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Research on the Optimization and Evaluation of Excavator Human-Machine Interface Layout Based on Situation Awareness

Zimu Cheng[1] & Jiashan Lyu[1]
[1] Xi'an University of Science and Technology
Correspondence: Zimu Cheng, Xi'an University of Science and Technology.

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Abstract

In order to solve the problem of a large number of types and complex layouts of control devices on the operator interface of mining excavators, and a large variety and number of control elements on the control panel, the layout optimization design is carried out by applying the theoretical model of situational awareness and the influencing factors to the layout design of the human-machine interface. The modularity of the interface and the hierarchy of the original components are divided, and the importance evaluation indicators established according to situational awareness are weighted according to the entropy weighting method, and then the results are combined with the VIKOR method to analyse the importance of the interface components and the control panel module respectively before the interface is optimised and designed. The results show that the application of situational awareness theory to HMI design can play an important role in enhancing the level of situational awareness of operators and meeting their needs.

Keywords: industrial design, human-machine interface, situational awareness, entropy method, VIKOR method

1. Introduction

The human-machine interface of the mining excavator cab is information-intensive and needs to be switched and adjusted between multiple tasks. This will result in the driver's limited attentional resources not being allocated in a rational manner, and in a state where the level of situational awareness has dropped significantly, resulting in incorrect operations and decisions, which will be a heavy blow to personal safety and society. Situation Awareness (SA) is a concept that first appeared in the field of aviation psychology to describe a pilot's understanding of the combat flight he or she is operating in (Endsley 1995).

With the widespread use of complex technologies, the creation of many information-intensive and operationally demanding systems, and the increasing frequency of highly complex cognitive tasks faced by practitioners in many industries, the study of SA has gradually expanded to include a number of areas relevant to everyday life, with searches using SA as a keyword in an AI-enabled search engine for academic publications on the web, Semantic Scholar, developed by the Allen AI Institute. A search in Scholar using SA as a keyword and sorting by academic impact shows that Endsley's article is widely recognised with 7,630 citations.

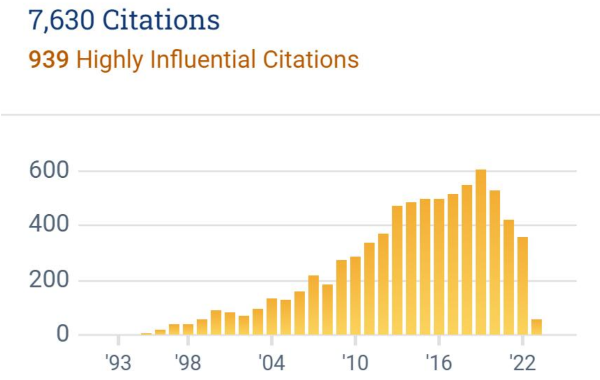

Figure 1. Endsley paper citation counts

In addition, Smith and Hancock (Smith & Hancock, 1995) and Bedny and Meister (Bedny & Meister, 1999)'s definition of situational awareness is also widely accepted. The three articles have similar and different descriptions of contextual awareness, with the difference being that Endsley tends to focus on the outcome of contextual awareness, whereas Smith, Bedny and others focus on the process of contextual awareness. The main areas of application for context awareness include interface design and evaluation, and personnel training. However, there are fewer applications for the field of excavator human-machine interface design.

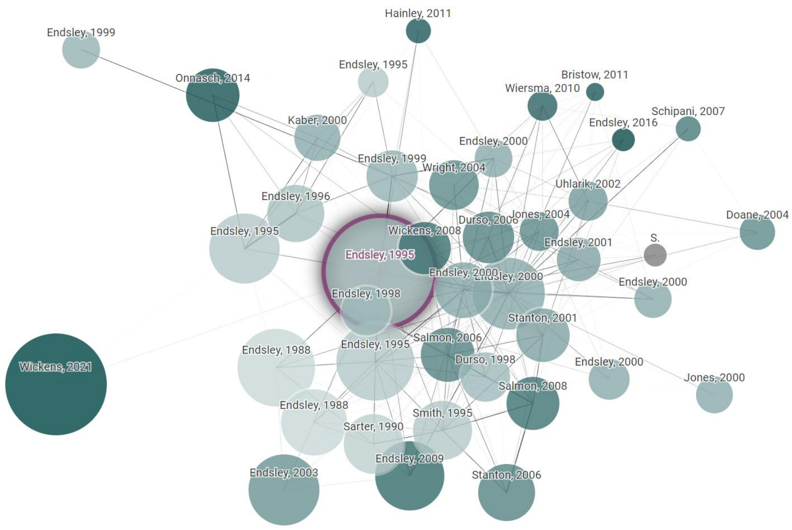

Figure 2. The mapping of SA theory development in connected papers

Using the online literature analysis website Connected Papers, the development of the theory can be traced by searching with "Situation Awareness" as the keyword (Figure 2). After publishing research results related to the definition and terminology analysis, theoretical model architecture, and influencing factors in 1995, Endsley (Endsley 1988; Endsley 2000) made a detailed study on the design and evaluation of SA in 1998 and specifically on Mental Models in 2000, and proposed a method to extract and reorganize human knowledge to create a human Wickens (Wickens 1992), who also has research in this area, reviewed Endsley's previous research in 2008 and summarized the results in the book Situational Awareness Design to give guidance on context-awareness-based design (Endsley 2021).

