Hierarchical planning control model of smart city based on urban micro community

WEN Wen*[1],LI Yan-dong [2],CHENG Shu [3]

{wenwen8779@163.com[1], sdfds8574@163.com[2],saefeas874@163.com[3]}

1.Yaha School of Built Environment, Haikou University of Economics,Haikou,571127,China;

2.Haikou University of Economics,Haikou,571127,China;

3.Haikou University of Economics,Haikou,571127,China)

Abstract: In view of the low control intensity of the traditional intelligent urban spatial hierarchical planning control model, which leads to the problem that the control effect is not obvious, a kind of intelligent urban spatial hierarchical planning control model based on urban micro-community is proposed. First of all, using the "urban microcommunity theory" to calculate the spatial hierarchical planning index, construct a hierarchical matrix, determine the intensity parameters of the control model, define the spatial stratification index as the search to meet a series of equality, inequality constraints, establish a mathematical control model, and complete the design of the intelligent urban spatial hierarchical planning control model based on the urban micro community. The experimental results show that compared with the traditional control model, the intelligent urban spatial hierarchical planning control model based on urban microcommunity has the highest control intensity grade and the best control effect.

Keywords: urban micro community; intelligent city; spatial stratification; planning control model;

1 Introduction

The concept of "smart city ", which emerged 10 years ago, is a concept of how to apply communication and information technology to improve urban function, enhance urban efficiency, enhance competitiveness, and provide us with a new concept of urban development to solve the problems of urban equity, poverty, social collapse and environmental pollution [1]. Smart cities are often described as digitally simulating the shape and operation of real cities, using the combination of various infrastructure and electronic devices, and connecting through the network to provide real-time urban dynamics, and to achieve equal and safe quality of life through data integration and analysis and feedback. In the future information and communication technology and urban research, more attention will inevitably be paid to how to serve these facilities in cities, citizens and various social organizations, and urban planning as the overall planning of urban operation will be more and more closely linked to the emergence of intelligent cities [2].

At present, our country does not attach importance to the integration of urban design

EAI MOBIMEDIA 2020, August 27-28, Harbin, People's Republic of China

DOI 10.4108/eai.27-8-2020.2294599

related concepts in the process of regulation compilation, but to the mandatory content in the control index, and despise the guiding content of urban design to the control index. At present, urban design is the best optimization method of urban space and urban form, the main purpose of which is to transform two-dimensional plane into the control of urban three-dimensional space and urban environment [3]. In order to solve the contradiction between the control and execution of the control regulations, we should combine the relevant concepts of urban design, start from the essence of the control rules, optimize the control system of land use intensity, and make the control regulations have a systematic control over the development of urban land [4].

At present, how to integrate urban design into the statutory regulation system, especially how to achieve remarkable results in shaping the characteristics of urban space environment, and effectively guide the establishment of land use intensity index more scientific and reasonable, has become a hot topic in academic research [5]. The control of land use intensity is the core content of control regulation, social, economic and policy all belong to the influencing factors of land use intensity, but these factors focus on the feasibility of implementation and the purpose of implementation effect, attach importance to the management and control of land use intensity of index to the "quantity" of space, lack the shaping of urban space environment, and lack the guidance of "quality" of space. Urban design is to shape the physical and spatial environment and characteristics of the city for the purpose of making up for the current regulations in urban aesthetics, urban environment. It cannot only create a pleasant and livable urban overall space environment, but also ensure and achieve the macro-level planning objectives such as urban master planning and zoning planning.

2Control Model of Intelligent Urban Spatial Stratified Planning Based on Urban Microcommunity

2.1Using "Urban Microcommunity Theory" to Calculate Spatial Stratified Planning Index

Whether it is human life or production activities, it needs the support of resources and environment, but also by the constraints of resources and environment. In combination with the actual situation, the resources and environment support mainly considers the land resources, the water resources support index, the restraint aspect mainly considers the geological environment restraint index. In calculation, the per capita available land area is expressed by the ratio of usable land area to population, that is, the per capita usable land area is two usable land area / rural population, which can be used by land area = slope less than 25° area = slope less than 25° one extremely important and important ecological space area [6].

When calculating the planning index, it mainly measures the quantity and quality of the ecological space of the evaluation unit. The ecological protection index uses the results of ecological importance evaluation, in quantity, mainly considers that the extremely important ecological space area accounts for the single element proportion of the evaluation a and the important ecological space area accounts for the proportion of the evaluation unit p quality separate.

