Land Evaluation Supported by MDS

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Abstract

GIS-MCE is the main method in land evaluation,but it is a linear method and neglects multidimensional complexity of factors used in land evaluation, which leads to information loss. Multidimensional scaling (MDS) originates from psychoanalysis, which is used to describe multidimensional data in higher dimensions by transforming data in higher dimensions into geometry structure in Lower dimensions. In the Land evaluation model supported by MDS, the data is transformed into a similar space and land evaluation is completed according to the spatial clustering based on the data's spatial similarity ,which is a method drived by data and not dependenting on others priori assumption.Taking expropriation division in Xuzhou city as an example, it shows that the land evaluation based on MDS meets the requirements of land classification.

Keywords：Land Evaluation MDS Spatial Cluster model

1. Introduction

Land evaluation involves factors of soil, climate, vegetation, topographic and hydrology, which is an analysis integrating spatial information.

In analysis of integrating spatial information, spatial data of different types and different sources can be taken as attribute of spatial cells, which have different spatial resolution and different spatial scale. So land evaluation can be taken as integrating spatial information of different sources and different spatial scales in specific information space.

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Multidimensional scaling(MDS) originated from psychoanalysis, and it is used to describe multidimensional data in higher dimensions by transforming data of higher dimensions into geometry structure in Lower Dimensions. Based on this,Land evaluation supported by MDS is a method drived by data and not dependenting on others priori assumption.

2.The principles of MDS

Set the Attribute measurement matrix C(C=（d_{ij}）$_{n\times n)}$ of n objects has been given in r-dimensional space,said C is the similarity matrix for the n objects. MDS using C to obtain p (p ≦ r)-dimensional vector Z = ($z_{(1)}$, $z_{(2)}$, ..., $z_{(n)}$), and n objects can be expressed by vector Z, said that Z is a Mimetic Structure of C. Set $\hat{D}$ is Attribute measurement matrix Obtained from the Z,and said $\hat{D}$ is Mimetic distance matrix of C. MDS's target is both to make the n objects to achieve p (p ≦ r)-dimensional expression, but also to make $\hat{D}$ as close as possible to C, and the process achieves the classification of n objects ,where only n-matrix C is available.

Young- Household theorem approachs creating p-dimensional vector Z from the matrix C. For the matrix

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$C = (d_{ij})_{n\times n}$, set $B = (b_{ij})_{n\times n}$, where

$$b_{ij}=\frac{1}{2}\left(-d_{ij}^{2}+\frac{1}{n}\sum_{j=1}^{n}\mathrm{dij}^{2}+\frac{1}{n}\sum_{i=1}^{n}\mathrm{dij}^{2}-\frac{1}{n^{2}}\sum_{i=1}^{n}\sum_{j=1}^{n}\mathrm{dij}^{2}\right) \qquad (1)$$

Set $\lambda_1 \geqq \lambda_2 \geqq \cdots \geqq \lambda_r$ is positive characteristic roots of B, e_1, $e_2 \cdots$, e_r is eigenvector corresponding to $\lambda_1 \geqq \lambda_2 \geqq \cdots \geqq \lambda_r$ take $Z = (e_1, e_2, ..., e_r) = (x_{ij})_{n\times r}$, each row of Z matrix corresponds to a mimetic spatial coordinate of object. Take Z dimension p <r to realiz the classification of n objects in low-dimensional space.

3. Land evaluation model based on MDS

in the process of anglicizing land information for different types of factors, there is big difference in data preprocessing, such as data quality control, data registration, space unit and so forth, but through a certain mode after pretreatment different sources, different scales, different elements of the land factor in the sampling data can be integrated in an information space, which can study the characteristics of spatial information.

Set X_i (i = 1 .... N) is the space evaluation unit of land, and the spatial coordinates is (xi, yj). land evaluation factors subordinate to X_i (i = 1 .... N) constitute a r-dimensional sampled data information space. C is the the spatial similarity matrix of X_i (i = 1 .... N) based on sampled data of land evaluation factors. Z is a Mimetic Structure of X_i (i = 1 .... N),in this mimetic Structure, Xi's spatial coordinates is (u_i , v_i). The process of land evaluation based on MDS can be expressed as:

$$\begin{cases} C=t\{X_i\}\ (i=1\ldots.n): \text{ t is the similarity measure matrix constructor;} \\ Z=H\{C\}: \text{ H is constructor to form Mimetic Structure;} \\ F'=E\{(u_i,\ v_i)\}: \text{ is spatial clustering for Xi Based on } (u_i, v_i) \text{ the, E is the analysis process;} \\ F=Q\{F'\}: \text{ F is cluster expression of the land evaluation space unit based on } (x_i, y_i) \text{ , Q is the} \end{cases}$$

transformation process of F' to F .

4. Realizing Model

Taking expropriation division in Xuzhou city as an example, Realizing the Model of land evaluation based on MDS as follows.

