attacks and disable it to do any process.

The reduction of dependency to defensive armaments.

In passive defense, site selection includes three bases: duty, dispersion and topography (Sahami, 2007).

Duty has the most important and highest role in comparison with other site selection factors. It is possible for a place to be suitable for establishment of a military or non military unit with regard to camouflage and concealment but not to be accommodating for our duty.

Dispersion is the distribution and decentralization of the forces, facilities, installations or domestic activities to reduce their vulnerability against threats. The main requirement in dispersion principle is the largeness and extent of a position. Since the dispersion of the facilities and installation makes the selected site vulnerable, it is necessary to disperse the facilities, facilities and installations.

During site selection, we may find some places that have an especial form which distinguishes them from other areas. In these areas, therefore, every change in the form can be an indication of activity and human existence. In other words, every kind of new building that is not harmonious with the environment can help the enemy to recognize and identify that area as a crucial point to focus on.

Considering the above principles and rules, we must select a site for facilities and installations so that it can satisfy the requirements of the passive defense. In the same way, we need a model to select the required site of the facilities and installations that can formulate all the limitations and demands.

3. Analysis of the Problem

In this problem, we deal with some places which are placed in one region. Their longitudinal and latitudinal distances (longitudinal and latitudinal coordinates) from a refer point is clear. These points, also, have a feature, named security coefficient that depends on some factors, including the ability of the points to help us to do our duty, the harmoniousness of the facilities with the environment, hiding the facilities from the enemy and other influential parameters that enables the enemy to identify the facilities. It is calculated by multiplying two above parameters by another one, named criticality (gravity).

We define the above parameters as follows:

Duty: the ability to correctly perform the duty based on the facilities in a region that is identified with a number between zero and one. The more this number is for a facility; the more that facility has the ability is to perform his duty in that certain point.

Criticality: it shows the intensity of the effects of enemy's attack on especial facility on the whole system and the usual circulation of the people life. The value of the criticality can be shown by a numerical parameter. The more severe the effects of the attack, the less the value of this parameter.

Recognition: the possibility of the recognition of the site selected facility in that place according to the influential factors in recognition of an facility by enemy's offensive armaments. The more the measure of recognition, the less the value of this number.

For example, if facility in a certain point can perform his duty with a probability of 0.9, and criticality of 0.05

and recognition of 0.85, the security coefficient of that point for that facility will be calculated as follows:

Security coefficient= duty × criticality × recognition = 0.90 × 0.05 × 0.85= 0.0382

These places have some distances too that are different from their spatial distances. The yare the same distances that must be traversed by the land forces who are busy with the system so that they can move from one place to another.
In this issue, there are two kinds of interaction between the facilities that are defined as follows:
Repulsion interaction (disagreement): it is identified by a number between zero and one. The less this number is, the more disagreement will be between those two facilities. This interaction shows that whether these two facilities should be placed far from each other or no. This coefficient is imposed on the system by the essence two facilities application, official policies and other influential factors.
The interaction of the synergetic relationship between two facilities: it is also identified by a number between zero and one that shows the relation weight between two facilities. The greater the value of this coefficient, there are more transportations between these two facilities and thus, the cost of the distance between two facilities.
Because of some spatial limitations and some other factors, we should determine the maximum air distance between different kinds of facilities. These distances are even defined for similar facilities. Our objectives in this model are:We can achieve the maximum dispersion with a focus on maximization of the sum of weighted distances by repulsion coefficients. This purpose seeks to make the created network by site selected facilities, provide the dispersion principle in the passive defense and also be dispersed through the entire network.
Minimization the system transportation cost which identified by synergetic relationship coefficient.
Achieving the maximum created security by the network if it maximize the security coefficient of the selected sites.
And minimizing the total cost included fixed and variable(production) costs.

