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REPRESENTATION OF AN OPTIMAL MODEL FOR ROUTING PATH CONSIDERING GEOMORPHOLOGICAL FEATURES IN THE CORRIDOR REGION

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ABSTRACT

The main important stage for designing road projects is to find the primary route. With representation of an optimal model for routing and considering the geomorphological features, the present paper examines and evaluates the optimal routing for all basic zones. It attempts to find a model with the lowest cost that has the best efficiency. The aim of the study is to represent a model to find an optimal route for the road that is available for all target original zones in which the route should not have passed from them for any reason. In this study, the PSO method has been used for modeling by optimization.

Keywords: Geo-morphological features, corridor region, road routing, optimum transport system

INTRODUCTION

Having the optimum networks for national roads is one of the development parameters for countries. Therefore, planning for optimum projects of massive routing is one of the necessities of the economic route network. At first, for each plan that is related to roads and routes, road routing should be examined and information related to the situation of

various regions and available routes should be collected. In order to find an optimum model, the general plan of connections between regions and the manner of their access to each other should be explainable by an optimum model. In this regard, recognition of geomorphological indexes plays an important role in optimal routing that can prevent

damages from taking place and provides economic benefits for humans (1).

Generally, by analyses related to previous routes and requirements of employers and general maps of topography, design engineers consider some options as the primary route. After an examination, these errors are improved. Since the quality of these routers has high dependencies on the analysis of a designer, it cannot be considered as a correct method. Large expenditures will be pended for research when the primary plan is incorrect. Thus, routing should not only have a technical and general standard, but it also should limit the damages of the environment. Also in planning, the regions in which the road should not cross for any reason must be specified (2).

The first step in optimum routing of a road is to find the primary route. When a route becomes an optimum route in which the main centers of the population have direct access, it can provide the highest efficiency and be cost-effective. Determining the primary route and finding the best option among them is a deterministic factor for the expenditure of construction and operation of a plan. Many factors in a route plan are considered, the main one being to consider geomorphology and geographical conditions of the corridor

region. In this regard, geomorphology science is used as a routing alignment.

Optimum routing:

In optimum routing of a road, recognition of all conditions such as mountains, lakes, valleys, marshes and elements such as these are effective factors in the corridor region. One of the important issues in a corridor region is not the passage of a road from protected areas of environmental and military value that are placed in the area. On the other hand, in plain and hill areas, crossing mountains, lakes and valleys imposes large costs to the plan. Thus, protected areas and these regions are considered as impassable areas for the corridor and their consideration in optimum routing is an outstanding point (4). This study intends to examine this issue of whether there is an optimum model for road routing considering the geomorphological features in the corridor region.

Generally, routing should be fulfilled based on a strong attitude. In this regard, construction of a road is a national and civil project that follows a stronger attitude when a road project becomes longer and crosses more cities. As a result, optimum routing should have no more costs and it must have necessary security. It should consider the welfare and ease of all people and it may have

less environmental damages and expenditures of operation and protection. In addition, it must be designed based on the mentioned standards in road and highway regulations (5). So, determining the best route is considered as the most important factor in proper operation at a corridor region. There were many routes that have imposed various costs such as construction costs, operation cost and etc. to the project because of their unsuitable crossing. The longer the route, the greater the problems. Thus, for optimum routing, considering exact changes is a necessary affair. Morphological features of a corridor region are one of the most important factors in optimum routing (6). Morphological features and roughness forms of the earth have always been an influence on routing. Concentration on the geomorphological features can have positive effects on the plan. In representation of engineering projects, planners should consider all necessary actions. In addition, the necessity of optimum operation from the transport network should be done before any action of routing (7).

