Unsupervised Part-Based Disentangling of Object Shape
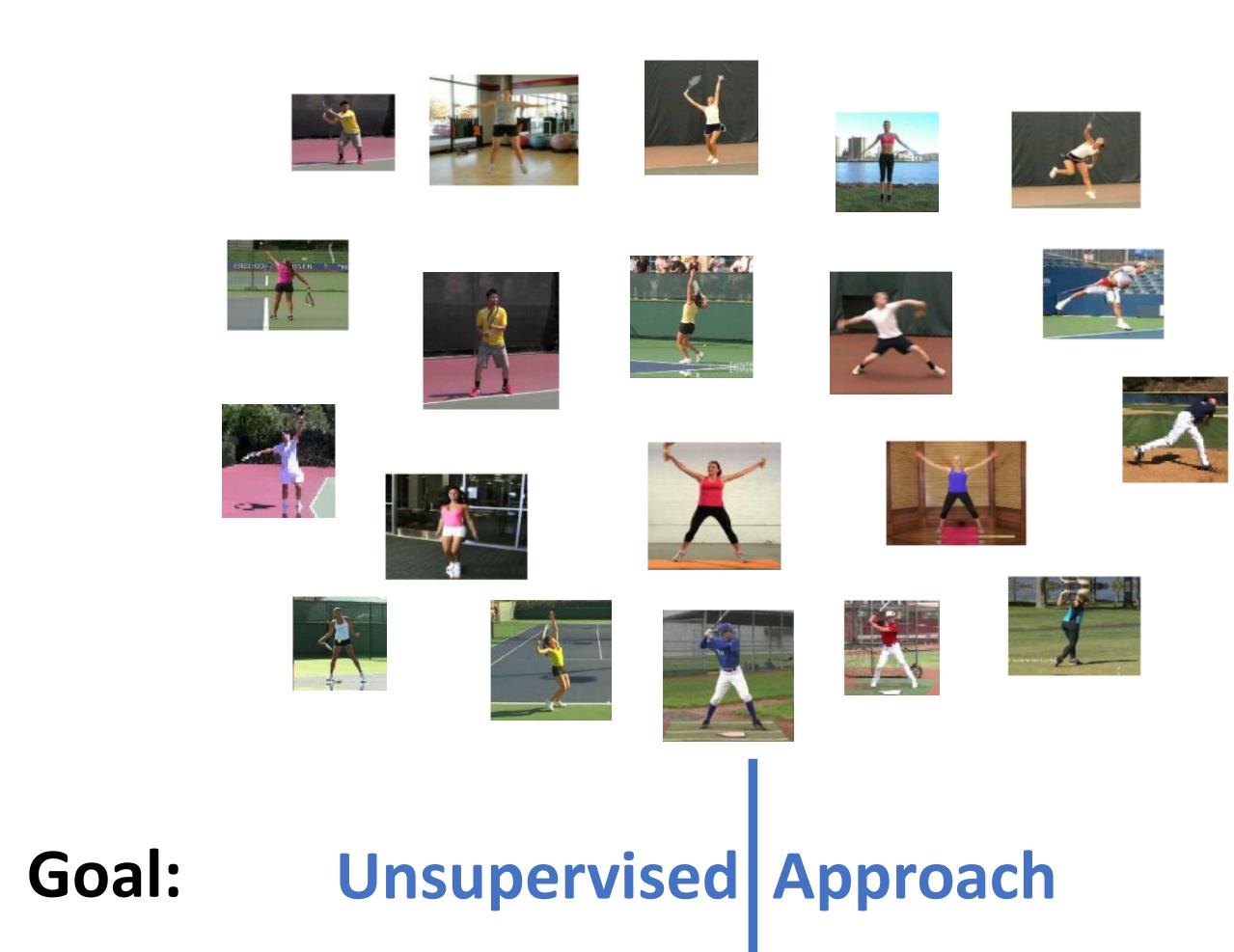
Dominik Lorenz   Leonard Bereska   Timo Milbich   Björn Ommer

