Class-Distinct and Class-Mutual Image Generation with GANs
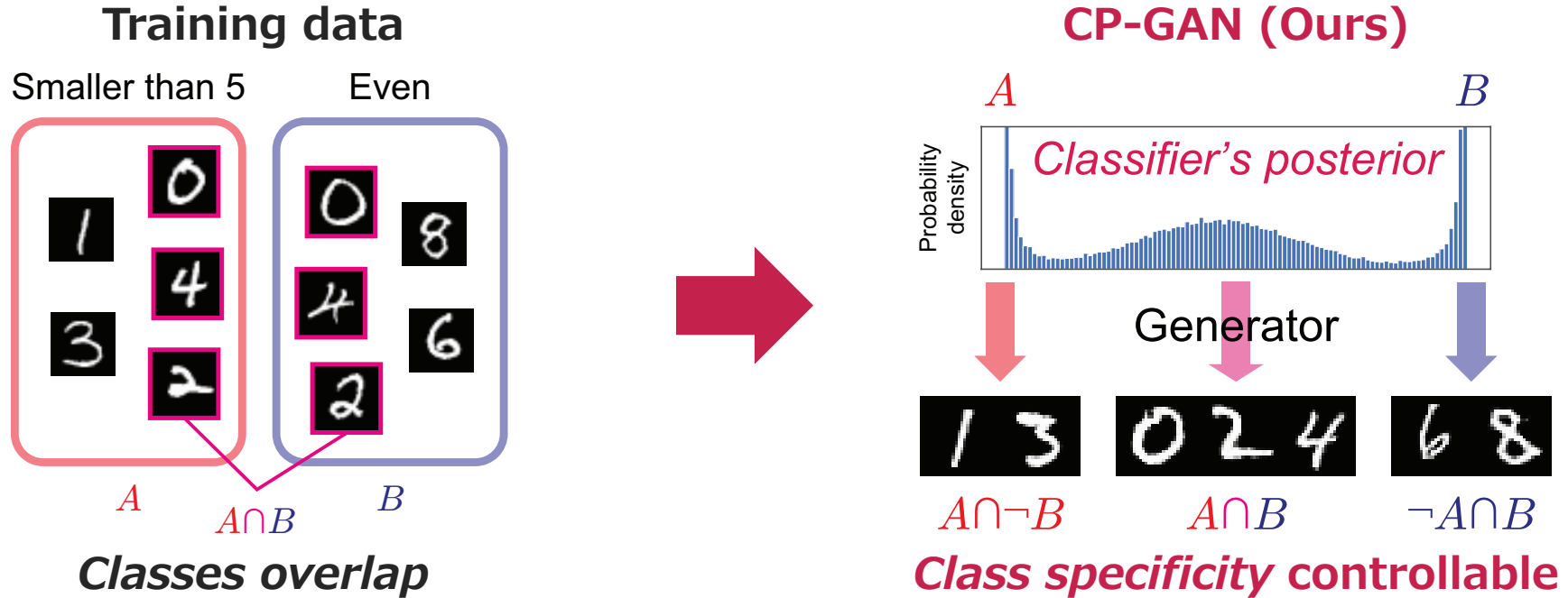
Takuhiro Kaneko[1] Yoshitaka Ushiku[1] Tatsuya Harada[1,2]
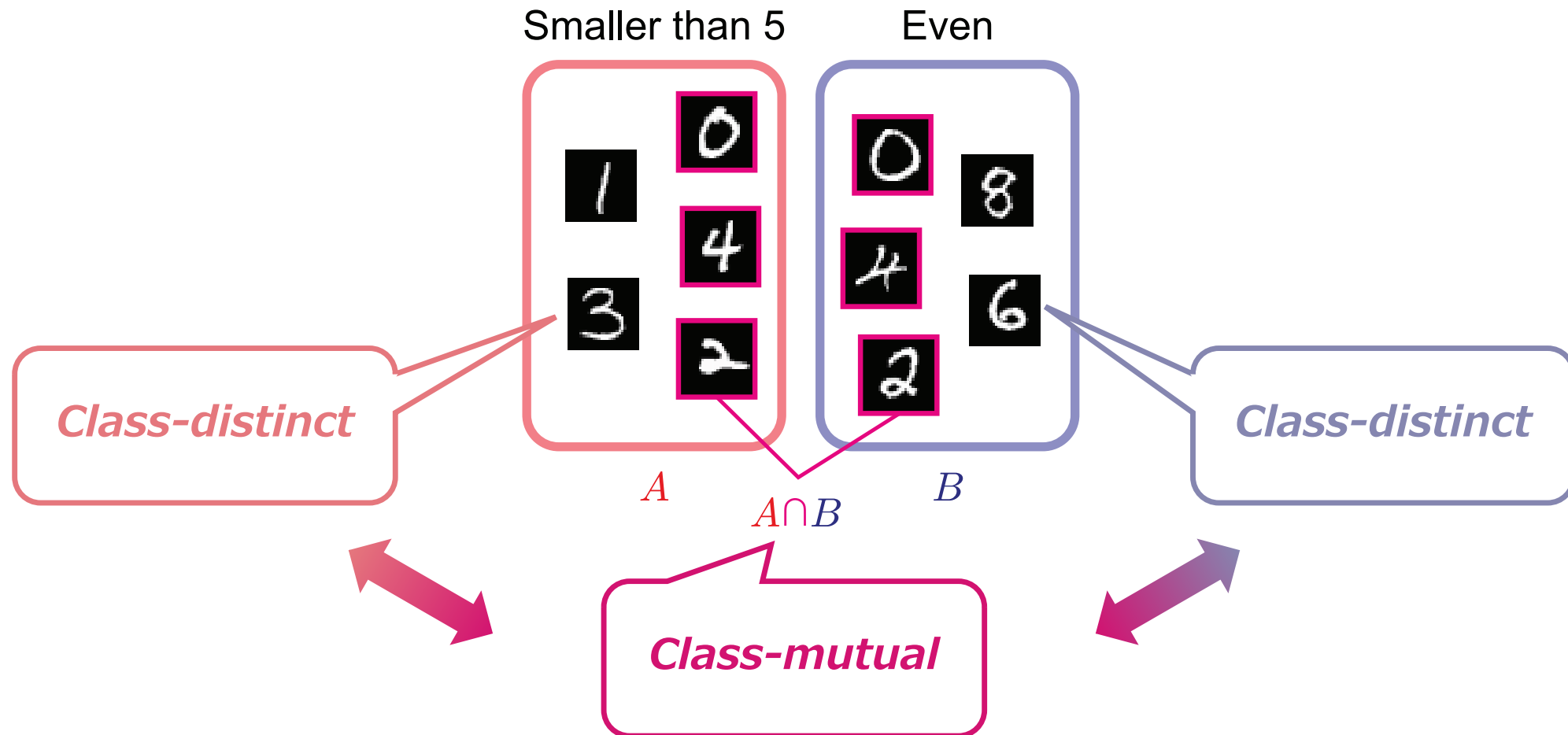
[1]The University of Tokyo [2]RIKEN

