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Fuzzy Comprehensive Evaluation of Urban Traffic Environment Quality

Han Zhengzhong[1*] Yang Tao[2] Fang Ningsheng[3]

([1] Department of Applied Mathematics, Southeast University, Nanjing 210096, China)
([2] Nanjing Institute of City Transportation Planning, Nanjing 210029, China)
([3] Department of Computer Science and Engineering, Southeast University, Nnajing 210096, China)

Abstract: In this paper, traffic environment quality assessment is achieved by applying fuzzy mathematics methods. Set up an assessment system, determine assessment criterion, formulate membership function, make program designs and conduct example analysis. The evaluation result is consistent with the real case. So that the method of the fuzzy evaluation is a good one for the environment quality assessment.

Key words: fuzzy evaluation, membership function, traffic environment quality

How to give an objective and scientific assessment of urban traffic environment quality is becoming more and more important nowadays. China has just begun to do some work in this field, most of which is limited in analyzing the existing state of traffic environment qualitatively. Anshan traffic environment is under study in this thesis. By applying fuzzy comprehensive evaluation[1] and processed by computer, a series of quantitative results of Anshan city from 1988 to 1993 are calculated.

1 Factors Analysis and Assessment Indices System

Traffic environment pollution mainly includes two aspects, automobile tail gas and noise. As shown in many references, 70% – 80% air pollution in Europe and America is from automobile tail gas. Vehicle noise is the major source of noise pollution in urban area.

According to the Air Environment Quality Standard of China(GB3095—82) and the Urban Area Environment Noise Standard of China(GB3096—82), two groups of assessment subsystems, eight assessment indices are selected to be used in urban traffic environment quality evaluation. The factors of air pollution are CO, SO_2, NOx, TSP and dust. Three noise factors are L_{eg}, L_{10} and L_{90} (See Fig.1).

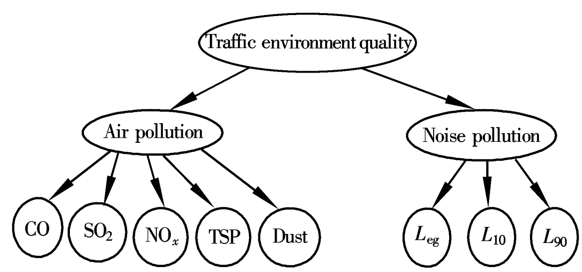

Fig.1 Urban traffic environment assessment system

According to the national environment standard and international experience, each index is classified into five levels, such as: excellent, good, ordinary, poor and bad. Each level's assessment criterion of the indices are determined.

$$\boldsymbol{V} = \{V_1(\text{excellent}), V_2(\text{good}), V_3(\text{ordinary}), V_4(\text{poor}), V_5(\text{bad})\}$$

Level "excellent" indicates advanced environment quality in west, and is the first class environment quality standard of our country. Level "good" indicates more advanced level in the country, and is lower than the first class and higher than the second class environment quality standard of the country. The situation lower than the third class standard is considered as "poor"or "bad". Each level's assessment criterion of each environment factor D_1 to D_5 are shown in Tab.1.

Tab.1 The assessment criterion of traffic environment quality

Criterion level	CO/(mg · m^{-3})	SO_2/(mg · m^{-3})	NO_x/(mg · m^{-3})	Dust/(t · km^{-2})	TSP/(mg · m^{-3})	L_{eg}/dB	L_{10}/dB	L_{90}/dB
D_1 (Excellent)	3.00	0.02	0.05	5.00	0.15	50	55	45
D_2 (Good)	3.50	0.10	0.07	8.00	0.20	55	60	50
D_3 (Ordinary)	4.00	0.15	0.10	15.00	0.30	60	65	55
D_4 (Poor)	4.50	0.20	0.13	20.00	0.40	65	70	60
D_5 (Bad)	5.00	0.25	0.15	40.00	0.50	70	75	65

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* Born in 1943, male, professor.

2 Formulae of Membership Function

The value of membership grade of each factor relative to five assessment levels can be described quantitatively by a set of formulae of membership functions as follows[2].

$$\mu_e(x) = \begin{cases} 1 & 0 \leqslant x \leqslant D_1 \\ \dfrac{D_2 - x}{D_2 - D_1} & D_1 < x < D_2 \\ 0 & x \geqslant D_2 \end{cases}$$

$$\mu_g(x) = \begin{cases} 0 & x \leqslant D_1 \text{ or } x \geqslant D_3 \\ \dfrac{x - D_1}{D_2 - D_1} & D_1 < x < D_2 \\ 1 & x = D_2 \\ \dfrac{D_3 - x}{D_3 - D_2} & D_2 < x < D_3 \end{cases}$$

$$\mu_o(x) = \begin{cases} 0 & 0 \leqslant x \leqslant D_2 \text{ or } x \geqslant D_4 \\ \dfrac{x - D_2}{D_3 - D_2} & D_2 < x < D_3 \\ 1 & x = D_3 \\ \dfrac{D_4 - x}{D_4 - D_3} & D_3 \leqslant x \leqslant D_4 \end{cases}$$

$$\mu_p(x) = \begin{cases} 0 & 0 \leqslant x \leqslant D_3 \text{ or } x \geqslant D_5 \\ \dfrac{x - D_3}{D_4 - D_3} & D_3 < x < D_4 \\ 1 & x = D_4 \\ \dfrac{D_5 - x}{D_5 - D_4} & D_4 \leqslant x \leqslant D_5 \end{cases}$$

$$\mu_b(x) = \begin{cases} 0 & 0 \leqslant x \leqslant D_4 \\ \dfrac{x - D_4}{D_5 - D_4} & D_4 < x < D_5 \\ 1 & x \geqslant D_5 \end{cases}$$