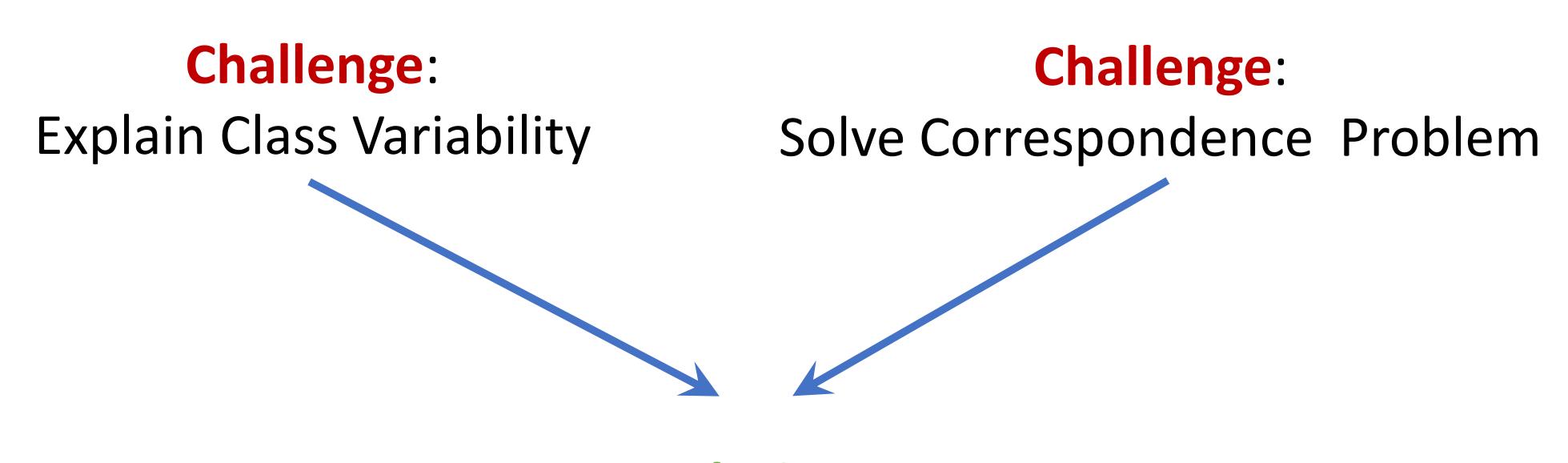Heidelberg Collaboratory for Image Processing / IWR, Heidelberg University
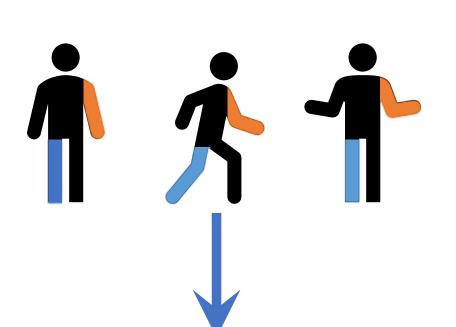
Motivation

