

Application of Genetic Algorithm in Regional Planning (Case Study: Site Selection for Comprehensive Universities)

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ABSTRACT

Today, inaccurate planning of higher education institutes cause indiscriminate expansion of diminutive higher education units in cities. Difficulties on entering valid and authentic universities and their limitation on accepting students, easy registration in these small units, etc. encourage young population to welcome these units. The issue causes a significant decline in quality of higher education in the country. Very little researches have been done on site selection ofuniversities. Some of them consider the issue as an economic enterprise. Expansion of higher education institutes after Islamic revolution of Iran follows no clear objective and plan. Spatial distribution of universities and higher education institutes clearly shows a lack of macro perspective and objective expansion of the institutes. Main objective of the research is site selection for comprehensive universities, indexes required for selecting their optimal location, and the area of comprehensive university are discussed in this research. Characteristics of higher education in North Khorasan Province was studied and analyzed. Appropriate indexes in site selection fora comprehensive university are collected and studied, and classified using GIS and Matlab software and analyzed by genetic algorithm. **Key words**: site selection, genetic algorithm, North Khorasan Province, GIS, Iran

1. INTRODUCTION

The current young population of the country requires a special view on their needs. Allocating spaces for this population is very important and improving quality of these spaces have better perspective on future of the country. One of the main requirements of this young generation is education, which clarifies significance of education institutes. Proportionality between educational center locations and other urban services and areas help to improve their efficiency.

Organization and management is required for every university to make better decisions on number of students, appropriate place of its services, and offering facilities. Moreover, proportionality between locations of educational center and other urban services and areas help to improve efficiency of educational institute. Regarding deficiencies of educational system in North Khorasan province, the aim of this research is to improve quality of higher education system and appropriate site selection of comprehensive university in this province. Genetic algorithm is a technique in computer to find a way to solve optimization and search difficulties. Genetic algorithm is a special type of evolutionary algorithm that uses evolutionary biology such as inheritance and mutation. This algorithm is an optimal way to find a solution of every problem [1].

Site selection

Site selection is analyzing capabilities and abilities of an area from viewpoint of having appropriate land and connecting with other urban forum to select suitable place for special applications [2].

The most important step in development planning process is selecting an appropriate and accurate place for accommodation after evaluating required factors. Planner should consider all factors such as human resources, strategies and economic [3].

University

University is an institute which offers higher education and doing research to promote, improve knowledge and train human resources in different scientific and technical areas and consists of at least three faculties. University is an independent urban system running with General Budget and includes a group of professors and students gathered to learn, improve and disseminate knowledge. This social organization occupy physical limit of the city and provide a sense of identity and social concentration. Some characteristics have been defined forth concept of the university, for instance, in the book "Campus life", authored to formulate principles of designing university environment and general policies of university, university life is defined in 6 general features:

- 1. University is a targeted society
- 2. University is an open community
- 3. University is a neutral society

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- 4. University is a disciplined community
- 5. University is a grower community
- 6. University is a memorable place

The importance of university site selection

University site selection is a part of general planning of higher education institutes to improve spatiallocation quality, capacity and improving facilities of universities and to guarantee selecting the place regarding their objectives and priorities. In macro level, university locationis determined within several cities or extended areas in the country, but in micro level itssite selection is within a city or some parts of the city. The aim of site selection and spatial organizing of higher education in the country is to make regional balance in educational spaces and offer their developmental framework regarding relative capacities and facilities and social-economic development policies of each region [4].

Site selection and desired spatial organizing features

1- In national level

Site selection and spatial organizing of higher education makes integration in developmental space. In this regard, specialized function of different areas is determined compared with other areas based on relative facilities of each region. Quantitative form of development should balance hierarchy system of higher education centers and qualitative form should balance different developmental level of higher education facilities.

