Information Competing Process for Learning Diversified Representations

Jie Hu[1], Rongrong Ji[1,2*], Shengchuan Zhang[1], Xiaoshuai Sun[1],
Qixiang Ye[3], Chia-Wen Lin[4], and Qi Tian[5]
[1]Media Analytics and Computing Lab, Department of Artificial Intelligence,
School of Informatics, Xiamen University. [2]Peng Cheng Laboratory.
[3]University of Chinese Academy of Sciences. [4]National Tsing Hua University. [5]Noah's Ark Lab, Huawei.

Introduction

- **Representation Learning** aims to make the learned representations more effective on extracting useful information from input for downstream tasks.
- **Diversified Representations** are learned with different information constraints which encourage representation parts to extract various and useful information from inputs, which results in powerful features to represent the inputs.
- **Information Competing Process** (ICP) for learning diversified representations.

Method

- **Unify Supervised and Self-Supervised Objectives.** Let t denote the downstream target (label/input itself), the objective linking the representation r of input x and the target t can be defined as:

$$max\,[\,I(r,t)\,]$$

- **Separate and Diversify the Representations.** To explicitly diversify the information, we directly separate the representation r into two parts $[z,y]$ with different constraints:

$$max\,[\,I(r,t)+\alpha I(y,x)-\beta I(z,x)\,]$$

Method

- **Competition of Representation Parts.** To prevent any one of the representation parts from dominating the downstream task, we let z and y to accomplish the downstream task t solely. For ensuring the representations catch diversified information through different constraints, we prevent z and y from knowing what each other learned for the downstream task. The objective is:

$$max\,[\,\underbrace{I(r,t)}_{\text{Synergy}}+\alpha \underbrace{I(y,x)}_{\text{Max}}-\beta \underbrace{I(z.x)}_{\text{Min}}+ \underbrace{I(z,t)+I(y,t)-\gamma I(z.y)}_{\text{Competition}}\,]$$

- **Optimization.** Please kindly refer to our paper.

Experiments

- **Supervised Setting** - Classification Task.

Table 1: Classification error rates (%) on CIFAR-10 test set.

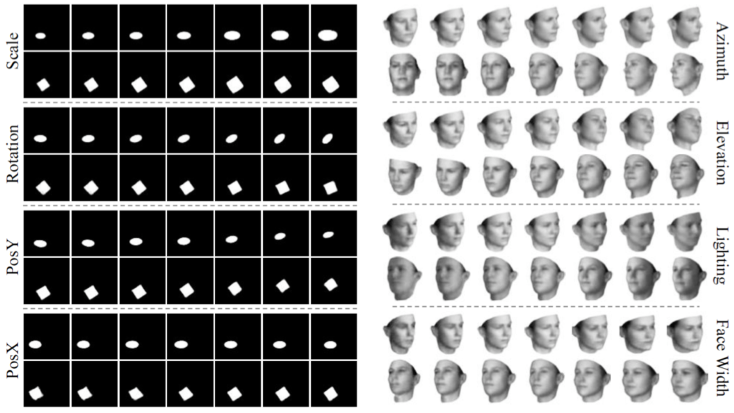
	VGG16 [34]	GoogLeNet [35]	ResNet20 [12]	DenseNet40 [16]
Baseline	6.67	4.92	7.63	5.83
VIB [1]	$6.81^{\uparrow 0.14}$	$5.09^{\uparrow 0.17}$	$6.95^{\downarrow 0.68}$	$5.72^{\downarrow 0.11}$
DIM* [14]	$6.54^{\downarrow 0.13}$	$4.65^{\downarrow 0.27}$	$7.61^{\downarrow 0.02}$	$6.15^{\uparrow 0.32}$
VIB×2	$6.86^{\uparrow 0.19}$	$4.88^{\downarrow 0.04}$	$6.85^{\downarrow 0.78}$	$6.36^{\uparrow 0.53}$
DIM*×2	$7.24^{\uparrow 0.57}$	$4.95^{\uparrow 0.03}$	$7.46^{\downarrow 0.17}$	$5.60^{\downarrow 0.23}$
ICP-ALL	$6.97^{\uparrow 0.30}$	$4.76^{\downarrow 0.16}$	$6.47^{\downarrow 1.16}$	$6.13^{\uparrow 0.30}$
ICP-COM	$6.59^{\downarrow 0.08}$	$4.67^{\downarrow 0.25}$	$7.33^{\downarrow 0.30}$	$5.63^{\downarrow 0.20}$
ICP	$\mathbf{6.10}^{\downarrow 0.57}$	$\mathbf{4.26}^{\downarrow 0.66}$	$\mathbf{6.01}^{\downarrow 1.62}$	$\mathbf{4.99}^{\downarrow 0.84}$

Experiments

Table 2: Classification error rates (%) on CIFAR-100 test set.

	VGG16 [34]	GoogLeNet [35]	ResNet20 [12]	DenseNet40 [16]
Baseline	26.41	20.68	31.91	27.55
VIB [1]	$26.56^{\uparrow 0.15}$	$20.93^{\uparrow 0.25}$	$30.84^{\downarrow 1.07}$	$26.37^{\downarrow 1.18}$
DIM* [14]	$26.74^{\uparrow 0.33}$	$20.94^{\uparrow 0.26}$	$32.62^{\uparrow 0.71}$	$27.51^{\downarrow 0.04}$
VIB×2	$26.08^{\downarrow 0.33}$	$22.09^{\uparrow 1.41}$	$29.74^{\downarrow 2.17}$	$29.33^{\uparrow 1.78}$
DIM*×2	$25.72^{\downarrow 0.69}$	$21.74^{\uparrow 1.06}$	$30.16^{\downarrow 1.75}$	$27.15^{\downarrow 0.40}$
ICP-ALL	$26.73^{\uparrow 0.32}$	$20.90^{\uparrow 0.22}$	$28.35^{\downarrow 3.56}$	$27.51^{\downarrow 0.04}$
ICP-COM	$26.37^{\downarrow 0.04}$	$20.81^{\uparrow 0.13}$	$32.76^{\uparrow 0.85}$	$26.85^{\downarrow 0.70}$
ICP	$\mathbf{24.54}^{\downarrow 1.87}$	$\mathbf{18.55}^{\downarrow 2.13}$	$\mathbf{28.13}^{\downarrow 3.78}$	$\mathbf{24.52}^{\downarrow 3.03}$

- **Self-supervised Setting** - Disentanglement Task.



(a) dSprites (b) 3D Faces

Table 3: MIG score of disentanglement.

	dSprites [24]	3D Faces [27]
β-VAE [13]	0.22	0.54
β-TCVAE [7]	0.38	0.62
ICP-ALL	0.33	0.26
ICP-COM	0.20	0.57
ICP	**0.48**	**0.73**

- **Project Page**