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Research Article

Optimal Localization of Shopping Centers Using Metaheuristic Genetic Algorithm

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Abstract

Efficiency and effectiveness is of importance for selection and localization. There should be regular methodology for targeting in the market by several methods. There is a necessity to have clear study for selection. In the current research, it has been studied the optimal localization at shopping centers. If there is not accuracy and validity, there will be achieved negative results for these centers such as high costs. Nowadays, these centers have turned into a part of consumer life. Today, they have penetrated consumers behavior and impacted on marketing mix. We can understand the importance of them from real shopping to window -shopping. As a meta-heuristic algorithm that inspired by natural systems, genetic algorithm has been used for problem salving as a mathematic model. The nature of genetic algorithm, which has created a relationship between humanity science and mathematics, is the reason for using it in the research. Given developed indices, Selected Iranian cities were selected for this study. Findings of the research showed that we can achieve accurate results with metaheuristic methods. The research is an applied research in terms of purpose, which is to develop applied knowledge in a certain field.

Keywords: Localization; Shopping Centers; Genetic Algorithm

1. Introduction

very complex and difficult. One cannot find answer for them considering conventional optimization methods and several simplifications. Conventional optimization methods based on gradients have many disadvantages including initial guess that leads to trapping at local optimum points. In recent years, many researchers have interested in the use of evolutionary algorithms in various fields of optimization(Desoer & Vidyasagar, 1975),(Arimoto & Miyazaki, 1985). Evolutionary algorithms are a gradual evolution method, of which general meaning is resulted from the natural evolution theory. However, the evolution process in this algorithm is much simpler than that used in nature.

Evolutionary algorithms are search and optimization methods which have formed based on gradual evolution. The gradual evolution algorithms can be classified as follows:

- Genetic Algorithm
- Evolutionary strategy
- Evolutionary planning
- Genetic planning

The basic concepts of all these algorithms are similar. Simply, an evolutionary algorithm is used to find and maintain a superior population among populations that are produced and selected in a random and iterative process. In all of these algorithms, a set of populations is considered as an answer candidate. Then, new populations are generated using random combinations. It is attempted to increase population fit using a selection algorithm. There are different approaches to genetic constructs, population selection, and applying operator, which lead to different algorithms (Porter & Jones, 1992),(D,E & Wesley, 1989).

2. Shopping Centers

Shopping centers are the results of industrialization and a kind of twentieth century architecture. These centers have been around in Europe and the United States for nearly 200 years. They have been known in many Islamic countries for their dimensions, applications, and arrangements (Long & Kozenza, 2002). However, changes in social and cultural structure of urban residents, particularly, the impact of entering various technologies into urban life are things that have made shopping centers a different space from previous years and centuries (Wesley et al., 2006). Therefore, urban health and prosperity can be measured with the conditions of its shopping centers and empty and low customer shopping centers are a sign of poor urban economy. On the other hand, the existence of active and lively shopping centers suggests an active city with booming economy, on which choosing the right localization and feasibility study greatly impact (Michon & Chobet, 2004).

Localization for shopping centers is a multi-purpose problem. There are two general approaches to solve multi-purpose problem: Using traditional or evolutionary methods. Traditional methods convert different goals into one goal by weighing and creating linear combinations of them. Given the work done, traditional methods have not presented proper efficiency for solving complex and big problems. In the research, we are also faced with a large search space for multipurpose localization of shopping centers. We have to use a method that is capable of achieving optimum response (Pareto). Therefore, heuristic methods were used to solve the problem. Genetic algorithm approach is the most popular evolutionary methods in localization problems (Ahergoot and Wikek, 2004).

Psychological development of location in developed and developing countries indicates that one has to achieve appropriate local patterns for locations with social/economical/cultural nature according to cultures and subcultures. These patterns not only enhance the attraction of shopping centers, but also they appear culture and cultural development. For example, designing shopping centers in Germany is structurally very different from that in Italy. We are confronted with postmodern structures in Germany while we are confronted with Roman views in Italy, each of which have been designed based on cultural studies appropriate to it. Therefore, the lack of a native pattern/design for Iranian culture can be considered as a challenge.

Attractions of shopping centers are not equally represented in shopping centers. Some of elements have always been of the most interest in some shopping centers and they have been allocated a large part of resources. This is considered as a priority because shopping centers are formed based on need and space restrictions where marketing studies and researches are professionally conducted whose results can provide best prioritize. Therefore, there is an important problem considering resource allocation in Iran due to the lack of a study to localize research in shopping centers. In today's world, study the consumer behavior has necessitated to improve markets and shopping centers due to changes in consumer purchase intentions in a location and under a roof instead of purchasing in multiple locations and from different retailers. Literature review indicates that there is very limited research on "the factors affecting buyer behavior in shopping centers" particularly considering the features of our country. Therefore, the need for such a study based on localization influencer factors is quite tangible and justified.

