CONSTRUCTION OF SPARE PARTS IMPORTANCE EVALUATION FOR CROSS-REGION HARVESTER BASED ON CRITIC AND TOPSIS METHOD
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基于 CRITIC 和 TOPSIS 方法的跨区收割机备件重要性评估

Weipeng ZHANG, Bo ZHAO*, Yashuo LI, Liming ZHOU, Kang NIU, Hanlu JIANG, Guangrui LI
State Key Laboratory of Soil Plant Machine System Technology, China Academy of Agricultural Mechanization Science Group Co., Ltd. Beijing 100083, China;
Tel: +86-(010)64882659; E-mail: zhaoboshi@126.com
Correspondent author: Bo ZHAO
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ABSTRACT
Aiming at the problem of insufficient research on the importance evaluation of agricultural machinery spare parts in the process of cross-region operation of combine harvester, based on CRITIC and TOPSIS, an evaluation model of the importance of spare parts for cross region combine harvesters was established. The CRITIC model was used to calculate the weight of each evaluation index, the weighted TOPSIS evaluation model was used to process the data, and the relative closeness between the spare parts of each harvester to be evaluated and the ideal solution was calculated. Finally, the spare parts resource management decision-making system platform is developed to effectively integrate the spare parts resource allocation. The results show that the model can reasonably and effectively evaluate the important demand degree of combine harvester spare parts, and has a good reference value for the cooperative service of agricultural machinery service vehicles and the priority degree of spare parts loading.

摘要
针对联合收割机跨区作业过程中，农机备件重要度评价研究不足的问题，建立了基于 CRITIC 和 TOPSIS 法的跨区作业联合收割机备件重要度评价模型。运用 CRITIC 模型计算得到各评价指标的权重，运用加权 TOPSIS 评价模型对数据进行处理，并计算各待评价收割机备件与理想解的相对贴近度。建立联合收割机备件重要需求度评价指标体系，最后开发备件资源管理决策系统平台，有效的将备件资源配置进行集成管理，模型能够较合理有效地对联合收割机备件重要需求度进行评价，对农机服务车的协同服务，备件装载优先度有较好的参考价值。

INTRODUCTION
In China, as crops mature seasonally from south to north, the demand for harvesters tends to develop across regions (*Chenbo et al., 2020*). Due to the cross-region operation of combine harvester, its work intensity is high and the machine operation load is heave, which easily leads to a sharp increase in the number of machine failure and a strong demand frequency. After the failure occurs (*Vezirov et al., 2021*), in order to ensure the normal field needs of farmers and the urgent request of the farmers for maintenance (*Xiusheng et al., 2017; Zhengxing et al., 2018*), rapid maintenance and replacement of spare parts is the best solution. In recent years, more and more attention has been paid to the development of optimization technology of agricultural machinery service (*Vlădut et al., 2012; Zhou et al., 2014; Han et al., 2020*).

In the process of maintenance and repair of harvester, spare parts are the key factor for the quick troubleshooting of combine harvester (*Chemweno et al., 2015*). At present, in preventive maintenance (*Yu et al., 2022*) and field maintenance *(Gilev et al., 2019),* relevant research on the maintenance configuration process of spare parts, maintenance personnel and joint optimization of maintenance personnel and spare parts had been carried out by the scholars. Adequate spare parts with high service intensity have better availability for equipment. Spare parts inventory reflects the effectiveness of service execution (*Wang et al., 2021*). For example, intelligent optimization algorithm is adopted to supervise and make decisions on a large number of spare parts. In the evaluation of the importance information of spare parts, the evaluation methods adopted, including AHP hierarchical analysis (*Zandi et al., 2020; Zhang et al., 2021*), CRITIC weight, TOPSIS evaluation (*Rostamzadeh et al., 2018; Wang et al., 2022*) and fuzzy comprehensive evaluation (*Li,et al., 2022*), have been effectively recognized.

Although the above methods have solved the problem of spare parts configuration to a certain extent, there are still shortcomings. The spare parts configuration scheme is directly presented without considering the priority of spare parts configuration.

In view of the above problems, this paper starts with the establishment of the evaluation system of spare parts maintenance demand, combines the Delphi method with the CRITIC method to compare and screen the importance of indicators, and reflects the objectivity of indicators reflected in the actual evaluation value on the basis of fully retaining the subjective intention of experts. An evaluation model of the importance of spare parts based on the weight of Delphi method and the weight of CRITIC method is established. Finally, the importance of spare parts is applied on the platform, and the evaluation results of the importance of spare parts are displayed. This method can determine the priority of spare parts allocation of operation and maintenance service vehicles when the space of service vehicles is limited in emergency service maintenance, and can provide reference for the cross-region operation of combine harvesters and the formulation of spare parts allocation scheme.

