DEVELOPING FEMALE SIZE CHARTS FOR FACILITATING GARMENT PRODUCTION BY USING DATA MINING

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ABSTRACT

Data mining has been successfully applied in many fields. However, little research has been done in the area of developing female size charts for consumer garment design. Focusing on the anthropometric data of adult females in Taiwan, the goal of this study was to develop garment-size charts, using a cluster-based data mining approach. Certain advantages may be observed when size charts are developed, using the data mining cycle. These include being able to cover a higher percentage of the population, using fewer sizes, and providing manufacturers with reference points to promote products, according to body type and distribution. Since an anthropometric database must be repeatedly updated, size charts may also be continuously renewed via application of the proposed data mining cycle. These newly developed size charts will remain continually beneficial for both production planning and reducing inventory costs, while facilitating the production of garments.

Keywords: anthropometric data, data mining, size charts, garment production

1. INTRODUCTION

Standard size charts can correctly predict numbers of items and ratio of sizes to be produced, resulting in accurate inventory control and production planning [3]. Due to differences in the body types of people in different countries, each country must have its own standard size charts for manufacturers and consumers to follow. Under traditional production procedures, Taiwan has not yet developed its own size charts. Most garments are manufactured using revised overseas sizing data; as a result, garment sizes differ from factory to factory, with no consistent standards. Apart from the fact that most overseas sizing data do not correspond to Taiwanese body types, domestic manufacturers have been inconsistent in their size classifications, so consumers must choose suitable garments by trial and error, resulting in enormous inconvenience, not to mention wasted time and money [13]. Thus, the development of standard size charts for garment manufacturers and consumers is long overdue.

In the late 18th century, garment-size charts originated from the rough proportional distribution developed by tailors. After accumulating a large number of original patterns, tailors developed these patterns into several styles, which could be used to make garments for people with similar body types. The important approaches, developing the size charts of today, are briefly discussed below.

Emanuel et al. [8] concentrated on applying different body types to garment-sizing classifications, and worked out a set of procedures to formulate standard sizes for all body types. According to these procedures, people of all body types were first classified, according to body weight, into four grades, within the same range of weight and then subdivided into two categories in terms of body height. As a result, people were divided into eight categories, each category comprising those of similar height and weight. In other studies, Tryfos proposed an integer programming approach to classify sizes, so as to maximize expected sales [24]; McCulloch et al. [20] proposed a non-linear optimization technique, in order to derive a set of sizes; Laing et al. [18] used multivariate analysis to establish size charts for the protective clothing used by New Zealand firemen; Gupta and Gangadhar [11] applied a statistical model to develop size charts for young Indian females, and Chung and Wang [6, 7] applied data mining to establish sizing systems for the students of elementary and high school.

Human body types can be distinguished by taking various approaches. When classifying garment

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sizes, instead of targeting every consumer, manufacturers simply produce garments in several sizes. Although a greater number of sizes offers consumers a greater number of choices, this can cause difficulties for manufacturers, as far as production and stock are concerned. As far as possible, the garment-size charts should have the fewest number of sizes and cover the greatest number of people. Therefore, it would be helpful to formulate size charts, which have the fewest number of sizes to fit the largest number of body types, for the majority of consumers [3, 16].

The application domain of data mining is quite broad and plausible in health insurance [4], surface roughness prediction [9], biomedical technology [19], investment risk prediction [1], human resource management [21], semiconductor manufacturing [5], production schedule [23] and so on. However, little research has also been applied to female size chart development using data mining. This study proposes the development of female sizing charts by using cluster-based data mining approach. By applying the proposed method, body types can be classified from a large anthropometric database. The female size charts can then be developed to facilitate garment production.

2. DATA MINING AND CLUSTER ANALYSIS

Berry and Linoff [2] defined data mining as the analysis of huge amounts of data by automatic or semi-automatic means, in order to identify significant patterns or rules. One of the most important data mining methods is cluster analysis, which is a data reduction technique, used to solve classification problems. Cluster analysis seeks to minimize within-group variances and maximize between-group variances, including both hierarchical and non-hierarchical methods [10].

