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Car active brake system design practice

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ABSTRACT

According to car active brake system design such subject, the paper studies on vehicles stability by learning domestic and foreign advanced achievements, and analyzes car active brake system design aspect from vehicle stability control's mechanical principle analysis, control system exploitation, control algorithm design, vehicle stability control system trial running four aspects.

KEYWORDS

Active brake; Stable system; Fuzzy comprehensive evaluation; Control system.

INTRODUCTION

With high speed development of science and technology, people's living standard are constantly improving, car has become an important off-walk vehicle, and road traffic conditions improvement and car technology further sublimate, modern limousines realize high speed, steady and flexible running, but improving car driving safety is still a key point of modern people studies, except for constantly improved driving environment, its important link is how to upgrade car active brake system.

By the expression of Figure 1 and Figure 2's car model, in Figure 1 it displays vertical distance between spring mass center and roll axis, vehicle yaw angular speed and so on.

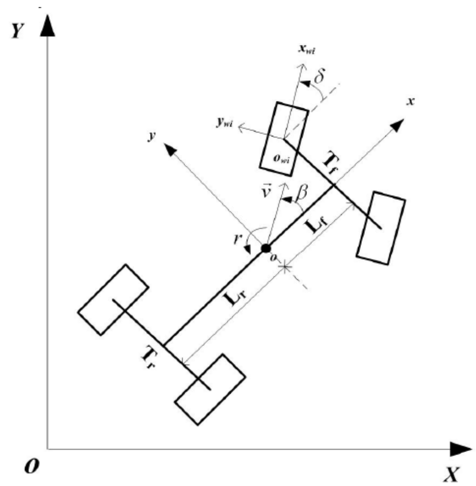

Figure 1 : Vertical distance between spring mass center and roll axis

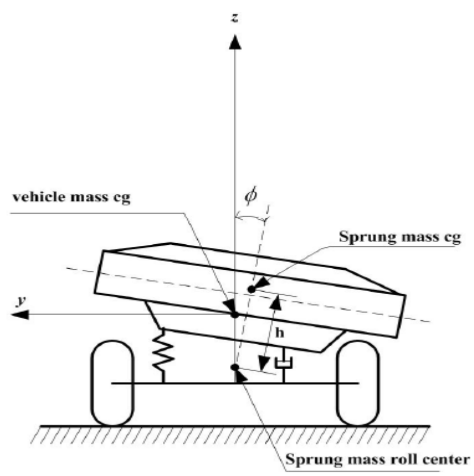

Figure 2 : Vehicle yaw angular speed

FUZZY EVALUATION MODEL ESTABLISHMENTS

Fuzzy comprehensive evaluation model

Fuzzy comprehensive evaluation model fits for fuzzy computation that multiple factors are uncertain, the paper utilizes fuzzy comprehensive evaluation, and steps are as following:

At first, the paper establishes factor set U : $U = (U_1 \quad U_2 \quad \cdots \quad U_k)$

Secondly, establish factor set V (evaluation set),

The paper establishes evaluation matrix fuzzy mapping from U to V , obtained fuzzy relation as following matrix show:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

For the topic, it establishes weight set, $A = (a_1, a_2, \cdots, a_n)$, it meets conditions:

$$\sum_{i=1}^{n} a_i = 1 \quad a_i \geq 0$$

Fuzzy relation R every line will reflect the line influence factors to object judgment degree, meanwhile, R every column will reflect the column influence factors to object judgment degree.

$$\sum_{i=1}^{n} r_{ij} \quad j = 1, 2, 3, \cdots, m$$

Secondly the paper carries on following computation according to fuzzy comprehensive evaluation:

$$\begin{aligned} B &= A \cdot R \\ &= \left(a_1, a_2, a_3, \cdots, a_n\right) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \\ &= \left(b_1, b_2, b_3, \cdots, b_n\right) \end{aligned}$$

In V , fuzzy combination is evaluation set B .

To sum up, actually fuzzy comprehensive evaluation obtained multimode system simple change model is as Figure 3 shows, Figure 3 model is simple model.