2. Overview of Situational Awareness Theory

2.1 Definition of Situational Awareness

Introduced by Endsley in 1988, Wickens' definition of situations is the perception of elements in the environment, the understanding of their meaning, and the prediction of future relationships between information about those elements, within a certain time and space. Wickens (Wickens 2008) proposed that, based on human information processing mechanisms, the operator continuously obtains information from the system and the environment and relates it to existing knowledge, forming impressions and experiences about the system and the environment, further adjusting task goals and strategies. The theory of information processing based on this information processing theory, Endsley proposed an information processing model of situational awareness that includes attention, working memory, and comprehension. Endsley proposes an information processing model of contextual awareness that includes attention, working memory and comprehension (Endsley 1995).

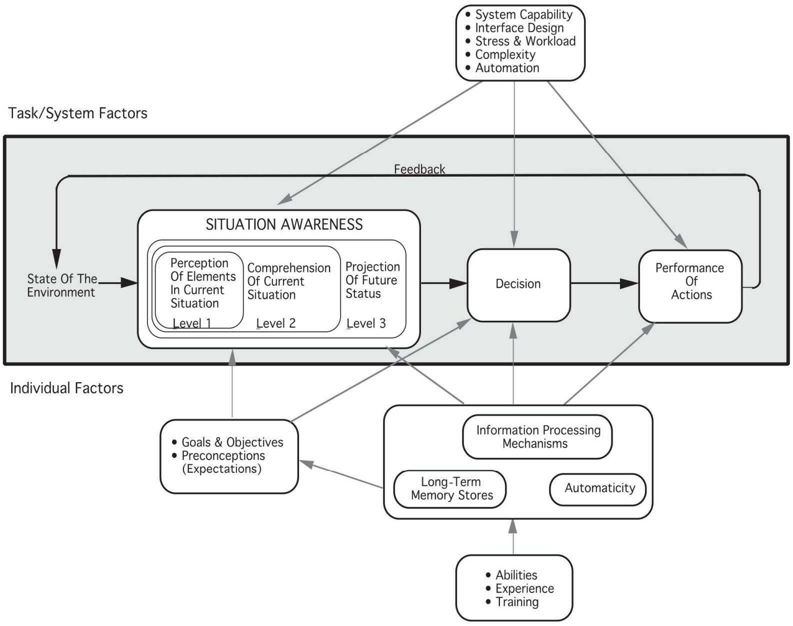

Figure 3. Model of SA in dynamic decision making.

Source: Endsley, 1995c. © 1995 SAGE Publications.

She defines SA as an internal mental model of one's current environmental state, and Endsley divides SA into three levels from low to high as shown in Figure 3 (Endsley 1995; Endsley 2021): level 1 perceives environmental elements, level 2 understands the environment, and level 3 predicts subsequent states, within which the acquisition of high levels of situational awareness is dependent on low levels of situational awareness. The three levels of the SA 3 model are not simply linear models, nor are they three distinct stages, but are rising levels of SA.

The three levels of the SA 3 model are not simply linear models, nor are they three distinct stages, but rather ascending levels of SA, where being able to predict what is likely to happen (level 3) is better than only understanding the current situation (level 2), both of which are better than only perceiving information but not understanding its importance (level 1). This does not mean that operators have to collect all level 1 data and then form understandings and projections in a linear order, in many cases people may use their higher level SA (understandings and projections) to generate hypotheses about elements of level 1 SA of which they have no direct knowledge, or to guide further data search decisions and behaviour.

2.2 Factors Influencing Situational Awareness Theory

Building and maintaining SA can be a difficult process for people in many different jobs and environments. In many other areas where systems are complex, large amounts of information need to be understood, information changes rapidly and information is difficult to access, particular attention needs to be paid to the factors that impact on the level of situational awareness.

Rothjen (Trice, 2009) by describing the structural arc of the relationship between people, product and environment, he describes the human-machine system model of contextual user experience design, in which the key influencing factor for user experience is the context of "people-product-environment", and discusses the role of contextual factors in the orientation of product elements and features. Endsley's definition of situational awareness is repeatedly referred to as the internal mental model of a person's current environmental state, which literally includes the operator, the environment and, because the three-level model of SA is non-linear and includes both goal-driven and data-driven aspects, the top-down information processing process, which is related to the goal and task, is also important for information acquisition and filtering. Therefore, after a comprehensive analysis of the literature, this paper classifies the contextual influencing factors in excavator HMI design into three categories: operator, task and environment (Endsley 2021; Liu Mengyu).

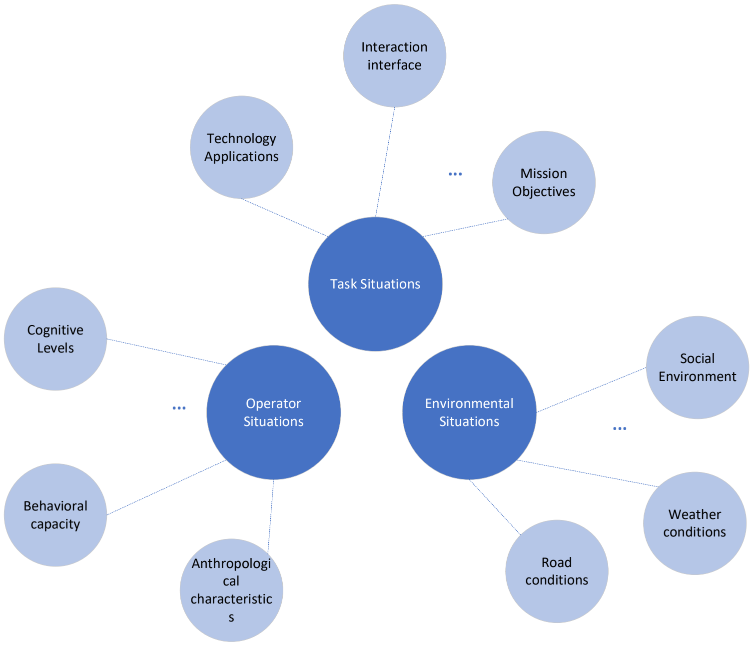

Figure 4. Elements of situational awareness influence

The operator context includes: the operator's experience, cognitive level, expertise, physiological factors and user needs, etc.; the user's life posture, i.e., the operator's behavioural level, competencies, etc. (Endsley 2019). The user's life posture, i.e. the operator's level of behaviour and ability, etc. The study of the user's situations can establish an accurate mapping between the user and the context, enabling a better understanding of the operator's needs and thus the design of a product interface that meets the user's needs.

