

Main Ideas

- A new generative adversarial network de 1) joint distribution matching.
- 2) Sample from a fully-learned joint distribution marginals and conditionals simultaneous
- 3) The design includes two generators for two generators for the conditionals, and softmax based discriminator.
- 4) Can be extended to joint distribution lea three or more random variables.

Model

Learning marginals with original GAN:

 $\min_{\boldsymbol{\alpha}} \max_{\boldsymbol{\omega}} \mathcal{L}_{\text{GAN}}(\boldsymbol{\alpha}, \boldsymbol{\omega}) = \mathbb{E}_{\boldsymbol{x} \sim q(\boldsymbol{x})}[\log \sigma(g_{\boldsymbol{\alpha}})]$ + $\mathbb{E}_{\epsilon_1 \sim p(\epsilon_1)} [\log (1 - \sigma(g_{\omega}))]$

where $\widetilde{x} = f_{\alpha}(\epsilon_1)$ is the synthetic data.

JointGAN with 5-way discriminator:

$$\min_{\boldsymbol{\theta},\boldsymbol{\phi}} \max_{\boldsymbol{\omega}} \mathcal{L}_{\text{JointGAN}}(\boldsymbol{\theta},\boldsymbol{\phi},\boldsymbol{\omega})$$

 $= \sum_{k=1}^{5} \mathbb{E}_{p_k(\boldsymbol{x},\boldsymbol{y})}[\log g_{\boldsymbol{\omega}}(\boldsymbol{x},\boldsymbol{y})[k]]$ (2)

where:

$$p_1(\mathbf{x}, \mathbf{y}) = q(\mathbf{x})p_{\theta}(\mathbf{y}|\mathbf{x}), \qquad p_2 = q(\mathbf{y})p_{\phi}(\mathbf{x}|\mathbf{y}),$$

$$p_3 = p_{\alpha}(\mathbf{x})p_{\theta}(\mathbf{y}|\mathbf{x}), \qquad p_4 = p_{\beta}(\mathbf{y})p_{\phi}(\mathbf{x}|\mathbf{y}),$$

$$p_5 = q(\mathbf{x}, \mathbf{y})$$

- and $g_{\omega}(\mathbf{x}, \mathbf{y}) \in \Delta^4$ has softmax on the top layer: $\sum_{k=1}^{5} \log g_{\omega}(x, y)[k] = 1, \quad g_{\omega}(x, y)[k] \in (0, 1)$
- The equilibrium for the minimax objective in (2) is achieved if and only if $p_1 = p_2 = p_3 = p_4 = p_5$.

JointGAN: Multi-Domain Joint Distribution Learning with Generative Adversarial Nets

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$$\begin{bmatrix} x = f_{\alpha}(\epsilon_{1}) & f_{\alpha}(\epsilon_{1}) & f_{\beta}(\epsilon_{1}) & f_{\alpha}(\epsilon_{1}) & f_{\alpha}(\epsilon_{1})$$



Figure 1. Generated pairs from the edges \leftrightarrow shoes dataset

Table 1. Human evaluation results				
Method	Realism	Relevance		
Trained with paired data				
WGAN-GP + Pix2pix wins JointGAN wins Not distinguishable	2.32% 17.93% 79.75%	3.1% 36.32% 60.58%		
Trained with unpaired data				
WGAN-GP + CycleGAN wins JointGAN wins Not distinguishable	0.13% 81.55% 18.32%	1.31% 40.87% 57.82%		



	edges↔shoes	$edges \leftrightarrow handbags$	labels⇔cityscapes	labels⇔facades	maps↔satellites
True pairs	0.684	0.672	0.591	0.529	0.514
Random pairs	0.008	0.005	0.012	0.011	0.054
Other pairs	0.113	0.139	0.092	0.076	0.081
WGAN-GP + Pix2pix	0.352	0.343	0.301	0.288	0.125
JointGAN (paired)	0.488	0.489	0.377	0.364	0.328
WGAN-GP + CycleGAN	0.203	0.195	0.201	0.139	0.091
JointGAN (unpaired)	0.452	0.461	0.339	0.341	0.299



patch and a short pointed this bird has red throat an

colored head and wings

a white and gray bird with

this bird has a small head belly and breast with a w red crown and cheek pate

Figure 3. Generated paired samples of caption features and images. Left: from generated images to caption features. Right: from generated caption features to images





generated from right to left.





Figure 2. Generated pairs from models on paired dataset

celevance sectes of generated pairs on the two-domain datesets							
lges⇔shoes	$edges \leftrightarrow handbags$	labels⇔cityscapes	labels↔facades	maps			
0.684	0.672	0.591	0.529				
0 000	0.005	0.010	0.011				

f brown with a grey cheek bill	small brown colored bird with greenish yellow and brown feathers on its breast and belly	
nd breast with a dark brown	this bird has light yellow eye ring brown breast and light brown spotted belly	A
h a black bill and gray body	a small blue bird with blue on its wings	A
and throat a bright yellow thite stripe on its back and a th	a colorful bird with a yellow green body and yellow brown feathers covering the rest of its body	200
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Figure 4. Generated paired samples from facades + labels + cityscapes. Top: generated from left to right. Bottom: