Relationship between Residential Area Distribution and Terrain Factors

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Abstract. Taking residential area as the research object, combined with variable dimension fractal theory, the influence degree of different terrain gradient of elevation, slope and aspect on the number distribution of residential area is studied. The results show that: there are three order cumulative and variable dimension fractal distribution characteristics between the number of residential area distribution and elevation, and the second-order cumulative and variable dimensional fractal distribution between the number of residential area distribution and slope aspect and slope. The influence degree of each topographical factor on the number distribution of residential areas from high to low is slope aspect > slope > elevation.

Keywords: Residential Area, Terrain Factor, Variable Dimension Fractal Theory

1. Introduction
Topography has an important impact on the structure and pattern of terrestrial ecosystem, human production and social activities. Residential area is the gathering place of human production and life. It is a manifestation of the relationship between human society and environment, and the separation degree of spatial distribution of residential areas can reflect the economic situation of the region to a certain extent. In recent years, more and more scholars at home and abroad combined with digital elevation model data to analyze the relationship between residential distribution and topography.

Taking administrative village as the research object, this paper selects elevation, aspect and slope as three terrain factors, uses the spatial analysis function of ArcGIS 10.2, and based on the variable dimension fractal theory, comprehensively analyzes the separation degree of residential areas and the relationship between the spatial distribution of residential areas and topographic factors, and reveals the distribution law of residential areas and the impact of topography on the number of residential areas. The research results are helpful to the overall planning and utilization of land and the construction of new countryside [1-4].

2. Data Sources and Processing in the Study Area
The research data mainly includes the national 1:1 million basic geographic data set in 2017, from
which the administrative division data is cut out; the residential area data set in 2018 is used to cut out the residential area data; the 30 m digital elevation model grid data of the research area can extract the terrain factor information such as elevation, aspect and slope [5].

Based on 30m DEM grid data, elevation, slope and aspect are selected as analysis indexes. According to the natural environment conditions in the study area, the elevation is divided into six grades, and the slope and aspect are divided into eight grades. Combined with the spatial statistical function of ArcGIS 10.2, the number of residential areas on different terrain positions of elevation, slope and aspect is analyzed.

3. Research Methods

3.1. Variable Dimension Fractal Method

For the nonlinear problem of any fractal dimension D in double logarithmic coordinates, it can be transformed into the form of constant dimension fractal by changing dimension fractal. Then the theory of variable dimension fractal can be introduced to study the sensitivity of residential area distribution to different terrain factors. The expression is as follows:

\[ D = F(r) \]  

Taking the number of settlements on a certain terrain position of a certain terrain factor in the study area as \( N(r) \) and the grading level of terrain level as \( R \), the first or multi-order cumulative sum series transformation is carried out until it is converted into the form of constant dimension fractal [6].

4. Results and Analysis

4.1. Distribution characteristics of topographic factors and residential area number

The number of residential areas on different terrain positions of elevation, slope and aspect is analyzed by ArcGIS 10.2. Research shows that the number distribution of residential areas in the study area has the characteristics of relatively low-level terrain position which is relatively concentrated in terrain factors, and decreases with the increase of terrain level. For example, in terms of elevation, residential areas are mainly distributed in 350-550 m, accounting for 80.05% of the total number of residential areas. From the elevation of 550 m, the number of residential areas decreases with the increase of elevation, the residential areas is mainly distributed in the range of 0° to 20° with the proportion of 75.85%. When the slope is greater than 20°, the number of residential areas decreases with the increase of slope; in aspect of aspect, the proportion of residential areas in each slope direction has no significant difference, and the proportion of residential areas in the East, northeast and southeast is 40.26%.