In addition, one of the strategies for constant usage of the sources is an optimum transport system. Transportation is one of the important infrastructures of any country that is the basic and necessary element of various access levels and transportation of people and goods

from one side to another that represents the amount of development of a country. So, as a result, optimum routing is making facilities in transportation; optimum transportation has a connection with three basic factors: time, security and costs. Although many studies have been done regarding road routing, a research that represents an optimum model considering geomorphological features in a corridor region for routing have not be done so far. Generally, in road routing all details of a route cannot be defined since there are many factors to select a route that create some problems. For this reason, consideration of geomorphological features in the corridor region can be effective (9). In this regard, this study attempts to represent an optimum model for road routing considering geomorphological features in the corridor region. Planning for an optimum plan of large routing is one of the necessities of an economic network (10). In order to find an optimum route, the general pattern of dots connection and method of their access to each other is done based on an optimum and justifiable model. Figure 1 shows two general patterns of 5 connection dots of city centers.

In figure 1a, the route from each center has directly been connected to the other center. Bang defined this pattern as the “lowest cost for consumer” (11). Figure 1a indicates that

cost of operation is in the lowest state but construction cost is very high, while figure 1b shows a state in which construction cost is at the least. In this situation, the length of the route has been limited, although civil centers have not been connected directly; so, it imposes more costs for consumers of routers. In fact, the maximum length of road construction creates a lower cost of transportation. Therefore, the most economical network is a network that has the lowest total cost (such as construction and operation costs). With regard to diversity in construction cost in any kilometer of road, for design of connecting roads, highways with higher bonds and connecting roads with lower bonds are selected. Not only type of the road but also volume of traffic or importance of the city that is between the roads can increase secondary roads of the network.

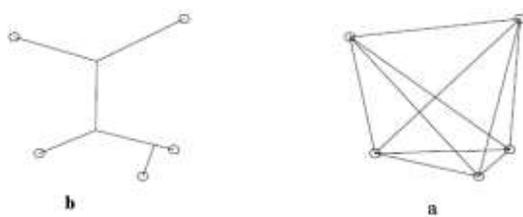


Figure 1: two patterns of transport networks, a) lowest cost for consumer pattern, b) lowest cost for construction pattern

Determining factors of road alignment

From the beginning routing has been a difficult issue. In this regard, designers should consider many factors. In order to design each route; social, economic, environmental and

cultural requirements should be observed. In addition, three main purposes: ease, security and speed in transportation should be created for the consumer of a country's routes. The exact location and detail of all routes cannot be distanced in one stage; so, the road router is determined by various stages, map and aerial photos (12). There are many factors in the selection of a road router that make it work with problems. Natural factors may affect many parts of suburban roads but the routes of the roads should not be determined without considering social, environmental and economic factors. Therefore, it can be concluded that selection of a route is an equilibrant situation that causes much access and less environmental injuries. The factors that should be considered in selecting a road consist of: access with regard to natural factors, standards of geometric design, geology, soil type, existence of suitable materials, preserving the road and protection of the environment (13). In order to decrease the costs of road construction, the volume of execution operations should be limited to the extent that natural factors are not contradictory with preservation of geometric design standards. Geological studies and recognition of groundwater especially in the construction site of tunnels has great importance since the type of soil and quality

of groundwater may doubly increase the cost of tunnel construction (14). Therefore, from the first step of route selection, geological studies should be done at least superficially and in the next stage, the studies should be completed in the main and sensitive locations (15).

LITERATURE

In a study that was done in 2006, Mahmud Saffarzadeh examined determination of path corridor based on the construction of mandatory locations and prohibited areas which was the main stage in designing of various projects of infrastructure regarding ground transportation paths such as railway and road in determining the path corridor. In this research, two mathematical models have been represented to routing the plain and foothill areas. In the first model, a spiral path that orbits the forbidden areas in the corridor and gives access to the defined road between paths with the lowest cost is defined by nonlinear mathematical planning. In the second model, an innovative model of designed path is used that has optimized the first model. At the end of this research, the Bafq –Mashhad road has been evaluated by the mentioned models. In a research that Turner performed in 1971 about the routing issue, routing is used as a network and then by using the network optimization method,

solved the routing problem. In another research, he used a method for transportation of material between two areas in order to find an optimum path instead of using the shortest path method (16).

In 1992, Hagun examined the primary routing of transportation routers. He designed routing as a three- dimensional routing by dynamic planning. His model was represented via a network to which more focus has been paid, and this was repeated to the extent that the router reached to an acceptable accuracy (17).

