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Enhancing Clothing Fit for Asian Women through Digital Transformation and Statistical Analysis

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Abstract

This study focuses on designing a solution to the perennial issue of clothing fit in Fashion Industry using tools offered by digital technology and statistical analysis, in particular, the data gathered on Asian women (Bangladeshi and Chinese). The study reveals that managing information can significantly enhance the capability of the industry to cater to the needs of its consumers and increase diversity. It centers on the effectiveness of turning dressmaking patterns into digital ones, thus transecting from traditional cutting and stitching to remote techniques. This entails the requirement to have correct self-measures and probable errors, which can arise in the process. Thus, with the help of regression analysis, the study identifies, which measurements are incorrect and influence the fit of the clothes, and, therefore, digital pattern creation is more accurate. Altogether, it can be observed how digitalization and statistical methods are crucial to transforming the way clothes are created to approach an ideal standard of measurements that fulfill every customer's needs to make operational and efficient the clothing sector.

Keywords

Digital Pattern Creation, Statistical Analysis, Clothing Fit, Garment Customization, Apparel Industry Innovation

1. Introduction

The garment industry has been quite sensitive on its sizing of the garments it produces both in Asian and Western countries [1]. Some technological developments were made and many investigations and studies were conducted to arrive at the right measurements to meet the customers' demands. The garment production industry advanced to the next level through three-dimensional body scanning, which includes accurate measurements of body size and fit for clothes in the body with high levels of precision.

Additionally, the majority of the Asian industries are still limited to the internationally standardized sizes and as a result, such sizes bring about serious sizing discrepancies and disappointments to the customers [2]. This paper shall seek to understand why the issue of garment fit remains a problem that still requires solution for Asian women. Also very important are the issues and semiotic dislocation that arise during that transition from cutting and sewing to the making of patterns with the aid of a computer. It is characterized by equal substance, which includes the problem of identifying algorithms that make it possible to eliminate some basic pattern construction and stock modelling operations in a computer-understandable fashion. It takes professional stylists who take body measurements for clothes making, drafting of garments' patterns according to the specifications given, and cutting specific fabric parts for the desired garments and fitting the almost completed garments until the last details of finishing the clothes are completed. However, should we increase the digital technologies imaging, there shall arise a different problem. And it is this one of remote realization of single items when extremely specific-fit garments are developed in virtual space and then oriented factories will manufacture those using digital templates. This shift means that activities like measurement taking and construction of patterns ought to be feasible using the digital tool while the physical manufacturing can be procured. As the conations cannot be made to establish physical fittings that can be done, there is the added pressure felt in making right fittings in patterns and placing data for feeding to the computer.

Based on the facts and the information for this research, over 30 patterns have been created for more than two hundred and fifty clients and their clothing models. Such types of work also comprise the calculation of all elements of the pattern and also the outline of each design incorporating measurement instruments as well as computer fittings, thus it can be proved how parts of the human body ratios relate to each other. This non-variability allows assuring control of the quality of the newly introduced data using the models and the customary metrics that were previously created, as well as control of program changes, which do not lead to significant changes in the tested models within the bounds of regression testing.

As such, the purpose of this study is to understand and address these crucial shortcomings in order to bring greater effectiveness and accuracy in arriving at an appropriate 2D custom-made garment/3D apparel pattern in a modern I.C.T environment, and also to try and resolve the problem of garment fit for Asian women which has eluded satisfactory rectification for quite some time now. The significance of the findings would lead to a remarkable positive contribution to the apparel industry and would enhance the clothing design as well as the understanding of the customer.

2. Problem Statement

Measurement issues, especially concerning Asian women's body measurements currently and, have contributed to the already existing sizing bias and poorly fitting clothes [3]. Asian women suffer from various critical points that greatly reduce the garment quality and the customers' satisfaction. First amongst them is the problem of measurement inaccuracies, as originating from the manual measurement technologies as well as from the modern 3D body scanning techniques, which are very common for customers. The problem is especially more serious among Asian women who are not within the body size measurement international standards. Moreover, the absence of a universal guideline on how to take measurements further compounds these problems because it causes variation in the size pattern design and garment making. It puts the variation in construction of the body-dress pattern system, and this is more critical as the closer the attention within plus correlates, the tighter or looser the dress can be in many areas.

