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An Exploratory Analysis of the Evaluation System in Landscape Design Based on Fuzzy Inference

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Abstract. This paper has described cases of landscape design in the real life and discussed the evaluation principles in landscape design. Meanwhile, it has analyzed models of the physical landscape design by adopting fuzzy inference evaluation system and explored its scientific based on the traditional four principles.

Keywords: Fuzzy Inference, Landscape Design, Evaluation System

1. Introduction

Landscape was originally a concept in aesthetics, which means natural scenery, ground forms and scenery views; it also refers to the combination of natural and human phenomena which can be seen with the human vision. Since the 15th century, landscape, once only referred to the scenery on surface which can be seen from the perspective, had gradually evolved into a concept with aesthetical, geographical, ecological meanings and even meanings in other different disciplines.

With the growing diversity of modern social life and a high degree of informatization, different types of architectural environment and the constant changes in the spatial form, characteristics and functional requirements of landscape have given the landscape design a wide range of applications, from the earth's ecological planning, watershed planning to the regional landscape planning ; from the national ecological protection to the national park building; from urban green space system planning to the city square and pedestrian planning; from the city park construction to the construction of private gardens; from the local environment construction to the city street sketches and sculptures design and so on and so forth., all of these have been brought into the system of landscape design. Thus the multiple values judgment of landscape is the basis of landscape planning and management.

2. Several Principles Which Should Be Followed When Evaluating the Landscape Design

2.1. The Principle Of Functional Applicability

In general, landscape designers first consider the problem of applicability, the so-called applicability refers to the "adjusting measures to local conditions" and what is fit to the functions of landscape, which includes the eternality and permanence. Even emperors in the Qing Dynasty who believed that "Kings have long arms" had taken local conditions into full account when constructing landscapes. For example, the original Wengshan and Wenghu in Summer Palace had had the framework with great mountains and rivers, and after the terrain management, it had been built into natural landscape which has the Longevity Hill and Kunming Lake as its framework and the Tower of Buddhist Incense as its central scenery. In addition, the Dan Ling Pan ground form of the Old Summer Palace, where natural fountains and rivers spread all over, had been built into a collective landscape with the center of Fuhai. It is just because adjusting measures to local conditions that the unique masterpiece of landscape has been created.

2.2. The Ecological Principle

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The ecological principle is an important criterion in landscape design evaluation. Bringing the idea of eco-design into the landscape design reflects the new dream of mankind. Ecological design means respecting the diversity of species and reducing the deprivation of resources, maintaining the water cycle, and protecting the living environment for animals and plants when designing landscapes, which are all conducive to the ecosystem so as to optimize and improve the living environment of residents. If the landscape design is understood as the analysis of any human use of outdoor spaces and the process of solving problems, planning and accomplishing plans, then landscape design, in essence, is the eco-design for grounds and outdoor spaces. The ecological principle is the core of landscape design, is the design of human ecological system, which maximizes the use of natural forces to create a sustainable landscape art based on the organic self-renewal and regeneration design of natural system.

2.3. The Cultural Principle

Landscape, which is the reflection of the worldview, values, ethical and moral principles of a person and the projection of human's love and hate, desire and dreams in the nature, expresses a certain spiritual meanings with the aid of landscape shape, texture, materials and space, that is, it can go beyond the physical function and run through the history, it is a spiritual product with aesthetic values representing the culture of the times. The cultural value is the vitality and the soul of the landscape and it is a vitally important and indispensible aspect in the landscape design evaluation. However, culture is a multi-faceted, multi-element and content-rich social science with national characters, territoriality, historic significance and epochal characters, and different social and cultural structures lead to different requirements for landscape, while different cultures enjoy different appreciation levels, which indicate that only when culture is respected and paid close attention, can the landscape design be recognized.