There are often different units between indicators, and there are great differences in values, which are not comparable and cannot be directly calculated. The standardization of indicators is to quantify non-comparative indicators into equivalent values in the same way, and to carry out operational analysis. In the index calculation, the stratified potential index represents the "wisdom" degree of urban space by the average of the three indicators of population density, urban economy and traffic superiority. The formula is as follows:

$$P_1 = \sqrt{\frac{1}{3}\sum_{i}^{3} a_i^2} \quad (1)$$

Where P_1 denotes the degree of wisdom and a_i denotes the population density. The ratio of the weighted average of available land resources b_1 and water resources b_2 to the geological environment index b_3 is used to express the comprehensive support and constraints.

$$P_2 = \frac{\sqrt{\frac{1}{2}(b_1^2 + b_2^2)}}{b_3} \quad (2)$$

Where, P_2 denotes the comprehensive support constraint coefficient. The ecological conservation index is used to calculate the quantity and quality of urban space.

$$P_3 = 3\alpha + 2\beta \quad (3)$$

Among them, α and β denote the proportion of extremely important ecological space and the proportion of important ecological space. Finally, the method for calculating the hierarchical indicators is shown in the following table:

Table 1 Method of calculating stratified index

Criterion level	Computing method	Index
Development potential index	$P_1 = \sqrt{\frac{1}{3}\sum_i^3 a_i^2}$	Population density urban Economy Traffic advantage
Resource environment support and constraint index	$P_2 = \frac{\sqrt{\frac{1}{2}(b_1^2 + b_2^2)}}{b_3}$	Available land resources b1 Available water resources Geological environment constraints
Ecological protection index	$P_3 = 3\alpha + 2\beta$	Proportion of important ecological environment Proportion of important urban space

Using the above calculations, the results of the indicators are shown in table 2 below:

Table 2 Calculation results of indicators

Code	Potential index	Constraint index	Protection index	Evaluation value
1	0.862	0.359	1.586	-0.856
2	0.775	0.425	0.965	-0.862
3	0..751	0.368	0.149	-0.582
4	0.865	0.458	0.865	-0.956
5	0.695	0.562	0.741	-1.535
6	0.965	0.258	0.625	-0.753
7	0.856	0.684	0.965	-0.635
8	0.742	0.631	0.598	-0.452
9	0.842	0.965	0.475	-0.692
10	1.268	0.589	0.465	-0.652
11	1.297	0.287	0.685	-0.485

the calculated results from the various indices calculated from the above table show that the larger the potential index is between 0.2 and 2.8, the greater the value indicates that the better the programmable potential is, and the greater the value of the constraint index is between 0.132 and 1.000, the stronger the supporting effect of resource and environment conditions on production and life, whereas the smaller the value indicates that the resource and environment support is weaker or even overloaded [7]. The more important the ecological conservation index values are distributed at 0.393-1. On the other hand, the smaller the value, the lower the proportion of ecological protection space is, the weaker the importance of ecological protection is, but the proportion of important ecological space is not reduced. The value of the ecological protection index is distributed between 0.39 and 1.484, and the larger the value, the higher the proportion of the ecological protection space required by the evaluation unit.

After calculating the spatial hierarchical planning index, the intensity parameters of the control model are determined according to the numerical value, and the hierarchical planning control model is established to realize the intelligent city stratification.

2.2Determination of control model strength parameters

Before determining the parameters of the control intensity model, calculate the urban spatial index, according to the results of table 2 above. The results are plotted in ascending order, and five inflection points are divided into six intervals. The values of the five inflection points are -0.1014,-0.832,-0.546,-0.224 and 0.368, respectively. For different layered units, using 1 and 2 as the living function space,3 and 4 as the production function space, and 5 and 6 as the ecological function space, the following line diagram is drawn:

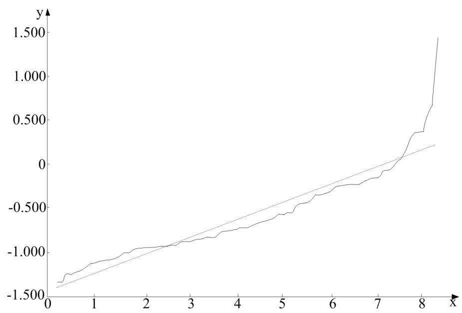


Fig.1. Spatial index ascending line diagram

As can be seen from figure 1 above, the intelligent city space contains two kinds of planning control parameters, which are combined (3) the objective function of the optimal planning problem at this time. To construct a hierarchical matrix, assuming that there are n control elements, the influence on the command urban spatial hierarchical planning Z , determine the proportion of each control factor in the planning, the expression of the control element can be expressed as:

$$y = (y_1, y_2, \ldots, y_n) \quad (4)$$

The two factors y_i and y_j in the above formula are denoted by a_{ij}, so the final n control indexes are compared to form a matrix:

$$A = (a_{ij})_{n \times n} \quad (5)$$

The interlocking formula (4)(5) ultimately constitutes a control positive and inverse matrix, as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (6)$$

