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THE EXTENSION ASSESSMENT METHOD OF THE AUTOMATIC VISUAL INSPECTION SYSTEM

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ABSTRACT

The multilevel extension priority degree evaluation method is applied to the automatic visual inspection (AVI) system evaluation area, which is affected by many factors. In this paper, the AVI system for integrative hierarchical model is built, and each factor relative weigh is determined using the analytic hierarchy process (AHP). Finally, the designed AVI system is evaluated by the multilevel extension priority degree evaluation method. A combination of qualitative and quantitative evaluation method proposed in this paper effectively solves the quantitative evaluation problem of the AVI system.

Keywords: *Automatic Visual Inspection (AVI), Measuring Index, Priority Degree Evaluation*

1. INTRODUCTION

AVI system is a complicated system that affected by many factors. In fact, to let the AVI system achieve 100% accurate detection is impossible. Therefore, the evaluation of AVI system should be used as the target of optimization design. The extension evaluation method is widely used in evaluation areas, such as the architectural design innovation, enterprise’s independent innovation ability, urban traffic sustainable development, helicopter maintenance support capability and the scheme selection for engineering programs[1-5]. Bing Luo[6] studied the performance evaluation for AVI, proposed a improved ROC curve for multiple defect inspection. Junming Yang[7] studied the inspection and evaluation system of elevator control cabinet, developed a on-line inspection and evaluation system based on virtual instrument.

AVI evaluation problem includes the soft, hardware and other factors. In this paper, section 2 builds the the comprehensive evaluation index system, section 3 introduces the multilevel priority degree evaluation method, section 4 gives the conclusin, and the section 5 is the acknowledgement.

2. ESTABLISHMENT OF AVI EVALUATION SYSTEM

AVI process can be divided into the acquisition, preprocessing, segmentation, recognition and executive layers [8-9]. Because this evaluation problem has many factors, this paper adopts the analytic hierarchy process to determine the weight of each factor. The AHP basic train of thought is the same as people’s thinking and judgment process about a complex decision problem. The AHP method establishes the evaluation index hierarchy model firstly, and then determines the index weight corresponding to the highest layer.

2.1 AVI comprehensive evaluation hierarchical model

According to the characteristics of AVI system, we give the AVI model on the basis of comprehensive analysis of the layer factors. The model is shown in Figure 1, and the meaning of each index is shown in Table 1.

2.2 Determining the weight

After establishing the hierarchy model, the upper and lower subordinating relationships are determined. The upper element SI_i is taken as the guideline, which has a dominant relationship in the

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lower elements SI_{ij}. Our goal is to determine the corresponding weight according to their relative importance by constructing pairwise comparison matrix. In the pairwise comparison process, the decision maker needs to repeatedly answer the question, which one is more important, and how much is the important number according to the guideline SI_i. In this paper, we use the T.L.Saaty nine scale method[10]. The meaning of the scale is shown in Table 2.

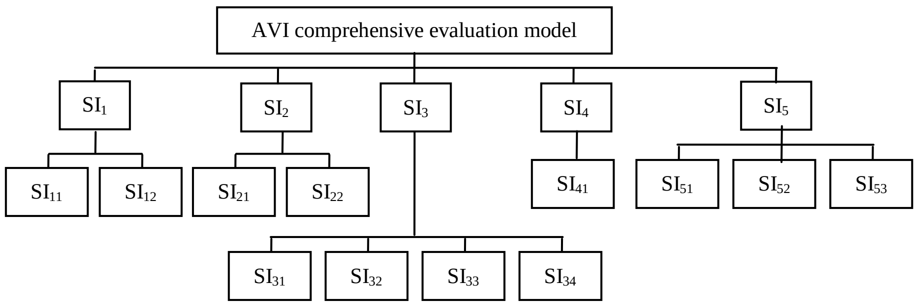

Figure 1． Comprehensive Evaluation Index Layer Model

Table 1. Meaning Of Each Index

Index	**Meaning**	**Index**	**Meaning**
SI_1	Acquisition subsystem	SI_{31}	The gray of the same region is uniform
SI_2	Preprocessing subsystem	SI_{32}	The inside of region is simple
SI_3	Segmentation subsystem	SI_{33}	Adjacent regions have significant differences
SI_4	Recognition subsystem	SI_{34}	Boundary simple and spatial position accuracy
SI_5	Executive subsystem	SI_{41}	Recognition rate
SI_{11}	Mean square error	SI_{51}	Rapidity
SI_{12}	Peak signal to noise ratio	SI_{52}	Stability
SI_{21}	Mean square error	SI_{53}	Accuracy
SI_{22}	Peak signal to noise ratio		

The pairwise comparison judgment matrix can be obtained by the pairwise comparison of the various elements under the same principle. Then, the eigen vector w is computed in according to the formula (1) using matlab programme. Finally, we need checking the consistency of and normalizing the vector to obtain the relative weight of each element.

$$Aw = \lambda_{max} w \qquad (1)$$

Table 2. The Scales Meaning

Value	Meaning
1	Compared two elements, they have the same importance
3	Compared two elements , one has a little importance
5	Compared two elements , one has obvious importance
7	Compared two elements, one has strong importance
9	Compared two elements, one has extreme importance
2，4，6，8 is the middle value of the adjacent judgement	

Steps for checking the consistency are as follows:

（1）Computing consistency index $C.I.$:

$C.I. = \dfrac{\lambda_{max} - n}{n-1}$, n is the order of the judgment matrix;

(2) Looking up the average random consistent index $R.I.$ [11]:

The average random consistency index correction values as shown in Table 3.

