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

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Nov. 2nd, 2023

Advanced Textiles EXPO

NC STATE Wilson College of Textiles

OUTLINE

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

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- **Textile Virtualization & Current Apparel Industry**
- Textile Digitization & State-of-Art Methods
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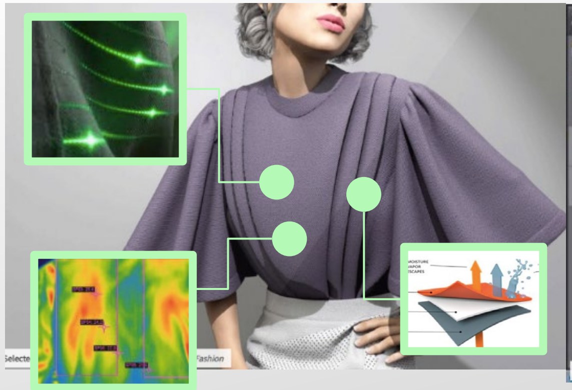
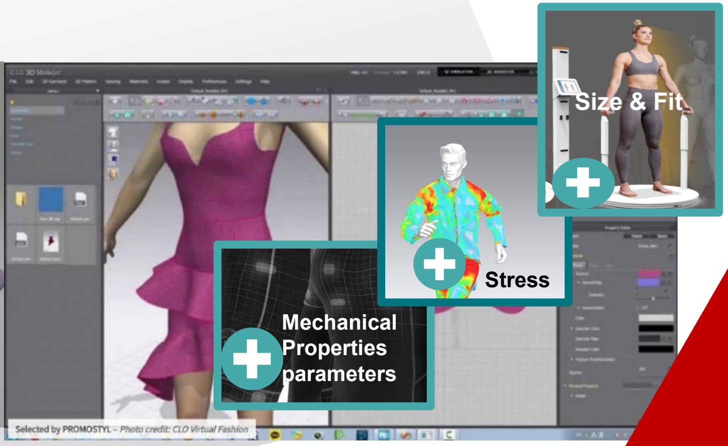
3D Garment Design Software (3DGS) – Global Apparel Industry