Task situations: The task context is mainly from the point of view of the human-machine interface, by analysing the relationship between the operator and the human-machine interface. The purpose, form and difficulty of the task are the main factors that make up the task context. The overall objective of driving operations is to achieve multiple objectives in the context of safeguarding personal safety, for example driving and excavation tasks.

Environmental situations: Environmental contexts mainly include the natural and social environment and are characterised by strong dynamics, variability, complexity and randomness.

3. Structure of the Importance Analysis Method Based on the Entropy and VIKOR Methods

3.1 Indicator Assignment Based on the Entropy Method

The entropy method, as an objective assignment method, is based on the principle that the weight of an indicator is determined based on the difference between the original data, and that if the information entropy of an indicator is lower, the greater the role it plays in the evaluation. The gain of entropy means the loss of information. The more orderly a system is, the lower the entropy and the more information it contains; conversely, the more disorderly it is, the higher the entropy and the less information it contains.

A questionnaire was administered to N' experts and drivers using a 7-point Likert scale to evaluate the importance of SA enhancement impact, and SPSSAU was used to process the data using the entropy weighting method and to determine the weights of each indicator.

The process of obtaining weights by the entropy weighting method is as follows:

The original evaluation matrix R' for the evaluator on the m n indicator was created and r'_{ij} was the mean of all subjects' evaluations for the i evaluator on the j indicator. R' is then normalised according to equation 1 (all indicators are positive in the article) to obtain $R = (r_{ij})_{m \times n}$.

$$r_{ij} = \frac{r'_{ij} - \underset{i}{Min}\left(r'_{ij}\right)}{\underset{i}{Max}\left(r'_{ij}\right) - \underset{i}{Min}\left(r'_{ij}\right)} \tag{1}$$

For the weighting of the indicator value of the i programme in the j indicator, see equation 6:

$$P_{ij} = r_{ij} / \sum_{i=1}^{m} r_{ij} \text{ (i=1,2,...m; j=1,2,...n)} \tag{2}$$

Information entropy of the j the factor, as in equation 3:

$$e_j = -k\sum_{i=1}^{m} P_{ij} \cdot \ln P_{ij} \tag{3}$$

Where: k is a constant and $k = 1/\ln m$.

The objective weights for each factor are then calculated as in equation 4:

$$w_{oj} = g_j / \sum_{j=1}^{n} g_j \tag{4}$$

Where: g_j is the deviation of the j indicator, i.e., the coefficient of variation: $g_j = 1 - e_j$.

3.2 Ranking of Excavator Human-Machine Interface Components Based on the VIKOR Method

The VIKOR method is an ideal point-based approach to solving compromise multi-attribute decision problems first proposed by Oriblict and Trazy. The core idea of VIKOR theory is to determine the optimal solution to a compromise through data analysis and to select the best and most compromising solution by ranking the preferences of the alternatives.

Steps in the application of the VIKOR method:

The original evaluation matrix L was obtained by scoring the h layout design alternatives against the n evaluation indicators established on the basis of situational awareness, as shown in equation 5:

$$L = \begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1n} \\ l_{21} & l_{22} & \cdots & l_{2n} \\ \vdots & \vdots & l_{ij} & \vdots \\ l_{h1} & l_{h2} & .. & l_{hn} \end{bmatrix} \tag{5}$$

The original evaluation matrix L is processed according to equation 6 (all indicators in the text are benefit type) to obtain the normalised matrix X .

$$x_{ij} = \frac{l_{ij}}{\sqrt{\sum_{i=1}^{h}\left(l_{ij}\right)^2}} \tag{6}$$

Determine the positive and negative ideal solutions for the set of options Z^+ , Z^- , as shown in equation 11:

$$Z^+ = \left\{x_j^+\right\} = \max_{i=1}^{h}\left\{x_{ij}\right\}$$

$$Z^- = \left\{x_j^-\right\} = \min_{i=1}^{h}\left\{x_{ij}\right\} \tag{7}$$

Calculate the group utility value S_i and the maximum individual regret value R_i for the options as shown in equations 8 to 9:

$$S_i = \sum_{j=1}^{n} w_j \frac{(x_j^+ - x_{ij})}{\left(x_j^+ - x_j^-\right)} \tag{8}$$

$$R_i = \max_j w_j \frac{(x_j^+ - x_{ij})}{\left(x_j^+ - x_j^-\right)} \tag{9}$$

Where: w_{oj} is the weight of the evaluation indicator calculated according to equation 8; x_{ij} is the value of l_{ij} normalised according to equation 10.

The compromise value Q_i is then calculated as shown in equation 14. ε is the compromise factor and takes a value in the range $[0,1]$, which is generally taken to be 0.5 when making decisions, indicating a balanced approach that takes into account group benefits as well as individual regrets:

$$Q_i = \varepsilon \frac{S_i - S^-}{S^+ - S^-} + (1-\varepsilon)\frac{R_i - R^-}{R^- - R^+} \tag{10}$$

where: $S^+ = \max_i \{S_i\}$; $S^- = \min_i \{S_i\}$; $R^+ = \max_i \{R_i\}$ $R^- = \min_i \{R_i\}$.

