I-Con: A Unifying Framework for Representation Learning

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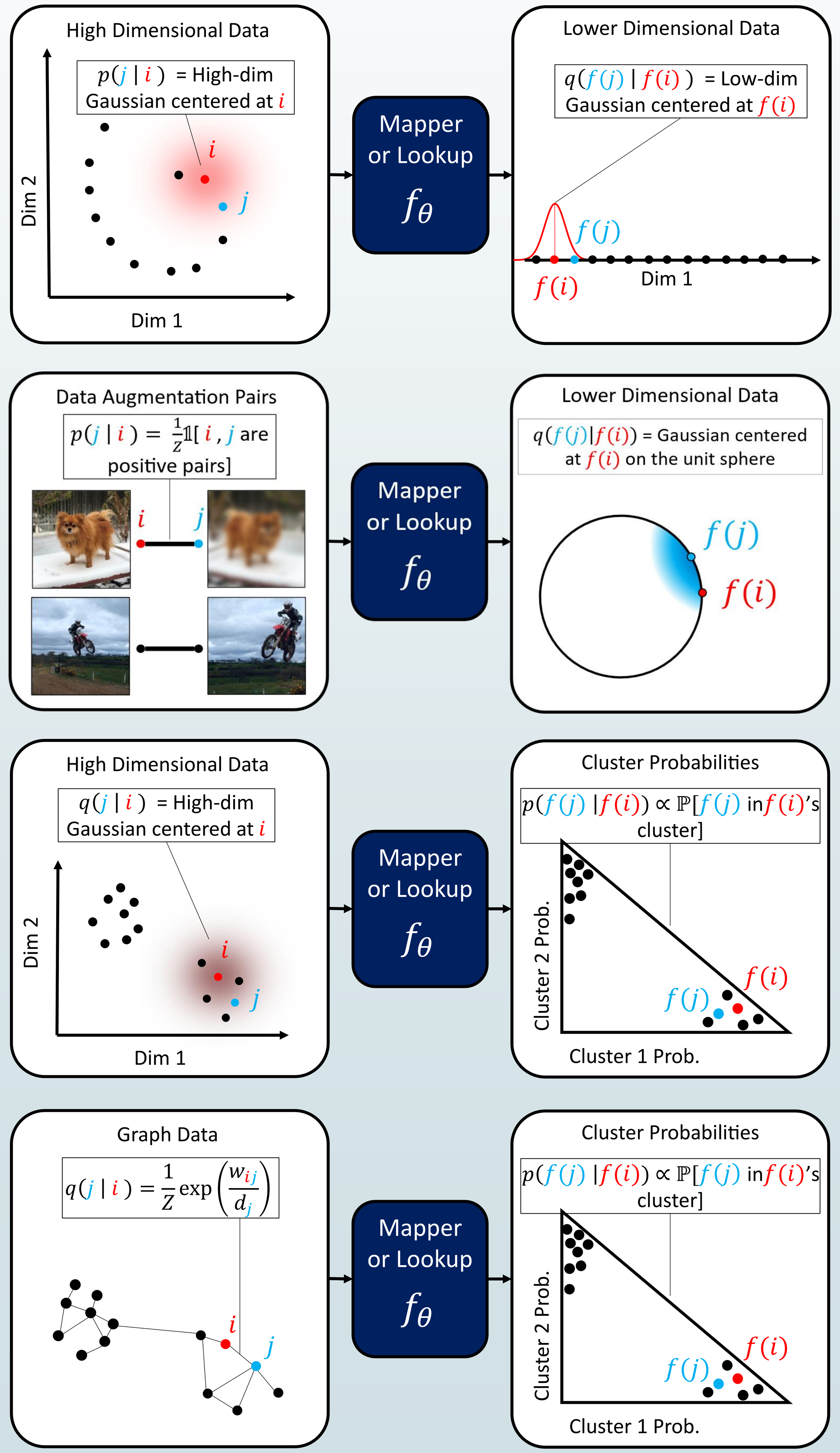
Unifying Clustering, Dim. Reduction, Contrastive Learning, and Spectral Graph Methods

Dimensionality Reduction (SNE)

Contrastive Learning (InfoNCE)

Clustering (K-Means)

Spectral Clustering



We introduce **a periodic table of machine learning** based on a single equation that **unifies >20 loss functions.** We use this to derive a new state-of-the-art unsupervised image classifier.