Agglomerative hierarchical algorithms are commonly used with hierarchical methods, to calculate the distance between observations; the two nearest observations are combined into a cluster. This procedure continues until all observations are appointed in one cluster. Ward's minimum variance is an important agglomerative hierarchical algorithm method, as the smallest increase in total within-group variance has the highest priority of combination [12].

On the other hand, the most widely used method for non-hierarchical algorithms is the K-means method. In this case, the initial clusters and the number of clusters are randomly chosen. The observations are reassigned, by moving them to the cluster whose centroid is closest to that observation. Reassignment continues, until every observation is appointed to the cluster with the closest centroid. The process implicitly minimizes the variance of each cluster.

Some research has proposed a feasible solution for clustering by integrating the hierarchical method with the non-hierarchical method [17]. Thus, this study has integrated Ward's minimum variance method with the K-means method to come up with a cluster-based data mining approach. A two-stage method was proposed, in order to mine the patterns of anthropometric data for developing garment size charts.

3. THE DATA MINING PROCESS

The data mining cycle involves a series of activities from defining the subject to evaluating and applying the results. The steps for developing the size charts are described below.

3.1 Defining the Subject for Data Mining

Owing to outdated and incomplete size charts for adult females in Taiwan, a large anthropometric database was created. Anthropometric variables were measured in each of 986 females according to the definition of the ISO 8559 [14]. Direct anthropometric measurements were performed.

The intent of this study was to explore and analyze a huge amount of data, by employing a cluster-based data mining approach, so as to identify systematic patterns within body dimensions. Based on these patterns, the body types of Taiwanese adult females may be classified and standard garment-size charts can be developed for use by manufacturers and consumers.

3.2 Data Preparation and Analysis for Data Mining

The data was processed, and analyzed, in order to enhance the efficiency and ensure the accuracy of the results [22]. Before mining the data, it had to be checked and processed, with all abnormal or missing data being separated out. As a result, of the 986 samples of adult females, 30, which had missing or abnormal data, were deleted; this left a total of 956 valid samples.

Not all of the anthropometric variables were suitable for use in developing the size charts; therefore, in coordination with the judgment of domain experts, as well as international standards, this study identified 11 anthropometric variables [14]. These 11 anthropometric variables included 7 linear measurements and 4 girth measurements.

To use all of the 11 anthropometric variables, as a basis for developing size charts, would make things too complicated; therefore, the more important factors were identified first. The Kaiser-Meyer-Olkin measure of sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis to proceed. The Bartlett's test is less than 0.05 for a suitable factor analysis. Based on the results of the Kaiser-Meyer-Olkin measure of sampling adequacy (0.85) and Bartlett's test ($p < 0.01$), these 11 dimensions were all suitable for factor analysis. Factor analysis gave the eigenvalues of the 11 anthropometric variables. In accordance with Kaiser's eigenvalue criterion, two factors whose eigenvalues were greater than 1 were selected [12]. Consequently, anthropometric variables, with factor loadings of greater than 0.5, were found to be clustered within Factors 1 and 2, as shown in Table 1. The major anthropometric variables concentrated within Factor 1 were bust girth, waist girth, hip girth, neck girth, bust width, back width and shoulder width; those in Factor 2 included body height, cervical height, arm length, and back waist length. From the distribution graph of Factors 1 and 2, it can be seen that all the anthropometric variables related to girth were concentrated together, as were those related to height. Therefore, two important factors were determined, with Factor 1 being named the girth factor and Factor 2, the height factor.

Table 1. Factor analysis results

	Factor 1	Factor 2
Bust girth	−0.875*	0.236
Waist girth	−0.885*	0.264
Hip girth	−0.876*	0.139
Neck girth	−0.816*	0.247
Bust width	−0.918*	0.136
Back width	−0.798*	0.216
Shoulder width	−0.744*	0.115
Body height	−0.317	−0.929*
Cervical height	−0.311	−0.927*
Arm length	−0.318	−0.906*
Back waist length	−0.317	−0.864*
Variance explained	5.413	3.573
Total proportion	49.2%	32.5%

3.3 Data Mining by Cluster Analysis

Through factor analysis, the girth factor and the height factor were found to be the most important factors in garment making. Subsequently, data mining was undertaken, using a two-stage cluster analysis, which included both hierarchical and non-hierarchical clustering. Ward's minimum variance method was integrated with the K-means method, to mine the patterns of anthropometric data, for developing garment-size charts. Ward's minimum variance method was used to determine the initial clustering information for the K-means method, while the K-means method determined the final clusters.

