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A Proposal for Clothing Size Recommendation System Using Chinese Online Shopping Malls: The New Era of Data

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Abstract: Research was conducted in this study to design data-based size recommendation and size coding systems specifically for online shopping malls, expecting to lighten the burden of holding excessive inventories often caused by the high return rate in these online malls. The recommendation system has been implemented focusing mainly on size extraction and recommendation functions along with a UI (user interface). For the former function, data are necessary to extract customers' sizes and, for instance, the system to be used in China adopts their Chinese standard body size GB/T (Chinese national standard) considering that there are a variety of body types in their substantial population. The system shows the most similar size dataset among the body size GB/T dataset to the customer once he/she inputs his/her height and weight. Each GB/T data was entered after categorizing it according to the proportion between height and weight. For the latter function, size recommendation, size coding was performed first for all the clothes by the shop owner by entering individual size data. The clothes providing the most suitable fit for the customer are recommended by the selection of that which has the smallest deviation between coded clothes size and the customer body data after performing a series of comparative calculations. To validate the effectiveness of the extraction, a method that checks whether the difference between extracted size and the body size that has been measured remains within the error range of 4cm was used. The result showed there to be an approximate 88% matching rate for women and a slightly lower accuracy of 80% for men. Moreover, the error rate was relatively smaller for the upper half clothing such as shirts, jackets, and blouses or one-piece dresses. Such a result may have been generated since the GB/T data were actually the average data entered 10 years prior without categorizing nationalities, ages, and body types in detail. This research emphasized the necessity of a database containing a more segmented human body size data, which can be effective for extracting and recommending sizes more accurately as the latest ones continue to accumulate.

Keywords: data analysis for affective computing; recommend size; utilization of human body's data; automatic size extraction; online shopping mall size monitoring

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1. Introduction

This paper compiles existing size data into a format that can be coded in a computer. Next, a customer personal size extraction function was developed on the Design U apparel web platform followed by the development of a coding system that providers can input actual size of the products. Finally, we presented the application of the technology to the shopping customer as an example of the recommended user interface that is a simple visual as part of the shopping process. This study was conducted to solve the problems for customers who do not have expertise in clothing when choosing sizes. An important part of the study is to have more complete and varied body shape types of data. In addition, it is necessary to provide more precise size recommendations to customers by constantly

upgrading more accurate numerical data. Furthermore, as the automatic size generation based on height and weight is often affected by the user's nationality, age, and body type, it is necessary to add more selection items for the relevant variables afterward.

This is an increasing number of clothing shopping malls coinciding with the development of the internet. While customers used to wear and buy clothes in offline shops in the past, there are an increasing number of customers who buy clothes through online malls. Online shopping platforms offer the convenience of easy shopping for the consumers wherever they are, and fashion items are the fastest growing products [1]. Many factors, such as reliability, mind, suitability, and feelings/mood, affect customers when they select their clothes online [2]. Among them, the 'clothing fit' has been proven to be a crucial index for the consumers to evaluate the degree of satisfaction on all the clothes [3]. However, as customers have no professional knowledge on clothing, the size of clothing cannot be of great help. In an article in 2017, more than 16% of people answered that they could not select accurate size when they buy in an online shop. Therefore, it is useful to recommend suitable clothing sizes to the customer automatically [4–7]. According to a study by Zhu (2018), the return rate of Chinese online clothing purchase was about 15% to 35% in which over 60% was associated with the clothing size [8].

For this purpose, it is necessary to collect and analyze customers' body size data and clothing size fit data for recommendations. Thus, research on the size-related data followed by development of an appropriate system is required. Data is often referred as a substantial volume of data that cannot be collected, stored, and analyzed by existing databases and many countries or companies are increasing their investment in it as they expect it will determine their future competitiveness.

The current clothing industry in the era of data anticipates that a large body of customer data along with relevant clothing size data that varies with the seasons will be deemed as data and used for size recommendations, body type analysis, style recommendations, as well as product manufacturing in the future.

This study collects and sorts out reference data for recommendation when customers input height, weight, and other body size variables. The scope of study sizes are women, men, and children. The size of men ranges from S–5XL, the size of women ranges from 2XS–3XL and the size of children aged 1, 6, 9 months and 2–15 years of age. Compared with the customer numerical value, the actual size of clothing products is coded in terms of size coding when uploading the product. Therefore, it compares and recommends customer size on a real-time basis. The applied body sizes include three girth lengths and horizontal lengths. Therefore, the seller of clothing at a shopping mall can enter the tags in the shopping mall size coding system immediately and recommend the most appropriate size of ready-made clothing product to the customer through automatic comparison by the system.

Furthermore, if these technologies can be applied to the shopping malls together with a customer-friendly UX/UI (user experience/user interface) design, it will be possible to serve customers' convenience by reducing the uncertainties involved in online size selections. This is much more convenient than relying on the existing heavy and low-accuracy 3D scanners that require a time-consuming and tedious work of measuring sizes directly.

This study used the average Chinese body size GB/T data collected over a decade ago as a database; however, if it is possible to construct it in a way that suits the new era of data, it will be possible to develop a larger market in the fields of E-beauty, E-health, etc.

2. Related Research

2.1. Size Extraction System

In a study by Park and Chin (2010) [9] on "Extraction of full body size parameters for personalized recommendation module" and"Intelligent code recommendation system using body size". It is a method of product recommendation through quick body area

detection and AAM (active appearance model) using Haar-like features and the AdaBoost algorithm. The research process is as follows in Figure 1 [9].

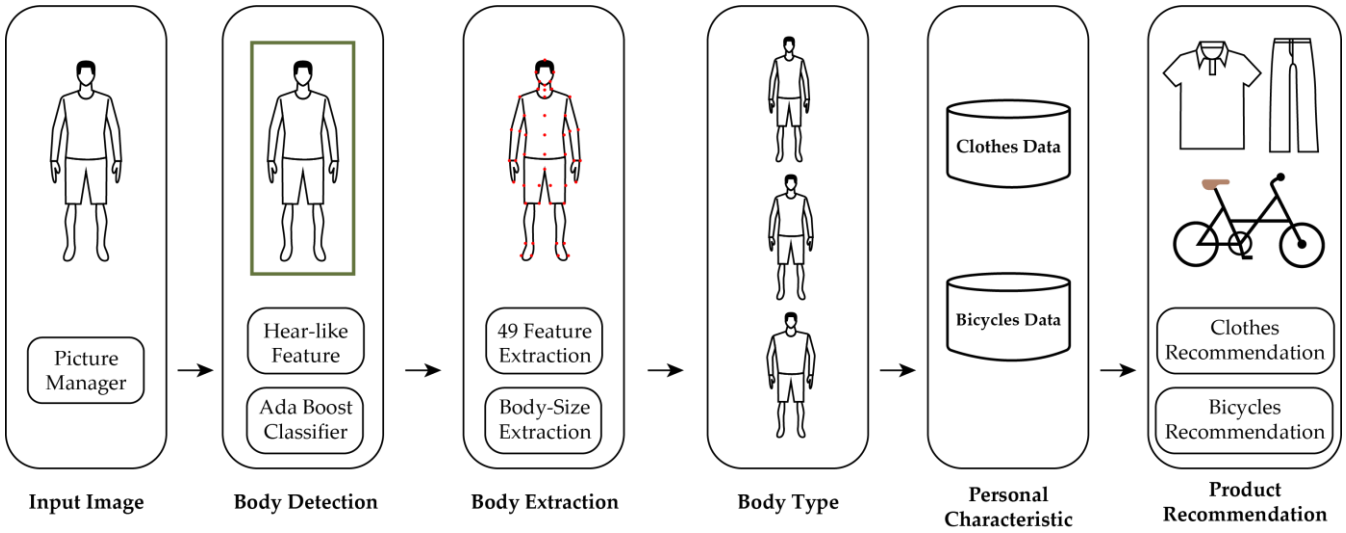


Figure 1. A flexible supply chain and digital system.

The study extracted more complicated customer numerical values. The process involved photo-taking and the recommended data were not real-time sold products but limited to existing classic products.

The study below was implemented to reflect user convenience. Customers were not required to take a photo, and only had to input height and weight. Moreover, the product provider made recommendations with an internal comparison system by codifying the size in the product information. Therefore, it is convenient for use in ordinary internet shopping malls. Customers merely input height and weight without complicated operation in existing shopping malls and can receive the most suitable size of the product. Jidong and Ying (2016) proposed [10] a method of recommending different sizes for the women's clothing by using a machine-learning technique based on the feature data of body types in different age groups to focus on solving the problem of changing clothing sizes.

First, the data of body types of 300 women aged between 18 and 50 were selected randomly from an experimental database where the body features included the lengths (height, back, arm), widths (shoulder, neck, hip, bust, and waist circumferences). Then, after training a series of models by using SVM (support vector machine) and RBF (radial basis function) kernel function, the recommendation was made for the clothing sizes by selecting the final choices by vote. The accuracy of this model was known to be over 98%. It was explained that in their study, the sizes were recommended with a predictive model where a group of 30 women were trained for the individual clothing sizes of S (155/80A), M (160/84A), L (165/88A) and XL (170/92A) [10]. Another similar study using an SVM-based technique was performed by Mao et al. (2016) who compared a person's body sizes with all the clothing sizes (S, M, L, XL) and calculated the percent deviations of corresponding items, including height, neck, shoulder and waist measurements, to define the clothes having a least F-deviation value as the most suitable one for the recommendation. This method too is possible only when the body sizes of a customer are measured in advance [11].

