A Minimum Spanning Tree Clustering Algorithm Inspired by P System

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Abstract. In recent years, urbanization development in Shandong Province is rapidly and turns into a transition period. The main research work in this paper focused on the following aspects: In the first place, we introduce a new method called Membrane Computing in computing which is abstracted from living cells. Then we modify the traditional tissue-like P systems, and the object is viewed as control signal to conduct the rules execution flow. What is more, we summarize a P system model according to tissue-like P System to implement Minimum Spanning Tree (MST) algorithm. On the basis of this, we use the new MST algorithm based P system model to research differences of urbanization development in Shandong Province and solve the realistic problems of the seventeen cities' urbanization level. Finally, we give our advice for Urbanization development such as tax, science and technology plan, finance and insurance, land policy and so on.

Keywords: Urbanization development · Membrane computing
Minimum Spanning Tree algorithm

1 Introduction

1.1 Urbanization

Urbanization is the most significant change in contemporary human society. Urbanization is a "population-economy-space" three-dimensional integration process. Its internal coordination is the key to sustainable urban development. Based on the retrospective analysis of the existing about the quality of urbanization, this paper starts from the economic urbanization, population urbanization, space urbanization three dimensions and its related relation, and establishes the evaluation system of urbanization.

This article selects the data of 2013, and combines P system with MST-based clustering together. Then use the membrane in P system to achieve the whole process of cluster computing. The research results show that the urbanization level of Shandong province has rapidly developed in recent years. Urban population is still leading into the early stages of development in a period of rapid urbanization. However, such cities as Liaocheng and Heze which are in the west of Shandong Province, there is still a large gap compared with the eastern cities. Finally, from the scientific planning and

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population development, economic development, urban space in Shandong Province using four aspects proposed "the population- economy-space" the coordinated development of the related countermeasures. We expect to offer some useful evidence in the smooth implementation of the new urbanization development through the research.

1.2 Membrane Computing

Membrane computing is a new branch of natural computing. As a hot cross-discipline, it includes computer science, mathematics, biology and artificial intelligence, etc. It was initiated by Pãun in 1998, inspired from the structure and the function of biological cells. So, we call it P system sometimes. P system have the characteristics of distribution and highly parallelism, thus have high efficiency. It shows a huge development potential [7].

P system is mainly used to summarize models of computation motivated of a living cell. There are different biochemical reactions in tissues or biological cells. On the basis of these, there are three main types of P system: Cell-like P System, Tissue-like P System and Neural-like P System. As you can see, they are abstracted from cells, tissues and the nervous system respectively. Due to the parallelism, the research in this area developed very fast in the theoretical direction as well as in the direction of applications. Membrane computing has been applied to economics, linguistics, biological modeling, cryptography, computer graphics, and other fields [8].

2 Background

2.1 Significance of Urbanization Research

Shandong Province is a large coastal economic province and there are more than 9600 million people. For the past few years, people's living standards continue to improve. And as we can see, Shandong plays a more and more important role in eastern coastal of our country. This paper starts from three dimensions-population, economic and space. Then build a "population-economy-space" urbanization integrated measure index by P system to analyze the differential development of urbanization in Shandong Province. This can help us know more about the problems in urbanization development [3].

2.2 Progress of Urbanization Research

At present, urbanization is a more systematic and comprehensive research at home and abroad. Urbanization refers to the historical process of human production and life style turn into a modern way from the form of rural. The main performance is the increasing people in cities as well as the process of continuous development and improvement of the city.

Shimou Yao and Dadao Lu proposed the urbanization development strategy of China in a comprehensive and scientific way [4]. Linchuang Fang and Deli Wang have come up with a new method to evaluate the quality of urbanization development which called three-dimensional spherical model. And the model covers 12 economic efficiency indexes from three aspects: the quality of economic development of urbanization, social urbanization development quality and the protection quality of space urbanization. The model is based on Delphi AHP model in order to assign weights related indicators [5]. In the research of urbanization developments, some scholars have focused on the process of urbanization in two areas. Fenggui Chen options two points-the urbanization of population and the land urbanization to measure the level of urbanization in China. According to the research, they proposed that spatial pattern of population urbanization and land urbanization coordinated development has such features as overall low, stage disparities and regional differentiation distinctive [6]. This paper is from a “population-economy-space” three dimensional integration way. The related research is fewer.

