Research framework on the analytical method of the contributing factor of settlement generation

Song Jinghua
Yu Yang
Xiong yan
Guo xisheng
School of Urban Design, Wuhan University

Abstract:
the contributing factor in settlement generation can be summarized as four aspects, namely, the natural environment factor, the social ethic factor,visual esthetics factor, socioeconomic contributing factor etc. Presently, large numbers of qualitative and quantitive analyses are being conducted in these four aspects, however the vast majority of them are partial, one dimensional researches. Whereas any partial research has its own limitations the results of which are often remote from the actual effects. From the perspective of human settlements, the author made a systematic and general research by means of systematic approach and futher discussed how to organicly combine these four aspects to form a evaluation system of the effect of settlement generation, and further obtain an ideal outcome of settlement generation.

[Keywords: settlement; settlement generation; systems analysis method

1 Research subject of settlement generation

1.1 settlement

As the place for working, living and other social activities, human settlement is the spatial pattern for the inhabiting of human being on the earth surface; while from the cultural perspective, it is also the carrier of human civilization.

The human ettlement stemed from nature, but not a place formed naturally. It is the outcome of the planned, purposive utilization and modification of nature by humanity so as to protect ourselves and to conquer nature. Therefor, human settlement is the composite of natural environment and the social environment of humanity. Based on its nature, function or spatial scale, setterments can be categorized as group houses, villages（urban communities）, cities or urban groupes etc. The form of a favorable settlement system demostrates a unique isomorphismus or structure.

The research scope of the paper has been narrowed down to villages or urban communities, still is a very complicated system. The question is: how to analyse the generation and/or regeneration processes of settlements, and how to accurately quantify and simulate this process? Methods and theories based on quantive analysis are gerneral absent presently in this area, most design approaches are perceptual judgements drawn upon subjective experiences and often lack accurate basis of scientific quantitative analysis, therefore unable to make scientific quantive evaluation of expected outcome of the design.

1.2 settlement generation

In the prolonged period of its generation, the human settlement assumed rich and complicated forms and textures as well as characteristic spatial and cultural identity. Under the seemingling chaotic surface is the highly ordered intrinsic structure. In the process of social and economic developments, it formed a highly rational spatial order with its internal logic.

Various researches are now being made in this field: urban physics stresses the quantitative description and research of the city as a whole, although it has the advantage of quantitative analyses, it tends to simplified the complicated behaviour of human, therefore as the subsqent result of the analyses, the urban model are disengaged from the individual experience of humanbing which made it hard to touch the core of architecture. Urban sociology the established a hierarchy system from the perspective of sociology which can serve as important reference for the research of space hierarchies in the field of architecture. Bill hiller used space syntax theory in the research of urban space with emphasis on the sociological significance and particularly on the relations between spatial organization and the human society. Researchers of digital city and/or virtual reality has establish a 3D urban simulation system which converts design ideas into three-dimensional virtual images, howerver this process is still a process from intuitive design to intuitive experience and lacks the multifactor quantitive comparative research. Human settlement theory recognizes the human settlement as a integral whole and discusses the topic roundly, systematicly, comprehensively from the perspectives of politics, economy, society, culture and technology instead of involving just one aspect of human settlement as in the cases of urban planning, geography and sociology. By integrating multi-disciplinary research findings, human settlement theory makes in-depth researches into human settlements and it dynamic evolutionary process in an effort to reflect the overall features of human settlements. However presently, systematic theory with the overall settlement system as the research subject is still absent and therefore effective research which can link various phenomena together generally is also in need.

These quantitive analysis and researches in different areas are mostly partial and one dimensional researches. Since the finding of every partial research tends to be romote from the actual result,the research findings may be limited in the practical application of settlement generation.

GA is a newly rising approach from both home and abroad which employs system science to study the development of organic bodies. With this approach, we can make systematic and holistic research on various contributing factor which affect the generating of human settlement so as to establish a evaluation system and further obtain a ideal result of settlement generation.