Manual pattern design
2D CAD

PAST

- Struggle to handle repetitive edits and corrections requested by buyers





Smart 3D Garment Manufacturing

Today

- 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

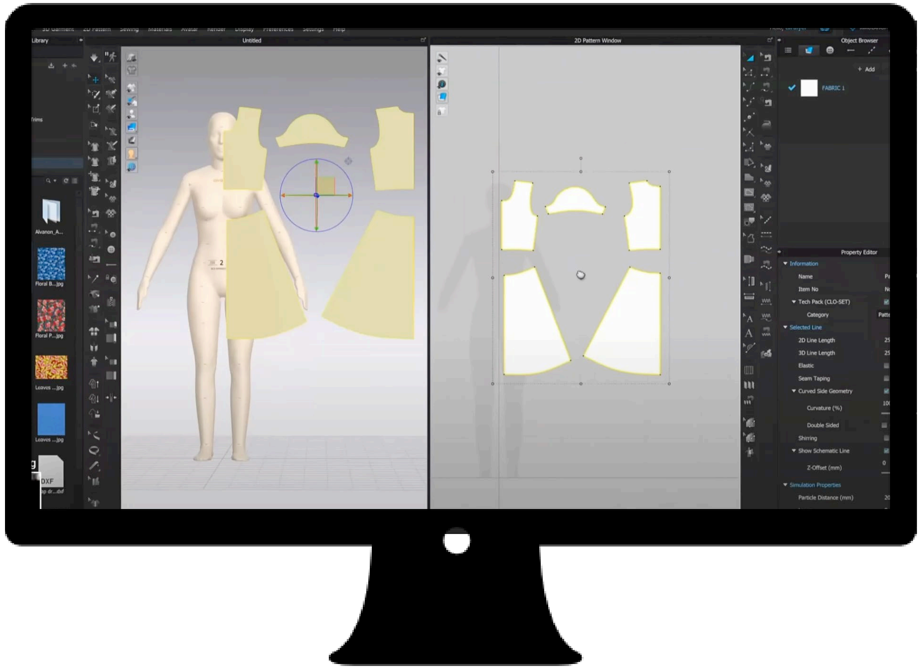
Physical Sampling

Review

Production Sampling

Sales

Digital Integrated Manufacturing Process



2~3 Weeks

Note: The video originates from a CLO 3D user demonstration

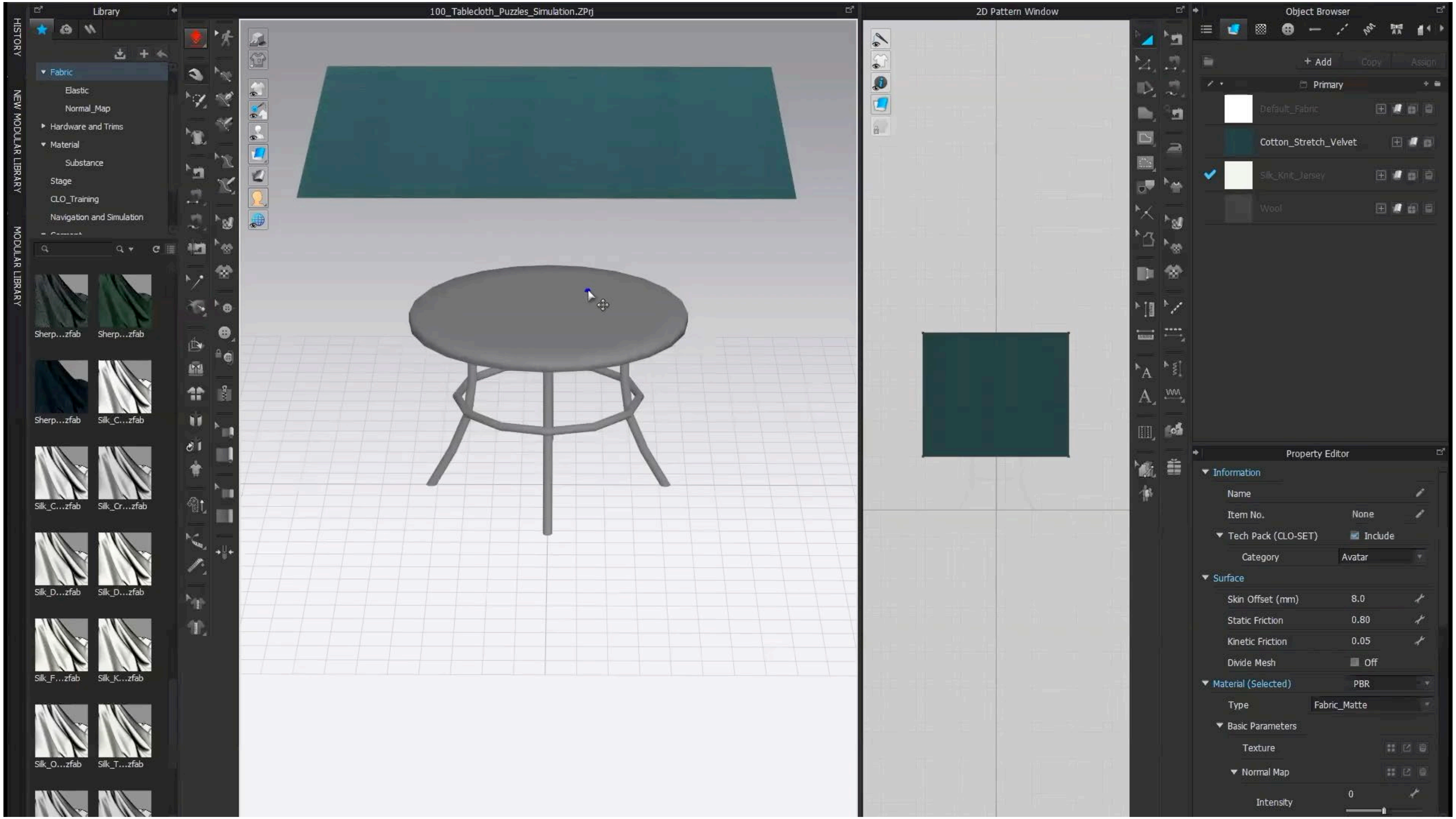
Textile Virtualization & Apparel Industry: Manufacturing Results

Made by CLO

Real-life garment

https://www.clo3d.com/en/clo

Textile Virtualization & Apparel Industry: Representation of fabrics



Cotton-stretch Velvet

100% silk woven

100% wool knit

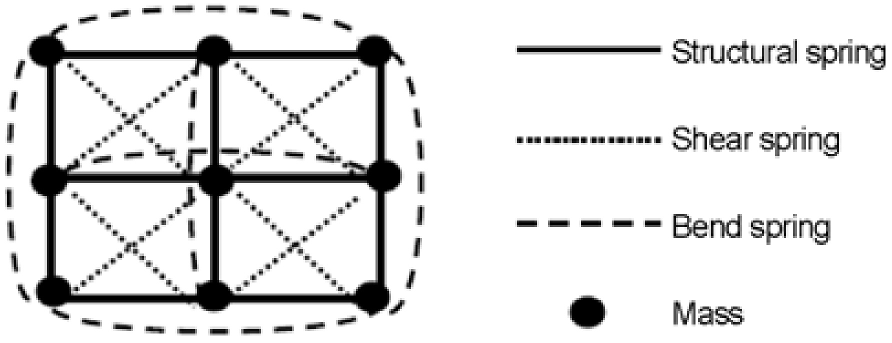
The virtual representation of fabrics

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.

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

$\boldsymbol{x}$: Geometric state of cloth

$\ddot{\boldsymbol{x}}$: Acceleration

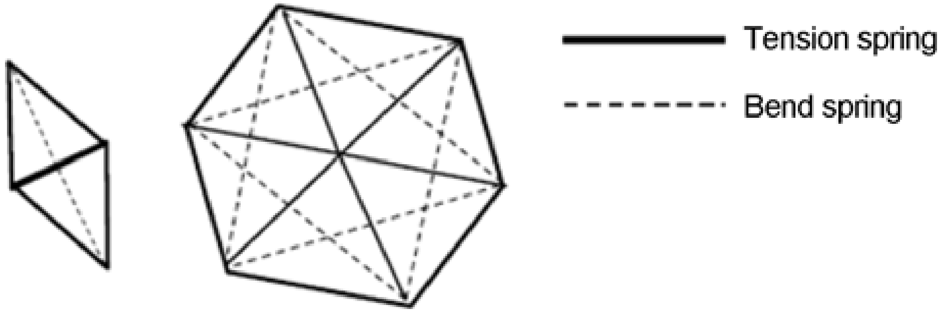
$\boldsymbol{M}^{-1}$: Mass distribution matrix

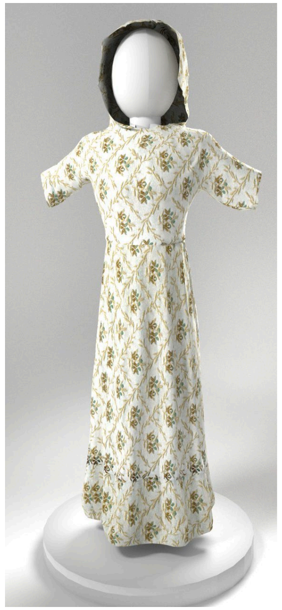
E : Cloth's internal energy (scalar function of x)