In determining the value of a_{ij} in the preceding formula, the reference number 1 to 9 is used as a scale. The meaning of the scale is shown in the following table:

Table 3 Scale Scale

Serial number	Scale	Meaning
1	1	The two factors are of the same importance
2	3	The former is slightly more important than the latter
3	5	The former is more important than the latter
4	7	The former is more important than the latter
5	9	The former is more important than the latter
6	2/4/6	Mean value of the above adjacent judgments

The final control model parameters are obtained by selecting the scale corresponding to the ordinal number 5 from the data in the scale in the table above. The formula is as follows:

$$P_1 = \sum_{i=0}^{n} f_i(x) g(x) \quad (7)$$

Where, f_i is the i -th urban maturity. using the final calculated parameters of the control model, the mathematical computational model of spatial hierarchical planning control of mathematical wisdom city is established [8].

2.3Establish mathematical control model

When the mathematical control model is established, the spatial stratification index is defined as a set of decision variable values of the optimal objective function when the search satisfies a series of equality and inequality constraints [9]. The multi-objective optimization is not to find the optimal solution of a given sub-objective, but to find the optimal solution set satisfying multiple objectives. To establish a minimum objective planning program with a mathematical model of:

$$\begin{cases} \min F(x) = [f_1(x), f_1(x), ..., f_k(x)]^T \\ s,t, g(x) \geq 0 \\ h(x) = 0 \end{cases} \quad (8)$$

Of which, $\min F(x)$ Represents the minimum optimization target for hierarchical planning control indicators, $f_i(x)$ For the sub-objectives included in the planning issue, i Subtarget number, $i = 1, 2, ..., k$, k Number of sub-targets. The solution vector of multi-objective programming is: $x = (x_1, x_2, ..., x_n)^T, x \in R$, R Represents the real domain, $g(x)$ Represents inequality constraints, $h(x)$ denotes the equality constraint condition. If x_0 is the optimal solution of the programming control model, the solution for any solution $x \neq x_0$, $f_i(x) \geq f_i(x_0)$, that is, the optimal solution x_0 ensures that any subtarget in the control model function is the smallest in space.

If x_0 is a non-inferior solution to a planning problem, there should be no one solution $x \neq x_0$, make $F(x) \leq F(x_0)$, that is, when taking x_0, at least one or more sub-objectives are minimized, and no other solution makes all sub-objectives in f(x) superior to that non-inferior solution. In general, multi-objective programming can be translated into single-objective programming for individual sub-objectives:

$$\begin{cases} \min f_i(x) \\ s,t,g(x) \geq 0 \\ h(x) = 0 \end{cases} \quad (9)$$

Where $f_i(x)$ is the sub-goal. If $x^i = (x_1, x_2, ..., x_n)^T$ is the optimal solution of the sub-objective, then the optimal solution x_0 of the multi-objective programming is equal to the optimal solution x^i of each sub-objective.

$$x_0 = x_1 = \cdots = x^i \quad (10)$$

In general, each sub-goal restricts each other, and finds a x_0 that satisfies the requirement of each sub-target taking the minimum value at the same time, selects the optimal solution from it, and establishes an intelligent urban spatial hierarchical planning control model. The final control flow is shown in the following figure:

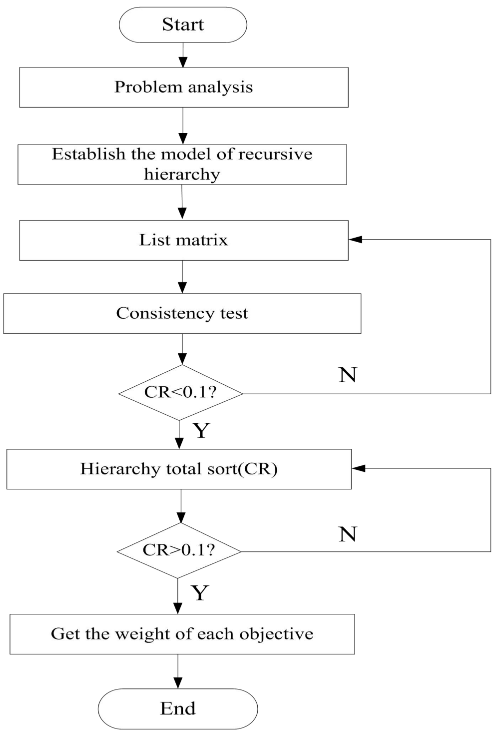


Fig. 2 Model control flow

By the control flow above, and finally complete the design of the intelligent urban spatial hierarchical planning control model based on the urban microcommunity [10].