These points culminate in a systemic failure in understanding the diverse body types and proportions of Asian women, resulting in multiple fit problems. Its effects are broader, affecting not only the comfort and fashion of consumers but also increasing the level of returns and alterations rates, which in turn affect the sustainability and profitability of the fashion business. In addition, the difficulty of obtaining properly fitting clothes can be detrimental to the selves of Asian women by having an adverse effect on their body image and self-confidence. The state of affairs demands a solution that is able to capture and explain the intricate features of Asian women's bodies. In order to solve these problem points, the solution adopted a multi-headed approach combining digital transformation and advanced statistical analysis. The solution involves the digitization of dressmaking patterns with the aim of changing the old-fashioned cutting and stitching processes to more accurate, data-oriented processes. Statistical techniques, including regression analysis and measurement of pattern pictures area and perimeter, which are derived from the real body dimension measurements can also do a lot of corrections and enhance the waist of the apparel sector in this particular clothing apparatus. The utilization of regression analysis works to modify any possible discrepancies that might result from measurement by postulating the method. This data-driven procedure, as illustrated by the examination of several important body measurement ratios and their relationships, could change the clothing fitting paradigm for Asian women in a positive way. To address the issues of measurement error, uncontrolled pattern variation and pattern making, the offered solution elucidates the opportunity of satisfaction in who wears a good garment by addressing the critical issue of ineffective delivery of properly fitted clothes for the Asian female populace by developing a more holistic scientific and statistically better approach to garment designing and manufacture.

These analytical approaches also help the apparel industry to improve on fitting solutions to problems, thereby enhancing the market to be more productive and fruitful than before.

3. Experimental Design and Data Set

The dataset for this research consisted of records of 500 Asian women using both 3D body scanning technology and manual measurements [4], each from Bangladesh and China, with an age range of 18 - 45 years. This sample consists mostly of students, but some academic professionals also participated in the survey. These measurements were analyzed using computer algorithms and statistical methods to understand the relationships between various body measurements and garment dimensions. The shape of fabric contours was made over all the cut lengths by computing the areas and perimeters of the respective parts or panels of the garment patterns, rendering accurate cuts even in the digital models through CLO3D software. The patterns were likewise used for the cutting of mainly the corresponding portions of fabric, which very nearly completed the garment aside from any remaining detail finishing methods. This composition helps to understand the variations in body composition among Bangladeshi and Chinese women who are genetically and culturally predisposed to possess different body types in terms of both height and volume. The equal representation of population from both countries records distinct Asian populations with different backgrounds, which is also important to the variability of clothing fit requirements in Asia. This study utilizes a parameter on the customer comprising both the 3D scanning machine and the process of manual measurement as well.

During the research of the project, more than 250 clothing pattern measurements were made out of the 500-sample size and full body pattern measurements of 30 were taken out of 30 patterns that were drawn with manual drafting 15 and virtual drafting of 15.

In this case, taking the measurements of any customer is of importance, so that the foam clothing model of that fit can actually fit. Further, it was discovered that there are no less than thirty-nine fundamentals body measurements of women's adjustment that are very important features in creation of different cuttings of pants, skirts, jackets, dresses, and coats among others. Especially, when designing the try-on dress patterns, especially for Misses' and Women's Tops clothing patterns, 30 different measurements were included.