Finally, the options were evaluated using the three values of S_i, R_i and Q_i, and the results were ranked according to the smallest to the largest value of: Q_i $l_1, l_2, \ldots l_{21}$, the option with the smallest value being the best. The best option is evaluated if l_1 meets two conditions, condition 1: $Q_{(l_2)} - Q_{(l_1)} \geq 1/(h-1)$ and condition 2: l_1. At least one of S_i and R_i is the best option.

4. Situational Awareness-Based Local Optimisation of the Excavator's Human-Machine Interface

4.1 Analysis of Excavator Operator Requirements

The analysis of the literature and the result of the fieldwork shows that the operator's tasks consist mainly of starting, walking, steering, digging (pushing, lifting, lowering), unloading, stopping and fault stopping (Li Bo, & Yu Guoying, 2016). The operator's tasks include starting, walking, steering, digging (pushing, lifting, lowering), unloading, parking and stopping.

The operator is required to frequently observe the working environment and the results of the operation of the various indicators while carrying out operations, as well as operating the holding brake more frequently. For other tasks, the operator needs to locate the appropriate component on the operator interface according to the task objective and complete the task according to the safety requirements.

Fifteen subjects were invited, including five operators, two staff members and eight university researchers, with the relevant practitioners responding on the basis of practical operational experience and real-life workplace experiences, and the university researchers answering the questionnaire content based mainly on observations, literature findings and simulated operations.

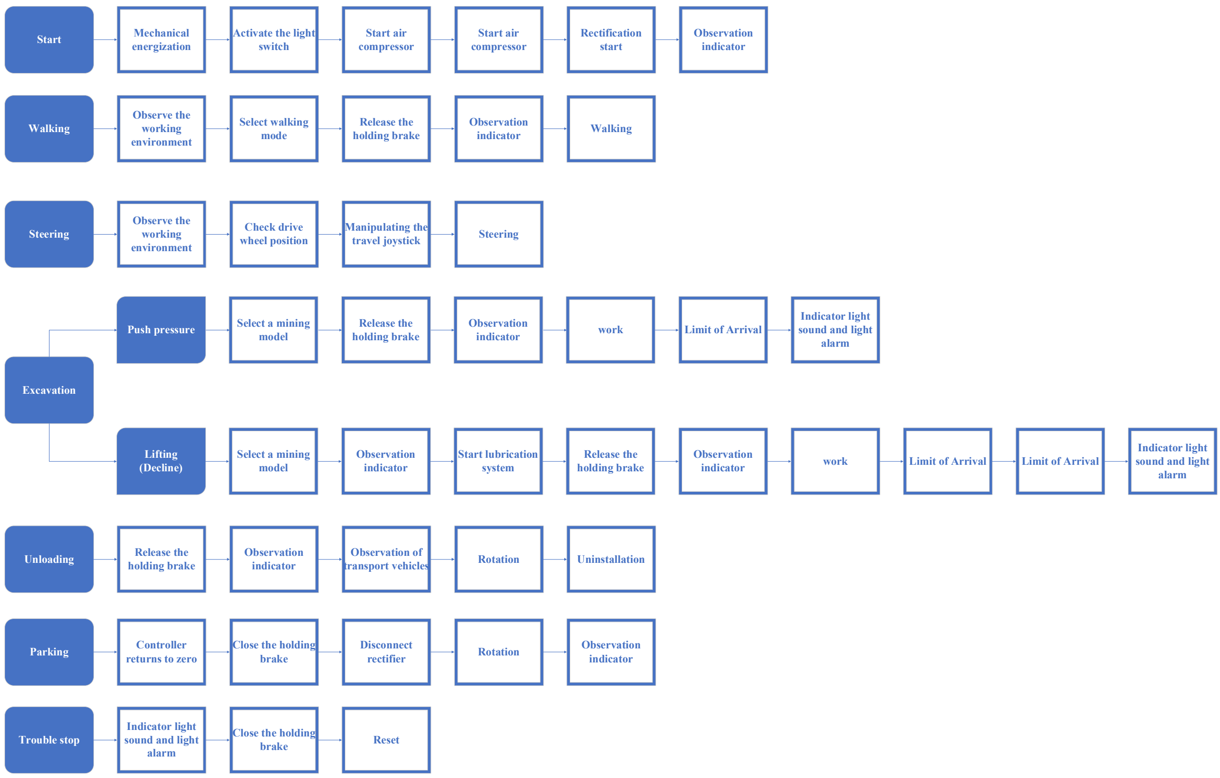

Figure 5. Excavator driver operation process

The results show that the main problems with the interface design after the behavioural analysis during the completion of the main tasks are in the areas shown in Table 1.

Table 1. Problem formulation

No.	Description of the problem
1	Mis-touching behaviour from time to time
2	Long distances between components related to the same task and inconvenient handling
3	Information is disorganised and not easily understood
4	Operating panel (a) Functional partitioning integration not easily identifiable
5	Important but infrequently used components not clearly differentiated by design

80% of the respondents felt that the operating panel (a) was far from the driver's seat, making it inconvenient for the driver to operate; 95% of the respondents felt that the overall arrangement of the control elements was cluttered, prone to mis-touching and affecting the efficiency of operation, causing a serious obstacle to the novice's understanding and learning; 60% of the respondents felt that the joystick was not sufficiently responsive, with insufficient feedback and a poor user experience, but as this issue is an engineering issue, it will not be studied in depth in this paper.