$\boldsymbol{F}$: 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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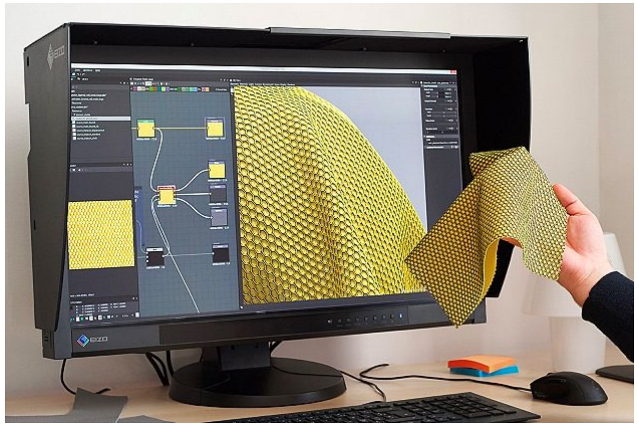
Textile Digitization Process - Overview

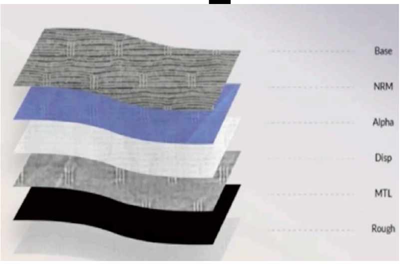
- Material Sourcing & Concept Design
- Textile digitization
- 2D/3D Design (Virtual Sampling)
- Review (Co-creation)
- Production Sampling
- Sales

Real-world Fabric

Virtual Fabric



1



\+

2

Physical Properties Data

\+

3

Spec Data
Fiber components,
Yarn specs,
etc.

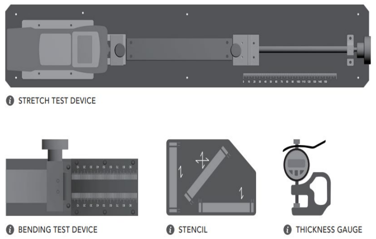
3D Fabric Files

Image source: https://www.texintel.com/press-room/digital-concept-meets-real-fabrica-new-material-collaboration-between-cotton-incorporated-and-adobe

Textile Digitization – Physical Property Test

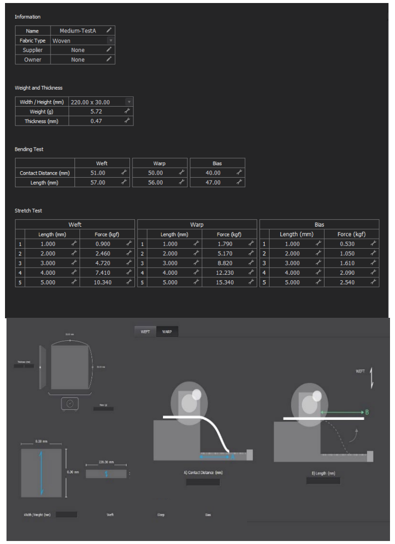
Step 1 – **Physical testing measurements**

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



23 data

Step 2 – **Measured input data into emulator**

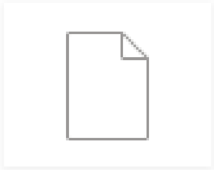


Step 3 – **Digitizing physical properties**

- 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)

