Title:
**Dynamic Display of Clothing Based on Clothing Design Flow and Graph Neural Network**

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Keywords:
Cloth design flow, GNN, Dynamic Human-Garment Interaction Virtual Try-On Digital Fashion

DOI: 10.14733/cadconfP.2025.296-299

Introduction:
With the transformation of the clothing industry towards personalization and customization, the rise of digital fashion and smart fitting mirrors has driven the development of virtual fitting technology. Currently, the core technical principle of the virtual fitting system is based on two-dimensional image processing. By analyzing human body images, including pose, contour, skin texture, etc., it detects the target human figure area and estimates the pose of the human body. Then, it analyzes clothing images, including patterns, cuts, etc., and integrates the deformation projection of the adapted clothing, supplemented by image generation technologies such as generative adversarial networks and diffusion models. Achieve a natural fit between the clothing and the human body, and generate a visual and realistic try-on effect.

Nowadays, we have proposed a method to develop a dynamic clothing demonstration method. Through parametric clothing modeling and GNN-driven human-clothing interaction, it achieves personalized and highly realistic dynamic try-on effects and seamlessly integrates with the clothing production process.

From an academic perspective, the virtual fitting system fuses clothing materials with human body materials through forms such as images, 3D models, and topological structures to generate realistic 2D or 3D fitting effects, supporting static or dynamic previews. This system integrates the relevant technologies of computer vision, deep learning, image processing, physical simulation, and human-computer interaction. The related research covers high-precision 3D human body modeling, pose estimation, flexible object interaction, and other fields. The research results can be extended to 3D modeling and dynamic interaction, providing a new paradigm for VR/AR digital human research.

| *Project Name* | *Display Dimension* | *Animation* | *Realistic Human Model* | *Clothing Model* | *Physical Simulation* | *Machine Learning* |
|---|---|---|---|---|---|---|
| viton[1] | 2 | × | × | × | × | √ |
| OOtDiffusion[2] | 2 | × | × | × | × | √ |
| SC[3] | 3 | × | × | √ | √ | × |
| GarNet[4] | 3 | × | √ | × | × | √ |
| SMPLicit[5] | 3 | × | √ | √ | × | √ |
| HOOD[6] | 3 | √ | × | × | √ | √ |

Tab. 1: Summary of widely accepted virtual fitting technologies.

Main Idea:

Establish a complete process as shown in the figure, and establish a correct and appropriate human body model and clothing grid model from 2D to 3D based on the video, respectively. Then, simulate the 3D physical model and fabric model by using the physics engine to realize the display of various aspects of the dressing effect, and select the most fitting clothing for dynamic prediction according to GNN, mechanics, and ergonomics.

The research consists of three main parts:, here are the details:

- Clothing modeling: Utilizing the physical simulation engine of clothing design software, 2D sheets (based on real design parameters) are transformed into 3D clothing models.
- Dynamic human-clothing interaction: Introducing the hierarchical information transmission architecture of GNN and efficiently predicting clothing deformation under human motion sequences through unsupervised learning of physical models[6].
- System Integration: Integrate clothing design parameters, dynamic interaction modules, and monocular video input and realize the complete process from design to dynamic try-on [7].

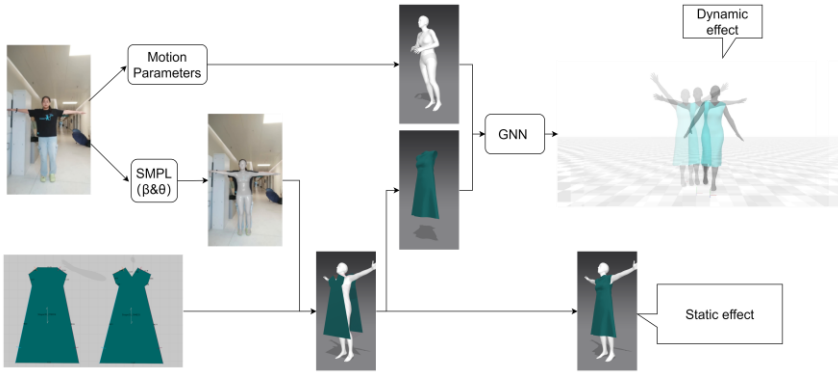


Fig. 1: Complete intelligent fitting workflow diagram.

In order to better connect with reality, this project takes an ordinary two-piece dress as an example. In marvelous designer, the front and back two-piece slices of three types of S-M-L skirts are printed in two dimensions and physical motion simulation is used to generate three-dimensional clothing models for 3D human models. According to the dressing effect and mechanical data of multiple models, the clothing size most suitable for the model is selected.

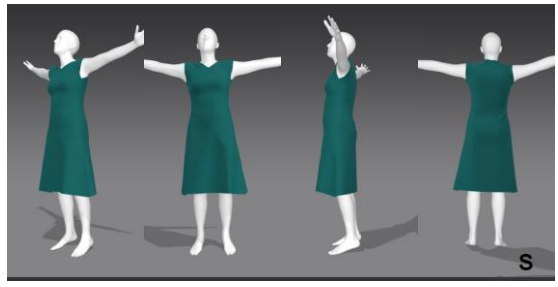


Fig. 2: Multi-angle dressing display effects for S sizes.