Table 3. The Average Random Consistent Index

Order	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49

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(3) Computing consistency ratio $C.R.$:

$C.R. = \frac{C.I.}{R.I.}$, when $C.R. < 0.1$, the consistency of the judgment matrix is acceptable.

For example: Calculating the weights α_{11} and α_{12}.

Firstly, establishing judgement matrix A_{11}.

Through the matlab program, we can obtain the eigen vector w_{11} and the largest eigen value $\lambda_{max11} = 2$, then normalize w_{11} ,and get $\tilde{w}_{11}$.

$$A_{11} = \begin{bmatrix} 1 & 1/2 \\ 2 & 1 \end{bmatrix}, w_{11} = \begin{bmatrix} 0.3162 \\ 0.9487 \end{bmatrix}, \tilde{w}_{11} = \begin{bmatrix} 0.25 \\ 0.75 \end{bmatrix}$$

Secondly, checking the consistency of A_{11}.

Computing $C.I.$ and $C.R.$ as the above consistency checking steps.

$$C.I. = \frac{\lambda_{max11} - n}{n-1} = \frac{2-2}{2-1} = 0, \quad R.I. = 0,$$

$$C.R = \frac{C.I.}{R.I.} = 0 < 0.1$$

Therefore, the matrix consistency meets the requirements.

Thus ,we get $\alpha_{11} = 0.25$, $\alpha_{12} = 0.75$.

All the other element weights can be got using the same method, and meet the condition $\sum_{i=1}^{5} \alpha_i = 1$ and $\sum_{k=1}^{m_i} a_{ik} = 1$.

In addition, we also need to establish a feature set corresponding to the measuring condition set. Ⅰ, Ⅱ, Ⅲ, Ⅳ and Ⅴ are used to represent the feature element measuring condition of AVI system, and their value range is the same [0, 10]. Ⅰ, Ⅱ, Ⅲ, Ⅳ and Ⅴ separately represents excellent, good, secondary, poor and bad.

Table 4. Evaluating Index Value Of The AVI On The Measuring Condition Set

subsystem	weight	Ev□luating index	weight	excellent	good	secondary	poor	bad
SI_1	0.41	SI_{11}	0.25	0-0.75	0.75-1.5	1.5-2.25	2.25-3	>3
		SI_{12}	0.75	>50	40-50	30-40	20-30	<20
SI_2	0.04	SI_{21}	0.25	0-0.75	0.75-1.5	1.5-2.25	2.25-3	>3
		SI_{22}	0.75	>50	40-50	30-40	20-30	<20
SI_3	0.14	SI_{31}	0.11	A	B	C	D	E
		SI_{32}	0.19	A	B	C	D	E
		SI_{33}	0.35	A	B	C	D	E
		SI_{34}	0.35	A	B	C	D	E
SI_4	0.19	SI_{41}	1	>90%	80%-89%	70%-79%	60%-69%	<60%
SI_5	0.19	SI_{51}	0.17	A	B	C	D	E
		SI_{52}	0.44	A	B	C	D	E
		SI_{53}	0.39	>90%	80%-89%	70%-79%	60%-69%	<60%

3. MULTISTAGE PRIORITY DEGREE EVALUATION METHOD

Priority degree evaluation method is a basic method in extension evaluation [12]. Because there are many measuring indexes in the problem of complex object evaluation, we need to adopt the multistage evaluation. The steps are as follows: building the dependent function of the lowest measuring indexes, computing the priority degree, then computing the upper priority degree, finally obtains the comprehensive priority degree.

3.1 Building the dependent function of second level measuring index

In fact, the basic requirements interval is the same as qualitative change interval , thus, the simple dependent function can be used to express

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the object degree which in line with the requirements. The dependent function is built according to the positive domain interval type, which can be classified three types, such as finite interval, infinite interval and discrete data set.

(1)Finite interval

The mean square deviation is the index that reacting the data set fluctuation. In this paper, SI_{11} is the image mean-square deviation. V_{11} is the finite interval, Through the experiment it can be determined that the interval [0,3] is an acceptable range and the optimal value is on the left of the interval. Therefore, building the dependent function $K_{11}(x)$. SI_{41} is the recognition rate, SI_{53} is the rate of accuracy. Ideally, recognition rate and accuracy rate are required to achieve 100%, other cases are less than 100%. According to the experimental data, the value quantity interval is[0.6,1], and the optimal value is on the right of the interval. Therefore, building the dependent function $k_{41}(x)$ and $k_{53}(x)$.

