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ABSTRACT:
In the present work, tools are proposed to predict the opinion of consumers about decorative elements. The proposed models are based on the relationship between elements color and shape. Color and geometric features of these elements are selected. Feature vectors are selected. The data from these vectors are reduced by principal components and latent variables. An analytical model is proposed, which describes 96% of the change in consumer desire. It has been proven that the use of numerical data on the color and shape of decorative elements for textiles, as well as their joint use has the potential to improve the prediction power of consumer demand. The obtained results would help to better illustrate the presented materials and the consistency in the design of textile fabrics and in general will support the specialized training of specialists in the field of fabric design.

Key words: Modern textile products, Decoration technology, Re-evaluation textile decoration, Application

1. Introduction
Creative practice is presented as a result of research work or the application of theoretical knowledge in a specific production environment (Niedderer et al., 2007). As a creative practice based on research, we can mention the analysis of the relationship between colors and shapes, in the development of new textile designs and analysis of consumer demand (Sliburyte & Skeryte, 2014). Color occupies an important place in the design of textile fabrics, as it is a key element in the formation of decorations that are printed, woven, embroidered on them. Apart from the technical issues of the application of color to decorative motifs, color theory is one of the elements that connects textiles with art (Stamou, 2022). Color analysis can be done both descriptively and quantitatively. In this way, the hue, brightness and saturation of the color can be presented, as well as its visualization in a color wheel. The mathematical description of the shape of the decorative elements visualized on the textile fabric is applied in their automated analysis. The contour of the decorative element, obtained with a system for processing and analyzing of images, determines: area, perimeter, large and small diameter, different coefficients: shape, eccentricity, density. The shape of the graphic objects on the textile fabric is an important feature in the setting of the machines for their production, by printing, embroidery, weaving.
According to designers, architects and theorists, shape, function and color are interrelated (Kazlacheva, 2014; Indrie et al., 2019). This type of research was conducted by Georgieva (2017). The author presents results on the relationship between colors and shapes of elements of Bulgarian folklore costumes. The main disadvantage of her research is that she does not offer a model for forecasting consumer demand. Also, the study covers only one ethnographic area in Bulgaria.

The use of numerical data on the color and shape of decorative elements for textiles, as well as their joint use has the potential to improve the forecasting of consumer demand. Mladenov (2020) proposes a method for sharing data on the color and shape of objects. By combining data from different sources, the predictive power of the models proposed by him is increased. The application of such methods has the potential to provide a solid basis for the further development of research in the field of art and design (Secan et al., 2012; Stoykova, 2015; Kazlacheva, 2017).

In most cases, color is the first sign that the consumer of textile fabrics and clothing makes his choice. Next is their form (Elnashar & Boneva, 2016). Thereof. On the other hand, the results of such a study will increase the opportunities for creative use of the data obtained. The richness and tangibility of such data can have a variety of applications in areas such as art, design, culture and textile production.

### 2. Material and methods

In the present work, data from consumer opinion polls for decorative elements are used. These elements are decorations on costumes, geometric shapes, curves created by mathematical dependencies. They are colored with the colors typical for the costumes, as well as with those that are relevant for the year in which the survey was conducted. The surveys are for 250 elements. A total of 632 respondents took part in them. Respondents were selected regardless of their gender, education, place of work. All respondents are familiar with the purpose and what the survey data will be used for. Table 1 lists the publications from which data on decorative elements are used. The arrangement is according to the participating authors, year of publication, magazine or conference in which they are presented. It is also indicated and the title of the respective publication.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Journal/Conference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boneva et al.</td>
<td>2017</td>
<td>Online magazine for textiles, clothing, leather and technology, 1, 2-5</td>
<td>Transfer of computer generated forms to the contemporary textile</td>
</tr>
<tr>
<td>Elnashar et al.</td>
<td>2017</td>
<td>Innovation and entrepreneurship, 5, 2, 78-88</td>
<td>Bulgarian national folk elements for the contemporary fashion</td>
</tr>
<tr>
<td>Elnashar et al.</td>
<td>2017</td>
<td>Innovation and entrepreneurship, 5, 3, 127-137</td>
<td>Transfer of colors from traditional costume to modern textiles</td>
</tr>
<tr>
<td>Boneva et al.</td>
<td>2018</td>
<td>Online magazine for Textiles Clothing, Leather and Technology, 1, 4-8</td>
<td>Adaptation of folklore motifs to contemporary textile,</td>
</tr>
<tr>
<td>Indrie et al.</td>
<td>2019</td>
<td>Annals of the university of Oradea fascicle of textiles, leathernwork, 20, 1, 125-130</td>
<td>Analysis on colors of folk costume and their application in contemporary textile design</td>
</tr>
<tr>
<td>Indrie et al.</td>
<td>2020</td>
<td>Annals of the university of Oradea fascicle of textiles, leathernwork, 21, 1, 41-46</td>
<td>Nature-inspired colors and shapes in clothing design</td>
</tr>
</tbody>
</table>

The color and shape of the decorative elements is an indicator by which the consumer would accept or reject a product. Therefore, the present study focuses on the development and research of effective approaches, including descriptions, models and tools for determining consumer opinion on decorative elements based on features of color and shape, as well as combinations thereof. The indices of yellow, white and brown, as well as those according to the formulas summarized in the available literature, have been determined (Ghodke et al., 2007; Pathare et al., 2013). The form coefficients were calculated according to (Elnashar & Boneva, 2016). Table 2 shows the mathematical dependences on which the features describing the decorative elements are calculated. The
calculations used: $L$, $a$ and $b$ color components of the Lab model; $C$ and $h$ of LCh; $P$ – perimeter of the element; $A$ – area; $d$ – small axis; $D$ – large axis; $K_o$ – orientation; $A_1$ – ideal area; $A_{MR}$ – area of a minimum rectangle.

Table 2. Features for describing decorative elements

Table 3 shows the mean and standard deviation of the features used to describe the decorative elements. Five groups were made, which correspond to the percentage of respondents who liked elements described by the values of their respective traits. Up to 10% are Strongly dislike; up to 25% Dislike; up to 40% Neither like nor dislike; up to 60% Like; up to 100% Strongly like. As can be seen from the table, in some of the features the scattering of data around their average value is minimal (C1, C2, C3, C4), and in others it is significant (C19, K4).

The selection of informative features is made by methods of consistently improving assessments (Mladenov, 2020), which significantly reduce the number of resulting combinations of traits. The FSRNCA, Relieff and SFCPP methods were used. They are suitable for the selection of signs for prediction by regression methods.

Method for selection of regression features by analysis of neighbor components, FSRNCA. The weight coefficients of the characteristics are determined by diagonal adaptation of the method of analysis of the adjacent components. A method for selecting significant predictors, Relieff. This algorithm is suitable for assessing the significance of characteristics for distance-based models.