Unlabeled Images

Goal: **Unsupervised Approach**

Representation of Category & its Variability

Challenge: Explain Class Variability
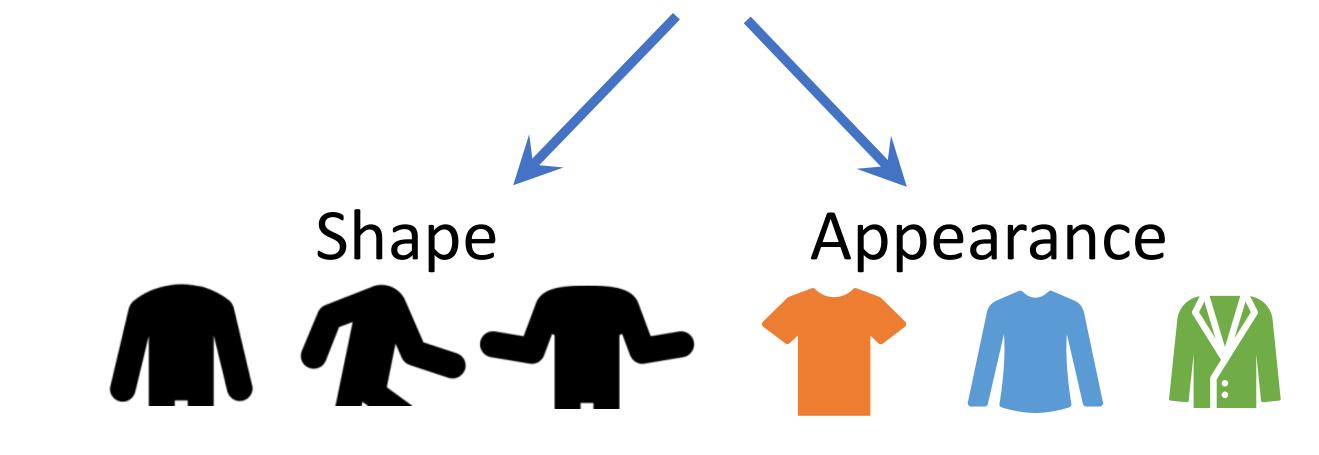
Challenge: Solve Correspondence Problem

Solution:

Unsupervised Learning of Consistent Parts across Images

Explaining Class Variability by **Unsupervised** Part-Based Disentangling
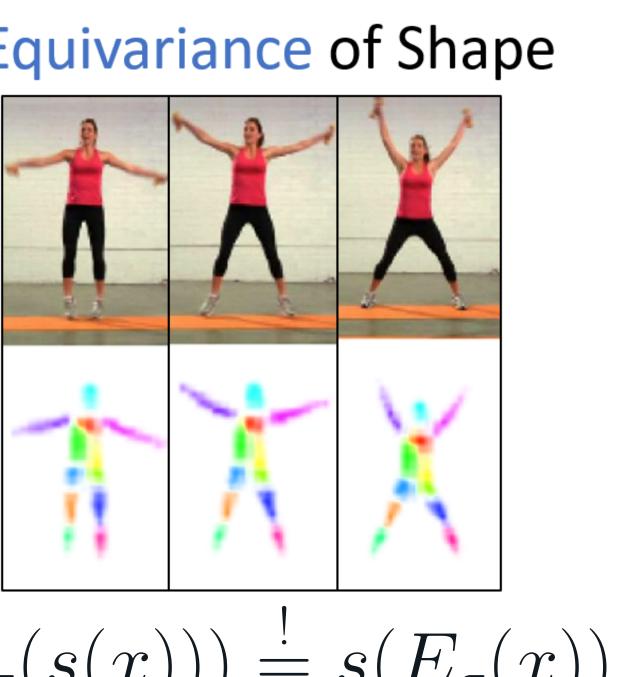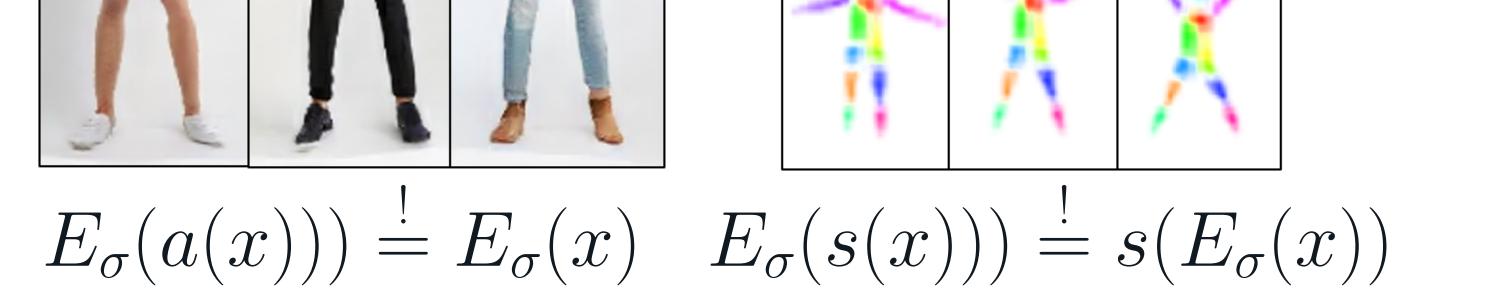
Shape   Appearance