3 Approaches

3.1 Tissue-like P System

This paper mainly research Tissue-like P System. Tissue-like P System is an important expansion of the cell-like membrane system. Tissue-like P System includes three basic elements: membrane structure, rules and objects. Membranes divide the whole system into different regions. Rules and objects exist in regions. The outermost membrane is called skin membrane. Basic membrane refers to that there are no membranes in it (Fig. 1).

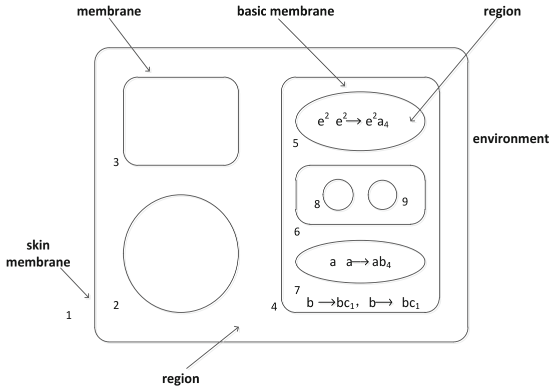

Fig. 1. The structure of P system

Tissue-like P System refers to that many cells are placed freely in the same environment. Both cells and the environment can contain objects. Transport rules are used for communication, not only between cells but also between cells and the environment [9, 10].

3.2 The Membrane Structure of P System

When calculating, the membrane structure of P systems with active membranes changes with the rules. P system can generate space of exponential growth in linear operation steps. It is very useful to solve computationally hard problems in a feasible time frame [12].

In general, P system m is as follows:

$$\Pi = (\mathrm{V}, \mathrm{O}, \mathrm{H}, \quad \mu, \mathrm{w}_1, \ldots, \mathrm{w}_\mathrm{m}, \mathrm{R}_1, \ldots, \mathrm{R}_\mathrm{m}, \mathrm{i}_0). \tag{1}$$

Where:

O is an alphabet. It's elements are called objects;
μ is a membrane structure of degree m, each membrane has a corresponding label
H = {1, 2, …, m} is the label set of $\prod$;
$W_i(\mathrm{i} = 1, 2, \ldots, \mathrm{m})$ is the multiset of objects in membrane i;
$R_i(\mathrm{i} = 1, 2, \ldots, \mathrm{m})$ is the evolution rules of membrane i

The basic evolution rule is a pair (u, v) in the form of (u → v), where u is a string over V and v = v' or v = v'δ where v' is a string over $\{a_{here}, a_{out}, a_{in} \mid \mathrm{a} \in \mathrm{V}, 1 \leq \mathrm{j} \leq \mathrm{m}\}$, and δ is a special symbol not in V. When there is δ in a rule, the membrane will be dissolved after performing the rule. r is promoters or inhibitors and r = r' or r = ¬r'. One rule can execute only the promoters r' appear and one rule can stop only the inhibitors appear. What is more, the radius of the rule u → v refers to the length of u. R is the finite set of the evolution rules. Each R_i is associated with the region i over the membrane structure μ. ρi is a partial order relation over R_i which is called precedence relation. High priority rule is executed prior [11].

3.3 P System for MST Algorithm

The parallel computing feature of P systems can significantly improve the performance of the algorithm. The MST clustering algorithm has advantages in finding irregular boundary clusters [13]. And the constructed P system model can make use to accomplish better clustering. So P system was combined with MST-based clustering together. And use the membrane in P system to achieve the whole process of cluster computing. The rewrite, transport rules in membrane can build a MST. Therefore, we can divide the spanning tree, and obtain k clusters [14, 15].

