THE UNCERTAINTY INQUIRY OF LAND PRICE INFORMATION BASED ON CLOUD MODEL

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ABSTRACT:

This paper takes the cloud model into land price information inquiry, using cloud model to express the spatial concept and the attributes of spatial entity described with qualitative language, it integrates the fuzziness and randomness of land price spatial information and attribute information and then realizes the quantitative conversion of qualitative language. At last, it realizes the uncertain inquiry of land price data with the help of GIS.The results shows that this method integrates the fuzziness and randomness, which makes the inquiry results more random and agglomerate, and gets more flexibility and representationalism than the fuzzy query method based on the fuzzy sets.

1. INTRODUCTION

Land price information inquiry is one of the important applications of urban land evaluation results. At present, the information inquiries in all the spatial information systems are all mutual search based on the accurate attribute values or the scope of attribute values or precise location of space, which are not conducive to get information conveniently for non-professional users. Some researchers take fuzzy theory into GIS to realize fuzzy inquiry. They define some membership functions of some language value. Then, Users enter the query expression containing language value, and turn the fuzzy expressions to accurate enquiry expression to realize fuzzy inquiry. This method brought convenience to the users in some degree, but it can't represent the uncertainty due to the exactness of membership functions. This paper tries to take the cloud model into land price information inquiry, uses cloud model to express the uncertainty of land price data space location and description of attribution, and realizes the uncertain inquiry of land price information by uncertain reasoning and GIS inquiry modules.

2. SPATIAL CONCEPTION EXPRESSION BASED ON CLOUD MODEL

The uncertain expressions and processing of spatial entity is one of the active researching field of GIS.The uncertainty models of spatial entity location include point, line and polygon models. The processing methods are mainly probability statistical method and fuzzy math method. We often use the former method to deal with spatial data error and other random problems, and use the latter method to deal with fuzzy problems. Because of the incompleteness of traditional fuzzy set theory, the expression and processing of the uncertain problems which include both fuzziness and randomness are not well solved.

Spatial conceptions are always have fuzziness. The more complex and abstract the conception is ,the more the fuzziness is.

To the same element in the domain,differernt person gives different membership grade. So, there are randomness when we use membership grade to describe the fuzziness. Against the uncertainty of spatial data , this paper brings forward cloud models of uncertain point ,uncertain line, uncertain area and uncertain direction to express the uncertainty of spatial conceptions and the conversion between qualitative conceptions and quantitative values.

2.1 uncertain point

Uncertain point is expressed by two-dimensional normal cloud model just like $P(Ex, Enx, Hex, Ey, Eny, Hey)$ (Ex, Ey) is the x、y coordinate of Point concept centre, which means the points whose membership grade is 1.

$Eny◆Hey$ and $Enx◆Hex$ are the entropies and ultra-entropies in x,y directions. We often suppose that the entropies and ultra-entropies in x,y directions are the same . So we can use four parameters to express an uncertain point. The generation algorithm of uncertainty point cloud model is as follows

（1） $◆x_i, y_i◆= G(Ex, Enx, Ey, Eny)$

Generating a two-dimensional normal random number (x_i, y_i) , which takes (Enx, Eny) as its expectation and (Ex, Ey) as its standard deviation ;

（2） $◆Enx'i, Eny'i◆= G(Enx, Hex, Eny, Hey)$

Generating a two-dimensional normal random number $◆Enx'i, Eny'i◆$, (Enx, Eny) which takes as its expectation and (Hex, Hey) as its standard deviation;

（3） Calculating

$$\mu_i = \exp(-\tfrac{1}{2}(\frac{(x_i - Ex)^2}{Enx'i^2} + \frac{(y_i - Ey)^2}{Eny'i^2})) \text{ ,suppose}$$

(x_i, y_i, μ_i) as cloud drop.

We use uncertain point cloud model to express conceptions such as : "the surrounding of Hongshan square", "the places near the hilltop" and other spatial conceptions.

2.2 Uncertain line

Uncertain line is expressed by two-dimensional normal cloud models L（Iine,En,He）. Line is the spatial location of a precision line which represents the expectation of the uncertain line,En and He are the entropy and ultra-entropy of the line.To a special point P（x,y） in the two-dimensional domain,the membership grade that it belongs to the line is calculated as follows:

（1） Calculating the distance between point P to line L, d=Dist（P,Line）;

（2） Generating a normal random number En' , which takes En as its expectation and He as its standard deviation, $En' = G(En, He)$;

（3） Calculate $\mu = \exp(-\frac{d^2}{2En'^2})$, membership grade is a random value that can be generated several times according to our needs.

Uncertain line cloud model is used to express spatial concepts such as "the location along Beijing-Guangzhou railway line", "along Changjiang River" and so on.