Method of subsample of features with comparable predictive power SFCPP. Through this method, an optimal set of features is found that differ from each other and can effectively represent the objects being compared. Those features that have weight coefficients above 0,6 and

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C9</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>G</td>
<td>B</td>
<td>L</td>
<td>a</td>
<td>b</td>
<td>C</td>
<td>h</td>
<td>112.86b</td>
</tr>
<tr>
<td>C10</td>
<td>C11</td>
<td>C12</td>
<td>C13</td>
<td>C14</td>
<td>C15</td>
<td>C16</td>
<td>C17</td>
<td>C18</td>
</tr>
</tbody>
</table>

### Table 3. Summarized results of surveys

<table>
<thead>
<tr>
<th>Emoticon</th>
<th>Percentage Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10%</td>
</tr>
<tr>
<td></td>
<td>11-25%</td>
</tr>
<tr>
<td></td>
<td>26-40%</td>
</tr>
<tr>
<td></td>
<td>41-60%</td>
</tr>
<tr>
<td></td>
<td>61-100%</td>
</tr>
<tr>
<td>Decision</td>
<td>Strongly dislike</td>
</tr>
<tr>
<td></td>
<td>Dislike</td>
</tr>
<tr>
<td></td>
<td>Neither like nor dislike</td>
</tr>
<tr>
<td></td>
<td>Like</td>
</tr>
<tr>
<td></td>
<td>Strongly like</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>0-10%</th>
<th>11-25%</th>
<th>26-40%</th>
<th>41-60%</th>
<th>61-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>247.52</td>
<td>245.32</td>
<td>178.75</td>
<td>183.27</td>
<td>187.74</td>
</tr>
<tr>
<td>C3</td>
<td>187.66</td>
<td>187.66</td>
<td>178.75</td>
<td>183.27</td>
<td>187.74</td>
</tr>
<tr>
<td>C4</td>
<td>74.56</td>
<td>74.56</td>
<td>74.56</td>
<td>74.56</td>
<td>74.56</td>
</tr>
<tr>
<td>C5</td>
<td>2000a</td>
<td>2000a</td>
<td>2000a</td>
<td>2000a</td>
<td>2000a</td>
</tr>
<tr>
<td>C6</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
</tr>
<tr>
<td>C7</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
</tr>
<tr>
<td>C8</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
</tr>
<tr>
<td>C9</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
<td>1000a</td>
</tr>
</tbody>
</table>

The selection of informative features is made by methods of consistently improving assessments (Mladenov, 2020), which significantly reduce the number of resulting combinations of traits. The FSRNCA, Relieff and SFCPP methods were used. They are suitable for the selection of signs for prediction by regression methods. A method for selecting significant predictors, Relieff. This algorithm is suitable for assessing the significance of characteristics for distance-based models. Method of subsample of features with comparable predictive power SFCPP. Through this method, an optimal set of features is found that differ from each other and can effectively represent the objects being compared. Those features that have weight coefficients above 0,6 and
calculated by the respective method, have been selected. The principal components (PC), obtained by Principal component analysis and Latent Variables (LV) values, obtained by the method of partial regression of least squares, were used to reduce the data volume of the feature vectors. The task of the analysis of the principal components is to separate the variables that are linear combinations of orthogonal variables and are not correlated. Latent variables summarize the influence of actually observed features in a sample (Lazarov, 2012). One way to predict consumer opinion is based on predictive models. Regression prediction models of the type $Z=f(X,Y)$ make it possible to determine the value of a characteristic at any point in time, including future moments. A baseline model was used to describe the relationship between selected characteristics of the type:

$$z = b_3 + b_1x + b_2y + b_3x^2 + b_4xy + b_5y^2 \quad (1)$$

In this equation, $z$ is a dependent variable, $x$ and $y$ are independent variables, $b$ are the coefficients of the model. The accuracy of the predictive models was evaluated on the basis of statistical parameters such as coefficient of determination ($R^2$), coefficients of the model, their standard error (SE), t-statistics (tStat), p-value. Non-informative coefficients are rejected by the model. A residue analysis was performed. The online tool “Critical F-value Calculator” (https://www.danielsoper.com) was used to determine the critical values of “F”. The Student T-Value Calculator (https://goodcalculators.com) was used to determine the critical values of “t”.

All data were processed at a level of significance $\alpha=0,05$. Matlab 2017b software product (The mathworks Inc., Natick, MA, USA) and Stat Soft Statistica 12 (TIBCO Software Inc., Palo Alto, CA, USA) were used to process the experimental data. The Matlab software system is used to convert RGB to Lab and LCh color models. Also when calculating the color and geometric indices of decorative elements. Feature selection methods as well as data volume reduction methods are used in this software system. The Statistica software package was used to compile and evaluate models for forecasting consumer opinion. Visualization of accessories and elements of interior design has been made. The tools of the online tool Design Lab (https://artofwhere.com) were used for this purpose.

3. Results and discussion

FSRNCA, RelieFf and SFCPP methods were used to determine the information value of color and geometric features, depending on user preferences. Figure 1 shows graphically the results of the selection of informative features. The three methods mentioned above were used for selection. A line is drawn indicating the value of 0,6 of the weighting factors. All signs that have a value of weighting factors above 0,6 are considered informative.

Table 4 shows the formed feature vectors. The smallest number of features, compared to other methods used, is in the vector FV1. It includes four colors and one feature describing the shape of the decorative elements. The FV2 feature vector contains a total of nine color and four shape features. It involves the R (RGB) color component, b (Lab), C and h (LCh) color components. The same four features describing the shape of the decorative elements are involved in the vector FV3. In addition, ten color features are selected in this vector, which contain only one color component b (Lab).

<table>
<thead>
<tr>
<th>Vector</th>
<th>Method for Selection</th>
<th>Selected signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FV1</td>
<td>FSRNCA</td>
<td>C8, C9, C11, C19, K4</td>
</tr>
<tr>
<td>FV2</td>
<td>RelieFf</td>
<td>C1, C5, C7, C8, C12, C14, C15, C18, C19, K2, K4, K5, K6</td>
</tr>
<tr>
<td>FV3</td>
<td>SFCPP</td>
<td>C5, C8, C9, C11, C12, C14, C15, C16, C18, C19, K2, K4, K5, K6</td>
</tr>
</tbody>
</table>
The data in the resulting feature vectors are reduced by principal components (PC) and latent variables (LV). From these reduced data, models are calculated that describe the relationship between consumer opinion (O) for decorative elements and PC and LV. Preliminary analysis has shown that using two principal components and two latent variables, more than 95% of the variance can be described in the data from the three feature vectors. Table 5 shows the results for the obtained model O=f(PC1,PC2). After removing the insignificant coefficients, F is less than Fcr(3,42)=2,827. At tcr(42)=±2,018 for the model coefficients, the low value of the coefficient of determination (R²=0,14) and the high values of the error SE=1,2 indicate that the model does not describe the experimental data with sufficient accuracy.

Table 5. Data for FV1 model reduced by PC

<table>
<thead>
<tr>
<th>Intercept</th>
<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(42)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>2,313</td>
<td>0,096</td>
<td>20,114</td>
<td>7,794</td>
<td>2,581</td>
<td>0,013</td>
</tr>
<tr>
<td>y</td>
<td>-0,745</td>
<td>0,359</td>
<td>-18,644</td>
<td>9,666</td>
<td>-2,079</td>
<td>0,044</td>
</tr>
<tr>
<td>x*y</td>
<td>-2,542</td>
<td>0,411</td>
<td>238,552</td>
<td>93,910</td>
<td>-2,540</td>
<td>0,015</td>
</tr>
</tbody>
</table>

Table 6 shows the results for the obtained model O=f(LV1,LV2). After removing the insignificant coefficients, F is greater than Fcr(4,41)=2,599. At tcr(41)=±2,019 for the coefficients of the model, the high value of the coefficient of determination (R²=0,94) and the low values of the error SE=0,3 indicate that the model describes with sufficient accuracy the experimental data.