1.3 contributing factor of settlement generation

The major contributing factor of settlement generation can be categorized as natural factor, social and ethic factor, visual and esthetics factor、socioeconomic factor. In these four factors, natural factor, social and ethic factor decide the initial space composition of settlements; individual element and socioeconomic elements in the social and ethic factor further propell the development of settlement spaces; while visual and esthetics factor plays a role of adjusting and enriching in the evolutionary process of the spatial development of settlements. Speaking of these four majors factors, organic connections exist between each factor and the whole; factors and the spatial environment therefore

creating certain structure and order both inside and outside of the system. Social individuals are the main body of settlement life and also the most active factor in the settlement regeneration; regional natural and physical environment physical environment self-identity constitutes the material basis of settlement live life; social rules and ritual structure are the adjuster of various relations in community life; the specific culture, life style and the sense of belonging of the settlement member are not only the results of the collective social life of community members in certain geographic scope, they also serve as the glue of all the members which stick them together and link them with the large cultural background of the society.

Based on the analysis of the natural,social and ethic, visual and esthetics, socioeconomic contributing factors of villages or urban communities and the intergating of advantages of theoretical empirical researches, the research is aimed at establishing a system of research methods which comprises overall generation simulation and sectional quantitive analysis. The objective of the research is not only to obtan a favorable result of settlement regeneration but also to establish a feasible scientific method which can help us out of the situation of being unable to communicate and the intuitive design method which is hard to evaluate.

2. Research framework on the analytical method of the contributing factor of settlement generation

2.1 simulation analysis of the natural environment factor

The natural environment factor of the settlement covers five aspects: the impact of geographic location on the spatial expansion of settlement; physiognomic type, mainly mountainous terrain, plateaus, hill, basin, flat land, river terrace etc, affects the spatial form, scale and structure of the settlement; water resources affects the spatial pattern of settlements; climatic conditions such as wind environment affects the spatial expansion of settlements; elements of natural ecological environment such as noise control, sun radiation, green landscape etc have comprehensive impact on the settlement spatial quality. Tending towards favorable situation and avoiding possible impairments is a basic instinct of human being in choose natural environment, these factors decide the basic patterns of natural space in the formation and development of human settlements. Expect climatic conditions, most of the constraining factors can be improved or solved through artificial technology, whereas the humidity, wind condition in the regional environment of the settlement are still difficult to change through technological measures.

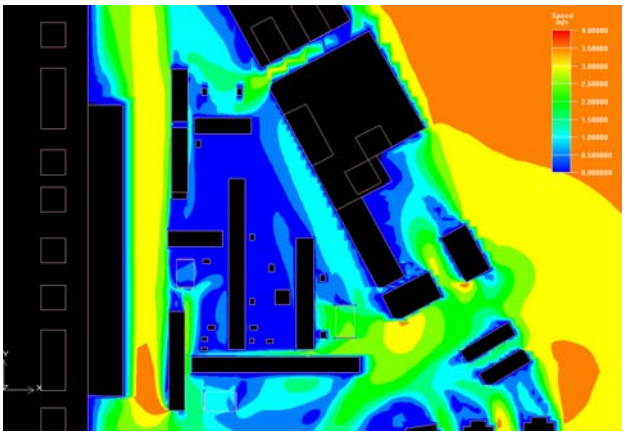
Wind is the air flow under the combined effects of pressure-gradient force, rotation of the earth and frictional ground force. From the perspective of aerodynamics, these can be generalized as the flowing of particular shearing turbulence surrounding the bluff body or the wall turbulence flowing problem with different surface conditions; all in all, they are being called the wind environment problems. With the acceleration of urbanization and the high density and extreme height of urban architecture, researches on the wind environments within and between different architectural complexes are becoming more and more important. For instance, overly high wind speed and whirl wind inside of the narrow pass-ways between high-rise building can make people uncomfortable or even bring potential hazard; unreasonable architectural composition or architectural form may result in dead zone of whirl wind between architectural complexes which is undesirable for airflow or the dispersion of exhausted air or hot air, hence makes the air quality both

indoor and outdoor unable to reach the health standards for human body. Therefore, it is necessary to discuss the impact of wind environment on settlement layout.