Shopping centers have played a major role in producing the spatial content of tourism and have materialized urban tourism product so that shopping centers are among the most attractive places in the city for tourists. Commercial centers are strongly attractive to pedestrians and cars traffic. This leads to the creation of urban nodes. People access to commercial centers is also high so improving their facilities is essential.

Designing shopping centers (Farsi-Code; the website favorite for architecture and civil engineering lovers) is often a very difficult and crucial commitment. A shopping center should have a complete human complex. There are mainly three levels of shopping center for designing: MiniMall, MaxiMall, and MegaMall.

For designing shopping centers, not only the physical design of shopping center environment should be taken into consideration, but also all parts such as passages, entrances, parking, sidewalks, facilities of the path, lighting, furniture, and public spaces should be supervised and controlled. Creating the right atmosphere is crucial for shopping. The main points for designing shopping centers are as follows:

1. Site locating
   - Locating the shopping center in the right place
   - Attraction of shopping center for customers
2. Website design
   - Allocating the retreat for street yard parking
   - Building specified and attractive entrance for the complex
   - Building a sidewalk in retreat
   - Building a path from the street corner to shopping center
   - Building a proper parking
   - Creating view from different parts of surrounding streets
   - Connecting public sidewalks to side sidewalk
   - Building public-social spaces in the site. Perhaps, public spaces are the most important element in the site plan of shopping center. These spaces should be designed to give the buyer a sense of community. Therefore, conventional visual elements of the world should be used in these spaces.
3. Interior design and furniture selection:
   Benches, tables, chairs, and all urban furniture should be chosen to reflect the best of the shopping center. Color, design, and movement are the key and visual passion for making a successful purchase.
4. Lighting
   In addition to light-related entertainment and signs, the lighting of a shopping center should be hidden, covered, and changeable while it is intense. A permanent light can be boring. A proper lighting makes the buyer spend a long time shopping at the shopping center.
5. Catering - Entertainment
   In a complex, honesty and trust are the most effective factors to attract people. A shopping space should be designed so that mothers can bring their children together and spend a day shopping. The great variety of shopping will encourage children. Therefore, providing entertainment and catering for children are the most important principle. Items such as sculptures, ponds, fountains, etc. will keep kids entertained for a long time. Performing encouraging works such as clowning, comedy, badger musician, carnival, etc. can also be effective; otherwise, the atmosphere can be boring. Carousel and train can also be used in the larger shopping centers. Babysitter is also required so mothers can leave their children for hours and feel that they are in good health and safety. A music band and cultural institute can be helpful for adults. Thus, cafeteria, restaurant, pause space and lobby for customer rest, play area for children, entertainment facilities for adult, drinking water fountain, show halls and platforms, CCTVs, closets and shelves to store

customer goods, etc. are considered as essentials for shopping centers.

6. Color
   Color diversity is one of the principles for successfully designing shopping centers. In a corectly designed shopping center, the landscape will be more important than the building itself. The colors and textures dedicated to the spaces for any place whatsoever are more used in providing content. Choosing an image for the shopping center is not by accident rather than an effort to introduce products and encourage people to shop.
7. Advertising
   Today, the importance of advertising to make influential perception of a product or place and extraordinarily influencing on business is clear for everyone. Among others, an advertisement is more successful to be able to attract more people's attention.

4.1. Situational impact on consumer behavior

Common sense tells us to shop in a particular situation and how our feeling at a certain point in time affects what we are buying or doing. Smart marketers understand these patterns and plan their efforts to match with situations in which we are likely to buy. For example, book clubs invest strongly in comprehensive advertising programs in June when many are looking to buy books for so they can read it in the summer. Even, our moods change essentially throughout the day. Therefore, we may be more or less interested in marketers' suggestions at different times.
It has been used a technique to track these changes in a study, which the researchers call "Day Reconstruction Method." More than 900 female workers recorded everything they did during the day, from reading newspaper in the morning to sleeping in front of television at night. The next day, they remembered each of the entries in the notebook. Then, they scored their feelings at the time (for example, uncomfortable, happy, etc.). Generally, researchers found that participants in the study were a little deep down when they woke up at first; but soon entered a state of mild pleasure, which would gradually increase throughout the day, during which anxiety, frustration, and anger attacks would occur. Not surprisingly, people were the least happy when doing activities such as going work or doing housework, while they were most pleasure when socializing with friends or resting. However, contrary to earlier findings, these women reported that when they were watching television, they were happier than when shopping or talking on the phone. They also scored to caring for children lower than cooking and almost as much as the housework. Generally, the good news is that people seem to be very happy and these scores are greatly not affected by factors such as family income or job security. So far, nighttime sleepiness and short work deadlines were two factors that had the most negative impact on daily mood.
In addition to functional relationships between products and using situation, another reason for taking environmental situations seriously is that one's own situational self-concept (i.e. a role he/she plays at a time) helps determine what he/she wants to buy or consume. A man, who wants to influence his fiancee by playing the role of Man-about-town, may spend more money with big spend. Let us see how these behavioral dynamics affect how people think about the reason for their purchase.
One of the most challenging issues in marketing and consumer behavior is customer choice and buying behavior. For purchasing, there are many factors involved in and impact on its complexity, of which the most important include individual factors, commodity factors, and situational factors. All stores and shopping centers around the world are trying to influence people through these factors and encourage them to buy goods. They pursue this goal by creating environmental attractions, training employees, new technologies, and trying to become aware of individual behavior (Heidarzadeh & Taherkia, 2010). Today, there is more competition in the retail industry than ever. Retailers try to reach a specific segment of market and sell a brand or a particular product. These retailers should pay particular attention to the key elements that differentiate them from other retailers including landscaping and appearance of the store (Moor et al., 2012).