3.1 Establishing multi-dimensional information space

Taking village-level administrative areas as the basic spatial unit,and Taking Annual output value of unit land area (PV), affect degree of central city (CD), accessibility to roads (RD), external transport facilitation degree (TD) status of land use (LU), land supply and demand (LS), the local economic development (EL) as the information dimension,establish multi-dimensional information space:

$$y_i\ (pv_i,\ cd_i,\ rd_i,\ td_i,\ lu_i,\ ls_i,\ el_i)$$

Where pv_i, cd_i, rd_i, td_i, lu_i, ls_i, el_i is the regular, standardized property value of annual output value per unit area (PV), center city degree (CD), accessibility to roads (RD), external transport facilities degrees (TD) land-use conditions (LU), land supply and demand (LS), the local economic development (EL).

3.2 The similarity structure of spatial cells

Taking pv_i, cd_i, rd_i, td_i, lu_i, ls_i, el_i as distance measure, establish Euclidean distance similarity measure between spatial unit i, j:

$$s_i=\sqrt{(pv_j-pv_i)^2+(cd_j-cd_i)^2+(rd_j-rd_i)^2+(td_j-td_i)^2+(lu_j-lu_i)^2+(ls_j-ls_i)^2+(el_j-el_i)^2}$$

taking s_i as a similarity measure to establish spatial attribute similarity matrix of Expropriation Division as a table1 (Local)

Tab.1 Similarity Matrix of Spatial Cells' Attribute

	Zhangxiaolou	Zhangzhuang	Xinjian	Liumalu	Pangzhuang	Shixi	Shidong	Linhuang	Chengzhuang	Gushan	Wangxinzhuang	Zhoutun	Yangxi
Zhangxiaolou	0.000												
Zhangzhuang	0.040	0.000											
Xinjian	0.100	0.137	0.000										
Liumalu	0.233	0.247	0.181	0.000									
Pangzhuang	0.493	0.467	0.529	0.422	0.000								
Shixi	1.515	1.477	1.591	1.535	1.127	0.000							
Shidong	0.277	0.284	0.238	0.063	0.373	1.494	0.000						
Linhuang	0.325	0.361	0.276	0.430	0.804	1.836	0.493	0.000					
Chengzhuang	0.443	0.477	0.343	0.314	0.724	1.846	0.353	0.380	0.000				
Gushan	0.779	0.774	0.755	0.577	0.456	1.383	0.516	1.001	0.737	0.000			
Wangxinzhuang	0.555	0.556	0.520	0.340	0.374	1.455	0.282	0.759	0.508	0.242	0.000		
Zhoutun	0.267	0.307	0.180	0.290	0.693	1.770	0.352	0.159	0.241	0.848	0.606	0.000	
Yangxi													
Yangdong	0.381	0.392	0.324	0.148	0.428	1.554	0.113	0.547	0.316	0.456	0.214	0.392	0.179
Wutun	0.439	0.464	0.352	0.235	0.594	1.721	0.244	0.495	0.171	0.566	0.339	0.337	0.215
Liwo	1.056	1.061	1.005	0.827	0.819	1.698	0.779	1.204	0.862	0.368	0.510	1.045	0.859
Liulou	0.927	0.938	0.863	0.693	0.781	1.766	0.654	1.037	0.680	0.384	0.422	0.879	0.714
Tianqi	0.753	0.771	0.675	0.525	0.738	1.815	0.502	0.815	0.445	0.471	0.368	0.660	0.529

3.3 Coordinates calculation of mimetic structure

Using ALSCAL in MATLAB to calculat the space coordinates (u_i, v_i) in mimetic structure for each spatial unit as shown in Table 2:

Tab.2 Spatial Cells' Coordinate in Common Mimetic Structure

Village Name	Coordinate		Village Name	Coordinate		Village Name	Coordinate	
qianpantao	-0.072	0.741	zhaowu	-0.478	-0.184	xiadian	1.071	0.043
jingshan	-0.23	-0.134	zhangtun	-0.223	-0.226	huangshan	0.63	-0.35
dahuangshan	-0.418	-0.029	dahan	-0.384	-0.125	luotuoshan	1.075	-0.145
kelianzhuang	-0.54	-0.066	lizhuang	-0.564	-0.039	shizishan	0.858	0.046
wangkele	-0.73	-0.144	mazhuang	-0.517	-0.044	xiahetou	0.275	-0.054
langgudun	-0.825	-0.265	dingzhuang	0.344	1.241	sanguanmiao	0.727	0.011
xiaohuangshan	-0.765	-0.294	shanghetou	-0.097	-0.384	houshanwo	0.844	-0.224
xizhujia	-0.739	-0.259	dawangmiao	0.108	0.555	jianshan	0.46	0.102
qianwangjia	-0.866	-0.083	chengzhuang	-0.208	0.566	taishan	0.617	0.125
poli	-0.784	-0.138	liupu	-0.509	-0.254	chapeng	0.375	0.224
damiao	-0.777	0.41	chaan	-0.229	0.908	dashantou	0.32	0.339
anran	-0.589	0.365	liuji	-0.365	-0.752	hanshan	0.671	0.23
gushan	-0.474	0.443	zhaodian	-0.285	0.083	xingshanzi	0.179	0.34
zhangzhuang	-0.653	-0.04	sundian	-0.258	0.291	shizhuang	-0.06	0.106
houyao	-0.66	-0.161	pantang	-0.518	-0.009	qunying	0.002	0.119
houji	-0.575	0.303	jianglou	-0.557	-0.197	dinglou	-0.03	-0.104
qianyao	-0.562	0.169	tangfang	0.078	0.147	sushan	0.399	0.193
hetao	-0.604	0.483	cuizhuang	0.535	0.922	huohua	0.326	0.242
dongcun	-0.58	0.205	duanshan	0.129	-0.108	duanzhuang	0.878	-0.464
houba	-0.688	-0.077	caoshan	-0.135	-0.229	shangshan	-0.354	0.487

