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The Simulation of Ancient Kiln Landscape based on MA-PSO-CA Model

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Abstract. The objective of this essay is to create ancient virtual maps of study area and propose such constructs to unambiguously denote a multi-agent system integrating CA and PSO. The whole system constitutes a utility model, in which land-use and land cover changes are represented through a cellular model, decision processes are controlled beyond the multi-agent, and spatial optimization is performed by particle swarm optimization. In addition, we apply the system to model a dynamic interaction environment and conduct a series of spatial analyses of the land-use pattern from 1271 to 1554. Compared with model PSO-CA, the simulation of this new model is of richer changing hierarchy and can better reflect the whole process from the first to the last firing. Furthermore, the model has creative mind that it can better reflect the interaction between political environment and natural environment of different dynasties with the lack of ancient GIS spatial data, which has filled in gap in the simulation of ancient kiln landscape.

Keywords: Multi-agent; Particle Swarm Optimization; Cellular Automata; Kiln; landscape evolution

1 Introduction

In land-use change studies, many scholars have discussed some effective methods to solve those special problems. Such as the ecological and sociological effects of land conversion for agricultural uses have been studied (Riebsame et al 1994), the effects of land conversion for urbanization have also been studied (Jenerette & Wu 2001), in addition, the effects of land conversion into grassland have been studied (Conant et al 2001), but the effects of land conversion for ancient kiln landscape is less understood. The objective of this essay is to create ancient virtual maps of study area and propose such constructs to unambiguously denote a multi-agent system integrating CA and PSO. We also compare the simulation under multi-agent to the simulation without multi-agent for simulating the evolution of Donghe River Basin kiln landscape in Jingdezhen under lacking Geographic Information System and find the former can better reflect the whole process from the first to the last firing.

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2 The Virtual Map of Study Area in Ancient Time

In the actual drawing process, by comparison with the screenshot of the study area via Google Maps, located DongHe and the surrounding mountain land can be firstly identified and then the land information except mountain and river is randomly generated. With this method, we can effectively explore the effect of the evolution of different geographical environment. This paper only shows one of them.

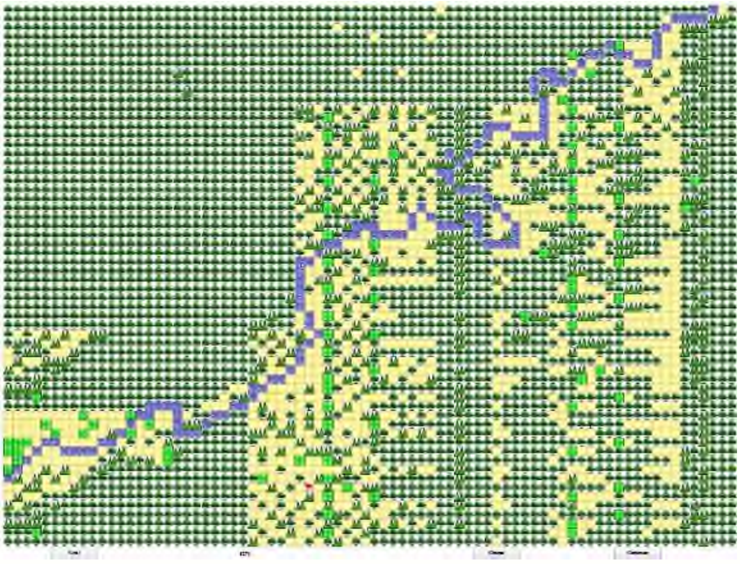

Fig. 2. Study area grid map

In FlashCS3.0 software environment, the indicated study area in figure 1 can be divided into 60 rows and 78 columns grid data by use of ActionScript3.0 language, and each grid land area is 20*20pixels. With the above method, we can get the two spatial dimensions grid map. The map is shown in figure 2, in this map, the idle land, the farmland, the clay mine, shrub, forest, the river, and kiln are indicated.

3 Classification and Presentation of Multi-agent

In this study, we use two types of agents to simulate the kiln site development in Jingdezhen Donghe river basin. They are the political agent and artificial agent.

3.1 Artificial Agent

In this study, the particle of PSO stands for artificial agent, namely kiln site agent, used for spatial optimization, which sparsely distributes and moves as time goes in space grid. For solving the special optimization problem, we redefine the fitness function of PSO. In ancient times, Jingdezhen Ceramic production used clay as raw material and wood as fuel, and finished products were transported through rivers, so the development of a land into a kiln to a large extent was affected by the distance from the river, the distance from the mountain and the distance from the clay mine. According to this characteristic, the fitness function of particle swarm optimization algorithm is defined as Equation 1.

(1)

Among them, is the nearest river coordinates away from the current grid, is nearest mountain coordinates away from the current grid, is current grid coordinates. value of is 2, when none of the river distance, mountain distance, is 2; when one of them is zero, is 1.In addition, the nearer distance of the nearest clay mine coordinates from the current grid is better.

