Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 Spl Issue III 2014: 215-222

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

Full Length Article

Modeling framework for optimal evacuation in a historic preservation area

Assadollah karnema[1] ,Samira,Hasanzadeh[2] ,Mohadeseh Hamedi[3],Zahra Asghari[4]
[1] Faculty member of Shahid Bahonar University of Kerman
[2] Department of Crisis Management, Shakhes Pajoh Research Institute in Isfahan
[3] Department of Crisis Management, Shakhes Pajoh research Institute in Isfahan
[4] Department of Computer, Shahid Bahonar University of Kerman

ABSTRACT
This paper presents a optimization modeling framework to determine the optimal evacuation plan for a Historic areas are extremely vulnerable to disasters because many persons in need of aids live in the many old houses standing close together. It is also difficult to widen narrow streets to prevent disasters. Therefore, securing emergency evacuation routes is very important for people living in such areas. Considering these circumstances, this study aims to discover how to secure emergency evacuation routes for a historic area Since the Routing problem is among the problems with hard complexity genetic Algorithm due to is simplicity and high speed in analyzing the webs with high dimensions, is used in this study to determine the optimal route for reaching the safe places. The study Historic area is, located in kerman City. the results of the study show that the suggested method by considering the population density and the passage width finds the shortest path for reaching the safe places Hence it can be used effectively for emergency evacuation.
Keywords: Evacuation, Historic preservation area, Disaster prevention Genetic algorithms, Routing

Received 17.03.2014 Revised 15.05.2014 Accepted 22.06. 2014

INTRODUCTION

Hazards, such as tornadoes, earthquakes, toxic spills and terrorist attacks, can be broadly categorized as either natural or human induced ,and most natural hazards owe their origin to human beings [13]. When hazards intersect with the vulnerability of human society, they become devastating disasters, causing consider able destruction, claiming countless casualties, and lead into catastrophic consequences. Cities are areas where hazards are more likely to escalate into disasters due to the large and highly concentrated populations that are likely to be affected. The complex layout of urban transportation networks and multi-story buildings make it even more challenging for rescuers to reach victims, which leads to greater vulnerability of cities and the potential increase of casualties as the hazardous consequences would be exacerbated [18]. Evacuation is a necessary course of action to mitigate the losses from disasters. immediate response to disasters. As a crucial component of emergency response and management, evacuation serves to transfer people from risky areas to safer ones in an attempt to alleviate loss of life and property to a great extent [29]. On the other hand, evacuation can also be carried out before a disaster even occurs. Since disasters are unexpected events full of uncertainty ,effective evacuation as a precautionary course of action is one way in which such uncertainty may be addressed [10]. several researchers have examined methods of disaster prevention for historical areas. Kanazawa City is an example of an advanced city in which two-way evacuation routes have been investigated for enacting a relaxation ordinance relative to the Building Standards Act; consequently, a prevention plan was investigated to protect the city's traditional buildings(Okubo، 2010). In Senbonsyaka-do, Kyoto, the shortening of evacuation routes was studied to increase local safety (Toyoda،2009) In another Kyoto location, historic wooden back doors were found to be effective for evacuation [39] Using questionnaire survey data from Shin-Hua, Tainan County, Taiwan, researchers proposed a simple method of analyzing the road network factors and evacuation choices of residents in case of an earthquake [33].

The present authors investigated the situation of evacuation routes in a historic preservation area through intensive interviews with its residents(Miyamoto،2011؛Mishima،2013) and proposed steps for

planning and providing evacuation routes in that area (Mishima‹2012)The lead author studied a proposal for preventing fire from spreading in a historic preservation area as well [9]. Several researchers have studied numerous aspects of the vulnerability of urban habitation area to natural disaster. Urban earthquakes inflict serious damage to regions experiencing rapid rates of population growth and to developing countries undergoing urbanization (Torry‹1980). In designing evacuation methods for urban areas post-earthquake, it is useful to consider multiple scenarios of fire spread (Nishino‹2012)
As for evacuation from buildings ,numerous studies have considered evacuation behavior in panics [12].
Some researchers have focused on the evacuation time of the World Trade Center on September11,2001 [40]. Such studies have significant potential to inform us about preparedness ,response policies, and procedures for dis- asters in residential areas. Historic preservation areas,however ,are among the most vulnerable to disaster ,particularly in a country subject to earthquakes like Japan necessary solutions for disaster prevention for people in a historic preservation area, at the same time maintaining the width of the narrow paths .have proposed some other models and put them into practice, under different emergency conditions. It takes a considerable amount of computation to calculate the operating characteristics of individual vehicles. Little progress has been achieved from decades as a result of low computation power. Over the last decade, the rapid development of computer technology has greatly promoted the
research of emergency evacuation and obtained many research results. These can be generally classified into mathematical, analytical [41].
The main contribution of this paper is that it proposes an optimal traffic assignment model based on the shortest emergency evacuation time, by determining traffic assignment adaptively, according to the time varying conditions, so that the evacuation strategy can respond to a disaster rapidly and effectively. Evacuation route construction algorithm and network distribution algorithm are employed to deliver the traffic flow rapidly and safely from the evacuation areas to safe regions.