METHODOLOGY

In this research, the meta-heuristic algorithm of Particle Swarm Optimization (PSO) and genetic algorithm are used in a combinative way in order to find the optimized spots and also determination of accurate cost function. We discuss these two algorithms further. It should be considered that solving the routing problem with or without limitations and observing geomorphologic characteristics by meta-heuristic algorithms is not bound to change the whole method, since the boundaries of these algorithms can easily be added to solve the problem again.

In recent years, one of the most important and promising researches have been “intuitive methods derived from nature”; these methods have some similarities with social and natural systems. Their function is inspired by

integrated intuitive methods which have produced exceptionally good results in solving difficult combinative problems (NP-Hard)(18).

Particle Swarm optimization

The meta-heuristic algorithm for particular swarm optimization is an evolutionary computing method based on a population of answers. Similar to other meta-heuristic algorithms, this algorithm is a tool for optimization which can be utilized for solving various types of optimization-related problems. This algorithm is one of the newest meta-heuristic methods which was generated by Kennedy and Eberhart in 1995 and is inspired from the social behavior of a flock of immigrant birds which are trying to find an unknown destination. In the PSO algorithm, the population of answers is called “swarm”

and each answer is like a bird in a flock and is called “particle”, such as a chromosome in the genetic algorithm. All particles have a fitness value which can be calculated by fitness function and the fitness function of particles should be optimized. The direction of each particle’s movement is determined by the velocity vector of the particular particle. Contrary to the genetic algorithm, no new flock is created from the previous generation (new answers out of previous answers), but each bird develops its social behavior based on its experiences and the behavior of other birds and improves his movement toward a destination. In other words, there is no evolutionary actuator such as crossover and mutation in this algorithm (19). The general structure of the algorithm of Particle Swarm Optimization is shown in **Figure 2-3**.

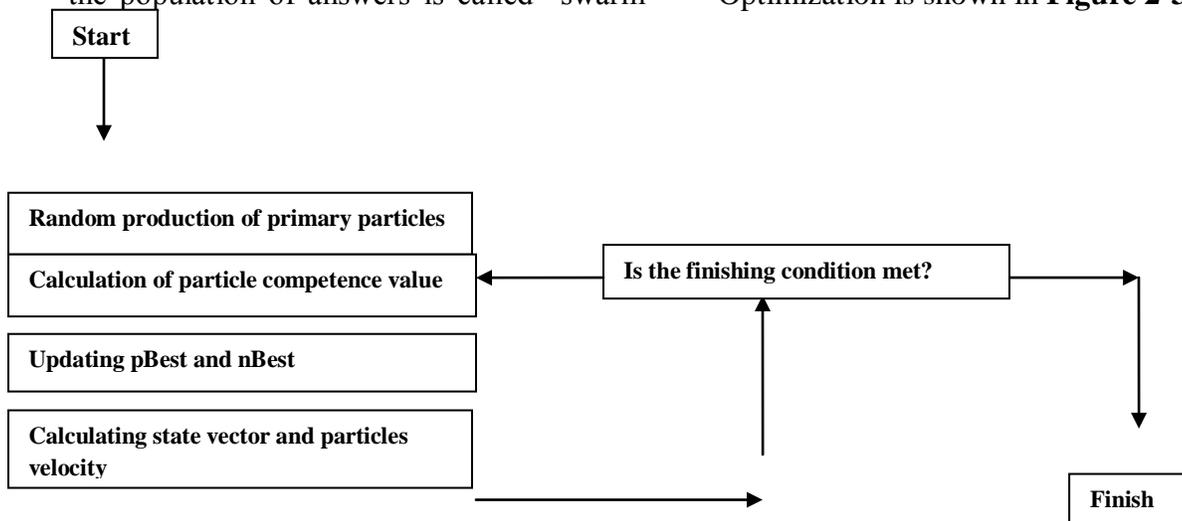


Figure 2-3: The structure of particles swarm optimization algorithm

PSO algorithm begins with a few random answers (particles) and becomes optimized with updating particles in each repetition (19). If we assume that decision variables, and

consequently, the particles situation are from “1” and “0” type, then velocity and situation vectors of each particle in each algorithm repetition will be calculated according to (2-3) to (5-3) equations.

