

D-Garment

*Physically Grounded Latent Diffusion
for Dynamic Garment Deformations*

Antoine Dumoulin

Adnane Boukhayma

Laurence Boissieux

Bharath Bhushan Damodaran

Pierre Hellier

Stefanie Wuhrer

TMLR 2026

NENO AI LAB
by interdigital & Inria

 interdigital

Inria



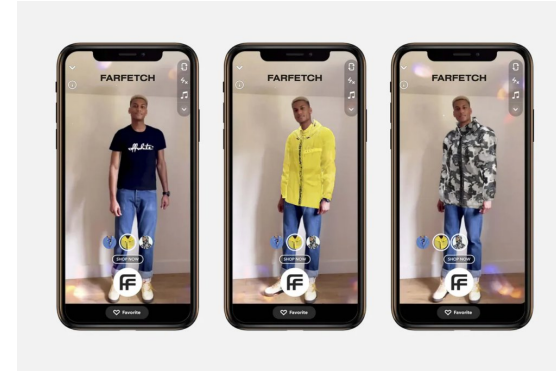
Motivation: interactive dynamic clothing

- **Virtual try-on**

- Real-world observations fitting
- Diverse body shape, poses, and garments

- **Garment design**

- Controllable parameters
- Physically plausible dynamics



Snapchat



Sims 4



VRchat

$c = (M, \dots)$

Representation

- Garment design



Korosteleva et al, 2024. GarmentCodeData: A Dataset of 3D Made-to-Measure Garments With Sewing Patterns.

$$c = (M, \beta, \theta_t, \dots)$$

Representation

- Garment design
- Body shape, pose and motion



Mahmood et al, 2021. AMASS: Archive of Motion Capture As Surface Shapes.

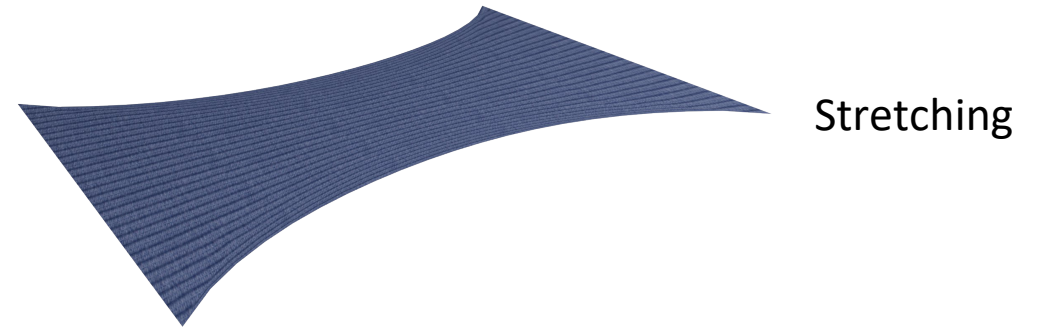
$$c = (M, \beta, \theta_t, \gamma)$$

Representation

- Garment design
- Body shape, pose and motion
- Physical material



Korosteleva et al, 2024. GarmentCodeData: A Dataset of 3D Made-to-Measure Garments With Sewing Patterns.



