Evaluation of Sewing Quality in Appearance Based on Fuzzy Recognition

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Abstract

Grading standard of sewing quality in appearance is established according to four indexes that are average displacement, shrinkage rate of seam, seam pucker and straight degree of seam based on sewing experiment of typical fabrics. Then, in virtue of fuzzy mode recognition method, the fuzzy recognition model is established which can effectively evaluate the sewing grade in appearance of specimens that are testified by many instances.

1. Introduction

During apparel process, sewing process is one of the important factors that affect the ready-clothing quality. The research on this question can contribute to improvement of technical and adjustment of equipments [1]. Many of domestic and overseas researchers have carried out a lot of researches on the sewing process properties and obtained several fruits. At present, one of the questions that must be solved in sewing field is how to objectively and comprehensively evaluate the sewing quality, and how to predict possible sewing quality, without mistake in produce, waste of materials, and dallying time. In this paper, after various factors that affect sewing quality in appearance are analyzed, four pivotal indexes are regarded as elemental factors to evaluate sewing quality in appearance and evaluation standard is set up, based on which, the fuzzy recognition model is established. Consequently, comprehensive and quantitative evaluation of sewing quality in appearance can be realized.

2. Fundamental theory of fuzzy recognition

Now, there is no clear standard to evaluate the sewing quality, and fuzzy mathematic theory is specially adapted to solve it. Fuzzy mathematics is a method that uses mathematic means to analyze fuzzy phenomena. Membership decision function, which is imported to fuzzy gather theory, is used to describe middle transition of difference, which is an approach of accuracy to illegibility. Moreover, approach degree is imported to identify similarity of objects. Nearer is object, bigger is approach degree. So by computing membership decision functions and approach degree, the similarity between two fuzzy subsets can be scaled, and evaluating conclusion can be obtained [2].

Fuzzy recognition is a method to identify which fuzzy specimen is the most similar to selected object, namely, it distinguishes that selected object should belong to which group after fuzzy specimens have been classified to several groups. In evaluating sewing quality, all aspects including appearance and inherence must be considered, so integrated related factors must be reviewed. There are two methods, namely direct and indirect methods, used to put fuzzy recognition into practice [3].

Maximal degree of membership principle is adopted in the direct method, with which the selected object does not absolutely belong to some standard style. Namely, there is a degree of membership on (0, 1). When these questions are processed, the bigger degree of membership value is submitted according to above bigger degree of membership principle which is the simplest and most common fuzzy recognition principle.

Approach degree and selection-nearness principle are adopted in indirect method. When one fuzzy subset is compared with the other in some properties, two quantitative indexes of fuzzy distance and approach

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degree can be used. The former describes the difference degree of two fuzzy subsets, and the latter describes the adjacency degree.

Approach degree is used to describe similarity of two fuzzy subsets, which is a quantitative index and can be computed by several forms, such as hamming approach degree, euclide approach degree, fuzzy approach degree etc. Different computing methods have different applied field. In this paper the hamming approach degree is selected which is computed by below formula.

$$\rho(A,B)=1-\frac{1}{n}\sum_{i=1}^{n} w_i \,|\, u_A(X_i)-u_B(X_i)\,| \cdots\cdots \quad (1)$$

$\rho(A,B)$ — approach degree between evaluated fuzzy subset B to fuzzy subset A;

$u_A(X_i)$ —degree of membership of the ith value in fuzzy subset A;

$u_B(X_i)$ —degree of membership of the ith value in fuzzy subset B;

In general, based on the approach degree, selection-nearness principle is adopted to judge which group the specimen should belong to. Selection-nearness principle is described by below theory. There are an aggregation U, and A_1, $A_2, \cdots, Ac$, which are standard groups, B which is an evaluated object, and ρ which is the approach degree on aggregation U. If

$$\rho(A_i,B)=\max\{\rho(A_j,B)\,|\,1\le j\le n\} \cdots\cdots\cdots\cdots \quad (2)$$

Then B is considered to be more similar to A, i.e. B belongs to A_i [4].