$$(2-3) \quad V_{it} = w \cdot V_{it-1} + c_1 \cdot r_1 \cdot (pBest_i - X_{it}) + c_2 \cdot r_2 \cdot (nBest_i - X_{it})$$

$$(2-3)$$

$$-V_{max} \leq V_{it} \leq V_{max}$$

$$(3-3)$$

$$S_i = 1/1 + e^{-v_{it}}$$

$$(4-3)$$

$$X_{it} = \begin{cases} 1 & p \leq S_i \\ 0 & otherwise \end{cases}$$

$$(5-3)$$

According to (2-3) equation, the new velocity vector of each particle based on the previous velocity of the particle itself ($V_{i(t-1)}$), best state of the particle so far ($pBest_i$) and the position of the best particle near the first particle so far ($nBest_i$) is calculated. In case of having a neighbor which includes all particles of the swamp, then $nBest_i$ best describes the state of best particle in the swamp, which is referred to as $gBest_i$. r_1 and r_2 are two random numbers (with the same distribution between [0 and 1]) which are created separately. C_1 and C_2 which are named “learning indices”, control the effect of $pBest_i$ and $nBest_i$ on the searching process. “ w ” is the inertial weight index. The vector of particles velocity is limited by V_{max} . V_{max} is defined as a limitation which controls the global searching capability

of the particles swarm. In the aforementioned equation, S_i states the possibility of $x_{it} = 1$. Then using (5-3) equation, the state vector of each particle will be updated. In the aforementioned equation, p is a random number with monotonous frequency between 0 and 1.

The multi-period and multi-product routing problem with direct transferring under the assumed points in this dissertation (on which we have a discussion at the end of this chapter) is a problem with a high degree of complexity. Therefore, we have used the genetic algorithm to find optimized spots for PSO.

Genetic algorithm

Genetic algorithm (GA) is a searching technique in computer science to find an approximate solution for optimization and search-related issues. Genetic algorithm is a specific type of evolutionary algorithm which uses biological techniques such as crossover and mutation. This algorithm which is known as one of the random methods for optimization has been invented by John Holland in 1967. Further, this method consolidates its position through Goldberg’s efforts in 1989 and today it has a suitable status among other techniques due to its useful capabilities.

Genetic algorithms are usually implemented as a computer simulator in which an abstract sample (chromosomes) of candidate solutions of an optimization problem leads to a better solution. Traditionally, the solutions are in the form of “0” and “1” strings, but other forms have been developed today. The hypothesis starts with a completely unique and random population and continues in generations. In each generation, the capacity of the whole population is evaluated and a few unique people are selected from the present generation in a random process (based on competence) and will be reformed for developing a new generation (they will be eliminated or combined again). In the next repetition, the algorithm will transform into the present generation.

Using the genetic algorithm, we regulate a super-formula or plan which states a phrase like “the price of oil in “t” time is a function of maximum 4 variables”. Then, we will provide some data for a group of different variables (about 20 variables). The genetic algorithm will be implemented afterwards and search for the best function and variables. The genetic algorithm working method is misleadingly simple, comprehensible and with a high probability, is the method by which animals have passed evolution. Any formula which follows the aforementioned

plan is considered an individual of possible formula population. Variables which determine each given formula are demonstrated as a series of numbers that are equal to the individual’s DNA.

The genetic algorithm motor generates a primary population of the formula. Each person is placed before a set of tested data and the most appropriate of them (maybe 10% of them) remain and the rest will be put aside. The most appropriate people will mate (substitute DNA elements) and change (random change of DNA elements). It is observed that by passing through many generations, the genetic algorithm tends to create more precise formulas. While neural networks are non-linear and non-parametric, the advantage and attraction of the genetic algorithm is that their final results are more obvious and can be observed. The final formula for the human user is observable and conventional statistical techniques can be applied on these formulas to present a confidence level of results. Technology of the genetic algorithm is constantly improving. An example is virus equations which are produced alongside with formulas to contradict weak formulas, resulting in strengthening the population.