According to the information of the initial three-dimensional clothing, the roughening layers are established. According to the experimental method HOOD [6], the trained GNN network is directly used for clothing dynamic prediction. The calculation formula is as follows.

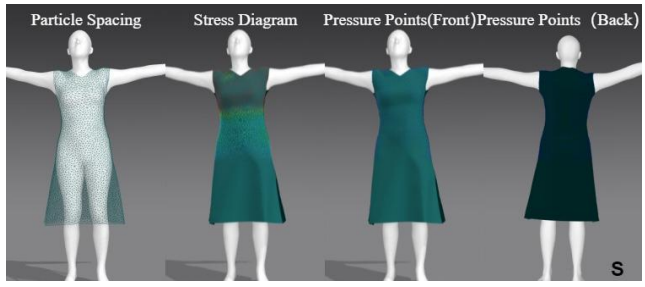


Fig. 3: Dressing stress effects for S, M, L sizes.

$$
\begin{aligned}
v_i &= [\mathrm{p}_i, \mathrm{v}_i, m_i, \mu_i, \lambda_i] \in R^{d_{node}} \\
e_{ij} &= [\Delta p_{ij}, L_{ij}^0, k_{bending,ij}, c_{ij}] \in R^{d_{edge}} \\
e_{ij} &\leftarrow f_{v\to e}(e_{ij}, v_i, v_j) \\
v_i &\leftarrow f_{e\to v}(v_i, \sum_j e_{ij}^{body}, \sum_j e_{ij})
\end{aligned}
\tag{1}
$$

Grid motion updating.

$$
\begin{aligned}
e_{ij}^l &\leftarrow f_{v\to e}^l(e_{ij}^l, v_i^0, v_j^0) \\
Aggregate_i &= \left[ \sum_{j\in\mathcal{N}^1(i)} e_{ij}^1, \sum_{j\in\mathcal{N}^2(i)} e_{ij}^2, \cdots, \sum_{j\in\mathcal{N}^L(i)} e_{ij}^L \right] \\
v_i &\leftarrow f_{e\to v}(v_i, Aggregate_i)
\end{aligned}
\tag{2}
$$

Hierarchical coarsening.

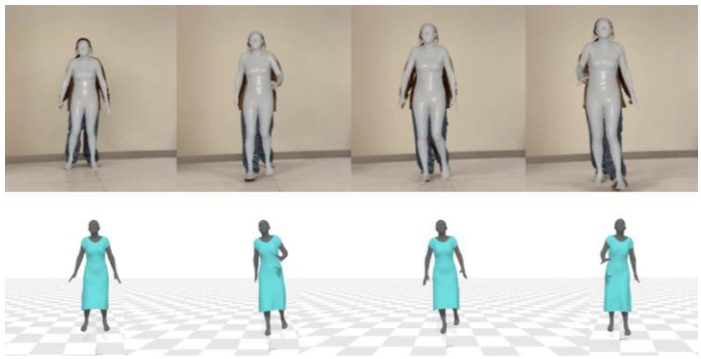

Fig. 4: Modeling and garments' dynamic effects of the walk motion.

Conclusions:

A virtual fitting system is designed. To realize more real and close-fitting clothing modeling, the two-dimensional design drawing of clothing is converted into three-dimensional models. The GNN neural network is used to simulate the dynamic performance of human body dressing, and finally a scheme with faster operation speed and better display effect is realized.

Acknowledgements:

The authors would appreciate the startup fund from SUSTech (#Y01336236 for Y Ma) and Shenzhen City (#Y01336136, Y Ma) provided to Y Ma when he joined SUSTech. This project would also highlight

the support of Fudajing-SUSTech Collaboration Project (#K2233Z212, for Y Ma), and Guandong provincial support on “Advanced 3D Model Reconstruction and Intelligent Measurement in Manufacturing”, via Fundamental and Applied General Research Regional Fund (#2023B1515120017).

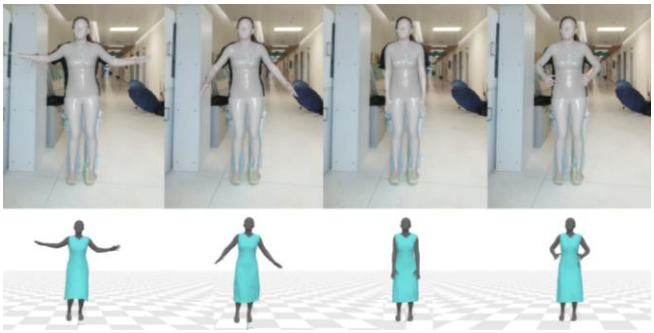

Fig. 5: Modeling and garments' dynamic effects of the wave motion.

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