3. Fuzzy recognition model of sewing quality in appearance

3.1. Establishing evaluation index

Referring to previous research, evaluation indexes of sewing quality in appearance can involve in seam pucker, seam straight, displacement of layers, shrink rate of stitch, and seam uniformity etc. [5]. But some indexes are highly correlative, so seam pucker, shrink rate of stitch, seam straight and average displacement quantity of layers are selected to be regarded as the elementary evaluating indexes based on practical experience in apparel test. Some of these indexes are obtained by subjective evaluation and some are obtained by objective measurement.

Seam pucker is a general method to evaluate sewing quality which is measured by subjective identification. After the specimen is laundered, it is compared with standard template in standard illumination according to AATCC-88B. Then sewing quality can be classified to 5 levels, the 1st level is the worst and the 5th level is best.

Shrink rate of stitch is a quantitative evaluating method of sewing quality which can be computed by below formula [6].

$$Sp=\frac{L_0-L}{L_0}\times 100\% \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (3)$$

Sp —shrink rate of stitch，%；

L_0 —length of specimen before sewing, cm；

L —length of specimen after sewing, cm；

Average displacement quantity of layers is the displacement of above and below layers in sewing with the result that friction resistances between fabric and teeth on sewing machine, and fabric and foot on sewing machine are different, which can be directly measured by rule. Seam straight degree responses the distortion and deflection of seam on specimen after sewing, which is generally tested by subjective method. In this paper it is marked by experts then average value is computed, which is also classified to 5 levels, the1st level is the worst and the 5th level is best.

3.2. Grade standard of the sewing quality

To evaluate sewing quality in appearance, sewing specimens of typical fabrics must be tested and statistically analyzed then grade standard is established. In this paper, referring to the subjective grade method, 5 levels of sewing quality in appearance are established and shown in table 1.

Table 1. Grading standard of sewing quality

Grade of sewing quality	Average displacement quantity /cm	Shrink rate of stitch /%	Seam pucker /grade	Seam straight degree /grade	Description of sewing quality
L1	>=0.5	>=1.5	1	1	worst
L2	0.4	1.2	2	2	bad
L3	0.3	0.9	3	3	good
L4	0.2	0.6	4	4	better
L5	<=0.1	<=0.3	5	5	best

3.3. Fuzzy recognition of sewing quality

Aggregation U of grade of sewing quality is defined as $U=\{A_1,A_2,A_3,A_4,A_5\}$, whose fuzzy subsets A_1,A_2,A_3,A_4,A_5 construct standard model database. Each level of sewing quality is descried by four indexes, i.e. $X=(X_1,X_2,X_3,X_4)$, which respectively corresponds to average displacement quantity, shrink rate of stitch, seam pucker, and seam straight degree.

Matrix is constructed with evaluated specimen B and standard model database, which is below.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & & & \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (n = 6, m = 4) \cdots (4)$$

To eliminate difference of statistical indexes in dimension and degree of quantities, data standard is processed by computing degree of membership of test value on each index, and method is below.

$u_{ij}=(x_{ij}-x_{imin})/(x_{imax}-x_{imin})$ ……………………（5）

u_{ij}— degree of membership of the value on the ith parameter in the jth project;

x_{ij}— the value of the ith parameter in the jth project (j=1,2,…，n)；

x_{imax}— the maximum value of the ith parameter in all the jth project;

x_{imin}— the minimal value of the ith parameter in all the jth project;

Based on practice experience and analysis, four grade indexes have different affect to sewing quality in appearance, so standard weight factor w_i is imported which can be denoted a fuzzy subset, meanwhile below requirement must be meet.

$$\sum_{i=1}^{m} w_i = 1 \cdots\cdots\cdots\cdots \quad (6)$$

Distribution of weight is a pivotal work. In general, subjective method (marking by experts is one of examples) and objective method (statistical test is one of examples) are all used to obtained weight. In this paper, the former is used from marking by 20 experts and getting average value to obtain $w_1=0.13$，$w_2=0.33$，$w_3=0.38$，$w_4=0.16$.

For any specimen, if only the value of four indexes are measured, hamming approach degrees between each index and standard database can be computed by formula (1), then grade of sewing quality can be evaluated by formula (2).