2.4. The aesthetic principle

The beauty of landscape, stemming from the nature but exceeding it, is a typical summary of the nature's creation and a reproduction of the beauty of the nature, and it develops with the development of culture, art of painting and religious activities, therefore, it is the high degree of unity of natural landscape and cultural landscape. Making landscape design beautiful, that is meeting the requirements of the landscape layout and the art of landscaping, and creating the proper aestheticism. The aesthetic quality of landscape is the functional representation when the landscape system and human aesthetic consciousness system relating to and interacting with each other, therefore, the aesthetic quality of landscape not only lie in the objectivity of landscape, but also in the subjective aesthetic taste. There often exists natural, artistic and ecological beauty in the landscape design.

3. The Choice of Applying the Fuzzy Inference and the Probe into Its Advancement

On account of the cases of landscape design in the real life and based on the evaluation of these four principles mentioned above, the traditional methods usually provide a reasonable emotional evaluation for

$$\mu_{A1}=\mu_{B1}=\mu_{C1}=\mu_{D1}=\begin{cases}\mu_{bad}(x)=e^{\frac{-x^2}{5.78}}.....x\in(0,5)\\ \mu_{normal}(x)=e^{\frac{-(x-5)^2}{5.78}}.....x\in(0,10)\\ \mu_{good}(x)=e^{\frac{-(x-10)^2}{5.78}}.....x\in(5,10)\end{cases}$$

Eexperts according to design experience, investigating impression and subjective aesthetic taste, the competitive trend in the large-scale production presses for higher maneuverability, efficiency, accuracy and the very important predictability in product design. The traditional experts' evaluation has failed to meet its requirements.

So the famous German physiologist Weber Ernst Heinrich and physicist Fechner GustavTheodor pointed out that: the intensity of the sense is in proportion to the logarithm of the intensity of the stimulus, the former one increases based on arithmetic progression, while the latter one increases based on the geometric progression.

Namely:

$S = K\lg R$

There, S stands for feeling, R for the intensity of the stimulus, K is a constant.

Weber formula solves the problem of changing the stimulus of external landscape into people's response very

well and establishes a more precise quantitative relationship. Unfortunately, it is just an overall and macro evaluation, and the actual evaluating principles are often multi-faceted, as four types of evaluation mentioned above. It can not distinguish which part of S generates from which part of the stimulus R, and the internal relationship in all parts of R can not be well expressed in S. In addition, the formula itself has a higher requirement in the identification of the parameter K and the precision of the experimental data.

In 1965, Professor L.A.Zadehh in the University of California established Fuzzy Set Theory. Till now, the Fuzzy System Theory, not depending on precise mathematical models, has been applied rapidly in all fields where the controlled objects are hard to obtain. To our surprise, it had successfully solved the problem quantification for many traditional qualitative problems. The maturity of this theory has provided a scientific, but bold and innovative form for us to establish landscape evaluation system.

3.1. Establishing the model

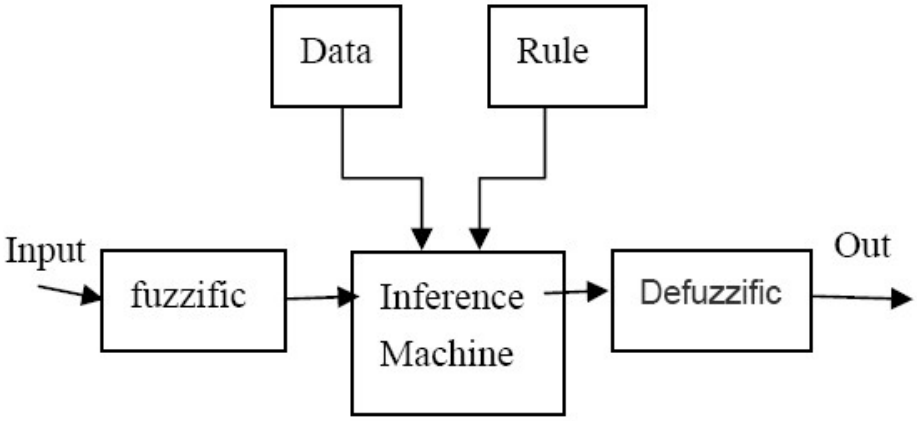


Diagram 3.1 the Structure Diagram of Fuzzy Evaluation System

3.2. Model Assumptions

1.)Landscape evaluation system only evaluates the following four aspects: the function applicable, landscape ecology, cultural value and aesthetic value.