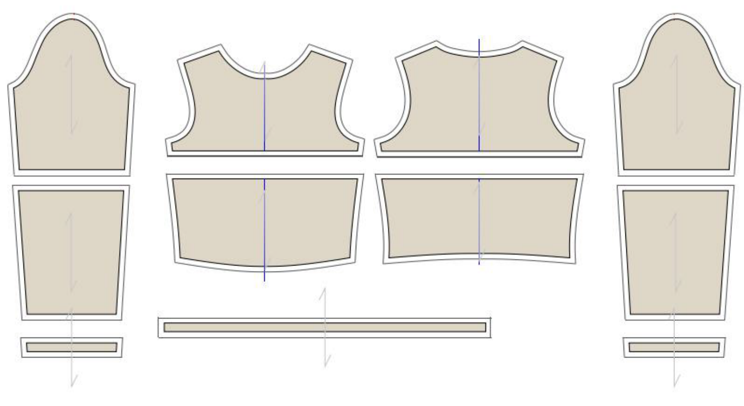

Figure 1. Pieces of the misses' and women's top pattern.

Table 1. Measurement table with initials.

Measurements	
Code	Name
BH	Body Height
BC	Bust Circumference
HC	Hip Circumference
NC	Neck Circumference
FLF	Full Length Front
WA	Waist to Ankle
SL	Sleeve Length
AS	Across Shoulder
BS	Bust Span
FC	Forearm Circumference
AC	Abdomen Circumference
ACT	Across Chest
WA	Waist Arc
BC	Biceps Circumference
Etc.	39 in total

Each specific clothing model requires a certain set of measurements. For example, to create basic body patterns that do not require measurements such as hip or abdomen circumference, but they do require bust and neck measurements, among others. Not necessarily do all the 39 measurements have to be taken in order to produce a single piece of clothing. Each clothing pattern consists of multiple pieces based on the style of the clothing.

Within the scope of the study, the Misses' and Women's basic bodice clothing pattern was chosen, which consists of 5 pieces (**Figure 1**) and utilizes 25 measurements [5]: BH, BC, HC, NC, FLF, WA, SL, AS, BS, FC, AC, ACT, WA, and BC (**Table 1**).

4. Analysis

4.1. Regression Analysis of Asian Measurement Chart

This particular study focuses on linear regression relationship of the body measurement data of Asian women is determined [6]. This data set contains bust, waist and hip circumferences, height, and shoulder slopes of measurements from Asian women. In the analysis of these relations using Coherency, rather high coefficients of concordance values were achieved, for instance, in a two-tailed test wherein FS Shoulder Slope and BS Shoulder Slope were also observed to be correlated up to 0.9999, which is termed as "Almost Perfect" with regards to correlation. Several more striking results were, for example, Hip Arc Back and Hip Circumference correlation being equal to 0.9604, Waist Arc Back Ear Buried and Waist relationship equal to 0.9599.

