

# Study on Evaluation Model of Smart Transportation Development Level Based on Entropy Method and Grey Relational Analysis

Mengxi Ma<sup>a</sup>, Jun Zhang<sup>b</sup>

Wuhan University of Technology, Wuhan 430070, China.

<sup>a</sup>mamengxi656593@163.com, <sup>b</sup>zhangjun@whut.edu.cn

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**Abstract.** With the continuous development of social economy, traffic problems have gradually become one of the pain points of urban development. The construction of smart transportation can effectively integrate urban transportation resources and solve urban traffic problems. Based on the development goals and connotation of smart transportation, this paper constructs an evaluation index system for the development level of urban smart transportation, selects eight cities as research samples, and uses entropy weight method and gray correlation method to evaluate the level of smart transportation development.

## 1. Introduction

At the end of 2008, IBM introduced the "Smart Earth" development strategy, and on the basis of digital cities, it started the development of smart cities. On January 28th, 2009, IBM's CEO Ming sheng Pang proposed the concept of "Smart earth" to President Barack Obama [1], summed up as follows: embedded in various objects such as power grids, railways, buildings, dams, oil-gas pipelines, etc. Equipped with sensors, it forms a pattern of objects, and then uses Super Computer and Cloud Computing technology to combine the natural world with the physical world [2]. As an important application of smart city construction, smart transportation has become a hot topic today.

At present, China's research on smart transportation is still in its infancy and no standard definition has been formed. Tao Chen proposed that intelligent transportation is the result of changing intelligent traffic from quantitative to qualitative. Intelligent transportation is an important means of solving various traffic problems through very advanced communication and control technologies. It is the application of information technology itself, and smart transportation is the higher stage of intelligent transportation development [3]. Smart transportation is the mining and analysis of massive traffic information, emphasizing the real-time nature of the system, human-computer interaction, and the extensiveness of service objects [4], emphasizing people-oriented, intelligent decision analysis [5], and promoting the transportation to more advanced and harmonious the direction of development [6].

Establish an evaluation index system for assessing the level of development of smart transportation, and through the identification of indicators, controllable and timely feedback on the weak links found in the construction, it is of practical significance to improve the people's life experience and urban competitiveness.

## 2. Construction of Indicator System

### 2.1 Selection of Indicators.

In order to make the index system scientific and standardized, based on the system principle, typical principle, dynamic principle, concise scientific principle, comprehensive principle, comparable and operable quantifiable principle [7], the concept of intelligent traffic construction objectives and characteristics, determine the evaluation system for the development level of smart transportation as shown in table 1.

**Table 1. Smart transportation development level evaluation index**

First-level indicators	Second-level indicators
Infrastructure level	Total investment in transport construction (100 million yuan)
	Smart Parking Electronic Payment Ratio
Information service level	Smart parking coverage
	Smart travel
Traffic management level	Intelligent transportation
	Political influence
	Motor vehicle ownership (10,000 vehicles)
Environmental protection level	The average speed of the whole road network in the main urban area (km/h)
	Peak Congestion Delay Index
	Traffic accidents (times)
	Car death rate
Environmental protection level	Good air quality
	The average equivalent sound level of ambient noise in built-up areas (decibels)
	Built-up area green coverage
	Pm2.5 average (mg/m <sup>2</sup> )

**2.2 Weight Determination Based on Entropy Weight Method.**

**2.2.1 Data Preprocessing.**

In order to facilitate the evaluation of the development level of smart transportation, the data of quantitative indicators and qualitative indicators require being dimensionless processed, that is, the change of data is controlled between [0,1]. The processing method is:

$$Y_{ij} = \begin{cases} \frac{X_{ij}-X_{min}}{X_{max}-X_{min}} & \text{Positive indicator} \\ \frac{X_{max}-X_{ij}}{X_{max}-X_{min}} & \text{Negative indicator} \end{cases} \tag{1}$$

where  $Y_{ij}$  is the standard score of the indicator;  $X_{ij}$  is the index value before processing,  $X_{max}$  is the maximum value of the indicator before processing,  $X_{min}$  is the minimum value of the indicator before processing,  $i$  is the sample number;  $j$  is the index number.