Stretching



Bending



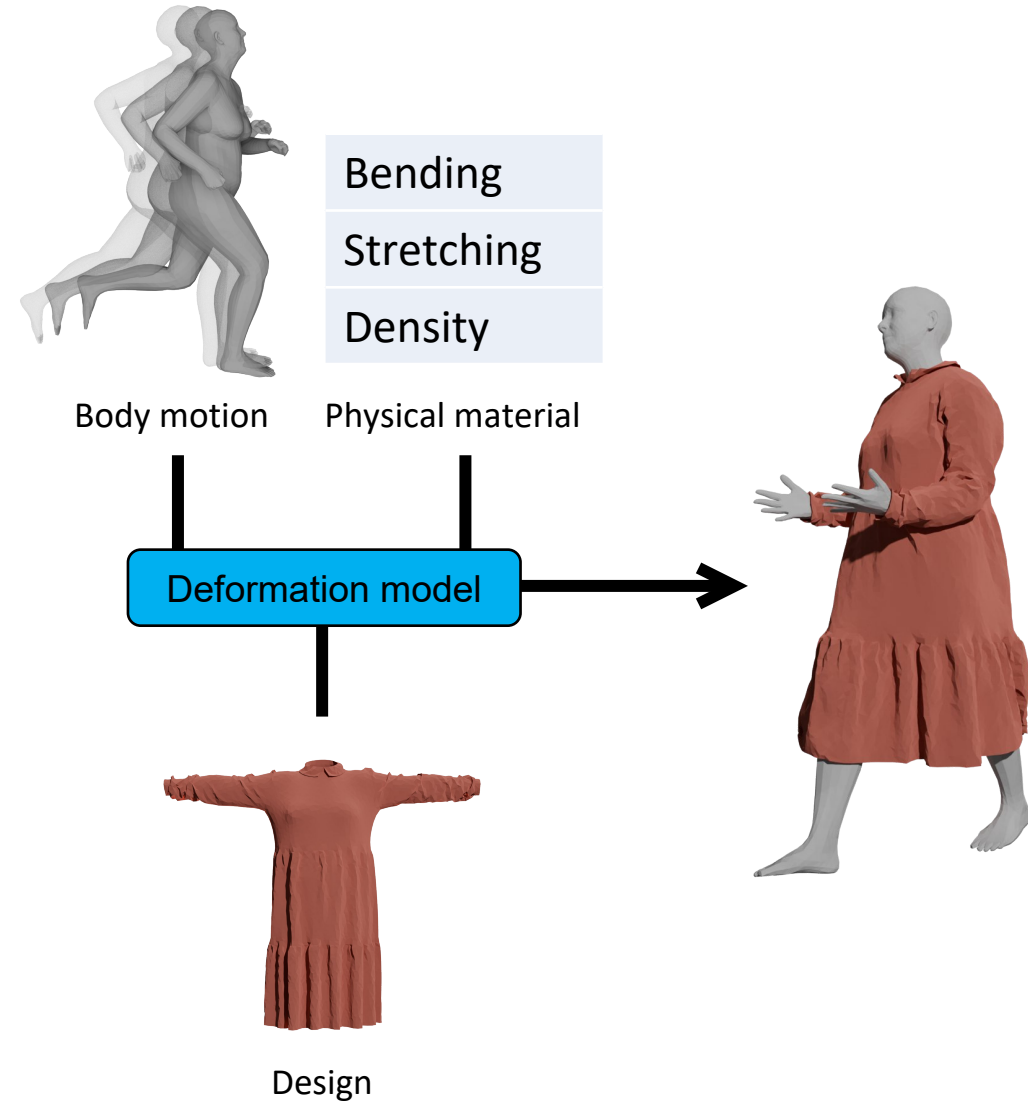
Density

$$c = (M, \beta, \theta_t, \gamma) \Rightarrow M_t$$

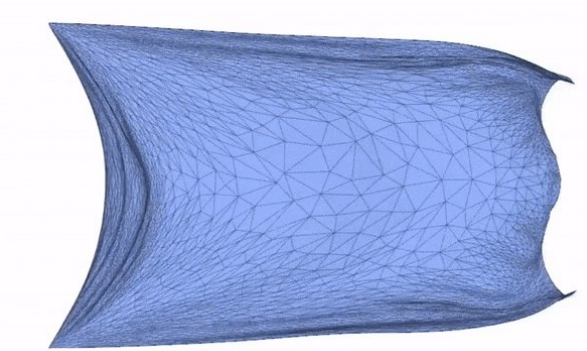
Representation

- Garment design
- Body shape, pose and motion
- Physical material

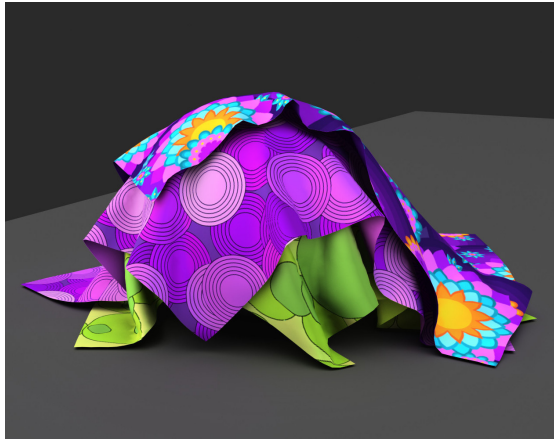
→ Generate deformations



Physics-based Cloth Simulation



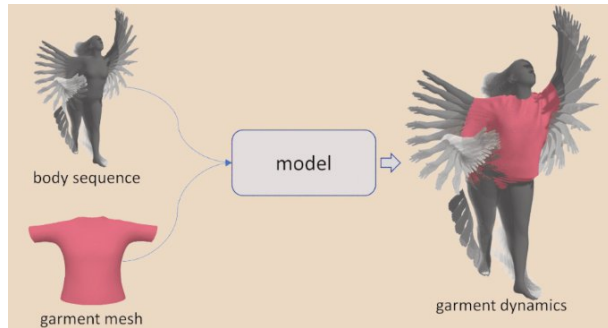
Narain et al. *Arcsim*, SIGGRAPH Asia 2012.



Ly et al. *Projective Dynamics with Dry Frictional Contact*, Siggraph 2020.

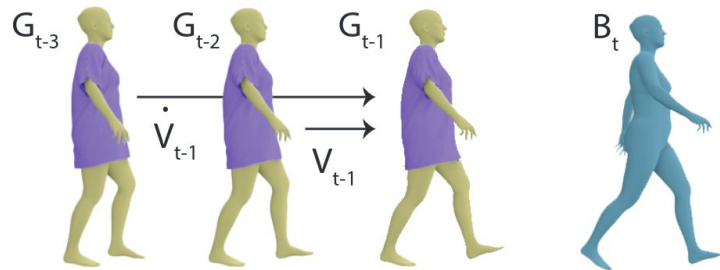
- + Models physically accurate cloth
- + Generalizes across garments, body shapes, motions and physical materials
