Class-Distinct and Class-Mutual Image Generation with GANs

Training data
Smaller than 5

Even

1 0 4 2 6

A

A ∩ B

B

Classes overlap

CP-GAN (Ours)

A

Classifier’s posterior

Generator

A ∩ B

A ∩ ¬B

¬A ∩ B

Class specificity controllable

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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**.

![Diagram showing class-distinct and class-mutual sets](image-url)
Challenges: 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**.

![Diagram](image)

Contributions: Proposal of classifier’s posterior GAN

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

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

![Diagram showing training data and CP-GAN (Ours)]

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

**Classes overlap**

**CP-GAN (Ours)**

- Probability density
- Generator
- Classifier’s posterior

**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 (Previous)**

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

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

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

- $x^r$ represents real data.
- $s^r$ represents the classifier's posterior.
- $D/C$ indicates a discriminator/critic block.
- $G$ represents a generator block.

**Discrete prior:** $y^g$, $z^g$
Baseline: **AC-GAN**

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

- Real data $x^r$
- Classifier's posterior
- Real/Fake $s^r$
- Fits discrete prior

Discrete prior $y^g$
- G
- AC loss
- D/C
- Classifier's posterior $s^g$
Baseline: **AC-GAN**

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

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

```
\[ x^r \rightarrow D/C \rightarrow \text{Real/Fake} \rightarrow s^r \]
```

- **Real data**
- **D/C**
- **Real/Fake**
- **Classifier’s posterior**

```
\[ s^r \rightarrow G \rightarrow \text{Reused} \]
```

- **Classifier’s posterior**
- **G**

**Represents class-overlapping state**
Proposal: **CP-GAN**

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

![Diagram of CP-GAN model with real and fake data, classifier's posterior, and KL-CP loss](attachment:diagram.png)
Proposal: CP-GAN

Training data: Two-class Gaussian distributions with class overlapping
Experiment I: Controlled class-overlapping data

**CIFAR-10to5:** The original ten classes [4] are divided into five classes *synthetically.*

<table>
<thead>
<tr>
<th>Expected states</th>
<th>A</th>
<th>A ∩ B</th>
<th>B ∩ C</th>
<th>C ∩ D</th>
<th>D ∩ E</th>
<th>E ∩ A</th>
<th>FID↓</th>
<th>DMA↑</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-GAN [1]</td>
<td>![AC-GAN Images]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13.7</td>
<td>36.6</td>
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<td>cGAN [3]</td>
<td>![cGAN Images]</td>
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<td>16.9</td>
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<td>CFGAN [5]</td>
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<td>15.8</td>
<td>50.9</td>
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<tr>
<td>CP-GAN</td>
<td>![CP-GAN Images]</td>
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<td>12.5</td>
<td>95.0</td>
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</table>

FID (Fréchet Inception distance) [6], DMA (Class-distinct and class-mutual accuracy)

✓ Achieves the best FID.
✓ Generates class-distinct and class-mutual images selectively.

**Experiment II: Real-world class-overlapping data**

**Clothing1M [7]:** Includes *real-world* class-overlapping data (the annotation accuracy: 61.54%).

<table>
<thead>
<tr>
<th>Expected states</th>
<th>T-Shirt</th>
<th>Knitwear</th>
<th>Chiffon</th>
<th>Sweater</th>
<th>Windbreaker</th>
<th>Jacket</th>
<th>Down Coat</th>
<th>Suit</th>
<th>Shawl</th>
<th>Vest</th>
<th>Underwear</th>
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<tr>
<td><strong>AC-GAN [1]</strong></td>
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<td>49.2</td>
<td>23.7</td>
<td>52.4</td>
<td>5.9</td>
<td>27.0</td>
<td>23.8</td>
<td>70.4</td>
<td>81.3</td>
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<td><strong>CP-GAN</strong></td>
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**FID** (Fréchet Inception distance) [6], **DMA** (Class-distinct accuracy; numbers below images)

✓ Achieves the **best FID**.
✓ Generates **class-distinct images selectively**.

Thank you!

Our code is publicly available at
https://github.com/takuhirok/CP-GAN/

AC-GAN (Previous)

CP-GAN (Ours)

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