4. Model

4-1. Hypotheses

It is supposed that the number of the facilities is less or equal to the number of all the sites.
The land distances can not be less than air distances.
The presented repulsion coefficients are taken from the system specialists and experts.
The synergetic relationship coefficient shows the coming and going cost according to the distance between two facilities. These coming and going can be due to non-production relationships too.
The facilities that are in the process of site selection must be kept in a certain distance from each other. Because they may have poisonous and flammable material.
The reference point is not a part of selected sites, but it is located at the low and left of all the sites.
Except the facility site determination variable, other features and parameters related to the sites, facilities, costs and coefficients are known parts of the issue.
All the distances are specified in a center to center mode.
All demands most be satisfied.

5. Definitions

The set of selected points (P) has the following features for site selection:
Longitudinal coordinate that shows the sites distance from the reference point on the X axis in the coordinate system.
Latitudinal coordinate that shows the sites distance from the reference point on the Y axis in the coordinate system.
Each two places have a distance from each other that must be traversed on the land.
The total number of the selected sites is clean cut.
Fixed and variable costs both depend on the facility type and the selected site.
The set of different kind of facilities in site selection (t) have the following features:
The repulsion coefficient between facilities is based on their kind not their places.
The weight coefficient, also, is changed based on the kind of facilities and not their places.
In site selection, the number of every kind of facility is certain.

6. Nomenclatures

In order to define the considered model, we use the following symbols:
N : The total number of the selected sites.
n : The number of the kind of facilities.
X_i : The longitudinal coordinate of the selected site *i*.
Y_i : The latitudinal coordinate of the selected site *i*.
D_{ij} : The distance between two selected sites, *i* and *j*, that ranges from 1 to *N*.
R_{kl} : The repulsion coefficient between *k* and *l* facilities that ranges from 1 to *t*.
C_{kl} : The cost of communication between *k* and *l* facilities that ranges according to the distance unit.
F_{ik} : The fixed cost of placing facility type *k* in site *i*.
V_{ik} : The variable cost of producing one unit of production of facility type *k* in site *i*.
P_{ik} : The capacity for production of facility type *k* in site *i*.

Q_k : The demand for production of facility type *k*.

H_k : The maximum number of facility type *k*.

MD_{kl} : The minimum distance between facilities of type *k* and *l*.

S_{ik} : The security coefficient of the place *i* for the facility *k* that ranges from zero to one.

α_i : The function weight of the ith objective functions in the TOPSIS.

The decision variable of the following model is defined as follows:

$$Z_{ik}\begin{cases} =\mathbf{1}: & \text{If the facility of type } k \text{ is placed in } i. \\ =\mathbf{0}: & \text{Otherwise} \end{cases}$$

7. Formulation of the Model

Because the mentioned purposes can not be explained with a single objective function and in some cases have contradictory with each other, we just can represent the issue as a multi-objective model. Therefore, we formulate the problem as follows:

$$Z_1 = Max\sum_{i=1}^{N}\sum_{j=1}^{N}\sqrt{\left(X_i - X_j\right)^2 + \left(Y_i - Y_j\right)^2} \times \left[\sum_{k=1}^{n}\sum_{l=1}^{n} Z_{ik} Z_{jl} R_{kl}\right] \quad (1)$$

$$Z_2 = Min\sum_{i=1}^{N}\sum_{j=1}^{N} D_{ij} \times \left[\sum_{k=1}^{n}\sum_{l=1}^{n} Z_{ik} Z_{jl} C_{kl}\right] \quad (2)$$

$$Z_3 = MaxMinS_{ik} \quad (3)$$

$$Z_4 = Min\sum_{i=1}^{N}\sum_{k=1}^{n}(F_{ik} + V_{ik} \times P_{ik}) \times Z_{ik} \quad (4)$$

Considering the following restrictions:

$$\sum_{k=1}^{n} Z_{ik} \le 1 \qquad \forall i = 1,..., N \quad (5)$$

$$\sum_{i=1}^{N} Z_{ik} = H_k \qquad \forall k = 1,..., n \quad (6)$$

$$\sqrt{\left(X_i - X_j\right)^2 + \left(Y_i - Y_j\right)^2} \times Z_{ik} \times Z_{jl} \ge MD_{kl} \qquad \forall i = 1,..., N-1, i+1 \le j \le N \quad k,l = 1,..., n, Z_{ik} = 1 \quad (7)$$

$$\sum_{i=1}^{N} P_{ik} \times Z_{ik} \ge Q_k \quad (8)$$

The objective function (1) is to maximizing the sum of weighted Euclidean distances by the repulsion coefficient that tries to maximizing the dispersion of network. The objective function (2) is to minimizing weighted distances by the weight of interactional relationships.