- Manual adjustments
- Quality / performance trade-off
- Requires an initial state
- Hard to fit on observations

Learning-Based Cloth Simulation



Grigorev et al. *HOOD*, CVPR 2023.

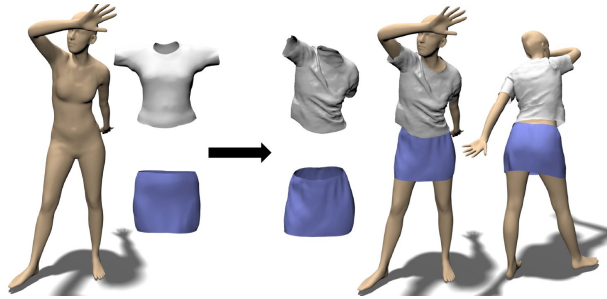
- + Fast (real time) and easy to setup
- + Models realistic cloth dynamics
- + Generalizes across garments, body shapes, motions and physical materials



Zhang et al. *Motion Guided Deep Dynamic 3D Garments*, TOG 2022.

- Requires an initial state
- Hard to fit on observations
- (Physical accuracy is not well studied)

Pose-Dependent Deformations



Patel et al. *Tailornet*, CVPR 2020.



Vidaurre et al. *DiffusedWrinkles*, BMVC 2025.