In fact, size selection can be carried out without developing a complicated predictive model if each item's value is known beforehand; however, what makes recommendation difficult is that when the customer does not know his/her own sizes or cannot measure them on the spot, or it is not possible to put the clothes on him/herself but if individual sizes are available, the sales staff will be able to make a recommendation. The body sizes customers usually know well are height and weight. In the same year (2016), Mao performed an additional study on extracting body sizes from a person's images considering

the convenience of online shopping (Figure 2) [12]. He was able to achieve an average of over 91% accuracy by combining the study performed on non-contact size measuring technique that can extract sizes with only the photos taken from front and side views [12]. However, not being able to provide an actual example that can be implemented for the shopping malls was a shortcoming of the study.

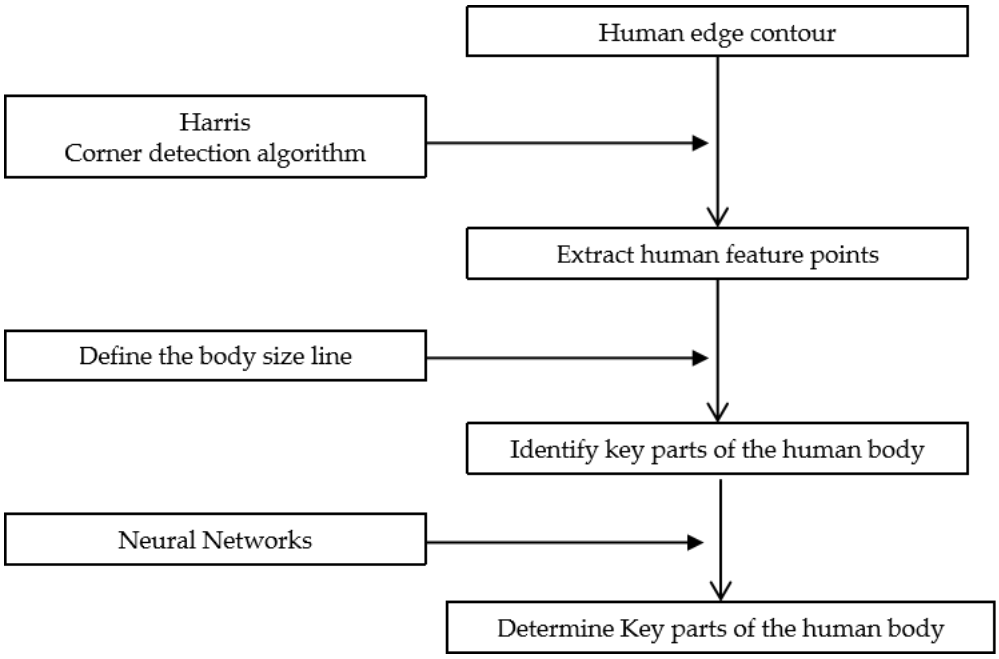


Figure 2. A method of acquiring body sizes from images.

A method of estimating sizes from available images was once studied by Meunier, and Yin in 2000 [13] and its scientific significance was that they did not design their concept after anticipating the future emergence of online shopping. They attempted to estimate body sizes with stationary images as it was their perception that several factors, including posture, measurement tools and their pressure [14], and measurer [15], interrupt exact measurement in the process of performing a conventional body size measurement [16]. Indeed, they did not take measurements with true values [4]. The experiment was conducted with two Kodak cameras and a blue wall behind the subject, which resulted in a high accuracy of having an error range within ±15 mm. This might have been the result of strict control on the camera's fixed focus, subject's clothes, and posture.

2.2. Size Recommendation System

There are several studies associated with the customized recommendation services in e-commerce. Studies recommending taste and affinities based on the customer's past interactions are being carried out widely [17–20]. However, such a system just makes recommendation of a taste on a certain style, thus, the recommendation models dealing with sizes are rare. Kurniawati et al. (2020) proposed a method of recommending the most suitable clothing sizes based on the customer's movement and the distance to the point where he/she is standing using a 3D virtual clothing (simulation) technology [21]. The 3D virtual technology is one of the rising technologies being integrated with the clothing services currently and used for the online VFMs (virtual fitting rooms) where customers can check the clothes either in 2D or 3D [22–25].

Although 3D virtual technology is a flashy technology that can attract customers greatly, it is still a heavy technology to be used for the clothing services as far as the accuracy of size recommendation is concerned [21]. The accuracies (men: 81%, women: 69%) show that it may be difficult for this technology to serve customers in making a quick decision in this fast moving contemporary society and according to the studies conducted

for the fitness of 3D virtual body-based services [26–28], many services overly relied on the database used when the body was constructed [29] or used a method that extracts a human form from the images [30]. Thus, to deal with such limitations, Abdulla and Borar (2017) proposed [31] a method that recommends right sizes by inferring the customer's body information through the feedback provided on the online platform.

However, as this method requires the feedback to be completed through two or more purchases, it only applies to the customers who visit the platform more than twice, leaving yet another problem.

2.3. UX/UI Design Examples Being Adopted for Actual Online Clothing Services

One of the clothing services provided based on body size extraction from photo images is 3DLOOK [32]. 3DLOOK Inc. (2019) is providing the APIs dealing with clothing sizes (i.e., API for size recommendation, API for building 3D models, API for getting measurements) and supports the languages, including shell, Python, Java script. The clothing sizes are recommended through SAIA Perfect Fit API.

Meanwhile, API for acquiring measurements adopts a method of inputting pictures after decoding them into a Base 64 format and usually require two photos (front and side) of the subject to calculate and extract right sizes. The company is marketing the 'getting measurements' technology to be used for the MTM (made measure) service mainly whereas their 'size recommendation' is used together with 'getting measurements' for the photos. It seems that the former's major objective is to allow it to be used for the size recommendation service for a specific brand among several famous fashion brands stored in the database with available sizes. When attempting to extract sizes, the items that each customer is required to submit are his/her gender, height, weight and two photos (front and side views). The UI design for this service is shown in Figure 3 [32].

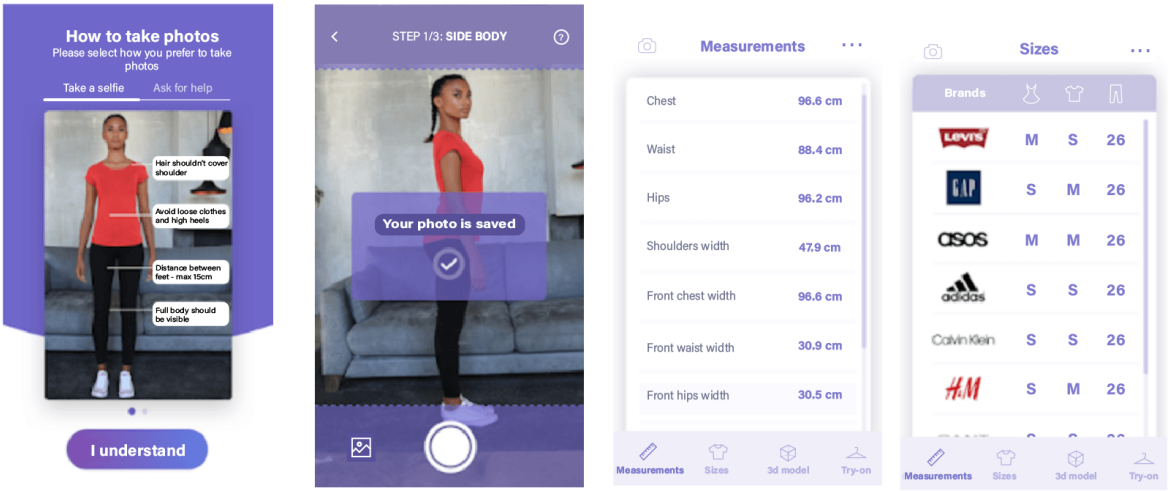


Figure 3. The screen of extracting and recommending sizes with 3DLOOK.

Another example of recommending sizes based on the feedbacks from the customer's purchase experience is 'THE FIT' (Korea) [33–36]. THE FIT service is providing a more convenient service to both consumers and business operators by offering an AI-based size recommendation solution on online shopping malls [37–41]. THE FIT size recommendation solution can be started by clicking a <size recommendation> button included in my product detail page. Once the button has been clicked, the right product size will be recommended after comparing the customer's foot size or the size of a shoe model he/she is wearing with available shoe products. The recommendation process is as follows: after finding the shoe information from the customer's past purchase information, an evaluation will be proceeded by clicking a button that corresponds most with his/her past experience. The available buttons are <too short>, <fits perfectly>, and <too large>. Next, for the shoe, he/she wishes to buy, customer clicks one of the three buttons on which different types of

adjectives describing the wearing comfort are printed (i.e., shorter, normal, larger, much larger) [33].

