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Full Length Research Paper

Billboard advertising optimization by using imperialist competitive algorithm (Case study: Tehran city)

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It is very important for organizations to be effective and efficient in business advertisements. Targeting the market by means of any media should be according to a regular method. The balance between the quality of the message and the media in achieving the objectives of the ads is necessary for a successful advertisement. The present paper undertakes the optimization of billboard media considering the existing factors such as costs, number of visits and the coverage. Billboards can give negative result, that is, visual annoyance when they are not exact and précised. The purpose of the present paper is to increase the exactness in using this effective outdoor medium. Imperialist competitive algorithm as a new Meta-heuristic algorithm which is derived from a socio-political system is used as a mathematical model for the solution. Regarding the limitation of budget, this model helps us to have the best selection of billboards by paying attention to a number of visits and coverage. 116 billboards were chosen in Tehran. Performing of this model offered pleasant results especially in number of visits and coverage. The present paper is an experimental research and aims to develop practical knowledge in a special area.

Key words: Billboard, advertising, imperialist competitive algorithm, optimization.

INTRODUCTION

In the school of competition, advertisement market is like an information source which increases the sensitivity of the user about the price and encourages competition (Vernon, 1971). Advertisement in an economical role helps the society to achieve abundance by announcing to the people the products, services and ideals (Sandage, 1973). Advertisement in a social role reflects the trends of plans and fashions and shares in our aesthetic sense (Wells et al., 1926). Advertisement is an open, active public tribune in which commercial benefits, creativity, consumer needs and governmental rules meet each other (Bowes, 1991).

Media convey advertising messages (Khan, 2006). Choosing the media for advertising campaigns is based on some factors such as the size of the target addressee (effects, availability), repetition of exposure opportunities (message abundance), cost practicality and important quality specifications like content state and other compatible environments with the message (Wells et al., 1926).

Considering the importance of advertising in marketing, the purpose of the present paper is to use billboard medium purposefully through a Meta-heuristic algorithm and familiarizing the behavioral science with mathematical issues. Innovative algorithms are the algorithms which are designed for getting good answers not necessarily the optimized ones (Wolsey and Nemhauser, 1999).

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The main research question

Can using the Imperialist competition algorithm lead to more success in recognizing the suitable places for installing the advertisement billboards and attracting more people?

RESEARCH LITERATURE

Outdoor advertising

The signs between cities, on the roads or out-of- home which advertise products and services are the oldest way of advertising which goes back to prehistory era. Nowadays, the advertising messages, in different shapes and forms, reach to a majority of people who are commuting between cities. Urban traditional tableaus are still the main and essential part of this industry. But, besides, other tableaus in different shapes and forms are added which are widely used these days (Lane, 1999). Outdoor advertising is deemed much more effective in terms of cost-per-thousand than the other media (Lopez-Pumarejo and Bassell, 2009).

There are various categorizations for the out-of-home and/or urban commercial advertisements (in other words, environmental advertisements). One of them is categorizing the out-of-home advertisements into two categories of immovable and movable (Lane, 1999). Size of the vehicles' traffic is very important for choosing the place of installing tads; not only must the size of the traffic but also the direction of the traffic move be considered (Kia, 1970).

Billboards

These are very big luminous tableaus based on a high pedestal which is visible from far distances and are installed besides the streets and highways. Billboard's background refers back to early civilizations. In the history of the ancient Egypt, we encounter the Obelisk stony pillars which are four-sided monuments that end in a pyramid-like shape at the top and are monolithic. These monuments were not only as complementary but were also used for promoting religion, and a lot of religious phrases and prayers were sculptured on them. Billboard, the oldest form of advertising, has experienced a steady and significant rate of growth worldwide and is widely available (Lopez-Pumarejo and Bassell, 2009).Billboards are more effective than recall (Robinson, 2008; Azhari and Kamen, 1984). The billboard media in comparison with the broadcasting media is more reliable (Prendergast et al., 2009). American merchants and shoppers were the first to use billboard advertisements. Therefore, specific columns and boxes for advertisements were established in the crowded parts of the cities. There are two types of billboards: poster frames and canvases or the painted bulletins (Wells et al., 1926).