Objective: Class-distinct and class-mutual image generation

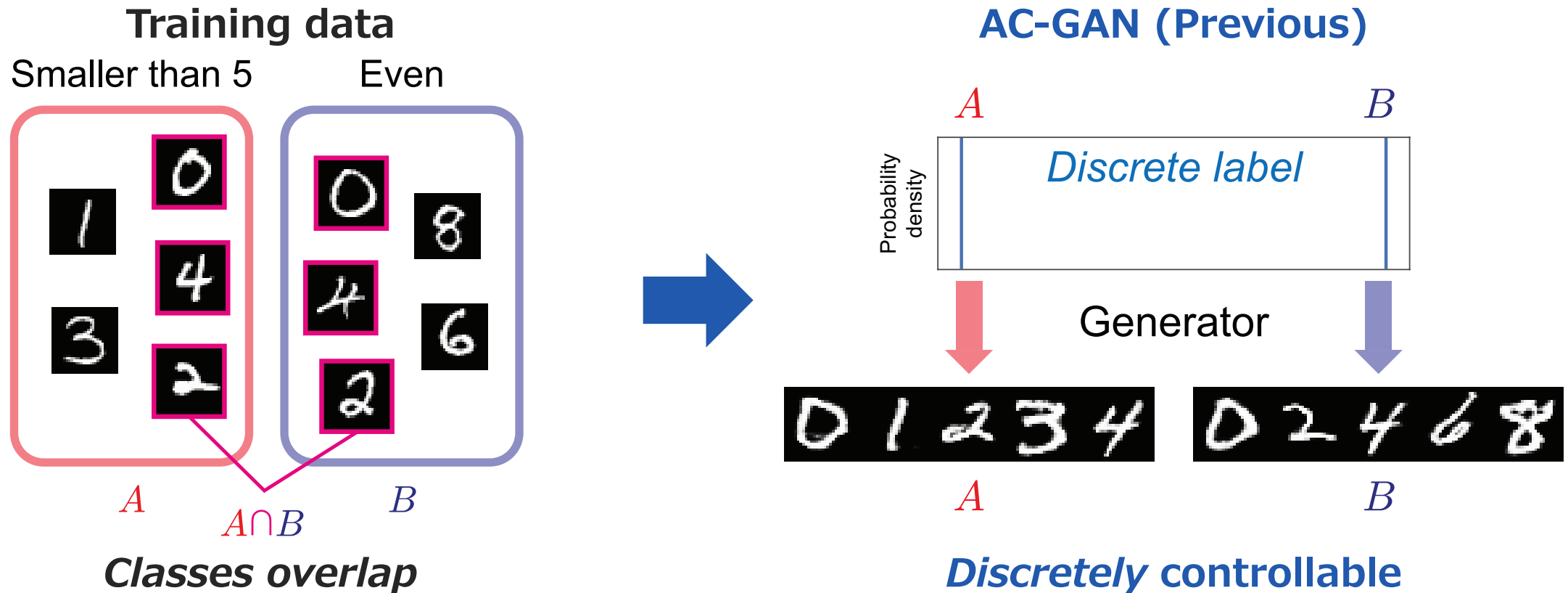Our goal is to construct a **class-distinct and class-mutual image generator**