4.2. Apparent variables are divided into four parts:

Apparent variables are divided into four parts: Exterior, interior, design and designing, and decoration variables. Exterior of the store includes facade, entrance door, windows, physical features of the building such as height and size, surroundings of the store, and parking. Store interior includes floor covering, color, light, fragrance, sounds, equipment, temperature, wares, and cleanliness. Design is how wares are categorized and arranged inside the store (Berman & Evans, 1998). Decoration variables include images and artwork, signs, certificates, product display and arrangement, etc. (Torley & Miliman, 2000). Exterior of the store is what customers see for the first time, which is considered as an influential factor in shopping behavior and an important and positive opportunity for the store. Exterior may be less important for great retailers because they may now pay less attention to exterior of their store for reasons such as reputation based raised products, convenient store location, and competitive position. However, for smaller retailers who lack strong or valid brands, exterior of the store plays an important role in creating a customer positive perception and attracting them. In smaller stores, exterior such as appearance of the store helps to make customer perception of the product in store positive before entering the store so they accept the product more easily and their trust enhance. The US Census Bureau researches in 2007 show that there are small retailers with fewer than ten cosmetics employees accounting for 65% of the sales market. This is resulted from the attention of these stores to exterior variables. In addition, clothing boutiques and other retailers are important components of business in central areas of the city whose proper spatialization have been played an important role in their development and customer buying behavior (Padilla & Stellick, 2009). In today's competitive retail environment, many retailers need to develop their own strategy to compete with other stores.

McGee and Finney (1997) consider marketing strategies as one of the retailer tools to compete with other stores. Stores can be more prominent than other competitors with packaging, expanding, and displaying products (McGee & Finney, 1997). In fact, ruling atmosphere in stores leads to a positive image of the store; as a result, it increases sales by stimulating customer behavior (Shafei, Narimani, 2017).

Market segmentation strategies can position products by systematically identifying the main situations in order to meet the specific needs of these situations. We can apply this type of segmentation to many types of product categories. For example, we often choose our furniture according to the specific situation. We prefer different styles for an urban apartment, a beachfront home, and/or an office suite. We distinguish motorcycles based on how people ride them (for example, going to work, riding them for desert climbing, using them on farm, or moving in highway).

Coach, manufacturer of luxurious leather goods, decided to change its marketing strategy completely in order to convince women that they need more than one bag (one for everyday use and one for stylish situations). Now, they help women to make their closets fuller with a variety of bags such as quilted, clutches, backpacks, handbags, wallets, shoulder bags, attach case, hobo, purse, tote bag, and wristlet which is a small bag inside the bag. The company even produces new bags for what is called "vacuum for use," that is, it develops activities ranging from weekend trips to going to store. Coach introduced his Hamptons weekend collection by displaying bags filled with colorful beach towels and flip-flops. Buy a bag, get a trip.

5. Genetic Algorithm

The main idea of genetic algorithm method was inspired by biological processes of living creatures. The basics of genetic algorithm were first made by John Holland in 1975. The algorithm works with a population of people, each of which is an answer to a problem. Each person receives a degree of fitness according to what extent is he a good answer to the problem. Those having a higher degree of fitness are more likely to mate or generate. The new population is generated by selecting the best people of current generation and mating them together. In this way, good traits are spreading throughout the population during breeding of many generations (Bisli and et.al, 1993).

Fitness function is one of the concepts used in genetic algorithm. For each specific person, the fitness function returns a value indicating the individual ability and capability (Bisli and et.al, 1993).

John Holland invented a method of optimization for the first time, which later became the basis of many designs and optimizations. Those who use the genetic algorithm believe that everything in nature is as optimal as possible, so we will get better designs if we can primarily design with nature modeling. Then, we should try to develop a mathematical formula for everything that exists in the nature. Thus, he took this step and made some significant progress.