In June 2020, Virtual Size Korea (Republic of Korea) announced that they were operating an app service that assists consumers to select an 'accurate size' on an online shopping mall based on their data being accumulated for the last decade [42].

The service's key function is 'item-to-body', which requires customers to input their body measurements for a total of five items, such as height, weight, waist, and chest sizes along with hip size. The demerit of this system is that it does not recommend the right size immediately but just provides a descriptive information of the selected clothes such as 'tight around shoulders' or 'tight around hips' each time a size has been clicked, making the users hesitate in coming to a decision. This service also enables the users to compare the clothes they currently have with other brands based on their model and size data, but such a function cannot be used if the users are not wearing or trying to purchase a standard size clothing due to lack of size data of non-standard clothing brands (Figure 4) [43].

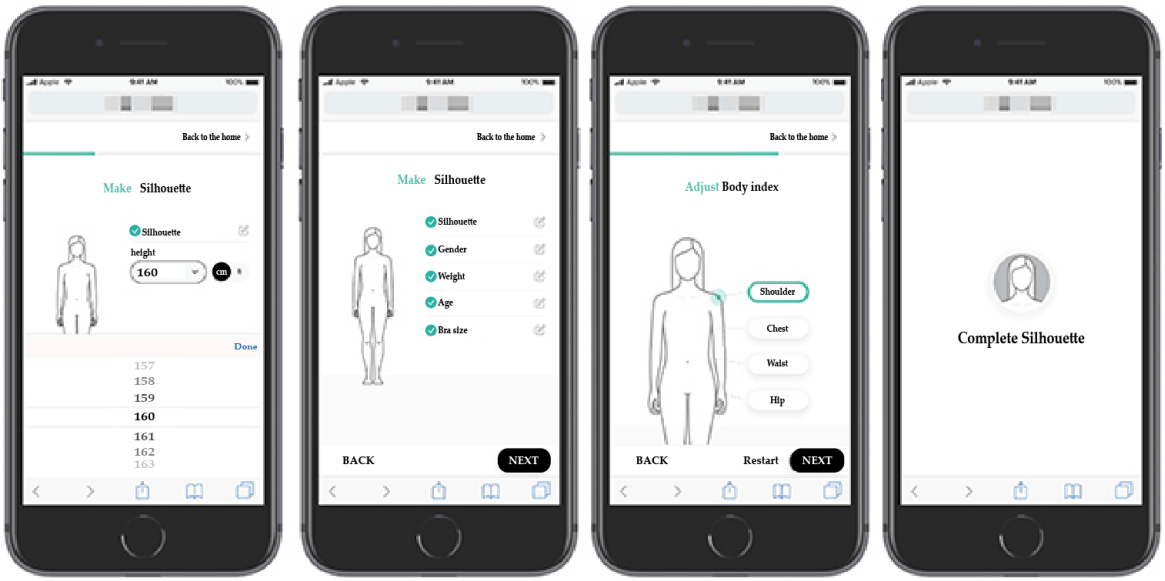


Figure 4. Virtual Size App Service.

Furthermore, data utilizing these words is being used for many clothing recommendations services. Taobao is a popular online shopping mall that features the latest aspects of online shopping mall platforms by continually introducing cutting-edge technologies. This mall also offers size input and recommendation functions. Although automatic size extraction is not available, a customer can input his/her own size for each item on the premise that he/she knows the sizes exactly. Moreover, they offer an UI design that makes the comparison between the sizes entered by the shop owner and customer easy at a glance (Figure 5) [35].

However, not many users use this function. In fact, most above mentioned customers roughly estimate right sizes by merely looking at the pictures included in the purchase postscripts. That is, they determine whether the clothes would fit well by looking at the actual appearance presented by other customer(s) having a similar body type to them. They can also infer several other elements, including the quality of clothes based on the product reliability formed by summarizing the adjectives often appearing in the customers' postscripts. The reason for not using the above-mentioned function frequently is that most of online sellers do not input clothing sizes separately in the system but instead, they simply post products to be used as a reference image for the size chart in the detail page so that it is possible that many clothes will not be subjected to the recommendation. The next reason is that the customer him/herself does know his/her own sizes or it is difficult to

input accurate body sizes based on the measurements taken by hand, which often causes a high margin of error [35].

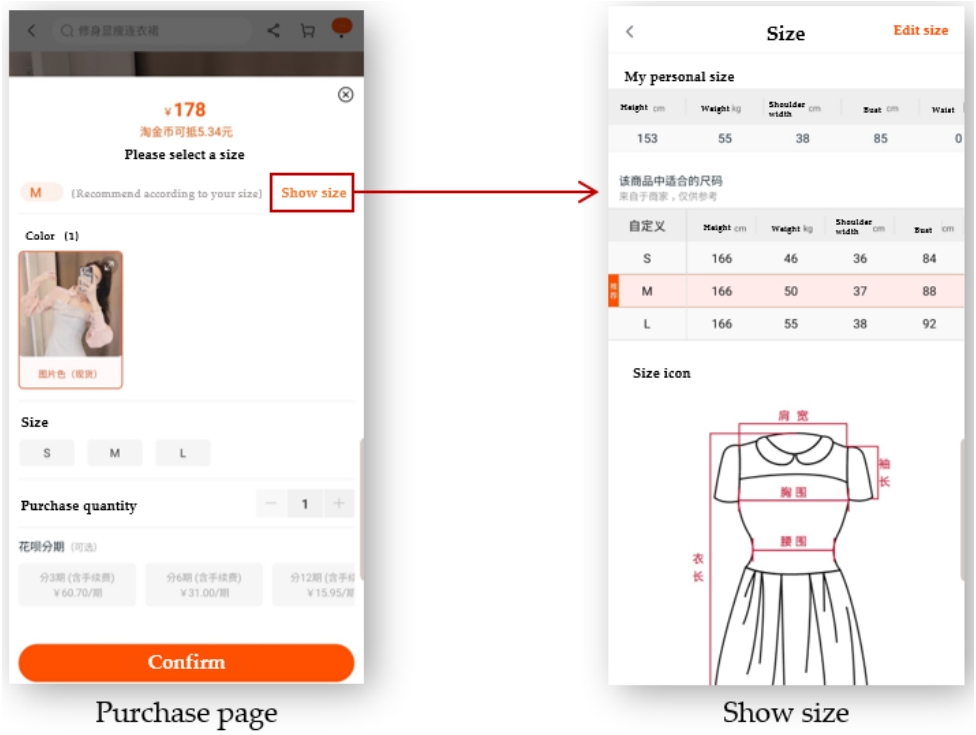


Figure 5. Taobao's size recommendation screen.

Meanwhile, the Korean research works of body size performed by the clothing-related researchers mainly include the studies pertaining to the actual condition of body sizes or standards being used and the body type analysis. Such research findings can be used when one attempts to modify the original pattern according to the views of body and aesthetics of newly changing people. Hong and (2000) [35], Kang and Sung (2007) [36] and Doh (2003) [37] conducted related studies on this matter. These research results are usually used for the research on the clothing patterns; the national standards are often used for size research.

As for the global size standards, there are ISO standards, Japanese JIS, Korean KS, Chinese GB/T, and French NF/G. From these standards, Y. S. Kang and H. K. Sung (2007) arranged the men's sizing system as in (Tables 1 and 2) [36].

Table 1. Body Type Classification Standard for each Standard and Body Type.

Specification Type	Standard of Body Type	Body Type
ISO 3636 ISO/TR(National)	Chest circumference and waist circumference difference	A(16), R(12), P(6), S(0), C(−6)
NF G 03 003(France)	Chest circumference and waist circumference difference	Athletique(14–16), Elance(8~12), Fort(4~8), Trapu(4~8), Corpulent(4~0), Ventru(−4~−8)
JIS L 4004(Japan)	Chest circumference and waist circumference difference	J(20), JY(18), Y(16), YA(14), A(12), AB(10), B(8), BB(6), BE(4), E(below 4)
GB/T 1335.1(China)	Chest circumference and waist circumference difference	Y(17~22), A(12~16), B(7~11), C(2~6)
KS 0050 (Korea)	Chest circumference and waist circumference difference	YY(22~28), Y(18~22), A(14~18), B(10~14), BB(6~10)

Table 2. The Gaps and the Scales of Basic Body Sizes in each Standard.

Size / Specification Type	Size Interval (cm)			Size Range (cm)			Total Example Title Number
	Bust	Waist	Height	Bust	Waist	Height	(Title Ex.)
ISO 3636, ISO/TR 16052	4	4~6	6	88~116	68~120	164~188	165 (100-82-176)
G 03 003-1977 (France)	4	4	6	82~120	64~128	156~186	96–80 (174)
JIS L 4004-2001 (Japan)	2	2	5	86~104	70~104	155~190	117 (96JY7)
GB/T 1335.1 (China)	4	2	5	72~112	56~108	150~185	117 (170/88A)
KS 0050 (Korea)	2~4	2	5	88~104	68~92	155~185	100-82-175

As shown in the table, the size standards are determined after classifying the body types, which are usually categorized by the deviations in each body item.