Posters: posters are printed by a printer, lithography or silk screening and move to an external advertising company. Then, glue is used on their back and is installed in the special frames applied for them in the place (Wells et al., 1926).

Painted canvases: they are made by artists who work for the external local advertising companies. These tableaus are handmade paintings which are made on separate sheets in the place or in the workshop which can stick them to the frames of the advertising installation tableaus (Wells et al., 1926).

Accuracy and precision in advertising

As per competitiveness of advertising environment, it needs to be both accurate as well as precise, advertising policies about content, message quality and the medium specifications (Patsioura et al., 2009) ; without them, purposeful advertisement is impossible. Purposeful advertisement is the only way for competition (Wells et al., 1926).

Accuracy in performing advertisement

The famous 4 Ps in the marketing industry include: product, place or distribution, price and promotion or marketing relationships (McCarthy and Perrault, 1995). advertisement, personal selling, sale promotion, public relationship, direct marketing and sale place/packaging show the existing basic techniques to the business person for making relationship with the target markets. These composite techniques are known as promotion or marketing relationships. Marketing promotion can be described as: encouraging relationships designed for sending marketing-related messages to a related-nominated addressee (Bogast, 1990).

Advertising is the sub-category of marketing and is based on evaluating and coordinating product-related and consumer- related policies (Wells et al., 1926). The message that is expressed through the media in order to communicate with the consumer must follow the framework of the AIDA model, that is, to attract the addressee attention, encourage their desire and ultimately lead to their action (Kotler and Armstrong, 2009). Other models such as AICCA[1] can be considered too (Gabriel et al., 2006).

Precision in performing advertisement

Communication channels are divided into two main groups:

[1] . Attention, Interest, Confidence, Conviction, Action

Personal communication channels and Imper-sonal communication channels. Impersonal communi-cation channels are the media which send the messages without the need for the person's contact or receiving the feedback from the addressee. These channels include mass media, surrounding environment and the events. The main mass media themselves include the printing media (newspapers, magazines and direct mails), broad-casting media (radio, television) and expository media (tableaus, signs and symbols and posters). Surrounding environment, are the environments which are inten-tionally made to create or encourage the buyer's interest to purchase a product (Kotler and Armstrong, 2009).

Different media lead to different reactions as per their unique effects on the addressee. Television seems to be better for creating spirits in the addressee or a kind of positive feeling while printing media are more suitable for expressing precise and interpreting information (Assael, 2006).

One of the important necessities for the person who intends programming for the media is to have an open and active mind to be able to choose the best medium or media among others for advertising. The media programmer should consider all the media from radio and television up to the very modern media of today such as internet and should be able to categorize them and choose the best which suits and matches with the marketing and advertising purposes of the company and make a practical use of them (Lane, 1999).

The advertiser who chooses the medium to enhance the advertising purposes should determine the covering area, the necessary abundance of the message repetition and the especial medium of conveying the message. Covering area, in other words, the medium expressive-ness is the percentage of the people in the target market which at a specific duration are exposed to the advertising program (Mohammadian, 2006). And also exposure of the consumers to the information is the first stage of the understanding process. Person encounters information in which a bracing factor falls in the domain of the sensational sensors (Hawkins and Mothersbaugh, 2012). Advertisers need to decide the effect of the medium. The medium effect is just the qualitative value of seeing the message which is conveyed from a special medium (Kotler, 2000).

Precision in choosing a medium

Medium designers consider different factors for choosing a suitable medium. Medium interests of the target consumers affect the medium selection. Product nature is also important for choosing the medium. For example, colorful magazines are good for showing various ranges of clothes and on this basis, photographing camera is better to be advertised on TV. The message type may also play role in choosing the medium (Kotler and Armstrong, 2009).