Evacuation planning

Evacuation is a complex process consisting of several consecutive phases. After the detection of an incident, decision makers evaluate the potential threat for specific areas and then issue an evacuation order for these areas if the risk is significant and there are no shelters to provide adequate in-place protection [31].
The type of disaster will dictate total or partial evacuation to distant or near-by relief location and if it is long term or temporary process [3]. Evacuation alert is communicated to the population, who makes a decision to evacuate or not depending on their perception of danger and then the population is transferred through a transportation network to designated safe areas [31]. Condition of the infrastructure will force which mode of transport to use but the evacuation also depends on the available fleet of vehicles, their capacity and on circumstances surrounding the evacuee [3]. Finally, evacuees arrive to areas outside of danger and a verification that they have made it safely must be carried out .The evacuation time may range from hours to weeks or even months (Church et al, 2002; [31], depending on the scale of the disaster. Han et al. [15] suggests that the major problem in evacuation operations is that evacuation-zone exit routes are often limited in number and insufficient in capacity to handle the traffic surge during a large-scale emergency evacuation. Stepanov et al [32] reinforces that capacity of transportation networks generally cannot satisfy the intense demand for transportation during an evacuation, and that even on small neighborhood-scale evacuations, transportation networks can impede the fast clearing of the population from an effected area .In order to manage such emergencies more effectively, decision makers may benefit from having in-place evacuation plans for scenarios which are most likely to happen, even though real-time design or re-evaluation of evacuation plans may be required after the disaster strikes [1]. Therefore, studies have focused on methods to improve the planning and operational aspects of the evacuation process to maximize the utility of the existing transportation network [15]. Apte [3] presents a summary of some of the research in evacuation. Stepanov et al [31] also reviewed a series of evacuation models and proposed that modeling techniques can be grouped by computation techniques into analytical and simulation techniques. From a review of the evacuation models, Stepanov et al [31] conclude that two approaches are evident: (i) the first approach defines a set of optimal routes and evaluates performance measures simultaneously; and (ii) a second approach uses an analytical optimization technique to offer a routing policy, and then this policy is evaluated with traffic simulation model. According to Stepanov and Smith [32], the first approach is prevalent in practice. In this context, this paper presents a heuristics algorithm that can be applied for defining independent routes for developing in-place evacuation plans. According to Stepanov et al [31] classification, the algorithm proposed applies analytical techniques to define a set of optimal routes and evaluate measures simultaneously. The characteristics of the method are presented on the following section.

Characteristics of the Method According to Graph theory [6], there is a limited number (k) of independent paths (called disjoint paths) between a pair of nodes in a network; however it is possible to exist several sets (of k elements) of these paths in the same network. In mathematics and computer science, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. In the most common sense of the term [4] a graph is an ordered pair G = (V, E) comprising a set V of vertices or nodes together with a set E of edges or lines, which are 2-element subsets of V (i.e., an edge is related with two vertices, and the relation is represented as an unordered pair of the vertices with respect to the particular edge). To avoid ambiguity, this type of graph may be described precisely as undirected and simple.

Other senses of graph stem from different conceptions of the edge set. In one more generalized notion, E is a set together with a relation of incidence that associates with each edge two vertices. In another generalized notion, E is a multi set of unordered pairs of (not necessarily distinct) vertices. Many authors call this type of object a multi graph or pseudo graph .All of these variants and others are described more fully below.

The vertices belonging to an edge are called the ends, endpoints, or end vertices of the edge. A vertex may exist in a graph and not belong to an edge.

V and E are usually taken to be finite, and many of the well-known results are not true (or are rather different) for infinite graphs because many of the arguments fail in the infinite case. The order of a graph is |V| (the number of vertices). A graph's size is |E|, the number of edges. The degree of a vertex is the number of edges that connect to it, where an edge that connects to the vertex at both ends (a loop) is counted twice. For an edge {u, v}, graph theorists usually use the somewhat shorter notation [2].