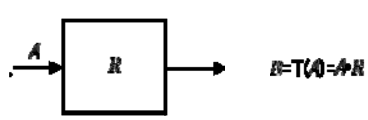

Figure 3 : Simple model

According to Figure 3 marked contents, it gets fuzzy comprehensive evaluation change model, and can establish corresponding every factor grade evaluation transformation function, evaluation factors u1, u2, u3, u4, u5 membership functions can be expressed as following formula (1)、(2)、(3) shows:

$$u_{v1}(u_1) = \begin{cases} 0.5(1 + \dfrac{u_i - k_1}{u_i - k_2}), & u_i \geq k_1 \\ 0.5(1 - \dfrac{k_1 - u_i}{k_1 - k_2}), & k_2 \leq u_i < k_1 \\ 0 \quad , & u_i < k_2 \end{cases} \tag{1}$$

$$u_{v2}(u_1)=\begin{cases}0.5(1-\frac{u_i-k_1}{u_i-k_2}), & u_i \geq k_1 \\ 0.5(1+\frac{k_1-u_i}{k_1-k_2}), & k_2 \leq u_i < k_1 \\ 0.5(1-\frac{u_i-k_3}{k_2-k_3}), & k_3 \leq u_i < k_2 \\ 0.5(1-\frac{k_3-u_i}{k_2-u_i}), & u_i < k_3\end{cases} \tag{2}$$

$$u_{v1}(u_1)=\begin{cases}0, & u_i \geq k_2 \\ 0.5(1-\frac{k_1-u_i}{k_2-k_3}), & k_3 \leq u_i < k_2 \\ 0.5(1+\frac{k_3-u_i}{k_2-u_i}), & u_i < k_3\end{cases} \tag{3}$$

Combine with fuzzy evaluation model to evaluate

By fuzzy comprehensive evaluation model principle, the paper establishes factor set U, from which $U=(U_1 \quad U_2 \quad U_3 \quad U_4)$. According to four important factors like vehicle stability control's mechanical principle analysis U_1, control system exploitation U_2, control algorithm design U_3, vehicle stability control system trial running U_4, it gets TABLE 1. The paper establishes small factors sets in four important factor sets.

TABLE 1 : Active brake system design evaluation indicator system

Vehicle stability control's mechanical principle analysis U_1	Control system exploitation U_2	Control algorithm design U_3	Vehicle stability control system trial running U_4
ABS control system u_{11}	Control system staff cultivation u_{21}	Tire u_{31}	Test drive pattern u_{41}
TC system u_{12}	Active safety techniques improvements u_{22}	Complete vehicle u_{32}	Test drive result analysis u_{42}
YSC System u_{13}	Auxiliary system and engine management system u_{23}	Hydraulic system u_{33}	Real vehicle model u_{43}
Mechanical principle analysis application u_{14}	Cultivation expense u_{24}	Brake u_{34}	

By TABLE 3 listed factors, it gets evaluation set.

$$U_1=\{u_{11},u_{12},u_{13},u_{14}\}$$
$$U_2=\{u_{21},u_{22},u_{23},u_{24}\}$$
$$U_3=\{u_{31},u_{32},u_{33}\}$$
$$U_4=\{u_{41},u_{42},u_{43}\}$$

By collecting data and analyzing, it gets four factors importance degree ranking statistics as TABLE 2 shows.

By TABLE 2 sorting, it gets vehicle stability control's mechanical principle analysis U_1, control system exploitation U_2, control algorithm design U_3, vehicle stability control system trial running U_4 four aspects ranking matrix.

$U_2 = \{25, 5, 4, 0\}$
$U_2 = \{0, 2, 18, 12\}$
$U_3 = \{0, 9, 13, 12\}$
$U_4 = \{3, 20, 10, 0\}$

Obtained weighted vector from rank 1 to rank 2

$\beta = \{\beta_1, \beta_2, \beta_3, \beta_4\} = \{0.4, 0.3, 0.2, 0.1\}$
$U_i^* = U_i \cdot \beta^T$
$U_1^* = 14$, $U_2^* = 9.4$, $U_3^* = 4$, $U_4^* = 5.6$

The paper takes normalization processing

$U_1^* = 0.35$, $U_2^* = 0.3$, $U_3^* = 0.2$, $U_4^* = 0.15$

It gets

$\bar{A} = (0.35 \quad 0.3 \quad 0.2 \quad 0.15)$

The paper establishes remarks membership, as TABLE 3 show.