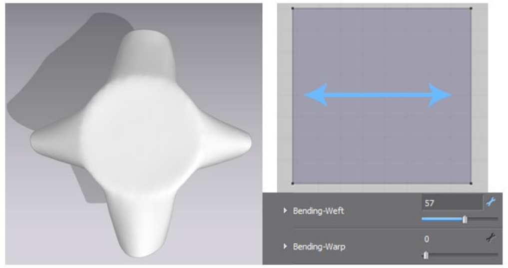
6 data

Step 4 – **ZFAB. file creation (Physical property file)**



SP 320.zfab

Step 5 – **Apply ZFAB file to virtual cloth**

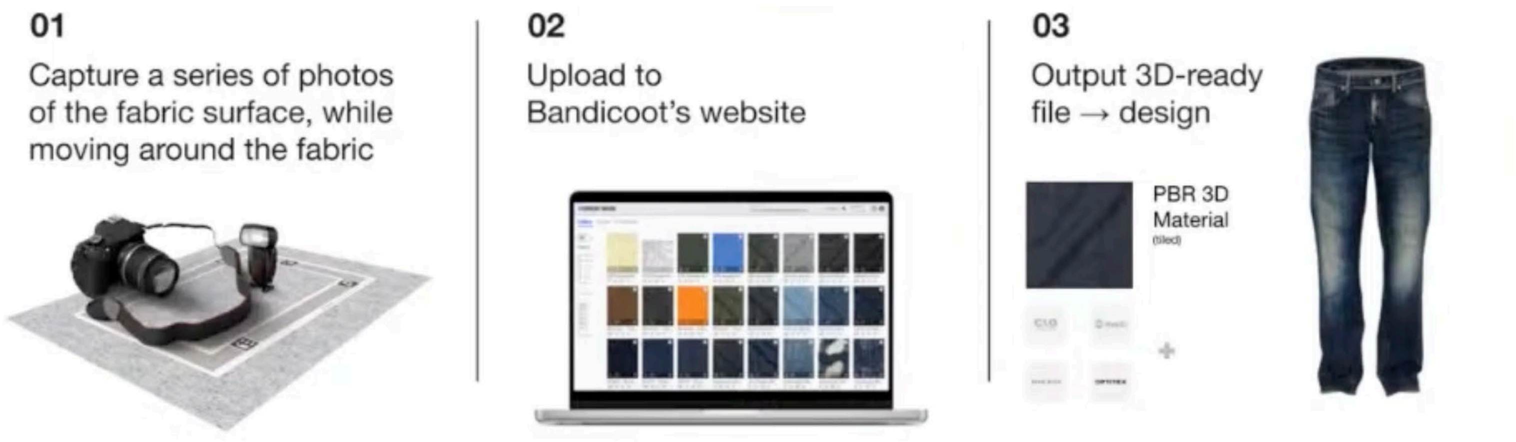


It takes about 20 minutes per one fabric sample digitization

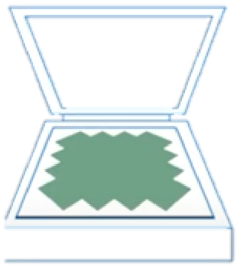
AI-Powered Textile Digitization

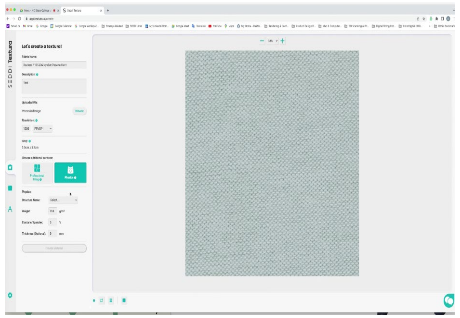
- Recently, AI-based textile digitization processes have been introduced.
- AI-powered textile digitization offers a straightforward and practical method to automatically digitize fabric properties based on image scanning.

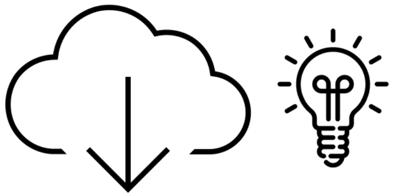
AI-Powered Textile Digitization Process



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



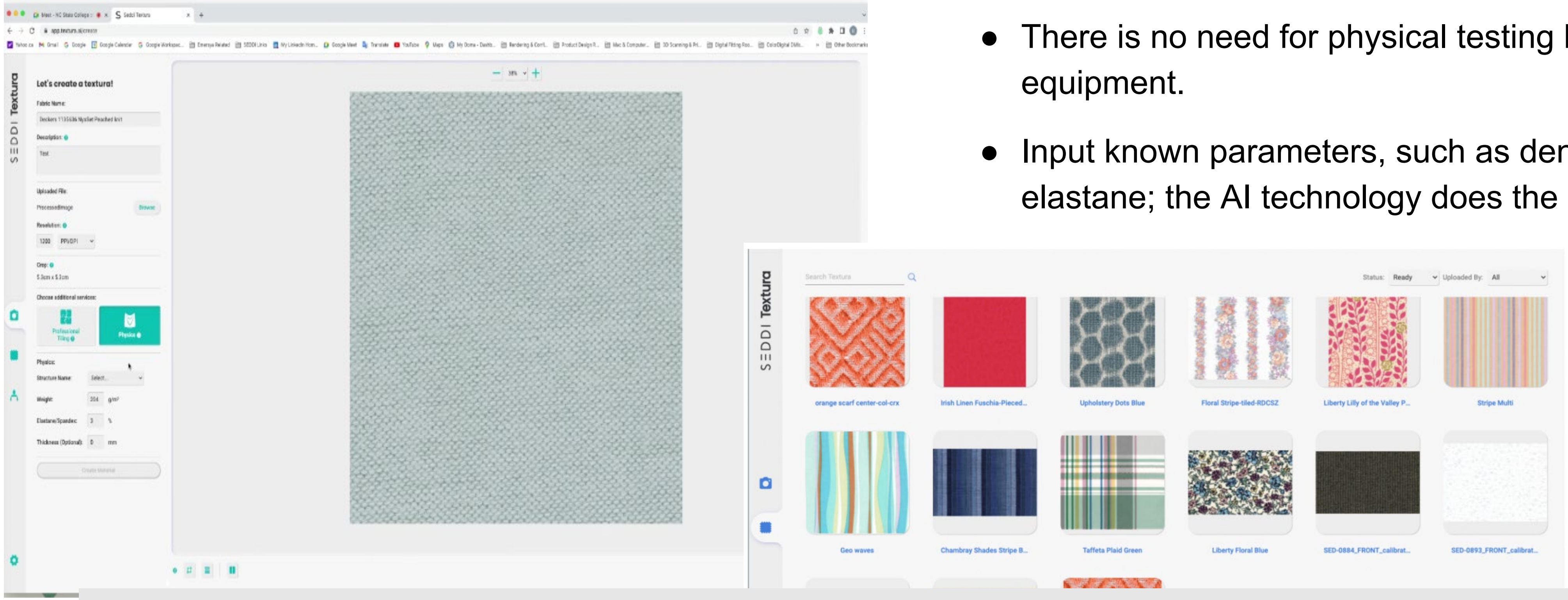




Takes 5 minutes per one sample!

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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- **Evaluation of Virtualized Textiles Using Drape**
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How do we evaluate the virtualized fabric?