Precision in using the medium

Medium designer, after choosing the medium, needs to choose the best medium conveyer. Medium conveyer is the medium which is selected among the other media. For example, on TV, the tools are the programs conveyers (Kotler and Armstrong, 2009).

We used to discuss the message (accuracy) and medium (precision). If the advertising is not accurate enough and precise, it will be difficult to decide the budget to be allocated for the advertising. Advertising budget eclipses all the advertising activities and in a wider range, effectively affects the communicating activi-ties of marketing. Allocating low budget for advertising can simply lead to the loss of some of the potential addresses and customers who intend to buy the products of the company and make them unaware of the product/ or the advertising purpose or vice versa. Allocating a huge budget, more than what is needed, for advertising leads to profit decline and loss of some of the amounts gathered by the company. Therefore, precision in arranging and comprising suitable budget for advertising activities plays an important role which needs to be done through study and systematically. Many of the advertising expertise believe that in spite of all the available technologies and the technical knowledge which can help us know the amount we can spend on advertising, the final decision depends on the judgment of the company management, and the management effectively affects such decisions (Russel and Lane, 1999).

The purpose of this research is to increase the performance and effectiveness of billboard ads with focus on exactness using this medium; this is because just having exactness in selection will not increase ads quality.

Imperialist competitive algorithm

Imperialist Competitive Algorithm (ICA) (Gargari and Lucas, 2007) is a new evolutionary algorithm in the evolutionary computation field based on human socio-political evolution. The algorithm starts with an initial random population called countries. Some of the best countries in the population are selected to be the imperialists and the rest from the colonies of these imperialists. In an N dimensional optimization problem a country is a 1 × N array. This array is defined as,

Country = $[p_1 , p_2 , \ldots . , p_N]$

The cost of a country is found by evaluating the cost function f at the variables $(p_1 , p_2 , \ldots , p_N)$. Then $c_i = f(country_i) = f(p_{i1}, p_{i2}, \ldots . . , p_{iN})$

The algorithm starts with N initial countries and the N_{imp}

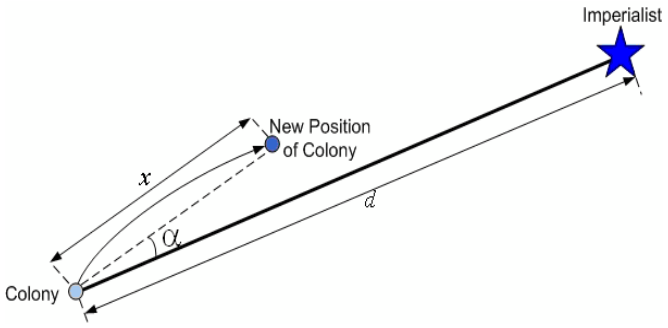

Figure 1. Moving colonies toward their imperialist.

best of them (countries with minimum cost) are chosen as the imperialists. The remaining countries are colonies that belong to an empire. The initial colonies belong to imperialists in convenience with their powers. To distribute the colonies among imperialists proportionally, the normalized cost of an imperialist is defined as follows:

$C_n = max_i c_i - c_n$

Where, c_n is the cost of nth imperialist and C_n is its normalized cost. Each imperialist that has more cost value will have less normalized cost value. Having the normalized cost, the power of each imperialist is calculated as below and based on the colonies distributed among the imperialist countries.

$$p_n = \left| \frac{c_n}{\sum_{i=1}^{N_{imp}} c_i} \right|$$

On the other hand, the normalized power of an imperialist is assessed by its colonies. Then, the initial number of colonies of an empire will be.

$NC_n = rand\{p_n . (N_{col})\}$

Where, NC_n is initial number of colonies of nth empire and N_{col} is the number of all colonies.

To distribute the colonies among imperialist, NC_n of the colonies is selected randomly and assigned to their imperialist. The imperialist countries absorb the colonies towards themselves using the absorption policy. The absorption policy shown in Figure 1 makes the main core of this algorithm and causes the countries move towards to their minimum optima. The imperialist absorb these colonies towards themselves with respect to their power that described in TC_n. The total power of each imperialist is determined by the power of its both parts, the empire power plus percent of its average colonies power.

$$TC_n = cost(imperialist_n) + \varepsilon mean\{cost(colonies\ of empire_n)\}$$

Where, TC_n is the total cost of the nth empire and ε is a positive number which is considered to be less than one.

