Construction and Empirical Study of Dynamic Optimal Evolution Model for Urban Rail Transit Hyper Networks Based on Allometric Growth Relationship

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Abstract

The development of an urban rail transit network conforms to the characteristics of logistic dynamic equations. Studying the evolution laws of urban rail transit networks and accurately reproducing the entire process of evolution can provide targeted guidance for rail transit network planning and phased construction. This article studies the structure and evolution laws of urban rail transit networks and finds that the evolution and development of urban rail transit networks are based on the evolution of lines, which aligns with the evolution characteristics of hyperedge-driven hyper networks. At the same time, the links between lines have the evolutionary characteristics of combining randomness and prioritization. On this basis, a hyper network model of urban rail transit was established with stations as nodes and lines as hyperedges. Based on the allometry growth relationship between transfer nodes and common nodes in urban rail transit networks, this paper proposes a hyper network evolution model of rail transit that can simulate the evolution process and generate a network similar to the existing network. Finally, a comparative analysis was conducted between the network generated by the model and four different levels of urban rail transit networks, including Beijing, Shanghai, Guangzhou, and Tianjin. The evolutionary network generated by the new model is highly consistent with the leading critical indicators of the existing network and has a high degree of similarity. A comparative verification was conducted with the evolution data of the Beijing Rail Transit Network (1984-2020) over a total of 45 years. Both network evolution processes were found to conform to the dynamic logistic equation, proving that the evolution model can reproduce the evolution process of the urban rail transit network, which has practical guiding significance for the study of rail transit network evolution.

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