**2.2.2 Calculating Entropy and Entropy.**

When evaluating the development level of urban smart transport, a scientific smart urban traffic evaluation index system should be established and the weight of evaluation index should be determined. The greater the weight of the evaluation index, the more important the evaluation index is in the evaluation index system and can provide more valuable information.

First of all, this article needs to understand the formula of entropy, defined as follows:

$$H_i = -K \sum_{j=1}^n f_{ij} \ln f_{ij} \tag{2}$$

Among them,  $H_i$  expresses the information entropy of the  $i$  evaluation index.

$$\text{If } f_{ij} = 0, f_{ij} \ln f_{ij} = 0.$$

$$f_{ij} = \frac{r_{ij}}{\sum_{j=1}^n r_{ij}} \quad (3)$$

$$K = \frac{1}{\ln n} \quad (4)$$

$$w_i = \frac{1-H_{ij}}{m-\sum_{i=1}^m H_i} \quad (5)$$

Among them,  $w_i$  represents the weight of the evaluation index.

### 3. Evaluation of Development Level of Smart Transportation Based on Grey Correlation analysis method

Gray correlation analysis method is a multi-factor statistical analysis method. It is based on the sample data of each factor and uses gray correlation degree to describe the strength, size, and order of the relationship between factors [8]. If the sample data reflects the two factors change, the situation (direction, size, speed, etc.) is basically the same, then the degree of correlation between them is greater; conversely, the degree of association is small; the overall data can be analyzed using the comprehensive rating coefficient.

#### 3.1 Research Methods.

After the normalized data is processed after normalization, the pre-processed main sequence is  $X'_0$ , and the subsequence is  $X'_i$ . The absolute value sequence of the difference between the corresponding components of  $X'_0$  and  $X'_i$  is first obtained. Recorded as:

$$\Delta_i(k) = |X'_0(k) - X'_i(k)|, k = 1, 2, \dots, n; i = 1, 2, \dots, m \quad (6)$$

Then find the maximum ( $M$ ) and minimum ( $m$ ) of the above equation, then the correlation coefficient is:

$$\gamma_i(k) = \frac{m+\xi M}{\Delta_i(k)+\xi M}, \xi \in (0,1); k = 1, 2, \dots, n; i = 1, 2, \dots, m \quad (7)$$

Where  $\xi$  is said to be the resolution coefficient, usually taken as 0.5. The function of the resolution coefficient is to eliminate the distortion problem caused by the large value of  $\Delta_{max}$ , and to mention the differences between the values of the correlation coefficients.

According to the above formula, the correlation coefficient  $\gamma_i(k)$  table can be obtained, and all correlation coefficients are arithmetically averaged to be the desired correlation degree:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^n \gamma_i(k), i = 1, 2, \dots, m \quad (8)$$

For each indicator proposed in this paper, the degree of importance and the corresponding weight index are not the same. In order to eliminate the influence of the weight size on the index correlation degree, a method of weighted analysis of the grey correlation degree is generally used. If the indicators' weight vector is:

$$W = (w_1, w_2, \dots, w_n)^T \quad (9)$$

In the formula,  $\sum_1^n w_n = 1$ , the calculation formula of the degree of association is:

$$R = (\gamma_i)_{1 \times n} \times W^T = (\gamma_1, \gamma_2, \dots, \gamma_m) \times (w_1, w_2, \dots, w_n)^T \quad (10)$$

#### 3.2 Case Study.

This article selected eight cities Beijing, Shenzhen, Guangzhou, Wuhan, Chengdu, Shanghai, Suzhou and Chongqing as research samples. As these 8 cities are the pilot cities for the construction of national smart cities, various urban infrastructures are relatively complete, and the level of economic development is relatively high. Smart transportation facilities are relatively complete and

all are located in cities across the country or provinces. In the first place, it is selected as a sample of research.