The Information-Contrastive (I-Con) Loss:

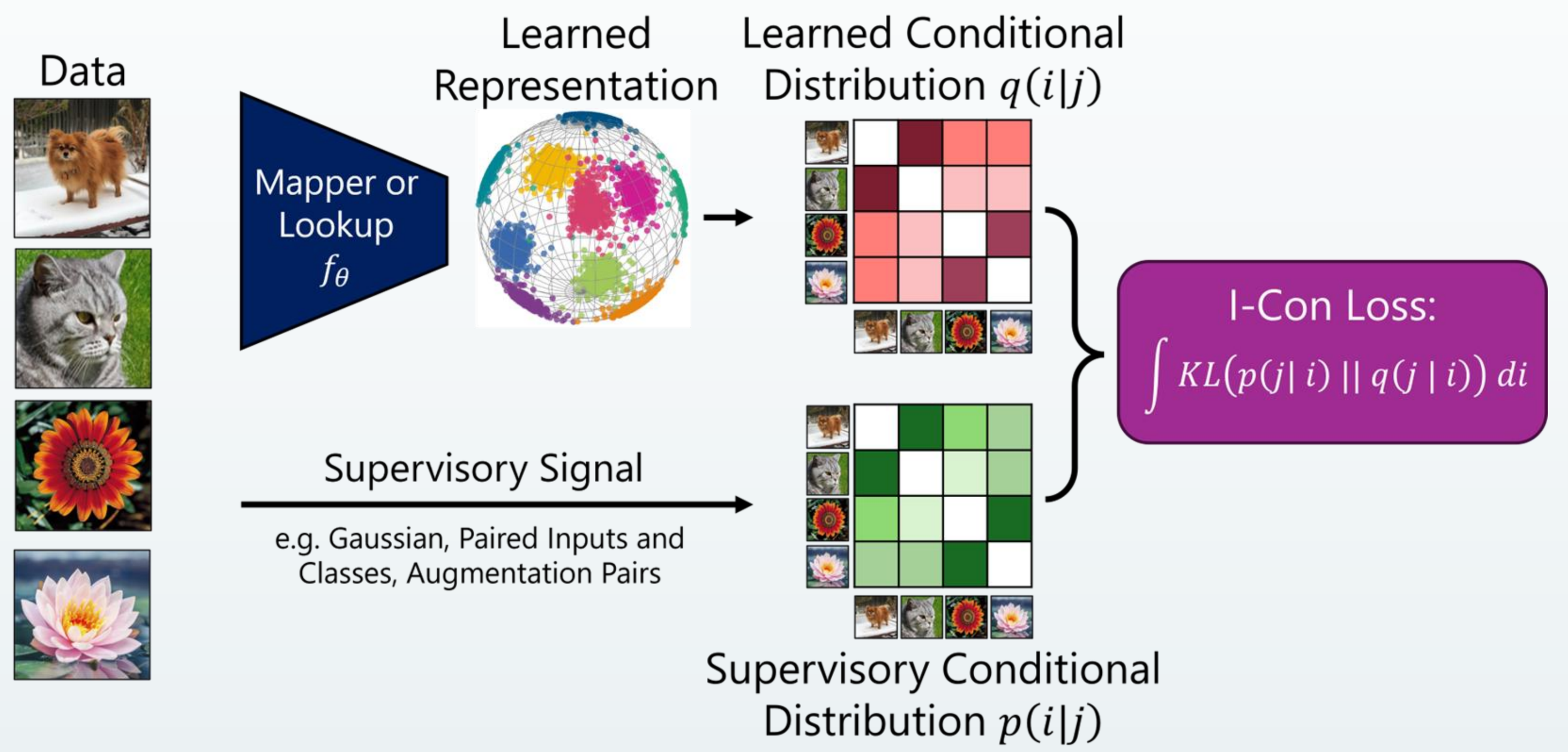
$$L = \int KL\big(p(j|i) \parallel q(j|i)\big)\, di$$

Supervisory Signal (columns) / **Learned Representation** (rows)