It is briefly stated that the genetic algorithm is a programming technique which uses genetic

evolution as a problem solution pattern. The problem which should be solved is input and the solutions are being coded according to a pattern called “fitness function” and evaluate each candidate solution. Most of them are being selected randomly.

The next step is creating the second generation of population which will be produced upon selected features with genetic actuators: linking chromosomes to the head of one another, and changing.

A pair of parents is selected for each individual. The objective is selecting the most appropriate elements to give a chance to the weakest ones and avoid obtaining a local result. There are several selection patterns: roulette selection, tournament selection, etc.

Genetic algorithm flowchart (for twenty

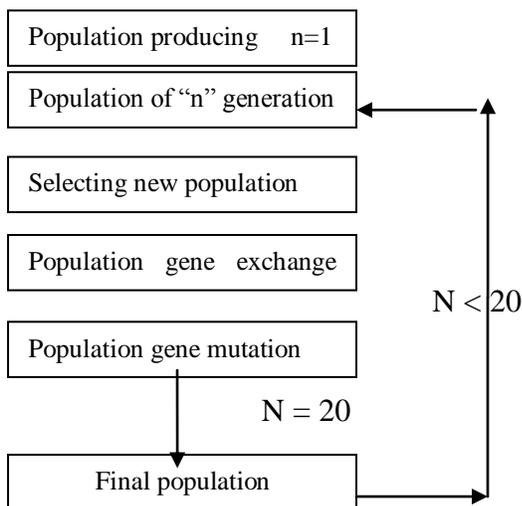


Figure 2-3 Structure of genetic algorithm

Usually, genetic algorithms have a probability number of connection which is between 0.6

and 1 and reveals the possibility of child production. The organisms are recombined with each other by this possibility. Linking two chromosomes leads to producing a child which will be added to the next generation. This procedure continues until appropriate candidates for the answer are found out. The next step is changing the new children. Genetic algorithms have a little and fixed probability of change which is approximately 0.01 or less. Based on this probability, children chromosomes change randomly or mutate, especially by bit mutation in the chromosome structure of our data.

This process results in producing a new generation of chromosomes different from the previous one. The whole process will be repeated for the next generation and pairs will be selected for a combination, and the population of the third generation will be created, etc. The process will be repeated until reaching the final step.

The optimization procedure in genetic algorithms is based on a random- guided process. This method is generated upon the theory of gradual evolution and Darwin’s essential ideas. In this method, a set of target parameters is produced randomly for a fixed number which is called population. After that, we attribute the number which introduces standard deviation of information to that

member of that population following implementation of the simulating program. Then we repeat this process for each of the produced members and we form the mating, mutation and selection of the next generation by genetic algorithm actuators. This procedure continues until the convergence standard is satisfied. In this research, for modeling, optimization is based on the PSO method. In the methods, at first the problem changes to a mathematical model and then it is solved. Transformation of the problem to a mathematical model increases the ability of its examination and provides the ability of utility of various mathematical plans.

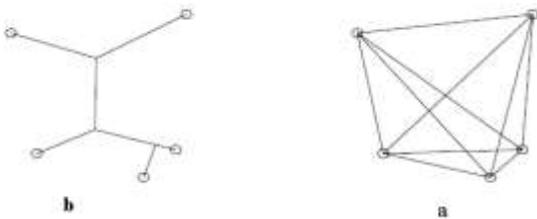


Figure 2: 2 patterns of transport network. A) Lowest cost for consumer pattern, b) lowest cost for construction pattern

Thus, a definition of mathematical planning model and a fundamental theorem that is used to solve the problem has been represented. Mathematical planning model consists of:

$$\begin{aligned} & \text{Min } f(x) \\ & x \in S \\ & x \in E^n, \end{aligned}$$

Where $f: R^n \rightarrow R$ is arbitrary function and S is a subset of E^n vector space. If S is E^n total vector space, this model is called

mathematical planning model without restriction. Otherwise, this model is called mathematical planning model with restriction. Mathematical planning model with restriction can be expressed as follows:

$$\begin{aligned} & \text{Min } f(x) \\ & g_i(x) \geq 0 \quad i=1,2,\dots,m \\ & h_j(x)=0 \quad j=1,2,\dots,p. \end{aligned} \dots 1$$