4. Example

In this paper, 15 types of fabrics are selected which are obviously different in material, thickness and texture in order to validate above model. 3 groups including 6 blocks of strips whose dimension are 10×30cm (length × width) are cut respectively along longitude, latitude and oblique direction, then 2 stripes in each direction are sewed. Finally, average displacement quantity, shrink rate of stitch, seam pucker, and seam straight degree are measured. Because study method along three directions is uniform, so research on sewing specimens along longitude is regarded as an example and their test value are shown in table 2.

Table 2. Test value of four grade indexes

specimens	Average displacement quantity /cm	Shrink rate of stitch /%	Seam pucker /grade	Seam straight degree /grade
1#	0.22	0.22	5	4
2#	0.32	0.89	4	4
3#	0.19	0.84	4	4
4#	0.15	0.59	5	3
5#	0.21	0.22	5	4
6#	0.05	0.51	5	4
7#	0.11	0.39	4	5
8#	0.13	0.39	4	4
9#	0.16	1.12	4	4
10#	0.17	1.06	1	5
11#	0.24	0.04	5	4
12#	0.16	1.56	3	4
13#	0.41	1.53	3	4
14#	0.23	0.31	5	4
15#	0.16	0.54	4	4

The first specimen is acted as an example. Tested value of four indexes about sewing quality and grade standard value are processed to become standard data, and results are in table 3.

Table 3. Result after standardizing process

A_i	X_1	X_2	X_3	X_4
A_1	1	1	0	0
A_2	0.75	0.75	0.25	0.25
A_3	0.5	0.5	0.5	0.5
A_4	0.25	0.25	0.75	0.75
A_5	0	0	1	1
B	0.3	0	1	0.75

Hamming approach degree between B and data of standard model database is computed by formula (1).

$\rho(A_i, B) = (0.770, 0.832, 0.895, 0.954, 0.980)$

According selection-nearness principle formula (2), $\rho(A_5, B) = \max\{\rho(A_j, B) | 1 \le j \le n\}$ is obtained, so B belong to grade A_5, namely, sewing quality of first specimen is level L5 (best). Consequently, hamming approach degree between other specimens and data of standard model database are computed and their grades of sewing quality are evaluated. Results are in table 4.

Table 4. Result of evaluating sewing quality

specimens	ρ (A_1, B)	ρ (A_2, B)	ρ (A_3, B)	ρ (A_4, B)	ρ (A_5, B)	Grade	Description
1#	0.77	0.83	0.90	0.95	0.98	L5	best
2#	0.84	0.91	0.96	0.97	0.91	L4	good
3#	0.83	0.89	0.95	0.98	0.92	L4	good
4#	0.79	0.86	0.92	0.95	0.96	L4	good
5#	0.77	0.83	0.89	0.96	0.98	L5	best
6#	0.77	0.84	0.90	0.96	0.98	L5	best
7#	0.78	0.84	0.91	0.97	0.98	L5	best
8#	0.79	0.86	0.92	0.98	0.96	L4	good
9#	0.85	0.91	0.94	0.96	0.91	L4	good
10#	0.90	0.92	0.91	0.89	0.85	L2	bad
11#	0.77	0.83	0.90	0.95	0.98	L5	best
12#	0.89	0.91	0.93	0.91	0.85	L3	better
13#	0.91	0.93	0.94	0.90	0.83	L3	better
14#	0.77	0.83	0.90	0.95	0.98	L5	best
15#	0.81	0.87	0.93	0.99	0.95	L4	good

Thus it can be seen that quantitative evaluation of sewing quality in appearance can be realized by applying above fuzzy recognition model. It is an all-around evaluation including subjective and objective factors, which is more comprehensive and exact.

5. Conclusion

The pivotal step of fuzzy recognition for evaluating sewing quality is to establish grade index and standard. Seam pucker and shrink rate of stitch are two important factors to affect sewing quality in appearance according to analysis and practical test experience, but average displacement quantity and seam straight degree are oppositely unimportant. So their weights are difference. These four indexes are selected to act as the grade standard to establish fuzzy recognition which can comprehensively and quantitatively evaluate grade of sewing quality. Fruit of this study can offer reference and gist for apparel industry to improve and optimize sewing technical. Applied example proves that this model is good to evaluation of sewing quality in appearance, so this model has better applied and generalized value.

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