Table 6. Data for FV1 model reduced by LV

<table>
<thead>
<tr>
<th>Intercept</th>
<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(42)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>2,362</td>
<td>0,193</td>
<td>20,208</td>
<td>1,652</td>
<td>12,236</td>
<td>0,000</td>
</tr>
<tr>
<td>y</td>
<td>0,482</td>
<td>0,081</td>
<td>4,125</td>
<td>0,686</td>
<td>6,938</td>
<td>0,000</td>
</tr>
<tr>
<td>x*y</td>
<td>-1,922</td>
<td>0,200</td>
<td>-18,888</td>
<td>1,968</td>
<td>-9,597</td>
<td>0,000</td>
</tr>
</tbody>
</table>

Table 7 shows the results for the obtained model O=f(LV1,LV2). After removing the insignificant coefficients, F is greater than Fcr(3,42)=2,827. At tcr(42)=±2,018 for the model coefficients, the low value of the coefficient of determination (R²=0,55) and the high values of the error SE=0,4 indicate that the model does not describe the experimental data with sufficient accuracy.

Table 7. Data for FV2 model reduced by PC

<table>
<thead>
<tr>
<th>Intercept</th>
<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(42)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>2,085</td>
<td>0,161</td>
<td>45,112</td>
<td>3,475</td>
<td>12,981</td>
<td>0,000</td>
</tr>
<tr>
<td>y</td>
<td>0,067</td>
<td>0,047</td>
<td>0,613</td>
<td>0,433</td>
<td>1,414</td>
<td>0,046</td>
</tr>
<tr>
<td>x*y</td>
<td>1,245</td>
<td>0,161</td>
<td>71,312</td>
<td>7,731</td>
<td>17,731</td>
<td>0,000</td>
</tr>
</tbody>
</table>

Table 8 shows the results for the obtained model O=f(LV1,LV2). After removing the insignificant coefficients, F is greater than Fcr(4,41)=2,599. At tcr(41)=±2,019 for the coefficients of the model, the high value of the coefficient of determination (R²=0,96) and the low values of the error SE=0,4 indicate that the model describes with sufficient accuracy the experimental data.

Table 8. Data for FV2 model reduced by LV

<table>
<thead>
<tr>
<th>Intercept</th>
<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(41)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>1,212</td>
<td>0,059</td>
<td>10,374</td>
<td>5,050</td>
<td>20,535</td>
<td>0,000</td>
</tr>
<tr>
<td>y</td>
<td>-0,192</td>
<td>0,060</td>
<td>-1,647</td>
<td>0,515</td>
<td>-3,197</td>
<td>0,003</td>
</tr>
<tr>
<td>x*y</td>
<td>0,508</td>
<td>0,058</td>
<td>14,133</td>
<td>1,626</td>
<td>8,693</td>
<td>0,000</td>
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<tr>
<td>y²</td>
<td>-0,147</td>
<td>0,060</td>
<td>-4,327</td>
<td>1,759</td>
<td>-2,460</td>
<td>0,018</td>
</tr>
</tbody>
</table>

Table 9 shows the results for the obtained model O=f(PC1,PC2). After removing the insignificant coefficients, F is greater than Fcr(3,42)=2,827. At tcr(42)=±2,018 for the model coefficients, the low value of the coefficient of determination (R²=0,56) and the high values of the error SE=0,73 indicate that the model does not describe the experimental data with sufficient accuracy.

Table 9. FV3 model data reduced by PC

<table>
<thead>
<tr>
<th>Intercept</th>
<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(42)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>-1,862</td>
<td>0,099</td>
<td>-26,789</td>
<td>1,446</td>
<td>-18,523</td>
<td>0,000</td>
</tr>
<tr>
<td>y</td>
<td>1,079</td>
<td>0,101</td>
<td>38,330</td>
<td>3,576</td>
<td>10,719</td>
<td>0,000</td>
</tr>
<tr>
<td>x*y</td>
<td>-0,041</td>
<td>0,039</td>
<td>-4,435</td>
<td>4,206</td>
<td>-1,033</td>
<td>0,477</td>
</tr>
</tbody>
</table>

Table 10 shows the results for the obtained model O=f(PC1,PC2). After removing the insignificant coefficients, F is greater than Fcr(4,41)=2,827. At tcr(41)=±2,018 for the model coefficients, the high value of the coefficient of determination (R²=0,87) and the low values of the error SE=0,46 indicate that the model describes with sufficient accuracy the experimental data.

Table 10. Data for FV3 model reduced by LV

<table>
<thead>
<tr>
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<th>b*</th>
<th>SE</th>
<th>b</th>
<th>SE</th>
<th>t(42)</th>
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Table 11 shows the results of this comparison of the obtained models. As can be seen from the table with the lowest values of the evaluation characteristics are the models obtained by the feature vector FV1, followed by the models by FV3. Regardless of the method used to reduce
the volume of data, the FV3 models have the highest values of the characteristics for their evaluation, compared to other compared models. This vector of features was used in compiling a model for predicting the opinion of consumers when choosing decorative elements.

<table>
<thead>
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<th>Table 11. Comparative analysis of the obtained models</th>
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The model for predicting consumer opinion about decorative elements has the form:

$$O = 2.562 + 10.374.LV_1^1 - 1.647.LV_2^1 + 14.133.LV_1^2 - 4.327.LV_2^2$$

(2)

The coefficients of the model are greater than 0.1.

Validation of the obtained model has been done. Data for decorative elements that did not participate in the compilation of the model were used. Elements of interior design are offered (Figure 3). Decorative elements were used, which have ratings of 4 and 5 by users. The first object is a pillow used green background and decorative elements with levels of this color. The repetition is half drop. The make-up bag object has green ribbons and floral motifs, with levels of this color. Gray bars have been added to the background. The bag variant has a dark blue background and green decorative elements in which minimalist light purple flowers are woven. The last object is a bed cover, which has mainly green and red elements located on top of each other. Below them is a much lighter background. In this way, the other elements involved in the design of this site stand out.

The results obtained in this work complement those presented in the available literature. The use of latent variables is an appropriate method for reducing the volume of data, as well as for predicting the opinion of users to choose or reject decorative elements. Ilieva et al. (2020) indicate that latent variables are appropriate for predicting consumer choice of costume items. These results are supplemented in the present work with decorations on costumes, geometric shapes, curves created by mathematical dependencies.

An example of application of decorative elements selected by consumers in interior design and accessories is proposed. In addition to the results reported by Kazlacheva (2017), online software tools for creating designs on textiles have been implemented. The proposed models can be considered relevant because the color green is preferred in the year of publication of this paper (View Sofia, 2022).

The joint use of data on the color and shape of decorative elements leads to an improvement in the predictive power of the created regression models, which confirms the results of Mladenov (2020).
4. Conclusion
Tools have been developed to predict the opinion of consumers about decorative elements. An analytical model has been created, which is based on a vector of features reduced by latent variables, containing color and geometric data for decorative elements. The model can be applied in predicting the choice of users of this type of decorations on textile fabrics. The proposed model describes 96% of the change in consumer desire.