3. Chinese Online Shopping Malls Data Based Size Recommendation and Size Coding

3.1. Method and Materials

This study was the development of a size recommendation system for cloth shopping malls. The recommendation method was created by comparing actual cloth size and customer size. Firstly, as customers do not remember all body size features, this method only requires them to input height and weight. It thus develops a system to extract minimum required item values automatically. In doing so, the clothing products in the shopping mall provide actual size on ready-made clothing for reference with the customer's size. Secondly, instead of uploading the table style image file, it is developed to input to the system by direct coding. Thirdly, it is a study on screen user interface for the automatic recommendation calculation and shopping by comparing customer size with codified product size in the system.

3.2. Foundation of Adopted Numerical Value

The minimum required sizes for clothing are height, bust size, waist and hip size. These four are minimum requirements for designing a cloth. However, sleeve length, pants length and shoulder width is required additionally for customized clothing. This study attempts to develop an automatic value extraction system for six body item values including three girth sizes for ready-made clothing and three length sizes for customized service. For reference of ready-made and customizing clothing, the following items were adopted. In the girth items, bust size, waist and hop size are adopted. In the length items, shoulder width, sleeve length and pants length are included in Figure 6. For the convenience of expression, the study uses abbreviations. Bust is B, Waist is W and Hip is H. Sleeve Length is SL, Shoulder Width is SW and Pants Length is PL.

Body Circumference

- Bust (**B**)
- Waist (**W**)
- Hip (**H**)

Body Length

- Sleeve Length (**SL**)
- Shoulder Width (**SW**)
- Pants Length (**PL**)

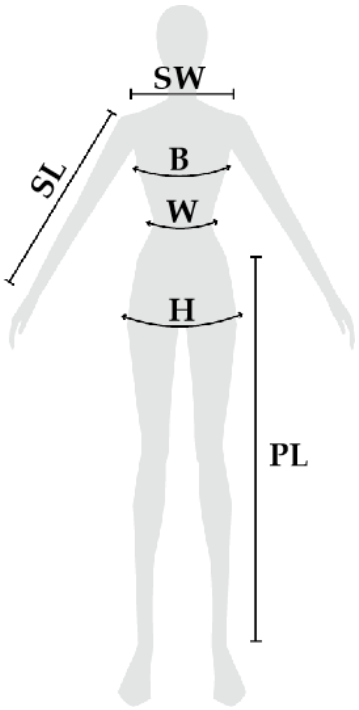


Figure 6. Items required for clothing size recommendation.

3.3. Size Data

3.3.1. Size Recommendation Table

The size recommendation table is a table for recommending suitable sizes based on height and weight (Table 3). The table is based on an average 5cm interval per height and average 2.5kg interval per weight. The recommended size uses international standard such as S, M and L. Customers find an appropriate size based on their height and weight to buy clothing. The table is provided with clothing service products in the international shopping mall and may vary by brand and country.

Table 3. Recommend Size Table.

Height/Weight	80	85	90	95	100	105	110	115	120	125	130	135	140
150 cm	S	S	M	M	L	L	XL	XL	2XL	2XL	3XL	3XL	3XL
155 cm	S	S	M	M	L	L	XL	XL	2XL	2XL	3XL	3XL	3XL
160 cm	S	S	M	M	L	L	XL	XL	2XL	2XL	3XL	3XL	3XL
165 cm	S	S	M	M	L	L	XL	XL	XL	2XL	3XL	3XL	3XL
170 cm	S	S	M	M	L	L	XL	XL	XL	2XL	3XL	3XL	3XL
173 cm	S	S	M	M	L	L	XL	XL	XL	XL	2XL	3XL	3XL
175 cm	S	S	M	M	L	L	XL	XL	XL	XL	2XL	2XL	3XL

3.3.2. Size Comparison Table

Size comparison table is a table for reference by arranging items with height based on a standard body shape Table 4. The size comparison table includes top and bottom clothing, and it provides height, bust, waist and hip values, sleeve length, pants length, bust width and more. It provides necessary items only by clothing classification; however, it is only for the standard body shape with balanced height and weight. It is insufficient to those with short height and heavy weight, or with tall height but slim weight.

Table 4. Woman's Size Chart.

US/CA	X-Small 4	Small 5	Medium 8	Large 10	X-Large 12	XX-Large 14
Spain/ Desigual	**X-Small 36**	**Small 38**	**Medium 40**	**Large 42**	**X-Large 44**	**XX-Large 46**
Height	164 cm	166 cm	168 cm	170 cm	172 cm	174 cm
Chest	81 cm	85 cm	89 cm	94 cm	99 cm	104 cm
Waist	62 cm	66 cm	70 cm	75 cm	80 cm	85 cm
Hips	88 cm	92 cm	96 cm	101 cm	106 cm	111 cm

3.4. Data Extraction of Size Value by Customer Height and Weight

The human body values are classified into girth and length. A size comparison table is provided for the reference of clothing size with height at the standard weight. Therefore, the width and length items in the body items are proportionate to the height. Accordingly, the girth length is relevant to the fat level, which is proportionate to length and weight. The size recommendation table is a system to recommend the size based on the proportion between height and weight. If the size obtained from size recommendation table is inputted to the table, this reflects the level of fat. Thus, it is proportionate to girth length. To the contrary, since the length item is related to height, the length item in the table is accurate. Therefore, if the customer provides height and weight information, when the two tables are compared, the most approximate body size of the customer can be obtained. Therefore, the size extraction by height and weight in terms of relation of six items, including height, weight, recommended cloth size, comparison cloth size, length item value and girth item value, is shown in Figure 7.

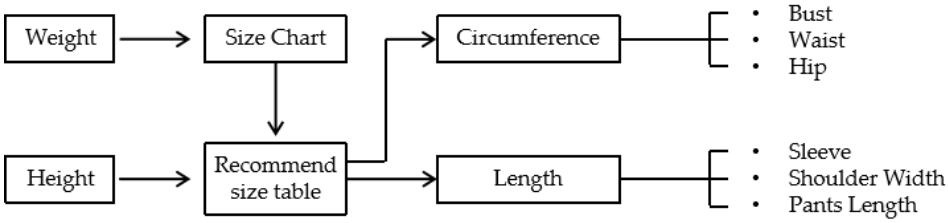


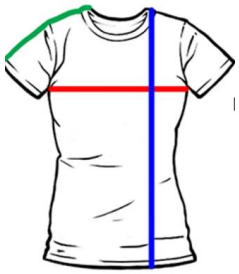
Figure 7. Relationship diagram and process.

3.4.1. Actual Measurement Size

Actual measurement size of clothing is the actual size of clothing, which aims to help to compare customers with their own sizes. Most clothing shopping malls provide actual size and size recommendation tables together. The actual measurement size of the clothing is measured by properly laying the clothing out. Measurement is obtained by overlapping two layers in the front and rear. Therefore, length measurement (Figure 8, first and third figure) uses actual value to compare with the customer size. The girth length (Figure 8, s figure) is a value that multiplies the measurement value by two, which is used to compare with customer size.

Figure 8. Measuring actual size of clothes.

In the past, the measured size was made in table. Additionally, it is uploaded in an image file in the shopping mall screen (Figure 9).



	SHIRT LENGTH		CHEST WIDTH		SLEEVE LENGTH	
SMALL	25.5″	(65 cm)	18″	(46 cm)	9.5″	(24 cm)
MEDIUM	26″	(66 cm)	19.5″	(50 cm)	10″	(25 cm)
LARGE	27.5″	(70 cm)	21″	(53 cm)	11″	(28 cm)
XL	29″	(74 cm)	23″	(58 cm)	12″	(30 cm)
XXL	30″	(76 cm)	25″	(64 cm)	13″	(33 cm)

Figure 9. Example of actual size provided.

3.4.2. Actual Measurement Size Coding

Existing attachment method performed in shopping malls requires a process of comparing customer size. In this study, it is designed to update clothing products to the shopping mall and to input size comparison table at the same time, and the input product size is codified in the system at once. So, when the customer sees the product and selects the size, the size can be recommended automatically. There are 6 size coding items as in the automatic extracting body size items. It is bust length, waist length, hip length, shoulder width, sleeve length and pants length. The cloth provider does not need to provide all 6 items. For example, in the top, pants length is not necessary. In a short skirt, waist length is necessary only. The comparison process of size coding and customer size is as follows (Figure 10).

