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

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Main Ideas

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

Model

- Learning marginals with original GAN:
  \[
  \min_{\alpha} \max_{\omega} \mathcal{L}_{\text{GAN}}(\alpha, \omega) = \mathbb{E}_{x \sim q(x)}[\log \sigma(g_{\omega}(x))] + \mathbb{E}_{\epsilon \sim p(\epsilon)}[\log (1 - \sigma(g_{\omega}(\epsilon)))]
  \] (1)

- JointGAN with 5-way discriminator:
  \[
  \min_{\phi, \omega} \max_{\mathcal{L}_{\text{JointGAN}}(\phi, \omega)}
  \sum_{k=1}^{S} \mathbb{E}_{p_k(x,y)}[\log g_{\omega}(x,y)[k]]
  \] (2)

where:

- \( p_1(x,y) = q(x)p(y|x) \), \( p_2(y|x) \)
- \( p_3 = p_4 = p_5 = q(x,y) \)
- \( g_{\omega}(x,y) \in \Delta^4 \) has softmax on the top layer:
  \[
  \sum_{k=1}^{S} \log g_{\omega}(x,y)[k] = 1, \quad g_{\omega}(x,y)[k] \in (0,1)
  \] (3)

- The equilibrium for the minimax objective in (2) is achieved if and only if \( p_1 = p_2 = p_3 = p_4 = p_5 \).

Experiments

<table>
<thead>
<tr>
<th>Table 1: Human evaluation results</th>
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<tbody>
<tr>
<td>Method</td>
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<tr>
<td>----------------------------------</td>
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<tr>
<td>Trained with paired data</td>
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<tr>
<td>WGAN-GP + Pos2Pts w/ JointGAN</td>
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<tr>
<td>Not distinguishable</td>
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<tr>
<td>Trained with unpaired data</td>
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<tr>
<td>WGAN-GP + CyclicGAN w/ JointGAN</td>
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<td>Not distinguishable</td>
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Figure 1: Generated pairs from the edges→shores dataset

Figure 2: Generated pairs from models on paired dataset

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

Figure 4: Generated paired samples from facades→labels→cityscapes. Top: generated from left to right. Bottom: generated from right to left.