Research of the Assessment for Agricultural Machinery Driving Safety Based on AHP-FUZZY Method

Wenlong Chen [a], Wentao Han [b]

Equipment and Transportation Department, Engineering University of CAPF, Xi'an 710086, China

[a]525692448@qq.com, [b]hanwentao_1@sohu.com

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Abstract. In order to realize the assessment of agricultural machinery driving safety, the key factors of influencing agricultural machinery driving safety were selected and an indexes system of agricultural machinery driving safety assessment was built up. Based on AHP-FUZZY, the assessment weight coefficients of agricultural machinery driving safety were established, which realized quantitative evaluation to the agricultural machinery driving safety, and at the same time provided scientific basis for enterprises to choose the safety allocation scheme of agricultural machinery.

Introduction

As the rapid development of the agricultural mechanization industry in china, the national level has been remarkably improved, which speeds up the construction of our agricultural modernization. However, the condition for the operation of agricultural machinery is complex. The cultural quality of people in rural areas is relatively low in face of the demand to promote the use of agricultural machinery. This inevitably gives the pressure to the safety in production of agricultural machinery. Therefore, we need to strength the management of operational safety of the agricultural machinery and ensure the safety in driving the farm machines and avoid the accidents. Those are the hotspot issues in agricultural production .The factors concerning the safety in driving farm machines include the people, machines and environment and so on, which are complex, subjective, unpredictable and hard to quantify. This paper, cased on the method called AHP-FUZZY[2], sets up a math model of evaluation on the safety in driving agricultural machines and provides the scientific reference.

The establishment of the evaluation system on the driving safety of agricultural machinery

The operational system of the agricultural machinery is a three-part one composed of the people, machines and environment. The three components are interconnected and interact on each other. Once the coordination among them lost, safe reliability in the whole system will be affected, causing the accidents [3].

Therefore, it is important to strike a balance between people, machines and environment namely drivers, agricultural machinery and the operational environment to enhance the safety in driving the farm machines. The factor of driver includes the driving skills, driving experience, attention and reaction time, etc. The factor of the agricultural machinery includes structure design of the agricultural machines, brake performance, technical state, and lifetime, etc. The factor of operational environment consists of weather condition, terrain and topography, road transportation and social environment, etc. This paper chooses the driving skills, driving experience, physical fitness, structure design, brake performance, technical state, weather condition, topography, road transportation and other indexes to measure and evaluate the safety in driving the farm machines.

Evaluation indexes system. The evaluation indexes system of driving safety of agricultural machinery is an important foundation and basis to evaluate the safety in driving the farm machines. It can reflect the causes of the driving risks and weightiness of all factors through a series of scientific, integrated and systemic indexes. The evaluation indexes system of driving safety of agricultural machinery is set up by using the method of establishing hierarchical structure model in accordance with the analytic hierarchy process. As the PIC 1 shows:

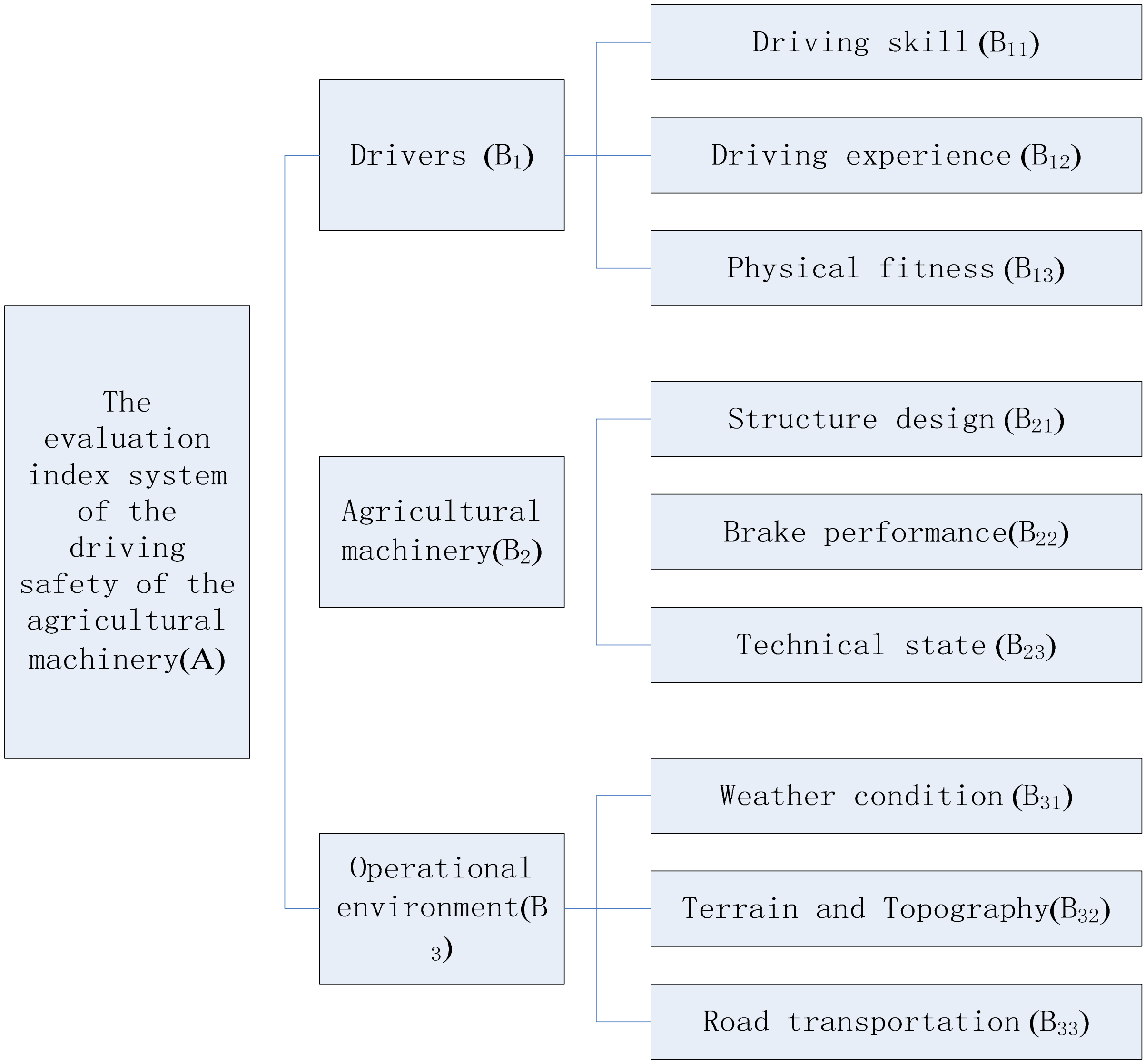

Fig 1. Evaluation indexes system of driving safety of agricultural machinery

The determination of weighting of evaluation indexes on driving safety of agricultural machinery

The main idea of analytic hierarchy process is to divide the targets into the several components according to the nature of the subjects and to stratify them and build a hierarchical structure model according to the subordination relations among components and then finally achieve the weight of the importance of the lowest layer to the highest layer (total objective) according to hierarchical structure analysis or order them in light with advantages and disadvantages.

Building the matrix of the **weightiness judgment.** (1) In order to compare the indexes and attain the quantified judgment matrix, we need to introduce the scale 1-9 as shown in table 1. Scale 1-9 is one that compares the influence of B_i and B_j on A. In the scale 1-9, the range of values allowed by b_{ij} is from 1 to 9 and its reciprocal numbers 1,1/2,…,1/9.

Table 1 AHP index weighting scale

Value(v)	Meaning
1	i is important as j
3	i is more important than j
5	i is apparently more important than j
7	i is certainly more important than j
9	i is definitely more important than j
2,4,6,8 can be used as other medians; If i is not important as j, the value can be $1/v$ (v=1-9).	

(2)As for the three-layered index structure, there exist two types of judgment matrix: Target—standard judgment matrix and standard—measure judgment matrix. The former is mainly used to calculate the relative weights of all indexes at the level of the standards. The latter is mainly used to calculate the relative weights of all indexes under one standard.