MATERIALS AND METHODS

Improve the optimization of spare parts allocation of CRITIC-TOPSIS evaluation model

Problem analysis

As shown in Figure 1, the cross region operation of the combine is a mechanical harvesting method of rice and wheat in the three summer season of China. The cross region operation and maintenance service of the harvester is a process in which the failed agricultural machinery seeks service and maintenance personnel to provide services. However, in the agricultural scene, once the agricultural machinery fails, it is difficult to carry out consignment to the service outlets for maintenance due to the special operation conditions of agricultural machinery. At the same time, the field crops need to be harvested as soon as possible, so effective time processing can improve the speed and efficiency of the entire operation. However, the maintenance process is mostly through reporting to the agricultural machinery enterprises for repair, so that maintenance service vehicles can come to rescue. In the whole transregional maintenance process, the effective allocation of spare parts resources can quickly solve the problem of harvester failures. However, a service vehicle needs to repair multiple faulty agricultural machinery, and the fixed space can only be equipped with a certain number of spare parts. At the same time, the seasonal requirements of transregional operations and the different types of crops lead to different types of demand for spare parts. To avoid the occurrence of spare parts with low configuration importance on the vehicle, it is necessary to evaluate the importance of spare parts. As the harvester is overloaded and continues to operate in transregional operation, the failure problem is mostly vulnerable parts. If the maintenance service vehicle carries reasonable spare parts configuration strategy, combined with the harvester maintenance support force of the agricultural machinery manufacturer, the field emergency repair can be carried out quickly, so as to realize the harvester's reoperation in the field.

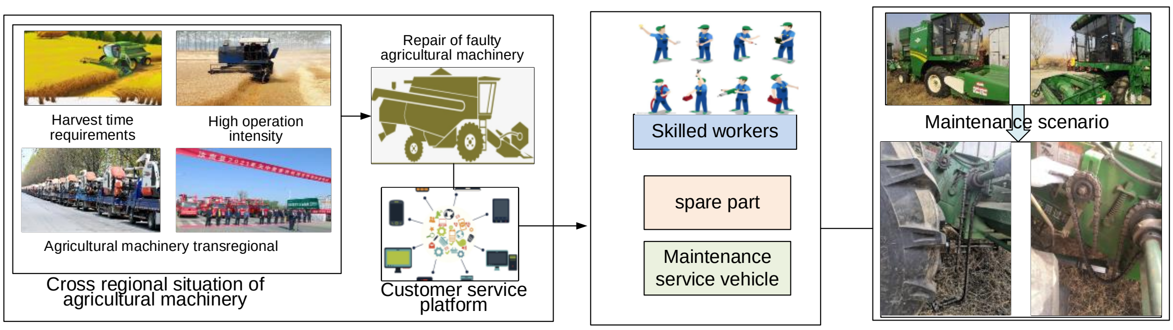

Fig. 1 - Cross region and maintenance scenario of agricultural machinery

Delphi empowerment

Delphi method is a subjective expert opinion evaluation method, which can not only reduce the one-sided caused by experts' personal preferences, but also reflect the differences of opinions among experts. In this paper, the Delphi method is used to give weight to each index in the comprehensive evaluation index system by using experts' knowledge, experience and personal views. The consistency of expert opinions is used as the standard to determine the index weight.

First, use the Delphi method to sort the evaluation element set and calculate the evaluation weight w_{ij} of each factor:

$$w_{ij}=\frac{\sum_{i=1}^{m} v_{ij}\times w_{\exp}}{\sum_{i=1}^{m}\sum_{j=1}^{n} v_{ij}\times w_{\exp}} \tag{1}$$

In formula (1), m is the number of experts; n is the number of evaluation elements; v_{ij} is the evaluation value of each expert on each evaluation element; the weight w_{exp} is the weight of each expert. Thus, we can get the weight vector $W_{DELF}=(w_1,w_2,w_3,w_4)$.