It has been proven that the use of numerical data on the color and shape of decorative elements for textiles, as well as their joint use has the potential to improve the forecast of consumer demand. Consumers have been found to like decorative elements with high form factor values to be combined with related or contrasting colors. The combinations with the participation of red and yellow are not preferred by the users, and those with the participation of blue, green or colors from the blue and green range are preferred.

The made researches give main directions for application of mathematical models in the modern textile, there are different possibilities for their interpretation, according to the requirements of the consumers. The obtained results increase the knowledge about the relationship between colors and shapes and their importance for textile design. They would help to better illustrate the materials presented and the consistency in the design of textile fabrics and will generally support the specialized training of specialists in the field of fabric design.

Acknowledgements
The research in the present work is partially supported by the project 2.FTT/2020, on the topic: “Design and solutions for sustainable fashion”.

REFERENCES:


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Realistic Models

Anthropometric modelling and ergonomics for product designers to test their designs, models that are driven from the anthropometry play an important role. Timely detection of ergonomic deficiencies results in higher quality and prevents additional costs invoked by available corrections [1].

Size vs. Shape Arguably, anthropometric measurements allow the most complete control over the shape of the body but it would be almost impractical to provide all the measurements required to detail the model. Therefore it is not uncommon to use a subset of measurements. (we use 8 primary measurements to make 3D mannequin for the clothing application.) In such cases, the problem of estimating other measurements and determining appropriate shape of the full geometry need to be solved. To take an example, there exist infinite numbers of ways to determine the shape of a closed contour given its length constraint.

Until now, the shape has been dealt with as a passive constituent – the final body shape is a result of a series of deformation such that it satisfies the given measurement. At times, they have tried to keep as much as possible the shape of the template model.

We show how we exploit existing models to automatically derive realistic body shapes on the fly. Fast generation in various applications of anthropometric body modeling technique, one cannot assume the potential users are 3D artist who are familiar with graphics packages. If 3D body creation techniques are to be meaningful in this context, they must be able to produce correctly sized body models and be efficient enough to be used in an interactive runtime setting with minimum user intervention. Thus, one key challenge is how to hide the complexities of the human body and to efficiently transform the information to the manipulation of body geometry.

Research work on human body modeling, also included is a summary of anthropometry and its application in computer graphics. Our method is based on examples and we start in with a description of the database of 3D body scans that our synthesizers are built on. Because we want to represent the body geometry as a vector in the body space, the topology of all the body meshes in the example database should be identical. The procedures for preparing the example models are outlined in the same section. There exist two different types of synthesizers: modeling synthesizers that create new body geometries using body measurements as input parameters, and modifier synthesizer that manipulate existing models. We introduce our modeling synthesizers and explain how we derive them by making use of the database. Gives a description of the modifier synthesizer.

Anthropometric human models

Anthropometry means, literally, the measurement of people [2]. It has come however to be used in a more restrictive sense to mean the comparative study of sizes and proportions of the human body.

In this lecture, our focus is more on sizes, say height and/or hip girth, than on physical performance or composition of the body. Anthropometry, the biological science of human body measurement, systematically studies human variability in faces and bodies. The procedures for measurement in anthropometry are precisely specified, allowing data between individuals to be successfully compared, and for useful statistics of population groups to be derived. When applied in graphics, it allows for not only the automatic generation of varied human body geometries but also more likely occurring individuals[3].

Our approaches rely on this large body of existing data that describes the statistical information on measurement of people’s bodies. The description of the human form by proportions goes back to da Vinci, a Renaissance artist, who created the drawing of the Vitruvian Man based on the “ideal proportions”.

Anthropometrists have found that proportions give useful information about the correlations between features and can serve as more reliable indicators of group membership than can simple measurements [3,4].

Marcus Vitruvius Pollio (born c. 80–70 BC, died after c. 15 BC), commonly known as Vitruvius, was a Roman author, architect, and engineer during the 1st century BC perhaps best known for his multi-volume work entitled De Architectura.
Leonardo da Vinci’s drawing Vitruvian Man shows how the proportions of the human body fit perfectly into a circle or a square. This diagram by Leonardo da Vinci is an illustration of Vitruvius’ theory. According to Vitruvius’ theory the distance from fingertip to fingertip (arm span) should be equal to the distance from head to heel (height). In this activity you will explore the legitimacy of Vitruvius’ theory by developing a hypothesis regarding the Vitruvian Man.

Vitruvian Man by Leonardo da Vinci, an illustration of the human body inscribed in the circle and the square derived from a passage about geometry and human proportions in Vitruvius’ writings.

Anthropometric evaluation begins with the identification of particular locations on a subject, called landmark points. Anatomical landmarks are features (usually points or curves) on the surface of a human body that indicate the location of a body organ or component. These features do not necessarily have a robust definition in terms of differential geometry. However, their definitions are more intuitive and, since they are anatomically meaningful, they can easily be located by a human expert. Such landmarks are typically used in the clothing industry, but also in anatomy and anthropology. Typical examples include: Nape of neck (7th cervical vertebra), top of head, iliac crests, under bust and mid-clavicle point. A series of measurements between these landmarks is then taken using carefully specified procedures and measuring instruments such as calipers and measuring tape. Typically the measurements are taken in scientific surveys, and involve careful positioning of people before measurements are taken.

Computer graphics for modern anthropometry much of the anthropometric data currently in general use is derived from data acquired by manual measurement of a sample of the population nearly 50 years ago. Improvements in diet and healthcare in recent years have resulted in an increase in the average size of the population, thus making the 50-year-old data redundant. Recent surveys conducted by the British and US Army and others have endeavored to remedy this situation by utilizing 3D scanners for acquiring dense, accurate 3Dimensional human body data quickly and effectively.

Manual techniques, which involve the use of callipers and measuring tapes, are extremely slow and costly, pro-[®] http://en.wikipedia.org/wiki/Vitruvius
[**] http://www.reshafim.org.il/ad/egypt/timelines/topics/clothing.htm
duce sparse data and are almost impossible to automate. Since the advent of 3D image capture technology, there has been a great deal of interest in the application of this technology to the measurement of the human body and the goal is now to develop a 3D image capture system capable of routinely providing dense, accurate anthropometric data [5].

Accordingly, recent algorithms include automatic processing of scan data to extract features or measurements. [7] Presents an incremental approach that progressively refines the identification of data points. The first phase of identification is to orient and segment the human body data points. Algorithms for these tasks are presented, including the ‘discrete point cusp detector’, with a description of their use. In order to show the robustness of the software, it has been tested on twenty different body scan data sets [8]. On the identification indicates that there are robust ways to find about 100 anatomical landmarks on a human body, at least for specific categories [6].

A partially automatic landmark detection method was used in CAESAR (Civilian American and European Surface Anthropometry Resource. Digitized and skinned scan subject, with anthropometric landmarks [8] [9] concentrate on human body modeling for the purpose of measurement of human body for the clothes industry. They use a hexagonal supporting framework to form a closed space for imaging with 12 cameras for upper and lower body parts in six views. Additionally a slide projector with a grid pattern is used to catch the chest area using the stereo pair of the intersections of horizontal and vertical lines. [10] Proposes two-dimensional, image-based anthropometric measurement systems that offer an interesting alternative to traditional and three-dimensional methods in applications such as clothing sizing.