4.2 Establishment of Evaluation Indicators Guided by Situational Awareness Theory

According to the research process constructed in section 3.1, a questionnaire was administered to the above subjects to collect their needs in three dimensions: operator context, task context and environment context, which were collated and analysed to construct component and module evaluation indicators. Based on the results of the previous research and analysis, the KJ method was used to organise and classify the user requirements in detail. The KJ method (Type A diagramming, affinity diagramming) is a collective, democratic decision-making method commonly used by QC teams. The steps for implementing the KJ method are shown in Figure 6.

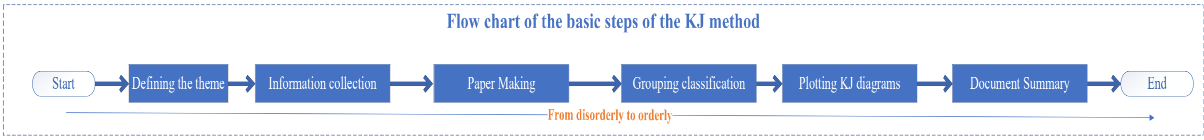

Figure 6. Flow chart of the KJ method

After obtaining the results of the interviews and questionnaires, the main directions of the user's needs are obtained based on the classification of the SA elements and the three-level theory, based on the merging of needs with the same or similar interrelationships and affinities into broad categories to achieve the establishment of evaluation indicators.

Figure 7. Diagram of the KJ method analysis process

The operator needs were first recorded on the cards, then the cards were collated, part of the collation process is shown in Figure 7, and finally the hierarchical grouping was combined with the general layout principles and the SA three-level theoretical model, the results are shown in Table 2.

Table 2. Evaluation indicators for interface components

	Secondary indicators	Tertiary indicators
Component and module evaluation indicators	Perception	a1 visual attention, a2 frequency of use, the
	Understanding	a3 component relevance, a4 functional importance
	Projections	a5 security, a6 task relevance

The human-machine interface plays the function of taking over the driver's audio-visual interaction. Information enters the corresponding sensory channels and generates the corresponding channel load, i.e., brain load. Different brain loads trigger different attentional resource allocation strategies for the driver, and when the amount of activation of the role exceeds the threshold value, the driver's perception of the situation is formed when the descriptive knowledge is successfully evoked. At the same time, attentional resources enter sensory memory and start decaying simultaneously for contextual component updating. After the perceptual state is reached, the later stages of situational awareness, comprehension (SA2) and prediction (SA3), are entered. The driver makes operational decisions in the prediction (SA3) stage, i.e., the actions and commands fed back on the human-machine interface.

The driver's perceptual processing in the driving scenario involves the interaction between the level of situational awareness acquisition and the human-machine interface, where the situational awareness determines information screening and decision making, and the human-machine interface input information takes over the operational decision after the situational awareness is reached. The analysis of the KJ method shows that drivers attach importance to criteria such as visual attention, frequency of use, component relevance, and importance in traditional human-machine interfaces, which are aspects to be paid attention to in subsequent interface optimization designs.

4.3 Entropy Weighting Method to Calculate Evaluation Index Weights

For the six indicators established in Table 3, a group of 20 experts were invited to score them on a 7-point Likert scale (1 being very unimportant, 4 being average and 7 being very important) and the original scoring matrix is shown in the table below.

Table 3. Raw scores for evaluation indicators

Component number	a1	a2	a3	a4	a5	a6
A1	5.4	5.6	5.45	6	4.8	5.4
A2	4.5	2.1	3.25	5.9	5.4	4.5
A3	4.5	2.1	3.25	5.9	5.4	4.5
A4	4.75	2.85	3.9	5.9	5.6	4.3
A5	4.65	5.25	4.7	3.2	3.1	3.5
B1	5.8	6.45	6	6.15	5.75	6.4
B2	5.65	6.45	5.9	5.85	4.15	6.5
B3	4.8	3.75	3.8	3.95	4	4.1
B4	3.95	3.55	3.5	4.25	5.05	3.65
B5	2.35	4.15	2.8	2.85	2.1	3.2
C1	4.4	4.15	3.45	3.95	4.85	4.85
C2	5.8	2.55	3.35	5.7	5.55	4.35
D1	3.35	5.05	3.95	3.1	2.95	3.6
D2	2.8	3.7	3.05	2.95	2.45	3.65
D3	2.55	3	3.9	2.8	2.2	3.25
E1	2.55	2.3	2.25	2.35	2.85	2.25

Table 3 was imported into SPSSAU to analyse and calculate the weights of each indicator according to the entropy weighting method, based on Equation 1 to Equation 5.

Table 4. Entropy weighting method for solving evaluation index weights

Evaluation indicators	Information entropy value	Information utility value	Weight coefficient
a1	0.9163	0.0837	16.52%
a2	0.8842	0.1158	22.84%
a3	0.929	0.071	14.00%
a4	0.9088	0.0912	18.00%
a5	0.9115	0.0885	17.45%
a6	0.9433	0.0567	11.19%

Taking indicator a1 as an example, the value of information entropy e is 0.9503 calculated through equation 2 and equation 3, and the difference coefficient g is calculated based on the difference between 1 and e, so the difference number of indicator a1 is 0.0497. Similarly, the e value and difference coefficient value of other indicators are obtained. The coefficient of difference represents the utility value of information. The larger the g-value, the greater the importance of evaluation. Similarly, the corresponding indicator weight is greater. Among the six indicators, the coefficient of difference of a6 is 0.0839, which is the highest value among all indicators, and its weight is 21.60%, which is also a high weight coefficient. The calculation of weight is obtained through equation 4, and the sum of the differences in all indicators is 0.3887. The weight coefficient is obtained by the ratio of the difference coefficient values of each indicator to the sum. Similarly, taking a1 as an example, 0.0497 accounts for 12.79% of 0.3887, so the weight value of a1 is 0.1279. In order to facilitate observation, the weight calculation results of the above indicators are presented in bar chart, as shown in Figure 8.