CRITIC empowerment

The multi-index (attribute) comprehensive evaluation method focuses on determining the weight of each evaluation index and evaluating the evaluation object according to the weight of each index. The weight size indicates the importance and influence of the indicator in the evaluation process. Therefore, the objectivity and accuracy of each evaluation index weight directly affect the reliability of the final evaluation results. The existing subjective weighting method relies too much on human factors. The index weights obtained by this weighting method vary from person to person, which makes it difficult to form a unified opinion. The accuracy and credibility of the weighting results are not high. Entropy weight method is a commonly used objective weighting method, which calculates the objective weight according to the difference of each evaluation index, but there is not only difference but also correlation between evaluation indexes. An objective and comprehensive evaluation strategy for the importance of harvester spare parts is particularly important. The specific calculation steps are as follows:

Step 1: Build judgment matrix. Suppose that in an evaluation model, the original evaluation matrix of m evaluation indicators of n evaluation objects is $X=\left(x_{ij}\right)\ n\times m$. Where, x_{ij} is the state value of the i-th evaluation object corresponding to the j-th evaluation index, which is the judgment matrix.

Step 2: Calculate the standard deviation of each index:

$$\sigma_j=\sqrt{\frac{1}{m-1}\sum_{i=1}^{m}(x_{ij}-\bar{x}_j)^2} \qquad j=1,2,\ldots m \tag{2}$$

In formula (2): σ_j is the standard deviation of evaluation index x_i; $\bar{x}_j$ is the average value of index x_j in m schemes.

Step 3: Build the correlation coefficient matrix. Let the average value of all schemes in index x_i be $\bar{x}_i$. The average value of all schemes in index x_j is $\bar{x}_j$, so the correlation coefficient r_{ij} between index x_i and index X_j is:

$$r_{ij}=\frac{\sum_{i=1}^{n}(x_i-\bar{x}_i)(x_j-\bar{x}_j)}{\sum_{i=1}^{n}(x_i-\bar{x}_i)^2\sum_{j=1}^{n}(x_j-\bar{x}_j)^2} \tag{3}$$

Step 4: Calculate the information content C_j contained in each indicator, and calculate the comprehensive weight W_{CRITIC} of each indicator. C_i represents the information amount of the indicator in the indicator j system. The calculation formula is:

$$C_j=\sigma_j\sum_{i=1}^{n}\left(1-r_{ij}\right) \qquad j=1,2,\ldots m \tag{4}$$

In formula (4): σ_j is the standard deviation of evaluation index X_i; r_{ij} is the correlation coefficient between index x_i and index x_j, so the objective weight of the j-th index is:

$$W_{CRITIC}=\frac{C_j}{\sum_{j=1}^{m}C_j} \qquad j=1,2,\ldots m \tag{5}$$

Coupling weight

As shown in Figure 2, in order to avoid ignoring the subjective analysis of indicators because the objective weighting method relies too much on mathematical statistical methods, the comprehensive weight of spare parts configuration is determined by combining CRITIC objective weight W_{CRITIC} and subjective weight Delphi method W_{DELF}. In order to reflect the relative relationship between the weights of various spare parts indicators and the weight proportion in all indicators as much as possible, the multiplier synthesis normalization method is used when coupling the subjective and objective weights. The calculation formula of comprehensive weight is:

$$W = \frac{W_{DELF} W_{CRITIC}}{\sum_{j=1}^{n} W_{DELF} W_{CRITIC}} \tag{6}$$

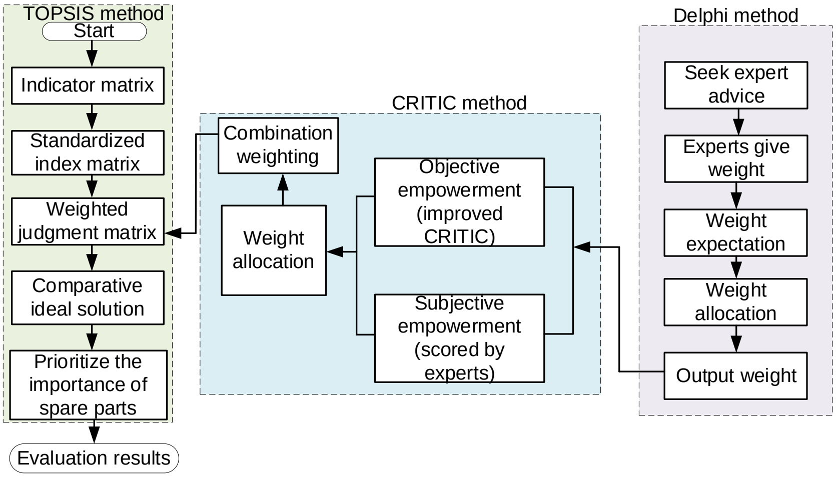

Fig. 2 - Improved CRITIC-TOPSIS evaluation process

Comprehensive evaluation model based on improved TOPSIS

Model building

Suppose there are m alternatives A_1, A_2,…, A_m and n attribute indicators C_1, C_2,…, C_n. x_{ij} is the index value of A_i under C_j ($i=1, 2,…, m$; $j=1, 2,…, n$). The basic steps to improve TOPSIS are as follows.