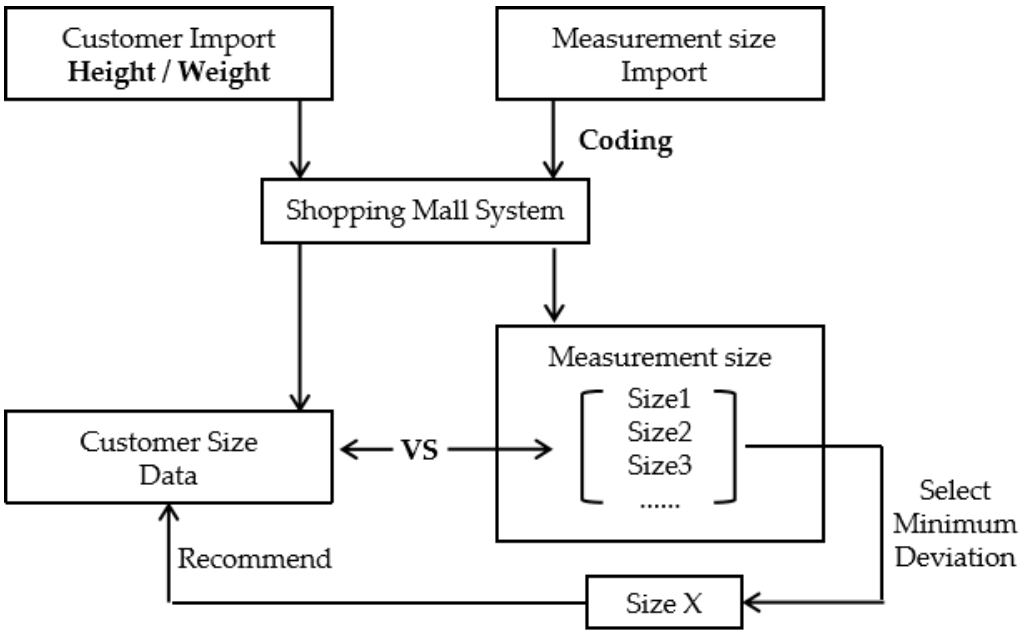


Figure 10. Size coding comparing and recommendation system process.

4. Data Analysis Result

4.1. Size Data Result Table System Data for Recommending Size Table

The newly edited data with reference to the existing size recommendation table are as follows, which provide data of men (Table 5) and women (Table 6). The data referred to was obtained from several shopping malls and the Chinese national standards GB/T 13355_1~2. For the men's size data GB/T 13355.1, the deviations in B category were used

for the body type distinction, whereas the same for the women's size data GB/T. The deviations in body type A were utilized [37–42]. A small modification was made based on the data provided by several shopping malls.

Table 5. System Data for Man's Recommend Size Table.

Cm/Kg	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80	82.5	85	87.5	90	92.5
160	L	L	L	L	XL	XL	XL	2XL	2XL	2XL	3XL	3XL	3XL	4XL	4XL	4XL	4XL	4XL
165	L	M	M	M	XL	XL	XL	XL	XL	2XL	3XL	3XL	3XL	4XL	4XL	4XL	4XL	4XL
170	M	M	M	M	L	L	XL	XL	XL	XL	2XL	3XL	3XL	3XL	3XL	3XL	4XL	4XL
175	S	S	M	M	L	L	L	XL	XL	XL	2XL	2XL	2XL	3XL	3XL	3XL	3XL	3XL
180	S	S	S	M	L	L	L	L	L	XL	2XL	2XL	2XL	3XL	3XL	3XL	3XL	3XL
185	S	S	S	S	L	M	M	L	L	XL	XL	XL	XL	3XL	2XL	2XL	3XL	3XL
190	S	S	S	S	S	M	M	M	M	L	XL	XL	XL	2XL	2XL	2XL	3XL	3XL

Table 6. System Data for Women's Recommend Size Table.

Cm/Kg	40	42.5	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70
150	XS	S	M	M	M	M	L	XL	XL	2XL	3XL	3XL	3XL
155	XS	S	M	M	M	M	M	XL	XL	2XL	3XL	3XL	3XL
160	2XS	XS	S	S	M	M	M	L	XL	2XL	2XL	3XL	3XL
165	2XS	XS	S	S	M	M	M	L	XL	2XL	2XL	3XL	3XL
170	2XS	XS	S	S	M	M	M	L	XL	2XL	2XL	3XL	3XL
173	2XS	2XS	XS	XS	S	S	S	M	L	XL	XL	3XL	3XL
175	2XS	2XS	XS	XS	S	S	S	M	L	XL	XL	2XL	3XL

4.2. Size Data Result Table System Data for Size Chart

Newly edited data with existing size comparison table are as follows. The following size aims at international size. It provides data of men (Table 7), women (Table 8) and children (Table 9).

Table 7. System Data for Men's Size Chart.

	Man						
	Height	**B**	**W**	**H**	**SW**	**SL**	**PL**
XS	155	76	68	83.1	41.6	54.5	93
S	160	80	72	85.9	42.8	55.5	96
M	165	84	74	88.7	44	56.5	99
L	170	88	78	91.5	45.2	57.5	102
XL	175	92	80	94.3	46.4	59	105
2XL	180	96	82	97.1	47.6	60	108
3XL	185	100	84	99.9	48.8	61.5	111
4XL	190	104	88	102.7	50	62	114
5XL	195	106	90	105.5	51.2	63	117

Table 8. System Data for Woman's Size Chart.

	Woman						
	Height	**B**	**W**	**H**	**SW**	**SL**	**PL**
3XS	148	75	59	81	34	54	83
2XS	151	77	61	82.5	35	54	85.5
XS	154	79	64	84	36	55	88
S	159	83	68	87	38	56	90.5
M	164	87	72	90	40	57	93.5
L	169	91	76	93	42	58	96.5
XL	174	95	81	97	44	59	99.5
2XL	178	99	86	100	46	60	102.5
3XL	180	102	89	102	46	61	105.5

Table 9. System Data for Child's Size Chart.

Internation	**Height**	**B**	**W**	**SW**	**SL**	**PL**
3M	50	40	30	-	17.5	-
9M	65	44	33	-	19.6	-
1Y	75	48	48	23	24	45
2Y	90	52	50	24.5	27	49
3Y,4Y	100	54	51	27	31	55
5Y	110	57	52	28.4	34	60
6Y,7Y	120	60	54	30	37	65
8Y,9Y	130	64	57	31.6	41	70
10Y,11Y	140	68	61	33.2	45	78
12Y,13Y	150	72	64	34.8	49	84
14Y,15Y	160	76	66	36.4	-	89

4.3. Size Numerical Value Extraction Result by Height and Weight of Customer

Six item values can be saved after manual modification from the development of an automatic size extraction screen. Figure 11 shows results of the customer size extraction user interface. In ①, the information and the name of the owner who forms the sizes are to be entered. His/her gender is selected in ②, whereas his/her height and weight are entered in ③. The enter key is then pressed. By doing so, a recommended size according to the inputs will be shown in domain ④. All the sizes in that domain are the ones that have been in the size recommendation table and refer to the 3 measurements (i.e., waist, bust and hip), not the clothing sizes.

In domain ⑤, the 3 measurements according to the height and weight and the other 3 measurements depending on the height will be automatically produced. In here, the modifications can be made to the sizes of the items when they do not match the known sizes. Then ⑥ is pressed to store the information. The recommendations will be accurate if the user knows their exact body sizes. Otherwise, the height and weight can just be inputted to conveniently achieve a recommendable size. Nevertheless, as this automated recommendation does not accurately fit the customer's size, it would be wise to measure the body items by him/herself for input.

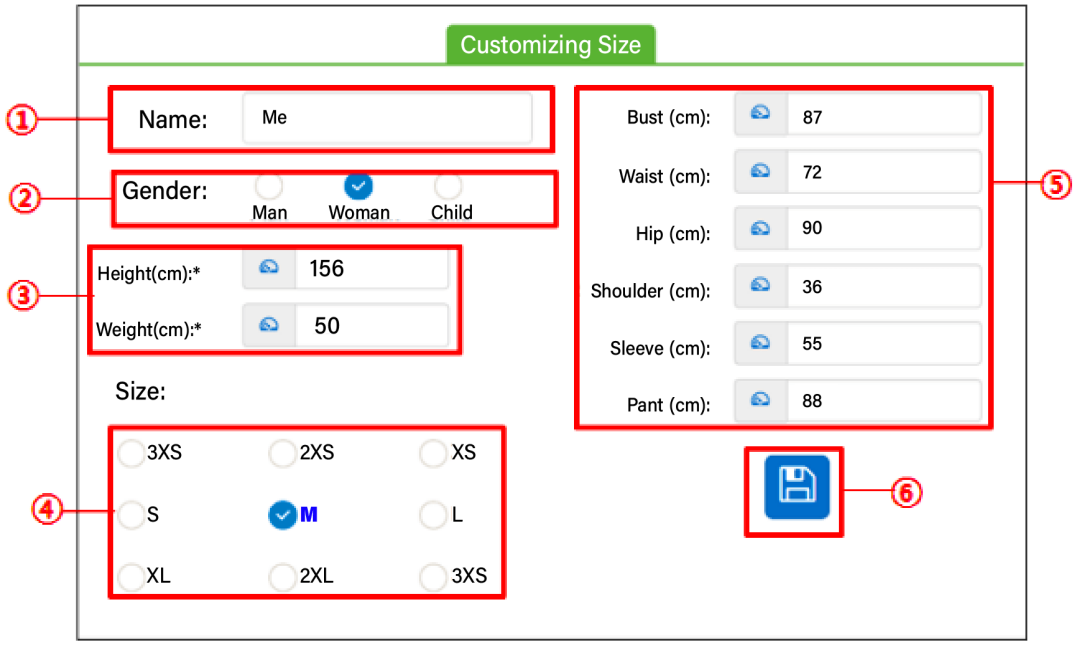


Figure 11. Result of customer size extraction user interface.

Figure 12 describes the size box. The sizes for several people can be produced on that screen and one box is created for each person for storage. After completing the storing process in Figure 10, a single box will appear in ① Figure 11.