(2)Infinite interval

The range V_{12} and V_{22} of the index SI_{12} and SI_{22} are defined as $[20,+\infty)$ according to massive experiments, and their dependent function $k(x)$ has not maximum value in the interval $[20,+\infty)$.Therefore, building the dependent function $k_{12}(x)$ and $k_{22}(x)$.

$$k_{12}(x)=k_{22}(x)=x-a=x-20\,.$$

(3)Discrete data set

The range V_{22} of the Index SI_{31} is a set which consists of discrete data. Supposed $V_{31}=\{A,B,C,D,E\}$, then the dependent function $k_{31}(x)$ can can be built. $SI_{32},SI_{33},SI_{34},SI_{51}$ and SI_{52} are the same as SI_{31} ,and the V_{im} is also the set consisting of discrete data. Thus, we can get $k_{31}(x)=k_{32}(x)=k_{33}(x)=k_{34}(x)=k_{51}(x)=k_{52}(x)$.

$$k_{11}(x)=\begin{cases}\dfrac{x}{3},x\le 0\\[2mm] \dfrac{3-x}{3},x\ge 0\\ k(1)=0\vee 1,x=0\end{cases}$$

$$k_{41}(x)=\begin{cases}\dfrac{x-0.6}{1-0.6},x\le 1\\[2mm] \dfrac{1-x}{1-0.6},x\ge 1\\ k(1)=0\vee 1,x=1\end{cases}\qquad K_{31}(x)=\begin{cases}5, & x=A\\ 4, & x=B\\ 3, & x=C\\ 2, & x=D\\ 1, & x=E\end{cases}$$

3.2 Computing priority degree

The dependent functions of secondary index all have been computed in 3.1, then the priority degree about SI_i for object Z can be obtained.

$$k_i=\sum_{k=1}^{m_i}\alpha_{ik}k_{im_i}\qquad(2)$$

$$K(Z_j)=\begin{bmatrix}k_1\\ k_2\\ \dots\\ k_i\end{bmatrix}\qquad(3)$$

$$C(Z_j)=\alpha K(Z_j)==\sum_{i=1}^{n}\alpha_i k_i\qquad(4)$$

Suppose there are three systems, according to the above analysis, the various index values of Z_1,Z_2,Z_3 can be computed. Their measuring indexes values are as shown in Table 5.

According to the formula (2) and (3), $k(Z_1)$,$k(Z_2)$ and $k(Z_3)$ are obtained.

$$k(Z_1)=\begin{bmatrix}18.93\\ 15.23\\ 3.81\\ 0.25\\ 2.76\end{bmatrix},\quad k(Z_2)=\begin{bmatrix}7.58\\ 7.61\\ 2.84\\ 0.5\\ 2.47\end{bmatrix},\quad k(Z_3)=\begin{bmatrix}0.04\\ 6.02\\ 2.54\\ 0.63\\ 2.1\end{bmatrix}.$$

According to the formula (4), $C(Z_1)=9.47$, $C(Z_2)=4.37$ and $C(Z_3)=1.14$ are obtained. So the system Z_1 is the better system.

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Table 5. Measuring Indexes Values For Z_1 , Z_2, And Z_3

Measuring index	weight	Evaluating index	weight	Z1	Z2	Z3	Relevance $k_{im}(Zj)$		
							Z1	Z2	Z3
SI_1	0.41	SI_{11}	0.25	0.8	2	2.5	0.73	0.33	0.17
		SI_{12}	0.75	45	30	20	25	10	0
SI_2	0.04	SI_{21}	0.25	0.2	1.7	2.8	0.93	0.43	0.07
		SI_{22}	0.75	40	30	28	20	10	8
SI_3	0.14	SI_{31}	0.11	B	C	D	4	3	2
		SI_{32}	0.19	C	B	C	3	4	3
		SI_{33}	0.35	B	C	D	4	3	2
		SI_{34}	0.35	A	D	C	5	2	3
SI_4	0.19	SI_{41}	1	75%	80%	85%	0.25	0.5	0.625
SI_5	0.19	SI_{51}	0.17	C	C	B	3	3	4
		SI_{52}	0.44	A	B	C	5	4	3
		SI_{53}	0.39	65%	80%	75%	0.125	0.5	0.25

4. CONCLUSIONS

The extension priority degree evaluation method is discussed in this paper. The detailed steps can be found: building the AVI hierarchical model is built, determining the value range , seting up the dependent function, computing the relevance and comprehensive priority degree. Experiment shows that the proposed extension priority degree evaluation method can give direct and quantitative evaluation for the AVI system.

5. ACKNOWLEDGEMENT

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