Transforming

How to Disentangle Shape and Appearance? → **Invariance** Constraints

How should Shape Transform under Spatial Transformations? → **Equivariant**

Invariance of Appearance   Invariance of Shape   Equivariance of Shape

$$E_\alpha(s(x)) \overset{!}{=} E_\alpha(x) \qquad E_\sigma(a(x)) \overset{!}{=} E_\sigma(x) \qquad E_\sigma(s(x)) \overset{!}{=} s(E_\sigma(x))$$
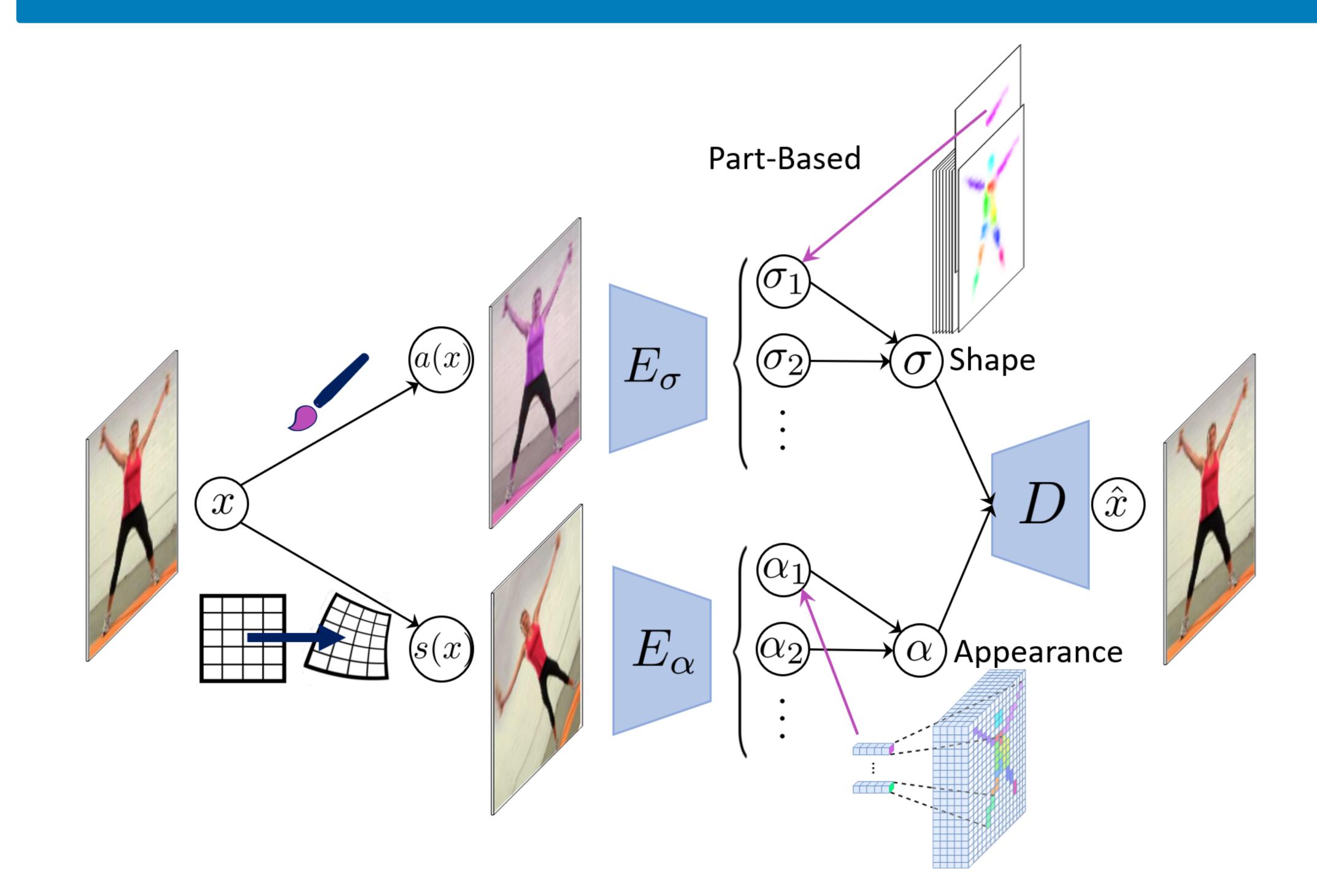
Approach

