ClothBot: Cloth Manipulation using Value Network

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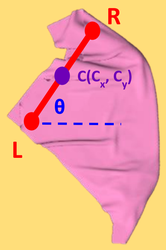
Introduction:

We investigate high-velocity dynamic actions such as fling for deformable object manipulation task of cloth unfolding. Cloth manipulation is extremely challenging due to cloth's complex dynamics, infinite DoF and severe self-occlusions.

Input-Output:

Input: Top-down RGB image $I \in \mathbb{R}^{H \times W \times 3}$

Output: Set of two fling grasp points $L, R \in \mathbb{R}^2$ parameterized as $\{C_x, C_y, \theta, w\}$ where $w = \|\overline{LR}\|$ and $C = \{C_x, C_y\}$



Framework details:

- **Simulation Environment:** built on PyFleX bindings via SoftGym
- **Training:** end-to-end, self-supervised
- **Supervision Signal:** coverage area
- **Action Prediction:** using spatial action maps

Dataset information:

Seed: Training begins with initial 2000 random configurations of a normal-sized cloth (0.4m × 0.65m)

Replay Buffer: Cloth configurations are stored after each step and sampled to initialize new episodes.

Evaluation:

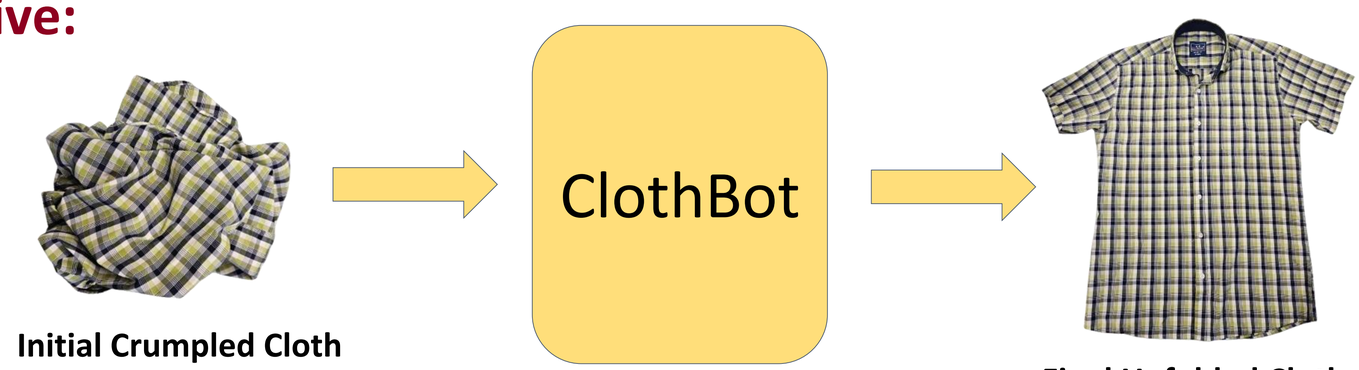
The model is evaluated on **200 unseen rectangular cloths**, featuring at least one edge > 0.70m (other edges sampled from [0.40m, 0.75m]), and **200 unseen T-shirts** from CLOTH3D's test split, resized to fit within the reach range, including tank tops, crop tops, and short/long sleeves.

References:

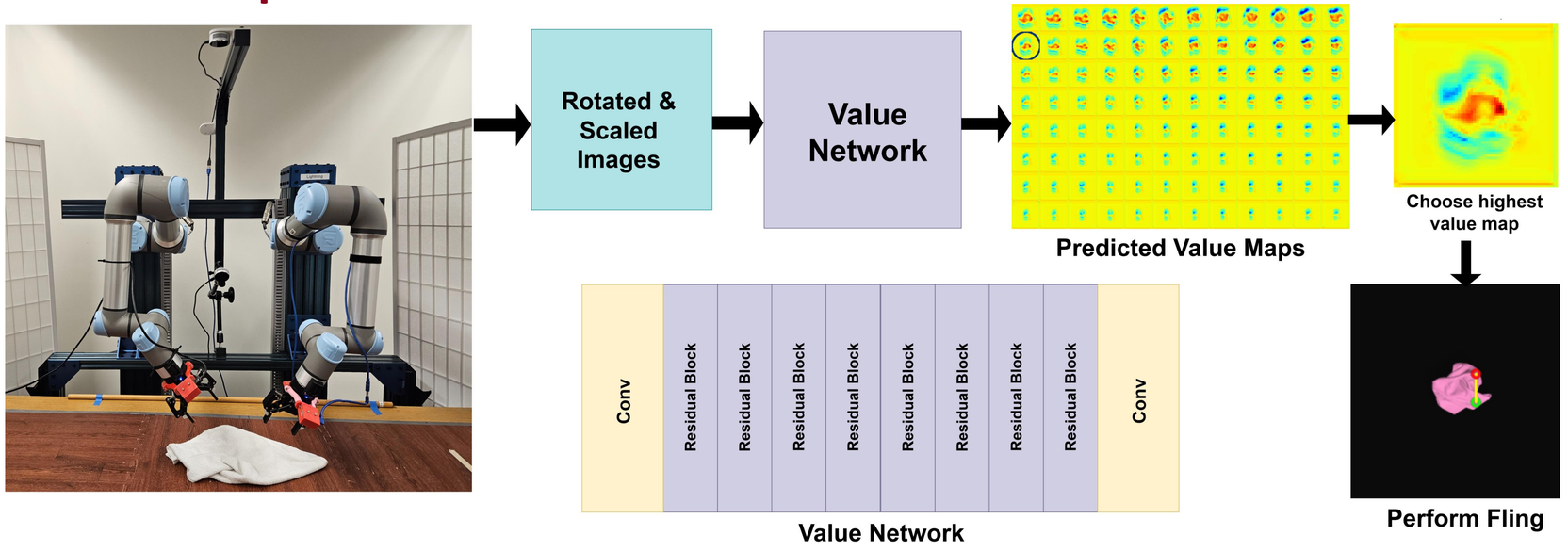
1. "Flingbot: The unreasonable effectiveness of dynamic manipulation for cloth unfolding",Huy Ha and Shuran Song, Conference on Robot Learning, 2022.
2. "Softgym: Benchmarking deep reinforcement learning for deformable object manipulation",Xingyu Lin, Yufei Wang, Jake Olkin, and David Held, Conference on Robot Learning, 2020.
3. "Unfolding the literature: A review of robotic cloth manipulation.", Longhini, Alberta et al, Annual Review of Control, Robotics, and Autonomous Systems 8, 2024.
4. "Learning particle dynamics for manipulating rigid bodies, deformable objects, and fluids.", Li, Y., Wu, J., Tedrake, R., Tenenbaum, J., & Torralba, A. (2018). arXiv:1810.01566.