The two types of matrix are same in forms while different in levels. Through the broad professional consultations and collection of data, we can handle the average value of attained judgment matrix.

$$B=\begin{bmatrix} 1 & \sum_{k=1}^{k=m}\left(b_{12}^{k}/m\right) & \cdots & \sum_{k=1}^{k=m}\left(b_{1n}^{k}/m\right) \\ \sum_{k=1}^{k=m}\left(b_{21}^{k}/m\right) & 1 & \cdots & \sum_{k=1}^{k=m}\left(b_{2n}^{k}/m\right) \\ \cdots & \cdots & \cdots & \cdots \\ \sum_{k=1}^{k=m}\left(b_{n1}^{k}/m\right) & \sum_{k=1}^{k=m}\left(b_{n2}^{k}/m\right) & \cdots & 1 \end{bmatrix} \quad (1)$$

The calculation of the index weightiness and consistent test. The index weightiness calculation by using analytic hierarchy process can be concluded as the calculation of the feature vector of judgment matrix and the maximum eigen value. The main methods include square root method, sum quadrature method and power method. Taking the judgment matrix B at the level of standards as an example, the calculation steps of introducing the square root method is shown as follow.

(1)Calculating the product of elements in each line

$$M_i=\prod_{j=1}^{n}B_{ij},i=1,2,3,\cdots,n \quad (2)$$

(2)Calculating n-th root of M_i

$$\overline{b_i}=(M_i)^{\frac{1}{n}},i=1,2,3,\cdots,n \quad (3)$$

(3)Normalizing the $\overline{b_i}$

$$b_i=\frac{\overline{b_i}}{(\sum_{i=1}^{n}\overline{b_i})},i=1,2,3,\cdots,n \quad (4)$$

Weight vector $B=\left[b_1,b_2,b_3,\cdots,b_n\right]^T$

(4)Calculating the maximum Eigen value in judgment matrix B

$$\lambda_{\max}=\sum_{i=1}^{n}\frac{\left[Bb\right]_i}{nb_i} \quad (5)$$

In the equation, $\left[Bb\right]_i$ is the i-th element in the vector Bb.

Because people can't know the consistent measurement in comparing the factors of complex objects and there exist certain errors, we need to consistently test the judgment matrix in order to enhance the reliability of the weightiness evaluation

In the method to make consistent test

$$CI = \frac{\lambda_{\max} - n}{n-1} \qquad (6)$$

In the equation, n is the dimensionality of the matrix, which in fact is total number of indexes in the same matrix. $\lambda_{\max}$ is the maximum Eigen value

When the dimensionality of the matrix is relatively big, the consistent index is needed to corrected. The operator is shown as follow

$$CR = \frac{CI}{RI} \qquad (7)$$

RI is the correction factor, the value of which is shown in the table 2

Table 2 Correction function table

Dimensionality	1	2	3	4	5	6	7	8	
RI	0	0	0.58	0.96	1.12	1.24	1.32	1.41	1.45

As the index dimensionality is less than 3, the judgment matrix is easily to be consistent; it is no need to calculate the consistent index. In the general condition, when CR is less than 0.1, it will meet the consistent need.

The calculation of the comprehensive weightiness. The standard-level weightiness vector achieved by the mentioned method is

$$B = (b_1, b_2, b_3) \qquad (8)$$

b_i is the relative weight in the level of standard of the index i.

If the measure-level index weigh is $B_i = (b_{i1}, b_{i2}, b_{i3})$ as for the i-th standard-level index, then

$$B_i = (b_{i1}, b_{i2}, b_{i3}) \qquad (9)$$

The calculation operator for the integrated weight of the index j under the standard j in the hierarchical structure is

$$b_{ij} = b_i \cdot b_{i_j} \qquad (10)$$

In the end, through the broad professional consultation and the collection of data , we can attain the weight of all evaluation indexes according to the mentioned calculating method.