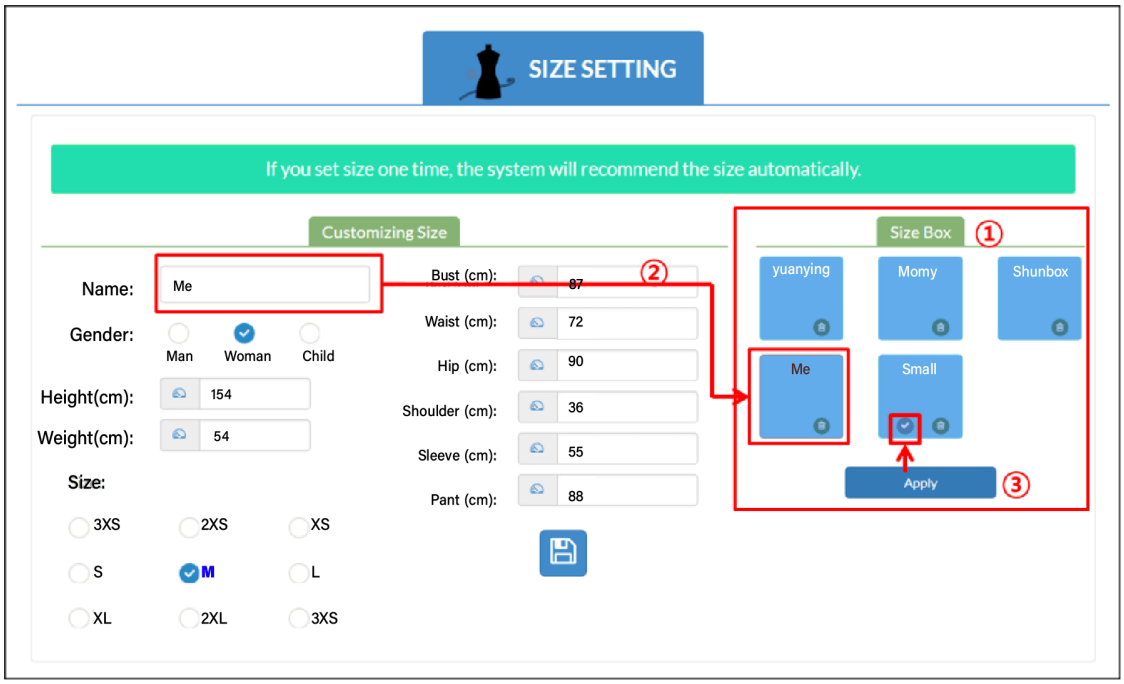


Figure 12. Size box user interface.

The name of the box is the same as the customer information or name who will receive a recommendation, as in ② (arrow). Only one size box can be applied while shopping so that the box currently being applied is marked as in ③. If one wishes to change the size box being used, he/she just needs to click the size recommendation button to do it.

4.4. Actual Measurement Size Coding User Interface

Figure 13 shows the results of a research clothing measurement size coding. The first screen is a product information registration screen and the items to be registered are similar to the ones in the other shopping malls. In category ①, a selection is made from top, one piece, skirt, and pants. After entering the product information, the information pertaining to the size will be coded with the size coding button ②. The size coding screen ③ appears after clicking ②. Then, a size type is entered in ④. The size types vary in each country; some use S, M, L, etc. and the others may use 44, 55, 66 and so on. One can use whichever he/she is comfortable with. Six items can be coded in ⑤ but it is acceptable to code only one item. The size comparison calculations are performed only for the coded items. The grading deviations are entered in ⑥, and this function was added for the reason that it takes much time to input all the sizes manually if there are too many sizes. For example, by entering the items for the size S in ⑦ and then entering the deviation in step of each item, the value of each size applied with individual deviations will appear in a vertical line of the relevant item. The buttons ⑧ and ⑨ are for deletion and addition of a size, respectively. After coding all the sizes, the save button ⑩ is pressed.

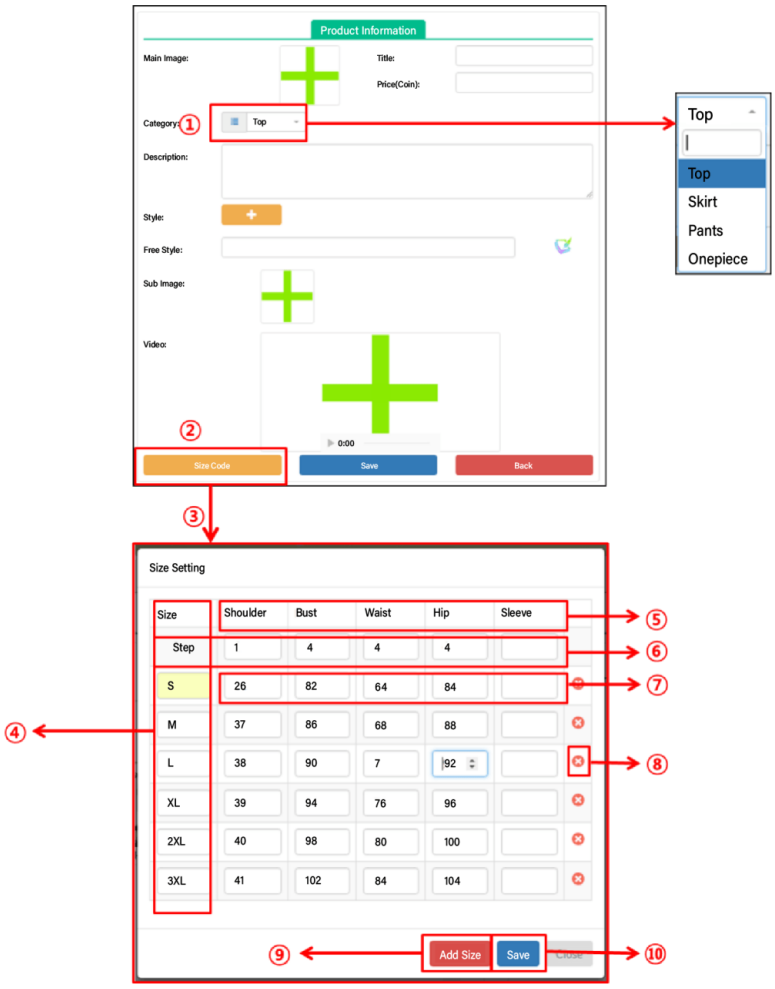


Figure 13. Clothing measurement size coding user interface.

4.5. Size Comparison Calculation

When comparing coding size and customer size, it is a method of recommending the size with the least deviation from customer size among coding sizes. When comparing deviation, it is the sum of deviation after adding weighted value to the item required for relevant classification. This is to prevent the comparison of hip length or pants length that are unnecessary for the comparison of top clothing. The weighted value by item classifica-

tion and item varies. When inputting weighted value, it is the higher weighted value with relatively higher size of latitude. At the bottom, the weighted value is put on important items by clothing size. The weighted value by classification is as follows (Table 10).

Table 10. Cavity by Clothing Classification.

	Bust	Waist	Hit
TOP	100% Deviation	50% Deviation	10% Deviation
SKIRT	–	100% Deviation	–
PANTS	–	100% Deviation	75% Deviation
ONEPIECE	100% Deviation	75% Deviation	75% Deviation

By comparing customer size (size C) and coding size (size 1, size 2, size 3 . . .), the smaller size (size X) with the sum of less deviation of weighted value in each item, can be a recommended size.

4.6. Size Recommended Main User Interface

Figure 14 shows a size recommending user interface developed in this study. The construction of the first picture is similar to the other shopping malls and basic items, such as size selection, style selection and number selection so that the customers would not feel confused when they get a recommendation. If the customer does not wish to be recommended for a size, he/she has selected, he/she just needs to drop the size and select another size. Thus far, it is not that different from other ordinary shopping malls. If the customer wishes to receive a recommendation, he/she needs to push the size recommendation button ① next to the size items. Then, a size setting screen, including the size boxes will appear. Selection should be made among the size boxes ②, and then push apply. Next, by dropping the size items again, one will see the text recommended for the size selected, as in ④.

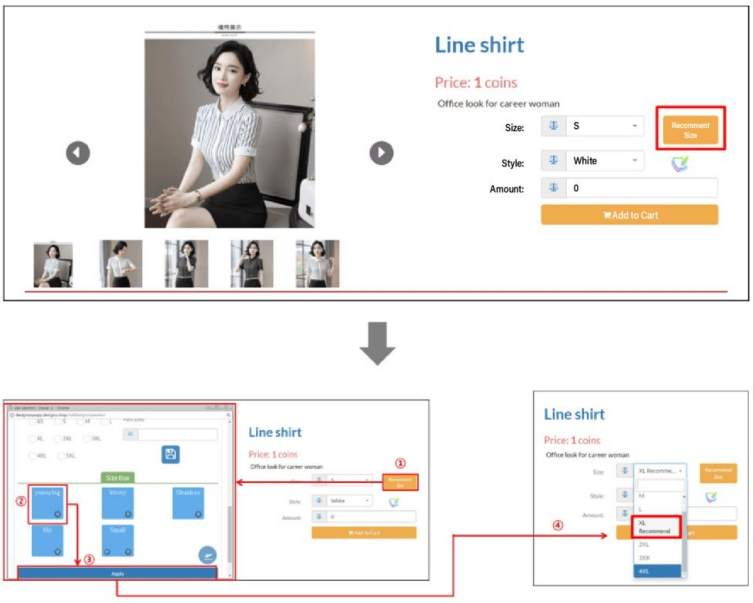


Figure 14. Size recommended main user interface.