$x \sim U(0, \beta \times d)$

In the absorption policy, the colony moves towards the imperialist by x unit. The direction of movement is the vector from colony to imperialist, as shown in Figure 1; in this figure, the distance between the imperialist and colony shown by d and x is a random variable with uniform distribution. Where $\beta$is greater than 1 and is near to 2. So, a proper choice can be $\beta = 2$.

In ICA algorithm, to search different points around the imperialist, a random amount of deviation is added to the direction of colony movement towards the imperialist. In Figure 1, this deflection angle is shown as θ, which is chosen randomly and with a uniform distribution. Moving toward the imperialist countries, a colony may reach a better position, so the colony position changes according to position of the imperialist. In this algorithm, the imperialistic competition has an important role. During the imperialistic competition, the weak empires will lose their power and their colonies. To model this competition, firstly we calculate the probability of possessing all the colonies by each empire considering the total cost of empire.

$NTC_n = max_i\{TC_i\} - TC_n$

Where, TC_n is the total cost of nth empire and NTC_n is the normalized total cost of nth empire. Having the normalized total cost, the possession probability of each empire is calculated as:

$$p_{pn} = \left| \frac{NTC_n}{\sum_{i=1}^{N_{imp}} NTC_i} \right|$$

To divide the mentioned colonies among empires, vector **P** is formed as follows:

$P = \left[P_{P1}, P_{P2}, P_{P3}, \dots, P_{PN_{imp}} \right]$

Then, the vector **R** with the same size as **P** whose elements are uniformly distributed random numbers is created.

$R = \left[r_1, r_2, r_3, \dots, r_{N_{imp}} \right], r_1, r_2, r_3, \dots, r_{N_{imp}} \sim U\,(0,1)$

Then, vector **D** is formed by subtracting **R** from **P**.

$D = P - R = \left[D_1, D_2, D_3, \dots, D_{N_{imp}} \right],$

$P = \left[P_{P1}, -r_1, P_{P2} - r_2, \dots, P_{PN_{imp}} - r_{N_{imp}} \right]$

Referring to vector **D**, the mentioned colony (colonies) is handed to an empire whose relevant index in **D** is maximized. The process of selecting an empire is similar to the roulette wheel process which is used in selecting parents in GA. But this method of selection is much faster than the conventional roulette wheel because it is not required to calculate the cumulative distribution function and the selection is based on only the values of probabilities. Hence, the process of selecting the empires can solely substitute the roulette wheel in GA and increase its execution speed.

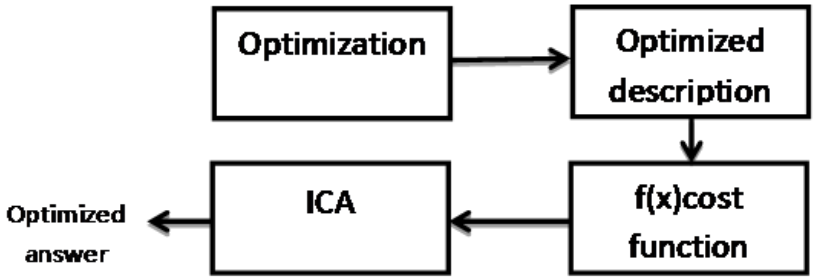

Figure 2. The model or the process of reaching the optimized answer.

ICA is used to solve different optimization problems in various areas of engineering and science. The followings are some of the applications of this algorithm (Gargari and Lucas, 2007):

1. Designing controller for industrial systems
2. Designing Intelligent Recommender Systems
3. Solving optimization problems in communication systems.
4. Solving scheduling and production management problems
5. Training and analysis of Artificial Neural Networks
6. Nash Equilibrium Point Achievement
7. Design and thermodynamic optimization of plate-fin heat exchangers.