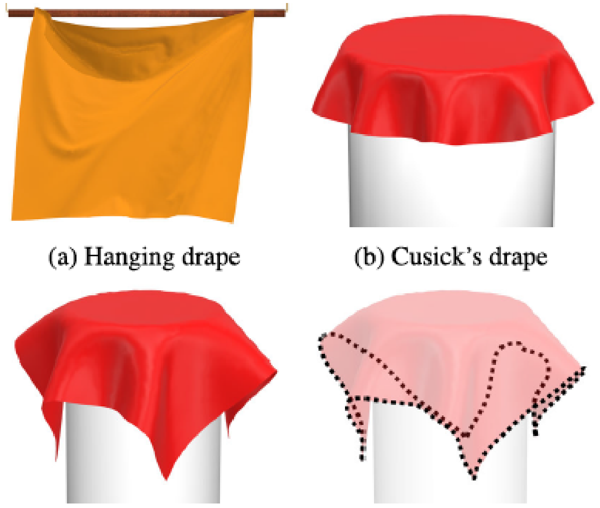
https://textura.ai/product/

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.

Virtual Textile Evaluation via Drape

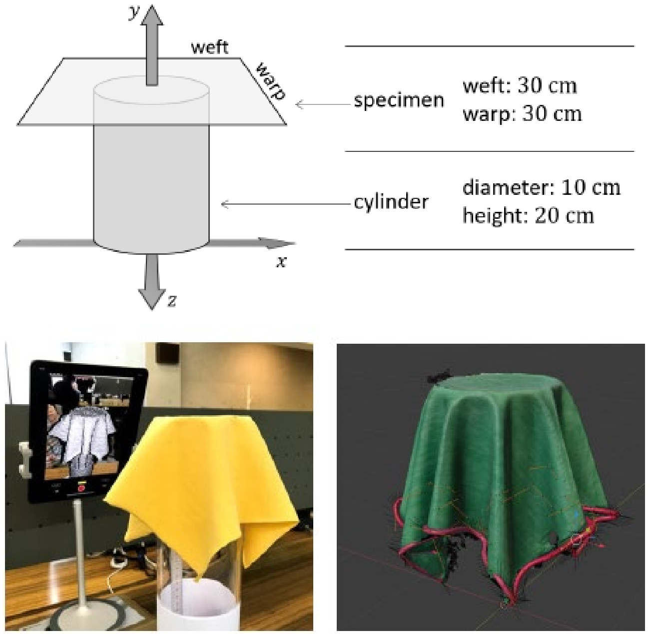
Virtual Drape Test Cases



(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.

Ju, Eunjung, and Myung Geol Choi. "Estimating Cloth Simulation Parameters From a Static Drape Using Neural Networks." IEEE Access 8 (2020): 195113-195121.

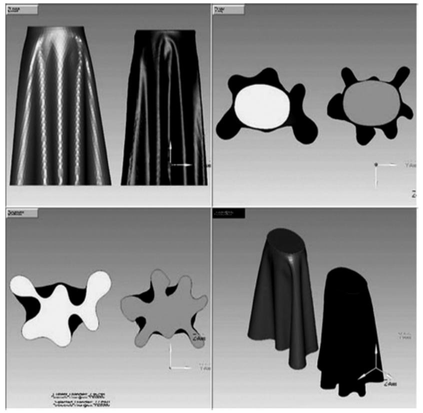


Figure 9 Scan (always on left, lighter shade) and simulation of a skirt.

Volume measurement

Table 2 Comparison of scan and simulation for skirt in Figure 9

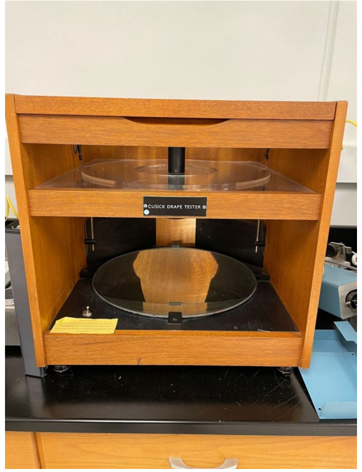
	Scan		Simulation		
Fabric	Target number of nodes	Target volume (cm^3)	Number of nodes obtained	Volume obtained (cm^3)	Percent difference between target and actual volumes
Lawn	7	65,064	6	65,008	0.09

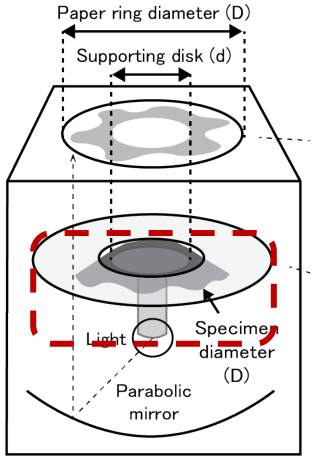
Pandurangan, et al. (2008). Enhancing accuracy of drape simulation. Part II: Optimized drape simulation using industry-specific software. Journal of The Textile Institute - J TEXT INST. 99. 219-226. 10.1080/00405000701489198.

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

Virtual Drape – Method Development

Cusick Drape



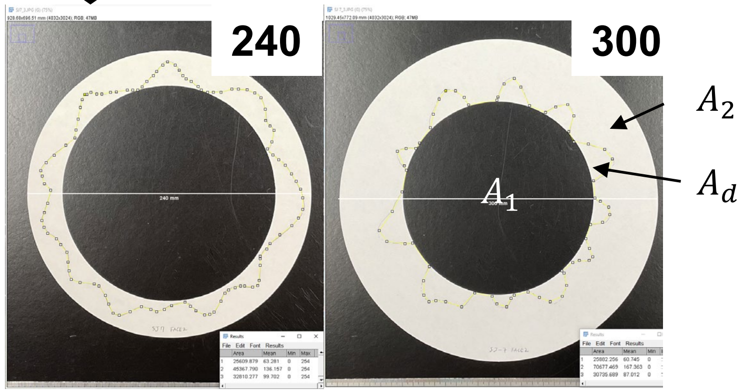


Ring diameter (=specimen diameter)

BS 5058 (British standard method)

