

# *Geometric Autoencoders*

*What You See is What You Decode*

Philipp Nazari, Sebastian Damrich, Fred A. Hamprecht

@ ICML 2023

# *Problem Setting*

- Problem: encoder need not encode faithfully
- Not visible in latent space

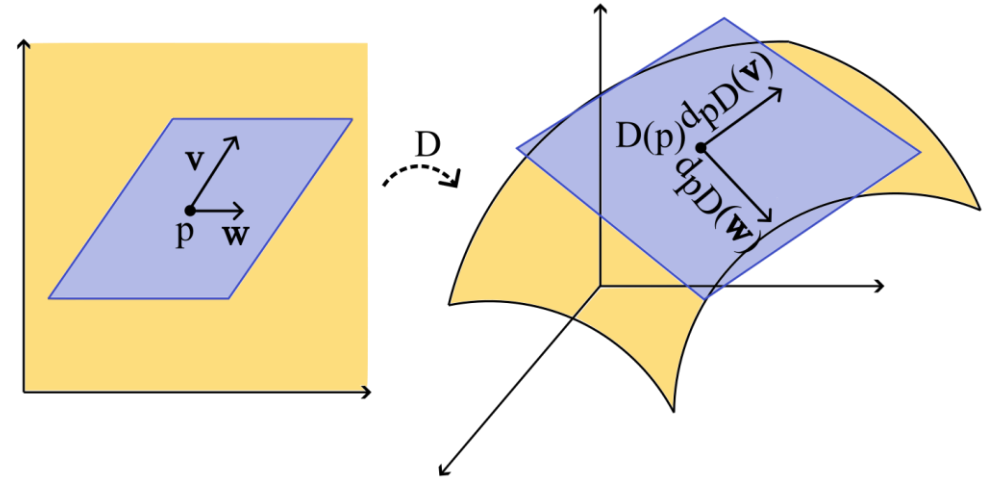


(a) Unfaithfull embedding of MNIST



(a) Faithfull embedding of MNIST

# Pullback Metric



- Output Space carries Euclidean metric  $g$
- Pullback:
- In Coordinates:

$$D^*g_p(v, w) = g_{D(p)}(d_p Dv, d_p Dw)$$

$$\langle \cdot, \cdot \rangle_p := D^*g_p = (J_p D)^t J_p D \in \mathbb{R}^{2,2}$$

# Regularization

$$\mathcal{L}_1 \approx \text{Var}_{x \sim u(X)} \left[ \log \left( \det \left( (J_{E(x)} D)^t J_{E(x)} D \right) \right) \right]$$