Step 1: construct the decision matrix X according to the attribute index value.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{7}$$

Step 2: Calculate the standardized matrix R. In order to eliminate the influence of different data dimensions in the decision matrix, the decision matrix is normalized to obtain a standardized matrix:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{8}$$

Step 3: Determine the positive and negative ideal schemes H^+ and H^-. The solution process of positive ideal scheme $H^+ = \left[h_1^+, h_2^+, h_3^+ \cdots h_n^+\right]$ and negative ideal scheme $H^- = \left[h_1^-, h_2^-, h_3^- \cdots h_n^-\right]$ is as follows:

When the index type of C_j is benefit type, there are:

$$\begin{cases} h_j^+ = \max\left\{v_{ij} \middle| 1 \leqslant i \leqslant m\right\} \\ h_j^- = \min\left\{v_{ij} \middle| 1 \leqslant i \leqslant m\right\} \end{cases} \tag{9}$$

When the indicator type of C_j is cost type, there are:

$$\begin{cases} h_j^+ = \min\left\{v_{ij} \middle| 1 \leqslant i \leqslant m\right\} \\ h_j^- = \max\left\{v_{ij} \middle| 1 \leqslant i \leqslant m\right\} \end{cases} \tag{10}$$

Step 4: Calculate Euclidean distance. The Euclidean distance calculation involves the Euclidean distance from A_i to D_i^+ and the Euclidean distance from A_i to D_i^- . The specific solution formula is:

$$D_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - h_j^+\right)^2} \qquad i=1,2,\dots,n \tag{11}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - h_j^-\right)^2} \qquad i=1,2,\dots,n \tag{12}$$

Step 5: Calculate the relative closeness.

$$C_i^* = \frac{D_i^-}{D_i^+ + D_i^-} \tag{13}$$

$$C_i^* = \frac{D_i^+}{D_i^+ + D_i^-} \tag{14}$$

Step 6: Determine the relative advantages and disadvantages of the scheme based on C_i^*.

It can be seen from Eq. (13) and Eq. (14) that $C_i^* \in [0,1]$, and the larger the C_i^* obtained from Eq. (13), the better the scheme, while the smaller the C_i^* obtained from Eq. (14), the better the scheme.

Factors influencing the determination of spare parts

In the process of spare parts configuration, the following factors will have an important impact on the determination of spare parts, as shown in Figure 3.

(1) Importance of spare parts. The importance of spare parts refers to the role played by spare parts in the whole operation process of the combine and the extent to which they determine the performance of the operation and body of the combine. The higher the criticality of parts, the greater their impact on the performance of the harvester, and the higher the demand for such spare parts. The criticality of spare parts is an important factor in determining the types of spare parts.

(2) Urgency of spare parts maintenance. The urgency of spare parts maintenance is due to the time requirements for harvesting crops in the field during the operation of the combine, and it also has influence on the efficiency of harvester operators. When the harvester is not urgently repaired, it will indirectly affect its harvesting efficiency and economic costs. According to the regional crops, harvester models and wear and tear conditions, spare parts with urgent requirements for harvester operation should be configured in advance as far as possible. The low loss spare parts can be configured in proper order to improve the utilization rate of spare parts.

(3) Replacement time of spare parts. When the parts of the harvester need to be replaced due to failure. In order to ensure the safe use performance of the harvester, under the condition of large consumption and short replacement time, when replacing spare parts, based on the enterprise knowledge base information, the parts with short replacement time are easy to break, and their configuration priority should be appropriately improved.

(4) Consumption of spare parts. The consumption of spare parts refers to the costs of spare parts, mainly including spare parts purchase costs, storage and maintenance costs, storage damage costs, etc. Annual consumption of a spare part in a region. It can be seen that the greater the annual consumption, the higher the criticality of spare parts.

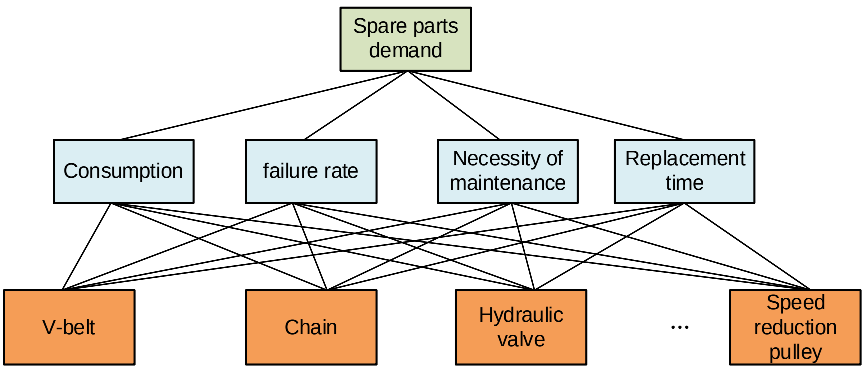

Fig. 3 - Spare parts factor distribution evaluation chart

Spare parts evaluation method

(1) Importance/priority (I). The importance of parts is divided into 10 levels, and the specific scores are shown in Table 1.