Genetic algorithms

In the computer science field of artificial intelligence, genetic algorithm (GA) is a search heuristic that mimics the process of natural selection. This heuristic (also sometimes called a meta heuristic) is routinely used to generate useful solutions to optimization and search problems (Mitchell,1996) Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

In a genetic algorithm, a population of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem is evolved toward better solutions. Each candidate solution has a set of properties (its chromosomes or genotype) which can be mutated and altered; traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible [37].

The evolution usually starts from a population of randomly generated individuals, and is an iterative process, with the population in each iteration called a generation. In each generation, the fitness of every individual in the population is evaluated; the fitness is usually the value of the objective function in the optimization problem being solved. The more fit individuals are stochastically selected from the current population, and each individual's genome is modified (recombined and possibly randomly mutated) to form a new generation. The new generation of candidate solutions is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population.

A typical genetic algorithm requires:

1. a genetic representation of the solution domain,
2. a fitness function to evaluate the solution domain.

Once the genetic representation and the fitness function are defined, a GA proceeds to initialize a population of solutions and then to improve it through repetitive application of the mutation, crossover, inversion and selection operators.

The algorithm steps can be summarized as:

1. Start with a randomly generated population of n l-bit strings (candidate solutions to a problem). (These "solutions" are not to be confused with "answers" to the problem, think of them as possible characteristics that the system would employ in order to reach the answer (1)
2. Calculate the fitness f(x) of each string in the population.
3. Repeat the following steps until n new strings have been created:

- Select a pair of parent strings from the current population, the probability of selection being an increasing function of fitness. Selection is done "with replacement" meaning that the same string can be selected more than once to become a parent.
- With the crossover probability, cross over the pair at a randomly chosen point to form two new strings. If no crossover takes place, form two new strings that are exact copies of their respective parents.

- Mutate the two new strings at each locus with the mutation probability, and place the resulting strings in the new population.

4. Replace the current population with the new population.
5. Go to step 2.

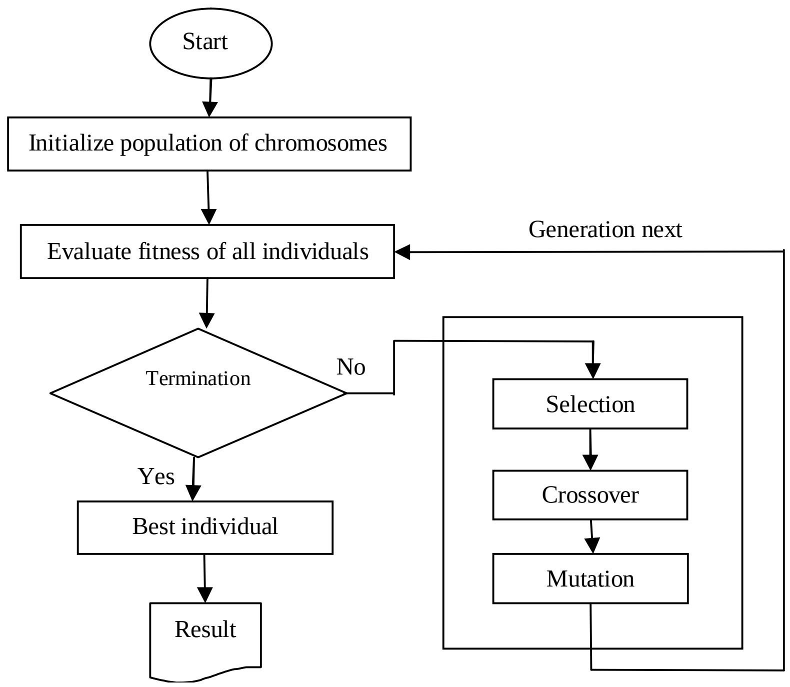

Fig. 1. The operation of a GA [16]

