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Deep Clustering with K-Means

Jarvis

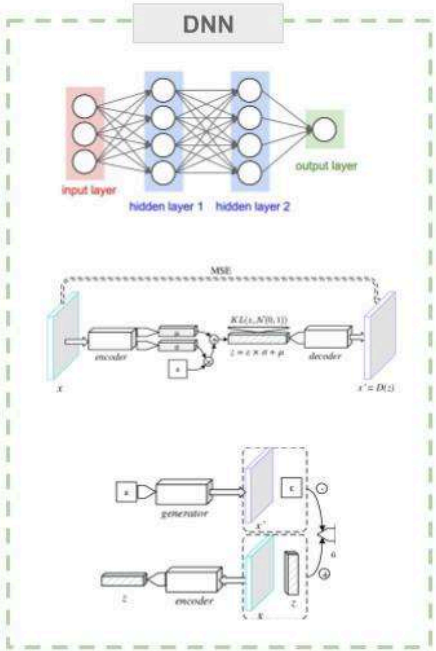
大纲

Framework Approaches End

Framework

Framework

Architecture



Network Loss

$$H((x_1, y_1), D) = -y_1 \log D(x_1) - (1 - y_1) \log(1 - D(x_1))$$

$$L_R = ||x - g_\phi(f_\theta(x))||^2$$

Clustering Loss

$$q_{ij} = \frac{\left(1+\|z_i-\mu_j\|^2/\alpha\right)^{-\frac{\alpha+1}{2}}}{\sum_{j'}\left(1+\|z_i-\mu_{j'}\|^2/\alpha\right)^{-\frac{\alpha+1}{2}}}$$

$$\|\boldsymbol{f}(\boldsymbol{x}_i) - \boldsymbol{M}\boldsymbol{s}_i\|_2^2$$

$$\mathcal{L}_{\mathrm{ELBO}}(\mathbf{x}) = E_{q(\mathbf{z},c|\mathbf{x})}[\log p(\mathbf{x}|\mathbf{z})] - D_{KL}(q(\mathbf{z},c|\mathbf{x})\|p(\mathbf{z},c))$$

Multi-Agent Artificial Intelligence Laboratory
East China Normal University

Framework

Loss

$$L = \lambda L_R + (1 - \lambda) L_C$$

Network Loss:

AutoEncoder

VAEs

GANs

Clustering Loss:

Cluster Assignment[0]

Cluster Regularization[1]

0. Provides cluster assignments directly(i.e. K-means loss)
1. Only enforce the network to preserve suitable discriminant infos

Framework

Metrics

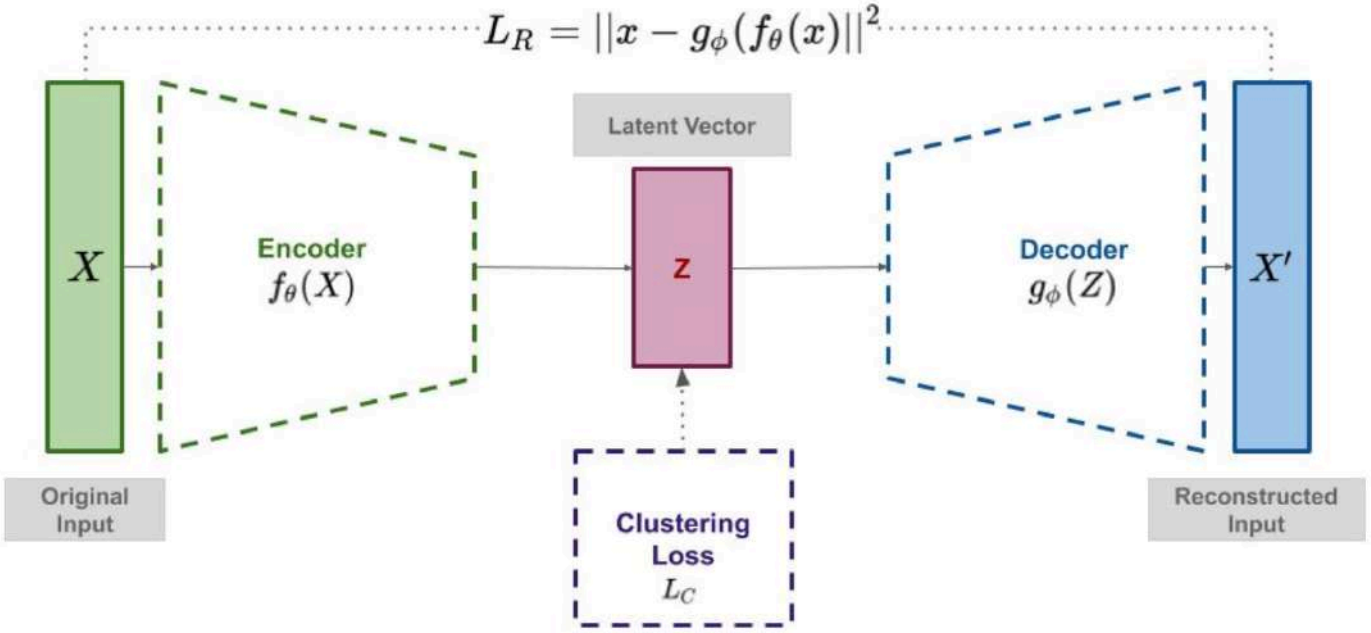
Accuracy: $$ACC = max_m \frac{\sum_{i=1}^{n} 1\{y_i = m(c_i)\}}{n}$$