2.3 uncertain area

Uncertain area is expressed by two-dimensional normal cloud model A（Area,En, He）,Area is the location of a polygon that means the expectation of this uncertain area , En and He are the entropy and ultra-entropy of the area. To a special point P（x,y） in the two-dimensional domain , the membership grade that it belongs to the area is calculated as follows:

(1) Judging that point P locates the inside or outside of area A. If inside,   , else, turn to（2） ;

(2)Calculating the distance between point P to area A, d=Dist(P,Area);

(3) Generating a normal random number En', which takes En as its expectation and He as its standard deviation, $En' = G(En, He)$,

(4) Calculating $\mu = \exp(-\frac{d^2}{2En'^2})$, membership grade is a random value that can be generated several times according to our needs.

Uncertain area cloud model is used to express spatial concepts such as "central areas of Wuhan"," city suburbs" and so on.

Besides, cloud model is also used to express uncertain direction ,uncertain distance to represent "east"、 "west"、"south"、"north"、"northeast"、"southeast" and "far", "near" and other language values. In general，Clouds model integrates the fuzziness and randomness of spatial conception, unified portrait the uncertainty of spatial concepts and conversion between qualitative description and quantitative value , and

supplys a foundation to the uncertainty inquiry based on cloud model.

3. UNCERTAINTY INQUIRY BASED ON CLOUD MODEL

The basic idea of uncertainty inquiry based on cloud model is like this: users define uncertainty inquiry expression that includes language values. These qualitative language values are expressed by cloud model and turn to a precision expression by a explanation and conversion module and finally realize the inquiry function of GIS by the precision expression.

In uncertainty inquiry , cloud models are used to express parcel location, land price level, sample types, classes and other qualitative language values of spatial attribution. The expression of uncertain enquiries are input by mouse operation, icons importation or the way similar the importation of natural language.

Suppose that T is a language value expressed by cloud model (Ex, En, He) , we can convert the uncertain expression " x is T " to precision general expression. The method is as follows:

(1) $En' = G(En, He)$,generating a normal random number that takes En as its expectation and He as its standard deviation;

(2) According to different situation, " x is T "can be converted to:

$x \le Ex + \sqrt{-2\ln\mu}En'$, if T is half-drop cloud, e.g. "the price is low";

$Ex - \sqrt{-2\ln\mu}En' \le x \le Ex + \sqrt{-2\ln\mu}En'$, if T is a whole cloud,e.g. "the price is moderate";

$x \ge Ex - \sqrt{-2\ln\mu}En'$ if T is half-rise -cloud，e.g. "the price is high". $\mu = 1$

μ is the membership degree , eg.0.7, means that when the value is greater than or equal to 0.7, we can consider it as this qualitative language value.

For the two-dimensional situation, uncertain expression"

$(x, y) \quad is \quad T(Ex, Enx, Hx, Ey, Eny, Hy)$,,

can be converted to precision general expression as follows:

(1) $(Enx', Eny') = G(Enx, Eny, Hx, Hy)$, generating a two-dimensional normal random number (Enx', Eny') ,which takes (Enx, Eny) as its expectation and (Hx, Hy) as its standard deviation;

(2) The expression is converted

$$\frac{(x-Ex)^2}{Enx^{'2}} + \frac{(y-Ey)}{Eny^{'2}} \leq -2\ln\mu$$

to .The result are numbers within the scope of an ellipse.

In practice, we can use kinds of mature GIS software to realize the uncertainty inquiries aforementioned. For example ,we use Avenue,MapObjects and other development language to develop modules to generate cloud model as well as moduels that explain and covert inquiry expressions. Users input inquiry expressions and membership degree threshold through interface dialog, and then be converted to general expression and realize inquiry and auto-tagging by GIS software.

An uncertain expression can be converted to different precision expression at different moments. So the inquiry results are random. This inquiry is more flexible than the one based on fuzzy set theory. It can simulate and express the uncertain recognizing of different users and a same user in different conditions.So,the uncertainty inquiry based on cloud model can express the fuzziness of inquiry languages and the randomness of fuzzy recognize.

4. THE EXPERIMENT ABOUT THE UNCERTAINTY INQUIRY OF LAND PRICE INFORMATION

We take the database from Bao'an district of Shenzhen city for the experiment about the uncertainty inquiry of land price information. The engineer's scale is 1：5000. The inquiries are as follow.