Their attractiveness lies in their low cost and the speed with which they can measure size and determine the best-fitting garment. In the market, there are now also available some systems that are optimized either for extracting accurate measurements from parts of the body, or for realistic visualization for use in games, virtual environments and, lately, e-commerce applications. Cyberware Inc.’s DigiSize was ‘partially developed in a joint government project to improve and automate fitting and issuing of military clothing’. They claim they offer complete and state-of-the-art solutions to age-old tape measurements and trial-and-error fitting problems (http::Cyberware).

Figure 2. (a) Anthropometric landmarks in H-Anim specification and (b) some measurements definition in commercial software [3].
Control Parameters
Before we discuss the synthesizer’s construction in detail, we explain the choice of control parameters. Arguably, the sizing parameters or anthropometric measurements allow the most complete control over the body geometry but providing tens of measurements required to detail the model would be almost impractical. Supporting dozens of measurements is beyond the scope of this work. Instead, we have chosen eight anthropometric measurements (5 girths and 3 lengths), which have been defined as the primary body measurements for product independent size assignment [11]. Descriptions of these sizing parameters along with the pictorial representation are shown in Figure 2. Using such a small measurement set not only provides compact parameters for the body geometry representation but also allows to be obtained easily by anyone, enabling applications such as an online clothing store, where a user is asked to enter his/her measurements for customized apparel design. Throughout this document, we assume that these key measurements are provided as input.

The variance or width parameter \( \sigma \) controls the degree of locality or smoothness properties of the interpolating function. When too small value is chosen for \( \sigma \), the resulting function is insufficiently smooth and gives a highly oscillatory function especially when the data is noisy. When too large, the function is over-smoothed, and gives again poor representation.

Although in general the width parameter can be chosen to be roughly twice the average spacing between the basic functions, various techniques for setting and fine-tuning the basis function parameters, including \( \sigma \), have been developed. We recommend readers to refer [13] for an extensive discussion on these techniques. In this work, instead of having a common width parameter \( \sigma \), each basis function is given its own width whose value is roughly twice the spacing of the nearest neighbor interpolant.

Shape Parameters
Body attributes such as hourglass, pear/apple shape are typically those that provide a global description and dramatically reduce the number of parameters. Unfortunately, it is difficult to find an objective metric to precisely describe these attributes numerically. More importantly, they cannot directly be used to describe a population. Thus, we choose parameters whose statistical information is available from literature such as anthropometry and somatotyping.

Somatotype [14] as opposed to anthropometry presents a metric to quantify the shape and composition of the body. A three-dimensional system is used to describe the size-dissociated properties of the body, namely Endomorphy, Mesomorph, and Ectomorphy. Endomorphy, the first component, is a rating on a continuum of relative fatness of a physique. Mesomorph, the second, is a rating on the relative predominance of muscle, bone and connective tissue. Ectomorphy, the third component, means relative linearity or ‘stretched-outness’ of a physique. In Figure 5, seven example bodies of drastically different sizes are illustrated along with their somatotype ratings.

There are two major problems in adopting the somatotype parameters directly. First, it requires inspection by a highly skilled somatotype in order to obtain a consistent rating, since the main part of the rating procedure is ‘horoscopic’ that is based on comparative observation of photographs. Second, it additionally requires some measurement information that is not available from the scanned data. For example, in the ‘anthropometric somatotyping’, skinfolds of four selected parts of the body are required to give an endomorphic rating [12].

Ancient Egyptian Civilization.
Anthropometric Measurements
The first known dissections with the aim of learning century BC were performed by scholars in Egypt [15]. In the most ancient cannon, “length of feet” (LF) was used as the module. Human figures drawn on the walls of the pyramids by Egyptian artists were depicted with heights six times longer than the length of their feet; however, when the artists noticed that the proportions did not reflect reality, they adjusted the height of taller human figures to a height equivalent to seven feet. According to our present arithmetic knowledge, they proportioned the horizontal lines based on height and the vertical lines based on the width of the human body [15, 16]. Drawing body shapes in the Pharaonic eras since seven thousand years BC... on the walls of temples and tombs.

Ancient Greek Civilization.
The most famous artist of this era was Polykleitos. Polykleitos evaluated the human body and wrote the first known artistic anatomy book.

The renowned scholars used the “width of hand” (WH) as a module and described the proportions he used between various body parts and the width of hand as well as the inequalities. During the period of Greek civilization, for the first time multiple equalities were used in drawings of the human body between the longitudinal, oblique, and transversal dimensions [15].

Roman Civilization.
Roman artists and scholars further developed studies of the “human body.” Moreover, some equalities were described after a human figure in the college position was placed in a square frame.

Because notables of the era such as Leonardo da Vinci...
(4) Neck girth: The girth of the neck-base

(3) Arm length: The distance from the armseye shoulder line intersection (acromion) over the elbow to the fully end of the prominent wrist bone (ulna) in line with small finger

(1) Stature: Vertical distance between the crown of the head and the ground

(5) Chest/Bust girth: Maximum circumference of the trunk measured at bust/chest height

(6) Under-bust girth: Horizontal girth of the body immediately below the breasts

(7) Waist girth: Horizontal girth at waist height

(8) Hip girth: Horizontal girth of the trunk measured at hip height

(2) Crotch length: The vertical distance between the crotch level at center of body and the ground.

Figure 3. Anthropometric measurements used in our modeling synthesizer. [12]

Figure 4. Male models generated from our modeling synthesizer using the input measurements listed in Table 2.
Table 1. Measurements used to generate male bodies shown in Figure 4.

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<th>Subject</th>
<th>Neck girth</th>
<th>Bust girth</th>
<th>Underbust girth</th>
<th>Waist girth</th>
<th>Hip girth</th>
<th>Height</th>
<th>Crotch length</th>
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Measurements listed in Table 2.

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Figure 5. Female models generated from our modeling synthesizer using the input measurements.

Figure 6. Drawing body shapes in the Pharaonic eras since seven thousand years BC. On the walls of temples and tombs, in Giza. [17]
Figure 7. Pharaonic eras since seven thousand years BC, Giza.

Figure 8. Pharaonic eras since seven thousand years BC. [17]

Figure 9. Pharaonic eras since seven thousand years BC.

Figure 10. Pharaonic eras since seven thousand years BC. [17]

Figure 11. Pharaonic eras since seven thousand years BC. [17]

Figure 12. Relief of the southern Wall of Niankhkhnumy Kḥnumhotep’s mastaba’s antechamber, in Saqqara. [17]

Figure 13. Pharaonic eras since seven thousand years BC.
Figure 14. Body position at work of Kaiemanj’s mastaba, in Giza. In other words, in some cases the chironomes would clap the palm of the hand on the muscle or using the elbow, as we can see it on Kadua and Kaiemanj’s Mastabas.

Figure 15. Cassified according three melodic modes.

Figure 16. We can distinguish as we did with the types of harps- various techniques of execution.
found that the human figure in the college position had an equal length and width, human paintings were often performed using a square frame [15, 16, and 17]. Artists during the era of the Roman Empire continued these studies by merging art with anatomy and quietly exploiting mathematics.