- Combining Invariance Constraints with Reconstruction:

$$\mathcal{L}_{rec} = \|x - D(\alpha(s(x)), \sigma(a(x)))\|_1$$

- Enforcing Equivariance:

$$\mathcal{L}_{equiv} = \sum_i \lambda_\mu \|\mu[\sigma_i(s(x))] - \mu[s(\sigma_i(a(x)))]\|_2$$
$$+ \lambda_\Sigma \|\Sigma[\sigma_i(s(x))] - \Sigma[s(\sigma_i(a(x)))]\|_1$$

Finding Part Correspondences

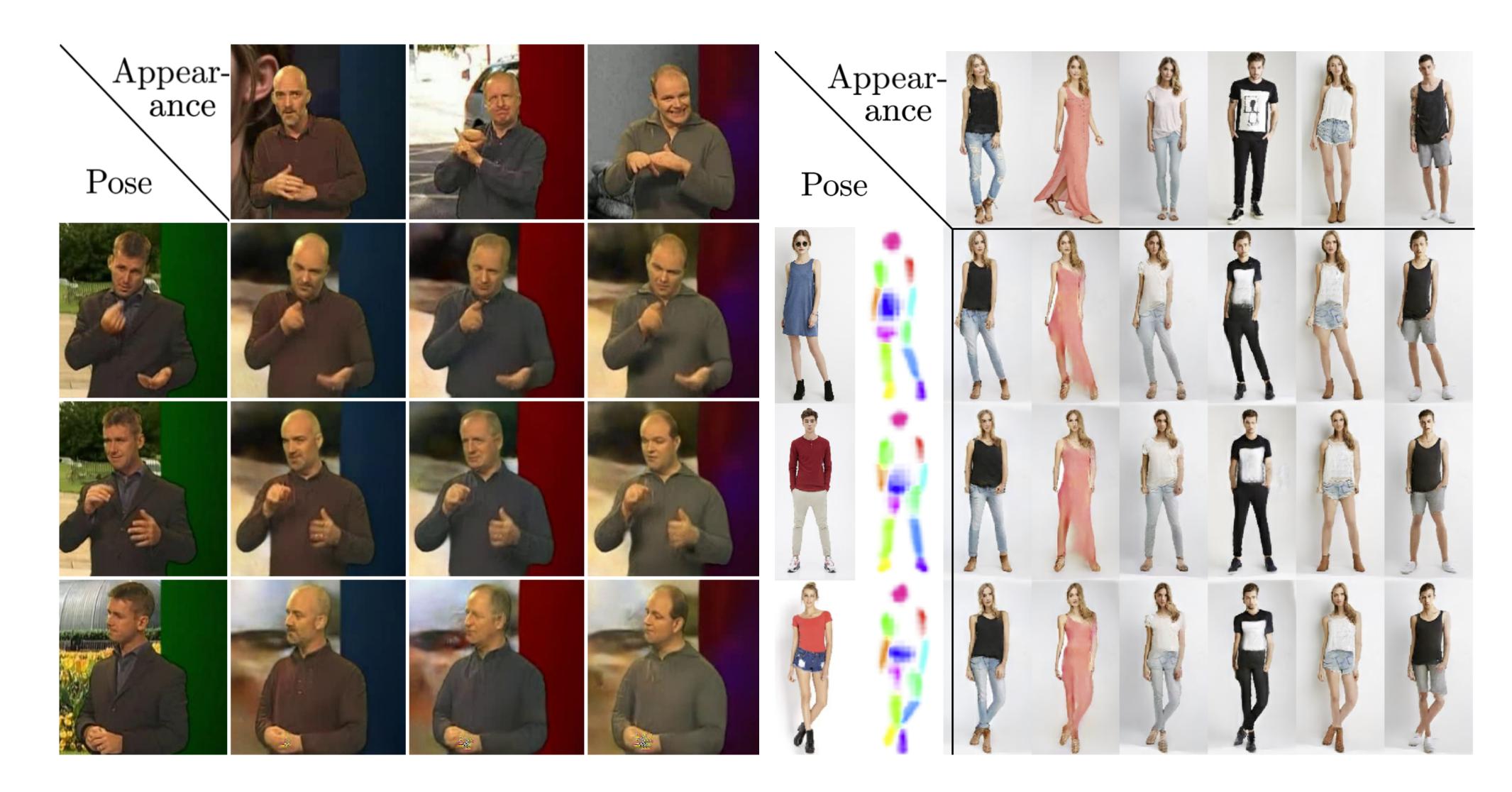Unsupervised Correspondences   Unsupervised Landmark Learning