The data of the article mainly comes from the "2017 China" Internet + Traffic "City Index Research Report", "2017 China's Major Urban Traffic Analysis Report", Statistical Yearbook of each city, and the traffic development annual report. Individual data comes from Internet search.

According to the entropy method, the weight of each indicator can be obtained as:

$$W = (0.034, 0.045, 0.083, 0.049, 0.055, 0.058, 0.098, 0.126, 0.054, 0.043, 0.063, 0.082, 0.044, 0.095, 0.072)^T$$

Then according to the grey correlation method, the correlation degree is as shown in table 2.

Table 2. Eight cities' grey relational degree

Cities	Gray correlation degree	Rank
Beijing	0.771	1
Shenzhen	0.554	3
Guangzhou	0.462	8
Wuhan	0.493	4
Chengdu	0.472	7
Shanghai	0.478	6
Suzhou	0.491	5
Chongqing	0.601	2

Through the empirical research on the level of development of smart transportation in eight cities, it was found that Beijing ranked first, Chongqing and Shenzhen ranked second and third respectively, Wuhan, Suzhou, Shanghai, Chengdu, and Guangzhou ranked relatively backward. Beijing ranks first in eight cities in terms of infrastructure, information service level, traffic management and green environmental protection level. The main reason is that Beijing, as the capital, has strong economic strength and scientific and technological strength, and smart transportation develops rapidly. In the past two years, Chongqing and Shenzhen have significantly increased their investment in transportation, providing a strong guarantee for the improvement of the efficiency of smart transportation development. While developing, Wuhan needs to pay more attention to environmental protection. The level of information services in Suzhou and Shanghai is relatively backward, and the infrastructure construction in Chengdu is relatively imperfect. Guangzhou needs to strengthen its traffic management.

#### 4. Summary

Scientifically and reasonably evaluating the development level of urban smart transportation can ensure the coordinated development of urban construction and transportation, effectively alleviate the problem of urban traffic congestion, and provide an important basis for scientific and rational decision-making of urban traffic management departments. At present, China's systemic research on traffic impact assessment is not yet in-depth, and it has not yet established a complete traffic impact evaluation index system, and the actual experience in carrying out traffic impact assessment work is also insufficient. Therefore, the construction of urban smart traffic evaluation index system can effectively assess the level of urban traffic development, recognize the current traffic development status of the city, and then adjust and improve the lack of traffic development in a timely manner.

#### References

- [1]. Information on: <https://www.ibm.com/smarterplanet/us/en/>.
- [2]. Li D, Yao Y, Shao Z, et al. From digital Earth to smart Earth. *Science Bulletin*. Vol. 59 (2014) No. 8, p. 722-733.

- [3]. Nam T, Pardo T A. Smart city as urban innovation: focusing on management, policy, and context. Proceedings of the International Conference on Theory and Practice of Electronic Governance. Tallinn Estonia. September 2011. P.185-194.
- [4]. Kun Chen, Jianguo Yang. Research on the Connotation and Characteristics of Intelligent Transportation. China Traffic Information. Vol. 59 (2014) No. 8, p. 28-30. (in Chinese)
- [5]. Hinging Zhang, Yanling Chen, Jizhen Guan, et al. The definition, connotation and extension of smart traffic. 2014 China Intelligent Transportation Annual Conference. Guangzhou China. November 2014. p.765-769. (in Chinese)
- [6]. Zhe Li, Pingsha Wang, Chunhui Wang, et al. Analysis of the Overall Architecture Construction Mode of Domestic Smart Transportation. Traffic Energy Conservation and Environmental Protection. Vol. 2(2014) No. 10, p. 85-88.(in Chinese)
- [7]. Lun Zhang, Wencheng Yang, Meng Zhang. Intelligent Transportation and Smart City. Science. Vol. 66 (2014) No. 1, p. 33-36. (in Chinese)
- [8]. Deng J L. Introduction grey system theory. Journal of Grey System. Vol. 1 (1989) No. 1, p. 191-243.