(m is mapping func
c_i is cluster output)

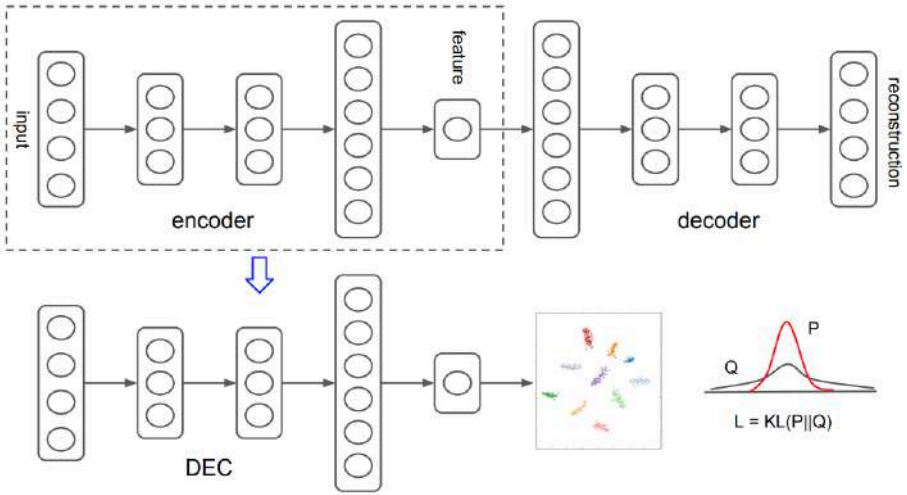
Normalized Mutual Information: $$NMI(Y, C) = \frac{I(Y, C)}{\frac{1}{2}[H(Y) + H(C)]}$$

Approaches

AutoEncoders based



Deep Embedded Clustering (DEC):



AutoEncoder

↓

KMeans-Init

↓

FineTune

* Unsupervised Deep Embedding for Clustering Analysis.ICML 2016

Deep Embedded Clustering (DEC):

$$q_{ij} = \frac{(1 + \|z_i - \mu_j\|^2/\alpha)^{-\frac{\alpha+1}{2}}}{\sum_{j'}(1 + \|z_i - \mu_{j'}\|^2/\alpha)^{-\frac{\alpha+1}{2}}},$$

$$L = \mathrm{KL}(P\|Q) = \sum_i \sum_j p_{ij} \log \frac{p_{ij}}{q_{ij}}.$$

How to choose P?