Modeling framework

The main purpose in this study is finding the optimal route among some places which include passages, damaged spot and safe place.it means the optimal route whose index is its shortness exists so that:
Route includes low population density with respect to the passage width present on the route
Route is unilateral which means it starts from source and ends in destination and there is no need to come back to the source
Routing process incudes Selecting the optimal route in Passage web .In large webs routing and Selecting the optimal route is complicated. In the web which we have selected for the problem it is possible to consider safe places damage spots and passage as Nods of a graph. Each damage block is S the start hend and the secure adjacent spots are as the final heads. using the genetic algorithm all the optimal routes for reaching safe places are found and in the next stage with respect to the routes density .the most suitable safe area is specified genetic Algorithm for finding the optimal route includes some important part a as the following :primary population :it is actually a series of a primary responses which are selected randomly. each primary responses is called a chromosome.
Chromosome**:** each Chromosome consist of some genes and each gene is actually an under route or a passage .since we use genetic binary for solving our problem the amount of the genes are zero and one.
The amount zero means one passage has not been selected on the route and the amount one in the chromosome means one passage or under route has been chosen .chromosome is a thread which
in fact creates a path between source and destination .The created path between source and destination should be integrated , otherwise this path is lost
The number of the gens which are selected for the chromosome is one less than the whole nodes in the graph
Selection: During each successive generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are selected through a fitness-based process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected. Certain selection methods rate the fitness of each solution and preferentially select the best solutions
In this work Individual solutions are selected using Roulette Wheel method through a fitness-based process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected.

Crossover and mutation: For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of One-point crossover and Generational replacement (mutation), a new solution is created which typically shares many of the characteristics of its "parents". New parents are selected for each new child, and the process continues until a new population of solutions of appropriate size is generated [12].

Cost function : it is actually an index based on which optimization is done and shows the improvement of the chromosome .The main part in reaching the proper answer in genetic Algorithm is the accurate definition of cost function .the used cost function in this study has been shown in formula 1.

In addition to considering the shortest path for reaching the safe place we also consider the population density and the passage width because only finding the shortest path is not always the best choice Hence in the passages with different widths the population density may be in a way that it is not possible to pass them in a short time Two aims are investigated in this study First some of the shortest paths are found using formula 1 and then with respect to the obtained paths population density and passage width are also considered. 44)and the way which satisfy both of the goals will be chosen

1) $\min\left(\sum_{j=1}^{S}\sqrt{\sum_{i=1}^{n}(p_i - q_i)^2}\right)$

In which $P=(P_1,\dots,P_n)$ and $q=(q_1,\dots,q_n)$ are 2 points in n dimentional Euclidean space .j is the counter of the passages and s is the total a mount of the places . after finding the best routes by genetic Algorithm , some of the optimal routes including the first best route , the second best route,... are chosen by users selection .now the following aim function is considered for selecting the final optimal route

2) $\min\left(\sum_{i=1}^{n} L_i + \sum_{j=1}^{n} W_j T_j\right)$

in which n is the amount of the passages which has been obtained in an optimal route L_i the length of the passage with i tag .T_j and w_j show population density in the passage with j tag and passage with j tag respectively . of course the user can put a weight for each of the optimal route factor s (shorter) and density in using this formula for selecting the best route and with respect to their importance change the optimal function as the following.

3) $\min\left(k1\sum_{i=1}^{n} L_i + k2\sum_{j=1}^{n} W_j T_j\right)$

In which k 1 and k2 show the degree of importance and their total is one it means we have.

4) $\sum(k_1 + k_2) = 1$

Since the considers parameters in the problems are not of the same kind. for combining them in the formulas first they should be normalized and a same unit should be specified for their weighing combination. so all the parameters are divided to their own normalized amount and then are combined.

DISCUSSION

In order to investigation the efficiency of the suggested method first a hypothetical web with is nodes has been considered in which the source and the Destination points are specified for finding the optimal route all the nodes are searched and 3 routes (in a real web after finding the best routes .the route which is more suitable regarding the population density is selected as the optimal route figure 2 shows the hypothetical web with the best route which has been specified with green blue and red colors respectively.

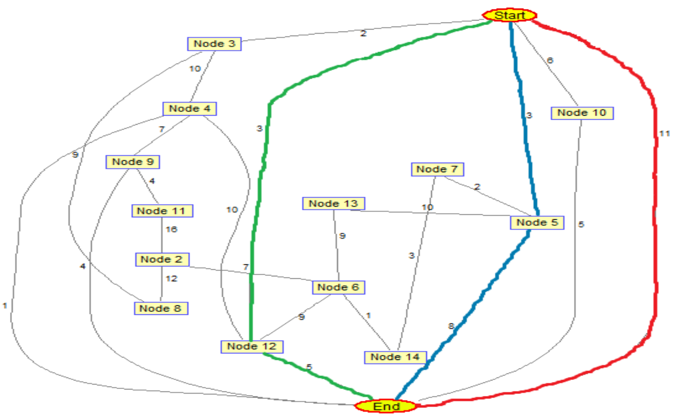

Fig 2.hypothetical web with the best route

for implementation of the suggested method in real web .kerman is area 3has been considered for preparing the data first information large related to the urban passages and blocks and also suitable spaces for emergency evacuation population information of urban blocks and urban passage with have been gathered from.