3Simulation experiment

3.1Experiment preparation

The model prepared for the experiment is carried out in a small example of three urban layers, four planning routes, and the layer-distributed network vertices of OD in 36 residential areas. The plan is shown in the following figure:

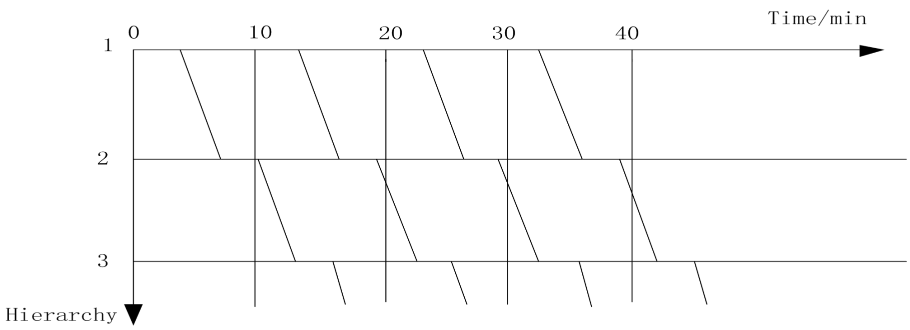


Fig.3 Planning of experimental preparation

The experimental preparation for the processing of computer parameters for quantization of urban space is shown in the following table:

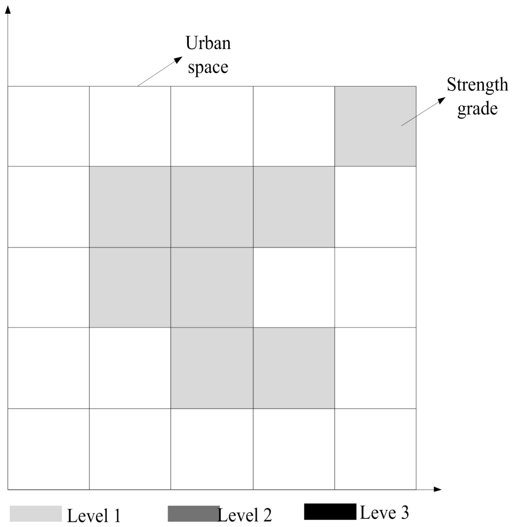
Table 4 Experimental computer parameters

Serial number	Name	Parameter
1	Operating system	Window7
2	System type	64 place
3	Processor	Intel（R）Core（TM）i5-4590
4	CPU	3.30GHz
5	Memory	4GB
6	Hard disk capacity	500G
7	Graphics card	Integrated graphics

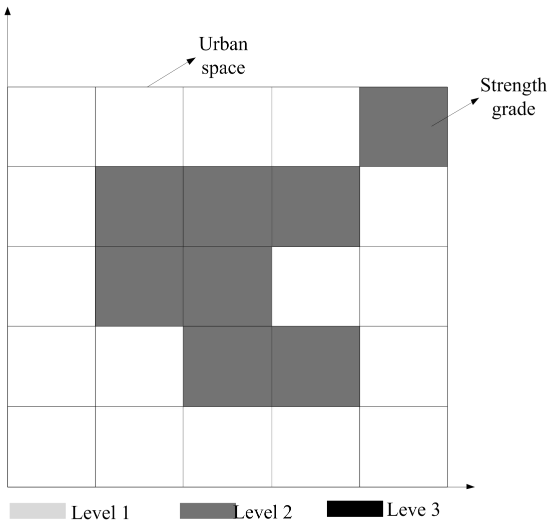
Based on the above preparation experiment preparation, two traditional planning control models and the intelligent urban spatial hierarchical planning control model based on the urban micro community are used respectively to carry out experiments, and the quantitative results of the three control models are compared.