The objective function (3) is to maximizing the minimum security coefficient of the selected points that is the same as maximization of the total security coefficient of the selected network. The (4) is the objective function of minimizing the fixed and variable costs of production in all sites.

The restrictions (5) are to have confidence that there is only one facility in each place. The restrictions (6) are to have confidence that all kinds of facilities are located and the restrictions (7) observing the air distance limitations between the facilities. The restriction set (8) guarantee that the demand of customers to be satisfied.

Using this form it makes the calculations simple and the problem of site selection in passive defense will change the qualitative form of problem to a quantitative form that the understanding of this form is much easier than qualitative form.

8. The Proposed Solving Method

As we know, two first objective functions are examples of QAP models that are related to major aspects of the issue, NP-Hard. Therefore, in order to solve the problem, we need Meta-Heuristic algorithms. Since the proposed model is a Multi-Objective one, one method of solving the Multi-Criteria problems must be used to quantify the appropriateness of produced answers by genetic algorithm. Here, because all the objectives change constantly, and we need a numerical quantity to value the answers, we integrate genetic algorithms to TOPSIS Method and solve the problem.

TOPSIS Method is integrated to genetic algorithm in this way, so that first the primary population is created accidentally by the algorithms and then, the ideal positive and anti-ideal vectors will be obtained. Some of the answers may be unacceptable, i.e. they may exceed the problem limitations.

The usual method to solve such problems is eliminating the unacceptable answers or using the Lagrange coefficients to incorporate the limitations to the objective function. We can not ignore the point that unacceptable answers may have positive features which can increase the fitness function of next generations. On the other hand, the unacceptable answers are worthless because we can not use them. In order to use the positive features of the unacceptable answers, they must be considered in the set of answers and simultaneously lead the seeking space to the areas of the solution space which includes possible answers, in order to have acceptable final answers.

In order to do that in the process of selecting, it is possible to decrease the probability of selecting the unacceptable answers. And in order to decrease the probability of selecting such answers, a ranked penalty has been considered for them in the value function.

By ranked penalty we mean more unacceptable the answer is, more severe the dedicated penalty will be. This penalty results in decreasing of the probability of selecting the unacceptable answers in comparison with their unacceptable elements. Therefore, a penalty has been calculated for the unacceptable answers as the following:

Penalty coefficient $\times$ the level exceeding from the ith limitation = the classified penalty of ith limitation

The work of the considered selection in this algorithm is a Roulet cycle and the probability of the considered crossover for 2 chromosomes is equal to 0.99. It is hypothesized that the number of selected generations, based on the obtained experience from solving the different accidental problems with this algorithm, is equal to 100.

It is worth mentioning that the weight of every objective function in TOPSIS has been obtained according to Decision Makers feedbacks.

The main point in this algorithm is that for each answer, a virtual objective function equal to sum of dedicated penalties must be calculated(fitness function).

We use it in calculation of the value of chromosome and we determine its quantity in the positive ideal vector equal to zero but in the anti-ideal vector equal to the maximum obtained quantity in that generation for this objective function. Therefore, the acceptable answers obtain more values. Also, regarding the algorithm work in the solved examples, we consider the weight of virtual objective function equal to sum of the weight of other objective functions, that is one because if this selected weight have a large quantity in comparison with the weight of other objective functions, the main goal of algorithm is led to achieve the acceptable answers and focus on other objective functions will be reduced and if it is not large, algorithm convergence in achieving the acceptable answers will decrease.