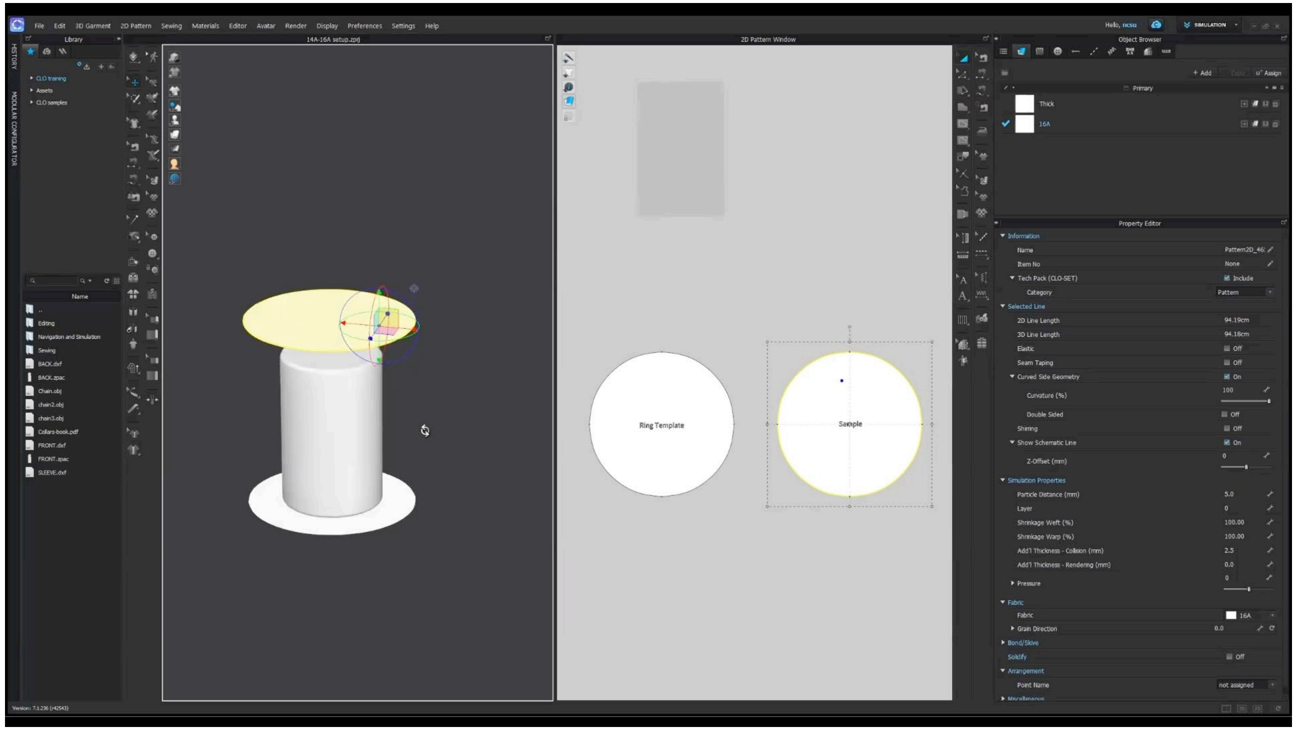
Compatibility with Cusick Drape's test results:

- Reliable **DCs**
- Accurate **visual representation**



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

Virtual Setups



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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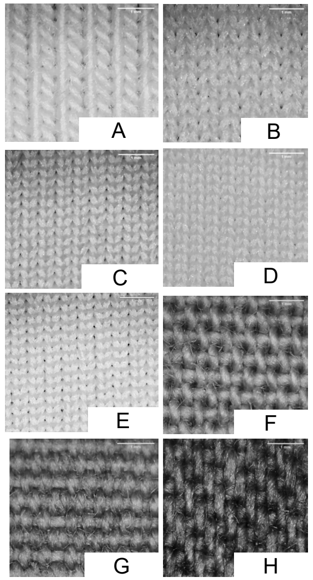
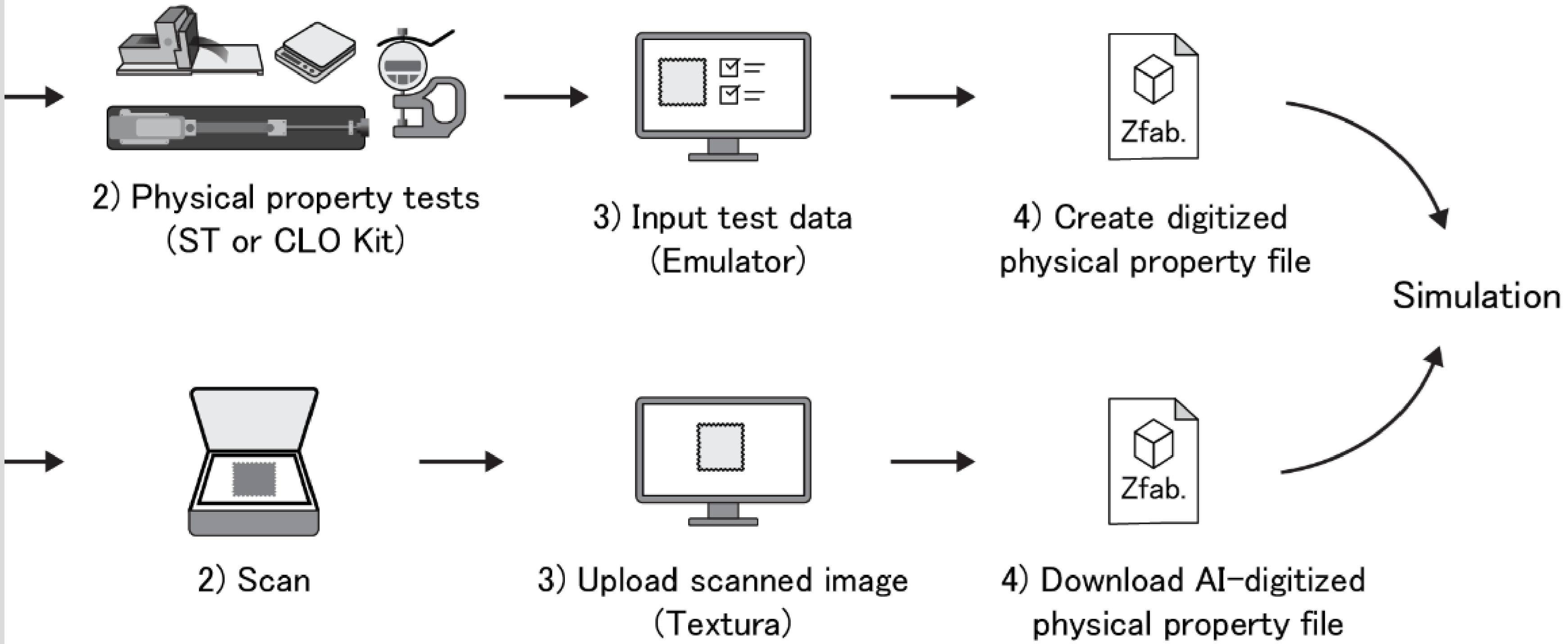
Case study: Physical vs. ATextile Digitization

