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Selecting Archaeological Sites using GIS and Fuzzy System

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Abstract

This aim of this research is to built a system that can entered to GIS environment and update attribute table and adding new fields gives a special important for the archaeological sites depending on that fields it can allocate the most important site automatically depending on a set of criteria by applying a Fuzzy logic system for each criteria.

Key words: GIS, archaeological sites, fuzzy logic system, GIS.

المستخلص :

الهدف من هذا البحث هو عمل نظام يدخل الي بيئة (GIS) ويقوم بتحديث جدول الخصائص (attribute table) بإضافة حقول جديدة تعطي أهمية خاصة للموقع الأثري(archaeological sites) وبالاعتماد علي هذه الحقول يمكن تحديد المواقع الأكثر أهمية من بصورة اوتوماتيكية وهذه العملية تتم بالاعتماد علي مجموعة من المعايير الخاصة بهذه المواقع وباستخدام المنطق المضبب (FUZZy logic)

1. **Introduction**

It is widely recognized that a knowledge and understanding of origins and development of human societies is of fundamental importance to humanity in identifying its cultural and social roots. The archaeological heritage constitutes the basic record of past human activities. Its protection and proper management is therefore essential to enable archaeologists and other scholars to study and interpret it on behalf of and for the benefit of present and future generations.

The protection of this heritage cannot be based upon the application of archaeological techniques alone. It requires a wider basis of professional and scientific knowledge and skills. Some elements of the archaeological heritage are components of the architectural structures and in such cases must be protected in accordance with the criteria for the protection of such archaeological sites. Hence, finding a procedure to locate the most important archaeological sites is appealing.

In this paper we have tried to analyze parameters which are important in locating suitable archaeological sites. These parameters may include high and area of archaeology, distance from Main Street and architecture of the archaeological sites. The most important parameters will be selected and then using a GIS-based fuzzy logic approach, the usage of a fuzzy procedure is due to the fact of locating the most important archaeological sites. With the aid of a fuzzy system it is possible to achieve an

optimum solution considering different uncertainties exist in selection for archaeological sites.

In this paper the influencing parameters and statistical data have been gathered for archaeological sites selection in Babylon. For the archaeological site selection, determination of degree of importunity is studied. Among a number of influencing parameters four of them have been selected and formulated in a fuzzy inference system. They are "area of archaeological sites ", "high of archaeological sites", "distance from archaeological site to Main Street "and" architecture of archaeological sites ". Raster and vector data are used in our study.

2 . Tools and Techniques

2.1. Fuzzy logic

Fuzzy logic has been used in a wide range of problem domains. A fuzzy set is a set whose elements have degrees of membership. An element of fuzzy set can be full member or a partial membership value assigned to an element is no longer restricted to just two values, but can be 0, 1 or any value in between. Mathematical function which defines the degree of an element’s membership in a fuzzy set is called membership function. The major advantage of this theory is the ability to describe the problem naturally in linguistic terms rather than in terms of relationships between precise numerical values. Fuzzy systems, on the other hand, have the capability to represent classification decisions explicitly in the form of fuzzy 'if-then'

rules. Fuzzy sets allow the assignment of partial and multiple valued memberships.

Fuzzy systems make use of vague, imprecise or uncertain information to generate simpler more suitable models that are easier to handle and more familiar to human thinking. Human expert is the main source of fuzzy rules, thus it is possible to improve the performance of the system by adding new rules, removing defective rules or update existing rules in the knowledge base. However, the construction of a knowledge base, especially the fine- tuning of the fuzzy set parameters of the fuzzy rules in a fuzzy expert system, is a tedious and subjective process[7][6].

2.2 Fuzzy Set

A fuzzy set, then, is a set containing elements that have varying degrees of membership in the set. Elements of a fuzzy set are mapped to a universe of membership values using a function-theoretic form.

A fuzzy set A in a universe of discourse X is defined as the following set pairs A{(μa(x)-.x €X} (1)

Where, μ a (x) x : (0.1) is a mapping called the membership function of fuzzy set A and μ A (X) is called the degree of belongingness or membership value or degree of membership of x €X in the fuzzy set A. we write (1) in the following form:

A{ μA{x)Ix: x X} (2)

For brevity, however, we often equate fuzzy sets with their membership functions i.e. instead of a fuzzy set A characterized by μ A (x) we will often say fuzzy sets μ A (7)(8).