*Teaching robots **dynamic actions** like **flings** to manipulate deformable objects like clothes*

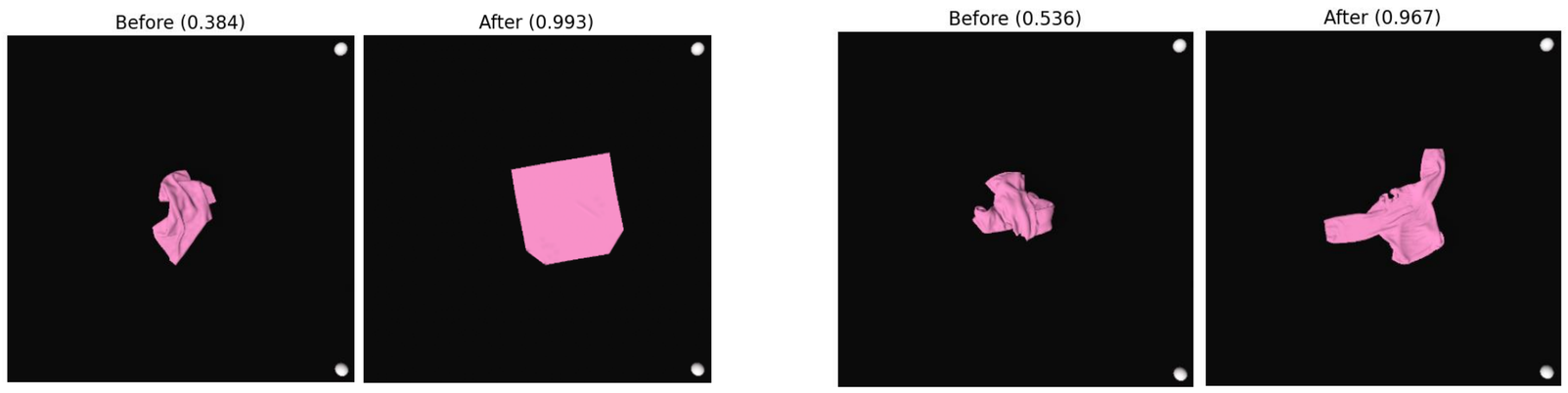
Objective:

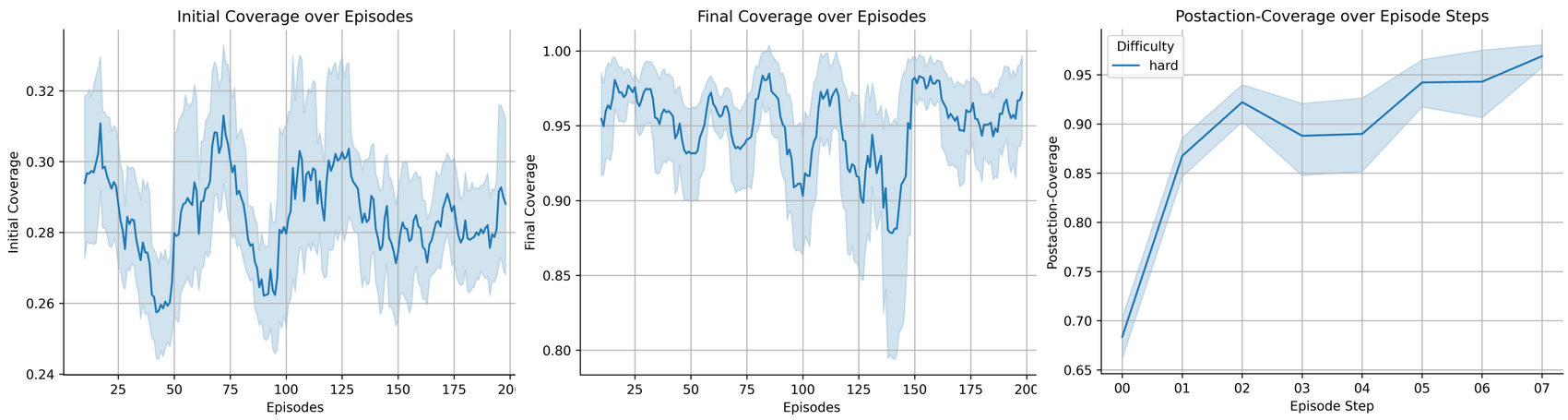


Network Pipeline:



Results:





Result distribution for 200 crumpled Rectangular cloths

Model Results	Rectangular Cloths (200 rollouts)	Unseen T-shirts (200 rollouts)
Mean Coverage (MC)	95.09 %	87.68 %
MC in single first step/fling	87.1 %	87.3 %

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