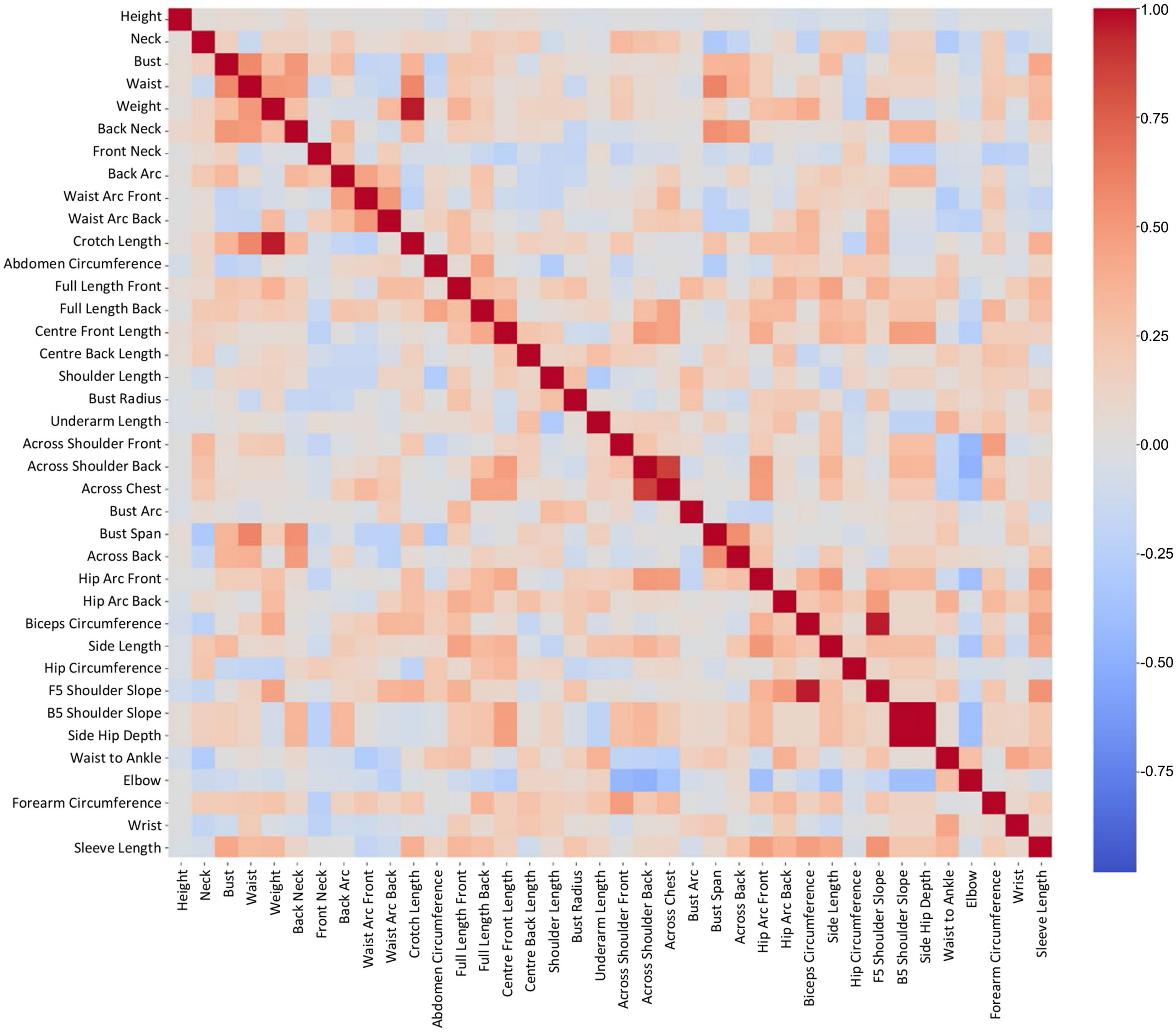

Figure 2. Correlation heat map of all numerical measurements.

This heat matrix (**Figure 2**) shows the relationship between every value in the dataset. The magnitude of the relationship of two variables is represented by the intensity of red color, where direction is used quite selectively and blue ontologically represents negative relationships.

This heat matrix (**Figure 2**) depicts the association of all data in the data points of multivariate analysis. The degree of association between 2 variables (**Table 2**) is measured by the color intensity of red, selective of the direction in which negative associations are in the blue. As such, a linear regression model that utilized all the various features to predict the bust size was able to give an R-squared of 0.9326 together with leaned mean square error of 2.8532. The model successfully defined four significant contributing features, *i.e.* FS Shoulder Slope, BS Shoulder Slope, Waist Arc Back and Waist. However, a little lower accuracy in making this selection R-square 0.4929 and MSE 21.4711, which demonstrates that some other systematic way is more suitable for making a prediction of the aforementioned dependent variable in this case.

Table 2. Top 10 highest correlations in the dataset.