Using the above algorithm, the sooner you will find the solution and in most cases achieve better solutions than other algorithms used to solve these kinds of problems.

9. Numerical example:

Consider a situation which there is 6 types of facilities to be located in 13 sites and other parameters of example are shown in Tables 1 to 12. we solved this problem with proposed method and found the results presented in Table 13 and for showing the applicability of proposed algorithm we compared the results with achieved results from Lingo with the same method.

Tab. 1. The objective function's weights in TOPSIS (α_i)

Obj. 1	Obj. 2	Obj. 3	Obj. 4	Penalty
0.3	0.2	0.2	0.3	1.0

Tab. 2. The fixed cost of site selection (F_{ik})

Site \ Facility Type	1	2	3	4	5	6
1	219	205	281	253	229	231
2	289	249	274	217	254	210
3	225	224	208	246	242	234
4	271	267	213	235	218	266
5	227	268	289	253	244	266
6	296	267	220	259	259	243
7	241	216	229	203	210	283
8	263	293	254	237	223	211
9	210	282	229	268	249	282
10	209	230	206	270	247	239
11	291	260	272	245	270	217
12	282	214	244	274	267	299
13	259	288	248	297	253	207

Tab. 3. The variable cost of production one unit in places by facilities (V_{ik})

Site \ Facility Type	1	2	3	4	5	6
1	26.1	21.1	27.1	22.6	23.6	24.3
2	20.6	26.4	25.6	24	26.9	24.3
3	23.2	21.3	21.9	20.8	23	21.3
4	27.8	21.4	22.2	26.9	25.4	20.3
5	27	21	20.8	24.1	28.4	23
6	21.3	21.5	29.2	29.9	26	23.2
7	21.4	21.7	27.1	24.1	23.4	26.6
8	21	22	25.6	26.3	23	29.6
9	20.1	23.2	23.2	21.6	24.6	29.4
10	24.3	23.2	21.7	23.9	24.3	24.6
11	26.6	22.2	26.3	21.7	23.6	22.5
12	27.3	22.6	29.9	27.6	25.6	27.7
13	25.4	29	21.8	28.8	27.5	27.6

Tab. 4.Security Coefficient of facilities in sites (S_{ik})

Site \ Facility Type	1	2	3	4	5	6
1	0.66	0.84	0.15	0.85	0.17	0.79
2	0.73	0.21	0.19	0.87	0.62	0.51
3	0.89	0.55	0.04	0.27	0.57	0.18
4	0.98	0.63	0.64	0.21	0.05	0.4
5	0.77	0.03	0.28	0.56	0.93	0.13
6	0.58	0.61	0.54	0.64	0.73	0.03
7	0.03	0.99	0.06	0.56	0.9	0.51
8	0.84	0.54	0.52	0.18	0.2	0.76
9	0.56	0.71	0.34	0.6	0.09	0.63
10	0.85	1	0.18	0.3	0.31	0.09
11	0.35	0.29	0.21	0.13	0.46	0.08
12	0.45	0.41	0.91	0.21	0.1	0.78
13	0.75	0.01	0.05	0.67	0.6	0.53

Tab. 5. Minimum required Euclidean distances between facilities (MD_{kl})

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Type 1	10	11	13	30	15	18
Type 2	10	24	14	15	21	24
Type 3	15	25	12	14	13	17
Type 4	14	19	14	13	24	16
Type 5	10	20	15	20	12	20
Type 6	10	20	13	15	13	20

Tab. 6. Production capacity of facilities in sites (P_{ik})

Site \ Facility Type	1	2	3	4	5	6
1	34	67	70	95	20	73
2	79	95	47	68	16	18
3	27	29	86	53	46	57
4	36	74	85	68	50	58
5	18	31	33	59	43	88
6	62	21	65	68	79	54
7	63	50	83	88	58	94
8	34	12	78	99	18	73
9	14	40	44	56	20	62
10	78	48	29	90	22	83
11	32	34	81	63	71	89
12	50	28	95	24	55	99
13	82	31	55	91	62	36