THEORETICAL FRAMEWORK

A Meta-heuristic Imperialist competition algorithm is used as an independent variable in the present research in order to optimize the type of billboard advertising (precision in using this medium) which is used as the dependent variable. Figure 2 shows the model or the process of reaching the optimized answer.

RESEARCHMETHODOLOGY

According to the research purpose, the present research is a practical research. In fact, the purpose of the present research is to expand the practical knowledge in a specific field. Also, according to the specification of the subject, it is a descriptive research and according to the duration of the data gathering, it is a survey research and according to the way of gathering the data, it is an experimental research.

The statistic population is the 22 areas of city Tehran. As per the various types of the billboards such as the fixed billboard, three or four dimensional billboards (fixed and rotating), sun roof billboards, logo billboards, clock billboard and mixed billboards, the fixed billboards are targeted in the present research. According to the gathering data, 116 billboards were extracted. The number includes the fixed billboards among the whole statistical gathered data.

The data in the present research is gathered through library sources, internet and reliable information centers. Data related to the network traffic as the second- hand sources of the studies done was used by means of the UTMS (urban transportation modeling system) (Babakan, 2009). The calculations are done by the Matlab software.

RESULTS AND DISCUSSION

The data and information are provided in the form of 3 arrays for the purpose of calculations in the present research. The optimization criteria in the present research are the amount of cost number of visit and the covering area; the arrays are provided for the purpose of optimization. The arrays include the cost of each billboard$[C_1\ C_2\ \dots\ C_N]_{1\times N}$, visit to each billboard (outcome of the occurrence matrix)$[traffic\ on\ each\ edge]_{1\times N}$and the area of each:$[R_1\ R_2\ R_3\ \dots\ R_N]_{1\times N}\ \ R_i \in \{1,2,3,\dots,22\}$. The data base is seen in Table 1.

Subject modeling

$$Max\ Z = \sum_{i=1}^{116} V_{x_{ij}}$$

Subject to:

$$\sum_{i=1}^{116} C_{x_{ij}} \le B$$

$$\sum_{j=1}^{22} \left(\frac{\sum x_j}{\sum x_j}\right) \le J$$

$$x = \{0,1\}$$

$$i = billboard\ 1, billboard\ 2, \dots\dots\dots, billboard\ 116$$

$$j = region\ 1, region\ 2, \dots\dots\dots, region\ 22$$

$$V = Number\ of\ visit$$

$$C = cost\ of\ billboard$$

$$B = budget$$

Goal function's purpose is to increase the visits. The first constraint is related to the budget which can have equal amounts or less than total costs of billboards. The second constraint is that region coverage is considered. In this

Table 1. Data base.

