Application of Contact Number in Suitability Evaluation of Human Settlement Environment—Taking Jiangxi Province as an Example

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Abstract. The human settlement environment is a dynamic subsystem in which people live, produce and live in the social system, and is constantly evolving. Aiming at how to comprehensively evaluate the suitability state of a given human settlement environment in a certain time and space and the evolutionary trend of this state, the set pair analysis theory and its partial connection numbers are introduced into the suitability evaluation of human settlements, and the set of human settlements is established. Analyze and evaluate the model and apply it to the suitability status and development trend of human settlements in Jiangxi Province from 2013 to 2016. The results show that the suitability of the province from 2013 to 2016 is between excellent and good, and it is going every year. The direction of more livable development, the intensity of development trend is between 0.5 and 0.53, suggesting that the relevant government decision-making departments need to continuously increase the investment in the livability of the province's human settlements, and ensure that the environmental livability is not weakened.

Introduction

The human settlement environment is an artificial environment built on the basis of the natural environment. It is a dynamic system in which people live, produce and live in a large social system, and is constantly evolving[1]. As China's economy continues to develop rapidly, the wave of urbanization is intensifying. Urbanization brings abundant material enjoyment and convenient living facilities and efficient information exchange. It also brings people such as environmental pollution, traffic congestion, and housing shortages. The problem of deteriorating living environment and the suitability of human settlements have become the focus of current research.

Set Pair Analysis and Partial Contact Number

Set Pair Analysis

The basic idea of set pair analysis is to study all the relationships of the two sets in the set of problems in a certain problem background, and divide these relationships into two categories and several small classes of certain relationships and uncertain relationships. A class of relationship numbers, get the set of feature functions—the number of contacts, and then use the number of contacts to establish a mathematical model of the problem, with the help of models to carry out related research. It is characterized by the organic combination of deterministic mathematical modeling and systematic analysis of uncertainty, “objective recognition, systematic description, quantitative description, and specific analysis” of the uncertainty of the research object and research process[2].

Partial Contact Number

The partial contact number is a companion function of the number of contacts[3]. For a set pair of two given sets H = (A, B), under a specific problem background (W), the characteristics of the set pair H are analyzed, and a total of N characteristics are obtained, of which S are The two sets A and B in the
set pair H have relative certainty; the two sets are opposite in the P characteristics, and also have relative certainty, and the other F=N-S-P characteristics are not mutually opposite and not shared by these two sets, with relative uncertainty, use:

\[ \mu = \frac{S}{N} + \frac{F}{N} i + \frac{P}{N} j \]  

As a set of features for \( H = (A, B) \) in the context of a given problem. Make:

\[ a = \frac{S}{N}, b = \frac{F}{N}, c = \frac{P}{N} \]

\[ \mu = a + bi + cj \]  

In the formula: \( \mu \) called the degree of connection, \( a,b,c \) which is called the degree of identity, the degree of difference and the degree of opposition, collectively referred to as the connected component; \( a,b,c \in [0,1] \) it is a real number, and satisfies the normalization condition \( a + b + c = 1 \), because it has three associated components, also called the normalized ternary The degree of connection, or the number of ternary contacts, referred to as the number of contacts, \( i \) which is the difference coefficient \( i \in [-1,1] \), \( j \) is the coefficient of oppositeness, and the value \(-1\) is specified in the number of positive and negative links.

The number of contacts is a system, hierarchical. First of all, \( a,b,c \) of \( \mu \), in the "+1" "+ -" indefinite, "-1" three different levels; followed a,b,c by the determination, \( i \) is a pending number, you need to go deep into one or more levels of analysis before you can get the value; The hierarchy of the number of contacts is also malleable. The number of ternary links shown in equations (1) and (2) can be expanded as needed to obtain the number of multiple connections:

\[\begin{align*}
\mu &= \frac{S}{N} + \frac{F}{N} i_1 + \frac{F}{N} i_2 + \ldots + \frac{F}{N} i_{n-2} + \frac{P}{N} j \\
&= a + b_i + c_j \\
\end{align*}\]  

Can be abbreviated as:

\[ \mu = a + bi + cj \]  

Take \( n=5 \) in equations (3) and (4), and get the commonly used five-member linkage equation (5) (6)

\[\begin{align*}
\mu &= \frac{S}{N} + \frac{F}{N} i_1 + \frac{F}{N} i_2 + \frac{F}{N} i_3 + \frac{P}{N} j \\
&= a + b_i + c_j + d_k + e_l \\
\end{align*}\]  

By using the hierarchical nature of the connected components in the number of contacts, the partial number of links of the number of contacts can be derived. The following only gives the partial contact number knowledge of the ternary number associated with the calculation of the example in this paper.