3.2 Political Agent

In this research, political agent consists of political situation and institution, on behalf of political situation and institution in the given dynasty, which is of no spatial attribute, and only changes its political attributes as time goes. In this model application, we divided the research into the following four stages in order to better describe political attributes:

1) A.D.1271-A.D.1349

In this period, Yuan dynasty was established and gradually became stable, so its political attribute is defined stable.

2) A.D.1350-A.D.1362

From the reference, we can know the leader of Red Army—Xiang pulv conquered Fuliang in A.D.1350, and this county was at war until the year of 1357.In A.D.1360, Li Yong guarded Fuliang and the political situation there grew gradually stable.

3) A.D.1363-A.D.1401

Fuliang was under the administration of Zhu Yuanzhang during the period, so we defined the political attribute in this period to tending towards stability.

4) A.D.1402-A.D.1554

During this period, Ming dynasty was established and the society was stable, furthermore Ming dynasty paid great attention to the development of handicraft industry. In 1402 the government set “Royal Kiln” factory, which can only be used by “Royal Kiln” factory.

4 A Multi-agent system melting PSO and CA

To facilitate research, this article looks on the study area as an island, the division of the CA of the square grid space as an experimental basis, using the Moore neighborhood, fixed value boundary. Suppose map _maps is a 60×78 grid map, each grid cell is 20*20 pixels, cellular space , dimension ,and state sets , number 0-6 respectively stands for idle land, river, mountain, shrub, farmland, porcelain corresponding productive land(kiln), clay mine. Center Cellular _maps[i][j] has eight neighbors cell. The conversion rules are described as follows:

(1)Artificial agent constantly moves in 60×78 grid space to determine the location of candidate target grids, making the average distance from candidate target distance grid to the clay mine, DongHe and the surrounding mountain is the minimum. These regions will be developed into candidate land of the kiln.

(2)To analyze the suitable conditions of the candidate land, if the suitable conditions are satisfactory, it can evolve into the kiln, or it can not. The adaptation function (Equation 2) will return [0, 1], such as if the land itself is river or mountain, the return value is 0, other land is impacted by political agent.

(2)

Among them, represents the state of (i,j) block at t moment.

(3)Whether a block can be developed into a kiln is affected by its own conditions as well as the surrounding neighbors cell, represented by the neighborhood function (Equation 3).

(3)

(4) Whether a region can be developed into a kiln can be obtained by the formula 4, and then set the probability threshold, if the result is greater than the probability threshold, it can evolve into the kiln; otherwise, it can't.

(4)

(5)

Influenced by political agent, conversion probability threshold also set different values according to the four periods. The first period is 0.8, the second period is 1.2, 0.6 is the third period, and the fourth period is 0.8.

5 Experimental simulation and analysis

At present, the model test methods are generally the overall comparison (Hashemi & Meybodi 2009). Moran's I index is calculated based on the covariance relation of statistical correlation coefficient. Moran's I index is commonly used to describe the spatial autocorrelation, and its formula is:

(5)

In the formula, is the number of spatial units involved in the analysis, and respectively stands for observations of an attribute feature in the spatial units and spatial unit , is the neighboring weight matrix of spatial units and . If adjacent, is 1, if not adjacent is 0. In this paper, Moran's I index is used for model checking, and the compared results of the table 1 are programmed in Matlab7.0, as shown in Table 1.

Table 1. Moran's I index contrast

years	Moran's I Index		
	real value	MA-PSO-CA model simulate value	PSO-CA model simulate value
A.D.1271-A.D.1349	0.1392	0.1383	0.1395
A.D.1350-A.D.1362	0.1383	0.1383	0.1395
A.D.1363-A.D.1401	0.1296	0.1302	0.1395
A.D.1402-A.D.1554	0.1309	0.1310	0.1349

From Table 1, we can find:

(1) In each study phase, simulating results from model MA - PSO - CA are better than those from model PSO - CA, because the index Moran's I of model MA-PSO-CA is closer to the actual Moran's I.

(2) The simulation of model MA-PSO-CA is of richer changing hierarchy, which not only reflects the evolving situation of different dynasties, but also shows the evolvement in different years of the same dynasty.

(3) Because of continuous evolvement, from the entire research phase, we can find that model MA-PSO-CA can better reflect the whole process from the first to the last firing compared with model PSO-CA, which shows changes of political environment in different dynasties can affect land use, and also bring the appearance, development, prosperity and extinction to ceramic production.

6 Conclusion

In this paper, we simulate a multi-agent system integrating PSO and CA by combining the advantages of multi-agents, PSO and CA in time and space, and simulate the evolvement of kilns along Jingdezhen Donghe River Basin from 1271 to 1554. Compared with that of model PSO-CA, the simulation result of this new model is of richer changing hierarchy and can better reflect the whole process from the first to the last firing due to the relation between agents and the environment can dynamically modify land suitability values and transition probability threshold.

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