- + Static deformations
- + Parametric control
- + Fitting to scan or image

- No dynamics
- Struggles with loose clothing

D-Garment

Training

Inference

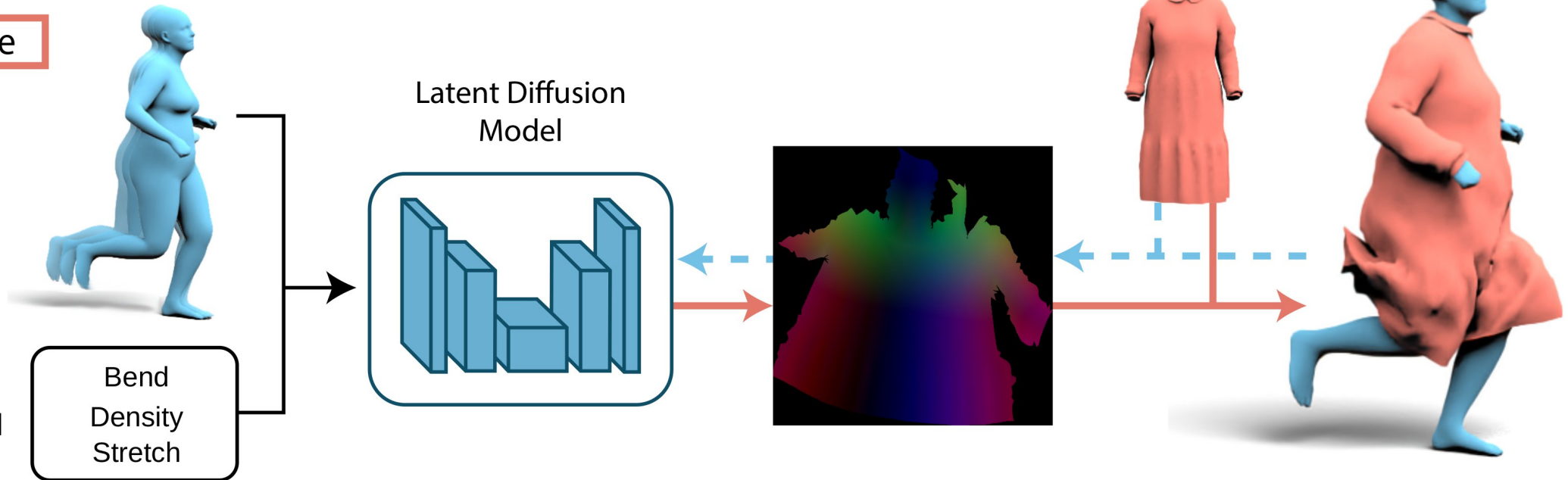