Tab. 7. Demand for each production type (Q_k)

Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
34	24	36	50	63	34

Tab. 8. Maximum available of facilities (H_k)

Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
4	2	4	2	5	2

Tab. 9. Repulsion coefficient between facilities (R_{kl})

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Type 1	0.13	0.8	0.74	0.95	0.28	0.51
Type 2	0.91	0.14	0.39	0.03	0.68	0.7
Type 3	0.63	0.42	0.66	0.44	0.66	0.89
Type 4	0.1	0.92	0.17	0.38	0.16	0.96
Type 5	0.28	0.79	0.71	0.77	0.12	0.55
Type 6	0.55	0.96	0.03	0.8	0.5	0.14

Tab. 10. Cost of communication between facilities (C_{kl})

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Type 1	0.24	0.37	0.23	0.74	0.45	0.88
Type 2	0.12	0.11	0.35	0.19	0.31	0.55
Type 3	0.18	0.78	0.82	0.69	0.51	0.62
Type 4	0.24	0.39	0.02	0.18	0.51	0.59
Type 5	0.42	0.24	0.04	0.37	0.82	0.21
Type 6	0.05	0.4	0.17	0.63	0.79	0.3

Tab. 11. Transportation distances between candidate sites (D_{ij})

Site \ Site	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	70	117	48	75	137	57	50	193	35	36	71	63
2	70	0	59	126	45	84	57	148	72	26	40	79	83
3	117	59	0	111	43	50	106	114	32	97	81	52	52
4	48	126	111	0	100	144	107	9	154	59	83	73	72
5	75	45	43	100	0	81	66	113	90	53	51	82	53
6	137	84	50	144	81	0	143	216	25	132	113	91	70
7	57	57	106	107	66	143	0	74	101	16	9	101	108
8	50	148	114	9	113	216	74	0	211	122	65	103	100
9	193	72	32	154	90	25	101	211	0	142	132	93	92
10	35	26	97	59	53	132	16	122	142	50	5	85	117
11	36	40	81	83	51	113	9	65	132	85	0	90	80
12	71	79	52	73	82	91	101	103	93	85	90	0	39
13	63	83	52	72	53	70	108	100	92	117	80	39	0

Tab. 12. Coordinates of candidate sites (X_i, Y_i)

Coordinates \ Site	1	2	3	4	5	6	7	8	9	10	11	12	13
Longitude	40	78	61	10	55	89	73	7	80	68	72	12	33
Latitude	6	34	74	13	49	80	5	9	94	13	11	64	65

Tab. 13. Comparison the results of GA.TOPSIS and Lingo.

	Obj. 1	**Obj. 2**	**Obj. 3**	**Obj. 4**	**Time to solve**
GA-TOPSIS	2912	2686	13394	0.34	8.5 S
TOPSIS in Lingo	2809	2858	14374	0.34	87231 S
Improvement ratio achieved from GA+TOPSIS	+4%	+6.4%	+7.3%	0%	∞

10. Conclusion

Since one of the main principles of passive defense is facility site selection in a manner that the possibility of the total network being damaged by the enemy be reduced, we presented a model in this paper that can select the site in a manner that not only the created network can perform its duty with maximum security coefficient but also the possibility of identification by the enemy be reduced to a minimum. At the same time, the proposed model helps the system to achieve to its maximum reliability when attacked by the enemy. What is important in this model is to achieve to the above obgectives with a significant reduction in the costs that is one of the main purposes of the passive defense.

This paper formulates the problem of site selection in passive defense and it considers all objectives of site selection in passive defense that is the unique model in this issue.

For solving this problem because two functions of the problem are NP-Hard have to use a metaheuristic algorithm and furthermore, due to several objective functions, have to use one of the multi-criteria methods for solving the problem. Also we proposed a method for solving the proposed model that uses the Genetic algorithm integrated with TOPSIS and then showed that the proposed method is good for solving Multi-objective constrained models.

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