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The anti-theft system of truck fuel tank based on AHP algorithm

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Abstract

Because the truck fuel tank is exposed outside the car body, it is often easy to be targeted by criminals. But domestic truck anti-theft equipment is not high precision, often misjudgment. To solve this problem, we introduce AHP algorithm, which takes the condition of truck fuel tank as the target, and takes temperature, pressure, vibration, gamma radiation and hydraulic sensor as the criterion. The weight of each criterion is calculated by weight comparison and comprehensive analysis between the two criteria, which greatly increases the accuracy of judging the state of the fuel tank and reduces the possibility of misjudgment to a relatively low level.

Keywords

Analytic hierarchy Process; AHP algorithm; Van guard against theft.

1. Introduction

1.1. Subject source and significance

The topic comes from the undergraduate innovation and entrepreneurship competition project I participated in: truck fuel tank anti-theft system.

The significance of choosing this topic is that the domestic truck safety problem is very serious. The fuel tank of some truck models is exposed outside the car body, because the tank storage of large truck is amazing, it is soon targeted by criminals. So how to protect the truck fuel tank and the owner of the property safety of the difficult problem is placed in front of people. Initially, sensors were added to the fuel tank. When a theft occurred, the signal was uploaded to a server and sent to a mobile phone to alert the owner. But the error rate is so high that even a passer-by could easily trigger an alarm, let alone a fallen leaf or something falling on the fuel tank. So it occurred to us that if we could introduce a sophisticated algorithm into the program as the sensor sends the signal to the server, it would be possible to greatly reduce the possibility of program misjudgment, so that the instrument is really accurate, not misjudgment. There are a number of factors, given that there are multiple sensors on the tank, the criterion layer. So I decided to use AHP algorithm in the program to comprehensively judge the state of the fuel tank.

1.2. Research status and review at home and abroad

We searched the Internet for effective ways to curb this kind of crime, with limited success. Domestic truck anti-theft equipment types are few, accuracy is not high, misjudgment problem is serious. So thefts happen all the time, and even if such devices are installed, the alarm may simply be sent by a passer-by, causing the lorry driver to rush back to his truck only to get a false alarm. In the long run, drivers suffer. Therefore, the market is in urgent need of a kind of high-precision and sophisticated equipment with less misjudgment. Such equipment is still in the blue sea in China, which is not enough to meet the broad demand of the market.

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1.3. Main research content and technical route of the paper

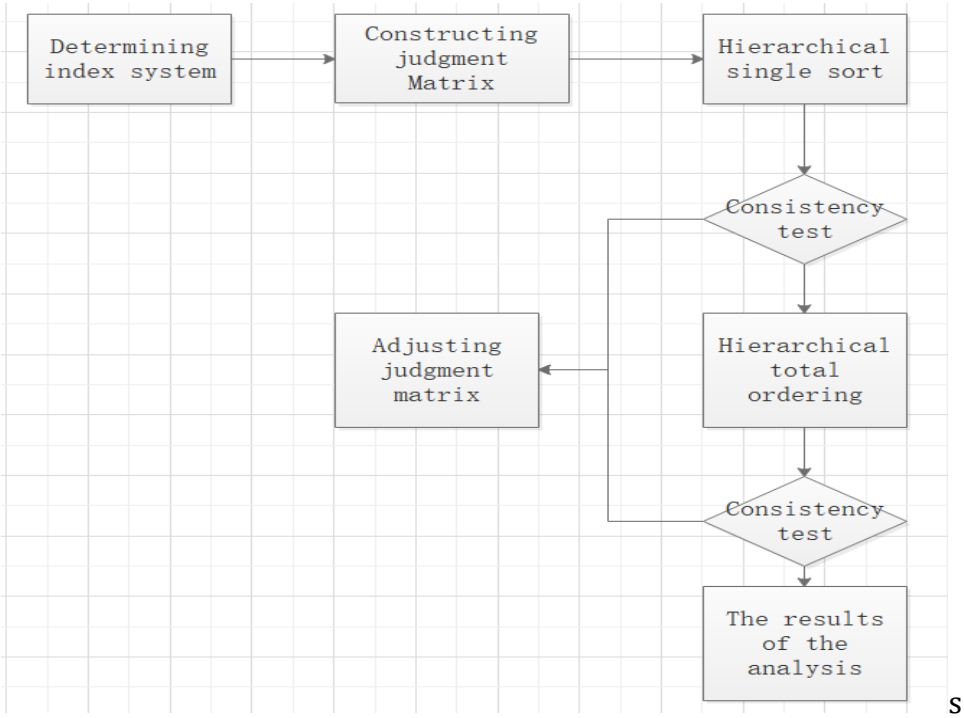
The main content of this paper is to solve the weight assignment problem of sensor parameters by designing reasonable program algorithm.