Table 1

Scoring method of component importance

Level	Describe	Score
1	Seriously affect the harvester harvest and function realization	10
2	It has a significant impact on the harvest operation and the realization of other functional tasks	9
3	Has a significant impact on harvesting operations and the realization of functional tasks	8
4	It has a slight impact on the harvesting operation and a great impact on the realization of functional tasks	7
5	Has a slight impact on harvesting jobs and affects the realization of functional tasks	6
6	Does not affect harvesting operations, but has significant effects on multiple functions	5
7	It does not affect harvesting operations and only has a minor impact on the implementation of multiple functions	4
8	Harvesting operations are not affected, but the impact on individual functions is significant	3
9	It does not affect harvesting operations and only has a small impact on the implementation of individual functions	2
10	It has no significant effect on the realization of harvesting jobs and functional tasks	1

(2) Fault maintenance emergency (S). After a fault occurs, according to the damage of the parts, the urgency of the need to quickly complete the replacement of spare parts is divided into five levels, the specific score is shown in Table 2.

Table 2

Scoring method of parts maintenance urgency

Level	Describe	Score
1	Seriously affect the work of harvester	5
2	It has great influence on the work of harvester	4
3	It has little effect on the work of the harvester	3
4	Has a slight effect on harvester work	2
5	No effect	1

(3) Replacement time (T). After a harvester fails, the time required for replacement of spare parts can be divided into five levels, and the specific scores are shown in Table 3.

Table 3

Scoring method of replacement time during parts maintenance

Level	Describe/ h	score
1	$T>10$	5
2	$7<T<10$	4
3	$5<T<7$	3
4	$3<T<5$	2
5	$0<T<3$	1

(4) Part consumption level/replacement frequency (F). The frequency of failure refers to the frequency of replacement of spare parts due to fault maintenance. The greater the consumption of spare parts, the higher the importance of spare parts maintenance. There are five levels in total, and the specific scores are shown in Table 4.

Table 4

Evaluation method of parts consumption and replacement

Level	Describe	Score
1	Heavy height wearing parts, frequent occurrence, high consumption frequency	5
2	Highly vulnerable parts, frequent occurrence, high consumption frequency	4
3	Moderate wear parts, occasional occurrence, medium consumption frequency	3
4	Low degree wear parts, rare occurrence, high consumption frequency	2
5	Very low wear parts, unlikely to occur, almost zero consumption frequency	1

RESULTS

Case analysis

Through consulting the relevant information that combine harvester spare parts have many kinds, including chain, gear, belt, regulator, belt, control valve, battery, power output assembly, hydraulic valve, moving blade, fixed blade, nozzle and so on. The above parts need to be analyzed in order to determine which spare parts are the most important in the cross-zone operation of the combine. As shown in Figure 5, the first 10 kinds of parts are selected for research to prove the feasibility of the method. The improved TOPSIS algorithm was used to sort the comprehensive benefits of spare parts, obtain the comprehensive evaluation value of the configuration effect of each spare part, and finally analyze and determine the priority of spare parts configuration.

Table 5

Maintenance spare parts data table

Number	Fault information	Name of spare parts	Label
1	The chain rupture	Chain	B1
2	Belt wheel wear	Gear	B2
3	Damage of regulator	Regulator	B3
4	Belt failure	Belt	B4
5	The grain conveying shaft is broken	Bearing	B5
6	Untight seal	Oil seal	B6
7	Control valve damage	Control valve	B7
8	Battery fault	Battery	B8
9	No power idling	Power output assembly	B9
10	The dashboard shows a fault	Dashboard	B10

Firstly, the weight of the value element set of spare parts is determined by coupling weight method. Six experts were invited to evaluate the importance of different value elements. The sum of all factors is a percentage scale, and the results are shown in Table 6.