3.2Experimental result

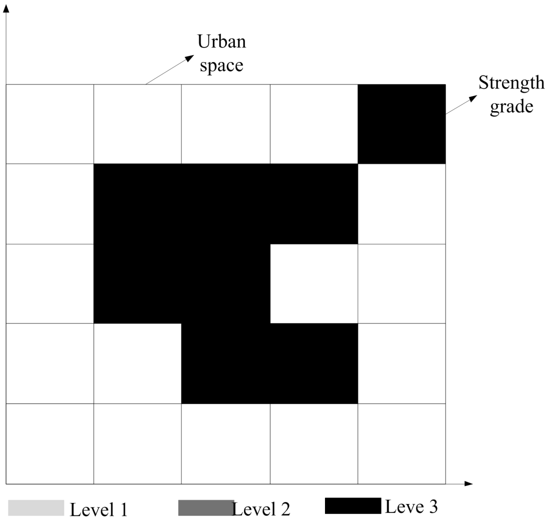
Three control models are required to control the urban space of the same area, and the final results of the three control models are shown in the following figure:



(a) Experimental results of traditional control model 1



(b) Experimental results of traditional control model 2



(c) Experimental results of intelligent urban spatial hierarchical planning control model based on urban microcommunity

Fig.4 Experimental results of three kinds of control models

As shown in the experimental results shown in the figure above, the traditional control model shows that the intensity level of control model is 1, the intensity level is low, the intensity level of traditional control model is 2, the intensity level is higher, and the control level of intelligent urban spatial hierarchical planning control model based on urban microcommunity is 3, the control intensity is higher, and the final control effect is the most obvious, which is suitable for practical use.

4Conclusion

Intelligent urban spatial stratification planning is one of the components of urban planning, which runs through the whole process of urban planning. Starting from the vertical relationship of urban design itself, urban design is divided into overall urban design, zoning urban design and detailed urban design. Starting from the subordinate relationship between urban design and urban planning system, urban design is divided into "separately compiled urban design" and "urban design that runs through all stages of urban planning ". The expression of urban design should be integrated with the requirements of urban planning, corresponding to the planning content of each stage of urban planning.

5Fund projects

supported by the philosophy and Social Sciences Planning of Hainan Province, Project No.: HNSK(YB) 18-52

University Project No.: hjky18-13

Reference

[1] MA Qing-tao，SHANG Guo-bei，JIAO Xin-ying. Evaluation of Smart City Construction Level Based on BP Neural Network[J].Mathematics in Practice and Theory，2018, 48(14)：64-72.

[2] JIANG Wenhua，XU Jian，LI Gang，etal. Analysis on Domestic Research Community of Libiary Science Based on Research Interest Similarity Network[J]. Modern Information 2019,39(09):21-27.

[3] WANG Dong，ZHANG Jie，JIN Jiu-cai，etal. Local steering collision avoidance path planning algorithm based on finite state machine model[J]. Marine Sciences, 2018,42(01):119-127.

[4] JIANG Feng ,XING Wei, WENG Wu. UAV Path Plcnning Model based on Terrain Optini Zation and its Application[J]. Mathematics in Practice and Theory, 2018, 48(15): 2018,48(15):75-82.

[5] HAN Yunxiang, TANG Xinmin, HUANG Xiaoqiong. Trajectory Planning Using Robust Control Theory[J].Journal of Nanjing University of Aeronautics & Astronautics, 2017, 49(1): 125-131

[6] ZHONG Jia-qing, JIN Guo-chen, ZHANG Xiao-hui,etal. Generation expansion planning model incorporating carbon trading cost and efficiency power plant[J]. Advanced Technology of Electrical Engineering and Energy, 2017, 36(12): 22-29

[7] ZHANG Zhao-ning,LI Wen-ya. Improved model for the risk control in the civil aviation industry based on the integer programming in the terminal area[J]. Journal of Safety and Environment, 2018, 18(4): 1403-1407.

[8]LIU Kai,GONG Jianwei, CHEN Shuping,etal. Dynamic Modeling Analysis of Optimal Motion Planning and Control for High-speed Self-driving Vehicles[J].Journal of MechanicalEngineering,2018,54(14):141-151.

[9] DONG Wei. Combined control predictive model and method for stochastic traffic flow[J]. Journal of Shenyang University of Technology, 2018,40(01):88-93.

[10] QIU Zhi，WANG Beibei，BEN Shujun，etal. Bi-level optimal configuration planning model of regional integrated energy system considering uncertainties[J]. Electric Power Automation Equipment，2019,39(08):176-185.