The technical route is analytic hierarchy process (AHP) algorithm to analyze the temperature, pressure, vibration, hydraulic, gamma radiation sensor data returned to the server, reasonably calculate the weight of each attribute, and finally establish a comprehensive evaluation model to evaluate the risk of fuel tank theft.

The first step to determine the index system, the establishment of the goal is to obtain the state of the tank. There are four schemes to establish the target, namely, the tank is in good condition, the tank is in normal condition, the tank is in poor condition and the tank is being stolen. The criteria for evaluating the state of the tank are temperature, pressure, vibration, hydraulic pressure and gamma radiation.

The second step is to construct a judgment matrix of one of the criteria according to the subjective importance degree.

The third step is to conduct consistency test according to the judgment matrix computing permission vector to check whether the judgment matrix constructed subjectively is consistent matrix. If the definition of consistent matrix is satisfied, different weight calculation methods can be used to calculate data according to the weight given by the judgment matrix to analyze the fuel tank state.



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2. Comprehensive evaluation model based on AHP algorithm

Analytic Hierarchy Process (AHP) algorithm is used to evaluate whether there is the risk of stolen oil. Generally, the theft risk is evaluated comprehensively according to the data returned by sensors. But often the weight is not easy to quantify, easy to consider careless or lose, so to divide and rule, two by comparison to get the weight. Ahp algorithm can be used to assign weight to criteria effectively.

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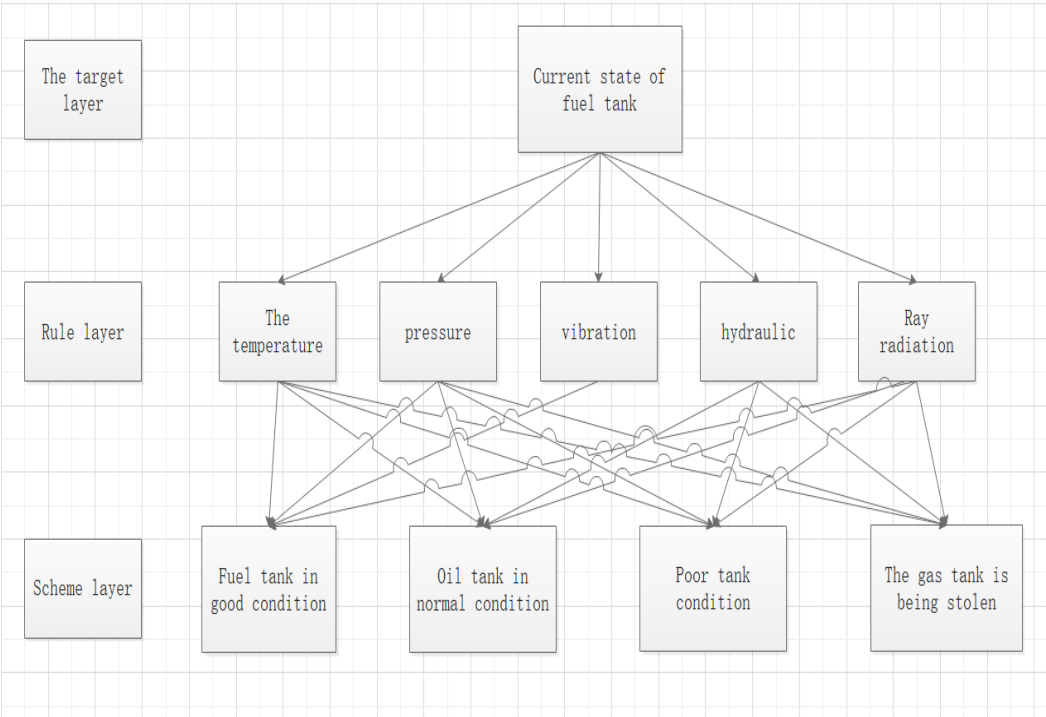
2.1. Factors of comprehensive evaluation

Evaluation objective: The fuel tank of the truck is taken as the evaluation objective, and the parameters of pressure, temperature, vibration, gamma radiation and liquid level sensor are used as the inspection standards.

