

# Unsupervised Image Classification

Dev Singh

CS Seminar: Machine Learning

May 23, 2022

# Overview

- ▶ Supervised methods for image classification require a “ground truth” which the model learns to assign images to.
- ▶ However, there is a high human burden for data-labeling.
- ▶ Unsupervised learning allows the model to assign the images (or other data) to categories within the latent space of the dataset.

# Important Concepts

1. Feature Extraction
2. Autoencoders
3. Clustering

# Feature Extraction

- ▶ “Learning the most important parts of an image.”
- ▶ Reliable feature extraction must preserve important features of the image.
- ▶ These features must be detectable even under various transformations (shear, rotation, etc.)
- ▶ High-contrast pixels such as edges are often targeted for this purpose.
- ▶ CNN-based architectures (such as ResNet) without the MLP classification head serve as effective feature extraction models.
- ▶ Output is called “embedding”, “feature representation”, or “latent-space representation” depending on the field.

# Autoencoders

- ▶ “Trained to increase the accuracy of the feature representation.”
- ▶ Use the opposite direction of the feature extraction model to “decompress” the feature representation.
- ▶ Compare the reconstructed version to the original dataset.
- ▶ Architecture is trained to reduce the loss (using functions such as Cross-Entropy Loss) between the two versions.
- ▶ When this loss is minimized, the feature representation most closely represents the original dataset.
- ▶ Often used as Variational Auto-Encoders, which learn the probability distribution instead of learning an function specific to the original dataset.

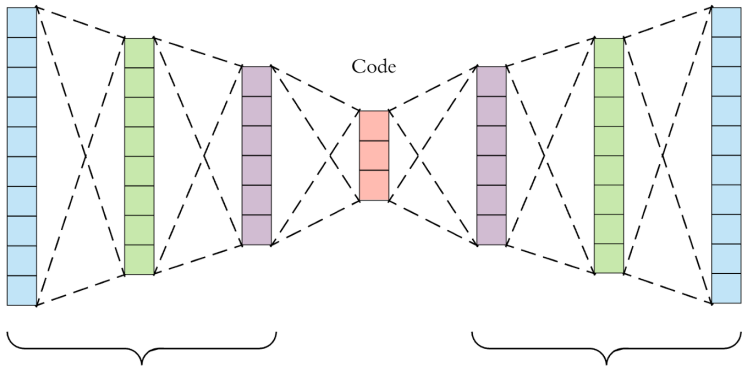
Input

Output

Code

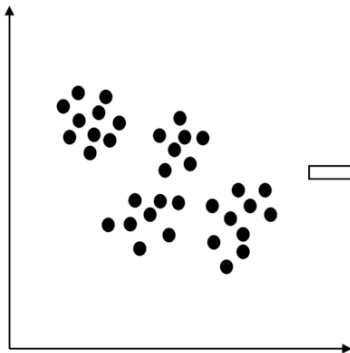
Encoder

Decoder

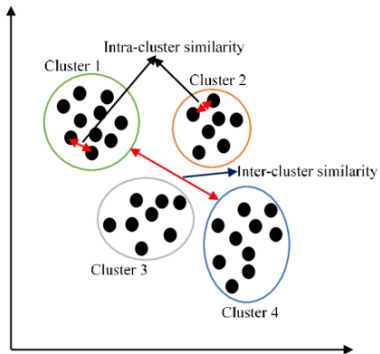


# Clustering

- ▶ “Group the feature representations together based on groupings present in the data.”
- ▶ Since feature representations are 1D outputs, they can be clustered using techniques such as  $k$ -means clustering or Power Iteration Clustering.
- ▶ Validation is applied to avoid empty-cluster and other trivial solutions during optimization.



a. Data objects



b. Clustered data objects



# Sources

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- ▶ Ian Goodfellow, Yoshua Bengio, Aaron Courville (2016). *Deep Learning*. MIT Press.
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- ▶ Wickramasinghe, C.S., Marino, D.L., Manic, M.. (2021). *ResNet Autoencoders for Unsupervised Feature Learning From High-Dimensional Data: Deep Models Resistant to Performance Degradation*, in IEEE Access, vol. 9, pp. 40511-40520, 2021, doi: 10.1109/ACCESS.2021.3064819.