The form expressions of P system are as follows:

$$\Pi = (\mathrm{O}, \sigma_0, \sigma_1, \sigma_2, \cdots \sigma_\mathrm{n}, \sigma_{\mathrm{n}+1}, \mathrm{ch}, \mathrm{c}_0, \rho)$$

Where

$$\mathrm{O} = (\delta_{11}, \mathrm{a}_1, \mathrm{a}_2, \ldots \mathrm{a}_\mathrm{n}, \alpha_1, \chi_1, \xi_1, \mathrm{T}_0, \varphi, \Phi_1)$$

$$\mathrm{Ch} = \{\{0,1\}, \{0,2\}, \{0,3\} \ldots \{0,\mathrm{n}\}, \{0, \mathrm{n}+1\}, \{\mathrm{n}+1, 1\}, \{\mathrm{n}+1, 2\} \ldots \{\mathrm{n}+1, \mathrm{n}\}, \{\mathrm{n}+1, \mathrm{c}_0\},$$

$$\sigma_0 = (\omega_0, 0, \mathrm{R}_0)$$

$$r_1' = \left\{ A_{i_1,j_1} A_{i_2,j_2} \ldots A_{i_{n-p},j_{n-p}} \to A_{i_1,j_1} A_{i_2,j_2} \ldots A_{i_p,j_p} U_{i_1,j_1}^{w_{i_1,j_1}} U_{i_2,j_2}^{w_{i_2,j_2}} \ldots U_{i_{n-p},j_{n-p}}^{w_{i_{n-p},j_{n-p}}} \right\}$$
$$|1 \le u, v, i_s, j_s, p \le n$$
$$r_2' = \left\{ \delta_{u,v} U_{i_s,j_s}^0 \to \delta_{u+1,i_s} \left(W_{u,i_s,j_s}^{w_{i_s,j_s}} \right)_{in_{n+1}} \left(V_{u+1,i_s} \right)_{in_{1,2,\ldots n}} \middle| 1 \le i_s, j_s, v \le n, 1 \le u \le n-1 \right\}$$
$$r_3' = \left\{ U_{i_1,j_1}^{w_{i_1,j_1}} U_{i_2,j_2}^{w_{i_2,j_2}} \ldots U_{i_{n-p},j_{n-p}}^{w_{i_{n-p},j_{n-p}}} \to U_{i_2,j_2}^{w_{i_1,j_1}-1} U_{i_2,j_2}^{w_{i_2,j_2}-1} \ldots U_{i_{n-p},j_{n-p}}^{w_{i_{n-p},j_{n-p}}-1} \middle| 1 \le i_s, j_s, p \le n \right\}$$
$$r_4' = \left\{ \delta_{n,j_n} \to \eta_{in_{n+1}} \right\}$$
$$\bullet \sigma_i = \left(w_{i,0}, R_i \right) (1 \le i \le n)$$

$$w_{i,0} = a_i, V_{1,1}$$
$$R_i (1 \le i \le n):$$
$$r_1 = \left\{ a_i, V_{s,i} \to V_{s,i} \middle| 1 \le i, s \le n \right\}$$
$$r_{1+p} = \left\{ a_i, V_{1,j_1} V_{2,j_2} \ldots V_{p,j_p} \to a_i, V_{1,j_1} V_{2,j_2} \ldots V_{p,j_p} U_{i,j_1}^{w_{ij_1}} U_{i,j_2}^{w_{ij_2}} \ldots U_{i,j_p}^{w_{ij_p}} \middle| 1 \le i,\ j_p \le n \right\}$$
$$r_{2+p} = \left\{ a_i, U_{i,j_s}^0 \to a_i \left(A_{i,j_s} \right)_{in_0} \middle| 1 \le i, s, j_s \le n \right\} U \left\{ U_{i,j_1}^{w_{ij_1}} U_{i,j_2}^{w_{ij_2}} \ldots U_{i,j_p}^{w_{ij_p}} \to \lambda \middle| 1 \le i,\ j_p \le n \right\}$$
$$r_{3+p} = \left\{ U_{i,j_1}^{w_{ij_1}} U_{i,j_2}^{w_{ij_2}} \ldots U_{i,j_p}^{w_{ij_p}} \to U_{i,j_1}^{w_{ij_1}-1} U_{i,j_2}^{w_{ij_2}-1} \ldots U_{i,j_p}^{w_{ij_p}-1} \middle| 1 \le i,\ j_p \le n \right\}$$
$$r_4 = \left\{ V_{1,j_1} V_{2,j_2} \ldots V_{n,j_n} \to \lambda \right\}$$
$$\bullet \sigma_{n+1} = \left(w_{n+1,0}, R_{n+1} \right)$$