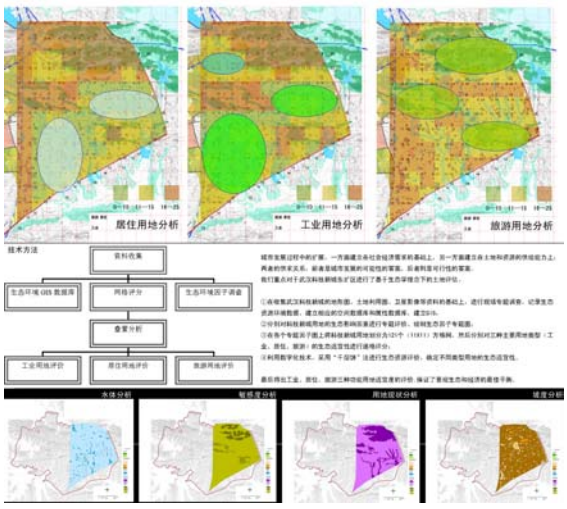
The major technique to predict the wind condition around a settlement is on site actual measurement, tunnel test and digital simulation. On site actual measurement is the most common of them all, for it provides not only information for digital simulation and theoretical research but all also can help test the result. As a matter of fact, various experience and semi empirical modes induced from field observation have played important roles in solving practical problems. However, this approach consumes considerable manpower, material resources and time. On the other hand, tunnel test are direct and direct-viewing, however it not possible to build extremely large or real-life model and over-sized model may render its boundary conditions unable to meet the demand of the simulation conditions. Though current digital simulation still see inaccuracy in the calculation of detailed wind pressure on building surfaces, it has assumed fine accuracy and use value on the reproduction of overall wind condition, and thus can be applied to the simulation analysis of settlement wind conditions.

Among all the software for wind condition simulation and analysis, Fluent and Phoenics are relatively widely used. We can use the software to analyze the wind condition of the settlement in terms of wind pressure, wind speed air age, swirl region etc. But an overall evaluation of the design proposal or built environment of a settlement involves various key technologies, such as the thermal environment simulation, computational fluid dynamics（CFD）、property analyses of the dwelling under-laying surface etc.

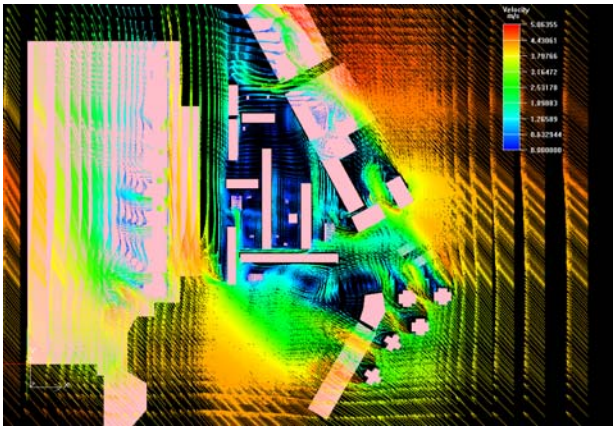
At the same time, we can utilize Gis to analyze and evaluate whether the topographical environment suits the growth and development of a settlement, thus serve as the reference for location choosing. Furthermore, through data fusion, we can synthesize analytical data from different contributing factors for cross-checking （ figure 1）.



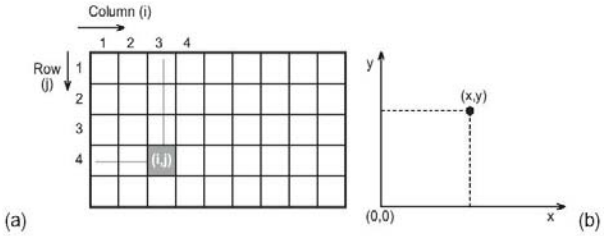
Wind simulation: Speed



GIS analysis



Wind simulation: Velocity



Data compound

figure 1

2.2 the spactial syntax analysis of the social & ethic factor

As a pattern of human habitat or human gathering, settlement fomulated in the development of human civilization. Once the settlement is formed, it will exert immense and long-lasting impactm on peoples social behaviors. Social ethics decides the social and spatial structure of the settlement and also the basis of behavioral models of the people's interaction with the environments. It penetrates the entire dynamic evolutional process of the settlement.

The living space in a settlement comprises family living space, neighborhood socializing space, community space and the regional socioculture environment. Correpondingly, the impact of social ethics on the regeneration of settlements are shown in four aspects: socioculture system, regional customs and traditions, social and economic organization, social individual.

