# The Application of Fuzzy Mathematics in Urban Traffic Environment Quality Assessment

Han Zheng-zhong
Mathematics Department, Southeast University
Nanjing, Jiangsu, 210018, P.R.China

Yang Tao
Nanjing Institute of City Transportation Planning
Nanjing,Jiangsu,210029, P.R.China

**Abstract:** In this paper, traffic environment quality assessment is achived by applying fuzzy mathematics methods ----- set up an assessment system, determine assessment criterion, formulate membership function, make program designs and conduct example analysis.
**Keywords**: fuzzy mathematics; membership function; traffic environment quality assessment

## 1. INTRODUCTION

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 research 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 and processed by computer, a series of quantitative results of Anshan city from 1988 to 1993 has been calculated.

## 2.ELEMENTS ANALYSIS AND ASSESSMENT INDEX SYSTEM

Traffic environment pollution includes primly two aspects, automobile tail gas and noise. As showing in many references, seventy percent to eighty percent of air pollution in Europe and America countries 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 indexes are selected to be used in urban traffic environment quality evaluation. The factors of air pollution are CO, $SO_2$, $NO_X$, TSP,dust.Three noise factors are Leg,$L_{10}$,$L_{90}$(see Fig.1).

According to the national environment standard and international experience, each index was classified five levels, such as: excellent, good, ordinary, poor, bad. The each level's assessment criterion of the indexes were determined.

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

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". The each level's assessment criterion of each environment factor $D_1$ to $D_5$ are showed as table 1.

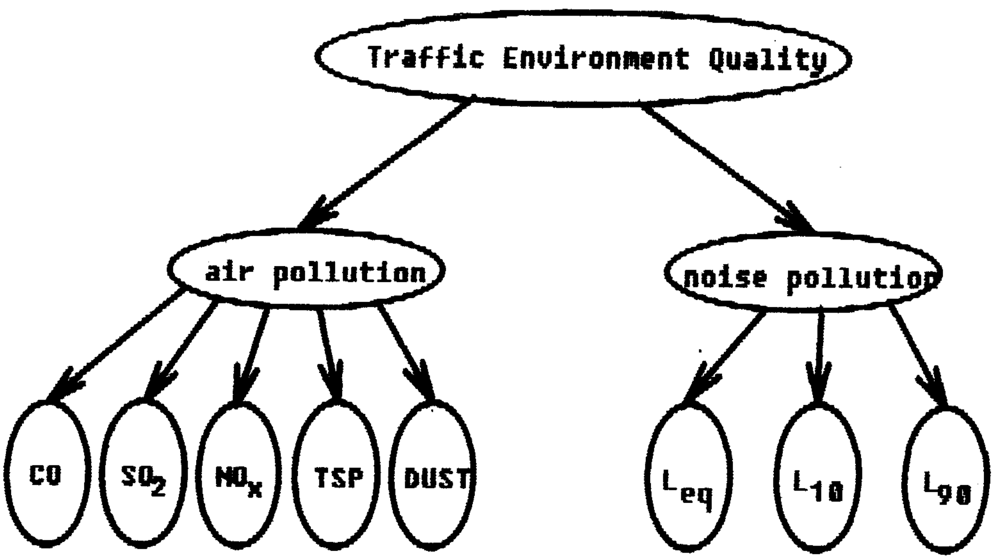

Figure 1. Urban Traffic Environment Assessment System

**Tab.1 The Assessment Criterion of Traffic Environment Quality**

| Criterion Levels | CO | $SO_2$ | $NO_X$ | Dust | TSP | $L_{eq}$ | $L_{10}$ | $L_{90}$ |
|---|---|---|---|---|---|---|---|---|
| $D_1$(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 |

Note: the unit of CO,$SO_2$,$NO_X$and TSP is mg/$m^3$, the unit of dust is t/$km^2$,noise unit is dB(A).

### *3. The 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 following:

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

$$\mu_g(x) = \begin{cases} 0 & x \le D_1 \quad or \quad x \ge D_3 \\ \dfrac{x - D_1}{D_2 - D_1} & D_1 < x < D_2 \\ 1 & x = D_2 \\ \dfrac{D_3 - x}{D_3 - D_2} & D_2 < x < D_3 \end{cases}$$

$$\mu_{b}(x)=\begin{cases}0 & 0\le x\le D_2 \quad or \quad x\ge D_4\\ \dfrac{x-D_2}{D_3-D_2} & D_2<x<D_3\\ 1 & x=D_3\\ \dfrac{D_4-x}{D_4-D_3} & D_3\le x\le D_4\end{cases}$$

$$\mu_{p}(x)=\begin{cases}0 & 0\le x\le D_3 \quad or \quad x\ge D_5\\ \dfrac{x-D_3}{D_4-D_3} & D_3<x<D_4\\ 1 & x=D_4\\ \dfrac{D_5-x}{D_5-D_4} & D_4\le x\le D_5\end{cases}$$

$$\mu_{vb}(x)=\begin{cases}0 & 0\le x\le D_4\\ \dfrac{x-D_4}{D_5-D_4} & D_4<x<D_5\\ 1 & x\ge D_5\end{cases}$$

The weights of assessment factors was determined as two levels .