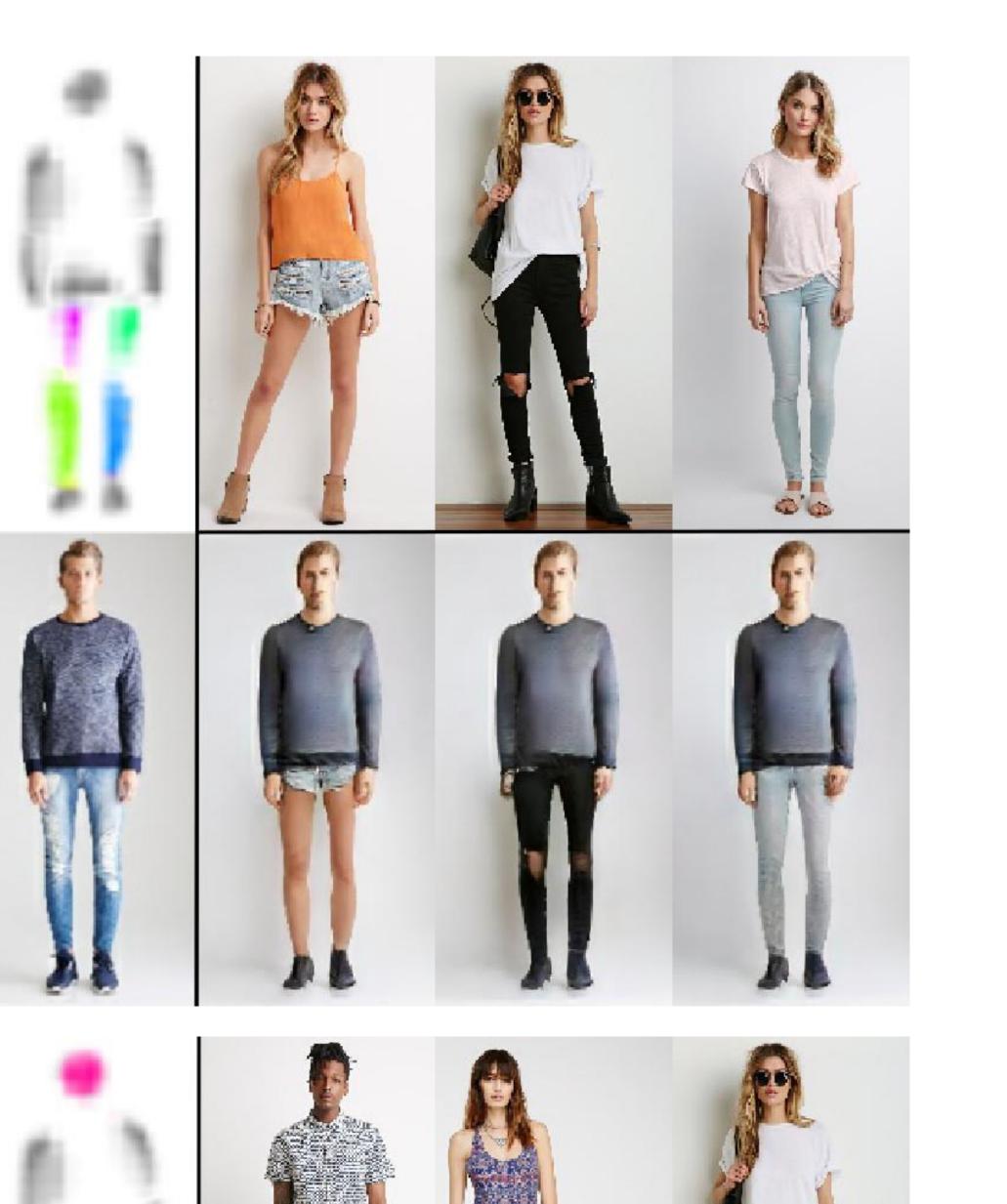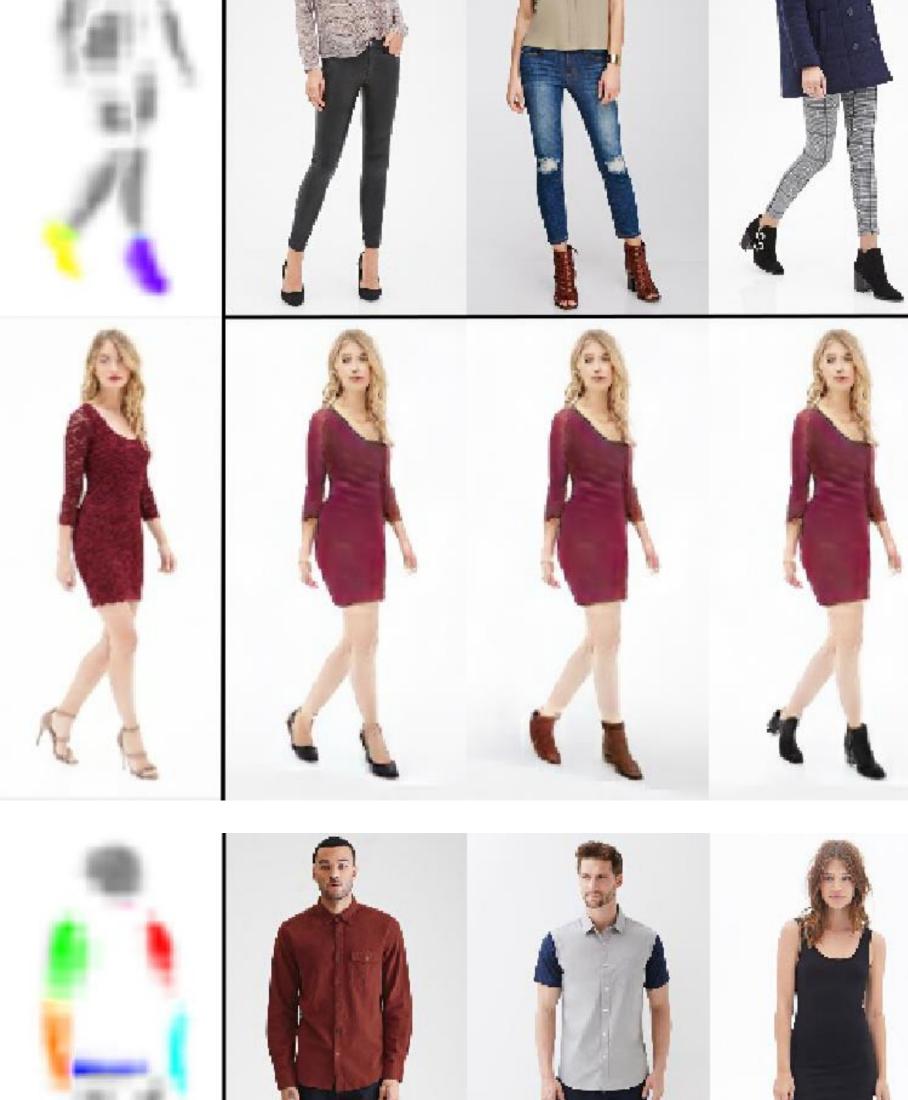| Landmark regression, mean error in pixels					Accuracy in PCK	
Dataset	Cat		MAFL	CUB	Human	BBC Pose	Accuracy
# KP	10	20	10	10	16	supervised	
Thewlis [3]	26.76	26.94	6.32	-	7.51	Pfister [2]	88.0%
Jakab [1]	-	-	**3.19**	-	-	unsupervised	
Zhang [4]	15.35	14.84	3.46	5.36	4.14	Jakab [1]	68.4%
Ours	**9.88**	**9.30**	3.24	**3.91**	**2.79**	Ours	**74.5%**