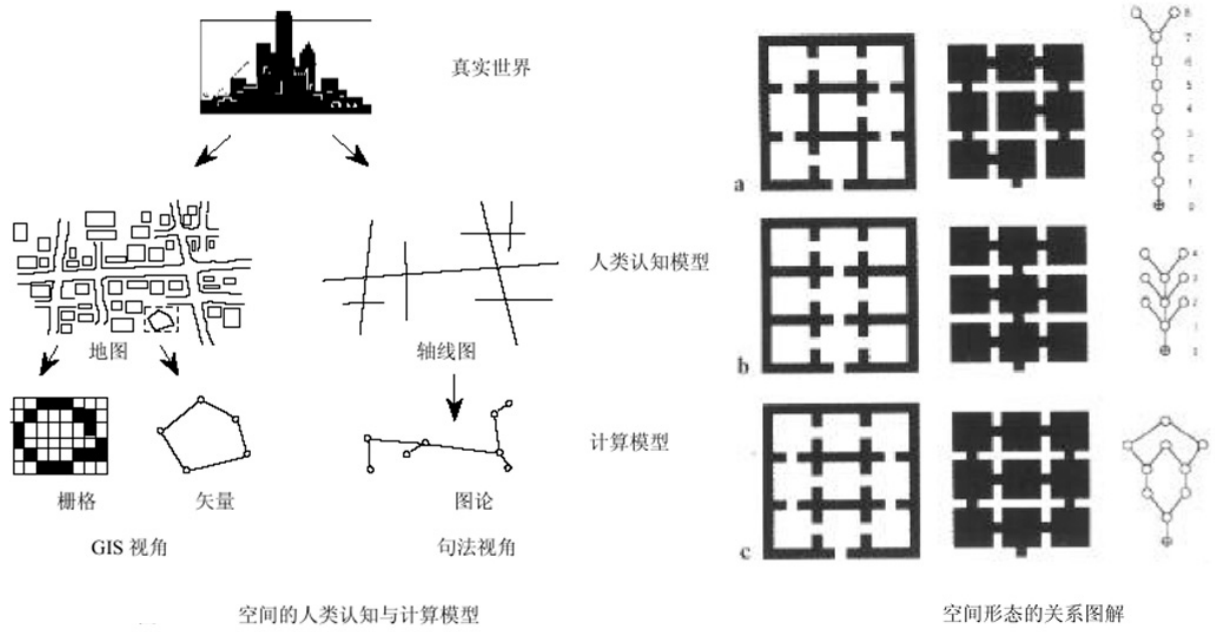
In these four aspects, the highest level is socioculture, the sociocultural system stated here refers to the concept of ethic values which affects the way of living and behaving of the people. It falls into the knowledge system of the human society and characterized by accumulativeness, inertia and/or relative independentability.

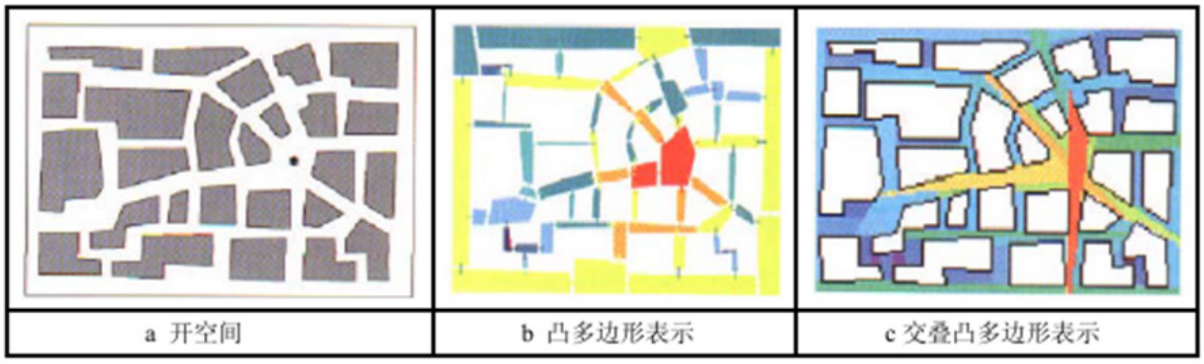
The impact of socioculture on the form of the settlement is comprehensive and long-lasting, whereas the impact from regional customs and traditions tends to have more direct and flexible impacts. The dynamic development of regional customs and traditions often directly affects the changes in the spatial configuration of settlements.