Genetic algorithms are search algorithms that use principles governing natural genetics to solve optimization problems. The original genetic algorithm was proposed by Holland in 1975. It has been later developed by Goldberg, Mikalowitch, and others. Holland's purpose to address this concept can be stated in two points:

1. A complete and clear explanation/expression of how choices are made in natural systems.
2. Designing an artificial software system that can help solve problems using nature's selection mechanism.

The benefits which this logic has taken into account in engineering systems, computer systems, jobs, etc., are the robustness, efficiency, and flexibility of biological systems. Since genetic logic has these characteristics, it is used as strong optimization logic.

It is analytically and empirically proven that genetic algorithms are very powerful tools in uncertain search spaces. Primary populations, on which genetic operators are applied, are defined as a strand called "chromosomes." Populations improve from generation to generation by applying genetic operators such as crossover and mutation leading to optimal populations. The crossover operator takes two chromosomes as parents and combines them into two offspring in order to search the entire search space by algorithm and to create diversity in populations. However, the purpose of mutation operator is to prevent them from being trapped in local optimal locations. An objective function or a fitness function plays a selective role among populations.

The following are of great importance in solving an optimization problem using the genetic algorithm:

1. Defining the right chromosome for the problem.
2. Generating primary population.
3. Defining an objective function that can describe the fitness of populations.
4. Genetic operators that can generate new populations.
5. Determining the initial values of genetic algorithm such as initial population number, probability of crossover, probability of mutation, number of replicates.

Most genetic algorithms are modified by simple genetic logic as suggested by Goldberg. Genetic algorithms can be divided into two categories:

1. Series genetic algorithm
2. Parallel genetic algorithm

Evolutionary algorithms establish optimization methods that are applied to a wide range of fields such as parametric optimization, search, combinatorial problems, and automated production of computer programs. Unlike conventional optimization methods that use the function derivative for optimization, evolutionary algorithms only use the value of the objective function itself and do not require function derivatives. Unlike conventional methods that use a single point to find the optimal solution, evolutionary algorithms use a set of populations for optimization, so it divides the search space into subsets and makes it possible to reach the global optimal point.

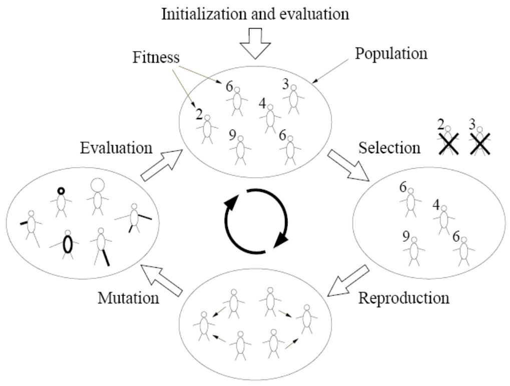

Fig. 1. Initial population and iterative cycle in evolutionary algorithm

According to the application of evolutionary algorithms, there are many differences in demographic structures and evolutionary operators in these algorithms. However, all evolutionary algorithms start with the initialization step and are followed by an iterative process to improve the initial population structure in order to obtain better answers to the optimization problem.

The crossover operator operates on two or more strands and produces a new pair of strands. In fact, two new offspring are generated in the crossover process by combining two or more parents' genes together. The "n-point" method is used for how to execute the crossover operator for two strands so that "n" common replacement point is randomly determined over two or more strands; and continuation of two strands are swapped at these common points.

In single-point crossover, the parental genomes are separated by "n" distance from a random point "p" and combined with other parental genomes at the same point. The first offspring genomes that have the "n" genes as their parents consist of two parts, the first part of which from gene (1) to gene (p-1) are related to parents 1 and the rest are related to parents 2. The second offspring genomes are in contrast to the first offspring genomes, i.e. from gene (1) to gene (p-1) are related to parents 2 and from gene (p) to gene (n) are related to parents 1 (Fig 2).

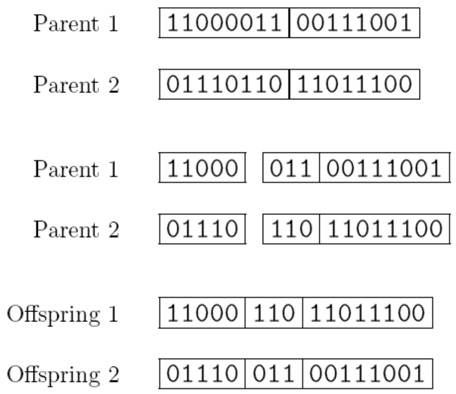

Fig. 2. Single-point crossover operator

As mentioned, the number of replacement points can be more than one point. More replacement points are to execute replacement in several steps. Usually, the number of points is between 1 and 4. In another type of crossover, which is called "uniform crossover", replacing or not replacing each character of two strands in the same place is done randomly and independently of one another (Fleming & Purshous, 2002),(R,K,Ursem, 2003).