2- In regional level

Regional expansion of educational spaces includes main domains of living and activity centers regarding their capacities and necessities. Accurate selection of areas to establish higher education institutes and their expansion limit accords with potential and actual facilities of the region. Transmittance of student population should be in a way to coordinate the number of students with population willing to enter higher education places and cultural, social, political and economic function of the region[4].

GENETIC ALGORITHM

General form of algorithm was defined byGoldberg [5]. Genetic algorithm is a statistical search method formed based on natural selection mechanism and natural genetic [5].

Due to its ability to find general optimality, this algorithm is flexible in complex series, simplification, and operation and integrates optimization. In every evolutionary generation, the next generation is created from optimal responses of possible selection and evolutionary operation such as expansion and mutation [6].

Differences between genetic algorithm and other optimization methods

Simulation of natural evolution process of the human body leads to creation of a statistical optimization method called evolutionary algorithm, which is more efficient than classic methods. Three main subject of evolutionary algorithm include genetic algorithm, evolutionary programming, and evolutionary strategies. Genetic algorithm is more common than other types[7].



Figure 1.Flowchart of Genetic Algorithms.(Goldberg, 1989)

Genetic algorithm is a search and optimization method based on natural evolution principles. It is placed in optimization algorithms class that is able to find general optimal answers or answers close to them [8].Genetic algorithm makes it possible to a population consist of many individuals formed based of special selection rules, to optimize fitness function during evolutionary process. This method was developed in the book "adaptation in natural and artificial systems" by John Holland [9]from Michigan University [10].

Advantages of genetic algorithm:

- 1. Optimizing capabilities in integrated discrete spaces
- 2. No need for information about function derivatives
- 3. Capability to work with great amount of decision variable
- 4. Optimizing complex objective functions
- 5. Using a set of potential answers in initiation

- 6. Using codified variables instead of variable itself
- 7. Using numerical, experimental and analytical data
- 8. Using probable rules than definitive rules to lead search process

2. MATERIALS AND METHODS

Case study: North Khorasan province

North Khorasan province with capital city Bojnourd, was created after division of Khorasan province in 2004 to three parts. Its extension is more than 28000 square kilometers. North and north-east of the province has common border with Turkmenistan.

In 2010, 33086 students were studying in higher education institutes of the province, containing 0.87% of total students of the country. From them, 58.7% were studying in state universities and 41.3% in non-state universities. M.A. courses are available only in two cities, Bojnourd and Shirvan, and there is no PhD course in province. Index of higher education students of the province is 1.9%.



Figure 2: Geographical Location of North Khorasan Province, Northeast of Iran. The study area is magnified in the left side of map.

Simulating issue in genetic algorithm

1- Input data in GIS

To analyze data using genetic algorithm, the code is written by Matlab software, geographic information should be placed in GIS environment to start connection with the software, and then the algorithm of the desired information would be analyzed by the outputs acquired from EXCEL software.

First, data are collected and necessary indexes of province and its cities are put in GIS. Understudy area is divided to equal squares of 1.5×1.5 kilometers to find the relation between data in GIS and genetic algorithm. Afterward, a site selection index of university is weighted. To do so, ranking method was used. In this method, the higher number of a variable is ranked as first, the next one number 2 and so on. This ranking can be ascending or descending, their difference has no effect on the result. The last step is getting output of data. In this step, after overlapping different layers of data, the output acquired from Excel format will be put on Matlab software and analyzed by genetic algorithm.

2- Determining chromosome structure

Chromosomes used in genetic algorithm are made by the inspiration of real chromosomes. Real chromosomes are made of DNA chains. These chains can be imagined as a string of genes, each gene as a parameter of the problem.

In university site selection, chromosomes are made of a set of x, y's each belonging to 1.5*1.5 kilometer squares. However, (x, y)s are chromosomes of the problem made of genes. Genes are our research hypothesis.



Figure 3. Genotype details of site selection

Figure 4 is drawn schematic and assumed as around the city limit. Each assumed squares are imagined as (x,y). These (x,y)s are not geographical coordinates of the earth, but are numbers from 1 to n to solve the problem using algorithm. In figure 4, for instance, marked square has coordinates of (1,1). Using x and y axis, we determine the numbers of each square (Figure 5).