Although social ethic is usually unchanging and unified, the values and behavior patterns of individuals may be diverse. Like Robert Frost has stated,one half of individuality is locality. Then vitality of individuality can never be generalized with locality. The individualities of a region may show certain shared characteristics, but more often they will have numerous individual differences. These unique individualities are often the genuine driving forces behind the profound changes behind regional customs and settlement spaces. The links between individuals and spatial configurations are demonstrated by the individual selectivity. For example, places with frequent individual participations will be re-enforced interms of its spatial significance, on the contrary, they will gradully fade away.

Considering such characteristics of individual behaviours, researcher such as Bill Hiller used the spatial syntax theory to study the urban space with emphasis on the

sociological significance. The focus was the relations between spatial organization and human society as well as the hierarchical relationship（figure 2）of spatial configuration through the topological approach. The mathematical analysis provided by spatial syntax can effectively help predict the behaviour characteristics of peple in a certain space and thus able to answer many questions related to environmental psychology,such as how human and environment interact or how human behavior is affected by the environment[1].





开空间的凸多边形与交叠凸多边形表示

figure 2

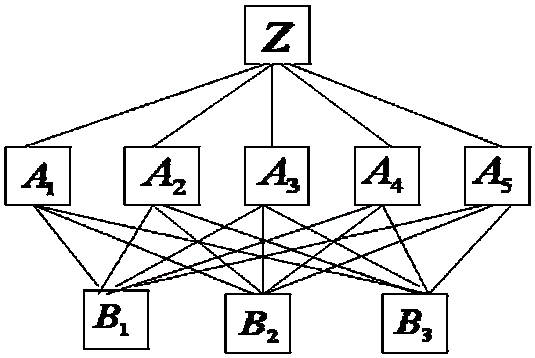
2.3 analytic hierarchy process of the visual & esthetics factors

How do we describe and evaluate the form of a settlement or the image of a building? How can architect know the real feelings and attitudes of future users towards his or her design so as to make improvement?

Different cultural background will inevitably bring enormous differences in the individual aesthetic perception. Therefore the aesthetic evaluation process is complicated and multi-tiered during which the subjective factor possesses a considerable gravity, thus brings about inconvenience for the quantitative analytic solution of practical issues. In the 1970s, T. L. Saaty put forward a practical approach to effectively solve these problem,

namely the analytic hierarchy process (AHP). It is a analytical method which is both qualitative and quantitative, also systematic and multi-tiered.
The analytic hierarchy process combines the quantitative and qualitative approaches and regards the subject investigated as a system and make decisions through the thinking mode of decompounding, comparison & judgment and then integrating. It then become a import instrument of systems analysis after mechanism analyses and statistical analysis. At the same time, such an approach enables the user and designers to make timely communications, the users can even directly us it, these in all can help enhance the validity fo the evaluation. What's more, the computational process is very simple and the outcome is clear-cut therefore easy for the users to understand and master.

However, this approach can only help us to optimize our choice among various proposals instead of generating a better solution. Secondly from the establishment of the hierarchical structure to the provision of the paired comparison matrices, the subjective factor of human can have enormous impact on the entire process, thus renders the outcome difficult to be accepted by all decision - maker, certainly the expert consultative method is one of the attempt to offset the weakness in this regard.
Through the establish of layers of target, criteria and scheme, the analytic hierarchy process is to firstly establish a comparative matrices of evaluation factors, then to sort the weight each scheme by the calculation of consistency check indices, and finally identify the optima evaluation（table 1）.