**Anthropometric principles of shaping work areas**

Anthropometric Measurements during the Renaissance. Great artists of the renaissance (Leonardo da Vinci and Albrecht Durer) created many works based on these rules and proportions. Works related to the human body were developed according to rules that were considered to represent classical anthropometrical measurement techniques [15].

- The renowned renaissance artist Leonardo da Vinci was interested in both art and sciences. He performed cadaver dissections and notated his measurements, notes, and drawings with the attention to detail of a scientific investigator.

- For the first time in history, he investigated the human face, head, neck, and other related parts in detail, mainly following the “Polykleitan theory.” He worked on a drawing belonging to Vitruvius, and after rigorous investigation of this work he demonstrated his success in this field. Indeed, the “Vitruvian man” became one of his most renowned works [15, 16].

Anthropometric history is the study of the history of human height and weight. [19,20] It has historical roots. [36] In the 1830s, Adolphe Quetelet and Louis R. Villermé studied the physical stature of populations. [21,22] In the 1960s, French historians analyzed the relationship between socio-economic variables and human height. [26] Anthropometric history was established as field of study in the late 1970s when economic historians and other academics began to study the history of human physical stature and its relationship to economic development. [28] A branch of clinometric, it uses trends and cross-sectional patterns in human physical stature to understand historical processes. [29].

Since ancient times, the human body has been measured for several reasons. During the ancient era, human body measurement was mostly practiced for the figurative arts. Eventually, the practice was adopted by the naturalist field and then by anthropologists to identify human basic morphological characteristics. The term anthropometry dates back to the 17th century in the naturalist field, when it first appeared in the short manual Anthropometria [30-33].

The manual seems to be the earliest recorded material that investigated the human body for scientific and medical purposes. It introduced a quantitative approach to seek information concerning variations and changes in the forms of organisms that described the relationship between the human body and disease. Proposed that the use of anthropometry constituted a valuable measurement strategy for different fields such as medical practice, physiology, the arts, and ethics [33, 34].

**Anthropometrics and Ergonomics**

Ergonomics is the scientific discipline that deals with understanding the interaction of human beings and other elements of a system, and the profession that applies theory, principles, data and methods to design to optimize human well-being and overall system performance. Ergonomics basically works towards optimizing the interaction between the work environment and the worker. In this blog, I would be explaining anthropometry and its importance in the ergonomic design of products. [35]

**Anthropometry and Its Types**

Anthropometry is defined as the systematic study of the physical properties of the human body. As a part of the anthropometric study, the three major human body parameters are measured. They are Size (e.g., height, weight, surface area, and volume), Structure (e.g., sitting vs. standing height, shoulder and hip width, arm/leg length, and neck circumference) and Composition (e.g., percentage of body fat, water content, and lean body mass). The above-measured parameters constitute the anthropometric data. [35]

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Certain special tools with high accuracy are used to obtain the anthropometric data [35]. They are as follows:

- **Stadiometers:** They are used to measure the height of the human body.
- **Anthropometers:** They are used to measure the length and circumference of body segments.
- **Biocondylar callipers:** They are used to measure the diameter of the bone.
- **Skinfold callipers:** They are used to measure skin thickness and subcutaneous fat.
- **Scales:** They are used to measure the weight of the body.

In the year 1880, Alphonse Bertillon was the chief of criminal identification for the Paris police. During his tenure working for the Paris police force in the criminal records department, he found it was becoming increasingly more difficult to identify repeat offenders. The criminal records were stored alphabetically and many criminals were successful in devising aliases to avoid deportation...
Body Position at Work, Anthropometric Principles of Shaping Work Areas

Figure 17. Anthropometric Data Used In the Ergonomic Design of A Car Driver Seat

Figure 18. Anthropometric Points in the Human Body. [35]
Figure 19. Anthropometric Tools [35]

Figure 20: The Vitruvian Man by da Vinci

Figure 21: The Bertillon system using the Anthropomorphic Measurements
and harsher sentences. He joined hands with his younger brother Jacques Bertillon to find a solution to this problem. Jacques Bertillon was a French statistician and demographer [35].

**Alphonse Bertillon**

To solve this problem, Alphonse Bertillon and his younger brother came up with a new classification system based on anthropomorphic measurements. The basic assumption of this classification was that the bone density is fixed past the age of 20 years, and human dimensions are intrinsically highly variable. He obtained the measurements of height, breadth, foot size, length and width of the head, length of the middle finger, and the length of the left forearm, as well as other morphological and distinguishing characteristics of criminals in custody.

From the above measurements, he classified each criminal into small, medium, or large and he also included frontal and profile photography in each file. This type of photography is till date used and it’s called “Mug Shot”. The Paris police were impressed with Alphonse Bertillon’s solution and it was implemented to quickly and easily identify unknown individuals and repeat offenders. The use of this anthropometric system spread to other countries all across the globe. Alphonse Bertillon is known as “The Father of Anthropometrics” [35].

**Principles Involved In Using Anthropometric Data**

For Ergonomic Product Design Anthropometry is important in several fields such as industrial design, architecture, interior design, and furniture products. In the above-cited domains, the human body dimension data is needed to produce optional and ergonomic products. When applying anthropometric data for ergonomic and optimal product design, there are four basic principles [35]. They are:

1. **Design for the Average:** This principle is used in the determination of the minimum size of the width and height of the emergency door.
2. **Design for Adjustability:** This principle is used in the design of a car seat that can be moved forward or backwards, and the angle of the backrest can be changed.
3. **Design for Extremes:** This principle is used to determine the minimum size of the width and height of the emergency door.
4. **Design for Individual:** This principle is used for designing a spacesuit for an individual.

The following Methods are Involved in Designing Products using Anthropometry [35]. They are as follows:
- Determine the design needs
- Determine and describe the users’ population
- Sample size selection that will be considered for the product design
- Determine the body dimensions that will be used
- Determine the principle involved in the anthropometric data for the product design and the percentile considered
- Prepare the measurement tools
- Data acquisition
- Data processing

**Applications of Anthropometry in Ergonomics**

Today, ergonomics professionals apply the principles of understanding human factors to the design of equipment, systems and working methods to improve comfort, health, safety, and productivity. This includes physical ergonomics, cognitive ergonomics, organizational ergonomics, environmental ergonomics, visual ergonomics and other types of ergonomics [35].

Measurements like eye height, the distance from the floor to a person’s eyes, can be taken sitting or standing. Other measurements include elbow height, hip breadth, overall stature, knuckle height, and popliteal height, or the distance from the floor to the back of the knee. These measurements play an important role in the design of architecture, furniture, tools, cars, clothes and more to fit the human body[35].

**Limitations of Anthropometry**

Anthropometric data has an important role in the design of optimal and ergonomic products. There are some limitations of the Anthropometric data which a designer or an architect must remember while developing their products and structures respectively [35]. They are as follows:

1- The anthropometric data always
needs to be revised. The world is growing at a dynamic pace. The anthropometric data considered a decade ago might not be relevant today.

2- There is a lack of standardization of the anthropometric data. The anthropometric data from the United States of America would not be useful for designing ergonomic products for a country like India. On a similar note, the anthropometric data from India would not be useful for designing products for the United States of America.

3- The arcs of motion of the human body are not considered in the anthropometric measurements.

