

The Research on the relationship between urban land and population -- Based on CA model of GIS

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Abstract. The study of the relationship between urban land and its population can further uncover the simple nature behind the complex relationship of urban elements, which is of critical theory and practical significance for solving the contradictions of the environment, economy and population for the current city. This paper, based on the geographic information system (GIS), has created a integrating model, taken cellular automaton (CA) as the dominant center. It would become an important point for the study of urban population and land relations in China. Moreover, the artificial neural network, intelligent system of genetic algorithm and related mathematical theories are introduced under the premise of the CA- GIS model. At the same time, the Urban Dynamics model is also given. Based on the theory, the model is developed into an intelligent integrated model system, and then some basic ideas for creating intelligent CA- GIS simulation experiment methods are pointed out.

1. Preface

Since 2010, the urbanization rate of our country has been getting higher and higher, and the construction land of each big city is also rising year by year. We can see that from 2010 to 2017, the proportion of urban population in China is higher and higher, and the level of urbanization is higher than the average level in the world, what's more, as the number of population increases, the area of urban constructional land is also promoted which rises from 39758.43 square kilometers in 2010 to 54806.2 square kilometers in 2017. At the same time, the areas of urban built-up area and urban areas in China also increase year by year. It shows that the area of cultivated land in rural areas is gradually decreasing, and more importantly, the density of urban population in China is becoming higher and higher. The contradiction between urban population and land will inevitably be the main contradiction of urban development in the future.