Objective: Z

Rules: A

Schemes: B

Hierarchy model

$$A=\left(a_{ij}\right)_{n\times n}=\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$$

A 称为成对比较矩阵

$$B_3 > B_1 > B_2$$

B 各方案的权重排序

table 1

2.4 the genetic algorithm of the socioeconomic factor

All contributing factors of the spatial development the settlement exsist under the socio-economic constraint, they are affected by the transportation, economic development levels, technical innovation abilities of the region concerned and have a direct bearing on the scale of spatial growth and development of the settlement. As for the reasonable

development of the land in the settlement, on one hand, it should be the careful preservation and rational utilization of the resources of the city, on the other hand it should also stress individual demands of the people. How to coordinate the overall and individual demands and to archive the harmonious, sustainable development of the human settlement is the shared objective of the urban administrators, designers and dwellers. The evolution of teh settlement space are demostrate in two aspects: firstly, during the land use expansion of the rapid development phase, spatial scale keeps on growing; secondly, the land-use ajustment throughout the entire development process. Both phases are the process of wearing in between the individual demand and overall coordination of the space in the settlement. Hence, the economic advisability of the land and space of the settlement is the basis for the coordinated development of the settlement, and further the key point of solving the spatial economic issues of the settlement.

Genetic algorithm is a bionic algorithm on a macro-level, the simulated mechanism of which is the formulation and evolution process of all life and intelligence. It put forward not only the idaas and basic concepts of natural evolution, but also the implementation methods and basic theories of simulating this process throung the mathematical approach. By simulation of the mendelian inheritance and variation theory, it seek to maintain the available structure and to find better compositon. The land selection in the growth of the space of a settlement can also be viewed as a optimization procedure of selections. It has assumed the characteristics of natural evolution and self-adaption. These characteristics of the genetic algorithm are compatible with the growth and evolution of settlement spaces in terms of its multiple objective, dynamic, natur development characteristics, if it is applied to the spatial evolutional analyses, undoutedly it would serve as a strong instrument. GIS is a technical system for the comprehensive analysis of spatial data which can have spatial analysis and data excavations for vast amount of spatial information. By combining GIS and the genetic algorithm together into the growth prediction and evaluation of the settlement space and at the same time meeting the calculation requirement of various spatial relations in the optimal combination of settlement spactial growth can provide a quantitative analytic approach for the ecomomic evaluation of the development of settlement spactial development.

3. Generation: a method of design of integration

Research method based on generation theories aims to integrate overall generation and sectional quantity together despite the fact that these to are often been regarded as two differen approached of mutual independence, mutual exclusion and complementation so as to explore the process of the development and evolution of the settlement as well as its driving forces. As for the generation of the settlement, what is important is not the movement in the material and spatial level but rather the trans- hierarchy transmission and transition of infomation, thus the overall settlement generation assumes the characteristics of mutation, multi-hierarchy, indivisibility and unreducibility. Correspondingly, as a basic method for the overall generation, the research will not decompound the settlement into certain basic layers, instead, it will discusss the universal laws of all hierarchies and social behaviors. Hence, what the generation approach is looking for is not the quantitative conservation law but rather the qualitative law of similitude, the focus is how to breakthrough the conventional method of restorational analysis and find a new research approach of viewing the whole as a whole, and non-linearity as non-linearity rather than attaching additional interactive relations to the basis of composition or considering how to

convert nonlinear problem into linear processing. System science has created a research technique suitable for the overall nature of the system, such as model method, analogy method, functional simulation method etc, whereas fractal, chaos theories too can be fully utilized in computer technology through the method of reiteration equation so as to give vivid potrait fo the generation process and it dynamic image. Thereof, different from conventional methods, the utilization of computer technology is no longer only for the description of spatial movement of the settlement, but rather rules of generation, or to say the codes of building in a bid to generate complicated, varied forms of settlement.

In the paper, we generalzie the major contributing elements of settlement generation as four factors for analysis. These elements are like the genetic coding system which controls the varing complexities in the evolutionary process. These elements not only have complicated links with the spatial form of the settlement, they also have even more complicated connections between themselves. Elements affecting spatial generations comprise both quantitative and qualitative ones which can be analyzed with different methods. How to make the overlaying analyses of research findings from difference analytical method and how to assign different weight to various elements will have a direct impact on the outcome of settlement generation

After 20 years of research, Professor Celestino Soddu create a Generative Arts based on computer technology and apply it to the generation of the urban forms of cities such as Milan, Venice etc. In his research, he discussed how to use the approach similar to DNA coding, through the dynamic generation rules and conversion program, to automatic generate a unique city form based on yet stands apart from the traditional form[2].