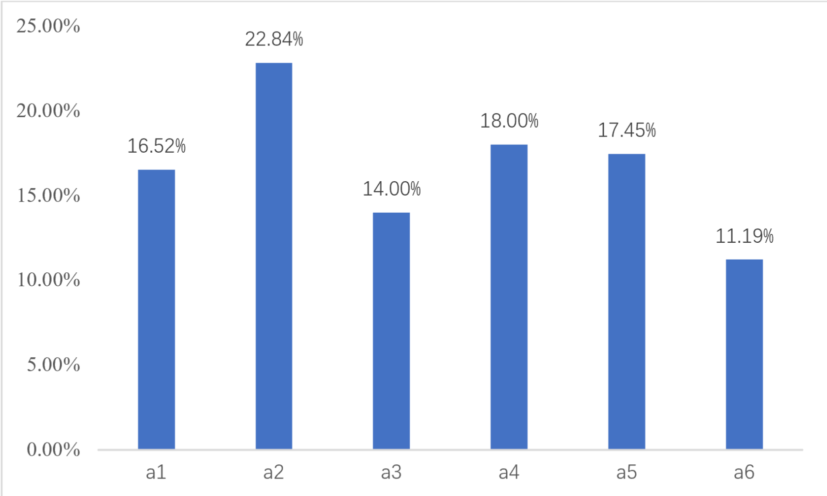

Figure 8. Histogram of indicator weights

The weight value of a2 usage frequency is the highest, indicating that researchers and relevant practitioners believe that in layout design, emphasis should be placed on the layout and design form of components frequently used by operators. By improving the convenience of using positions, operational efficiency can be improved; Secondly, the importance of a4 functions with a weight value of 0.18 and a5 safety with a weight value of 0.1745 are also important indicators. The importance of functions includes both the importance of completing normal tasks and the components related to safety operations. Safety is mainly aimed at the relevant components that need to be used in emergency situations, such as fault prompts and emergency stops. Although they are not frequently used in daily ordinary operations, However, in emergency situations, it plays an important role in ensuring the safety of the entire field. In layout design, consideration should be given to highlighting design elements such as position arrangement, button shape, and color; The weight values of a1 visual attention and a3 component correlation are similar, which are related to the driving habits and physiological characteristics of the operator. The analysis of visual habits and visual attention areas helps to improve operational efficiency and reduce the frequency of misoperation. The correlation between components needs to refer to the actual operating process, and the layout of components needs to comply with the logical order of the operator's use; The relevance of A6 tasks requires analyzing the importance of components based on specific tasks.

4.4 Optimal Design of the Excavator's Human-Machine Interface Layout

4.4.1 Hierarchy of Excavator HMI Components and Control Panel Modularity

According to the "Excavator Operator Skills Training Course" and the relevant excavator operating manuals as well as literature, the excavator cab HMI components and operating panels are divided into layers according to function and the operating panels are modularly abstracted.

The leftmost push-pull switch on the operating panel is far away from the driver's position and is a switch that does not need to be used frequently in the work; the push-button switch on the right side is closer to the driver's position and is a switch that is frequently used in the operation, including rectifier start/stop, high voltage start/stop, air compressor start, etc. The operating system of a large mining excavator is more complex than that of a small excavator, with more operating elements, and the location of each operating element emitted depends on the importance of its function. The control elements on the operation panel are many and complex, divided by function, including the operation lever, indicator, press switch, power switch, meter and touch screen, etc., divided by the form of the button can be divided into, rotary press switch, butterfly switch, etc., these components are placed on the three control panels.

In this paper, according to the function of each component, combined with the operation manual for hierarchical classification, can be from A-E 5 categories of components, and in the major categories in the subdivision, grading results are shown in Figure 9.