qianba	-0.855	-0.001	fengzhuang	-0.3	-0.166	donghe	-0.13	0.347
dahu	-0.607	-0.021	yaozhuang	0.58	0.157	xihe	-0.019	0.01
qiaohu	-0.102	-0.137	shili	0.505	-0.091	bali	0.976	-0.146
changshan	-0.42	-0.322	wafang	0.944	0.111	tunli	0.037	0.185
tushanshi	-0.041	-0.338	dianzi	0.641	-0.074			

*Coordinate value ois the relative value of 1 / 1000 as the basic unit

3.4 Spatial clustering in mimetic structure

Realizing spatial visualization of mimetic structure according to coordinates (u_i, v_i) as shown in Figure 1and realizing spatial cells aggregation according to spatial relations in mimetic structure as shown in Figure 2.

Fig.1 Mimetic Structure of Spatial Cells

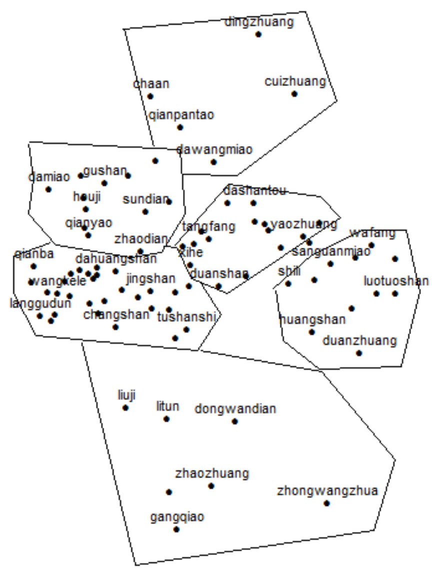

Fig.2 Partitioning Mimetic Structure

3.5 Implementation of expropriation division

Transform the classification of spatial cells in mimetic structure into real space to achieve expropriation division, results of the division shown in Figure 4. Figure 5 is the map of actual expropriation distribution, in Xuzhou city. Comparison of Figures 4 and 5, Comparison of Figures 4 and 5, both the spatial distribution between the two is consistent. Indicating the land evaluation method based on MDS meets the requirements of land classification.

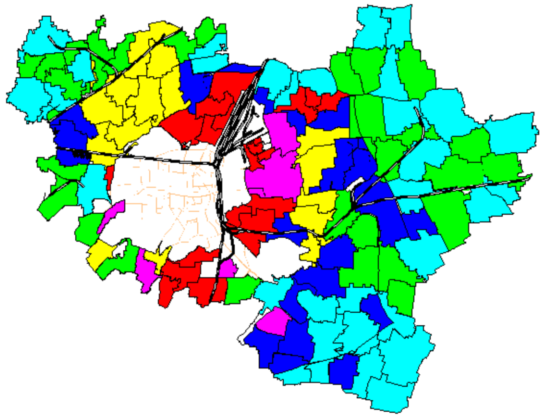

Fig.4 Land Requisition Blocks Partitioned by Multidimensional Scaling

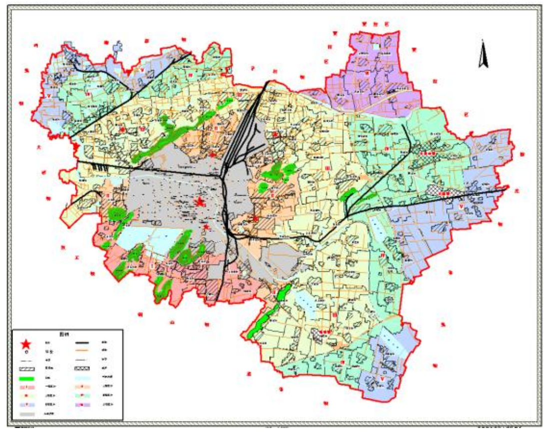

Fig.5 Actual Land Requisition Blocks of Xuzhou city

4.Summary

Land evaluation based on MDS does not rely on priori assumptions, the basic approach is to transform the data into a similar space and complete spatial clustering according to the spatial similarity of the data. The example of expropriation division in Xuzhou city shows that the land evaluation based on MDS meets the requirements of land classification.

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