4- The anthropometric data must be considered with a diverse group of people with different characteristics and abilities. By considering a diverse group of people with different characteristics and abilities can help in the development of ergonomic products.

5- The statistical range cut-off range for the anthropometric data is at times quite random. It’s not always guaranteed that the chosen cut-off would cater to everyone using the product.

6- Inter-observer errors during the measurement of the anthropometric data can prove costly in designing the product as it involves a statistical approach of obtaining the cut-off and percentile is used.

Ergonomics is the scientific discipline of designing products and environments to match the people who use them. It incorporates anthropometric data when designing products to improve user experience. For example, when you manufacture a door handle. You use the measurements of the hand to design the shape and size of the handle. The same theory applies to designing various products such as furniture, vehicles, clothes, etc.

Ergonomists Can help identify which user characteristics we should take into account during our design process. This is important when we consider how much individuals vary in terms of:

- Body Size
- Strength
- Mobility
- Sensory Sensitivity
- Mental Ability
- Experience
- Training
- Culture
- Emotions

**Categories of Ergonomics:**

There are three broad areas of ergonomics, namely-Physical ergonomics looks at how human anatomical, anthropometric, physiological, and biomechanical characteristics relate to physical activity [35]. This includes:

- Working Postures
- Manual Handling
Figure 24: Palm and Fist Measurements for the Ergonomic Design of Hand Held Devices like Computer Mouse.

Body Position at Work

Figure 25: Anthropometrics is the study of the human body and its movements.
Psychological ergonomics studies mental processes (e.g., perception, cognition, memory, reasoning, and emotion). And how people interact with products, systems, and environments. This includes:

- Mental Workload
- Decision-Making
- Human-Computer Interaction
- Human Reliability
- Attitudes
- Stress
- Motivation
- Pleasure
- Cultural Differences

REFERENCES:


MICAM 93
#BetterTogether
THE SPRING EDITION Closes WITH JUST UNDER 30,000 TRADE VISITORS

The events confirm their importance as a unique business and training platform.

Over the five-day period, a total of 29,468 trade visitors from both Italy and abroad attended the four trade-fairs dedicated to fashion and accessories.

MICAM, the International Footwear Exhibition, MIPEL, the event dedicated to leather goods and fashion accessories, THE ONE MILANO, the Haut-à-Porter Exhibition and HOMI Fashion&Jewels Exhibition, have shown once again that, by joining forces, it is possible to tackle the difficult international situation successfully.

United under the #BetterTogether hashtag and with the support of the Italian Trade Agency (ITA) which promotes foreign trade and Italy’s exports, the trade fairs showcased the products of over 1400 brands - the best that each sector has to offer – transforming the fair area into an exceptional business and networking opportunity thanks to this unique shared project.

Thanks also to a packed programme of seminars and events, the fairs also confirmed that they provide an increasingly important opportunity for exploring subjects of topical interest for their respective business sectors. These included digitalization, the metaverse and new ways of doing retail, increasingly linked to big data. Particular attention was also paid to sustainability and slow fashion, both on the exhibition level and as subjects for discussion.

Source: www.themicam.com

ANDTEX 2023
ANDTEX ANNOUNCES THE NEXT EDITION TRADESHOW FOR SOUTHEAST ASIA’S NONWOVENS AND ENGINEERED FABRICS INDUSTRY

E.J. Krause & Associates, the organizers of Southeast Asia Nonwovens and Hygiene Technology Exhibition & Conference (ANDTEX), is pleased to announce the 2nd edition of this major trade show taking place on March 1-3, 2023. ANDTEX is Southeast Asia’s premier trade event for the nonwovens and engineered fabrics industry. The three-day event will take place at the Bangkok International Trade and Exhibition Center (BITEC) in Thailand.

The market has demonstrated its readiness for growth as the need for nonwovens and engineered fabrics increasingly continued to rise during the pandemic. The event will showcase the entire industry value chain including engineered materials, disposable and durable hygiene products, equipment, and the latest manufacturing technologies. Related industries include hygiene, filtration, packaging, automotive, fabrics & apparels, medical, wiping, agriculture and furnishings.

ANDTEX will highlight global and regional insights from leading industry leaders on the future of nonwoven and engineered materials supply, production capacity and demand. The demand for nonwoven growth in Southeast Asia is driven by favorable demographics, economic conditions, increasing market penetration and vibrant local and export market demand.

ANDTEX will provide an unprecedented platform to facilitate business and promote the latest cutting-edge technology in engineered materials. The event will bring together suppliers, manufacturers, researchers, machinery and equipment providers, vendors, and all other major players involved in the industry.

ANDTEX is officially supported by the Ministry of Industry (MOI), and Thailand Convention and Exhibition Bureau (TCEB). It is organized in association with the Thai Nonwoven Fabrics Industry Trade Association (TNFA) and supported by the Asia Nonwoven Fabrics Association (ANFA), All Nippon Nonwovens Association (ANNA), Korea Nonwoven Industry Cooperative (KNIC), Indonesian Nonwoven Association (INWA), Taiwan Nonwoven Fabrics Industry Association (TNFIA), Hong Kong Nonwovens Association (HKNA), Thailand Textile Institute (THTI), Man-Made Fiber Industries Association (TMFA), National Metal and Materials Technology Center (MTEC) and more. We will be working closely with all participants to provide the necessary support for the change.

Source: http://www.andtex.com/
Before 3D printing, CNC routing, laser cutting and the tools of ubiquitous “making,” there was yarn and needle. For centuries, the earliest makers knitted things into being. Blankets, sweaters, gloves — all took shape by combining just a handful of basic stitches. Now a team of researchers at Drexel University is translating those loops and twists into a digital architecture of knitting — a key step in the process of incorporating new technologies into textiles.

While the promise of textile-embedded technology, or “functional fabrics,” has been on the horizon for decades, it has primarily been realized in the form of high-performance and technical military gear and high-end fashion concepts. In most of these garments, technology is an external addition, rather than an integrated feature, of the design.

TopoKnit translates stitch commands — like knit, purl and transfer — as they would appear in a knitting pattern, or the program of a digital knitting machine, into a map that shows where the yarn travels, loop by loop, and how it interacts with adjacent loops as the textile is formed. The resulting diagram, called a topology graph, allows designers to pinpoint where a piece of yarn is, with respect to the overall plane of the textile, at any given point within it.

Building up this baseline design information for knitting is coming at a time when more researchers are considering knits for making functional fabrics. Breen suggests this is partly because knitting supports more intricate yarn interactions than weaving, which is advantageous for creating electric circuits. In addition, knitting allows for more controllable design touch points, as well as the ability to generate 3D shapes without added manufacturing steps, such as cut and sew.

“What’s interesting about knitting is that, at the stitch level, it has a completely programmable microstructure. Knitting is a kind of programming that maps stitch operations to specific physical structures.” Breen said. “Because you have the loops forming many different connections, knitting is more complex than weaving. Knitted fabrics have always been more difficult to model than woven fabrics. But it gives designers more entry points to manipulate various aspects of the material, which makes it very promising for building in new functionality.”