2). This model can give a better evaluation for the corresponding item through the financial investment of principles, and brings in he relative investment force k $k \in (0,1)$ as the input of the evaluation system according to the unified quantification of the local investment.

3). Fuzzy rules can give a better reflection of the views of local residents' evaluation, and ignores the interim policies, natural disasters and other mutant factors.

4.) The system output, that is, a 10-point rating system.

3.3. The Definition of Database Definition

The fuzzy sets of system input:

Function Applicable Investment A: (bad), (normal), (good)

Landscape Ecology Investment B: (bad), (normal), (good)

Cultural Value Investment C: (bad), (normal), (good)

Aesthetic Value Investment D: (bad), (normal), (good)

Subordinate functions:

It is better to choose the following normal distribution subordinate function to fuzzily according to mechanism analysis and simulation testing.

The fuzzy sets of system output:

$$\mu_A=\mu_B=\mu_C=\mu_D=\begin{cases}\mu_{bad}(x)=e^{\frac{-x^2}{0.0578}} & .....x\in(0,0.5)\\ \mu_{normal}(x)=e^{\frac{-(x-0.5)^2}{0.0578}} & .....x\in(0,1)\\ \mu_{good}(x)=e^{\frac{-(x-1)^2}{0.0578}} & .....x\in(0.5,1)\end{cases}$$

Function Applicable Investment A1: (bad), (normal), (good)

Landscape Ecology Investment B1: (bad), (normal), (good) Cultural Value Investment C1: (bad), (normal), (good) .Aesthetic Value Investment D1: (bad), (normal), (good)Subordinate functions:It is better to choose

the following normal distribution subordinate function to fuzzify according to mechanism analysis and simulation testing.

3.4. The Definition of Fuzzy Rules

If the score of Function Applicable Investment A is high, then the score of A1 will be also high, and the scores of the rest three ones will never be the lowest.

If the score of Landscape Ecology Investment B is high, then the score of B1 will be also high, and the scores of the rest three ones will never be the lowest.

If the score of Cultural Value Investment C is high, then the score of C1 will be also high, and the scores of the rest three ones will never be the lowest.

If the score of Aesthetic Value Investment D is high, then the score of D1 will be also high, and the scores of the rest three ones will never be the lowest.

If the score of Function Applicable Investment A is low, then the score of A1 will be also low, and the scores of the rest three ones will never be the highest.

If the score of Landscape Ecology Investment B is low, then the score of B1 will be also low, and the scores of the rest three ones will never be the highest.

If the score of Cultural Value Investment C is low, then the score of C1 will be also low, and the scores of the rest three ones will never be the highest.

If the score of Aesthetic Value Investment D is low, then the score of D1 will be also low, and the scores of the rest three ones will never be the highest.

If the score of Function Applicable Investment A is medium, then the score of A1 will be also medium.

If the score of Landscape Ecology Investment B is medium, then the score of B1 will be also medium.

If the score of Cultural Value Investment C is medium, then the score of C1 will be also medium.

If the score of Aesthetic Value Investment D is medium, then the score of D1 will be also medium.

Suppose the weight coefficient of rules above is 1.

3.5. Inference Algorithm

This model adopts Mamdani algorithm which is widely used in fuzzy system, then conducts generalized modus ponens (GMP)

Premise: If x is P, then y is Q (fact)

Minor premise: x is A ', (knowledge)

Conclusion: y is Q '

Namely:

the similarity between P 'and P $q = \left\{ \bigvee_{x \in X} \left[P'(x) \wedge P(x) \right] \right\}$

$Q' = q \wedge Q(y)$

3.6. Defuzzification

by using the gravity method of defuzzification in this model, the output value is obtained.

$$V_o = \frac{\int_V u\mu_v(u)du}{\int_V \mu_v(u)du}$$

There: V stands for the overall scoring domain, V∈（0，10），$\mu_v(u)$ is the subordinate function value in the corresponding domain. V_o stands for the precise output after defuzzification, that is the score.