5. Performance Evaluation

Fourteen test subjects were randomly selected from the Korean and Chinese nationals regardless of their ages and genders because of their similarities in the standard body type. The collected data included individual subject's height and weight along with the other six items (i.e., bust, waist, hip, shoulder width, sleeve length and pant length). The actual measurements for these items have been taken three times to estimate their averages. And then, a size box was created for each recommended measurement and actual measurement. Three items for both men (shirt, jacket and pants) and women's wear (blouse, dress and pants skirt) were selected to check the accuracy in each item.

5.1. Reliability of Automated Size Extraction

The function was analyzed based on the degree of data deviations between automatically extracted sizes and actual sizes. Figure 15 shows the deviation graphs. The deviations were calculated for the three items such as bust (B), waist (W), and hip (H) lengths among the six items because these are the primary items which determine whether the clothes would fit or not. When grading a * wear, the universal latitude deviation is 4 cm so that the range within four (manifesting domain) will be considered as an ideally judged domain. Women's measurements were closer to approximated values compared to men's measurements. The B, W, and H are the deviations between actual measurements and automatically extracted sizes. As shown in the picture, all of them stayed within the range of 4 cm. However, the body types of those who were in a higher age group or with different body types could exceed the scope of the red domain.

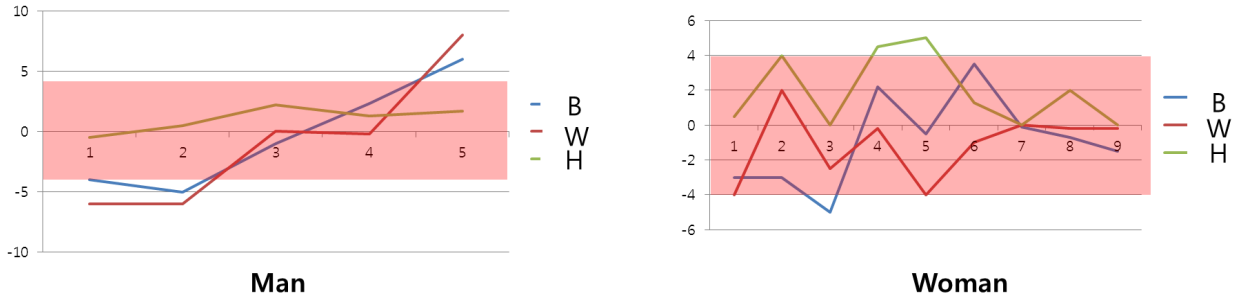


Figure 15. Data deviations between automatically extracted sizes and actual sizes.

Therefore, it is recommended that data should be entered after taking the measurements directly with a tapeline. Moreover, if one wishes to automatically extract the measurements of smaller deviations with just height and weight, the selection options, such as nationality, age, and body type should be added. Thus, the measurement data from several countries are required in addition to a dataset categorized by ages and body types. To achieve this, data of body measurements are necessary and the applications that allow a convenient scanning of body sizes with smart devices to accumulate the data will be expected to be useful to the size-recommending clothes shopping mall systems soon.

5.2. Test of Size Recommendation Function

In Figure 16, an evaluation was performed concerning the accuracy of the recommendation for each automatically extracted size and actual size. As the results from the size recommendation are based on the sizes entered during the setting process, the accuracy can be largely influenced by the inputs. '0' means that the automatic extraction has recommended an accurate size whereas '1' ('−1') means that it has recommended one size larger (lower). The recommended size will be more accurate if one's own measurements have been entered instead of automatically extracted sizes.

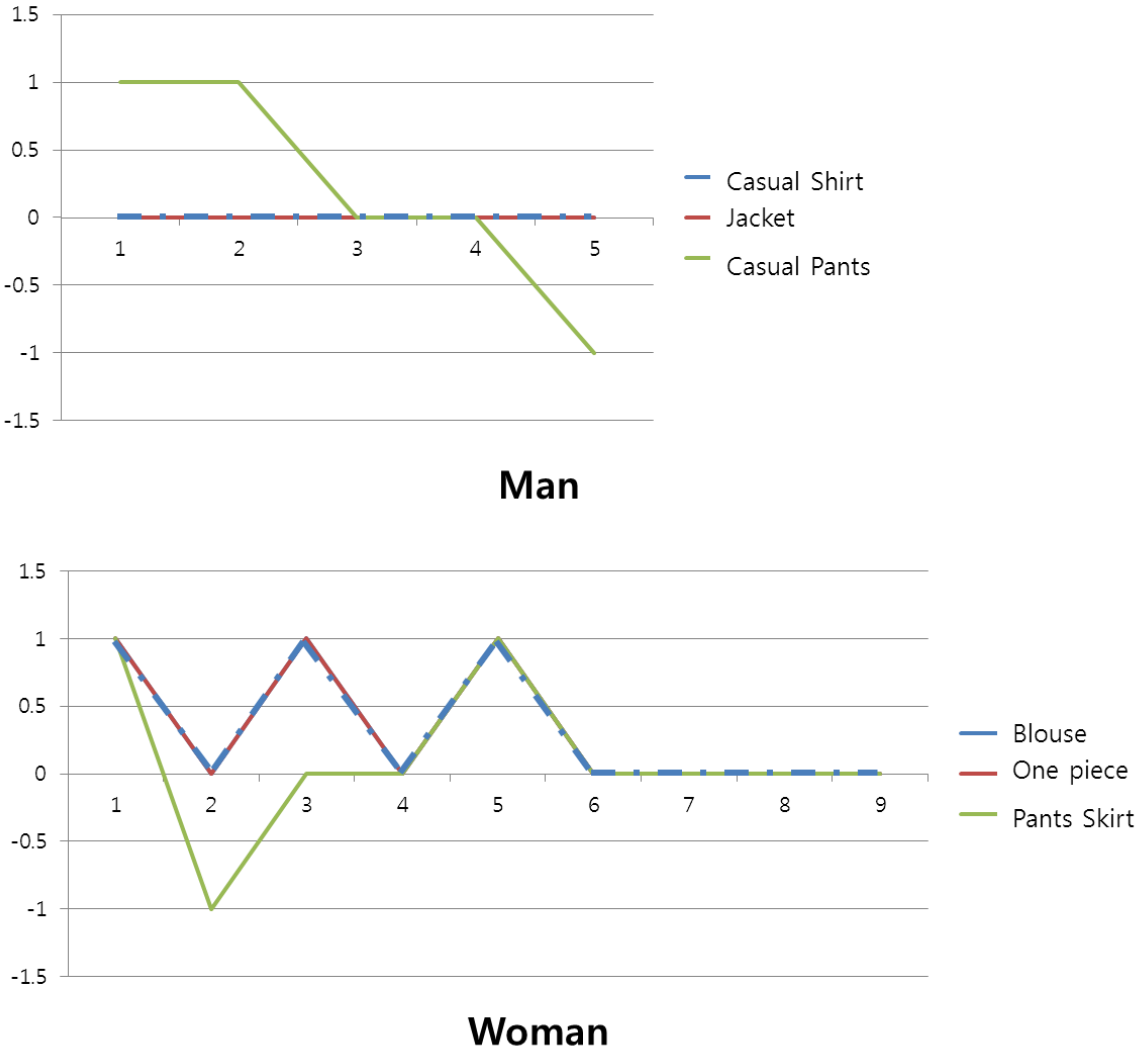


Figure 16. The data result of size recommendation.

Additionally, a selection can be made according to the customers' preferences. It is interesting to observe that the automated recommendation works better for the casual wear, and this is because their size differences often remain within four sizes. That is, the size recommendation is useful when one wishes to purchase casual wear based on his/her height and weight only but for the tight dresses, it is recommended to use the actual measurements for input.

5.3. Comparison with Other System

Smart Insole is a sort of a wearable IoT device, which transmits data to the smart devices, such as smartphones after measuring the activities of a person wearing the device embedded with various types of sensors. Several small or large domestic/foreign companies have commercialized it or are preparing to do so. For example, Samsung Electronics is planning to expand its wearable business by developing a series of smartwatches, bands or insoles, which work with smart devices. Samsung Advanced Institute of Technology (SAIT) has been conducting research and development for smart shoes for years and have recently begun their commercialization. It is expected that the research and development results will be used by Samsung's Information Technology (IM) and Mobile Communications section for commercialization purpose. The company officials stated that they are developing smart insoles with some of their key partners aiming to complete the commercialization project by early in the year and planning to attend Consumer Electronics Show (CES) next year.

The smart insoles can be used for healthcare management, such as monitoring/correcting one's gait or calculating travel distance or calories with various types of motion sensors embedded in them. They can receive the data with a smart app using Bluetooth technology. Wireless recharging technology is applied to the smart insoles being developed by Samsung Electronics so that the shoes are recharged automatically once they are placed on a shoe rack.