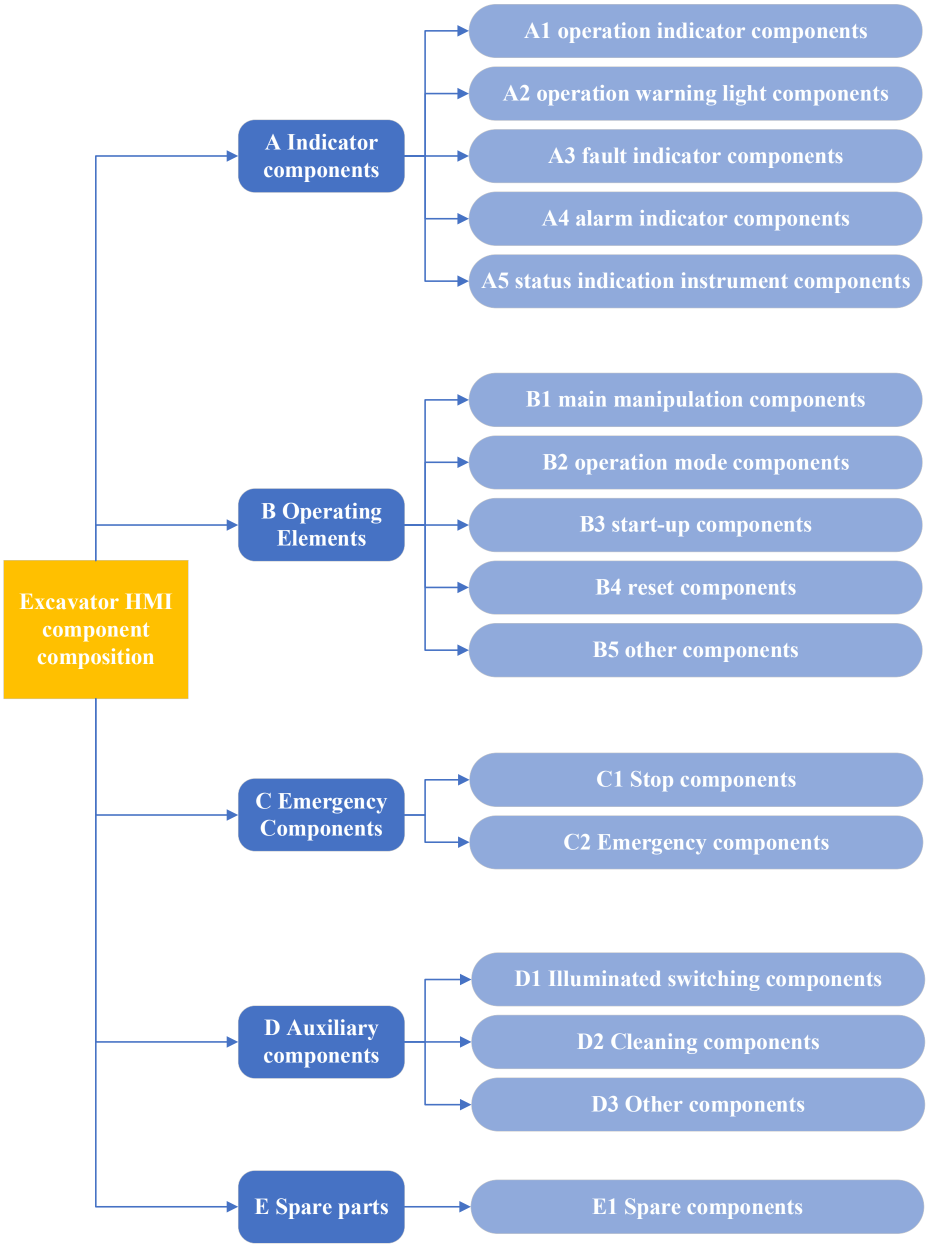

Figure 9. excavator human-machine interface component hierarchy

Operation panel analysis, mining excavator cab operation interface of the original control panel is more, the arrangement of the lack of human-computer interaction considerations, especially the control panel 1 in a large number of components and sorted more chaotic, is not conducive to the operation of the operator, so in the design of the choice of module importance analysis method to control panel area by area division, and build the importance of the distribution chart, the arrangement of control elements to scientific and objective guidance. The control panel is therefore divided evenly into 9 modules, as shown in the figure 10.

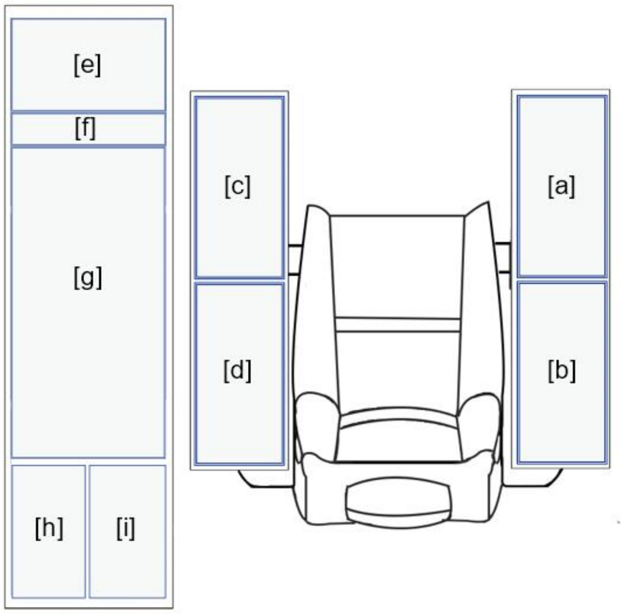

Figure 10. Control panel module division

4.4.2 VIKOR-Based Analysis of the Importance of the Components of the Excavator HMI

Scoring: A scoring team consisting of three operators, three industry experts and two design postgraduates scored the operational, instructional, emergency, auxiliary and standby components of the target 2 level of the mining excavator cab operator interface component hierarchy based on six indicators using a 7-point Likert scale, and standardised them. Table 4, using the VIKOR after indicator assignment, was used for the importance analysis of the interface component elements by calculating the relationship with the ideal distance to obtain Table 5.

Table 5. VIKOR component importance analysis

Component number	S	R	Q	Q-value ranking
A1	0.1658	0.0454	0.1814	2
A2	0.4745	0.2284	0.7506	12
A3	0.4745	0.2284	0.7506	12
A4	0.3946	0.189	0.621	8
A5	0.512	0.1397	0.5742	5
B1	0.0026	0.0026	0	1
B2	0.1016	0.0765	0.2161	3
B3	0.5228	0.1418	0.5844	6
B4	0.5327	0.1523	0.6129	7
B5	0.8231	0.1745	0.8164	14
C1	0.4737	0.1208	0.5118	4
C2	0.3912	0.2048	0.654	10
D1	0.622	0.1445	0.6431	9
D2	0.7826	0.1578	0.7578	13
D3	0.8291	0.1811	0.8343	15
E1	0.9441	0.2179	0.9767	16

Similarly, the results of the control panel module importance analysis can be reached, see figure 11.