The condition of existence of an answer for the models and fundamental theorem for solving the problems is expressed as follows. In the Kuhn Tucker theorem, if f , g_i and h_j is derivable from the first rate and condition of first rate restriction quality is continuous, x^* of general convex planning minimum is obtained from the following model:

Conditioning x^* :

$$g_i(x^*) \geq 0 \quad i=1,2,\dots,m \dots 2$$

$$h_j(x^*) = 0 \quad j=1,2,\dots,r \dots 3$$

Supplementary condition:

$$u_i^* g_i(x^*) = 0 \quad i=1,2,\dots,m \dots 4$$

Lagrangian condition:

$$\nabla f(x^*) - \sum_{i=1}^m u_i^* \nabla g_i(x^*) - \sum_{j=1}^r v_j^* \nabla h_j(x^*) = 0 \dots 5$$

Operator ∇ that has been used in the above equations is defined as follows:

$$\nabla f(x) = \left(\frac{\partial f(x)}{\partial x_1}, \frac{\partial f(x)}{\partial x_2}, \dots, \frac{\partial f(x)}{\partial x_n} \right)^T$$

This equation is called operator ∇ or gradient $f(x)$. Solving the equation arising from 5 relationships is difficult. Methods that are expressed in the next section, attempt to solve the equations.

RESULTS

In this study, the best route from geomorphological properties and type of soil is examined and the best route is defined according to the properties. In addition to geomorphological properties, some factors such as type of soil and the shortest path are considered. Geomorphological properties of the optimum route from the view point of ups and downs, hills and valleys that may make some problems for routing have been examined and soil type has been considered as the main and important factors to select the route. On the other hand, an attempt is made to determine the most optimum route after determining authorized places in an area.

The maximum length of road construction creates a lower cost of transportation. Therefore, the most economical network is a network that has the lowest total cost (such as construction) and operation costs. With regard to diversity in construction costs in any kilometer of road, for the design of connecting roads, highways with higher

bonds and connecting roads with lower bonds are selected.

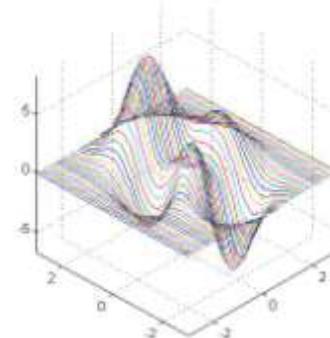


Figure 3: Geomorphological map of the area

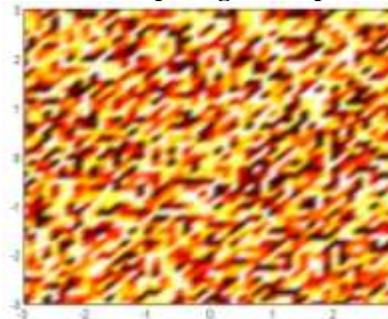


Figure 4: Desirable characteristics of soil for construction projects

After examination of a region from perspective of soil type, geomorphological conditions from perspective of access to desirable areas and also acceptable regions for specified areas are the main criteria for construction for which two criteria are used for this purpose.

$$C_{\text{total}} = C_C + C_O$$

Where:

C_C is construction cost per route length;

And C_O is average of operation costs per route length during lifetime of project.

$$L_i = \sqrt{(x_{i-1} - x_i)^2 + (y_{i-1} - y_i)^2}$$

$$d_i = \sqrt{(x_i - a_i)^2 + (y_i - b_i)^2}$$

Where L_i is length of i^{th} segment from the main route; x_i and y_i are coordinate of i^{th} point from the main route. D_i and a_i, b_i represents the length of i^{th} point from the bypass road and coordinate of the points that access toward them is necessary, respectively.

According to the information of **Table 1** that has been studied in many articles, this study calculated the distance parameters.