Squares in GIS are characterized by numbers from 1 to n, placed in an FID, but in genetic algorithm their characteristics are coordinates of (x,y).



		(3,3)	
(1,2)			
(1,1)	(2,1)		
x = (1, 2, n)			

Figure 4.Determining x, y of the squares. **Figure 5**. These(x, y)s are chromosomes of the problem and made of genes.

Figure 5.Determining x, y of the squares.

3- Mathematical formulating problem and selecting fitness function

An appropriate evaluation function was designed to evaluate chromosomes (responses). This step is very important since failure in designing applicable function to evaluate created chromosomes in different generations disturbs problem solving process of genetic algorithm [10].

This function is designed according to problem conditions and each problem has its own formula and function that must be find. Here, the following function is discussed:

MAX Z=
$$\sum_{i=1}^{n} \frac{1}{\sqrt{(x-x_1)^2(y-y_1)^2}} \left(\sum_{i=1}^{n} f_i \right)$$

where, x, y are chromosomes of the problem (figure 4,5) and also geographical coordinates of the optimal place studied in this research. X_1 and y_1 are coordinates of the squares in the map (places drawn in Figures 5 and 6). f_i is determined index of geographicalsite selection, and its related data are produced as informational FIDs in GIS and the output is put in exposure of algorithm.

Denominator of the formula gives us the space exist between two points, ex. one of them is square (1,1) and the other one is our optimal point. Since we are looking for a place with the highest value, this function should be as maximum (as denominator is smaller, the value is higher). Access factor has an important effectin finding a reasonable space for optimal site selection. So as the optimal place is closer, its space from selected points is lesser and dominator is smaller, so the function is maximum.

Primary parameter values of the algorithm are determined by the problem itself. The most important parameters include: number of primary population (N), probability of selection (P_S), probability of crossover (P_C), probability of mutation (P_M), probability of regeneration (P_R), probability of convergence (P_{CN}), selection and operators of crossover and mutation [10].

A random population with N chromosomes is created. N is the number of primary generation members and each chromosome is representative of a response to the problem. Quality of chromosomes in this generation is calculated and saved using evaluation function. Regarding quantity of probability of selection, pairs of chromosomes are selected as parents; parent selection process is proceeding by saved values of evaluation function. Based on probability of crossover, each pair of parents is combined with each other and produces one or two child chromosome. Each child chromosome is muted according to probability of mutation.

According to probability of regeneration, some of the children are selected to be replaced in new generation and the rest of new generation are selected from previous generation, then the new generation is replaced by previous generation. Stop and end conditions and convergence of chromosomes to optimal response are reviewed. If the stop condition is not set, algorithm performance will be restart from level 5, otherwise the best response of the current generation is selected as the final response and algorithm will end. Diagram 1 summarizes process of genetic algorithm.

Optimal location

In the last step of genetic algorithm, squares are ranked hierarchical. The highest rank has the best condition for establishing university according to assumed indexes.

According to current condition of Bojnourd, and regarding the fact that two important universities of the province are places in one area and close to each other, there are three suggested options.

- 1. Importance of three criteria of distance from city center, access to airplane, railway and terminals, and access to main roads. The suggested area is shown in map 1
- 2. Proximity to similar universities (described by weighting of algorithm) shown is map 3
- 3. All the universities are placed in west and south west of the city. So the third option is the field of western part that the university is placed in (map 4)







Map 3: suggested university location based on second choice







CONCLUSION

For a long time mathematical formulators have been focused on studying the location of establishing different facilities. Most of the researches in this area consider location of establishing factories, refineries and decoration of equipment within the factory.

Investigating all the researches done in site selection area, it's obvious that all of them try to find optimization ways. The concept of "the best" is different in these areas. Some believe the best place offer more benefits; others believe it in achieving lowest expense or customer satisfaction, etc. But, very little studied has been done on university site selection.