**Definition 1**, with a ternary contact number \( \mu = a + bi + cj \), \( a \in [0,1], b \in [0,1], c \in [0,1], a + b + c = 1 \), \( i \in [-1,1], j = -1 \). Note that the first-order positive contact number of \( a \) is \( b \), then there is

\[ \partial^+ \mu = \partial^+ a + i \partial^+ b = \frac{a}{a+b} + \frac{b}{b+c} - i \]

\[ \partial^+ a = \frac{a}{a+b}, \quad \partial^+ b = \frac{b}{b+c} \]

**Definition 2**, with a ternary contact number \( \mu = a + bi + cj \), \( a \in [0,1], b \in [0,1], c \in [0,1], a + b + c = 1 \), \( i \in [-1,1], j = -1 \). Note that the first-order negative contact number of \( \mu \) is \( \partial^- \mu \), then
\[ \partial^* \mu = i \partial^* b + j \partial^* c = \frac{b}{a + b} i + \frac{c}{b + c} j \]  

Further, there is a first-order all-bias contact number definition of the ternary contact number: 

Definition 3, with ternary contact numbers \( \mu = a + bi + cj \), \( a \in [0, 1] \), \( b \in [0, 1] \), \( c \in [0, 1] \), \( a + b + c = 1 \), \( i \in [-1, 1] \), \( j = -1 \). Then the first-order all-bias connection number is the algebraic sum of the

first-order partial positive connection number and the first-order partial negative connection number, and the first-order full-bias connection number is \( \partial^\pm \mu \), then

\[ \partial^+ \mu = \partial^+ \mu + \partial^- \mu = \frac{a}{a + b} + \frac{b}{b + c} i + \frac{b}{a + b} i + \frac{c}{b + c} j \]

There is still \( i, j \) in equation (9). Since \( j = -1 \), \( i \) is to be eliminated, for which is defined as 4.

**Definition 4**, with a ternary contact number \( \mu = a + bi + cj \), \( a \in [0, 1] \), \( b \in [0, 1] \), \( c \in [0, 1] \), \( i \in [-1, 1] \), \( j = -1 \), calculate the first-order partial positive connection number

\[ \partial^+ \mu = \partial^+ a + i \partial^+ b = \frac{a}{a + b} + \frac{b}{b + c} i \]

and calculate the second-order positive correlation number \( \partial^{2+} \mu \), which is denoted as

\[ \partial^{2+} \mu = \partial^+ (\partial^+ \mu) = \frac{\partial^+ a}{\partial^+ a + \partial^+ b} \]

In the equation, \( \partial^+ a = \frac{a}{a + b} \), \( \partial^+ b = \frac{b}{b + c} \).

The physical meaning of equation (11) is that \( \partial^+ a \) in equation (10) is also at the level of \( i \partial^+ b \), and

\( i \partial^+ b \) is evolved from the hierarchy to the forward direction. Therefore, using \( \frac{a}{a + b} \) to remove \( \left( \frac{a}{a + b} + \frac{b}{b + c} \right) \), the second-order evolution of \( \mu \) is obtained. Rate \( \partial^{2+} \mu \). Similarly, there is a second-order partial evolution rate \( \partial^{2-} \mu \) of \( \mu \), defined as follows.

**Definition 5**, with the ternary contact number given by definition 4, and known that the first-order partial contact number is \( \partial^+ \mu = i \partial^+ b + j \partial^+ c = \frac{b}{a + b} i + \frac{c}{b + c} j \), then there is a second-order negative contact number

\[ \partial^{2-} \mu = \partial^-(\partial^+ \mu) \]  

\[ \partial^{2-} \mu = \partial^-(\partial^+ \mu) = \frac{\partial^- c}{\partial^+ c + \partial^- b} j \]

In the equation, \( \partial^- b = \frac{b}{a + b} \), \( \partial^- c = \frac{c}{b + c} \). Further, there is a second-order all-bias contact number of the ternary contact number defined by 6.

**Definition 6**, with the ternary contact number \( \mu \) given in Definition 4, and the second-order partial positive connection equation (11) of known \( \mu \), and the second-order partial negative connection equation (12), then the second-order full-bias connection Number \( \partial^{2\pm} \mu \), then

Equation (13) is a real number without the uncertainty coefficient \( i \). The real physical meaning is that when \( \partial^{2\pm} \mu > 0 \), the evolution trend of the system indicating the ternary connection number \( \mu \) at the micro level is a positive trend. When \( \partial^{2\pm} \mu < 0 \), the evolution trend of the system showing the ternary connection number \( \mu \) at the micro level is a negative trend. When \( \partial^{2\pm} \mu = 0 \) the evolution trend of the system with the ternary connection number \( \mu \) at the micro level is in the positive and negative
critical state. Similarly, the quaternary total partial contact number and the five-yuan full partial contact number can be obtained.