$$w_{n+1,0} = \alpha_0, \chi_0, \xi_1, T_0, \phi_1, \varphi$$
$$R_{n+1}:$$
$$r_{1+n+1} = \left\{ \eta W_{1,i_1,j_1}^{w_1} W_{2,i_2,j_2}^{w_2} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1}} \to \eta W_{1,i_1,j_1}^{w_1} W_{2,i_2,j_2}^{w_2} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1}} W^{\varpi} | 1 \le i_s,\ j_s \le n \right\}$$
$$r_{2+n+1} = \left\{ \xi_s W_{s,i_s,j_s}^{w_s} W^{\varpi} \to \xi_{s+1} W_{s,i_s,j_s}^{w_s} W^{\varpi} Q_s^{w_s - \varpi} \middle| 1 \le i_s,\ j_s \le n, 1 \le s \le n-1 \right\}$$
$$\bigcup \left\{ W_{s,i_s,j_s}^{w_s} Q_s^{w_s} T_t \to T_{t+1,i_s,j_s} \middle| w_s' > 0 \right\}$$

$$r_{3+n+1} = \{ T_t \to \mu | t > k-1 \} \bigcup \{ T_t \to v | t < k-1 \} \bigcup \{ T_t \to \theta | t = k-1 \}$$
$$r_{4+n+1} = \left\{ v \chi_c W_{h,i_h,j_h}^0 \to v \chi_{c+1} T_{t+1,i_h,j_h} \middle| c \le k-1-t \right\}$$
$$r_{5+n+1} = \left\{ v W_{1,i_1,j_1}^{w_1} W_{2,i_2,j_2}^{w_2} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1}} \to v W_{1.i_1.j_1}^{w_1 - M} W_{2,i_2,j_2}^{w_2 - M} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1} - M} \right\}$$
$$r_{6+n+1} = \left\{ v W_{1,i_1,j_1}^{w_1'} W_{2,i_2,j_2}^{w_2'} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1}} \to v W_{1.i_1.j_1}^{w_1'+1} W_{2,i_2,j_2}^{w_2'+1} \ldots W_{n-1,i_{n-1},j_{n-1}}^{w_{n-1}' - M} \right\}$$
$$r_{7+n+1} = \left\{ \mu \alpha_f \omega W_{q,i_q,j_q} \to \mu \alpha_{f+1} \omega b_{f+1,i_q} b_{f+1,j_q} \middle| 1 \le f, i_q, i_q \le n \right\}$$
$$r_{8+n+1} = \left\{ \phi_q b_{q,j_1} b_{q,j_2} b_{q,j_3} \ldots \to \phi_q b_{q,j_1} b_{q,j_2} b_{q,j_3} \ldots U_{j_1,j_2}^{w_{j_1,j_2}} U_{j_1,j_3}^{w_{j_1,j_3}} \ldots \middle| 1 \le q, j_s \le n \right\}$$
$$r_{9+n+1} = \left\{ \phi_q U_{j_1,j_2}^{w_{j_1,j_2}} U_{j_1,j_3}^{w_{j_1,j_3}} \ldots \to \phi_q U_{j_1,j_2}^{w_{j_1,j_2}} U_{j_1,j_3}^{w_{j_1,j_3}} \ldots U_{j_1}^{w_{j_1}} \middle| 1 \le j_s \le n \right\}$$
$$r_{10+n+1} = \left\{ \phi_q U_{j_s}^0 b_{q,j_s} \to \phi_{q+1} \alpha_{j_s} \middle| 1 \le j_s \le n \right\} \bigcup \left\{ \varphi \alpha_{j_s} \to V_{1,j_s} \middle| 1 \le j_s \le n \right\}$$
$$r_{11+n+1} = \left\{ \phi_q U_{j_1}^{w_{j_1}} U_{j_2}^{w_{j_2}} \ldots \to \phi_q U_{j_1}^{w_{j1}-1} U_{j_2}^{w_{j_2}-1} \ldots \right\}$$