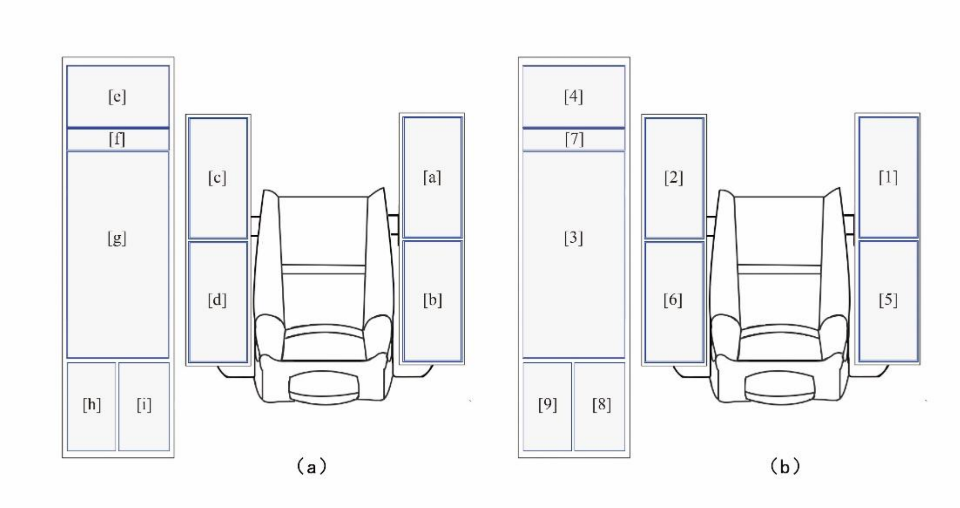

Figure 11. Before and after importance ranking results of control panel modules after partitioning

Importance matching: The results of the importance ranking of the operator panel control elements are matched with the ranking of the control panel modules and fine-tuned according to the general principles of human-machine interface design guided by SA theory as specified by Endsley, Mica R in Handbook of human factors and ergonomics (Endsley 2021). The general principles of human-machine interface design guided by SA theory, as specified in Endsley, Mica R, are fine-tuned.

4.4.3 Optimal Design of the Excavator's Human-Machine Interface Layout

Consider the layout design methods, there are many methods of interface layout, in the design of the more commonly used bracket method, wireframe method, separation method colour block method, etc., such as taking into account the obvious visual effect, this paper selects the colour block method and wireframe method layout of the different functional areas of the division of the main guide method. (Li Bo, & Yu Guoying, 2016)

According to the general layout principles of the HMI, the principles of functional partitioning, frequency of use, importance, order of operation and relevance, the results of Table 5 and Figure 11 were considered, and after focus group analysis, the optimized design scheme of the HMI layout was obtained as shown in Figure12:

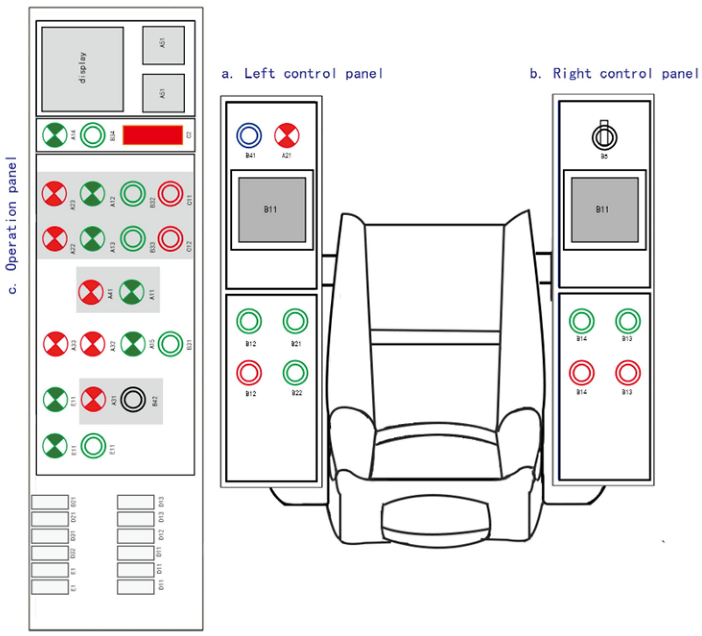

Figure 12. Excavator human-machine interface layout optimization diagram

The optimized excavator HMI firstly uses color distinction in module division. Through the design of color and frame lines, the boundaries of different functional areas are clearly delineated, making it easy for operators to find functional partitions. In terms of control components, the results of the importance analysis placed the top-ranked components in the control panel module partition with the same priority of importance. This distribution allows the excavator operator to quickly find the components associated with the task, increasing operational efficiency and reducing the frequency of errors.

5. Conclusion

This paper explores and researches the optimization of excavator operator interface layout based on the relevant research results of situational awareness theory. Through a comprehensive analysis of the combination of situational awareness theory and excavator human-machine interface layout design and evaluation, qualitative analysis methods such as literature research method and KJ method are used to extract the importance evaluation indexes for the interface components from the perspective of operator’s operational needs and cognitive laws, and combined with quantitative analysis methods such as entropy power method, VIKOR method, etc., realize the optimization and evaluation method of the human-machine interface layout of the excavator driving space proposed for the components, so that the operator’s behaviour and cognitive characteristics are valued and the operating comfort of the design scheme is significantly improved, and the research results are recognized by the design departments of enterprises, providing a new way of thinking and the research results have been recognised by the design departments of enterprises, providing a new way of thinking and reference for the rational design of mining excavator cabs.

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