Kerman s GIS data base . Then for using them local information of the blocks and crossing of the streets and also local information of safe places center are considered the considered are a includes building nodes , safe place node and urban passage or nodes of the graph.

Fig 3. Kerman area 3

In Routing test in real web a damaged spot has been specified as the start and a secure adjacent spot as the end.

Then using genetic Algorithm , 3 best rotes have been determined in which the route which is clear by color red is the best route between the damaged spot and safe place and considering the passage width and population density is low.

Fig 4. Optimal Routing in real web

CONCLUSIONS

Recurring emergency evacuation routes is very important for people living in a Historic areas. Historic areas are extremely vulnerable to disasters because many persons in need of aids live in the many old houses standing close together. It is also difficult to widen narrow streets to prevent disasters .As a crucial component of emergency response and management, evacuation serves to transfer people from risky areas to safer ones in an attempt to alleviate loss of life and property to a great extent. this study used genetic Algorithm to determine the optimal evacuation plan for Historic areas in Kerman City due to is simplicity and high speed in analyzing the webs with high dimentions . the results of the study show that the suggested method by considering the population density and the passage width finds the shortest path for reaching the safe places Hence it can be used effectively for emergency evacuation.

REFERENCES

1. Alexander, D(2002). Principles of Emergency Planning and Management. Oxford University Press.

2. Andrasfai, B. , Introductory Graph Theory. The Institute of Physics (1978)
3. Apte, A. (2009.) Humanitarian Logistics: a new field of research and action. Foundations and Trends in Technology, Information and Operations Management, 3 (1), 1-100
4. Biggs, N.; Lloyd, E.; Wilson, R. (1986), Graph Theory, 1736–1936, Oxford University Press.
5. Boa Ventura Netto, P. (1996). Grafos: theory, models, algorithms. São Paulo: Publishing Edgar Blucher.
6. Bollobs, B. (1978). Extremal Graph Theory. New York: Academic Press
7. Bollobs, B. (1978). Extremal Graph Theory. New York: Academic Press. Campos, V.B.G. (1997). Method for flow allocation in transport planning in emergency situations: definition of disjoint routes, Doctoral Thesis, Eng. of Produç COPPE/UFRJ
8. Chandes, J. & Paché, G. (2009).Investigating humanitarian logistics issues: from operations management to strategic action. Journal of Manufacturing Technology Management, 21(3), 320-340.
9. Cova, T. J., & Johnson, J. P. (2002). Micro simulation of neighborhood evacuation in the urban wildl and interface. Environment and Planning A, 34(12), 2211–2229.
10. Cutter, S. L. (2003). The vulnerability of science and the science of vulnerability. Annals of American Geographers, 93(1), 1–12.
11. Dahlke AE(1965),HillAH .Collective behavior in a simulated panic situation. JExpSocPsychol;1:20–54.
12. David E. Golldberg, (1989). "Genetic Algorithms in Search, Optimization and Machine Learning", Addison-Wesly Pub.
13. Ebert, C. (2000). Disasters: An analysis of natural and human-induced hazards (4th ed.). Iowa: Kendall/Hunt Publishing Company
14. Gershon RRM, Magda LA,Riley HEM, Sherman MF(2012).The World Trade Center evacuation study: factors associated within itiation and length oftimeforevacuation.FireMater;36:481–500
15. Han, L., Yuan, F., Chin, S. & Hwang, H(2006). Global Optimization of Emergency Evacuation Assignments. Interfaces, 36(6), 502-513
16. Homayouni ,S, Hong Tang,S, Motlagh,O(2014).A genetic algorithm for optimization of integrated scheduling of cranes, vehicles, and storage platforms at automated container terminalsJournal of Computational and Applied Mathematics 270 (2014) 545–556 Contents lists available at ScienceDirect
17. Huda K, Yamamoto N, Maki N,Funo S(2007).Rehabilitation of urban settlements in the early reconstruction stage after at sunami: a case study of Band a Aceh Municipality in Indonesia. J Asian Archit Build Eng;6:103–10