\[
\frac{\partial^2 \mu}{\partial^2 a} = \frac{\partial^2 \mu}{\partial^2 b} = \frac{\partial^2 \mu}{\partial^2 c} = \frac{\partial^2 \mu}{\partial^2 j}
\]

\[
= \frac{a + b}{a + b + c} - \frac{b + c}{a + b + c}
\]

(13)

**Evaluation of Suitability of Human Settlements in Jiangxi Province from 2013 to 2016**

**Overview of the Study Area**

Jiangxi Province has a long history. It is located on the south bank of the middle and lower reaches of the Yangtze River. It borders Zhejiang and Fujian in the east, Guangdong in the south, Hunan in the west, and Hubei and Anhui in the north. The climate is subtropical and humid, with abundant natural resources and rich culture. It has a reputation as a country with white cranes and fish. Jiangxi Province has convenient transportation and advantageous geographical location. At the same time, it is at the Golden Cross of the Yangtze River Golden Waterway.

The superior location advantage and unique geographical environment have created the reputation of “Wuhua Tianbao, Renjiediling” in Jiangxi Province. With the rapid development of Jiangxi Province economy and the acceleration of urbanization and industrialization, modernization has presented a new look; At the same time, the living standards have been greatly improved, as well as the problems of serious urban environmental pollution and shortage of resources.

**Selection of Indicators and Evaluation of Suitability of Human Settlements**

This study takes Jiangxi Province as an example to evaluate the suitability of human settlements in this evolution process by understanding the trends and current status of the quality of human settlements in Jiangxi Province from 2013 to 2016, and then summarize the evaluation results. According to the Statistical Yearbook of Jiangxi Province from 2013 to 2016, the Statistical Communiqué of the National Economic and Social Development of Jiangxi Province from 2013 to 2016, and the Communiqué of Jiangxi Province in 2013-2016, the per capita housing area, per capita GDP, water source of Jiangxi Province from 2013 to 2016 The actual water quality compliance rate, the actual data of urban green coverage (Table 1), and the evaluation criteria for the suitability of human settlements (Table 2), and the evaluation of the suitability of human settlements in Jiangxi Province from 2013 to 2016, and judged The short-term development trend of Jiangxi Province in 2013-2016.

<table>
<thead>
<tr>
<th>Year</th>
<th>Urban per capita housing area[m²][q1]</th>
<th>Per capita GDP[¥][q2]</th>
<th>Water source water quality compliance rate[%][q3]</th>
<th>Urban green coverage[%][q4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013[t1]</td>
<td>39</td>
<td>31930</td>
<td>97.59</td>
<td>46.20</td>
</tr>
<tr>
<td>2014[t2]</td>
<td>39</td>
<td>34674</td>
<td>96.46</td>
<td>44.60</td>
</tr>
<tr>
<td>2015[t3]</td>
<td>40</td>
<td>36724</td>
<td>98.40</td>
<td>44.10</td>
</tr>
<tr>
<td>2016[t4]</td>
<td>39</td>
<td>40400</td>
<td>100</td>
<td>42.30</td>
</tr>
</tbody>
</table>
Table 2. Evaluation index system for human settlement environment suitability and its rating criteria (s).

<table>
<thead>
<tr>
<th>Evaluation index</th>
<th>Standard division point of membership degree of &quot;suitability for human settlements&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V</td>
</tr>
<tr>
<td>h1City per capita housing area [m²]</td>
<td>45</td>
</tr>
<tr>
<td>h2Per capita GDP [yuan]</td>
<td>77400</td>
</tr>
<tr>
<td>h3Water source water quality</td>
<td>99</td>
</tr>
<tr>
<td>compliance rate (%)</td>
<td>70</td>
</tr>
<tr>
<td>h4Urban green coverage (%)</td>
<td></td>
</tr>
</tbody>
</table>

**Step 1** Establish a set pair [4]. According to the measured data in Table 1 and the evaluation index system and its grading standards for human settlements in Table 2 are a set pair.

**Step 2** Calculate the degree of identity of q and s at a given indicator level pn. Since the suitability status of the living environment given in Table 2 is divided into V level, IV level, III level, II level, and I level, a total of 5 levels, so the 5 yuan contact number

$$\mu(t) = a(t) + b(t)i + c(t)j + d(t)k + e(t)l$$

is selected as 4 subset pairs \( h_{2013} - s, h_{2014} - s, h_{2015} - s, h_{2016} - s \) characteristic function, where \( a(t) \) represents the sum of the weighted degrees of equality of the t-year indicator value \( q_n (n=1, 2, 3, 4) \) belonging to the V-level, similarly, \( b(t) \) indicates that the t-year index value \( q_n (n=1, 2, 3, 4) \) belongs to the sum of the weighted degrees of the IV level, and \( c(t) \) represents the weight of the t-year index value \( q_n (n=1, 2, 3, 4) \) belonging to the level III. The sum of the same degree, and so on \( d(t), e(t) : i, j, k, l \) as the level mark, when the value needs to be counted, take \( i \in [0.333], j \in [-0.333, 0.333], k \in [-1, 0] \) where \( i = -1 \), \( \mu(t) \) means that the t-year total index value belongs to the contact level of each standard level with.