2.3. Membership Function

In this paper we have used the trapezoid membership function for converting the crisp set into fuzzy set. A trapezoid membership function is specified by four parameters (a, b, c, d) as follows is shown in Figure 1[1]:

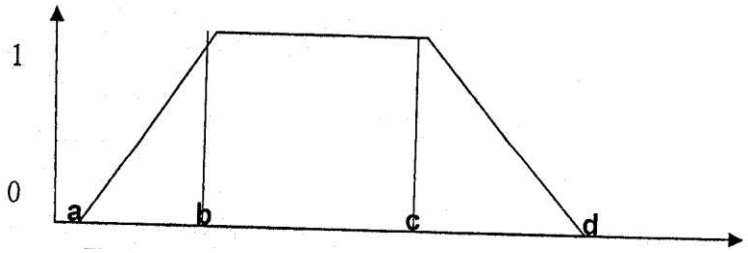


Figure 1: trapezoid membership function

3. Methodology

The methodology of this project is illustrated in figure 2. System for selection of archaeological site.

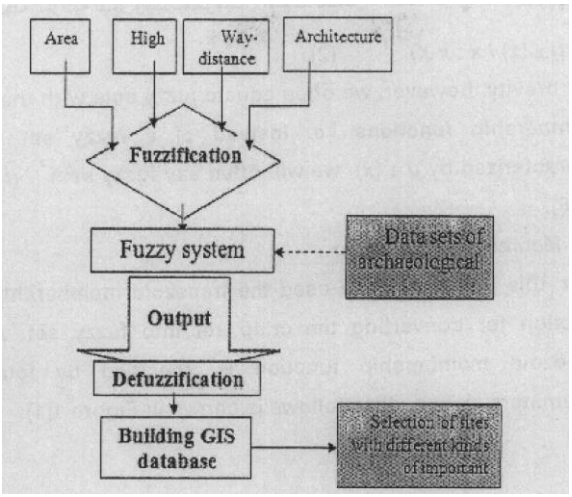


Figure 2 - workflow of the proposed GIS- based furzy

3. 1. Fuzzy system for locating the most important archaeological site

A programming language VB. NET has been developed to inter GIS environment and convert the parameters value to fuzzy values by using the trapezoidal membership function. The different stage of the system are elaborated in this section.

3. 2. Defining the input and output parameters

The four parameters were selected considering the experimental investigations. In the next stage, the linguistic parameter and their fuzzy range have been defined with table (1):

Table 1 - selected input parameters to be used In the fuzzy system

Title of input parameter	Input parameters
area	Area of archaeological sites
high	High of archaeological sites
Way-dist	Distance from archaeological site to main street
architecture	Architectural of archaeological sites

In the next stage, for each of the parameters a specific membership function has been defined. A trapezoidal function has been used for all variables.

One feature of this function is a specific range in its middle the maximum weight is equal to 1.

Table (2) indicates the chosen amounts for area variable. The other variables have been indicated in Tables 3 and

4. In Tables 2 to 4, parameters A, B, C and D are trapezoidal parameters functions for each linguistic variable. The data used is illustrated in figures 3.

Table 2 - linguistic variables and their values for area of archaeological site

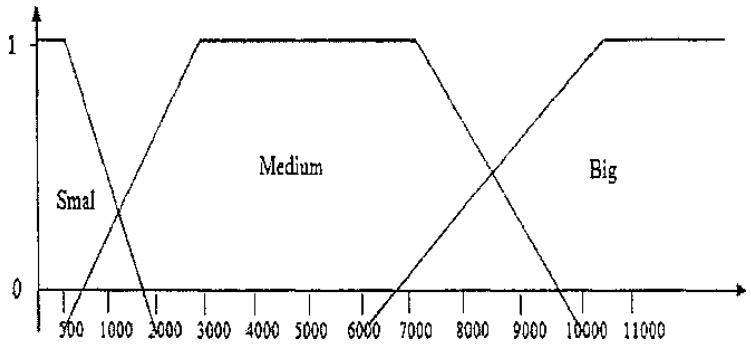
Area					
Values(m^2)	**Linguistic variable**	**A**	**B**	**C**	**D**
0 - 2000	Small	o	0	500	2000
500-10000	Medium	500	2500	7000	10000
6000 - 50000	Big	6000	10500	20000	50000

Table 3- linguistic variables and their values for high of archaeological site

High					
Values(Meter)	**Linguistic variable**	**A**	**B**	**C**	**D**
0-4	Low	0	0	2	4
2-10	Medium	2	5	7	10
7-30	High	7	11	20	30

Table 4 - linguistic variables and their values for distances from main streets

Way-distant					
Values(Meter)	**Linguistic variable**	**A**	**B**	**C**	**D**
0-3000	Good	0	0	500	3000
750-10000	Not good	750	2000	8000	10000



Figures 3 - illustrated the data used

The output is also divided into four classes for goodness of the selected sites. Because there exists four input parameters which two of them attain three membership functions and the others have two membership functions, so we could define (3 x 3 x 2 x 2 = 36) laws as the number of combinations.