In the first hierarchical clustering, this study analysed the factor scores of the girth factor and the height factor to decide the cluster numbers, using Ward's minimum variance method. A tree diagram, shown in Figure 1, presents the results. As shown, a total of 956 females were grouped into three obvious clusters; thus, these three clusters were chosen for the next stage of processing. In the second non-hierarchical clustering, this study analysed all of the anthropometric data belonging to the 956 females, to decide the numbers for each of the clusters by the K-means method. A total of 432 females were grouped into cluster 1, with 390 females being grouped into cluster 2 and 134 females into cluster 3.

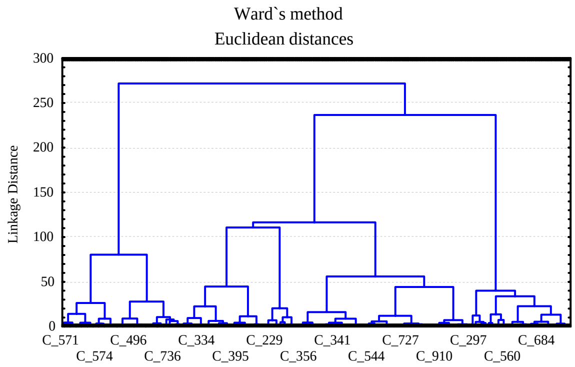


Figure 1. The tree diagram for the cluster analysis of the first stage

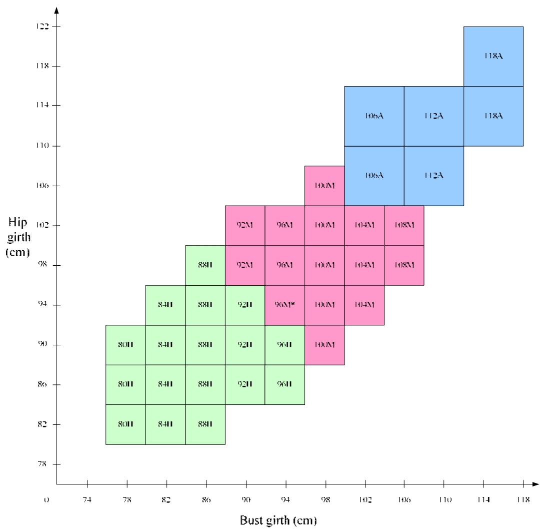
To gain a better insight into the differences between the three clusters resulting from the two-stage cluster analysis, a line plot was drawn of the averages of the three clusters and the eleven anthropometric variables. The three clusters bear marked differences, displaying a trend of cluster 3 > cluster 2 > cluster 1. The height anthropometric variables did not have significant differences. Analysis of variance (ANOVA) and the Scheffe's test were then conducted, in order to verify the anthropometric variables of all clusters, and to determine whether notable differences existed among them [12]. The results also uncovered the fact that differences did, indeed, exist between the girth anthropometric variables of the three clusters. Therefore, according to the ISO/TR10652 [15], this study defined the body types, formed by cluster 3, with larger girth anthropometric variables, as type A; the body types, formed by cluster 1, with smaller girth anthropometric variables, were defined as type H; and the body types, formed by cluster 2, were defined as type M. This definition of the three body types, used in this study, is shown in Table 2.

Table 2. Definitions of three body types

	Cluster 1	Cluster 2	Cluster 3
Numbers	432	390	134
Girth sizing variables	Small	Medium	Large
Height sizing variables	—*	—*	—*
Body types	H	M	A

* No significant differences among the three clusters

These three body types were produced by cluster analysis. Because bust girth, hip girth and body height are the most important anthropometric variables in female garment manufacturing throughout the world, this study drew a distribution graph of all three body types, with bust girth as the X-axis and hip girth as the Y-axis. By studying the distribution in detail, and coordinating our findings with the judgment of the domain experts, the size charts for the three body types were developed, using Emanuel's approach.