**Step 3** Calculate the sum of the weighted degrees of equality of the annual total indicator value \( h_n(n=1, 2, 3, 4) \) belonging to a certain level.

The weighted identity of all the indicator values at each level at this level is counted, that is, the contact component corresponding to this level is obtained, thereby determining the corresponding five-way contact number (Table 3) [5]. After calculation, the number of five-way contacts for the suitability of human settlements in 2013 was obtained.

Table 3. Calculation of the five-way number of people's living environment suitability evaluation in 2013.

<table>
<thead>
<tr>
<th>Habitat environment indicator</th>
<th>V级</th>
<th>IV级</th>
<th>III级</th>
<th>II级</th>
<th>I级</th>
</tr>
</thead>
<tbody>
<tr>
<td>City per capita housing area [m²]</td>
<td>0.0065</td>
<td>0.0260</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per capita GDP [yuan]</td>
<td>0.0543</td>
<td>0.1958</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water source water quality compliance rate (%)</td>
<td>0.2465</td>
<td>0.0035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban green coverage (%)</td>
<td></td>
<td></td>
<td>0.2310</td>
<td>0.019</td>
<td></td>
</tr>
</tbody>
</table>

\[ \mu(2013) = 0.3073 + 0.6738i + 0.019j + 0K + 0L \]

The same calculation:

\[ \mu(2014) = 0.3198 + 0.6533i + 0.0270j + 0K + 0L \]
\[ \mu(2015) = 0.3408 + 0.6298i + 0.0294j + 0K + 0L \]
\[ \mu(2016) = 0.3518 + 0.6097i + 0.0385j + 0K + 0L \]

**Step 4** From the theory of the number of pairs of pair analysis, it can be known that the normalized five-member linkage number \( \mu = a + bi + cj + dk + el \) has a value interval of \([-1, 1]\), and the interval of \([-1, 1]\) is divided into five sub-intervals, \([0.6, 1],[0.2, 0.6],[-0.2, 0.2],[-0.6,-0.2],[-0.6,-1]\), which respectively correspond to the "excellence" of the suitability of the human settlement environment, 5 levels of “good”, “medium”, “low” and “poor”. For \( \mu(2013), \mu(2014), \mu(2015), \mu(2016) \), calculate the values of \( i = 0.333, j = -0.333 \) and \( i = 1, j = 0.333 \), respectively, and get
\[ \mu(2014) = [0.5284, 0.982] \]
\[ \mu(2013) = [0.5250, 0.987] \]
\[ \mu(2015) = [0.5407, 0.9804] \]
\[ \mu(2016) = [0.5418, 0.9738] \]

According to the agreement of evaluation and grading, it can be seen that the suitability of human settlements in Jiangxi Province between 2013 and 2016 is between “excellent” and “good”.

**Step 5** Calculate the 4th-order all-bias contact number of the five-member contact number in the assessment of the suitability of human settlements environment in Jiangxi Province from 2013 to 2016. Get:
\[ \hat{\sigma}^{4+} \mu(2013) = 0.5003 \]
\[ \hat{\sigma}^{4+} \mu(2014) = 0.5101 \]
\[ \hat{\sigma}^{4+} \mu(2015) = 0.5195 \]
\[ \hat{\sigma}^{4+} \mu(2016) = 0.5288 \]

Since \( \hat{\sigma}^{4+} \mu(t) > 0 \), it is believed that the development trend of the suitability of human settlements in Jiangxi Province from 2013 to 2016 is developing in a better direction every year, but the intensity of this trend is not very large, between 0.5 and 0.53.

**Step 6** Integrate the evaluation of the suitability of human settlements environment and its development trend in Jiangxi Province from 2013 to 2016. It can be seen that the two are synchronous and inherently harmonious.

**Step 7** Recommends. Considering that the development trend of the suitability of human settlements is not very strong, it is only between 0.5 and 0.53. Therefore, the relevant government departments still need to continuously increase the investment in the suitability of human settlements, and the intensity of the development trend of suitability is not strong. Weakened and continued to work for a resource-conserving and environment-friendly society.

**Conclusion and Outlook**

Result shows that the suitability of human settlements in Jiangxi Province in 2013-2016 is between excellent and good, but biased excellent, and this excellent preferential state has a trend of further development, but its trend strength is not very large, at 0.50-0.53, suggesting that the relevant government decision-making departments need to continuously strengthen the investment in the suitability of human settlements, and maintain The intensity of the development trend of suitability status is not weakened, and efforts are made to build a resource-conserving and environment-friendly society.

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