Table 4 The weights of the evaluation index of driving safety of the agricultural machinery

	First-class indicator	Second-class indicator	Integrated weights
The evaluation index system of the driving safety of the agricultural machinery	Drivers b_1 0.552	Driving skill b_{11} 0.511	0.282
		Driving experience b_{12} 0.231	0.128
		Physical fitness b_{13} 0.258	0.142
	Agricultural machinery b_2 0.335	Structure design b_{21} 0.304	0.102
		Brake	0.112

	performance b_{22} 0.334	
	Technical state b_{23} 0.363	0.121
Operational environment b_3 0.113	Weather condition b_{31} 0.367	0.041
	Terrain and Topography b_{32} 0.325	0.037
	Road transportation b_{33} 0.308	0.035

Through the evaluation and calculation, it can be found than drivers have the greatest influence on the driving safety of agricultural machinery and the driving skills of the diver is the key factor. In the non-driver security factors, the technical state of the machinery has important effect in the driving safety.

Ambiguous integrated evaluation of the driving safety of the agricultural machinery

After doing the research on a small agricultural machinery lending company, we found that five machines (agricultural tractor) can be lent. During the busy periods on farmland, the machines lending cannot meet the demand due to the limited numbers of the machines. After doing research and analyzing data, we acquired two sets of lending plans of this company made in October, 2011.

This paper, based on the mentioned methods, after combining ambiguous and intergraded evaluation method and calculating and analyzing the safety, security and stability of all programs form the safe perspectives, evaluates the best program.

Normalization of the index. While evaluating the safety factors, the common collection is hard to correctly express the borderline of classification. For instance, the nice weather is good, while raining is bad. This standard of classification is limited. This paper uses the ambiguous integrated evaluation and divides the safety driving factors of agricultural machinery into five levels: A+, A,B,C,F , which can be shown in 5,4,3,2,1[4].Finally, we achieve the evaluation results of two sets of the plans. This is shown as table 5.

Table 5 Evaluation results of all indexes in agricultural machinery

Plan NO.	Agricultural machinery NO.	Safety driving factors of agricultural machinery								
		B 11	B 12	B 13	B 21	B 22	B 23	B 31	B 32	B 33
Plan A(C1)	1	4	3	4	4	4	5	3	4	4
	2	4	4	3	4	4	4	3	4	4
	3	4	4	5	4	5	3	3	4	4
	4	5	3	3	5	3	4	5	3	5
	5	5	3	4	5	4	4	5	3	5
Plan B(C2)	1	4	4	3	4	4	5	5	3	5
	2	5	3	4	4	4	4	3	4	4
	3	4	4	5	4	5	3	3	4	4
	4	5	3	3	5	3	4	3	4	4
	5	4	3	4	5	4	4	5	3	5

The evaluation results of safety based on AHP-FUZZY [6]. After acquiring the weights of all indexes and multiplying with the evaluation value, the final score is

$$c_{11} = \left(b_{11}, b_{12}, \cdots, b_{33}\right)\left(c_{11}, c_{12}, \cdots, c_{19}\right)^T \tag{11}$$

The same procedure can be adapted to calculate the scores of safety driving in other plans, average of the safety degree and its variance. This is shown in table 6.

Table 6 The sores of the driving safety of the agricultural machinery

Plan NO.	NO. of the driving safety degree of the agricultural machinery					Average of safety level	Variance of safety level
	1	2	3	4	5		
Plan A(C1)	3.952	3.817	4.092	4.041	4.295	4.0394	0.0313
Plan B(C2)	4.018	4.113	4.092	3.961	4.013	4.0394	0.0039

This table clearly shows that under the same safety degree, plan A is worse than plan B in terms of safety degree. Its safety degree is volatile and weak in stability. The safety degree of plan B is quite stable and good in stability. To this end, the evaluation results achieved by the mentioned ways can reflect the difference in stability of all plans through a set of clear data and finally determine the plan B as the best one in terms of stability.

Conclusion

This paper, on the basis of considering drivers, agricultural machinery and operational environment, puts forward a way of studying the driving safety of agricultural machinery in the way of AHP-FUZZY and setting up a relatively complete set of index evaluating system. Through analyzing and judging of agricultural machinery, this paper can quantify the various factors affecting the driving safety of agricultural machinery and clearly reflect the safety degree and stability of driving safety with a group of data and provide a new technical index for farming production. Meanwhile, this paper creatively accomplishes the reasonable evaluation on the agricultural machinery distribution of the enterprises from a safe perspective, increasing the production safety.

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