For a multi-objective optimization problem, a Pareto set ($\mathcal{P}^*$) contains all Pareto optimization vectors, so that (1) In other words, there is no X' in Ω set $\mathcal{P}^* = \{X \in \Omega | \nexists X' \in \Omega : F(X') \prec F(X)\}$ that can overcome any $X \in \mathcal{P}^*$.

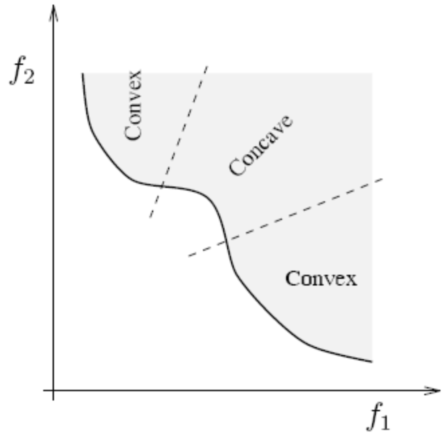

Fig. 3. Convexity and concordance in the Pareto set

One of the simplest methods in solving optimization problems is to use weighting coefficients. In this method, the objective functions in the problem are combined using weighted coefficients to form the final objective function. The weight coefficient of each objective function depends on the importance of that objective function. The more important the objective functions the larger the weight coefficients. This method converts the multi-objective optimization problem into a single-objective optimization problem. The objective function of the problem is defined as:

$$F_{ws}(X) = \sum_{i=1}^{n} w_i \ f_i(x) \quad (1)$$

where n is the number of objective functions and is constant weighting coefficients. This method tries to select the coefficients so that their sum equals one .

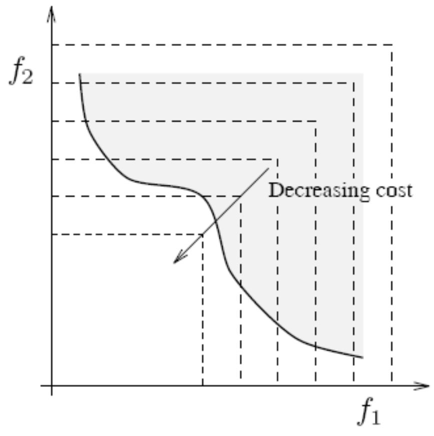

Fig. 4. Lines with values of equal objective functions for using in the Min-Max method

Note that the solution point obtained by weighting coefficients is one of the points in the Pareto curve.

5.1. Criteria for optimizing localization of shopping centers

To determine selection criteria, a number of qualitative and quantitative factors affecting the localization process of shopping centers should be taken into account. Following are indicators that can be taken into account in localization of shopping centers, which are urban management principles:

- ❖ Demographics: That is current population and population changes affected by population growth rate, population density, and age groups in the study area.
- ❖ Environmental considerations: That is, new commercial centers should not increase air pollution and noise pollution in the area. In addition, traffic volume should be considered in the localization due to sellers and customers.
- ❖ Competitive conditions: This criterion relates to other shopping centers located adjacent to the construction site.
- ❖ Accessibility criterion: That is, ease of access, adjacency, and use of location with different types of public transport.
- ❖ Being economic: In this criterion, considerations such as income level, residents' expenses, and residents' pattern of consumption in the area should also be taken into account.
- ❖ Total Cost: Refers to direct and indirect costs such as land cost that must be taken into account in project construction.
- ❖ Flexibility: This criterion is affected by sub-criteria such as capacity of selected location, capability of future developments, possibility of potential development, and possibility of changes in the complex.
- ❖ Attraction criterion: It consists of factors that lead to the attractiveness of the site in question such as adjacency to commercial, recreational, entertainment centers and activities, complex area, and urban management attitude to the shopping centers (Avant et al., 2011).

6. Research method

In the research, optimal shopping centers have been identified by genetic algorithm. Then, questionnaires were distributed in these centers.

The research is related to the selected shopping centers throughout Iran including Tehran, Alborz, Isfahan, and Mazandaran cities.