Correlation		
FS Shoulder Slope	BS Shoulder Slope	0.999991253
BS Shoulder Slope	FS Shoulder Slope	0.999991253
Hip Arc Back	Hip Circumference	0.960429652
Hip Circumference	Hip Arc Back	0.960429652
Waist Arc Back	Waist	0.959891313
Waist	Waist Arc Back	0.959891313
Across Shoulder Front	Across Shoulder Back	0.861203071
Across Shoulder Back	Across Shoulder Front	0.861203071
Bust Arc	Bust	0.595458678
Bust	Bust Arc	0.595458678

The regression equation for predicting bust size using FS Shoulder Slope is expressed as:

$$\text{Bust} = 0.2745 \times \text{FS Shoulder Slope} + 75.7522.$$

Stating that for each unit change in FS shoulder slope, there is an expectation of a bust size increase of around 0.2745. There was a moderate level of prediction for bust size based on the actual vs. predicted scatter diagrams (**Figure 3**), as illustrated by the coefficients of 0.7210, with the average absolute actual vs. predicted difference being 3.8901 units; almost 58.00% of the overall prediction was accurate to within 5% of the actual value. Even when dataset quality and within-measure consistency across observers is rather high—especially regarding the essential measurements—the "suspicion" of deviations from the expected norms remains and justifies one point: the need to know the sampled population represented.

The regression equation for predicting bust size using FS Shoulder Slope is expressed as:

$$\text{Bust} = 0.2745 \times \text{FS Shoulder Slope} + 75.7522.$$

The distribution checks, shown in box plots and statistics (**Figure 4**), showed that normal ranges could be attributed to most of the measurements with Height varying from 155.49 to 173.51 cm with a mean value of 164.78. The Outlier analysis of critical parameters using the IQR method highlighted, there are no outliers in Height, Bust, Waist, and Hip Circumference. The IQR has also been useful, particularly in reassuring the absence of outliers in critical measurements such as Height Bust waist and hip circumference and with reasonable ranges and tempered distributions indicating that the dataset is perfect with regards to this key variable and positively impacts on the overall quality and consistency of the dataset. The validity of the dataset was further proven by consistency checking using body measurement ratios (Waist-to-Hip, Bust-to-Height and Waist-to-Height), which evinced non-extreme and consistent distributions.

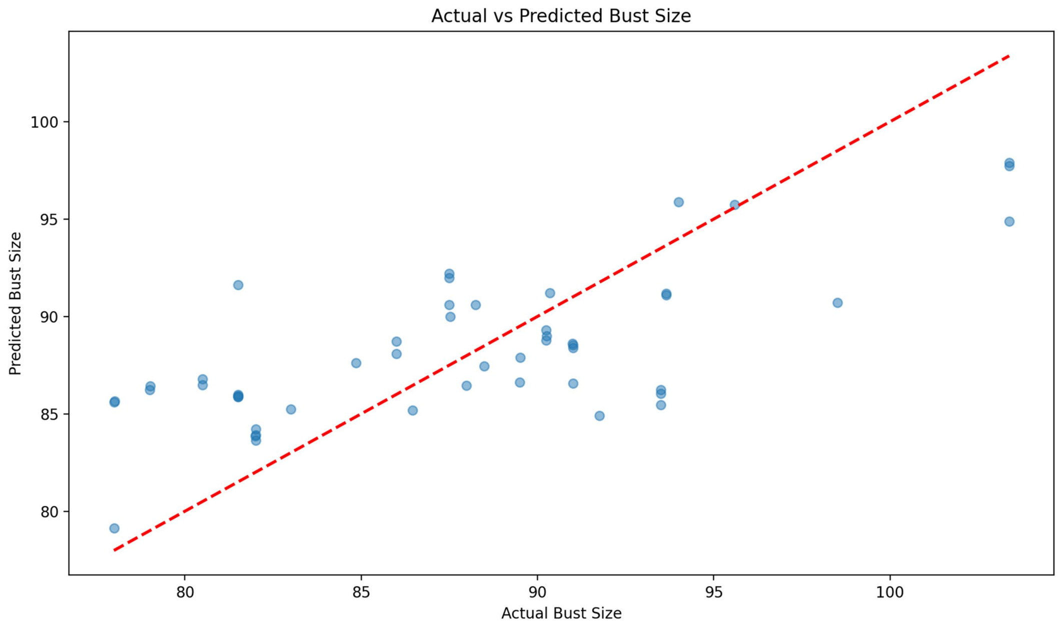

Figure 3. Bust size prediction results.