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

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

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

We have developed an practical software of urban traffic environment quality analysis applying multistage Fuzzy comprehensive method.

***4. Case Study***

Urban Transportation Environment of Anshan City (1994-2010) in 1994 is a case for study. Anshan is the largest steel city located northeast China. Fourteen major roads were 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 were collected based upon the environment survey data of the city. Based upon the data, and applying the dual stage comprehensive fuzzy assessment method, the evaluation values of each year's main lines were got(showed as table 2).

**Tab. 2 The Value of Road Traffic Environment Quality of Anshan City**

| Road Name | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Jian Guo Road | 57.71 (14 | 57.75 (14) | 56.83 (14) | 53.33 (14) | 53.02 (14) | 53.22 (14) |
| Sheng Li Road | 62.86 (8) | 59.85 (6) | 60.13 (7) | 62.32 (7) | 62.22 (6) | 63.57 (4) |
| Zhong Hua Road | 65.43 (5) | 63.57 (2) | 63.45 (2) | 65.64 (2) | 61.51 (4) | 64.31 (2) |
| Yuan Lin Road | 63.00 (7) | 59.85 (7) | 59.55 (10 | 61.71 (8) | 62.00 (7) | 62.27 (7) |
| Shuang Shan Road | 66.55 (1) | 65.39 (1) | 61.66 (4) | 63.85 (3) | 65.94 (2) | 63.23 (6) |
| Qian Jin Road | 59.20 (10 | 58.07 (11 | 57.62 (13 | 57.71 (12) | 55.56 (11 | 54.09 (12) |
| Tian Dong Er Dao Roa | 60.04 (9) | 58.50 (10) | 58.48 (11 | 58.57 (11 | 55.56 (12) | 54.09 (13) |
| Wu Yi Road | 65.53 (4) | 61.20 (4) | 62.66 (3) | 62.74 (5) | 58.64 (8) | 54.47 (10) |
| Jian Shen Road | 65.93 (2) | 59.85 (8) | 61.27 (5) | 63.27 (4) | 63.05 (5) | 63.95 (3) |
| Jian Fang Road | 63.61 (6) | 59.85 (9) | 60.41 (6) | 62.60 (6) | 67.76 (1) | 64.41 (1) |
| Min Shen Road | 58.76 (13 | 58.07 (12) | 59.82 (9) | 59.82 (10) | 56.22 (9) | 56.44 (8) |
| Ren min Road | 59.15 (11) | 58.07 (13) | 60.02 (8) | 60.10 (9) | 56.08 (10) | 55.81 (9) |
| Xing Sheng Road | 65.57 (3) | 60.33 (5) | 63.85 (1) | 66.04 (1) | 65.77 (3) | 63.36 (5) |
| Huan Gang Road | 58.77 (12) | 63.03 (3) | 58.22 (12) | 54.72 (13 | 54.27 (13 | 54.42 (11) |

On historical analysis, as table 2 showed, traffic environment quality of fourteen main lines tends to become poorer each year. There were five roads being poor or bad traffic environment quality in 1988, while in 1993 seven roads fall into those categories. On horizontal analysis , the assessment results showed that the worst roads in 1993 were Jian Guo Road, Qian Jin Road, Tian Dong Er Dao Road, Wu Yi Road, Min Shen Road, Ren Min Road, and Huan Gang Road. These roads are located dense residential area, business center , cultural and government area . So pollution is very serious and some measures should be taken to deal with it .

## 5. CONCLUSIONS

Urban traffic environment assessment is a new research program in the fields of urban 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.

## REFERENCES

1) Wang Pei-zhuang, *Fuzzy Sets and Their Applications*, Science and Technology Publishing Corporation, 1983

2) Shen Hong, *Fuzzy Mathematics Applicaitn in National Economy*, Science and Technology University of Central China Press, Sept. 1994

3) Han Zheng-zhong, *Fuzzy Mathematics*, Southeast University Press, 1993