Body motion

Cloth material

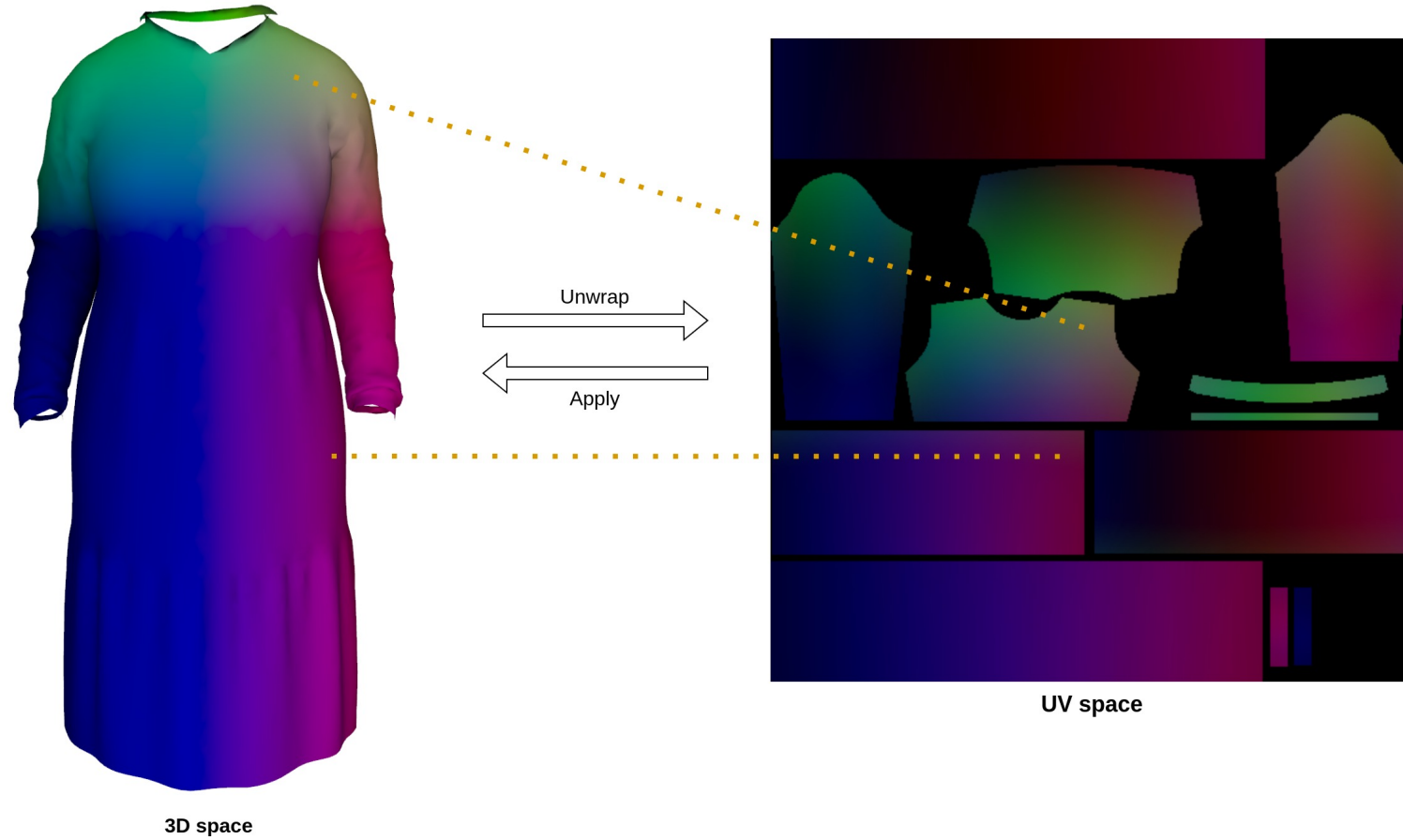
Bend
Density
Stretch

Latent Diffusion Model

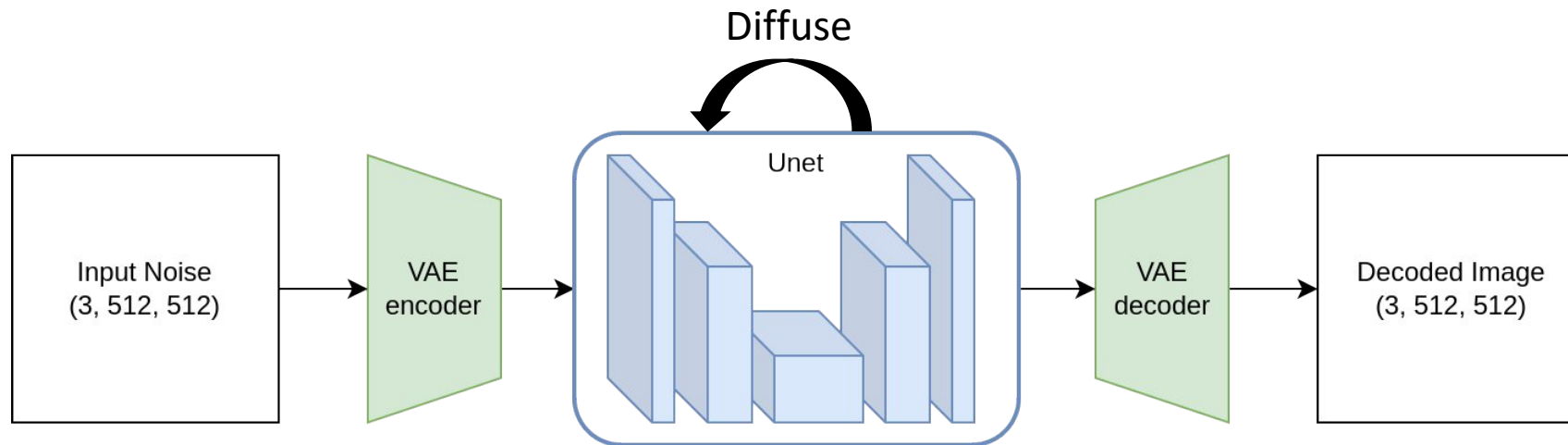