4. The Stimulation of MATLAB Model (Attaching the Program)

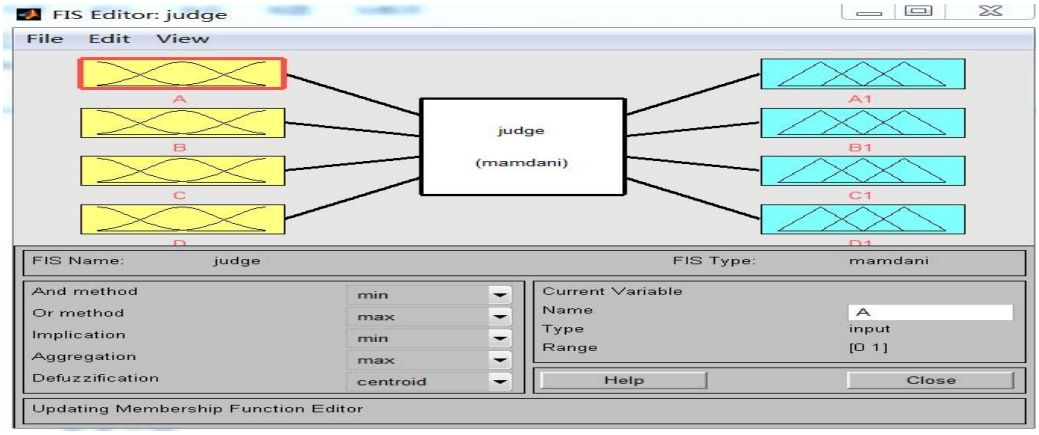
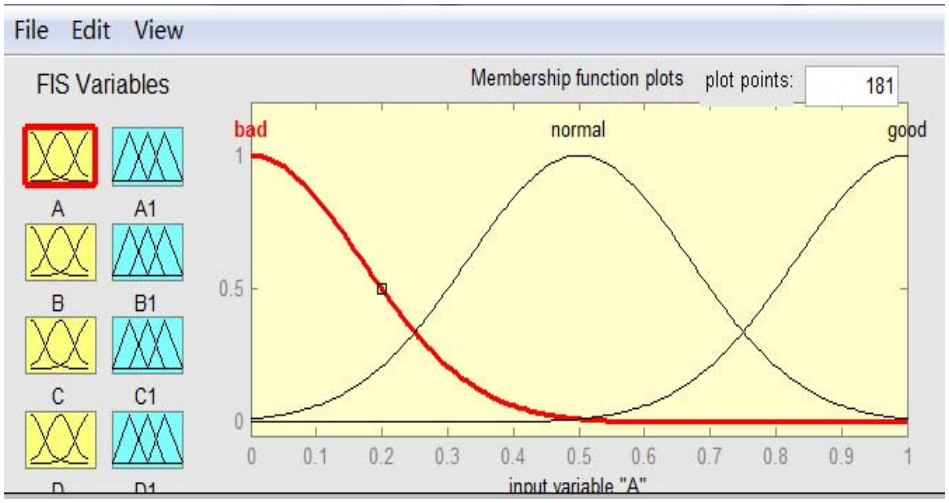