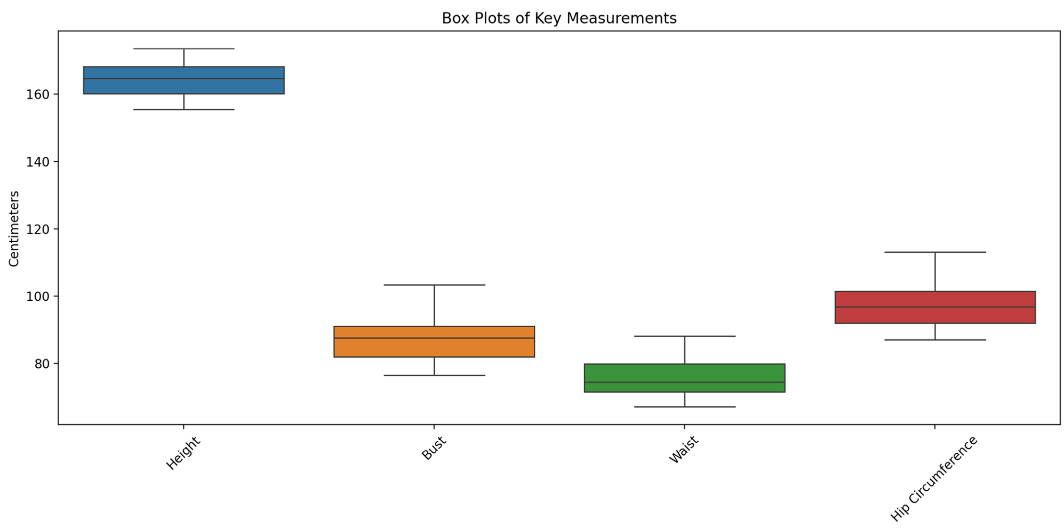

Figure 4. Box plot of key measurements.

4.2. Image Analysis and Pattern Recognition

Calculating the perimeter and area of each individual panel is also important to issues of data verification in the apparel industry, as it consolidates a consistent and accurate measurement of the same across different panels. It is paramount analysis concerning quality control, pattern designing, and fit evaluation in the field of Textile. As a result of understanding the correlation between two parameters, perimeter and area, it is possible to infer certain structural properties of one or another piece of clothing, enabling its abnormality or disorganization to be exposed within the data collection. The dataset for the analysis consists of existent measurements for five parts of the garment, which are front bodice, back bodice, and sleeve having their unique perimeter and area dimensions. In order to show the relation of these two variables, scatter plots were prepared for each piece, which depicted a positive correlation and reasoning that larger pieces of garments tend to have greater perimeters and areas.

However, the scatter plots indicated large three-dimensional combinations; even in two-dimensional projections, each piece was marked and corresponding characteristic size ranges were noticed (**Figure 4**). It is observed from the scatter plots of front, back and sleeve pieces that there exists good intra dot area and bone perimeter correlation. The results for the front piece show strong linearity ($R^2 = 0.99$) with mean perimeter of far 253.56 cm and mean area of far 3434.66 cm^2. In like manner, the results for the back piece were strong ($R^2 = 0.99$) with a mean perimeter of (257.71 cm) and mean area of (3615.20 cm^2). The voter sleeve piece, however, is more strongly correlated with average perimeter 166.34 cm and average area 1497.34 cm^2 ($R^2 = 0.97$). These scatter plots clearly depict a tendency where the tendency of the area of the piece increases proportionally with the increase in perimeter. The arrangement of points along a line for each plot indicates that the data for the particular plot was calculated sufficiently with respect to the dataset and no major outliers were present.