Table 6

Expert marking table

Assessment element	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Importance	40	35	25	35	30	25
Urgency	30	30	25	30	25	32
Replacement time	20	25	40	25	20	20
Consumption	10	10	20	10	25	20

Due to the differences in the credibility of the evaluation of the value factor set among experts, the weights of 6 experts are assigned as w_{exp} = (0.05, 0.05, 2.0, 15, 0.1) according to the expert level and importance. The subjective weight of each evaluation factor is W_{DEL} = (0.3483, 0.2935, 0.2214, 0.1368). The objective weight W_{CRI} was obtained by the weight method of CRITIC as W_{CRI} = (0.2608, 0.1491, 0.3097, 0.2804). According to Equation (6), the coupling weight W can be obtained as follows: W = (0.3760, 0.1812, 0.2839, 0.1589). Secondly, six experts scored each evaluation element of spare parts in turn. The specific scores are shown in Table 7, the comprehensive evaluation matrix of the above parts is:

$$R_1 = \begin{bmatrix} 6 & 5 & 5 & 6 & 5 & 7 \\ 4 & 1 & 3 & 1 & 3 & 2 \\ 5 & 2 & 4 & 3 & 2 & 2 \\ 1 & 1 & 2 & 1 & 1 & 1 \end{bmatrix} R_2 = \begin{bmatrix} 5 & 7 & 8 & 6 & 4 & 8 \\ 3 & 1 & 4 & 2 & 5 & 5 \\ 1 & 2 & 2 & 1 & 4 & 3 \\ 2 & 2 & 1 & 4 & 1 & 2 \end{bmatrix} R_3 = \begin{bmatrix} 7 & 5 & 7 & 4 & 5 & 6 \\ 4 & 4 & 3 & 5 & 3 & 4 \\ 5 & 3 & 5 & 4 & 2 & 4 \\ 2 & 2 & 3 & 2 & 2 & 2 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 6 & 7 & 6 & 7 & 7 & 8 \\ 4 & 2 & 3 & 2 & 4 & 2 \\ 2 & 4 & 4 & 5 & 4 & 3 \\ 2 & 3 & 3 & 2 & 2 & 1 \end{bmatrix} R_5 = \begin{bmatrix} 6 & 5 & 5 & 6 & 5 & 7 \\ 4 & 1 & 3 & 1 & 3 & 2 \\ 5 & 2 & 4 & 3 & 2 & 2 \\ 1 & 1 & 2 & 1 & 1 & 1 \end{bmatrix} R_6 = \begin{bmatrix} 5 & 7 & 8 & 6 & 4 & 8 \\ 3 & 1 & 4 & 2 & 5 & 5 \\ 1 & 2 & 2 & 1 & 4 & 3 \\ 2 & 2 & 1 & 4 & 1 & 2 \end{bmatrix}$$

Table 7

Priority configuration results of some spare parts

Expert	B1				B2				B3				B4			
	I	S	T	F	I	S	T	F	I	S	T	F	I	S	T	F
Expert1	6	4	5	1	5	3	1	2	7	4	5	2	6	4	2	2
Expert2	5	1	2	1	7	1	2	2	5	4	3	2	7	2	4	3
Expert3	5	3	4	2	8	4	2	1	7	3	5	3	6	3	4	3
Expert4	6	1	3	1	6	2	1	4	4	5	4	2	7	2	5	2
Expert5	5	3	2	1	4	5	4	1	5	3	2	2	7	4	4	2
Expert6	7	2	2	1	8	5	3	2	6	4	4	2	8	2	3	1

Expert	B5				B6				B7				B8			
	I	S	T	F	I	S	T	F	I	S	T	F	I	S	T	F
Expert1	9	4	5	3	9	2	2	3	9	4	4	5	9	3	3	4
Expert2	7	2	4	4	7	3	1	4	7	3	3	3	7	4	2	3
Expert3	5	2	1	3	6	2	4	2	5	4	4	4	5	4	4	5
Expert4	7	4	5	2	7	5	5	2	8	4	4	2	7	4	5	1
Expert5	6	1	3	2	6	4	4	2	6	2	2	2	4	5	3	1
Expert6	7	5	4	1	7	2	4	1	6	5	5	1	6	5	4	1

The priority of spare parts determined by the traditional TOPSIS algorithm and the improved TOPSIS algorithm is compared, as shown in Table 8. In Table 8, the priority of spare parts configuration corresponds to the numbers 1-10 from high to low. It can be seen that the priority of spare parts configuration determined by traditional TOPSIS and improved TOPSIS algorithms is higher for belts, chains, control valves, regulators and oil seals, and lower for gears, bearings, batteries, power take-off assemblies and instrument panels. The priority of spare parts mainly differs from that of gear, battery, power take-off assembly and bearing.

