Evaluation and Comparison of Advanced Textile Digitization and Virtualization Technology Using Drape

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I. Textile Virtualization & Current Apparel Industry

II. Textile Digitization & State-of-Art Methods

III. Evaluation of Virtualized Textiles Using Drape

IV. Our Case Study

V. Conclusion
OUTLINE

• Textile Virtualization & Current Apparel Industry

• Textile Digitization & State-of-Art Methods

• Evaluation of Virtualized Textiles Using Drape

• Our Case Study
Struggle to handle repetitive edits and corrections requested by buyers

Efficient communication & pattern modification through virtual simulation
No need physical sampling & material waste
Textile Virtualization & Apparel Industry: Manufacturing Process

Conventional Manufacturing Process

Material Sourcing & Concept Design

Pattern Design

Physical Sampling

Review

Production Sampling

Sales

4~5 Months

Digital Integrated Manufacturing Process

2~3 Weeks

Note: The video originates from a CLO 3D user demonstration
Textile Virtualization & Apparel Industry: Representation of fabrics

- Cotton-stretch
- Velvet
- 100% silk woven
- 100% wool knit
The virtual representation of fabrics

Virtualized Image

Mesh Image
Fabric Representation – Mass-Spring Model

Rectangular Mesh

- Fabric - represents a grid of mass points (mesh) & spring (connections between mass points)
- Each mass point has a position, velocity, and acceleration and responds to internal and external forces.

\[
\ddot{x} = M^{-1} \left( -\frac{\partial E}{\partial x} + F \right)
\]

\( \dot{x} \) : Geometric state of cloth
\( \ddot{x} \) : Acceleration
\( M^{-1} \) : Mass distribution matrix
\( E \) : Cloth's internal energy (scalar function of \( x \))
\( F \) : Forces acting on cloth (e.g., air-drag, internal damping)

D. Baraff and A. Witkin (1998)

Triangular Mesh

Mozafary, Vajiha, and Pedram Payvandy (2017)
Tuur Stuyck (2018)
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Conventional Method of Textile Digitization

Textile Digitization Process - Overview

1. Physical Properties Data
2. Spec Data
   - Fiber components,
   - Yarn specs, etc.
3. 3D Fabric Files

Textile Digitization – Physical Property Test

Step 1: Physical testing measurements
- Weight
- Thickness
- Bending properties (warp, weft, bias) for contact distance and bending length (mm)
- Stretch properties (warp, weft, bias): stretch force at 5 points

Step 2: Measured input data into emulator

Step 3: Digitizing physical properties
- Stretch stiffness CD (g/s²)
- Stretch stiffness MD (g/s²)
- Shear stiffness (g/s²)
- Bending stiffness CD (g·mm²/s²/rad)
- Bending stiffness MD ((g·mm²/s²/rad)
- Bending stiffness B (g·mm²/s²/rad)

Step 4: ZFAB file creation (Physical property file)

Step 5: Apply ZFAB file to virtual cloth

Conventional Method of Textile Digitization

Textile Digitization – Physical Property Test

It takes about 20 minutes per one fabric sample digitization
Recently, AI-based textile digitization processes have been introduced. AI-powered textile digitization offers a straightforward and practical method to automatically digitize fabric properties based on image scanning.
State-of-Art Method of Textile Digitization

AI-Powered Textile Digitization Process

01 Capture a series of photos of the fabric surface, while moving around the fabric
02 Upload to Bandicoot’s website
03 Output 3D-ready file → design

Scan Fabric
Upload File
Grab a Coffee
Download 3D Fabric File

Takes 5 minutes per one sample!

https://textura.ai/product/
https://www.theinterline.com/2023/01/19/dpc-conversations-dave-monaghan-ceo-bandicoot-imaging/
AI-Powered Textile Digitization

- There is no need for physical testing hardware or equipment.
- Input known parameters, such as density or % of elastane; the AI technology does the rest.

The reliability of AI-powered textile digitization remains a critical consideration compared to manual physical property measurements.

https://textura.ai/product/
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• Textile Virtualization & Current Apparel Industry

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• **Evaluation of Virtualized Textiles Using Drape**

• Our Case Study
How do we evaluate the virtualized fabric?

Drape

- The drape is a unique behavior of textile as it is a total visual expression based on its inherent mechanical and physical properties.
- The drape test can be an indicator to evaluate the simulated fabric’s performance.

https://textura.ai/product/
Virtual Textile Evaluation via Drape

Virtual Drape Test Cases

- (a) Hanging drape
- (b) Cusick’s drape
- (c) Modified Cusick’s drape
- (d) Boundary vector of (c)

**FIGURE 1.** Comparison of simulated hanging drape, Cusick’s drape, and our modified Cusick’s drape.

- (a) Scanning the 3D model.
- (b) Fitting a Bézier spline.

**FIGURE 11.** Extracting the boundary vector from the real fabric specimen.


✓ Key takeaway: There is a lack of reliability and standardized testing methods in a virtual environment.

Volume measurement
Evaluation of Virtualized Textiles Using Drape

Virtual Drape – Method Development

Compatibility with Cusick Drape's test results:
- Reliable DCs
- Accurate visual representation

Drape coefficient (DC, %) = \( \frac{A_d - A_1}{A_2 - A_1} \times 100 \)

Now, one can evaluate the accuracy of virtualized fabric using this method.
(Cylinder height: 100 mm, Ring diameter 240 or 300 mm)

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Evaluation of Virtualized Textiles Using Drape

Case study: Physical vs. ATextile Digitization

Physical VS. AI-Textile digitization

2) Scan

3) Upload scanned image (Textura)

4) Download AI-digitized physical property file

Simulation

2) Physical property tests (ST or CLO Kit)

3) Input test data (Emulator)

4) Create digitized physical property file

5 polyester-spandex jersey knits & 3 woven
Variable spandex content and areal density

Case study: Physical vs. AI Textile Digitization

Woven Simulation Example

<table>
<thead>
<tr>
<th>Cusick Drape (Real)</th>
<th>Physical Test-based (PT)</th>
<th>AI-based (AI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC: 47%</td>
<td>DC: 52%</td>
<td>DC: 45%</td>
</tr>
</tbody>
</table>

DC: 47%  DC: 52%  DC: 45%
Case study: Physical vs. ATextile Digitization

Knit Simulation Example

Cusick Drape

Physical Test-based (PT)

AI-based (AI)

PT

AI

DC: 12%

DC: 16%

DC: 27%

Evaluation of Virtualized Textiles Using Drape

Case study: Physical vs. ATextile Digitization

3D Clothing Example

Physical Test measurement based simulation

AI-textile digitization based simulation

Conclusion

- **Evidenced The potential of AI-powered digitization for rapid prototyping**
  - Al-based garment simulation could be effective and practical for evaluating silhouette and fits during the apparel manufacturing, although some limitations and challenges must be addressed.

- **Some Limitations of AI-powered digitization**
  - The AI model better simulates woven fabrics than knit fabrics for fabric drapes in this study
  - It might be because the AI model approximates yarn and fabric parameters for full-scale fabric as a regularly repeating pattern based on the scanned textile.
  - We observed differences in drape behavior and virtualized garments.
    - The complexity of garment simulation may be influenced by garment’s structure, stitching, and other factors.
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Thank you! Any Questions?
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See you next year!

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