Table 1
Selected shopping centers

No	Name of shopping center	Selection status based on the results of artificial intelligence
Shopping centers in Alborz		
1	Parsian	✓
2	Golestan	✓
3	Mahestan	✓
4	Mehrshahr	×
5	Life complex	×
6	Chechlas	×
7	Milad tower	✓
8	Yademan tower	✓
9	Goharan	×
10	Saviz	×
11	Nikamal	✓
12	Royan	×
13	Mabna	×
Isfahan shopping centers		
1	City center	✓
2	Park complex	×
3	Isfahan bazaar	✓
4	Geysarieh bazaar	✓
5	Martin	✓
6	Kosar	✓
7	Naqshe Jahan	✓
8	Sepahan	✓
9	Oyan	×
10	Nozhan	✓
11	Hakim	×
Shopping centers in Mazandaran		
1	Persia	×
2	Baroon	×
3	Narenjestan	✓
4	Negin	×
5	Milad-E-Nour	×
6	Aramesh	✓
7	Negin Ramsar	✓
8	Pardis	✓
9	Mahan	×
10	Azimzadeh	✓
11	Panaroma	✓
Shopping centers in Tehran		
1	Tirajeh	✓
2	Palladium	✓
3	Milade-E-Nour	✓
4	Hiland	×
5	Iranian	✓
6	Tandis	×
7	Mirdamad	✓
8	Kourosh	×
9	Sam center	✓
10	Doyaye Nour	✓
11	Mega Mall	✓
12	Rosha	×
13	Nour	✓
14	Goldis	✓
15	Scan	×
16	Morvarid	×

7. Conclusion

In this project, the NSGA-II correction algorithm has been used for multi-objective optimization. In the test, the number of initial population in the project was obtained 120; the number of genes was obtained 25; and optimal Pareto points was obtained 97 considering 0.85 probability of crossover and 0.01 probability of mutation after 300 generations. These points are not superior to each other.

These points are shown in pairs in graphs 1 to 6. In addition, some optimum points were selected from this set, which will be explained in the next section on how to select them among other points.

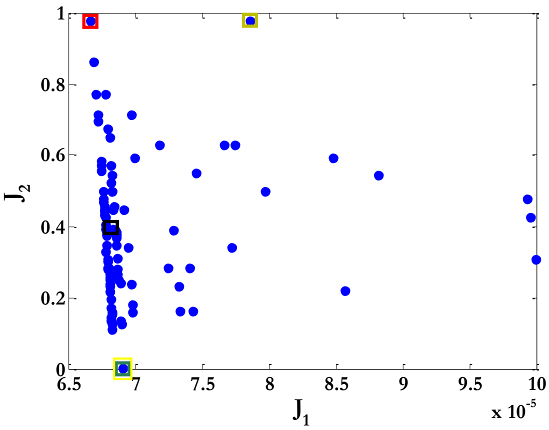

Fig. 5. Graph of objective functions relative to each other

In the Fig. 5, two objective functions (J_1, J_2) are compared. Five points are marked in the graph. The red dot represents the values of J_1, J_2 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_1, J_2 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_1, J_2 for the lowest value of objective function J_4; and the black dot represents the values of J_1, J_2 for the lowest value of objective function $\left\|\bar{J}\right\|_2$.

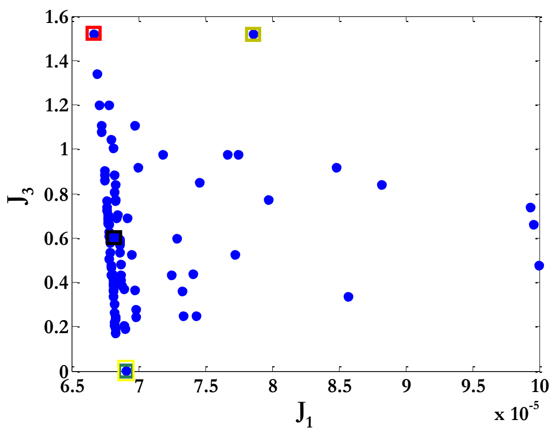

Fig. 6. Graph of objective functions relative to each other

In the Fig. 6, two objective functions (J_1, J_3) are compared. Five points are marked in the graph. The red dot represents the values of J_1, J_3 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_1, J_3 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_1, J_3 for the lowest value of objective function J_4; and the black dot represents the values of J_1, J_3 for the lowest value of objective function $\left\|\bar{J}\right\|_2$.

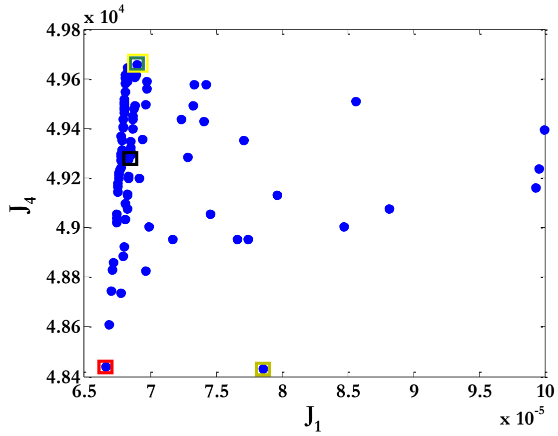

Fig. 7. Graph of objective functions relative to each other

In the Fig. 7, two objective functions (J_1, J_4) are compared. Five points are marked in the graph. The red dot represents the values of J_1, J_4 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_1, J_4 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_1, J_4 for the lowest value of objective function J_4; and the black dot represents the values of J_1, J_4 for the lowest value of objective function $\left\|\bar{J}\right\|_2$.