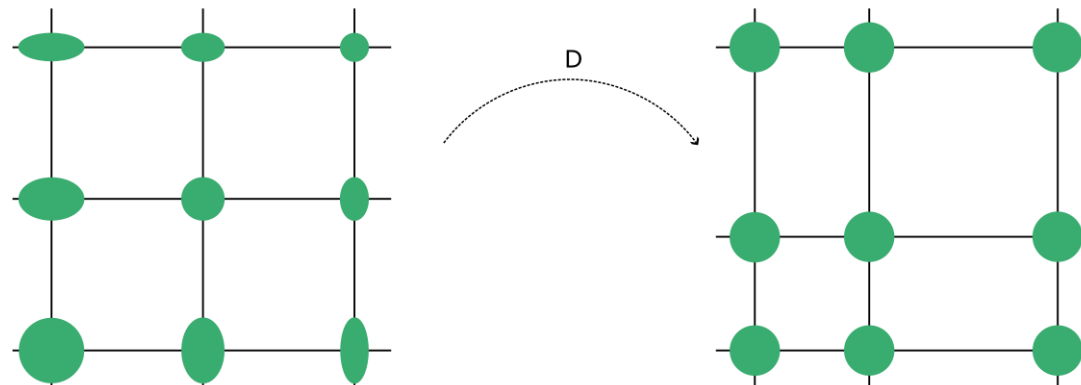
(a) Vanilla Embedding of MNIST



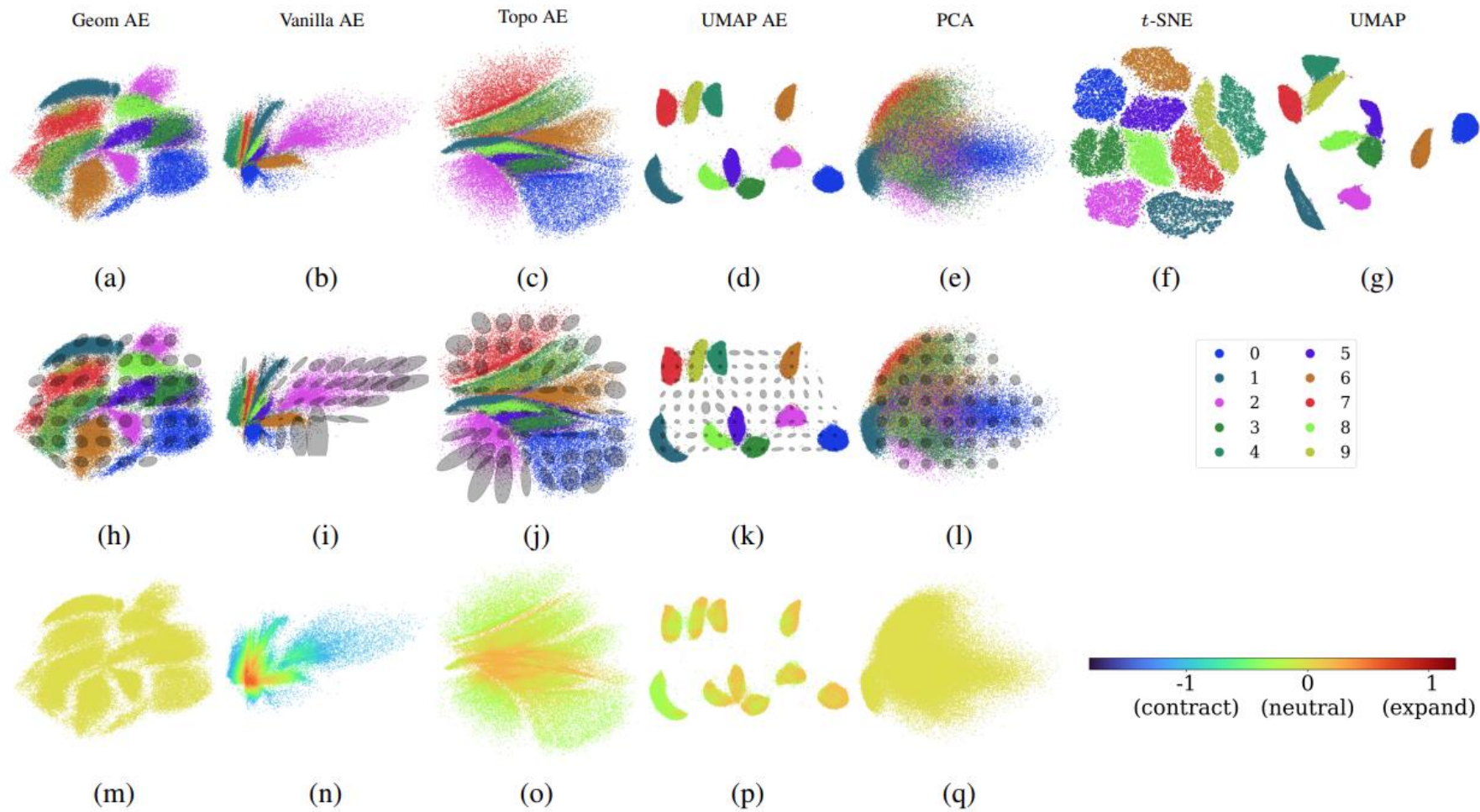
(a) Geometric Embedding of MNIST

# *Diagnostics*

- 1<sup>st</sup> color-code Jacobian Determinant
- 2<sup>nd</sup> indicatrices (Visualize pullback metric tensor field)
- Which directions are squeezed / expanded? How does decoder distort space?



# Results



# Results

	LOCAL				GLOBAL		
	KL <sub>0.1</sub>	KNN	TRUST	STRESS	KL <sub>100</sub>	SPEAR	⟨RANK⟩
GEOM AE (OURS)	<b><u>2.6</u></b>	3.4	<b>2.2</b>	3.4	<b><u>2.2</u></b>	3.4	<b><u>2.9</u></b>
VANILLA AE	5.4	5.4	4.4	6.2	4.8	5.0	5.2
TOPO AE	<b>2.8</b>	4.8	4.2	4.8	<b>2.2</b>	<b>1.8</b>	<b>3.4</b>
UMAP AE	4.4	<b><u>1.6</u></b>	<b><u>1.8</u></b>	<b>2.6</b>	6.0	5.0	3.6
UMAP	5.2	3.4	4.0	<b><u>1.6</u></b>	5.6	4.2	4.0
<i>t</i> -SNE	4.0	<b>2.4</b>	4.4	6.8	3.8	7.0	4.7
PCA	3.6	7.0	7.0	2.6	3.4	<b><u>1.6</u></b>	4.2

***Thank You for Your Attention!***