Diagram 3.1 General View of the System Structure of Fuzzy Evaluation



3.2 the Subordinate Function Diagram of Input and Output

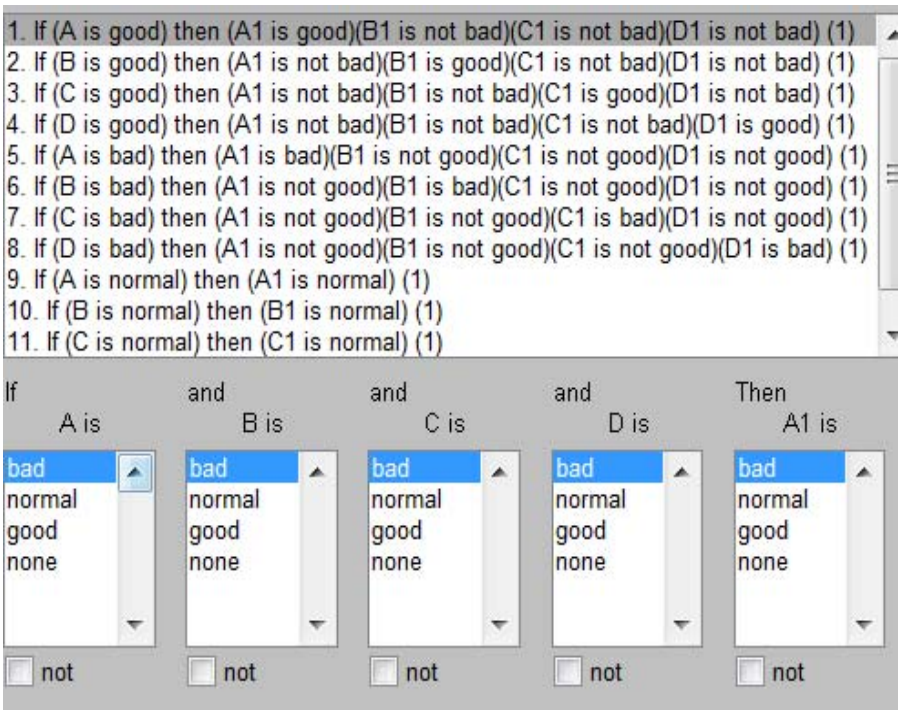


Diagram 3.3 the Diagram of Fuzzy Rules

4.1. Input

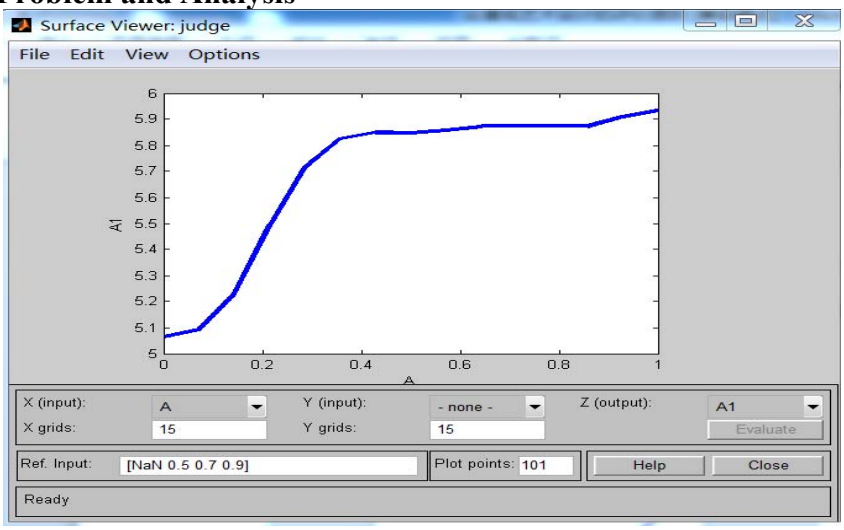
According to Nanchang Price Bereau and the same related industries, the function applicable investment of this landscape is 4,000,000 yuan, which is supposed to be the small-medium investment, fixed investment $X_A = 0.4$

Landscape ecology investment is 5,100,000 yuan, which is supposed to be the medium investment, fixed investment $X_B = 0.5$