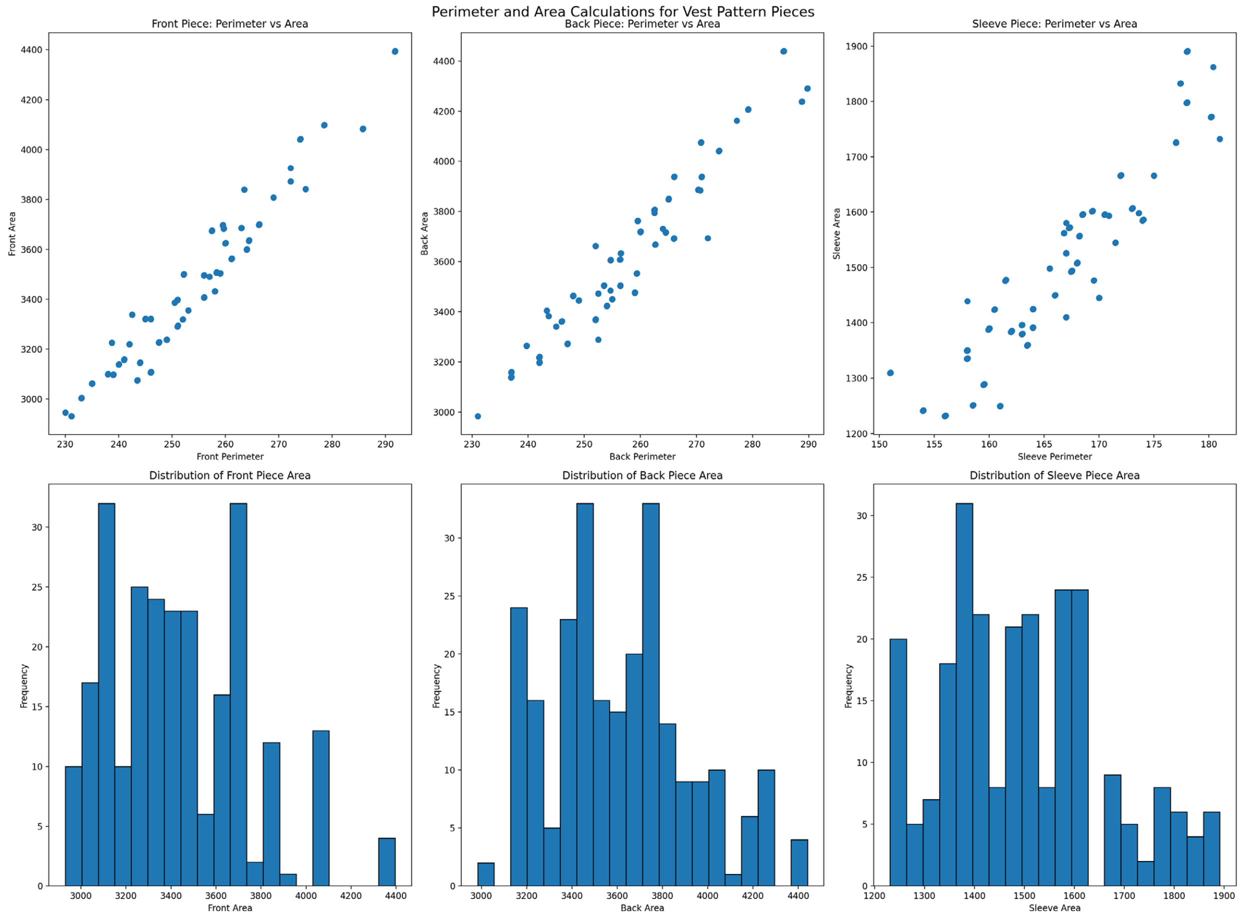

Figure 5. Scatter plots and seaborne pair plots for the perimeter and area calculations.

To provide a comprehensive view of data distribution and correlations among all garment pieces, a Seaborne pair plot was generated. These visualizations were generated using Python's Seaborn and Matplotlib libraries, which are industry-standard data visualization tools for creating statistical graphics and plots. This visualization confirmed the positive correlation between perimeter and area, forming distinct clusters for each piece (Figure 5). Additionally, Table 3 containing area and perimeter measurements for 6 different individuals in pixels demonstrates a logical size progression among the garment pieces: Piece 2 (Front bodice) is the largest with an average area of 5475 px^2 and perimeter of 278.83 px, Piece 3 (Back bodice) is slightly smaller (5175 px^2 and 258.83 px).