Table 8

Spare parts priority configuration results

Spare part	Traditional TOPSIS		Improve TOPSIS	
	Standardized score	Priority	Standardized score	Priority
Chain	0.0628	10	0.0676	9
Gear	0.0752	9	0.0686	10
Regulator	0.1039	3	0.1033	3
Belt	0.0834	6	0.0846	8
Bearing	0.1088	8	0.11119	7

Spare part	Traditional TOPSIS		Improve TOPSIS	
	Standardized score	Priority	Standardized score	Priority
Oil seal	0.0947	5	0.0953	5
Control valve	0.1192	4	0.1138	4
Battery	0.1105	7	0.1128	6
Power output assembly	0.1177	1	0.1161	1
Dashboard	0.1238	2	0.1261	2

In the traditional TOPSIS algorithm, the priority of gear spare parts configuration is 6. The spare parts configuration priority of bearing is 7, which is higher than that of battery 8. Priority of spare parts configuration of power take-off assembly is 9. The instrument cluster spare parts configuration priority is 10, which is at the end of the priority. In the improved TOPSIS algorithm, the priority of bearing spare parts allocation is 6. The priority of battery spare parts configuration is 7, which is higher than that of gear spare parts configuration 8. Priority of spare parts configuration of power take-off assembly is 9. The priority of spare parts configuration higher than the instrument cluster is 10.

It can be seen from the above analysis that, compared with the traditional TOPSIS, the improved TOPSIS method can better reflect the impact of prioritization, so as to assemble more valuable spare parts in the limited space for service vehicles, provide effective support for the operation and maintenance of service vehicles, and the configuration scheme of spare parts is better.

Development of agricultural machinery spare parts resource management platform

Platform architecture

The platform structure is shown in Figure 4. The platform system of spare parts resource management system can be divided into data layer, platform layer, access layer and application layer from the functional logic. The data layer includes spare parts inventory quantity, repair and replacement records, expert database data, spare parts category classification data, etc. The platform layer is mainly the embodiment of functions, including repair appointment, repair request, repair management, resource allocation, and spare parts management decisions.