As a matter of fact, the method of generation technology is to discuss the correlations between human and the environment from the perspective of human settlement,it stresses that the human settlement is an organic whole thus it neet to be roundly, systematically and comprehensively studied in terms of the society, culture, technology etc. Though the static and dynamic analyses of the human settlement, the objective of the method is to find the intrinsic law of human settlement and establish various mathematical models of human settlement. Through the generation technical system we can code different contributing factors so as to form a data matrix and set the generation rule, then by establishing the mathematical model, designing the calculational equation, we can identify the impact weight of contributing factors on the result; further, through a open data processing platform, we can realize the data exchanging between settlement spatial analysis models, analytical data of different contributing factors, formal simulation as well as other data matrix. All in all, these overlaping analytic result will be organically combined to formulate a evaluation system for settlement generation and renewl, thus realzie the prediction of the future development and evolution of settlements (table 2).

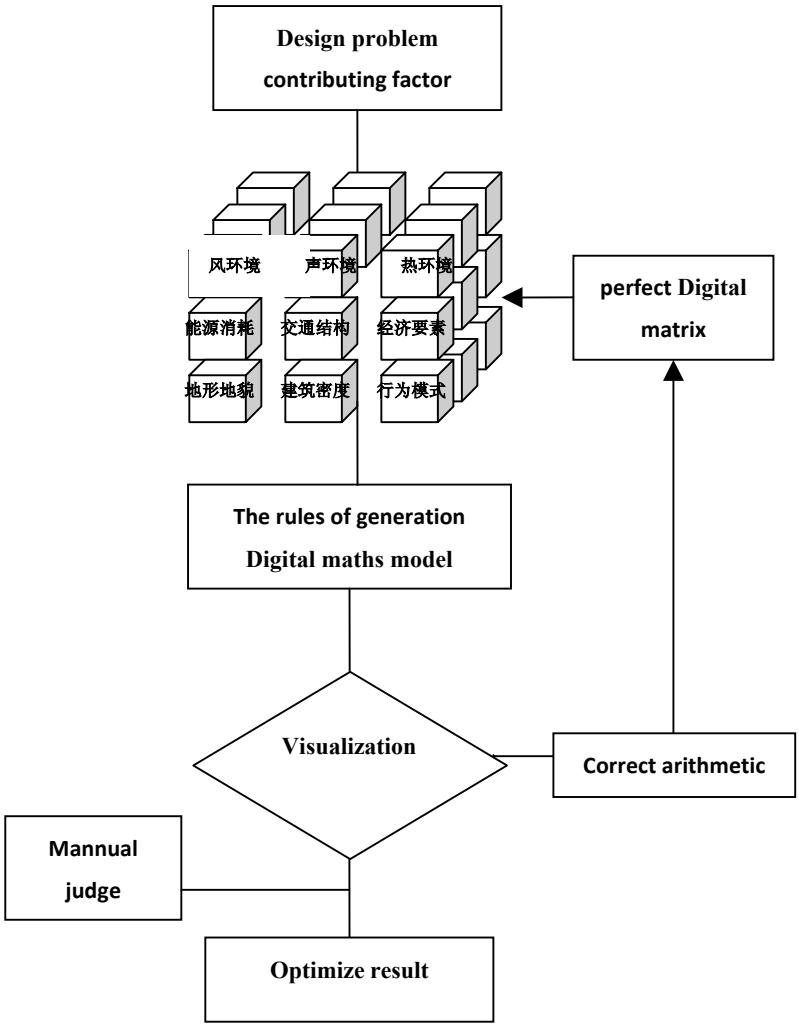


table 2

Although generation technologies still face acurracy problems in the universality of quantatitive computation model, it is more persuasive than qualitative description in methodology and it also has the possibility of inheriting and modifying theoretically. All these make it an import approach in the future spatial researches of settlement settlements.

Reference

1 Hillier B,Hanson J. The Social Logic of Space. Cambridge:Cambridge University Press,1984

2 Celestino Soddu, La città ideale, Generative Codes Design Identity. A city's Identity can be represented with an open system of transformation rules, of developing procedures able to identify how each city performs its increasing complexity, how it creates its own future.