TABLE 2: Four factors importance degree ranking statistics

Classification	Rank 1	Rank 2	Rank 3	Rank 4
Vehicle stability control's mechanical principle analysis U_1	25	5	4	0
Control system exploitation U_2	0	2	18	12
Control algorithm design U_3	0	9	13	12
Vehicle stability control system trial running U_4	3	20	10	0

TABLE 3 : Remarks membership

Evaluation way	Set scores interval			
	0-60	60-80	80-90	90-100
Very good	0	0	0.05	0.95
Good	0	0.05	0.9	0.05
Normal	0.05	0.9	0.05	0
Bad	0.95	0.05	0	0

The paper gets TABLE 4 by car active brake system designing in vehicle stability control's mechanical principle analysis U_1, control system exploitation U_2, control algorithm design U_3, vehicle stability control system trial running U_4 four aspects each indicator obtained evaluation.
By above model, it gets single layer indicator weight factor fuzzy set is

$U_1^* = \{U_{11}, U_{12}, U_{13}, U_{14}\} = \{0.25, 0.35, 0.25, 0.15\}$
$U_2^* = \{U_{21}, U_{22}, U_{23}, U_{24}\} = \{0.54, 0.1, 0.24, 0.14\}$

$$U_1^* = \{U_{31}, U_{32}, U_{33}, U_{34}\} = \{0.4\ 0.3\ 0.1\ 0.2\}$$
$$U_1^* = \{U_{41}, U_{42}, U_{43}\} = \{0.3\ 0.4\ 0.3\}$$

The paper relies on TABLE 5 evaluation, combines with TABLE 3 remarks membership, it gets vehicle stability control's mechanical principle analysis U_1, control system exploitation U_2, control algorithm design U_3, vehicle stability control system trial running U_4 each aspect evaluation set:

Vehicle stability control's mechanical principle analysis $U1 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$

Control system exploitation $U_2 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$

Control algorithm design $U_3 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0.05 & 0.9 & 0.05 & 0 \end{pmatrix}$

Vehicle stability control system trial running $U_4 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$

Carry on following computation on above evaluation set: $B_i = A_i \cdot R_i$
Make normalization processing with obtained B_i, it gets fuzzy evaluation matrix.

$$\bar{B} = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{pmatrix} = \begin{pmatrix} 0.07 & 0.26 & 0.13 & 0.42 \\ 0 & 0.15 & 0.76 & 0.54 \\ 0.14 & 0.24 & 0.21 & 0.17 \\ 0.14 & 0.2 & 0.3 & 0.36 \end{pmatrix}$$

It gets comprehensive evaluation value: $Z = U^* \cdot B = (0.33 \quad 0.28 \quad 0.24 \quad 0.15)$

TABLE 4 : Car active brake system design each indicator obtained evaluation value

Each layer indicator	Evaluation value	Each layer indicator	Evaluation value
ABS control system u_{11}	Very good	Tire u_{31}	Good
TC system u_{12}	Normal	Complete vehicle u_{32}	Good
YSC System u_{13}	Very good	Hydraulic system u_{33}	Good
Mechanical principle analysis application u_{14}	Very good	Brake u_{34}	Normal
Control system staff cultivation u_{21}	Normal	Test drive pattern u_{41}	Good
Active safety techniques improvements u_{22}	Very good	Test drive result analysis u_{42}	Normal
Auxiliary system and engine management system u_{23}	Very good	Real vehicle model u_{43}	Normal
Auxiliary system and engine management system u_{24}	Good		

CONCLUSION

The paper gets vehicle stability control's mechanical principle analysis, control system exploitation, control algorithm design, vehicle stability control system trial running four aspects importance degree to car active brake system design by fuzzy comprehensive evaluation, by fuzzy comprehensive evaluation value, it can get that 0.33 is maximum value of four evaluation values, it shows obtained evaluation interval is in the score phase of 90-100, which shows vehicle stability control's mechanical principle analysis, control system exploitation, control algorithm design, vehicle stability control system trial running can be used as car active brake system exploitation main study aspect to design them.

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