18. Kwan, M.-P., & Lee, J. (2005). Emergency response after 9/11: The potential of real time 3D GIS for quick emergency response in micro-spatial environments. Computers, Environment and Urban Systems, 29, 93–113.
19. Kwan, M.-P., & Rans berger, D. M. (2010). LiD AR assisted emergency response: Detection of transport network obstructions caused by major disasters. Computers, Environment and Urban Systems, 34(3), 179–188.
20. Ling FS, Shiozaki Y,HoritaY(2006).Evaluation of the reconstruction plans for tsunamivictimsinMalaysia .J Asian ArchitBuildEng;5: 293–300.
21. Liu Y, Lai X R, Chang G L(2006). Two-level integrated optimization system for planning of emergency evacuation. Journal of Transportation Engineering, 132(10): 800–807
22. Mishima ,N ,Miyamoto N, TaguchiY(2013).Evacuation route planning for a historic preservation are a in large disasters .JH a bitat Eng Des, 121–8 (SelectedpaperofISHEDConference2012,Shanghai).
23. Mishima N, Miyamoto N, TaguchiY (2012).Evacuation route planning for a historic preservationareainlargedisasters.JHabitatEngDes2013: 121–8 (Selected paper of ISHED Conference ,Shanghai).
24. Mitchell, Melanie (1996). An Introduction to Genetic Algorithms. Cambridge, MA: MIT Press. ISBN 9780585030944.
25. Miyamoto N, Mishima N, TaguchiY(2011).Research on securing evacuation route sin preservation of a historic town :based on resident interviewsinHizen-Hama-Syuku.RepSciEng;40:7–11.
26. Miyamoto N, Mishima N, TaguchiY(2011).Research on securing evacuation route sin preservation of a historic town :based on resident interviewsinHizen-Hama-Syuku.RepSciEng;40:7–11.
27. Nishino T, Tanaka T(2012),Hokugo A. A nevaluation method for the urban post-earthquake fire risk considering multiples cenarios of fire spread andevacuation.FireSafJ;54:167–80
28. Okubo T, Ikemoto T, Miyajima M, Gotou M,MurataA,SuzukiY(2010).A survey on disaster prevention planning of historical town preservation district Teramachi of Kanazawa city. Disaster Mitig Cult Herit Hist Cities;4:311–6.
29. Perry, R. W., & Lindell, M. K. (2003). Preparedness for emergency response: Guidelines for the emergency planning process. Disasters, 27(4), 336–350.
30. Sime JD(1983).Affiliative behavior during escape to building exits .J EnvironPsychol;3:21–41.
31. Stepanov, A. & Smith, J. (2009). Multi-objective evacuation routing in transportation networks. European Journal of Operational Research, 1498, 435-446.
32. Stepanov, A. & Smith, J. (2009). Multi-objective evacuation routing in transportation networks. *European Journal of Operational Research*,1498, 435-446.
33. Tai C-A, LeeY-L,LinC Y (2010). Urban disaster preventions helter location and evacuation behavior analysis. J Asian ArchitBuildEng;9: 215–20
34. Torry WI(1980).Urban earthquake hazard in developing countries: squat- ter settlementsandtheoutlookforTurkey.UrbanEcol;4: 317–27
35. Toyoda Y, Otsuki S,KanegaeH(2009).A study on local safety increased by shortening of evacuation routes in case of Senbon-syaka-domade use of as an emergency evacuation site. Disaster Mitig Cult Herit Hist Cities;3:259–66.
36. Tuydes H, Ziliasko poulos A(2006). Tabu-based heuristic approach for optimization of network evacuation contra flow. Transportation Research Record 1964, , 157–168

37. Whitley, Darrell (1994). "A genetic algorithm tutorial". Statistics and Computing 4 (2): 65–85.
38. Xiaoping Z(2009),Tingkuan Z, Mengting L. Modeling crowd evacuation of a building basedonsevenmethodologicalapproaches.BuildEnviron;44:437–45.
39. Yamasaki M, KurataY, Otsuki H(2011).A study a bout the existence of emergency evacuation doors in the back yards of traditional town- houses in Kyoto.DisasterMitigCultHeritHistCities;5:69–72.
40. YoshidaY(1996).A study of evacuation behavior in the World Trade Center explosion.FireTechnol;32:174–89.
41. YoshidaY.(1996)A study of evacuation behavior in the World Trade Center explosion.FireTechnol;32:174–89.
42. Zang H, Peng G X(2003). A Study of link travel time function during incident on urban expressway. Journal of Transportation Systems Engineering and Information Technology, 3(2):57–59