Table 3. Area and perimeter measurements for 6 different individuals.

Customer		Individual 1	Individual 2	Individual 3	Individual 4	Individual 5	Individual 6
Piece 1	Area (px)	5200	5100	5000	4950	4800	4800
	Perimeter (px)	260	255	250	248	240	240
Piece 2	Area (px)	5800	5700	5600	5550	5400	5400
	Perimeter (px)	290	285	280	278	270	270
Piece 3	Area (px)	5400	5300	5200	5150	5000	5000
	Perimeter (px)	270	265	260	258	250	250
Piece 4	Area (px)	5200	5100	5000	4950	4800	4800
	Perimeter (px)	260	255	250	248	240	240
Piece 5	Area (px)	4700	4600	4500	4450	4300	4300
	Perimeter (px)	235	230	225	223	215	215

Then, Pieces 1 and 4 (Sleeve) (4975 px^2 and 248.83 px), with Piece 5 (piping) being the smallest (4475 px^2 and 223 px). Even the correlation between the average area and the average perimeter is extremely high at a value of 0.9975 showing almost perfect proportional scaling between the various sizes. These data present a very good baseline for further studies and development in areas of pattern grading, fitting adjustments and the design of garments, facilitating improvement in fitting a diverse range of body types in the fashion market.

5. Future Directions and Potential Impact

Computational aid in design pattern generation and fit optimization for Asian women becomes adaptive in the perspective of future development within the fashion industry [7]. As there are some statistics and new technologies used in this study, many ideas for developing research and work in the area appear. One such direction is improving the measurement means designed, especially for the Asian female body structures. The studies stress on thinking "out of the box" indicates some exceptional problems that need to be solved in relation to this inclusive group. An interesting recommendation for future studies concerns the availability of more sophisticated technology, such as 3D imaging or analytical systems that could employ advanced image processing algorithms to decipher underlying body structures. The remarkable outcomes were also obtained with the use of a regression analysis model with R-squared equal to 0.9326 predicting bust size, which endorses data-based methods. Achieving this level of success sets the stage for the formulation of more sophisticated prediction models that can be used to change the face of pattern-making. Although the research used a dataset of 250 patterns, which involved 15 individuals, it would be appropriate more patterns in subsequent studies. A bigger and more heterogeneous dataset would make these processes more statistically powerful and could provide deeper integration between body measurement aspects.

The potential impact of this research on the apparel industry is substantial [8]. By enhancing the accuracy of measurements and pattern design, it could lead to a marked improvement in customer satisfaction [9]. This eventually results in a decrease in the number of returns due to poor fit. This is particularly crucial in the growing online retail sector, where customers cannot try on garments before purchase.

6. Conclusion

This research in clothing design has taken a step further to solve the problem of clothing fit for Asian women by employing information technology and statistical methods [10]. The study has also shown that there can be more precision in production of garments by switching from manual tailoring to digital pattern making. The regression analysis for finding the errors committed in measurements and correcting them has worked out since for bust size, R-squared was as high as 0.9326. This also demonstrates the reliability of the dataset used and the statistical models fitted. The use of imagery and the patterns showed the direction of shift from textile to image processing. Geometric parameters of garments have provided the basis for optimization of the accuracy of data support of the design processes and their quality control and fit problem-solving. Such progress implies not only the proceeds of pattern-making process, but also the quality and uniqueness of garment making. This study has advanced our understanding of some of the constraints in clothing design, particularly for Asian women. By making use of technology and statistics, it has opened doors to greater efficiency, accuracy, and inclusivity in garment manufacturing. The findings and methodologies presented here offer valuable insights into future research and hold promise for transforming the fashion industry.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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