Solution to reach target: tank in good condition, tank in good condition, tank in bad condition, tank being stolen.

Criteria and indicators for evaluation: temperature, pressure, vibration, gamma radiation, liquid level.



Note: Establish 5*5 matrix according to criteria layer factors, and compare in pairs

2.2. Evaluation scale and meaning

scale	meaning
1	Equally important
3	A little important
5	Obviously important
7	Highly important
9	Extremely important
2, 4, 6, 8	The median of the two adjacent judgments above
The bottom	A compared to B if the scale is 3, then B compared to A is 1/3

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Note: The two criteria are reciprocal. For example, if I is significantly more important than J, then AIj is 5 and Aji is 1/5.

If the scale between two criteria is even, then the intensity is between the odd numbers on both sides of the even number. For example, if AIj is 2, then I is slightly important.

2.3. Calculate the judgment matrix of weight according to scale

	Ray radiation	vibration	pressure	temperature	hydraulic
Ray radiation	1	1/2	4	1/5	1/5
vibration	2	1	1/3	1/7	1/9
pressure	1/4	3	1	1/3	1/6
temperature	5	7	3	1	1/3
hydraulic	5	9	6	3	1

Example: The 2 in the second row, first column, indicates that the vibration (row) is slightly more important than the gamma radiation (column) (between 1 and 3)

1. This is a square matrix of 5*5. Aij represents the importance of I compared with index i
2. If i = j, aij = 1
3. aij > 0 and aij * aji = 1 (matrices satisfying this condition are called reciprocal matrices)

Note: The numbers of the judgment matrix in the ANALYTIC hierarchy process can only be 1-9 and their reciprocal.

In the design, we believe that the liquid level can intuitively show the oil drop rate in the tank, so it is of the highest importance. Temperature, pressure, vibration and radiation decrease in descending order.

2.4. Conduct consistency test on the judgment matrix.

Since the matrix has not undergone a consistency test, it is not necessarily a consistent matrix. So there may be a contradiction in the degree of importance.

Therefore, consistency test must be carried out before using the judgment matrix to calculate the weight to determine whether the degree of inconsistency is acceptable.

Note: uniform matrix is a matrix of multiple relationships of rows and columns, satisfying AIK = AIJ * ajK

Step 1: Calculate consistency metrics

$$CI = \lambda\max - n / n-1$$

Step 2: Search for the corresponding average random consistency index RI

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

Note:In practical application, n rarely exceeds 10. If the number of indicators is greater than 10, a secondary index system or fuzzy comprehensive evaluation model can be considered

Step 3: Calculate the consistency ratio CR

$$CR = CI / RI$$

Note: If CR < 0.1, the consistency of the judgment matrix can be considered acceptable; Otherwise, the judgment matrix needs to be modified.

3. Comprehensive evaluation model based on AHP algorithm

After passing the consistency test, the weight is calculated by arithmetic average method. For the four schemes, the final score of the scheme is calculated by multiplying the criterion by the score of the scheme on this criterion and adding the sum.

Such as: Tank in good condition = tank in good condition score on temperature * weight of temperature + tank in good condition score on vibration * weight of vibration + tank in good condition score on pressure * weight of pressure + tank in good condition score on gamma radiation * weight of gamma radiation + Tank in good condition hydraulic score * hydraulic weight.

4. Conclusion

The application of analytic hierarchy process (AHP) to the anti-theft system of truck fuel tank can effectively calculate the reasonable weight of each factor and greatly reduce the possibility of program misjudgment. There is a significant improvement in system accuracy. In the application can meet the requirements of the system.

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