Physical VS. AI-Textile digitization



5 polyester-spandex jersey knits & 3 woven

Variable spandex content and areal density



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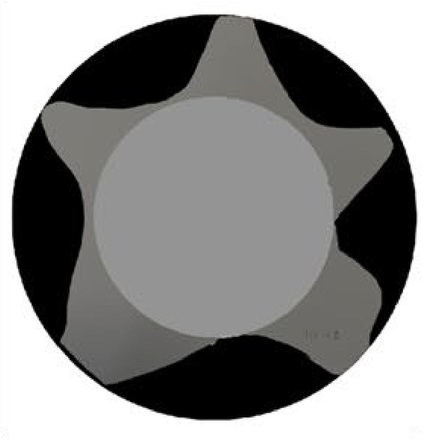
Case study: Physical vs. ATextile Digitization

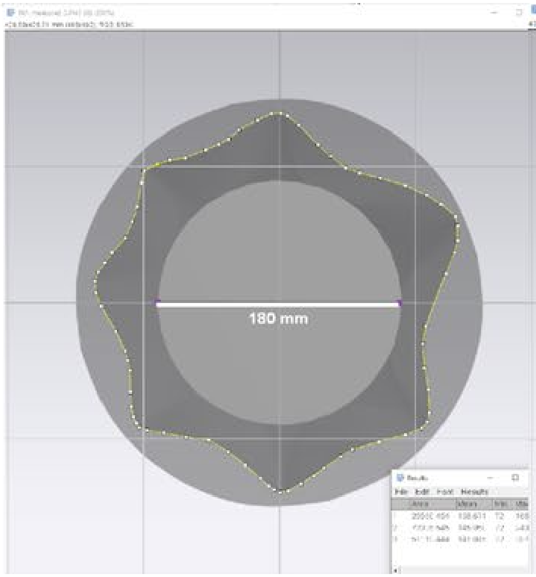
Woven Simulation Example

Cusick Drape (Real)



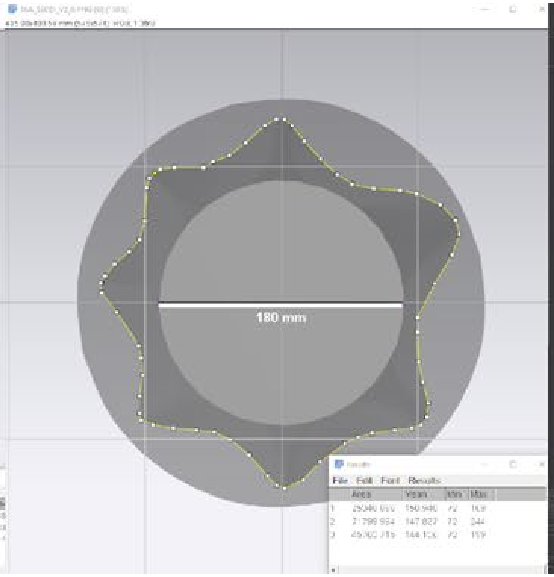
DC: 47%

Physical Test-based (PT)



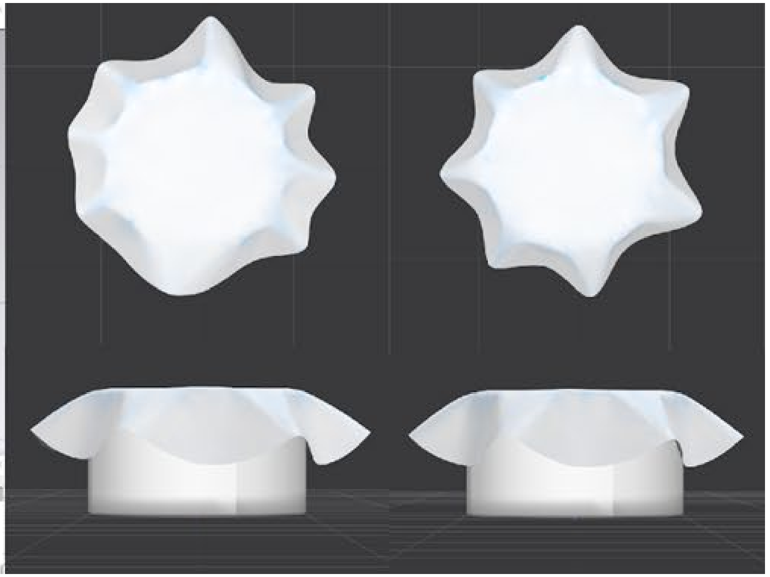
DC: 52%

AI-based (AI)