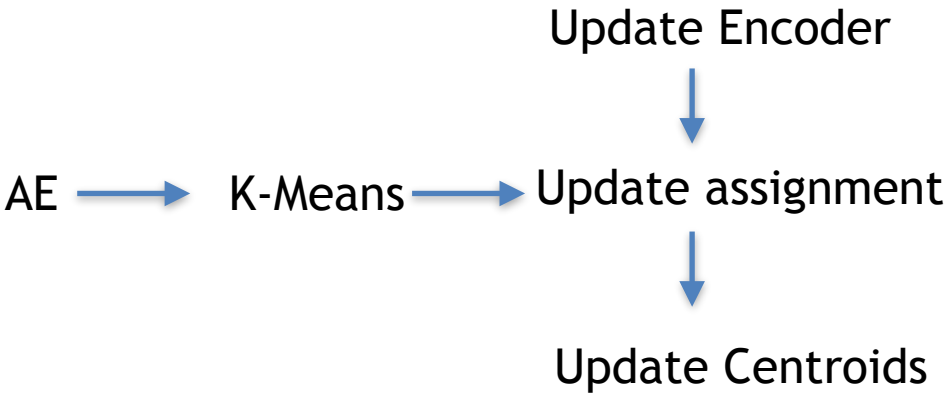
* strengthen prediction
* emphasis high confidence point
* prevent large clusters

$$p_{ij} = \frac{q_{ij}^2/f_j}{\sum_{j'} q_{ij'}^2/f_{j'}},$$

$$f_j = \sum_i q_{ij}$$

* Unsupervised Deep Embedding for Clustering Analysis.ICML 2016

Deep Clustering Network(DCN):

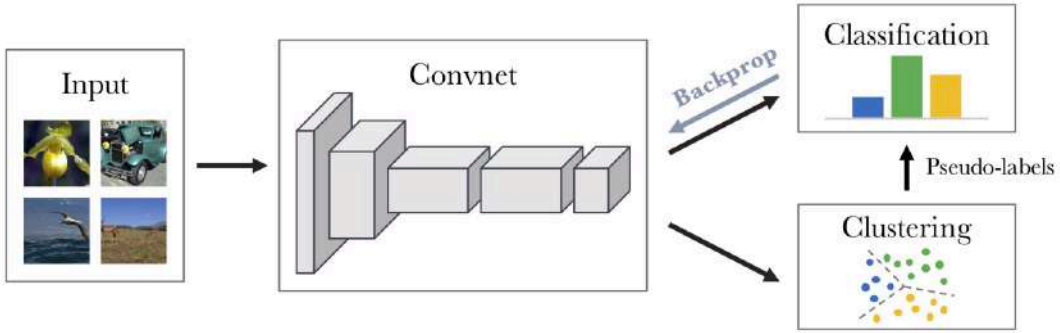


$$\min_{\mathcal{W},\mathcal{Z},\boldsymbol{M},\{\boldsymbol{s}_i\}} \sum_{i=1}^{N} \left(\ell\left(\boldsymbol{g}(\boldsymbol{f}(\boldsymbol{x}_i)), \boldsymbol{x}_i\right) + \frac{\lambda}{2} \left\| \boldsymbol{f}(\boldsymbol{x}_i) - \boldsymbol{M}\boldsymbol{s}_i \right\|_2^2 \right)$$

$$\text{s.t.} \quad s_{j,i} \in \{0,1\}, \ 1^T s_i = 1 \quad \forall i, j,$$

* Towards K-Means-friendly Spaces: Simultaneous Deep Learning and Clustering. HongMingYi.2016

DeepCluster



$$\min_{\theta, W} \frac{1}{N} \sum_{n=1}^{N} \ell\left(g_W\left(f_\theta(x_n)\right), y_n\right),$$

$$\min_{C \in \mathbb{R}^{d \times k}} \frac{1}{N} \sum_{n=1}^{N} \min_{y_n \in \{0,1\}^k} \|f_\theta(x_n) - C y_n\|_2^2$$

$$\text{s.t.} \quad y_n^\top 1_k = 1.$$

* Deep Clustering for Unsupervised Learning of Visual Features. ECCV 2018

DeepCluster

Avoid trivial solution: (happen in cluster learning)

automatically reassigning empty clusters

Avoid Trivial parameterization: (happen in inputing in classification)

sample images based on a uniform of pseudo-labels

* Deep Clustering for Unsupervised Learning of Visual Features. ECCV 2018

HAIL HYDRA