A conceptual Model of dynamic Urban potential Energy balance and pilot Model

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Abstract

Generally speaking, cities grow as civilizations develop economically or culturally. The form of cities is the most direct manifestation of this developmental process. Thus, differences in economies, cultures and environment, even when subtle mean that no two urban settlements are the same. Understanding the process and form of urban development provides insights which help policy makers allocate limited resources more effectively.

The most conventional urban researchers are in a large scale (exploring form change) in order to indicate mechanism of urban evolution. For this purpose, cities have been divided into urban factors, which including transport, environment, structure, population, economic and the like, to describe the city form. They mainly focus on a specific urban factor influencing on urban evolution for purpose of funding which are the best relationship patterns for these urban inner factors. For instance, planning traffic infrastructures to create positive influence on urban evolution. However, cities are complex systems. Many factors are involved in urban evolution and underlying relationship dependencies between them need to be discovered, which is vital to know the whole patterns of the urban issues. It is evident that highway infrastructure can promote the formation of low-density and urban expansion in Atlanta of the U.S., as well as urban railway can impact the multi-centre expansion patterns of urban in Tokyo of Japan.

This research aims to establish a theory, called dynamic urban potential energy balance, to indicate the mechanism of urban evolution and provide a model of urban planning for policy makers. There is a complicated interaction between urban factors. Complex interactions of factors produces emergent outcomes. Though complexity science is well established in academia, urban and particularly transport planning relies too much on overly simplistic and deterministic models. Thus, there is a gap between urban requirements and urban planning. But the urban potential energy balance will provide an urban evolution prediction model, which the theoretical significance is mainly presented as prediction of urban evolution when single or multiple urban factors have been changed intentionally or unintentionally, to related policy makers to make urban planning more predictable and controllable. It is of great theoretical and practical significance to develop and strengthen the dynamic urban potential energy balance study extend to the urban evolution field to support planning, geographic decision-making, and urban research fields.

The theory is that the whole city is represented as a grid. Vertexes represent stores of urban factors and edges in the grid represent flows. The vertex, which has potential energy to promote and extend itself, represents wealth centres or population centres and edges represent transportation infrastructure networks. Every vertex has its own weight, which describes how much potential energy it has to extend or promote itself and every edge has a specific weight to describe the cost of transport per unit length. All the vertexes are connected by edges as transport lines connect urban factors and the vertex casts its influence alongside the edge. Vertexes will automatically optimum select the most economical and effective path in order to exert maximal extension with minimal transport cost. If all the energy is

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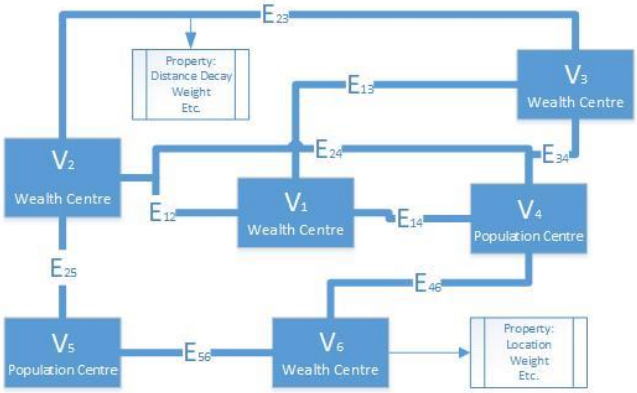
exhausted, the grid will in balance status. However, not all the urban factors are constant. The weight of vertexes and edges can be influenced by internal and external factors like investment, science & tech revolution and so on. Thus, the weight is dynamical changing, including increase, decrease, creation and extinction. (P1)

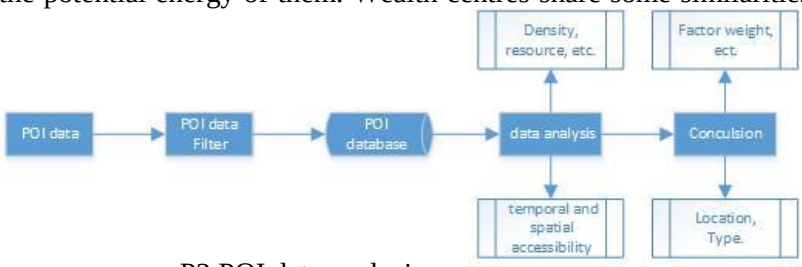
Generally speaking, the grid prefers to stabilize itself and the most stable formation is dominated by urban factors. For thousands of years, the location of capital city of China changing with the economic and political center moved from north to south and west to east, because that will reduce the costs of transport and communication and enforce the control of the Dynasty. Due to consistently and continually culture, science and tech development, the most stable formation is changing and that create forces driving the urban evolution. Just as the villages of agricultural age were replaced by the towns of the industrial age.



P1 Urban Grid

To setup a mathematical model to observe and summarize the interaction patterns and regulation between these urban factors, this research will concentrate on transport, population distribution and urban spatial evolution and culture, in order to explore the interaction mechanisms and evolution laws between them.

Inputs to the model are the spatial location and attributes of urban wealth centers, population centers and traffic networks. Transport network data is gathered from Baidu Map API and the like. An automatic data filter will be used to identify and choose wealth centres. Data will be entered into a database. The algorithms driving the automatic data filter take POI data, the method of nuclear density analysis, weighted superposition analysis and hot spot analysis was used to extract the location of urban wealth centres and population centres, and then classify them. In addition, spatial network accessibility and time consumption, attraction gravity model, resource evaluation and standard deviation elliptical analysis are used to analyse the extracted urban wealth centres and population centre in order to quantify the potential energy of them. Wealth centres share some similarities in many settlements so for each settlement they are objects of the same class. Depending upon the cultural context, there may be some differences in parameters and methods acting upon the centres of specific settlements.



P2 POI data analysis

The presentation will illustrate an initial case study of Xi'an, China, taking spatial structure of transport the network as a research object, to investigate its agglomeration and dispersion evolution, an extended and weighted model was established based on complex network methods. The evolution model was driven by an economic mechanism and established to minimize the total cost of traffic network. The proposed model also took dynamic change of network scale and spatial distance into consideration. The capacity of a traffic line decides the upper limit of the buffer area, which beside the traffic line, and costs of transport per unit distance decides the pace of the potential energy of wealth center declines. When a wealth center used up all its potential energy, it can no longer effects on other areas.

References

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