4.2. Variable dimension fractal characteristics of terrain factors and number of settlements

| Topographic factors | Cumulative sum Transformation Times | Fractal dimension value | Correlation coefficient |
|---------------------|-------------------------------------|------------------------|------------------------|
| Elevation           | 3                                   | 3.415                  | 0.978                  |
| Slope               | 2                                   | 1.347                  | 0.999                  |
| Aspect              | 2                                   | 1.703                  | 0.995                  |

Based on ArcGIS 10.2 platform, after re classification, the number of settlements in different topographical factors is obtained. On this basis, combined with formula (1), the cumulative sum of different terrain factors is obtained through the sequence transformation of cumulative sum, and the scatter map of cumulative sum sequence corresponding to different terrain factors is made by combining excel In order to select the best fitting results, the results of the segmented variable dimension to the settlements and terrain factors, and the segmented variable dimension sequence diagram of settlements on the shape and position gradients of different terrain factors can be selected.
It can be seen from Table 1 that the correlation coefficients of the piecewise variable dimension fitting function of the three terrain factors in the study area after 1-order or multi-order accumulation and variable dimension fractal transformation are above 0.978, which indicates that the data point sequence has good linear relationship. The cumulative sum Transformation Times of elevation are 3, the fractal dimension value is 3.415, the cumulative sum Transformation Times of slope are 2, the fractal dimension value is 1.347, the cumulative sum Transformation Times of slope aspect are 2, and the fractal dimension value is 1.703. It can be seen that the cumulative sum Transformation Times and fractal dimension values corresponding to each terrain factor are not exactly the same, which indicates that the distribution of the three terrain factors on the number of residential areas in the study area is different. There are obvious differences in the degree of influence and sensitivity [11-15].

Figure 1. Sequence diagram of the number of settlements and elevation accumulation and segmented fractal dimension

It can be seen from Figure 1 that there are three-order cumulative and variable dimension fractal distribution characteristics between the number of settlements and the elevation, which indicates that the number distribution of settlements has the lowest sensitivity to elevation, and also shows that the influence of elevation on the number distribution of residential areas is relatively weak [7].

Figure 2. Sequence diagram of cumulative number and graded fractal dimension of distribution
Figure 3. Sequence diagram of cumulative number and aspect fractal dimension of residential area distribution quantity and aspect

It can be seen from Figure 2 and figure 3 that there are two order cumulative and variable dimension fractal distributions among the residential area distribution, aspect and slope, which indicates that the fractal characteristics of these two factors and residential area are relatively complex. It can be seen from Table 1 that the fractal dimension of aspect is 1.703 and the fractal dimension of slope is 1.347 among the two terrain factors with cumulative sum transformation times of 2. Compared with the fractal dimension value of slope aspect, the fractal dimension value of slope aspect is the highest, which indicates that the influence degree of aspect on the distribution of residential area number is the highest, and the sensitivity of residential area distribution to slope aspect is the highest, followed by slope [16-20].

In conclusion, the sensitivity of residential area distribution to elevation, slope and aspect is from high to low: aspect > slope > elevation.

5. Conclusions
With the help of variable dimension fractal theory, this paper studies the influence of different terrain factors on the number and distribution of residential areas, getting three main conclusions:

(1) Residential area is the place where human beings live and produce. Its distribution is the result of human adaptation to the natural environment for a long time. The number of settlements is distributed in different topographic gradients of elevation, slope and aspect. The dominant topographical position of the number of residential areas in the study area is elevation 350-550 m, Southeast, East and northeast slope directions, and the gradient is 0 ° to 20 °. In the terrain position after the dominant terrain, the number of settlements decreases with the increase of elevation, slope and aspect.

(2) By calculating the cumulative sum sequence of the number of settlements and different terrain factors, the results show that the number of settlements and elevation presents a third-order cumulative and fractal distribution, and the fractal dimension value is 3.415, which indicates that the sensitivity of the number of settlements to elevation is the lowest; the number of settlements and slope aspect are of second-order cumulative and fractal distribution, and the fractal dimension values are 1.347 and 1.703 respectively, and the fractal dimension value of slope aspect is the most. This indicates that the slope aspect has the highest influence on the distribution of residential area number, and the sensitivity of residential area quantity distribution to slope aspect is the highest, and the slope is the second. The sensitivity of residential area distribution to terrain factors is slope aspect > slope > elevation.

(3) It is feasible to use the variable dimension fractal theory to study the relationship between the distribution of residential areas and the influence degree of terrain factors. By transforming the variable dimension fractal into the constant dimension fractal, the sensitivity of residential areas to various terrain factors can be quantitatively reflected, which can provide a new research direction for the future Research on the relationship between settlements and topography.
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