# Physics-guided Shape-from-Template
# Monocular Video Perception through Neural Surrogate Models

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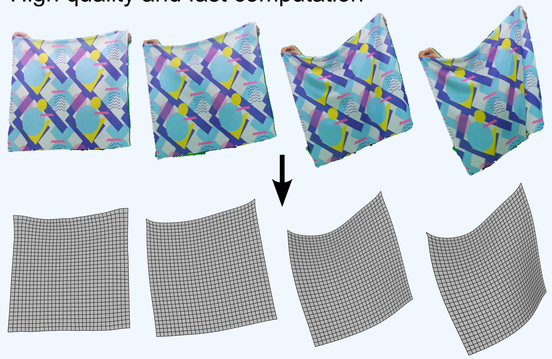
## Introduction and Overview

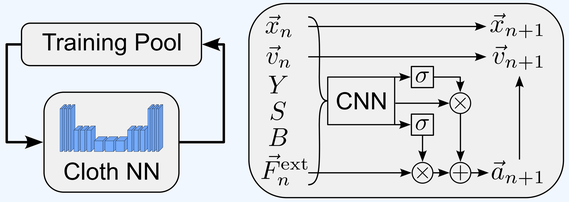
**Problem [1, 2]:**
- 3D reconstruction of dynamic cloth motion
- Monocular RGBA video sequence
- Known template mesh and camera parameters

**Goal:**
- Realistic sequence of deforming meshes
- High quality and fast computation

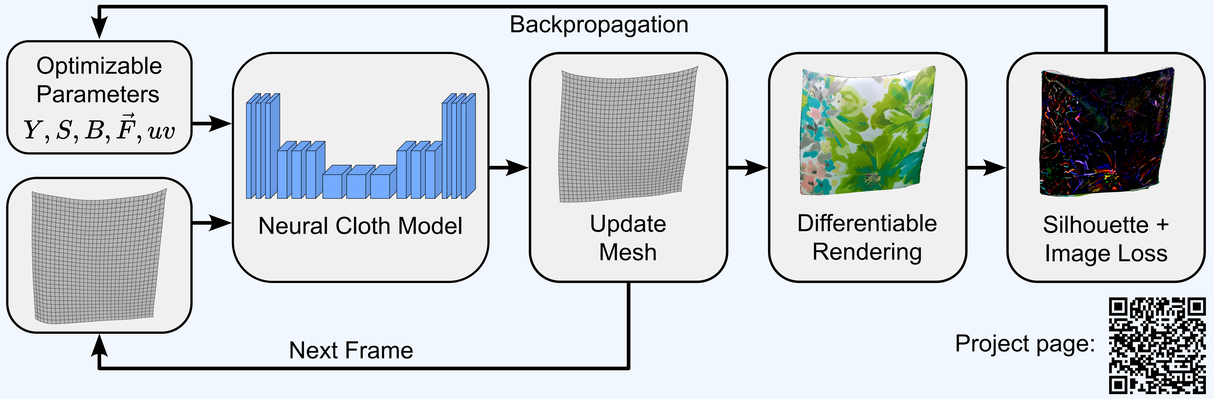


## Network Training

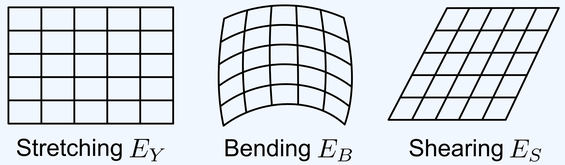
- Regular 32 x 32 square grid mesh
- Normalize length, time, and mass of the cloth
- Start in flat rest state with random parameters
- Fill training pool with learned results

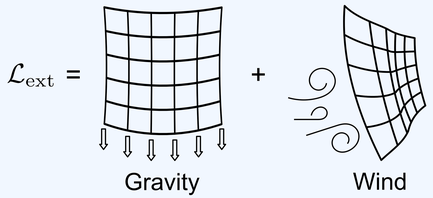



## Pipeline




## Physics-informed Loss



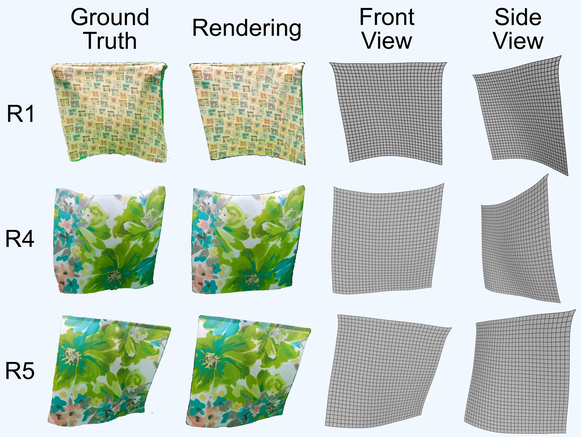




- Energy-based loss function [3]

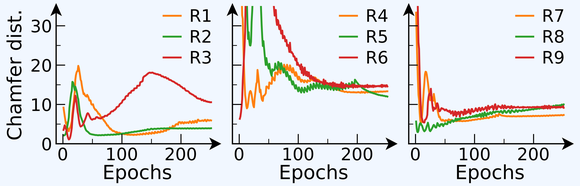
$$\mathcal{L}_{\text{cloth}} = E_Y + E_B + E_S + \mathcal{L}_{\text{ext}} + \mathcal{L}_{\text{inertia}}$$

## Qualitative Results

- Smooth and stable reconstruction
- Realistic motion due to a physical simulation




## Quantitative Results




- Quality comparable to state-of-the-art
- Symmetric Chamfer distance [x$10^{-4}$]:

| Method | R3 | R4 | R5 | R7 | R8 | R9 |
|---|---|---|---|---|---|---|
| $\phi$-SfT [2] | **7.9** | **10.3** | 14.4 | 9.1 | **3.7** | **2.9** |
| Ours | 12.5 | 14.5 | **11.7** | **6.9** | 10.1 | 8.6 |
| Ratio | 1.59 | 1.41 | 0.81 | 0.76 | 2.70 | 2.94 |

- 400 – 500 times faster optimization
- Runtime in minutes:

| Method | R3 | R4 | R5 | R7 | R8 | R9 |
|---|---|---|---|---|---|---|
| $\phi$-SfT [2] | 1204 | 1453 | 1152 | 1035 | 1186 | 1157 |
| Ours | **3.07** | **2.48** | **3.03** | **2.58** | **2.55** | **2.47** |
| Speedup | 393 | 585 | 380 | 412 | 465 | 469 |

## Acknowledgements and References

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[1] Adrien Bartoli, Yan Gérard, François Chadebecq, TobyCollins, and Daniel Pizarro. **Shape-from-template**. IEEE TPAMI, 37(10):2099–2118, 2015.

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