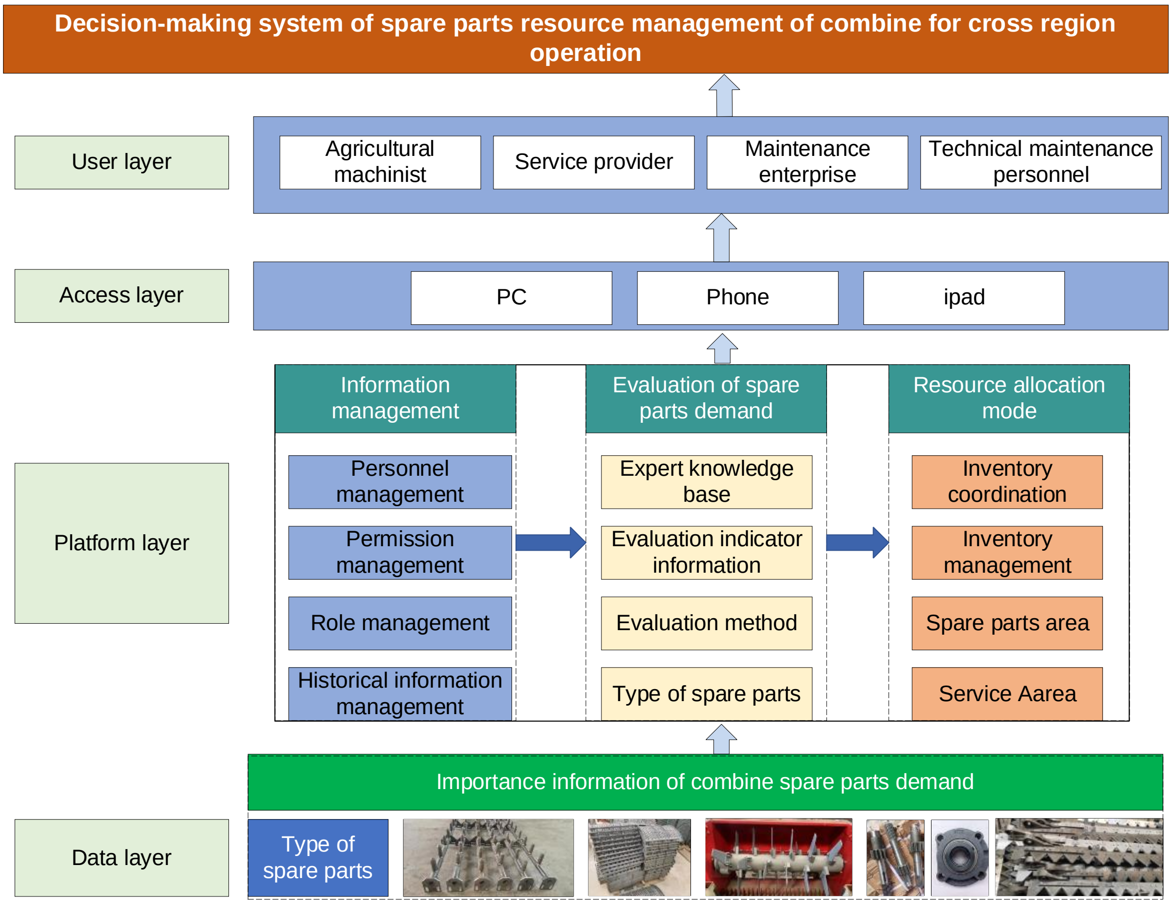

Fig. 4 - Spare parts factor distribution evaluation chart

Importance evaluation of spare parts

As shown in Figure 5, the spare parts data interface can retrieve the data of spare parts from the spare parts information database. Managers can obtain data from experts, click the repair importance evaluation on the data information table, and enter indicator data for calculation. The evaluation results of the repair importance of spare parts can be obtained and saved in the spare parts information. As shown in Figure 6, it is the system display interface.

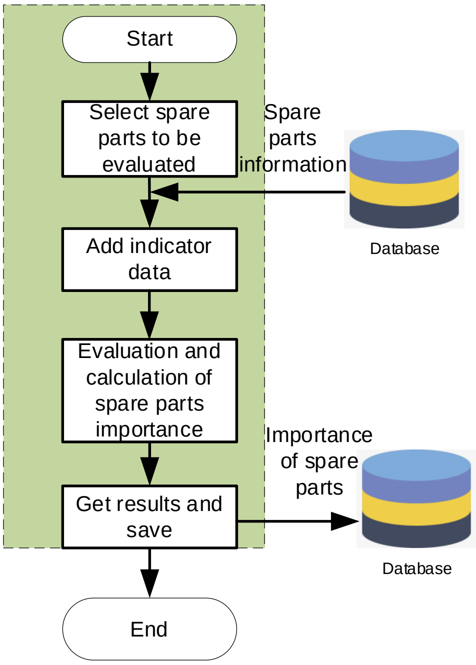

Fig. 5 - Platform system structure diagram of spare parts importance

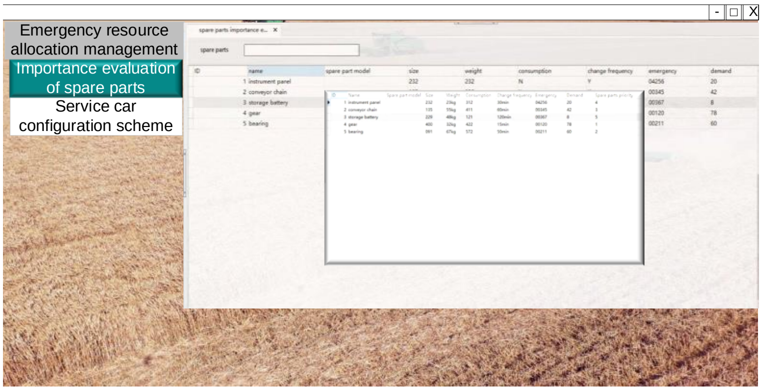

Fig. 6 - Display of spare parts importance evaluation results

CONCLUSIONS

(1) The efficient configuration of spare parts is an important content to improve the level of equipment supportability. On the basis of determining the types of vulnerable spare parts of the combine, the configuration priority of spare parts is studied, and a method for determining the priority of spare parts combined with the improved CRITIC-TOPSIS algorithm is proposed, which can further optimize the configuration scheme of onboard spare parts of the service vehicle, and has a certain role in promoting the precision and standardization of cross-region operation and maintenance service guarantee of the combine harvester.

(2) In this study, based on the establishment of spare parts importance evaluation, the development of the platform system has been expanded, which is convenient for spare parts managers and manufacturers to receive and process data in real-time, achieving a visual effect. At the same time, through the platform system, the importance of spare parts can be evaluated in real-time, and the results of required spare parts can be obtained in real-time.

(3) This study effectively combed the importance of key spare parts for the cross-region operation of the combine. In the later study, the weight, volume and loading capacity of spare parts can be combined to reasonably assemble spare parts for vehicles.

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