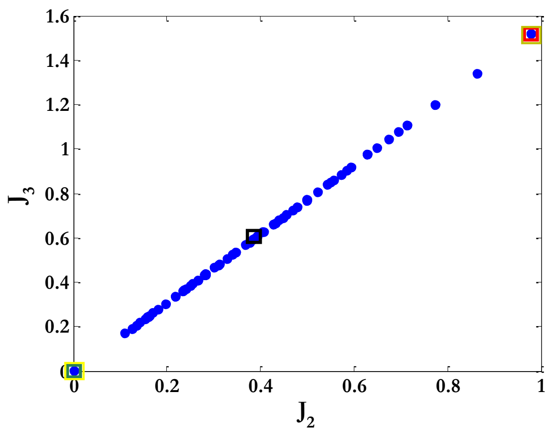

Fig. 8. Graph of objective functions relative to each other

In the Fig. 7, two objective functions (J_2, J_3) are compared. Five points are marked in the graph. The red dot represents the values of J_2, J_3 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_2, J_3 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_2, J_3 for the lowest value of objective function J_4; and the black dot represents the values of J_2, J_3 for the lowest value of objective function $\left\|\bar{J}\right\|_2$. In this graph, J_2, J_3 do not contradict each other and they are simultaneously optimized; increasing one caused another to increase and decreasing one causes another to decrease.

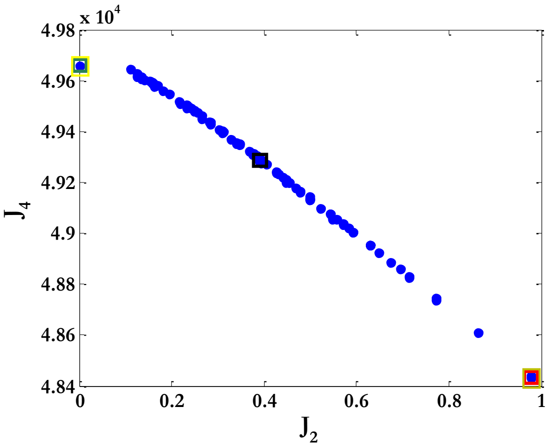

Fig. 9. Graph of objective functions relative to each other

In the Fig. 9, two objective functions (J_2, J_4) are compared. Five points are marked in the graph. The red dot represents the values of J_2, J_4 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_2, J_4 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_2, J_4 for the lowest value of objective function J_4; and the black dot represents the values of J_2, J_4 for the lowest value of objective function $\left\|\bar{J}\right\|_2$.

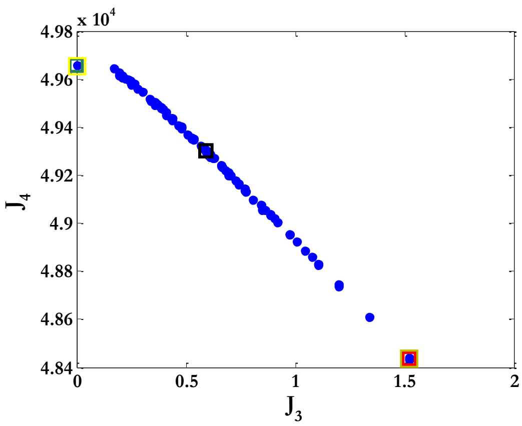

Fig. 10. Graph of objective functions relative to each other

In the Fig. 10, two objective functions (J_3, J_4) are compared. Five points are marked in the graph. The red dot represents the values of J_3, J_4 for the lowest value of objective function J_1; the green and yellow dots represent the values of J_3, J_4 for the lowest value of objective functions J_2, J_3; the orange dot represents the values of J_3, J_4 for the lowest value of objective function J_4; and the black dot represents the values of J_3, J_4 for the lowest value of objective function $\left\|\bar{J}\right\|_2$.

Values of objective functions for each of colored dots are five locations. Red color represents the positioning for the lowest value of first objective function J_1; green color represents the positioning for the lowest value of second objective function J_2; yellow color represents the positioning for the lowest value of third objective function J_3; orange color represents the positioning for the lowest value of fourth objective function J_4; and black color represents the positioning for the lowest norm $\left\|\bar{J}\right\|_2$, respectively. These locations are illustrated in the graphs 1 to 6 and are given in the following table.