Genetic algorithm is inspired by the evolution of creatures in nature during time. Evolution in nature is simulated by computer. To do so, operators are defined similar to environment. The algorithm is applicable in problems with large state space. It initiates with a random initial population and improves responses by producing various generations.

Compared with other methods in site selection applications, genetic algorithm is more applicable. Genetic algorithm is a search method based on natural evolution principles. Due to its ability in finding total optimality, the algorithm is flexible in complex sets and simplification of performance.

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REFERENCES

- 1. MichaelB.Lowry. 2004. Coordinated Regional and City Planning, Using a Genetic Algorithm, M.A. thesis Brigham Young University, Provo, UT.
- FeghhiFarahmand N. 2010. Site Selection for Firefighting Stations Using Multi-Indexes TOPSIS and SAW Decision Making Methods and Selecting Optimal Place Using Borda Method, Quantitative Research in Management Seasonal Journal (1974-1988).
- 3. Mir Riahy S. 2008. Site Selection Method in Biological Sets, Environment Science Publication, 6th year, 2nd edition, 155-166.
- 4. RadfarR. 2008. Site Selection Distribution of Islamic Azad University Branches and Strategy of Establishing New Branches in Iran, Tehran, Islamic Azad University, Research Deputy
- 5. Goldberg D. 1989. Genetic Algorithms in Search, Optimization and Machine Learning, Addision-Wesler, Wesley Longman Publishing Co., Inc. Boston, MA, p:71.
- 6. Mitchell M. 1996. An Introduction to Genetic Algorithms, MIT press, pp: 45-46
- 7. Gen M. and Cheng R. 1997. Genetic algorithm and Engineering Design, John Wiley & Sons, Inc, pp:220-232.
- 8. Zahraee B, Hosseini S.M. 2009. Genetic Algorithm and Engineering Optimization, Gutenberg Publication, Tehran, Iran, p. 44
- 9. Holland, J.H. 1975. Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence, MIT Press, Bradford Book Edition, pp: 13-14.
- 10. Shams Javi M. 2011. Implementation and Solving Practical Problems Using Genetic Algorithm, AryaPajouh Publication, pp:31-33.
- 11. Imanzadeh S. 2007. Perspective Design of New Pardis of Tehran University" M.A Thesis of Perspective Architecture, Tehran University, Iran, Fine Arts Faculty
- 12. Khalili A. 2008. Selecting Position of Appropriate Lands for Constructing Manufacturing Town Using Gis and AHP Models (Case Study: Makou and Chaldoran), M.A. Thesis of Urban Planning, Fine Arts Faculty, Tehran University, Iran
- Rahnamaei M.T. 2004. Optimal Distribution of Universities and Science Centers With a View on Cultural Geography in Iran, Science and Research Ministry, Social and Cultural Deputy, Social Planning Office and Cultural Studies
- 14. Higher Education Research and Planning Institute. 2011. Statistic Research and IT Group, Reporting Higher Education Status in North Khorasan
- 15. Mahdiyar L. 2006. Fine Arts Faculty Expansion Plan, M.A. Thesis in Architecture, Tehran University, Iran
- Balling, R. J., J. T. Taber, K. Day, and Wilson S.A.2000. Land Use and Transportation, Planning for Twin Cities Using a Genetic Algorithm." In Transportation, Research Record 1772, TRB, National Research Council, Washington D.C., pp.67-74.
- 17. Cheng-Min Feng, and Jen-Jia Lin. 1999. Using a Genetic Algorithm to Generate Alternative Sketch Maps for Urban Planning, Computers Environment and Urban Systems, 23, 91±108
- 18. Haupt R. and HauptS.E. 2004. Practical Genetic Algorithms, John Wiley and Sons, Inc. Publication, Second Edition
- 19. Robbins, L. 1972. An Essay on the Nature and Significance of Economic Sciences, Macmillan, London.