Class-Distinct and Class-Mutual Image Generation with GANs

Training data
Smaller than 5

Even

A \cap B

B

Classes overlap

A

CP-GAN (Ours)

Classifier’s posterior

A

Generator

\begin{align*}
& A \cap \neg B \\
& A \cap B \\
& \neg A \cap B
\end{align*}

Class specificity controllable

Takuhiro Kaneko$^1$, Yoshitaka Ushiku$^1$, Tatsuya Harada$^{1,2}$

$^1$The University of Tokyo $^2$RIKEN

Code
Objective: Class-distinct and class-mutual image generation

Our goal is to construct a **class-distinct and class-mutual image generator**

- Generates **class-distinct** ($A$ or $B$) and **class-mutual** ($A \cap B$) images **selectively**, when given **class-overlapping data**.

![](image)
Challenge: Limitations of naïve conditional generative models

Naïve conditional generative models (e.g., AC-GAN [1] and cGAN [2, 3])

- Optimized conditioned on discrete labels.
- Generate data of each class separately even if classes overlap.

Contribution: Proposal of classifier’s posterior GAN

We propose **classifier’s posterior GAN (CP-GAN)**

- Represents *between-class relationships* in the generator input.
- Generates an image *selectively* conditioned on the *class-specificity*.

**Training data**
- Smaller than 5
- Even

**CP-GAN (Ours)**
- **A**
- **B**
- **A ∩ B**
- **A ∩ ~B**
- **A ∩ B**
- **~A ∩ B**

**Class-specificity controllable**
Main idea: Redesign generator input and objective of AC-GAN

We redesign the **generator input** and the **objective function** of AC-GAN.

**AC-GAN**

**CP-GAN (Ours)**
Baseline: AC-GAN

Training data: Two-class Gaussian distributions with class overlapping

\[ x^r \rightarrow D/C \rightarrow Real/Fake \]

Classify

Classifier’s posterior

Represents class-overlapping state
Baseline: **AC-GAN**

**Training data:** Two-class Gaussian distributions with class overlapping

![Diagram of AC-GAN model](image)
Baseline: AC-GAN

Training data: Two-class Gaussian distributions with class overlapping
Baseline: **AC-GAN**

**Training data:** Two-class Gaussian distributions with class overlapping
Proposal: **CP-GAN**

**Training data:** Two-class Gaussian distributions with class overlapping
Proposal: **CP-GAN**

**Training data:** Two-class Gaussian distributions with class overlapping

![Diagram of CP-GAN model with real/fake classification and KL-CP loss](image-url)
Proposal: **CP-GAN**

**Training data:** Two-class Gaussian distributions with class overlapping

Class-overlapping distribution is learned

**KL-CP loss**
Experiments I: Controlled class-overlapping data

**CIFAR-10 [4]:** We made the class overlapping state in a *controlled* manner.

- **Expected states**
  - \(\{9, 0, 1\} \in A\)
  - \(\{1, 2, 3\} \in B\)
  - \(\{3, 4, 5\} \in C\)
  - \(\{5, 6, 7\} \in D\)
  - \(\{7, 8, 9\} \in E\)

<table>
<thead>
<tr>
<th>Expected states</th>
<th>A</th>
<th>A \cap B</th>
<th>B</th>
<th>B \cap C</th>
<th>C \cap D</th>
<th>D \cap E</th>
<th>E</th>
<th>E \cap A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AC-GAN [1]</strong></td>
<td><img src="ac-gan_images" alt="Images" /></td>
<td><img src="ac-gan_images" alt="Images" /></td>
<td><img src="ac-gan_images" alt="Images" /></td>
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</tr>
<tr>
<td><strong>cGAN [3]</strong></td>
<td><img src="cgan_images" alt="Images" /></td>
<td><img src="cgan_images" alt="Images" /></td>
<td><img src="cgan_images" alt="Images" /></td>
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<td><img src="cgan_images" alt="Images" /></td>
</tr>
<tr>
<td><strong>CFGAN [5]</strong></td>
<td><img src="cfgan_images" alt="Images" /></td>
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<tr>
<td><strong>CP-GAN</strong></td>
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</table>

- ✔ Achieves the **best FID** [6].
- ✔ Succeeds in generating **class-distinct and class-mutual images selectively**.

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Experiments II: Real-world class-overlapping data

**Clothing1M [7]:** Includes *real-world* class-overlapping data.

<table>
<thead>
<tr>
<th>Expected states</th>
<th>T-Shirt</th>
<th>Shirt</th>
<th>Knitwear</th>
<th>Chiffon</th>
<th>Sweater</th>
<th>Windbreaker</th>
<th>Hoodie</th>
<th>Jacket</th>
<th>Down Coat</th>
<th>Suit</th>
<th>Shawl</th>
<th>Dress</th>
<th>Underwear</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-GAN [1]</td>
<td>![Images]</td>
<td>![Images]</td>
<td>![Images]</td>
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<tr>
<td>cGAN [3]</td>
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<tr>
<td>CP-GAN</td>
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</tbody>
</table>

✓ Achieves the **best FID** [6].
✓ Succeeds in generating **class-distinct images selectively**.

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Thank you!

Our code is publicly available at

https://github.com/takuhirok/CP-GAN/

AC-GAN

CP-GAN (Ours)

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