$$r_{12+n+1} = \left\{ V_{1,j_s} a_{j_2} \ldots a_{j_p} \rightarrow \left(V_{1,j_s} \right)_{in_{j_s,j_1,j_2 \ldots j_p}} \left(a_{j_2} \right)_{in_{j_2}} \right\}$$
$$\bigcup \{ \eta Q \rightarrow \lambda \}$$
$$r_{13+n+1} = \left\{ \phi \omega W_{q,i_q,j_q} \rightarrow \left(\omega a_{iq} a_{jq} \right)_{in_{c0}} \middle| 1 \le q, i_q, j_q \le n \right\}$$
$$\rho = \left\{ r'_1 > r'_2 > r'_3 > r'_4 > \right\} \bigcup \left\{ r_i > r_j \middle| 1 \le i \le j \le 6 \right\} \bigcup \left\{ r_{i+n+1} > r_{j+n+1} \middle| 1 \le i \le j \le 12 \right\}$$

3.4 Operational Process in P System

After the start of the operation in the P system, limited by the initial multiple set and the regular set of the membrane, rule r_1 is executed first. This rule operates on objects a_i and $V_{s,i}$ that are contained in the membrane at the same time. When both are present, it means that object a_i in the membrane has been added to the node in MST. In order to avoid repeating object a_i added into MST, keeping object $V_{s,i}$ only. Then, the loop variable p controls rule r_{1+p} to start working. The objects $U_{i,j1}^{\omega_{ij1}} U_{i,j2}^{\omega_{ij2}} \ldots U_{i,jp}^{\omega_{ijp}}$ represent the distance between nodes. And $U_{i,js}^{\omega_{ijs}}(1 \le s \le p)$ indicates the distance between a_i and V_{s,j_s} is ω_{ij_s}, then rule r_{3+p} is looped until object $U_{i,js}^{0}$ appears, indicating that the distance between object a_i and node V_{s,j_s} is minimal. Copy the object a_i, one of which remains in the membrane i, the other is rewritten as A_{i,j_s} into the membrane 0,while the remaining object $U_{i,j}^{\omega_{ij}}$ is cleared.

When all the objects A_{i,j_s}(n − p, $1 \le i, j_s \le n$) enter into the membrane 0, rules are excited. Rule r'_1 represents the distance between a_i and V_{s,j_s}–$U_{i,js}^{\omega_{ijs}}$, then rule $r'_2 r'_3$ are looped until object $U_{i,js}^{0}$ appears. The distance can be the weight of the newly added edge. The object a_{i_s} becomes the new node V_{u+1,i_s}, and enter into the membrane $\sigma_i(1 \le i \le n)$.

Subsequently, the rule set in the membrane n + 1 will cluster the generated MST hierarchically.

4 Case Study

4.1 Data

In this article, we use the data of urbanization index in 2013 (Table 1). The meaning of the data in the table is as follows: PU2013 refers to the population urbanization rate in 2013. EU2013 refers to the economy urbanization rate in 2013. SU2013 refers to the spatial urbanization rate in 2013. U2013 refers to the comprehensive urbanization rate in 2013. Pe refers to the rate of population and economy urbanization development in 2013. Ps refers to the rate of population and spatial urbanization development in 2013. Es refers to the rate of economy and spatial urbanization development in 2013.

Table 1. The data of urbanization index in 2013

Number	City	Data				
		PU2013	EU2013	SU2013	U2013	Data object
1	Qingdao	8	9	6	8	(8, 9, 6, 8)
2	Jinan	8	9	5	7	(8, 9, 5, 7)
3	Zibo	7	7	6	7	(7, 7,6 , 7)
4	Dongying	6	8	8	7	(6, 8, 8, 7)
5	Weihai	6	7	9	8	(6, 7, 9, 8)
6	Yantai	5	7	7	6	(5, 7, 7, 6)
7	Taian	6	6	6	6	(6, 6, 6, 6)
8	Weifang	5	6	5	5	(5, 6, 5, 5)
9	Zaozhuang	5	5	6	5	(5, 5, 6, 5)
10	Jining	5	5	6	5	(5, 5, 6, 5)
11	Linyi	5	5	4	4	(5, 5, 4, 4)
12	Laiwu	5	5	8	6	(5, 5, 8, 6)
13	Binzhou	4	6	6	5	(4, 6, 6, 5)
14	Liaocheng	4	5	5	5	(4, 5, 5, 5)
15	Rizhao	4	5	6	5	(4, 5, 6, 5)
16	Dezhou	4	5	8	6	(4, 5, 8, 6)
17	Heze	4	4	3	4	(4, 4, 3, 4)

