The Mathematical Method to Construct Time-distance Maps for Analyzing Transportation and Economy

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Time-distance maps have scales expressed in time units rather than in distance units such that distances between points are proportional to the time-distances. Time-distance maps provide a visual summary of travel-time relationships, reveal spatial patterns induced by railway transportation system, and have valuable applications. Upon on analyzing the current methods to construct time-distance maps, including multidimensional scaling and network mapping, I proposed an approximation method coupling geographic distance and time-distance. With the objective function given from non-linear least-square method, L-M algorithm and regularization were applied to linearize objective function near the approximate values and to stabilize convergence. The formula transforming coordinates on the geographic maps to coordinates on time-distance maps is successfully deduced. To illustrate this method, the MATLAB code was written to construct a time-distance map of China featuring 30 provincial capital cities in China based on their coordinates and the high-speed railway time between them. I also analyzed the similarities and differences between topographic map and time-distance map of China, discussed reasons why time-distance maps got distorted, and analyzed the transportation system and economy. Since the approximation method avoids deficits in previous studies, and that time-distance map of China provides support for future railway development, this research has theoretical significance and practical value.

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