The procedure for defining the laws is such that for each input parameters, one of the functions has been selected and the "AND" operator applied with another membership function of another parameter and ultimately one of the possible output parameters to this new assumption has been assigned. Table (6) introduce the laws used by fuzzy system. The defined laws and their corresponding membership functions have been employed in a VB. NET program. The four sets of the classes are illustrated in table (5):

Table (5) the four sets of the classes

Class number	Description
1	Most Suitable
2	Suitable
3	Weakly Suitable
4	Unsuitable

Table (6) rules applied for the archaeological sites selection

No	area			High			Way_dis		arch		class
	small	medium	big	low	medium	high	Not good	good	visible	Not visible	
1	*			*			*		*		3
2		*		*			*		*		3
3			*	*			*		*		3
4	*				*		*		*		2
5		*			*		*		*		3
6			*		*		*		*		3
7	*					*	*		*		2
8		*				*	*		*		3
9			*			*	*		*		3
10	*			*				*	*		2
11		*		*				*	*		2
12			*	*				*	*		3
13	*				*			*	*		1
14		*			*			*	*		2
15			*		*			*	*		3
16	*					*		*	*		1
17		*				*		*	*		1
18			*			*		*	*		2
19	*			*			*			*	3
20		*		*			*			*	4
21			*	*			*			*	4
22	*				*		*			*	3
23		*			*		*			*	4
24			*		*		*			*	4
25	*					*	*			*	3
26		*				*	*			*	3
27			*			*	*			*	3
28	*			*				*		*	3
29		*		*				*		*	3
30			*	*				*		*	3
31	*				*			*		*	3
32		*			*			*		*	3
33			*		*			*		*	3
34	*					*		*		*	2
35		*				*		*		*	3
36			*			*		*		*	3

3- Proposed work

Finally after developing the related fuzzy system, we want to exploit the system achieve a result regarding the suitable archaeological sites. The study area is Babylon archaeological site at Babylon province. First the map has been exported to Arc

Map and add a polygon shape file which its attribute table contain the values of the four parameters. These values should be entered in programming language VB. NET environments based on the defined laws.

At this stage the result of fuzzy process has been used to find the best archaeological site. Bo one field have been added for representing the output value. The output field has values between 1 to 4 . if the output value is 1 , it is concluded that our polygon is most important, the figure below shows the GIS environments and shows the raster and vector layers have been used and shows the selection of the most important site by changing color of selected polygons .

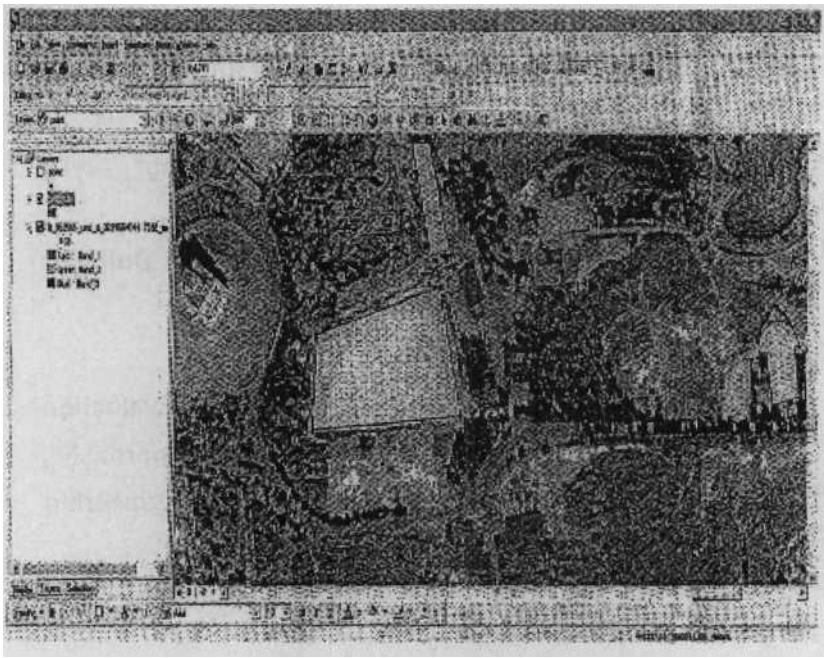


Figure (4) GIS environments with two layers

4- Conclusions

In this project to achieve more precise results, all the influencing parameters should be used, not only the four parameters were considered for archaeological site. The fuzzy system will be used when we have uncertainty in our parameters and its value, however, using other parameters and their associated ranges may give different answers. In this project we select the trapezoidal functions because they provided better results with respect to other functions.

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