Template



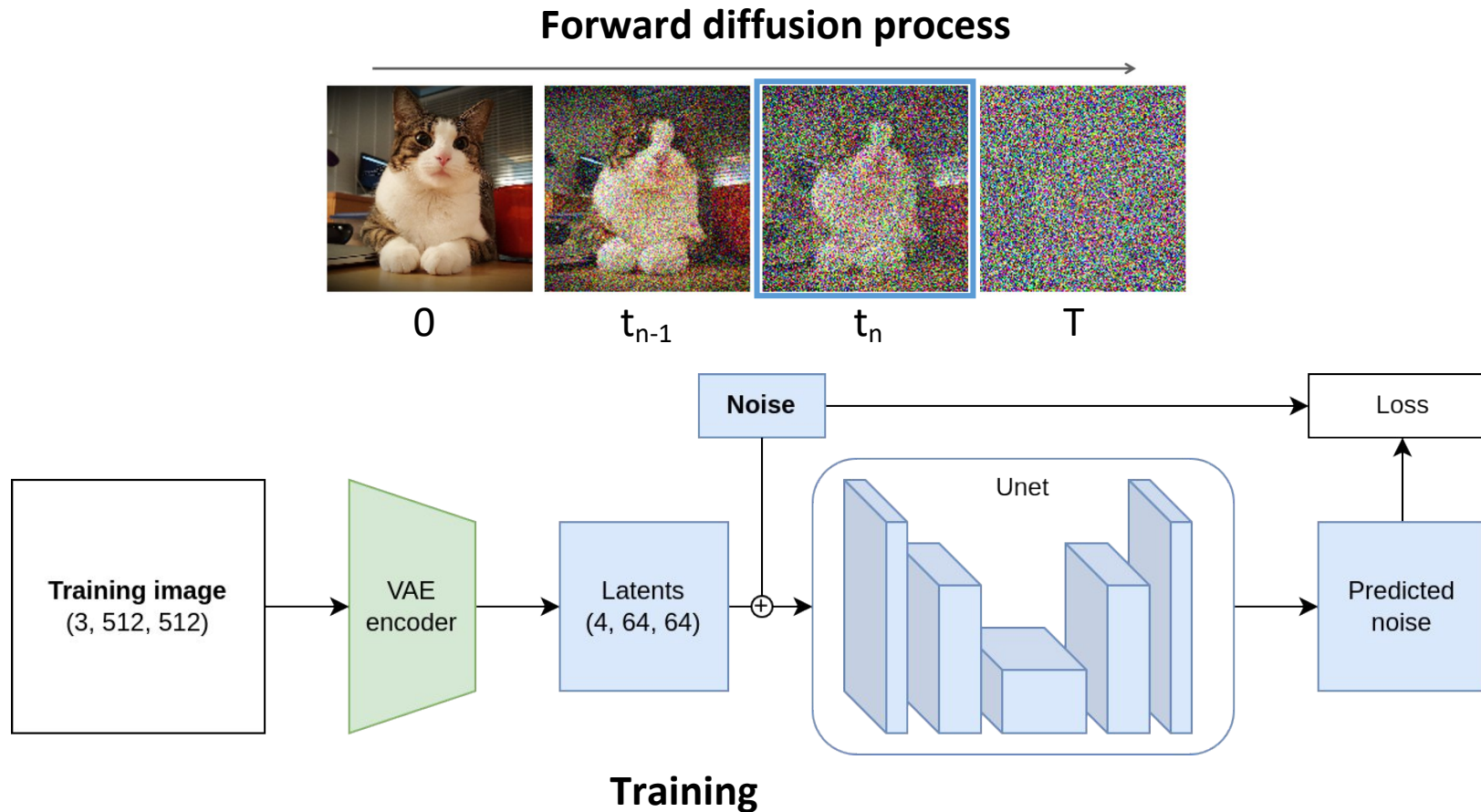
UV representation



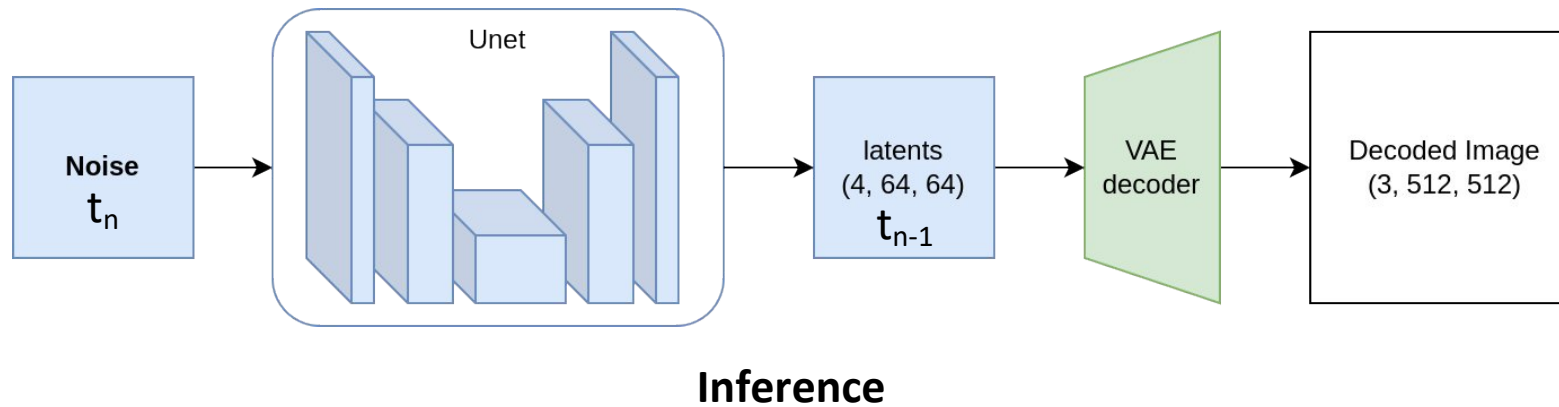
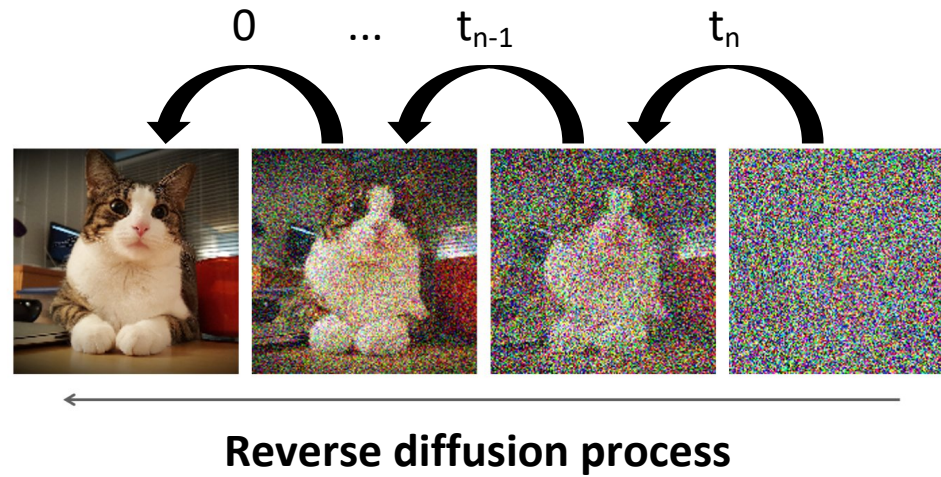
Latent Diffusion Model



Latent Diffusion Model



Latent Diffusion Model



D-Garment

Training

Inference

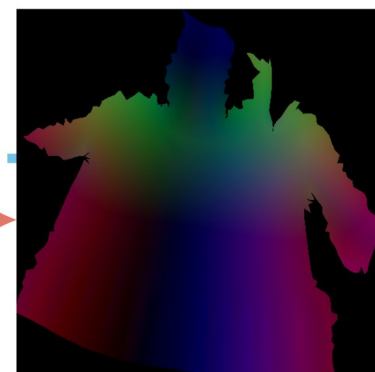
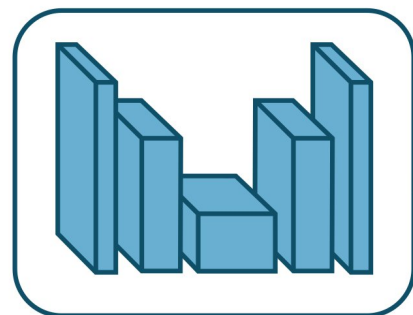
Body motion



