CRD

Problem Setup: $x \sim p_{data}(x)$ ← data

$S = f^S(x)$

$T = f^T(x)$

Two distribution: $q(T, S \mid C=1) = p(T,S)$ joint distribution

$q(T, S \mid C=0) = p(T)\, p(S)$

$q(C=1) = \frac{1}{N+1}$ → Same input for both T & S.

$q(C=0) = \frac{N}{N+1}$ → 1 congruent and N incongruent → Different input for T & S

$$q(C=1 \mid T, S) = \frac{q(T,S \mid C=1)\, q(C=1)}{q(T,S \mid C=1)\, q(C=1) + q(T,S \mid C=0)\, q(C=0)}$$

$$= \frac{p(T,S)}{p(T,S) + N\, p(T)\, p(S)}$$

connection to MI: $\log q(C=1 \mid T,S) = \log \frac{p(T,S)}{p(T,S) + N\, p(T)\, p(S)}$

$$= -\log\left(1 + N \frac{p(T)\,p(S)}{p(T,S)}\right) \le -\left\{\log N + \log \frac{p(T)\,p(S)}{p(T,S)}\right\}$$

(convexity of log) Taking expectation $p(T,S)$

$$I(T,S) \ge \log N + E_{q(T,S \mid C=1)} \log q(C=1 \mid T,S)$$

⇐ (Bound MI)

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$$\underbrace{E_{q(T,S|C=1)} \log q(C=1|T,S)}_{\text{maximization}} \Rightarrow ?? \text{ how}$$

$$h\underbrace{\{T, S\}}_{\text{Domain}} \to [0, 1]$$

P - cells

$h^*(T,S) = q(C=1|T,S)$ / Bernoulli distribution

$$L_{critic}(h) = E_{q(T,S|C=1)} \log h(T,S) + E_{q(T,S|C=0)} \log \cancel{h} (1 - h(T,S))$$

$$f^{S*} = \arg\max_{f_S} \max_{h} L_{critic}(h)$$

(Contrastive loss)

h chosen from family of function $h\{T,S\} \to [0,1]$

$$h(T,S) = \frac{\exp(g^T(T)' g^S(S)/\tau)}{\exp(g^T(T^*)' g^S(S)/\tau) + \frac{N}{M}}$$

NCE loss

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KD objective:

temperature

$$\mathcal{L}_{KD} = (1-\alpha) H(y, y^s) + \underbrace{\alpha \rho^2}_{\text{weight}} \underbrace{H}_{\text{cross entropy}} (\underbrace{\sigma}_{\text{softmax}}(z^T/\rho), \sigma(z^s/\rho))$$

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$$\mathcal{L}_{CMD-EN} = \underbrace{H(y, y^s)}_{\text{cross entropy}} - \beta \sum_i \mathcal{L}_{critic}(T_i, S)$$

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