One of the main factors to determine point coordinates of distance function is defined as follows. If the distance cost function is low, the points become suitable.

$$f = \sqrt{(x_{i-1} - x_i)^2 + (y_{i-1} - y_i)^2} + \sqrt{(x_i - a_i)^2 + (y_i - b_i)^2}$$

In the first step, it is assumed that there is no forbidden area in the route of a plan, so in this situation, the problem changes to a mathematical model without restriction. In this method, the first function of route cost is modeled and then minimum rate per changes of path situation is calculated in the plan by mathematical methods of suitable optimization. A situation that has the lowest cost is selected as the optimum answer.

The main factor to select a route from several options is proportion of profit to expenditure

(cost) during the lifetime of a plan. Costs of a road and railway in their lifetime are classified by 3 different groups: 1- the cost of designing and supervision; construction cost and operation cost that each of them contains. The economic organization of developed countries represents the type of cost of a path as shown in **Table 2**.

Since designing and supervision design is the same for all options and its amount is lower than construction and operation cost, it can be ignored in the economic analysis of route selection. The main costs of a road or railway in spite of their differences in cost, directly depends on path length. This means that the longer the route, the higher the costs. The cost of land preparation, excavation, pavement, security and road drainage are examples of the costs. Repair and maintenance of road and railway directly depends on the length of the route that can be searched and the manner of this relationship and its cost function in various studies. User costs are the other effective factor in designing of the route that contains various costs such as operation cost of vehicle (fuel, travel time and accident costs). Quantifying the social and environmental costs is not easily possible and their consideration in cost function for evaluation of the route is difficult.

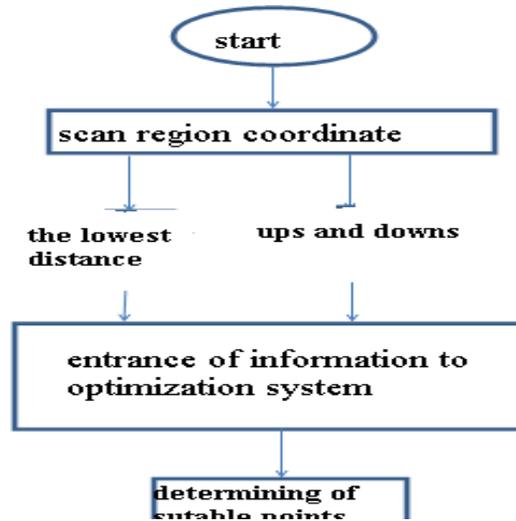
Table1: calculation of distance parameters

Point	Input			Output		Calculation	
	Access Point		bypass road	Optimum Point		Li	Di
	a	b	cost per length	X	y		
C1	0	5	-	0	5		
A	1	50	1	0.1	5	0.1	45
B	10.5	-20	1	10.9	3	11	23
C	24	-30	0.5	16	3.8	5.2	34.7
D	35	30	0.7	38.8	11.2	23.9	19.2
E	55	30	1.2	52.9	12.4	14.2	17.8
F	60	10	1.5	60	10	7.5	0
G	78	50	1	62.5	9.5	2.5	43.4
H	85	-20	1	90.1	-6.8	32	14.2
I	92	-30	1.3	91.5	-7.1	1.5	22.9
J	97	30	0.75	100	-5	8.7	35.1
C2	100	-5	-	100	-5	0	
main road cost per length=			3			Total Cost=	554

Table 2: cost types of a path in its lifetime

cost		example
Designing and supervision cost		The cost of consulting and monitoring firms
Construction cost		Cost of land preparing, excavation and pavement
Cost of operation	Maintenance cost	Road lighting, snow removal and repair
	Operation of vehicle	Fuel
	Travel time	Value of passenger time
	Accidents	Injuries and damages arising from accidents
	Environmental and social cost	Noise pollution, air pollution

Proposed algorithm:



Particles are scattered in a space with 3 * 3 meter and PSO algorithm in a space starts to research the points that optimize the target function. In this function, by involving ups and downs in the target function, the points that are suitable in view of geomorphology are calculated.