The weights of assessment factors are determined as two levels.

$$\boldsymbol{A} = \{A_1(0.4), A_2(0.6)\}$$

$$A_1 = \{A_{11}(0.3), A_{12}(0.15), A_{13}(0.1), A_{14}(0.3), A_{15}(0.15)\}$$

$$A_2 = \{A_{21}(0.25), A_{22}(0.35), A_{23}(0.40)\}$$

By calculating values of the membership function, we can obtain the evaluation matrix $\boldsymbol{R}$ of a single factor and the evaluation index system $\boldsymbol{B}$[3].

A practical software of environment quality analysis is developed by the use of multi-stage fuzzy comprehensive method.

3 Case Study

Urban Transportation Environment of Anshan City (1994—2010) in 1994 is a case for study. Anshan is the largest steel city located in northeast China. Fourteen major roads are selected as the samples of the traffic environment quality assessment. The volume of three noise indices and five air pollution indices as above of these roads from 1988 to 1993 are collected based upon the environment survey data of the city. Based upon the data, and applied the multi-stage fuzzy comprehensive evaluation method, the evaluation values of each year's main lines are got(shown as Tab. 2).

Tab.2 The value of road traffic environment quality of Anshan city

Road name	1988	1989	1990	1991	1992	1993
Jianguo Road	57.71(14)	57.75(14)	56.83(14)	53.33(14)	53.02(14)	53.22(14)
Shengli Road	62.86(8)	59.85(6)	60.13(7)	62.32(7)	62.22(6)	63.57(4)
Zhonghua Road	65.43(5)	63.57(2)	63.45(2)	65.64(2)	61.51(4)	64.31(2)
Yuanlin Road	63.00(7)	59.85(7)	59.55(10)	61.71(8)	62.00(7)	62.27(7)
Shuangshan Road	66.55(1)	65.39(1)	61.66(4)	63.85(3)	65.94(2)	63.23(6)
Qianjin Road	59.20(10)	58.07(11)	57.62(13)	57.71(12)	55.56(11)	54.09(12)
Tiandongerdao Road	60.04(9)	58.50(10)	58.48(11)	58.57(11)	55.56(12)	54.09(13)
Wuyi Road	65.53(4)	61.20(4)	62.66(3)	62.74(5)	58.64(8)	54.47(10)
Jianshen Road	65.93(2)	59.85(8)	61.27(5)	63.27(4)	63.05(5)	63.95(3)
Jianfang Road	63.61(6)	59.85(9)	60.41(6)	62.60(6)	67.76(1)	64.41(1)
Minshen Road	58.76(13)	58.07(12)	59.82(9)	59.82(10)	56.22(9)	56.44(8)
Renmin Road	59.15(11)	58.07(13)	60.02(8)	60.10(9)	56.08(10)	55.81(9)
Xingsheng Road	65.57(3)	60.33(5)	63.85(1)	66.04(1)	65.77(3)	63.36(5)
Huangang Road	58.77(12)	63.03(3)	58.22(12)	54.72(13)	54.27(13)	54.42(11)

On historical analysis, as shown in Tab.2, traffic environment quality of fourteen main lines tends to become poorer and poorer. There are five roads being poor or bad traffic environment quality in 1988, while in 1993 seven roads fell into those categories. On horizontal analysis, the assessment results show that the worst roads in 1993 were Jianguo Road, Qianjin Road, Tiandongerdao Road, Wuyi Road, Minshen Road, Renmin Road and Huangang Road. These roads are located in dense residential area, business center, cultural and government area. So the pollution is very serious and some measurements should be taken to deal with it.

4 Conclusion

Urban traffic environment is a new research program in the fields of urban traffic transportation planning and urban environment project planning. The methods applied in this paper are practical and effective in evaluating urban traffic environment scientifically and quantitatively.

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城市交通环境质量的模糊综合评估

韩正忠[1] 杨 涛[2] 方宁生[3]

([1] 东南大学应用数学系,南京 210096)
([2] 南京市城市交通规划研究所,南京 210029)
([3] 东南大学计算科学与工程系,南京 210096)

摘 要 运用模糊数学方法,评估城市交通环境质量.建立评价系统,确定评价标准,构造隶属函数,进行程序设计与实例分析,评估结果与实际情况相一致,运用模糊理论方法评估城市交通环境质量是一种有效的方法.

关键词 模糊评判, 隶属函数,交通环境质量

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