DC: 45%

PT | AI



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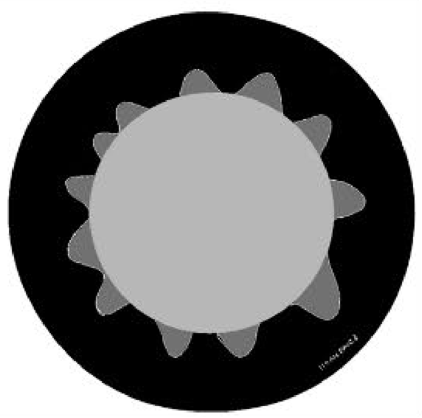
Case study: Physical vs. ATextile Digitization

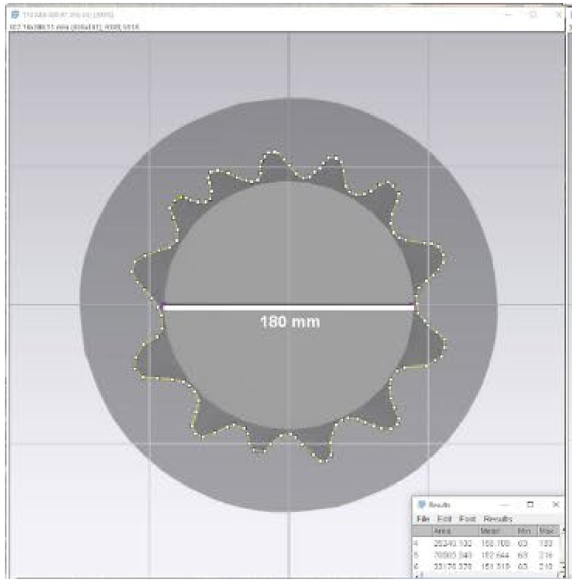
Knit Simulation Example

Cusick Drape



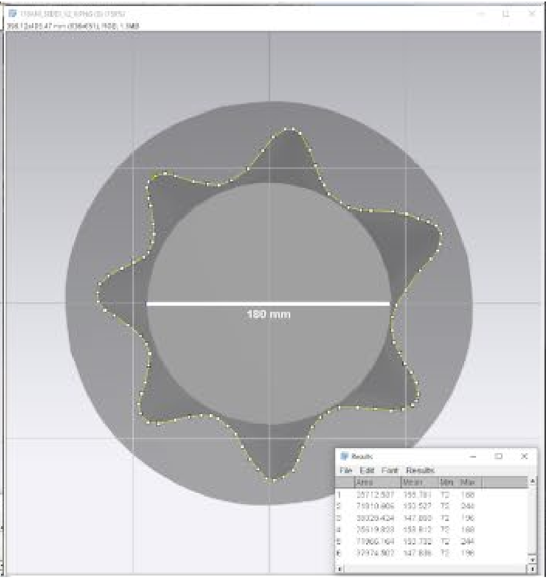
DC: 12%

Physical Test-based (PT)



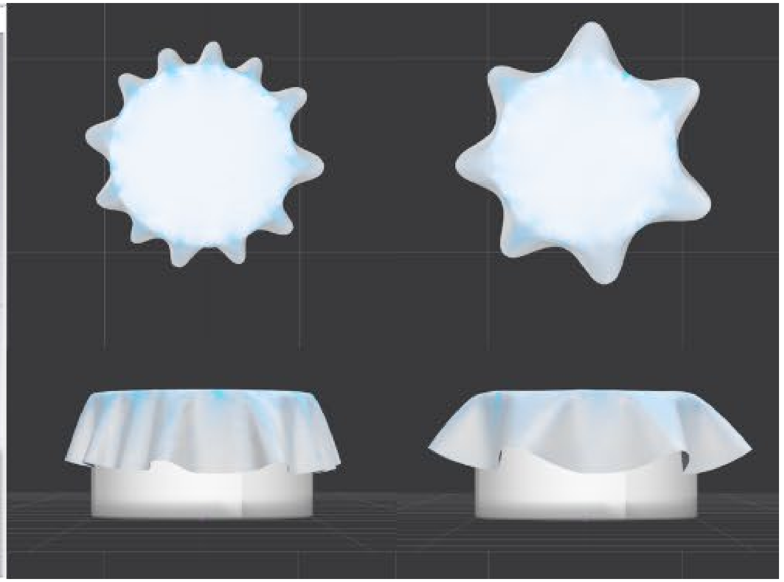
DC: 16%

AI-based (AI)



DC: 27%

PT | AI



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Case study: Physical vs. ATextile Digitization

3D Clothing Example

Physical Test measurement based simulation

AI-textile digitization based simulation

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Conclusion

- **Evidenced The potential of AI-powered digitization for rapid prototyping**
    - AI-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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Acknowledgment

The authors would like to thank the **North Carolina Defense Manufacturing Community Support Program (DMCSP)** from the Department of Defense (DoD) for providing student support, as well as **Zeis Textiles Extension** for granting access to the Physical Testing Lab and Wilson College of Textiles for providing access to Clo 3d software and its fabric kit. The authors would also like to acknowledge **Alejandro Rodríguez, Gabriel Cirio**, and **Alicia Nicas** from the optical and physics research team at **SEDDI** for their insightful discussions.. Special thanks to **Graham Sullivan** and **Bruce Wright** for introducing us to the latest technology.

Thank you! Any Questions?

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See you next year!

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