* 96M stand for the 96cm bust girth and M body type.
Figure 2. The distribution graph of bust girth vs. hip girth for the three body types

We take, as an example, the body type H, on the distribution graph. As most countries use 4 to 6cm as the interval for girth [25], and after coordinating this with the experts' judgment, as well as following the principle of "covering as many people as possible with the least number of sizes", this study set five sizes - 80cm, 84cm, 88cm, 92cm and 96cm - as representative bust girth sizes, and set five more sizes - 84cm, 88cm, 92cm, 96cm and 100cm - as representative hip girth sizes, for body type H. The setting of sizes for the other body types was carried out in the same manner, as shown in Figure 2.

Some samples were not included in determining the size charts for the three body types -- the A body type for example. Among them, the sample with 132cm bust girth and 133cm hip girth is at the far end of the scale for the size charts. The sample was eliminated, as it was felt to be unwise to add another group of sizes for such measurements, as it would increase costs. In the end, these 25 samples were still strictly excluded. Table 3 shows the body size distribution for all three body types. Out of the 956 samples, only 25 samples were excluded. Therefore, the coverage of the proposed "bust girth and hip girth" size charts was 97.38%. When the three sizing variables, bust girth, hip girth and body height, were taken into account, the total coverage of was 95.82%.

Table 3. Body size distribution with three body types

Body types	Bust girth (cm)	Body height (cm) / Hip girth (cm) 150(S)	158(R)	166(L)	Percentile %
H	**80**	84	—	—	1.36
		88	—	—	1.05
		—	92	—	0.84
	84	—	84	—	1.26
		88	88	—	2.72
		92	92	—	3.87
		—	96	96	1.36
	88	84	—	—	0.42
		88	88	—	3.24
		92	92	92	5.85
		—	96	96	3.45
		—	—	100	1.67
	92	88	88	—	2.61
		—	92	92	5.53
		—	96	96	4.07
	96	—	88	—	0.94
		—	—	92	4.49
M	**92**	100	100	—	6.58
		—	104	—	1.15
	96	96	96	—	5.85
		—	100	100	5.12
		—	—	104	1.98
	100	92	—	—	1.04
		96	96	—	2.51
		—	100	100	5.33
		—	104	104	4.07
		—	—	108	1.36
	104	—	96	—	2.19
		—	100	100	1.88
		—	—	104	2.19
	108	—	100	—	0.62
		—	—	104	0.73
A	**106**	110	110	—	4.71
		—	116	—	1.05
	112	—	110	110	3.35
		—	116	116	1.78
	118	—	—	116	1.05
		—	—	122	0.73

3.4 Evaluation and Application of Results

Three body types were obtained using a cluster-based, data mining approach, and female garment size charts were developed, according to the distribution conditions of the clusters, as well as the opinions of the domain experts. The new size charts were found to have the following characteristics.

The coverage rate of the size charts, including the three main anthropometric variables, was 95.82%. The size charts included 58 groups – fewer than that of any other country, e.g., 78 groups in Sweden, 79 groups in Germany, 128 groups in Bulgaria, 130 groups in Poland, and 351 groups in Japan. Table 4 shows the comparison of female garment-size charts for different countries [25]. In practice, manufacturers hope to work with as few sizes as possible, as too many sizes can result in too much inventory, which can encumber cash flow.

To obtain detailed production information, manufacturers may refer to Table 3. Taking the 80cm bust girth of body type H as an example, it can be seen that this bust girth of 80cm, matches up with three hip girths, of 84cm, 88cm and 92cm; this means that garments with three different hip girths can be produced for one bust girth of 80cm. Of course, body height must also be taken into account when planning the production of garments of a certain size. The percentage of females, within each particular body type and size were also recorded in the body size distribution; this may result in more accurate production planning and materials control for specific markets. In addition, Table 5 gives an example of size charts for body type A. Manufacturers can make different types of garments with various allowances, by referencing these size charts.