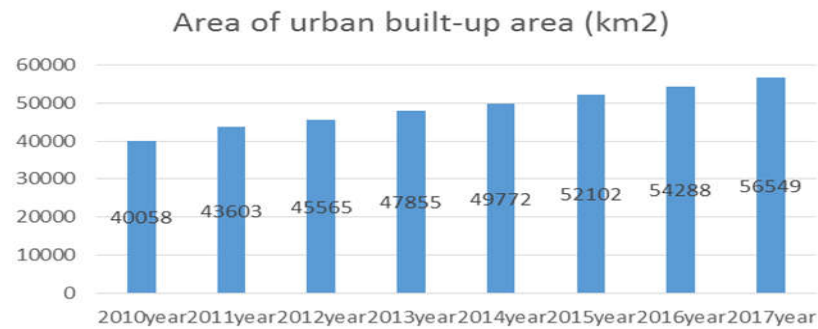


Figure 1. Statistics on the area of urban built-up area in China

Data source: National Bureau of Statistics

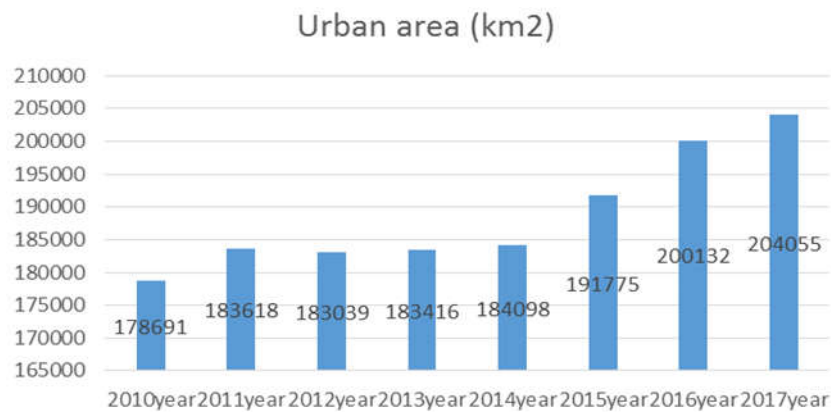


Figure 2. Urban area statistics in China

Data source: National Bureau of Statistics

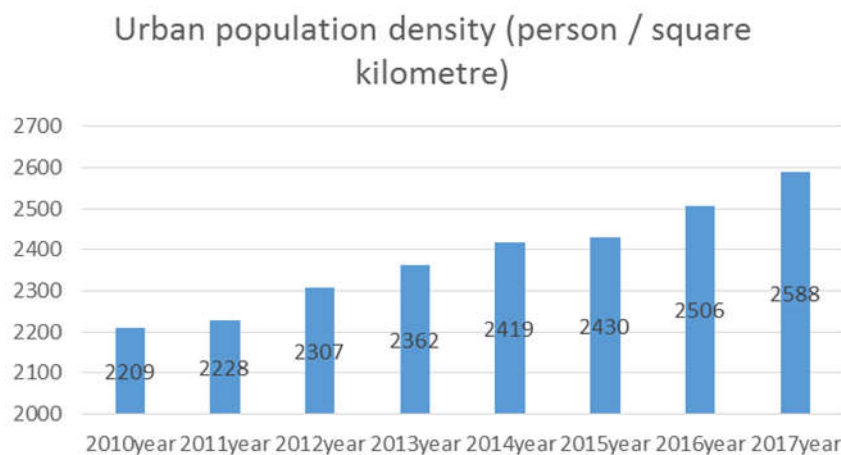


Figure 3. The density statistics of urban population in China

Data source: National Bureau of Statistics

Many contemporary geologists have gradually realized that in the cities of our country, the conflict between development and the increase of the population has been the key contradiction of geography, and it is not only shown in the study of relevant data, more importantly, it is also to establish a more comprehensive and systematic theoretical model, and then intuitively reflects the relationship between

urban land and the population in China and finds out the current problems in development in time. The author thinks that based on the geographic information system GIS and CA model, the technical model mentioned above can be realized step by step. In the theoretical researches of previous, they were more emphasis on theoretical or data analysis. The relationship between urban land and population is more complex in China now, and the amount of data to be reflected is quite large, however, the CA model has a more comprehensive and systematic function in the study of urban land construction. The complex problems can be simplified. If the CA and the related technologies of GIS are combined, it will be able to solve the contradictions and problems between the urban land and the population.

2. The Research on urban land population relationship based on CA model of GIS

2.1. Introductions of model integration

The integration of CA model and GIS technology system is based on CA. On the basis of using the function of GIS technology system, the researchers realized the related function of management, expression function, research function and visual display function of graphics and attribute information. Under the support of component GIM, the model type would be more general and practical, such as Figure 4. The idea of GIM model is to transform all functional modules into controls. This control is able to integrate with other controls through software tools. In detail, according to the standard requirements of ActiveX and Java Beans, the high-level programming language is used to implement some functions of the GIS technology system, and the model provides an effective interface to the CA, ensuring the normal operation of CA through the components, installation and integration.

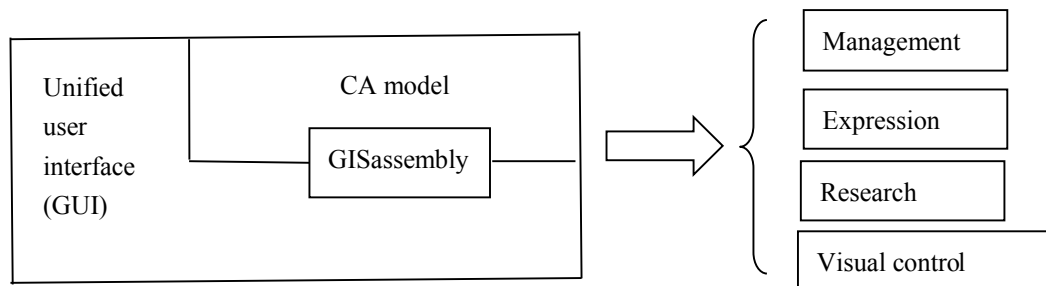


Figure 4. Integration in the CA model

2.2. The research on the simulation of land relationship in population

The cell state in this model represents the state of the city, and the transformation rules indicate function changes of the suitability of daily life and work of the target city, or as the changes of the adjacent relations in other cities. In the GIS technology system, the urban ecological environment or natural conditions which are relatively slow in urban change can be realized. The digital elevation model can also be used to express the state of urban construction, such as rivers, lakes and flowers and plants in the cities. The process of urban land and population is displayed under the interaction of CA and GIS. For example, an American scholar named White, studied the interaction between urban terrain, road traffic and urban land in detail when analyzing the fractal schema of the urban land usage and evolution, and then pointed out that it is the research result of using traffic to make the form of urban land use.