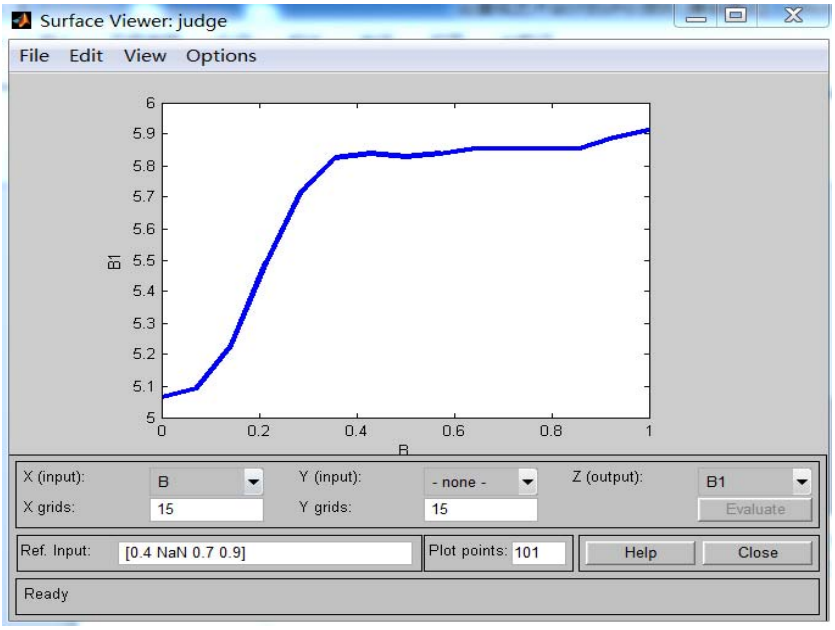
Cultural value investment is 6,000,000 yuan, which is supposed to be the relatively large investment, fixed investment X_C =0.7

Aesthetic value investment is 3,000,000 yuan, which supposed to be the large investment, fixed investment X_D =0.9O

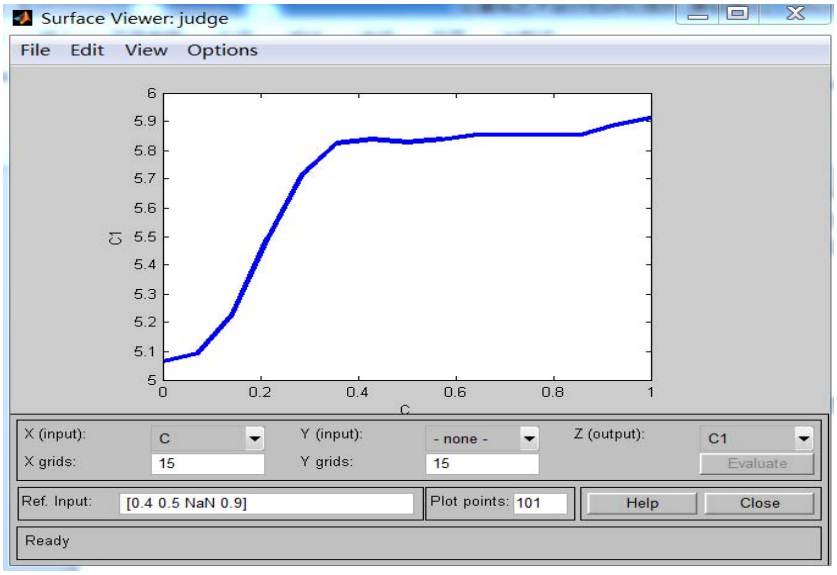
4.2. Solving the Problem and Analysis



Under the condition that B, C and D are constant values, A1 will change with the curve A, which shows that the score of ecological principle will increase with the increase of investment, A=0.4， A1=5.7，compared with other items of investment, the income of this investment has little space to increase, it is reasonable.



If the investment of A, C and D is constant, when B=0.5, B1=5.8, compared with other items of investment, this investment is too large according to the graph, it is unreasonable



If the investment of A, B and D is constant, when C=0.5, C1=5.8, compared with other items of investment, this investment is extremely large according to the graph, it is extremely unreasonable

IN CONCLUSION

	The Amount of Investment （ Ten thousand）	Investment Force x	The Corresponding Score	Arithmetic Average Score
Function Applicable Investment A	400	0.4	5.7	5.98
Ecological Principle B	510	0.5	5.8	
Cultural Value C	600	0.7	5.8	
Aesthetic Value D	300	0.9	6.6	

5. Conclusion

All the principles in landscape design evaluation are not solitary but integrated. The evaluation system, obtained from the result of sampling landscapes and adopting fuzzy evaluation system, is comprehensive, objective and scientific. It has provided an opportunity for shortening the cycle of landscape design and reducing the cost of design. Only if designers consider in a whole and evaluate correctly, can they create the ideal art works in landscape design. In addition, this method also can be extended to other types of product design evaluation so as to form a relatively complete design evaluation system.

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