These size charts used the size labels as a reference [14]. For example, 92MR100 means that bust girth is 92cm, body type is M, body height is "Regular" (158cm) and hip girth is 100cm, as shown in Table 3. In this way the detailed body dimensions of a female can be easily determined, using these easy-to-understand size charts. Moreover, it is very convenient for women to be able to find suitable clothes within a short time. The size labels can also be used as a communication tool among pattern makers, manufacturers, retailers and consumers. Of course, no

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Table 4. The comparison of female garment-size charts among different countries

Member country	Number of bodies	Bust girth (cm)		Hip girth (cm)		Body height (cm)			Number of sizes
		Range	Interval	Range	Interval	Groups	Range	Interval	
Bulgaria	6	80-112	4	92-124	4	4	150-170	6	128
China	4	82-122	4	88-122	—*	7	145-175	5	430
Finland	3	80-122	4&6	80-128	4&6	3	155-167	4	77
Germany	3	76-128	4&6	83-132	4&6	3	156-172	8	79
Japan	4	73-100	3	79-106	2	4	150-170	5	351
Poland	4	84-120	4	88-128	4	5	152-176	6	130
Sweden	6	78-128	4	76-144	4	7	150-186	6	78
Spain	5	80-108	4	84-112	4	6	140-176	6	93
Taiwan	3	76-118	4&6	80-122	4&6	3	146-170	8	58

* Uncertain interval.

Table 5. Example of a size chart for female's garment – A body type

Control dimensions									
Bust girth	106	106	106	112	112	112	112	118	118
Hip girth	110	110	116	110	110	116	116	116	122
Body height	150	158	158	158	166	158	166	166	166
Secondary dimensions*									
Waist girth	97	97	100	98	98	101	101	110	110
Neck girth	37	37	37	37	38	38	39	40	41
Bust width	33	33	33	33	34	34	34	35	35
Back width	39	39	39	41	42	42	42	44	44
Shoulder width	34	34	34	34	34	35	35	34	35
Cervical height	124	131	132	128	133	127	134	133	133
Arm length	54	57	57	57	59	58	59	59	59
Back waist length	38	40	41	39	41	40	41	40	41
Percentile %	1.78	2.93	1.05	1.47	1.88	1.06	0.72	1.05	0.73

* Secondary dimensions stand for the mean value in each size group.

size chart is suitable for everyone. If a woman finds it difficult to find a suitable size, she would be well advised to try the size closest to her own, with slightly larger being preferable.

4. CONCLUSIONS

Garment production is a high value-added manufacturing process, so accurate size charts are a critical aspect of garment manufacturing. This study applied a cluster-based data mining approach, using anthropometric data, to develop size charts of adult females for facilitating garment production. The advantages observed are as follows.

(1) The total coverage rate of the size charts reached 95.82%, with the total number of size groups being only 58, fewer than the number of groups in other countries. The size charts also used simple and easy-to-understand size labels to describe body dimensions, enabling consumers to quickly find suitable clothes.

(2) These size charts also provided the percentage of females within each size group, for every body type, as well as the distribution of body types; this allows manufacturers access to reference points, facilitating consumer product design and garment production.

These advantages supply effective manufacturing information, which can result in more accurate production planning and materials control. Furthermore, these precise body size charts can help garment factories improve the fit of their mass-produced clothing, by providing valuable information for reducing production costs and promoting market competition.

The data mining procedure emphasizes the dataset information by repeating interaction activities. Since people's body types and dimensions can change rapidly, the anthropometric database must be updated continually; therefore, the cluster-based data mining approach, proposed in this study, will continually update the anthropometric database and continually develop the latest size charts. These revised size charts will exactly represent female body types and dimensions, allowing manufacturers access to the latest size charts, thus facilitating garment production.