And White also carried out a detailed simulation study of the urban land use evolution schema in St. Lucia, North America. The model included the following three parts. The first one is GIS part which mainly used to preserve relevant data information, including information on urban land use, and the comprehensive response to the suitability of all land use the closed information. The second one is CA part, refers to the random CA in the non-homogeneous network space. In this model, the state of the cells indicates the use of urban land, and on this basis the local power of the region. The third one is about the integrated dynamic, mainly expressing urban population, urban economy and natural

environment. It included the parts of the natural environment, the social environment and the economic environment. In this model, the GIS technology system is the basis of the simulation, and the CA is the research center, also the macro dynamic model can reflect the dynamic relationship between the population and the land.

In addition, we should improve the model from the two aspects of following.

First is about the use of fractal mathematical tools. The relationship between urban land and population is a complex and not linear interaction process. The relationship between population and land under the model will generate fractal and complex structures. Therefore, fractal theory should be needed in this model to carry out detailed research. The mathematical theory of fractal is a kind of language. The CA model is a kind of simulation tool. The natures of the two are different, but the two are related to each other. Only by relying on the related algorithm language to write the fractal theory as the research software and then use it in the simulation system, the urban land can be better realized.

Secondly, artificial neural network and genetic algorithm should be brought into the model. In order to better verify the transformation function of the state in the CA model and to ensure the accurate values of the related parameters, we can use the artificial neural network to compare the similarity between the conclusions of the model and the image in the actual system. Then we can use the genetic algorithm to study the weights of neural networks then train them. An artificial neural network is a mathematical model of a neural network that is capable of imitating a biological neural network and is created in accordance with a fixed rule, and also has self-learning and discriminative ability for the input methods. The function of self-learning in the model and the dynamic changes in the connection right of the neuron mainly depend on the operation of the model. Genetic algorithm is a kind of advanced technology that imitates biological evolution. It is based on the survival of the fittest and the principle of unsuitable elimination by the biological community. It relies on breeding operation, assembly operation, exchange operation and mutation operation, exploring the optimal solution gradually. This makes the model change rules and artificial neural network in CA. Network weight transformation and other places are unified and integrated, and they would have the ability of self-learning and evolution to simulate more complex and changeable urban environment.

3. Conclusion

As the relationship between urban population and land is more and more complex, model theory that simulates the relationship between urban land and population should be taken more and more attention by scholars, then a successful and comprehensive simulation system will be successfully explored. This will make the study of Geography in China much richer, which needs to be emphasized. The model proposed by this study seems relatively simple in construction. However, the model's simulation conclusion research is quite complex. This requires the establishment of the relevant rules and requirements of the model to be simple and clear. After we have learned the study, we can find the roots of the problem, that is, to make the relations of urban land and the population what is a kind of nonlinear complex relationship transform into a simple and understandable rules of urban elements.

References

- [1] Chen Yanguang, Zhou Yixing. Space complexity simulation of cellular automaton and urban systems: history, status and prospects [J]. *Economic Geography*, 2000, 20 (3), 35-39.
- [2] Li Xia, Ye Jiaan. Automated evolution CA model of constrained units and simulation of sustainable urban development [J]. *Acta geographica Sinica*, 1999, 54 (4), 289-298.
- [3] Li Xia, Ye Jiayan. Use remote sensing to monitor and analyze the urban expansion process of pearl river delta -- take Dongguan as an example [J]. *Geographical Studies*, 1997, 16 (4) : 56-81.
- [4] Chen Yanguang, Liu Jisheng. Quantitative description of urban land use structure and form: from information entropy to fractal dimension geographical research [J]. 2001. 20 (2) : 146-152.