Example 1, seek high-price commerce zone in the city

Take the layer of the city parcel's commerce land price datum as the present one. Input the inquiry expression "Price=High" in the inquiry dialog box. The land price attributes of the parcel layer, which are generalized by the cloud model, are expressed as these five qualitative linguistics value "high"、 "comparatively high"、"moderate"、"comparatively low "、"low". The cloud characteristic of the land price whose qualitative linguistics value is "high" is (1840,35.94,1).The inquiry expression "Price=High" is transformed into different accurate expressions under different moments, e.g. "Price>=1785"、 "Price>=1821" and so on, and the corresponding result of the inquiries are separately 172 parcels and 97 parcels .Transforming the expectation of the accurate expression to "Price>=1803", the result of the inquiries is 103 parcels . Figure.1 is a typical inquiry result.
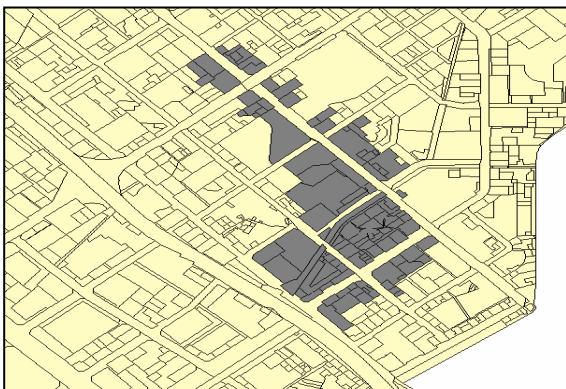

Figure1 City's commercial high-price zone

Example2. seek the status of the commercial land price of the vicinity around Taihua market.

The cloud model numerical characteristic of the linguistics value of the uncertainty point " vicinity" is（Point,350,45）, Taking the expectation "Distance<=392" in the inquiry expression "Distance=Close", which changes with different moment , as the inquiry presupposition, and overlaying the layer of the city parcel's commercial land price with the layer of the commerce center, we can get the parcels of the vicinity around Taihua market in 392 miles and reveal its information about land price. Figure 2 is a typical inquiry result.
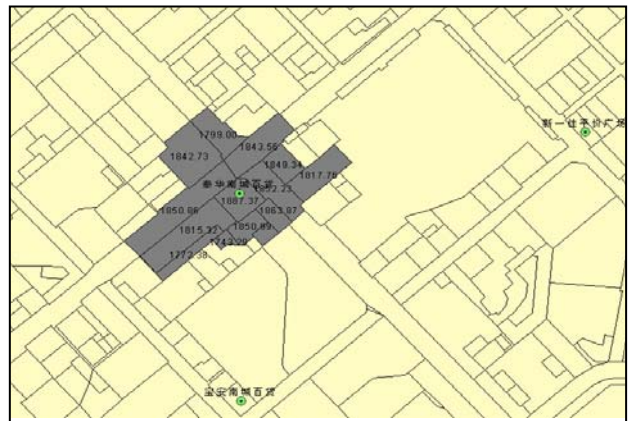

Figure2 The status of land price around Taihua market

Example 3. seek the land price information about the rim of Qianjin Road

The cloud model numerical characteristic of the linguistics value of the uncertainty line "rim" is（Line，50，12）, Taking the expectation "Distance<=58" in the inquiry expression "Distance=Close", which changes with different moment , as the inquiry presupposition, and overlaying the layer of the city parcel's commercial land price with the layer of road, we can get the parcels of the rim of Qianjin Road in 58 miles and reveal its information about land price. Figure 3 is a typical inquiry result.
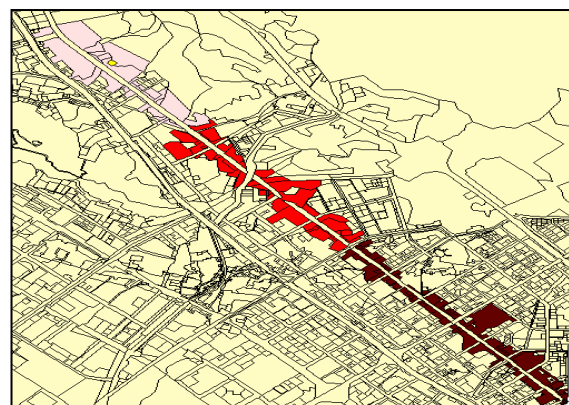

Figure3 Commercial land prices information surrounding Qianjin road

5. CONCLUSION

This paper directs towards the uncertainty inquiry of land price information, brings forth the expressions based on cloud model of the spatial conceptions such as uncertain point, uncertain line, uncertain area and uncertain direction, it integrates the fuzziness and randomness of land price spatial information and attribute information and realizes the quantitative conversion of qualitative language though the uncertainty reasoning .At the same time, it realizes the uncertain inquiry of land price data with the help of GIS. The results shows that this method integrates the fuzziness and randomness, which makes the inquiry results more random and agglomerate, and gets more flexibility and representationalism .

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REFERENCES

Li Deren, Wang Shuliang and Li Deyi. Spatial Data Minning Theories and Applications, Science Press, Beijing,2006.

Li Deyi. Artificial Intelligence with Uncertainty[M]. Beijing:National Defence Industry Press,2005

Di Kaichang. Spatial Data Mining and Knowledge Discovery[M]. WuHan:WuHan University Press,2003.

Wang Shuliang. Data Field and Cloud Model Based Spatial Data Mining and Knowledge Discovery[D].Wuhan: Wuhan University,2002

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