Table 2
The coordinates of points for the objective functions J_1, J_2, J_3, J_4

Colors	Objective functions
Red color	$J_1 = 6.66 \times 10^{-5}$
	$J_2 = 0.977215$
	$J_3 = 1.5209$
	$J_4 = 48438.18$
Green color	$J_1 = 6.9 \times 10^{-5}$
	$J_2 = 0.00075$
	$J_3 = 0.001553$
	$J_4 = 49658.87$
Yellow color	$J_1 = 6.9 \times 10^{-5}$
	$J_2 = 0.00075$
	$J_3 = 0.001553$
	$J_4 = 49658.87$
Orange color	$J_1 = 7.85 \times 10^{-5}$
	$J_2 = 0.977183$
	$J_3 = 1.520868$
	$J_4 = 48433.92$
Black color	$J_1 = 6.83 \times 10^{-5}$
	$J_2 = 0.393096$
	$J_3 = 0.607789$
	$J_4 = 49276.84$

As seen in the figures, it is not easy to analyze the obtained points, except for the graph ($J_3 - J_4$) where J_3 decreases with increasing energy consumption and J_3 increases with decreasing energy consumption. There is also a linear relationship between the two objective functions J_2, J_3. Therefore, this representation is not recommended for situations where there are too many objective functions. Another way of drawing a Pareto front with a large number of objective functions is to use a level diagram method, in which the objective functions are first normalized; then their norm are calculated. Many methods are used for level diagrams to see optimal results. These techniques make it easy to analyze the Pareto set. Therefore, it can be a useful tool for the designer to make several decisions. (N,N,Zadeh .A.Alasti .A.Jamali .A.Hajiloo, 2006).

To present the Pareto fronts using this method, each of the objective functions $(J_i(\theta), i = 1,..., n)$ is normalized according to their maximum and minimum values.

$$J_i^M = \max_{\theta \in \Theta^*} J_i(\theta), \qquad J_i^m = \min_{\theta \in \Theta^*} J_i(\theta), \qquad i = 1,..., n \tag{2}$$

$$\bar{J}_i(\theta) = \frac{J_i(\theta) - J_i^m}{J_i^M - J_i^m} \rightarrow \qquad 0 \le \bar{J}_i(\theta) \le 1 \tag{3}$$

where $\bar{J}_i(\theta)$ is normalized objective function. If we consider the optimal value of each normalized objective function to be zero, the nearest point to the zero point in the n-dimensional space of the objective functions will be the ideal point of the Pareto front. Therefore, any norm representing distance can be used. There are many definitions for norms that can be applied considering different properties of graphs.

The most common norms are as follows:

$$1 - norm : \left\| J(\bar{\theta}) \right\|_1 = \sum_{i=}^{n} \left| \bar{J}_i(\theta) \right|, \tag{4}$$

$$2 - norm : \left\| J(\bar{\theta}) \right\|_2 = \sqrt{\sum_{i=1}^{n} \bar{J}_i(\theta)^2}, (j_1, j_2, j_3, j_4, ...), \tag{5}$$

$$\infty - norm : \left\| J(\bar{\theta}) \right\|_\infty = \max \left\{ \bar{J}_i(\theta) \right\}, \tag{6}$$

To draw diagrams, level diagrams are first arranged in terms of $\left\| J(\bar{\theta}) \right\|_x$ for each objective function. Then, each objective function is written in terms of $\left\| J(\bar{\theta}) \right\|_x$. Therefore, the vertical axis of each graph will be equal to $\left\| J(\bar{\theta}) \right\|_x$. Thus, the points in the lower part of the graph will be the ones with fewer norms and less optimized.

Result shows that the model can well determine optimal locations of shopping centers considering the above mentioned indicators. Finally, an automatic weighting program is used to assess fitness of the model. In this case, each response is assigned a random weighted vector any time. Ultimately, a set of non-dominated response will be resulted, which gives decision maker the opportunity to select non-dominated responses according to specific conditions or their priority. The same results were obtained by Ameri et al. (2015). The research has been conducted using Genetic Algorithm. Genetic Algorithm is an optimization method and works by applying natural selection over a set of potential responses and aims to provide better responses in order to obtain optimal response which has proved this issue in certain repetitions. Given that the results prove this, Marzouk and Aboubekr (2016) confirmed the algorithm in localization for achieving optimal response.

The rapid Pareto genetic algorithm suggests points to build new shopping centers, where there are currently lacks of shopping centers in current situation. This is clearly demonstrated in the results. Given applying competitive conditions in the algorithm, most of proposed centers are far from the existing status centers. Attracting more demand by existing status centers is the reason for this scattering. However, there is still demand for new centers in some areas due to high population density or proper availability. Therefore, we witness the closeness between proposed centers and the existing status centers. Referring to the information layers, which are the inputs of genetic algorithm, we find that some points having proposed points density are potential areas with high demand or availability. This is also true for northern areas of the city, because despite the lack of shopping centers, few shopping centers have proposed in those areas due to low availability and population density.

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