Disentangling Shape and Appearance

Disentangled representation allows to alter shape and appearance to synthesize new images.
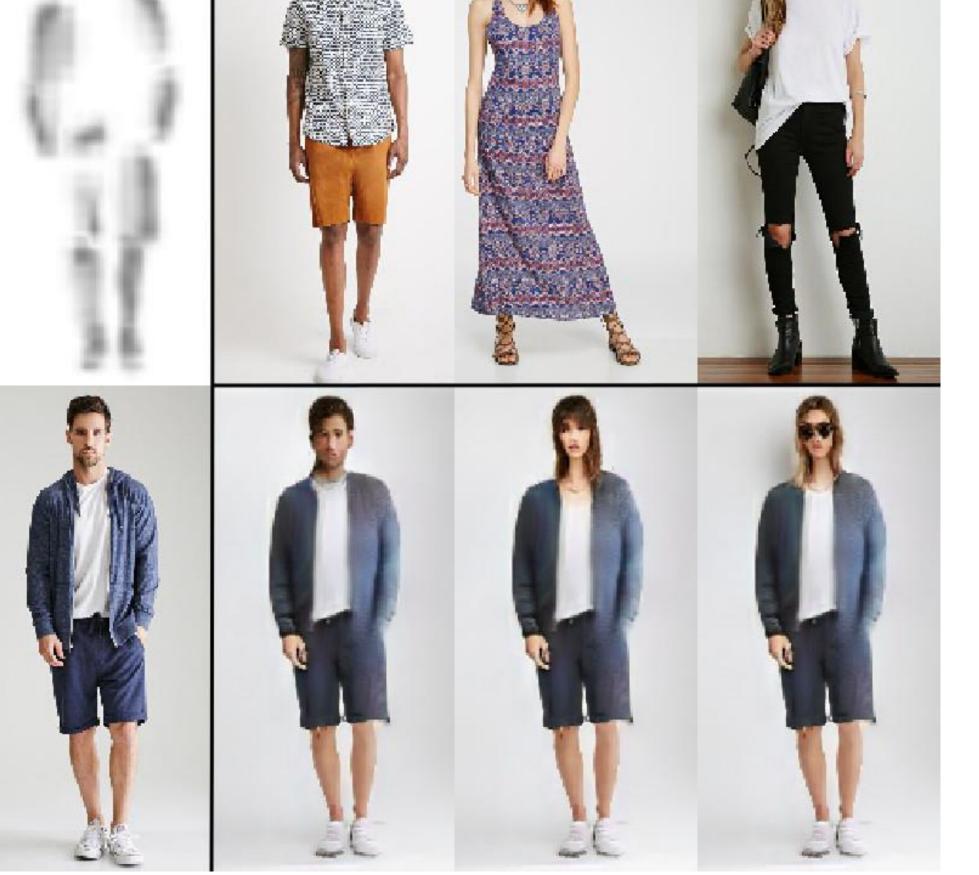

Part-Wise Appearance Transfer

Part-based representation enables local changes in generated images.

Take-Aways

- Unsupervised disentangling of shape and appearance by constraining transformation behavior.

- Unsupervised part learning by generating from localized appearance and shape

Project Page

References

[1] Tomas Jakab et al. In: *NIPS* (2018).

[2] Tomas Pfister, James Charles, and Andrew Zisserman. In: *ICCV*. 2015.

[3] James Thewlis, Hakan Bilen, and Andrea Vedaldi. In: *ICCV*. 2017.

[4] Yuting Zhang et al. In: *CVPR*. 2018.