Billboard	Visit	Cost	Region	Billboard	Visit	Cost	Region	Billboard	Visit	Cost	Region	Billboard	Visit	Cost	Region
1	124.1	4	1	31	121.7	18	6	61	127.7	1.6	2	91	139.9	24	6
2	120.4	14	1	32	114.5	9.5	4	62	72.5	15	11	92	125.2	9.5	2
3	36.9	12	6	33	79.9	10	8	63	132.2	12	2	93	52.8	7.5	11
4	119.4	15	1	34	109.8	12	2	64	133.1	9.6	2	94	55.9	7.5	11
5	154.8	17	1	35	137.7	30	6	65	37.9	10.5	9	95	78.9	16	8
6	153.9	17	1	36	129.6	30	1	66	135.7	28	2	96	90.7	12	7
7	41.1	15	6	37	127.4	30.8	1	67	134.9	28	2	97	138.1	30	2
8	42.4	5	6	38	130.1	26	6	68	134.9	25	2	98	188.1	16	4
9	170	19	2	39	114.9	33	2	69	132.7	8	15	99	119.4	4	12
10	137.9	30	3	40	129.4	32	1	70	50.6	8	16	100	151.1	29.5	6
11	150.7	24	5	41	135.5	36	6	71	124.8	10.8	3	101	136.9	31.5	3
12	145.1	25	5	42	127.4	32	1	72	137.6	45	1	102	135.6	25	2
13	164.7	32.5	2	43	125.9	21	1	73	137.9	80	3	103	135.3	26	3
14	155.2	27.5	1	44	128.3	28	1	74	135.1	80	2	104	124.1	14	1
15	128.6	17	3	45	112.2	13.2	2	75	128.9	37.5	2	105	130.1	8	3
16	163.2	42	1	46	127.9	48	2	76	147.1	37.5	6	106	150.7	44	5
17	159.9	41.5	1	47	131	30	2	77	176.9	25	4	107	137.4	1.7	6
18	168.1	23.5	2	48	129.5	54	1	78	119.4	52.5	12	108	137.9	6.5	6
19	54.7	18	11	49	124.3	9.9	1	79	136.9	45	3	109	138	55	6
20	165.3	17	2	50	137.9	58	3	80	129.7	35	2	110	121.9	12	12
21	100	6	3	51	147.2	28.8	6	81	130.2	10	1	111	51.3	15	17
22	76.9	18	6	52	129.9	39	3	82	80.7	16	7	112	87.9	10	18
23	110.6	30	3	53	131.1	35.2	1	83	171.2	18	4	113	57.3	12	13
24	137.9	69	3	54	171.5	14	4	84	133.5	15	1	114	94.4	14	14
25	111.9	43	3	55	149.5	28	6	85	136.3	43	2	115	37.6	10	19
26	121.8	48	3	56	141.7	72	2	86	139.7	3.5	6	116	111.6	40	22
27	101.9	28	4	57	119.9	14.4	1	87	135.9	44	1				
28	102.7	20	4	58	149.8	72	2	88	128.4	24	2				
29	114.8	24	5	59	104.6	1.5	3	89	128.4	24	2				
30	113.4	26	2	60	135.5	15	2	90	130.3	28	2				

model goal function is trying to cover 100% region.

The results of the program performing

According to the defined target function, to test the function of the Imperialist competition algorithm, the program is performed according to the following formula (Determine the amount of budget).

Test level = $\frac{(21-n)5}{100} \times B$

B = Total budget (for renting 116 billboards)

$n \in \{1, 2, \ldots, 20\}$

Number of test in each level is the function of complete absorption budget and repeatability in results.

Table 2 shows the result of the research for practical usage as a decision-making tool for organizations. The selections from this table are a guarantee for wide coverage of Tehran areas with the most optimized visit level. That is a kind of standardization. Previous research has shown that advertising standardization rarely happens (Fastoso and Whitelock, 2007***).*** It is worth mentioning, for increasing the separation power; the number of tests can be increased by changing the budget levels from 5 to 2.5%.

For example, a company whose purpose is to absorb 80% attention of billboard visits, referring to the testing level 8 and a cost between 0.6461-0.6500% of total budget, the purpose is reachable. Total number of billboards that are needed is 91-94 and 22 regions of Tehran will be covered.

Figure 3 shows the comparison of the algorithm results with the plans of an advertising company. In this graph, the lost opportunity of the visit level is obvious.

Conclusion

The imperialist competition algorithm as per its nature can

Table 2. Results summary (Decision tool)