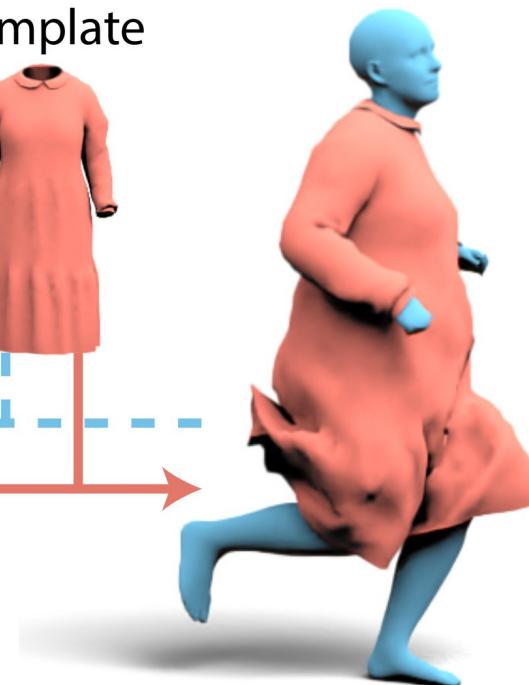
Cloth material

Bend
Density
Stretch

Latent Diffusion Model



Template



Results



Fitting to point clouds



(a) Fixed material

(b) Optimized material

Thank you for your attention

<https://dumoulina.github.io/d-garment/>

References

Mahmood et al, 2021. AMASS: Archive of Motion Capture As Surface Shapes.

Armando et al, 2023. 4DHumanOutfit: a multi-subject 4D dataset of human motion sequences in varying outfits exhibiting large displacements.

Wang et al, 2024. 4D-DRESS: A 4D Dataset of Real-world Human Clothing with Semantic Annotations.

Korosteleva et al, 2024. GarmentCodeData: A Dataset of 3D Made-to-Measure Garments With Sewing Patterns.

Physical metrics

$$E_c = \frac{100}{|U|} \sum_{v \in U} \delta_{\text{in}}(v, \mathcal{B}),$$

$$E_s = |\Psi_s(\mathcal{M}) - \Psi_s(\hat{\mathcal{M}})|,$$

$$E_b = \sqrt{\frac{1}{|E|} \sum_{e \in E} (\Theta(e) - \Theta(\hat{e}))^2},$$

Quantitative comparison

	Unseen body shape							Unseen motion							Time
	Shape Similarity			Physical Validity				Shape Similarity			Physical Validity				
	$E_v \downarrow$	$E_{CD} \downarrow$	$E_n \downarrow$	$E_c \downarrow$	$E_b \downarrow$	$E_s \downarrow$	$E_d \downarrow$	$E_v \downarrow$	$E_{CD} \downarrow$	$E_n \downarrow$	$E_c \downarrow$	$E_b \downarrow$	$E_s \downarrow$	$E_d \downarrow$	
HOOD	14.10	1.49	0.59	1.69	0.80	4.81	9.46	21.21	2.37	0.65	1.67	0.88	4.71	16.68	0.08s
Cont.Craft	9.69	0.43	0.53	1.43	0.72	6.31	5.03	11.10	0.48	0.56	1.25	0.74	4.42	7.13	0.23s
MGDDG	8.31	0.33	0.56	1.10	0.81	27.60	4.02	9.53	0.38	0.59	1.13	0.84	36.51	4.95	0.35s
<i>D-Garment</i>	3.49	0.10	0.41	0.54	0.60	3.94	1.51	6.14	0.25	0.48	0.70	0.64	5.00	2.88	0.13s
	Unseen material							Unseen all factors							
	Shape Similarity			Physical Validity				Shape Similarity			Physical Validity				
	E_v	E_{CD}	E_n	E_c	E_b	E_s	E_d	E_v	E_{CD}	E_n	E_c	E_b	E_s	E_d	
HOOD	25.31	3.24	0.67	1.58	0.91	4.61	20.96	19.75	2.52	0.61	1.79	0.82	7.65	14.88	
Cont.Craft	10.28	0.46	0.57	1.30	0.73	5.62	5.68	9.75	0.38	0.53	1.08	0.70	7.59	6.34	
MGDDG	8.68	0.34	0.58	1.00	0.84	29.08	3.77	8.51	0.34	0.56	0.96	0.81	31.23	4.28	
<i>D-Garment</i>	3.41	0.10	0.42	0.43	0.59	5.08	1.64	4.94	0.19	0.45	0.72	0.59	7.02	2.34	

Groundtruth



D-Garment



Hood



ContourCraft



MGDDG