4.2 Computing

4.2.1 Clustering Process

$$D_{17,17} = \begin{pmatrix} 00 & 02 & 06 & 10 & 17 & 18 & 17 & 28 & 34 & 34 & 45 & 33 & 34 & 42 & 41 & 40 & 66 \\ 02 & 00 & 06 & 14 & 25 & 16 & 15 & 22 & 30 & 30 & 35 & 35 & 30 & 36 & 37 & 42 & 54 \\ 06 & 06 & 00 & 06 & 11 & 06 & 03 & 10 & 12 & 12 & 21 & 13 & 14 & 18 & 17 & 18 & 36 \\ 10 & 14 & 06 & 00 & 03 & 04 & 09 & 18 & 18 & 18 & 35 & 11 & 16 & 26 & 21 & 14 & 54 \\ 17 & 25 & 11 & 03 & 00 & 09 & 14 & 27 & 23 & 23 & 44 & 10 & 23 & 33 & 26 & 13 & 65 \\ 18 & 16 & 06 & 04 & 09 & 00 & 03 & 06 & 06 & 06 & 17 & 05 & 04 & 10 & 07 & 06 & 30 \\ 17 & 15 & 03 & 09 & 14 & 03 & 00 & 03 & 03 & 03 & 10 & 06 & 05 & 07 & 06 & 09 & 21 \\ 28 & 22 & 10 & 18 & 27 & 06 & 03 & 00 & 02 & 02 & 03 & 11 & 02 & 02 & 03 & 12 & 10 \\ 34 & 30 & 12 & 18 & 23 & 06 & 03 & 02 & 00 & 00 & 05 & 05 & 02 & 02 & 01 & 06 & 12 \\ 34 & 30 & 12 & 18 & 23 & 06 & 03 & 02 & 00 & 00 & 05 & 05 & 02 & 02 & 01 & 06 & 12 \\ 45 & 35 & 21 & 35 & 44 & 17 & 10 & 03 & 05 & 05 & 00 & 20 & 07 & 03 & 06 & 21 & 03 \\ 33 & 35 & 13 & 11 & 10 & 05 & 06 & 11 & 05 & 05 & 20 & 00 & 07 & 11 & 06 & 01 & 31 \\ 34 & 30 & 14 & 16 & 23 & 04 & 05 & 02 & 02 & 02 & 07 & 07 & 00 & 02 & 01 & 06 & 14 \\ 42 & 36 & 18 & 26 & 33 & 10 & 07 & 02 & 02 & 02 & 03 & 11 & 02 & 00 & 01 & 10 & 06 \\ 41 & 37 & 17 & 21 & 26 & 07 & 06 & 03 & 01 & 01 & 06 & 06 & 01 & 01 & 00 & 05 & 11 \\ 40 & 42 & 18 & 14 & 13 & 06 & 09 & 12 & 06 & 06 & 21 & 01 & 06 & 10 & 05 & 00 & 30 \\ 66 & 54 & 36 & 54 & 65 & 30 & 21 & 10 & 12 & 12 & 03 & 31 & 14 & 06 & 11 & 30 & 00 \end{pmatrix}$$

Cities are represented by the object $a_i (1 \leq i \leq 17)$, and then calculate the dissimilarity matrix of the data object $D_{17,17}$.

The initial state of the P system performs evolutionary communication rules, and the MST containing the respective nodes are generated. Then calculate the mean of the weights of the edges, and the weights are removed beyond the mean. Sub-tree is formed, and the new MST is constructed on the representative node inside each sub-tree, until the number of sub-trees is equal to the number of cluster clusters.

By implementing the corresponding rules, the MST containing all the objects (nodes) is constructed, and its visualization is shown in the following Fig. 2.