Num.Billboard	Cover level	Visit level	b	Test level
Min – Max	Min – Max	Min – Max	Min – Max	
112 – 116	1	0.9785 – 1.0000	**0.9586 – 1.0000**	1
108 – 113	1	0.9561 – 0.9780	0.9357 – 0.9500	2
106 – 110	1	0.9303 – 0.9515	0.8940 – 0.9000	3
105 – 108	1	0.9021 – 0.9278	0.8458 – 0.8500	4
101 – 105	1	0.8850 – 0.9085	0.7960 – 0.8000	5
98 – 102	1	0.8503 – 0.8807	0.7388 – 0.7500	6
94 – 98	1	0.8257 – 0.8449	0.6998 – 0.7000	7
91 – 94	1	0.7860 – 0.8074	0.6461 – 0.6500	8
87 – 90	1	0.7563 – 0.7758	0.5955 – 0.6000	9
83 – 86	1	0.7153 – 0.7414	0.5469 – 0.5500	10
79 – 82	1	0.6789 – 0.6974	0.4955 – 0.5000	11
73 – 76	1	0.6340 – 0.6557	0.4466 – 0.4500	12
69 – 72	1	0.5872 – 0.6065	0.3980 – 0.4000	13
63 – 66	1	0.5413 – 0.5589	0.3473 – 0.3500	14
56 – 61	1	0.4709 – 0.5115	0.2964 – 0.3000	15
38 – 55	1	0.3600 – 0.4586	0.2409 – 0.2500	16
43 – 46	1	0.3587 – 0.3808	0.1971 – 0.2000	17
34 – 39	0.9474 – 1.0000	0.2734 – 0.3175	0.1475 – 0.1500	18
26 – 30	0.8947 – 1.0000	0.1934 – 0.2305	0.0955 – 0.1000	19
15 – 19	0.6316 – 0.7895	0.1087 – 0.1343	0.0483 – 0.0500	20

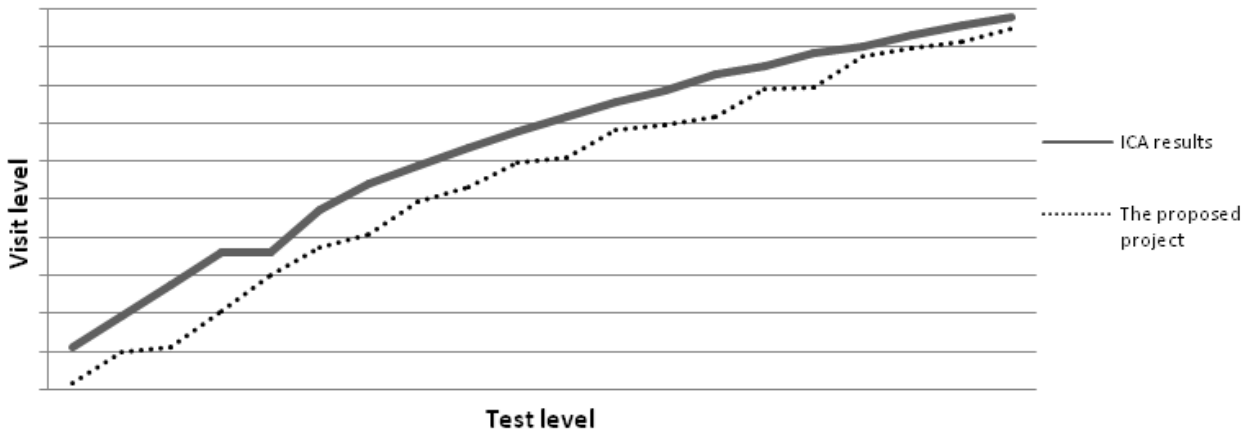

Figure 3. The comparison of ICA results with the plans of an advertising company.

relate the human sciences to the mathematics (Gargari and Lucas, 2007).In solving the problems, the algorithm has shown that it can perform better than the other algorithms (Bahrami et al., 2012; Hosseini et al., 2010; Khorani et al., 2010; Kunlei et al., 2012; Moadi et al., 2011; Mollaiy and Shahbazian, 2011; Nozarian and Vafaei, 2012). And in producing the data, it is more accurate. This tool can help the organizations to make the best decision(s) in the shortest period. In comparison with the method based on experiencing the algorithm outcomes we can conclude that the optimization has happened in choosing the billboard medium. Using the billboards which are not accurate or are out the standard can affect the reputation of a brand. Visual annoyance due to not considering the legal rules and necessities of billboard installation place can be generalized to the commercial name and logo of the product that is advertised at that place. Because advertising presents an image of corporate environmental responsibility (Leonidou et al., 2010; Banerjee et al., 1995), imprecision

in advertising can lead to the loss of capital and opportunities.

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