Target function is defined as follows:

$$f = p \sum_{i=1}^{n+1} \sqrt{(x_{i-1} - x_i)^2 + (y_{i-1} - y_i)^2} + h_i^2 + \sum_{i=1}^n q_i \sqrt{(x_i - a_i)^2}$$

Where:

F = total cost

P= cost per length of main path

Q_i= cost per length of ith point of bypass road

A_i , b_i = coordinate of the points that is necessary to access.

X_i , y_i= coordinate of main path points

N = number of access point

CONCLUSION

In this state, it can assume that cost per length of the main path is constant, however cost per length of bypass road considering their degree and the volume of transformation of goods and passenger is different. In the target function, geomorphological features are defined by the variable h for each coordinate, the points are selected that are optimum from perspective of access to upward and downward points. The problem is a convex problem if the aim of path optimization is access to special points. When upward and downward points in a region are considered as an undetermined and random function, the problem becomes up- hard and it has to use a

meta-heuristic algorithm which is why the PSO algorithm has been used in this

REFERENCES

- [1] Saffarzadeh, M., Brojerdian., Mirza, A., Rad, A.,(2006). Determining of primary corridor OF transportation paths according restriction of compulsory points and forbidden regions. Transportation research review. Third year, no: 1.
- [2] Safarzadeh, M., Mehr Azin, H.,brojerdian, A.,(2006). Optimum routing model of corridor design of road and railway path in plain areas. Volume 40, no: 5. Faculty of Engineering press.
- [3] Behbahani, A.,(2013). Road construction, the geometric design of the road. 19th edition, Tehran: center of university publishing.
- [4] Brojerdian,. Amin mirza. (2004). Optimum routing model considering access points in corridor region. Master's thesis, Tarbiat Modares University.
- [5] Ramesht, M.,(1996). Application of geomorphology in (national, economic and regional) planning. Esfahan university press.
- [6] Cooke, R. U. and Doornkamp, J. C. (1998). Geomorphology in Environmental

- Management, V. 1, translated by Shapur Gudarzinejad, SAMT Publishing House, P 9.
- [7] Maksud Kamal, A. S. M., & Midorikawa, S. (2004). GIS-based geomorphological mapping using remote sensing data and supplementary geoinformation: A case study of the Dhaka city area, Bangladesh. *International Journal of Applied Earth Observation and Geoinformation*, 6(2), 111-125.
- [8] Papli yazdi, M. (1997-2004). *Geographical research journal*. No: 46-73.pp: 440.
- [9] Motamed, A. & Moghimi, E. (1999). *Application of Geomorphology in Planning*, Tehran, SAMT Publishing House, P. 32.
- [10] Programming,” *TRB Part A*, Vol. 22A, No 2, 1988, pp. 121-136.
- [11] Mahmudi, A., (2001). *Geography of Transport*. Tehran: center of university publishing.
- [12] OECD (1973). *Optimization of Road Alignment by the Use of Computers*. Paris.
- [13] AASHTO (1987). *Maintenance Manual*. Washington, D.C.
- [14] JHA, M.-K., “Considering Maintainability in Highway Alignment Optimization,” *TRB*, 80th Annual Meeting, 2001, Paper no. 01-3170, pp 1-12.
- [15] Pignataro, L. J., Cantilli, E. J., Falcocchio, J. C., Crowley, K. W., McShane, W. R., Roess, R. P., & Lee, B. (1900). *Traffic engineering: theory and practice*
- [16] Turner, A.-K. et al., “A Computer Assisted Method of Regional Route Location,” *Highway Research Record*, No. 48, 1971, pp. 1-15.
- [17] Hogon, J.-D, “Experience with OPTLOC Optimum Location of Highways by Computer,” *PTRC Seminar Proceedings on Cost Models & Optimization in Highway*, 1973.
- [18] H. Th. Verstappen, *Applied Geomorphology: Geomorphological Surveys for Environmental Development*, *International Journal of Remote Sensing*, Volume 5, Issue 5, 1984
- [19] Hu, Z.Z. et al. (2004) iProLINK: an integrated protein resource for literature mining. *Comput. Biol. Chem.*, 28, 409–416.