To put TopoKnit to the test, Breen’s doctoral student Levi Kapllani Maharaj worked with research partners and designers in Drexel’s Center for Functional Fabrics to generate a series of 100 patterns of 5x5 stitch configurations using the graphics interface on one of the Center’s digital knitting machines. The same stitch commands that went into the machine were also entered into TopoKnit to produce a topology graph. The team compared each graph to its corresponding graphic rendering to see if the stitch map matched the rendered model.

The graphs were an exact match in each case, showing that the TopoKnit system could be used to reliably produce manufacturing instructions for knit textiles via a sequence of steps that produces specific yarn topologies. These to-

One of the greatest barriers to full integration of technology into textiles and broader retail adoption of functional fabrics, according to David Breen, PhD, a professor in Drexel’s College of Computing & Informatics who has been computer modeling fabric since the 1990s, is that current software used for industrial design and production of textiles lacks the thread-level detail necessary for digital sampling and precision manufacturing of fabric devices.

“In order for these [technical] textiles to be widely deployed and reach their full industrial potential, computer-based modeling and simulation tools must be developed to support the design and optimization of knitted structures,” Breen’s group wrote in a recent paper in the journal Graphical Models.

The piece introduced TopoKnit, a suite of algorithms they developed as a tool for modeling the path of a yarn within a knitted textile. While it doesn’t solve the entire modeling challenge, the program does provide an essential element of the design process: documentation of how parts come together to make a finished piece — the equivalent of a blueprint in architecture.
polologies, descriptions of how the yarns contact and interconnect with each other, allow the system to flag stitch patterns in a design that would not be viable in production, which is an important step for prototyping. While the accuracy of TopoKnit is important, Breen noted that it is still just the first of many steps toward a textile modeling program that can represent and simulate functional fabrics.

For any kind of high-level computer modeling, a topology graph is the foundation on which more noticeable characteristics, like shape, strength and movement, are built. But for textiles, that foundation was never established, because the process of churning out products was usually more urgent than redesigning them for high-level performance tools.

“It is ironic that fabric is one of the oldest human-created materials, but modeling it has proven to be extremely challenging and computationally expensive.” Breen said. “Steel beams are easier to study and model than knitted fabrics: because fabrics do things like stretch and twist, they require vast amounts of computational power when modeling them in the ways similar to that steel beam.”

Despite this engineering disconnect, research and development around functional fabrics has gained momentum mainly due to government projects focused on specific performance goals, like embedding communications or vital sign-monitoring technology into military uniforms. But to do this, the field has relied heavily on the expertise of individual designers and fabricators with deep experience in knitting.

The benefit of enhanced textile design platforms, Breen suggested, is that it would open up textile design to people with expertise in other areas, like electrical engineering or materials science. Topoknit is a technology-agnostic approach to developing tools for interoperability across machines and modeling platforms. And because it would allow designers to try new approaches with a better gauge on what will work – rather than spending time and resources on trial and error – better modeling should enable efforts more closely linked to consumer goods.

“Some of these materials are really expensive. You can’t afford to do trial and error testing because of the limited supply of some of these advanced fibers and yarns,” he said. “The vision for computer-aided design is that you model, simulate and explore the design space. You do it all virtually, computationally, so you don’t have to go through the expensive process of making it and then seeing if it works. Or you could at least explore the design options and narrow down the tests you want to do with the finished piece.”

Building on the topology framework provided by TopoKnit, the next step for this research is to optimize the shape and behaviors of knitted textiles. Ensuring accuracy and modeling the shape will prime computer programs to meticulously reproduce the mechanical properties of textiles and ultimately direct knitting machines to produce textiles with specific performance capabilities.

“If we’re going to see the potential of functional fabrics fully realized, we need to get to the point where knitting is even easier than 3D printing – where you can put in all the desired parameters from size and shape to flexibility and thermal or electrical conductivity and press ‘go’ and a knitting machine will produce it. This work is putting us on the path toward that reality.”

In addition to Breen, and Kapllani Maharaj; Genevieve Dion, director of Drexel’s Center for Functional Fabrics; Chelsea Amanatides, PhD, a senior research engineer in the Center; and Vadim Shapiro, PhD, of the University of Wisconsin have contributed to the development of TopoKnit. The project was initially funded by the National Science Foundation.

Read the full paper here: https://www.sciencedirect.com/science/article/abs/pii/S1524070321000199

Source: https://drexel.edu/
INTERNATIONAL FAIR
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The quality of composite systems made of cords of high-strength fibers such as polyester, aramid or polyamide and matrix materials of rubber is largely determined by the adhesion properties of the fibers to the matrix. In the established manufacturing process, adhesion promoters made of resorcinol-formaldehyde-latex (RFL) are used to improve the adhesion properties. Researchers at DITF are showing ways to replace the harmful formaldehyde with technically equivalent substances that are harmless to health.

In car tires, conveyor belts and V-belts, as well as in many applications in the manufacture of technical products, rubber materials are reinforced by cord. High-strength fibers made of polyester, polyamide or aramid are used. They provide the necessary strength and rigidity of the overall composite and counteract external forces. As a result, deformation, elongation and torsion of the material can be kept low.

However, these demands on the fiber composite material can only be met if there is sufficiently high adhesive strength between the fibers and the matrix (made of rubber or caoutchouc). Otherwise, delamination of the material composites, which are built up in alternating layers of fabric and rubber, is to be expected. Material failure would be the consequence.

Adhesion is increased by the use of adhesion promoters. Chemicals based on formaldehyde-resorcinol latex (RFL) have proven effective. They are applied to the fibers as so-called dips and ensure that their adhesion to the matrix of rubber is significantly improved. RFL is established as an adhesion promoter, but it has a significant drawback: since 2014, formaldehyde has been classified by the EU as demonstrably carcinogenic and mutagenic. The chemical industry is therefore urgently searching for alternatives that are harmless to health.

DITF have tackled the problem and developed a new, formaldehyde-free coating system. It is based on the substance hydroxymethylfurfural (HMF), which can be extracted from wood. HMF is formed during the thermal decomposition of carbohydrates. It is found in many heat-treated foods such as milk, coffee or fruit juices and is not considered to pose any health problems according to current scientific knowledge.
The HMF dips developed at the DITF are also promising from a technical point of view: In the case of yarns made of polyamide 6.6, a simple impregnation is sufficient to achieve the desired adhesion improvement. Yarns made of polyester or aramid require an additional prior plasma treatment or a sol-gel finish to achieve the necessary adhesion improvement. Application of the HMF dip is possible under the same conditions and with the same technology used for RFL dips. At this point, therefore, no additional investment is required to replace the adhesion promoter in production.

Both approaches to replacing chemicals in adhesion promoters with substances that are harmless to health carry the idea of sustainable management throughout: the new adhesion promoters made from HMF and lignin are based on natural raw materials. Solving the problem within a demanding, technical application while adhering to sustainability aspects reflects the commitments of research to societal requirements. For small and medium-sized industry, the research results provide the basis for innovations and thus a real advantage in international competition.

The advantages already demonstrated are to be expanded. Replacing resorcinol in the dip formulation is the next research goal. This is because resorcinol also has a toxic effect on humans. In cooperation with industrial partners, the extent to which resorcinol can be replaced by lignin is currently being investigated. The special feature of the lignin used is that it is obtained from annual plants. Thus, in contrast to the frequently used wood lignin, it is chemically much more active and offers more potential for further processing into a technically advantageous adhesion promoter.

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