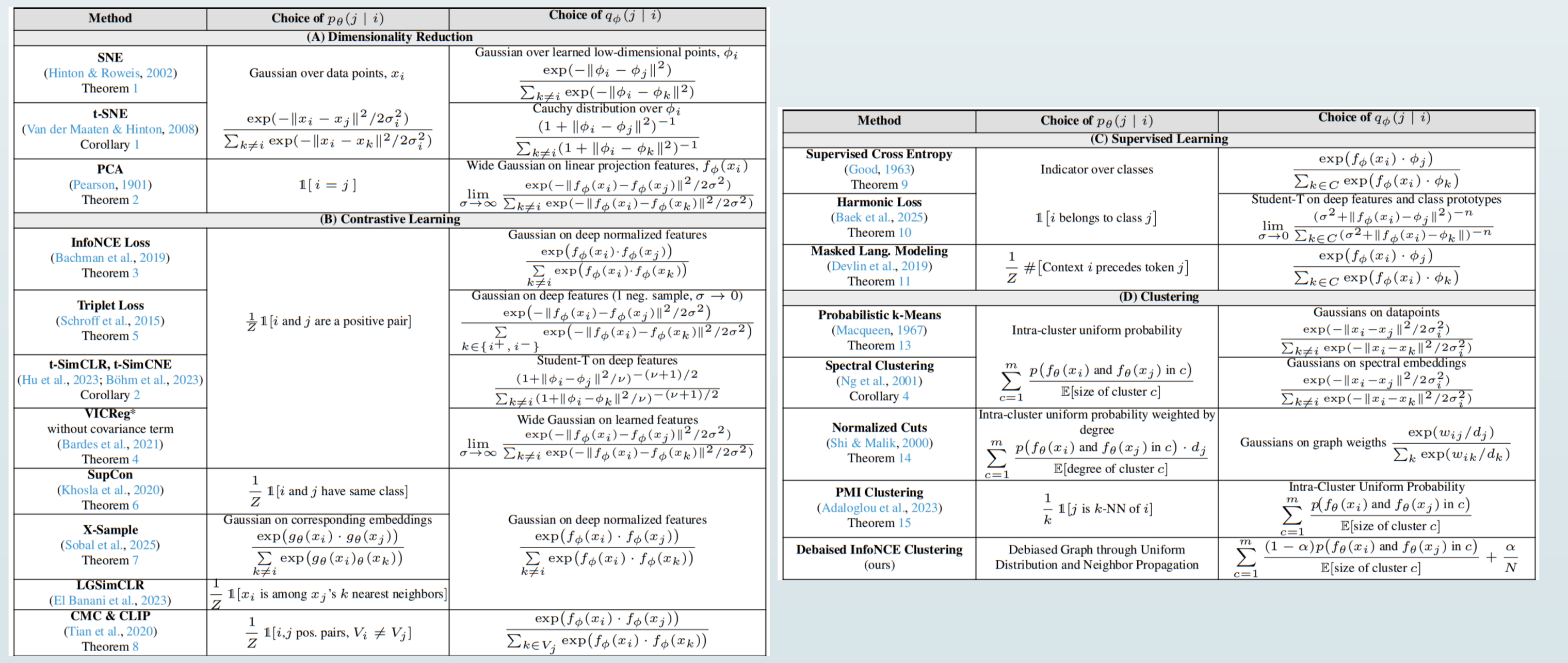
	Gaussian	Student-T	Identity	Graph Kernel Weights	Uniform over K-Neighbors	Uniform over Positive Pairs	Cross-Modal Pairs	Uniform over Classes	Data-Label Pairs
Gaussian	SNE [Hinton 2002]; X-Sample CL [Sobal 2025]	Dual t-SNE		SNE Graph Embeddings	SNE with Uniform Affinities; LGSimCLR [El Banani 2023]	InfoNCE [Bachman 2019]; SimCLR [Chen 2020]; MoCoV3 [Chen 2021]	CLIP [Radford 2021]; CMC [Tian 2020]	SupCon [Khosla 2020]	Cross Entropy [Good 1963]
Gaussian σ→∞			PCA [Pearson 1901]			VI-Reg [Bardes 2021]	Average Margin CLIP	Average Margin SupCon	
Gaussian σ→0						Triplet Loss [Schultz 2004]	Triplet CLIP	Triplet SupCon	Error rate
Student-T	t-SNE [Van der Maaten 2008]	Doubly t-SNE		t-SNE Graph Embedding	t-SNE with Uniform Affinities	t-SimCNE [Böhm 2023]; t-SimCLR [Hu 2023]	t-CLIP	t-SupCon	Harmonic Loss [Baek 2025]
Cluster Probabilities	K-Means [Macqueen 1967]	t K-Means		Normalized Cuts [Shi 2000]	DCD [Yang 2012]	NEW InfoNCE Clustering [Ours]		Supervised Clustering	

Dimensionality Reduction · Cluster Learning · Unimodal SSL · Multimodal SSL · Supervised Learning · Interpretation of Gaps

Architecture



Over 15 Theorems



Unsupervised Image Classification

Method	DiNO ViT-S/14	DiNO ViT-B/14	DiNO ViT-L/14
k-Means	51.84	52.26	53.36
Contrastive Clustering	47.35	55.64	59.84
SCAN	49.20	55.60	60.15
TEMI	56.84	58.62	–
Debiased InfoNCE Clustering (Ours)	**57.8** ± 0.26	**64.75** ± 0.18	**67.52** ± 0.28

Unsupervised (Hungarian) Accuracy on ImageNet-1K Validation Set