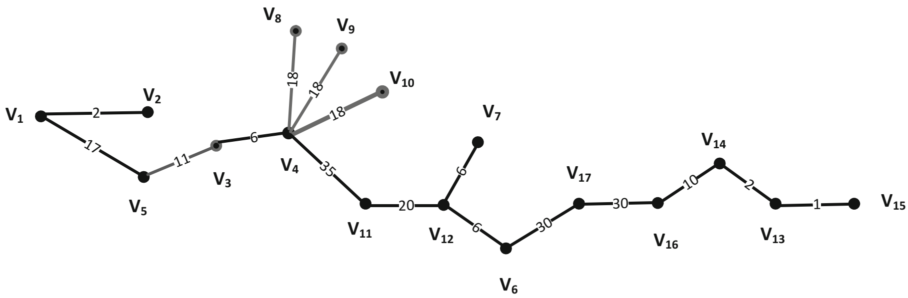

Fig. 2. The MST including all nodes

In the analysis of the operation of the clustering process in the P system, it is known that the minimum spanning tree is generated iteratively. Calculate the average of the weights in the MST, and then cut off the edges that exceed the mean, we can eventually get clustering results.

4.2.2 Results

After the calculated by P system combined with the MST algorithm, we can know that the average degree of urbanization development is 0.5309. At the same time, we get a conclusion that the cities in Shandong Province can be divided into four categories: high level of coordinated development (1, 2), middle level of coordinated development

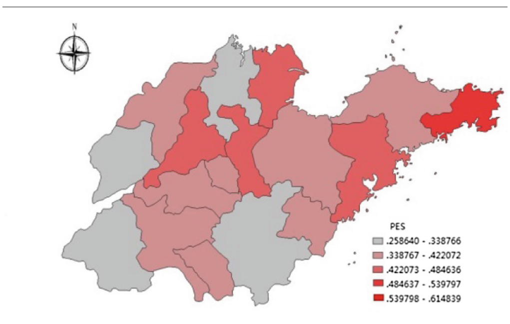

Fig. 3. The spatial differentiation of population-economy-space urbanization of Shandong province of 2013

(3, 4, 5), middle low level of coordinated development (6, 7, 8, 9, 10, 11, 12), low level of coordinated development (13, 14, 15, 16, 17). The results show in the following Fig. 3 [14]. From the result, we can know the urbanization development level for each city.

5 Discussions and Suggestions

5.1 Discussions

The pace of urbanization in Shandong Province is faster overall. As we can see, all of the population, economic, and space urbanization have a more significant development. Among them, the urbanization base on population is gradually turning into a kind of economy and space leading urbanization development. Since 2013, the level of economic urbanization is similar as space urbanization development, slightly higher than the population urbanization. Population - economy - space urbanization development is coordinated highly. And according to previous studies, this state is conducive to urbanization positive development.

We also found that, in the high level urbanization areas, the economic urbanization plays a very important role. It is a significant driving force for the development of urbanization. And in the lower level of coordinated development areas, spatial urbanization is dominant, which may be related to the local governments because of the dependents on land and finance policies. Objectively, the way of building infrastructure, creates a more favorable development for future of the region [16].

5.2 Suggestions

Measures should be taken to make population, resources and environment integrated and coordinated development. The city's development is inseparable from the support of population, resources and environment. From the perspective throughout Shandong Province, there are many problems such as enormous population pressure, the lack of resources, environmental pollution and other issues. We must start from the regional level to co-ordinate the development of the various problems and promote urban development.

Strengthen investment in education, and improve the quality of the population. Then there will be a huge capital and human resources which turned from the force adult population resources. Thus the urban economy will be better. Finally, the urban employment must increase on this occasion.

Only the development of urban economy can provide the power of improving employment and the welfare of urban residents. Actively develop the urban economy through capital investment, technological innovation, accelerate the growth of industrial scale. And then focus on improving the proportion of urban services, the development of new formats, new hot hatch, and gradually increase the proportion of tertiary industry.

The use of urban land should adjust to the size of population. And the reasonable land targets should be formulated. Then draw the urban land red line.

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