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REFERENCES

1. Becerra-Fernandez, I., S. H. Zanakis and S. Walczak, "Knowledge discovery techniques for predicting country investment risk," *Computer and Industrial Engineering*, **43**, 787-800 (2002).
2. Berry, M. and G. Linoff, *Data Mining Techniques: for Marketing, Sales and Customer Support*, Wiley, NY (1997).
3. Burns, L. D. and N. O. Bryant, *The Business of Fashion: Designing, Marketing and Manufacturing*, Fairchild, USA. (2000).
4. Chas, Y. M., S. H. Ho, K. W. Cho, D. H. Lee and S. H. Ji, "Data mining approach to policy analysis in a health insurance domain," *International Journal of Medical Informatics*, **62**, 103-111 (2001).
5. Chien, C. F., A. Hsiao and I. Wang, "Constructing semiconductor manufacturing performance indexes and applying data mining for manufacturing data analysis," *Journal of the Chinese Institute of Industrial Engineers*, **21**, 313-327 (2004).
6. Chung, M. J., *Applying Data Mining to Establish Sizing Systems for the Students of Elementary and High School*, Master thesis, Tsing Hua University, Hsin-Chu, Taiwan (2004).
7. Chung, M. J. and M. J. Wang, "The development of sizing systems for school students," *36th International Conference on Computers and Industrial Engineering*, Taipei, Taiwan, 2645-2652 (2006).
8. Emanuel, I., M. Alexander, E. Churchill and B. Truett, *A Height-Weight Sizing System for Flight Clothing*, WADCTR 56-365, Aero Med Lab, Ohio, USA. (1959).
9. Feng, C. X. and X. Wang, "Development of empirical models for surface roughness prediction in finish turning," *International Journal of Advanced Manufacturing Technology*, **20**, 348-356 (2002).
10. Giudici, P., *Applied Data Mining: Statistical Methods for Business and Industry*, Wiley, England (2003).
11. Gupta, D. and B. R. Gangadhar, "A statistical model for developing body size charts for garments," *International Journal of Clothing Science and Technology*, **16**, 459-469 (2004).
12. Hair, J. F., R. E. Anderson, R. L. Tatham and W. C. Black, *Multivariate Data Analysis*, Prentice Hall, NJ (1998).
13. Hsu, K. M. and S. H. Jing, "The chances of Taiwan apparel industry," *Journal of the China Textile Institute*, **9**, 1-6 (1999).
14. International Standards Organization, ISO 8559, *Garment Construction and Anthropometric Surveys - Body Dimensions*, (1989).
15. International Standards Organization, ISO/TR10652, *Standard Sizing Systems for Clothes*, (1991).
16. Jongsuk, C. Y. and C. R. Jasper, "Garment-sizing systems: an international comparison," International *Journal of Clothing Science and Technology*, **5**, 28-37 (1993).
17. Kuo, R. J., L. M. Ho and C. M. Hu, "Cluster analysis in industrial market segmentation through artificial neural network," *Computer and Industrial Engineering*, **42**, 391-399 (2002).
18. Laing, R. M., E. J. Holland, C. A. Wilson and B. E. Niven, "Development of sizing system for protective clothing for adult male," *Ergonomics*, **42**, 1249-1257 (1999).

19. Maddour, M. and M. Elloumi, "A data mining approach based on machine learning techniques to classify biological sequences," *Knowledge-Based Systems*, **15**, 217-223 (2002).
20. McCulloch, C. E., B. Paal and S. P. Ashdown, "An optimization approach to apparel sizing," *Journal of the Operational Research Society*, **49**, 492-499 (1998).
21. Min, H. and A. Emam, "Developing the profiles of truck drivers for their successful recruitment and retention: a data mining approach," *International Journal of Physical Distribution & Logistics Management*, **33**, 149-162 (2003).
22. Pyle, D., *Data Preparation for Data Mining*, Morgan Kaufmann, California (1999).
23. Sha, D. Y. and C. H. Liu, "Using data mining for due date assignment in a dynamic job shop environment," *International Journal of Advanced Manufacturing Technology*, 25, 1164-1174 (2005).
24. Tryfos, P., "An integer programming approach to the apparel sizing problem," *Journal of the Operational Research Society*, **37**, 1001-1006 (1986).
25. Winks, J. M., *Clothing Sizes: International Standardization*, Redwood, UK (1997).

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應用資料挖礦技術發展女性成衣生產尺碼圖

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摘要

資料挖礦已經成功地應用在許多領域，但在建立女性成衣設計與生產的尺碼圖上，卻未見相關的研究。本研究目的是以聚類分析爲基礎的資料挖礦技術挖掘台灣女性人體計測資料來發展成衣尺碼圖。研究結果顯示，使用資料挖礦循環所建立的尺碼圖有較高的尺碼覆蓋率、較少的尺碼組數，而且根據尺碼圖的分配比例與體型也可以提供生產者作爲成衣生產的參考。此外，由於人體計測資料庫必須不斷地更新，尺碼圖可經由本研究所建議的資料挖礦循環持續更新，除使設計更符合消費者需求外，對生產規劃與降低存貨成本也將有所助益。

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