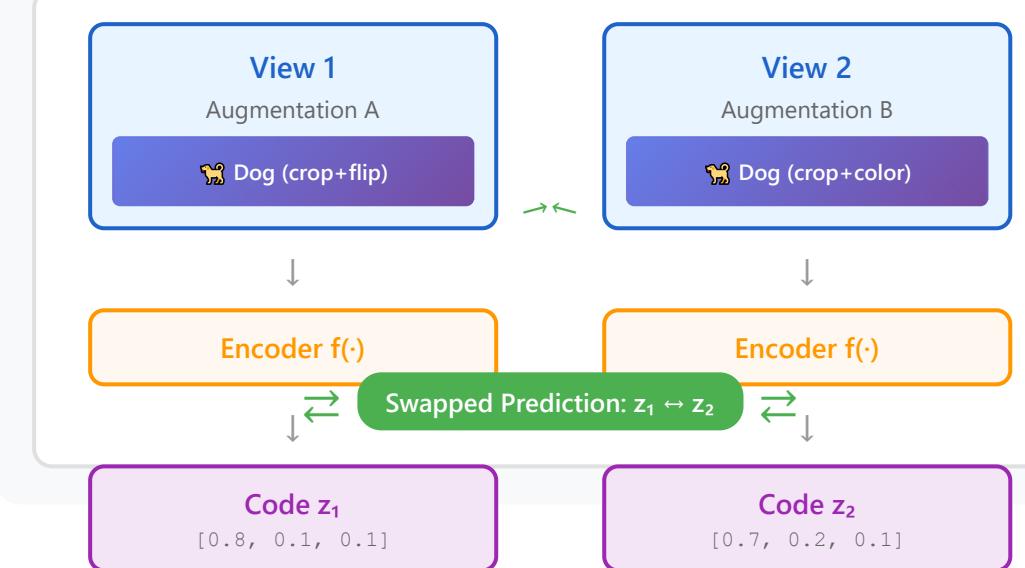




## DeepCluster

- ✓ Alternates clustering and representation learning
- ✓ Cluster assignments as pseudo-labels
- ✓ Iterative refinement process

## SwAV Architecture & Training Process



## SwAV

- ✓ Swapping Assignments between Views
- ✓ Online clustering with prototypes
- ✓ Learnable cluster centroids
- ✓ No pairwise comparisons needed



### Efficient

No pairwise comparisons



### Online

Real-time clustering



### Prototypes

Learnable centroids



### Scalable

Large datasets



State-of-the-Art Self-Supervised Learning Results



# DeepCluster Operating Principle

## Algorithm Flow

1

### Feature Extraction

Transform images into feature vectors using CNN

$$x \rightarrow f(x) \in \mathbb{R}^d$$

2

### K-means Clustering

Group features into K clusters

$$\text{assign: } \operatorname{argmin} \|f(x) - c_k\|^2$$

3

### Pseudo-label Assignment

Use cluster ID as pseudo-label

$$y_{\text{pseudo}} = \text{cluster\_id}$$

4

### Network Update

Train CNN with pseudo-labels (classification)

$$L = -\log P(y_{\text{pseudo}} | x)$$



### Problem: Trivial Solutions

All samples collapse into a single cluster



### Solution: Empty Cluster Reassignment

Fill empty clusters with samples from the largest cluster



# SwAV Operating Principle

## 1. Multi-Crop Augmentation

 224×224 ( $\times 2$ ) 96×96 ( $\times 4$ )

Generate multiple views with various crop sizes

## 2. Prototype Assignment

$$q = \text{softmax}(z \cdot C / \tau)$$

*z*: feature, *C*: prototypes,  $\tau$ : temperature

Soft-assign each view to prototypes

## 3. Swapped Prediction

$z_1 \rightarrow \text{predict } q_2$

$z_2 \rightarrow \text{predict } q_1$

Predict View 2 from View 1's code (and vice versa)

## 4. Loss Computation

$$L = \ell(z_1, q_2) + \ell(z_2, q_1)$$

Cross-entropy between predictions



### Online Clustering

Update prototypes every batch (no K-means needed)



### Sinkhorn-Knopp

Ensures balanced cluster assignment (equipartition)



### Memory Efficiency

No need to store negative pairs (vs SimCLR)