Nike is a leading company in the field of smart shoes. They embedded a single accelerometer sensor to show the work rate of the wearer on an iPod or iPhone.

Meanwhile, Adidas presented 'mi Coach' after adding a heartbeat-measuring band to the same technology used by Nike. On the other hand, the research on a smart shoe rack in the Republic of Korea has not been carried out sufficiently compared to smart shoes.

Deep learning is fast becoming the core technology in AI applications [43]. Interest in deep learning continues to increase as it has shown impressive performances in many fields, including computer vision, natural language processing and voice recognition. Another area where deep learning showed remarkable performance is image classification [44]. The purpose of image classification is to categorize the given images accurately. On the other hand, image classification can be approached with transfer learning in a deep learning aspect. As a matter of fact, some top-ranked image classifications were the results of transfer learning [45–47].

Transfer learning is popular in computer vision because it can show high accuracy relatively quickly [44].

The advantage of transfer learning is that it can use the already learned patterns instead of building the model from scratch when solving a problem that is different from the learned problems. Some pre-learned models used in a transfer learning have a large convolutional neural network (CNN) structure [48]. CNN has shown excellent performance in various computer vision problems [49]. The reason CNN has gained significant interest recently is the good performance and easy learning.

Therefore, this study focused on transfer learning for deep learning. This study used the Keras library generated with Python language and consequently evaluated the performance with VGG [46] and Inception [50] of the pre-learned models.

Meanwhile, LG Electronics (ROK) introduced their smart wardrobe, LG Styler ThinQ at IFA 2018, for the first time. They have been promoting the use of artificial intelligence (AI) throughout their company and applied it to the Styler following their ThinQ product line, including air conditioners and drum washers. LG's global brand, ThinQ, includes all the products and services involved with AI [51]. The styler ThinQ allows users to turn on/off power or set the clothes treatment control easily by voice without any manual instructions.

In the meantime, another smart wardrobe called Laundroid [52] was released in Japan. It is connected to the wireless internet and classifies clothes or even displays t-shirts or towels after neatly folding them using the AI sensors installed in the wardrobe.

Figure 17 shows Laundroid AI [52]. This machine picks up a dress with its multiple robot arms and scans it with a camera. The scanned image(s) is delivered to the object-analysis server through a Wi-Fi connection and then compared on a neural network containing 256,000 clothing items for analysis. Next, the robot arms start to fold the dress according to the best handling method determined by the wardrobe system. Since it takes about five to ten minutes to fold a T-shirt, the time required to handle all the clothes fully packed in the wardrobe is about two hours so that the owner can leave his/her home after simply placing them in the machine. Mothers with a baby can benefit from such a system as well. The real strong point of Laundroid is the way it collects and utilizes the clothing data by using AI.

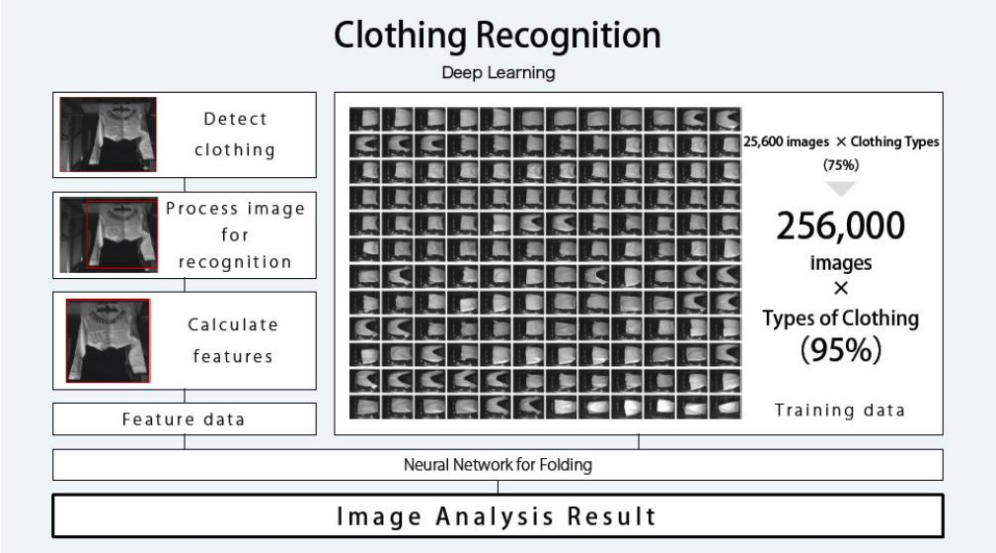


Figure 17. Laundroid AI in Japan.

Each clothing item is subjected to analysis to deliver the information to the robot arms, but the machine classifies all the items in various ways based on their type, size and color data. At this point, the machine's application, Companion App, tracks all the clothes analyzed by Laundroid to let the user itemize or sort them out according to the family members. Once dried, clothes are put into the machine, the entire automatic process of recognizing them with a camera and then folding/itemizing them afterward is a representative feature of Laundroid, the world's first 'clothes folding robot'. Amid the recent rapid mechanization of housework, Laundroid is expected to allow its users to have more relaxing and free time, at least liberating them from some of tiresome laundry works.

6. Conclusions

This research aims to set the size of a customer who doesn't have knowledge of clothing easily by the input of height and weight and recommend clothing while shopping. The method is simply calculating the minimum deviation by comparing the precise measurements of the customer with the measurements of ready-made products. Most clothing shopping malls indicate size of clothing, but it is not sufficient to be used by customers who do not have much knowledge of clothing.

Therefore, the seller of clothing at a shopping mall can enter the tags in the shopping mall size coding system immediately and recommend the most appropriate size of ready-made clothing product to the customer through automatic comparison by the system. The length values are calculated automatically by the height value put in by the customer, and the girth values can be calculated by the clothing size made with the proportion of height and weight. The length and girth data per size and the data of appropriate size per height and weight are saved in advance, and then the data of the least deviance from the values entered by the customer is brought out. Such data entered by customers is expected to be used for the study of classification of human body by converting it into saved data regularly. It can be also used for production of clothing by showing precise measurements when personal customization service is attempted. To develop a data-based clothes size recommendation system, it is important to select a suitable dataset to be used and process it in a proper form. Considering the largest population of China, their data were used in view of the data's standard deviation.

However, the standard data provided by some countries, including China is the product of about ten years ago, it is necessary to accumulate a new data and perform analysis on it for utilization. Additionally, the similar system will be constructed based on the clothing size data rather than the Chinese standard data in the future.

In this study, data of relatively accurate size recommendation function in the future, it is expected that more various body data will be secured and can be utilized for men and women children's clothing. Furthermore, it is technically necessary to expand the use of the technology by studying the methodology of adding the body type selection items and performing data classification work by body type. The size saving function of this service system is expected to extend to a service where the fitted wears can be immediately produced based on the customer data pertaining to the six items.

Meanwhile, one of the other problems was that the GB/T data were outdated, making it unsuitable for current recommendations and clearly producing some deviations. It is important to find a good and sized body data that can replace GB/T before verifying the recommendation system with more actual measurement samples. As for Table 6, Table 7, Table 8, Table 9, the number of body datasets that can be extracted by the system increases as two kinds of datasets (i.e., a dataset of the shoulder width, arm length, and slacks length in accordance with one's height and another dataset of chest, waist, and hip sizes proportional to one's height and weight) matches differently depending on the circumstances. For this data, a more segmented size table proportional to one's height and weight was prepared after considering the Chinese standard body sizes (GB/T-based) and the Chinese standard clothing sizes. This size table is different from those that can be seen at the clothing sales shopping malls, but it is useful for the apparel study that aims to study human bodies. Research that targets the customers in several other countries will be performed in the follow-up study.

7. Discussion

This study utilized the GB/T data for clothing size recommendations by inferring the right size for people with different heights and weights based. It was regrettable that only 14 test subjects were involved in the comparison test using actual size measurements due to the limited budget. Nonetheless, it was possible to recognize without more actual measurement data that the system needed further segmentation as they were some deviations between the sizes recommended by the system and the sizes measured. This might have been the result of non-upgraded GB/T data that created some gap between past and current standard body types. This problem can be dealt with the size data measured manually or the that which is inputted through an image scanning function. When these data are accumulated and become data, a more accurate size can be recommended just based on the height and weight in the future without taking actual measurements. This system will be applied to the clothing shopping malls where the consumers will see an additional 'size recommendation' button alongside with 'product', 'size selection', style selection, 'shopping cart', and 'payment' buttons.

Meanwhile, although it is just a visual addition, the existing actual measurement data stored in the system and the new size data recommended to the customers by the same system will be accumulated and shared by the collaborating companies around the world easily facilitating a borderless online clothing recommendation service. However, as every country's physical characteristics vary and it is not easy to collect enough target measurement data, we are considering utilizing each country's standard body size data as a criteria. For example, GB/T for China, NF G 03 003 for France, JIS L4004 for Japan and KS 0050 for Korea, along with additional recommendation categories possible for each of them. We expect that a more accurate recommendation can be made in the future with these standards and the actual measurements that will keep accumulating.

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