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

Challenges: Limitations of naïve conditional generative models

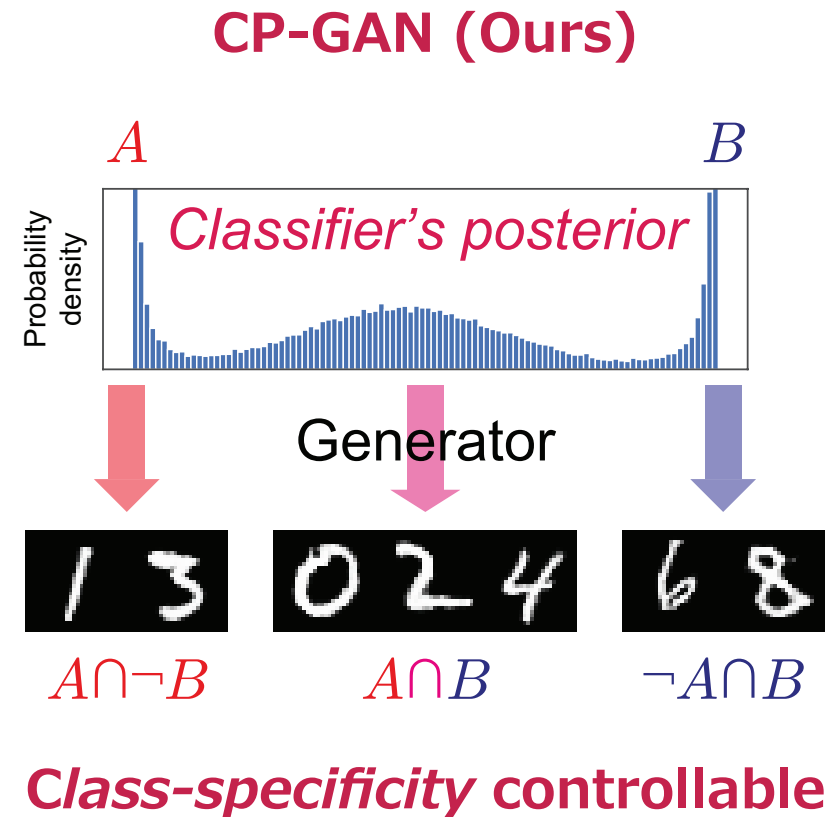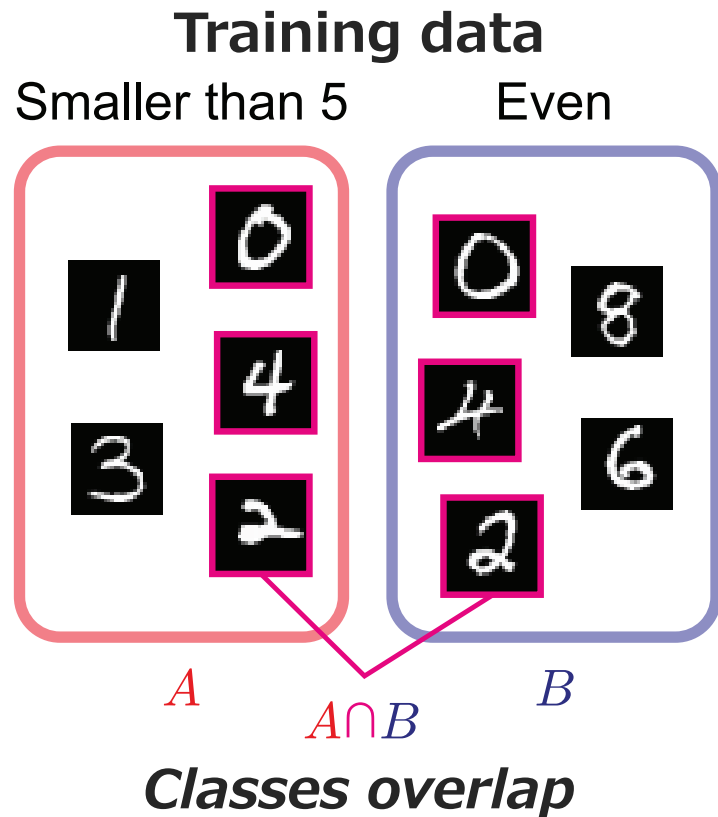Naïve **conditional generative models** (*e.g.*, **AC-GAN** [1] and **cGAN** [2, 3])

- Optimized conditioned on *discrete labels*.

- Generate data of each class *separately* even if *classes overlap*.

Training data

Smaller than 5   Even

A

$A \cap B$

B

Classes overlap

AC-GAN (Previous)

A B

Probability density

Discrete label

Generator

A B

Discretely controllable

[1] Odena et al. ICML 2017. [2] Mirza & Osindero. arXiv 2014. [3] Miyato & Koyama. ICLR 2018.

Contributions: Proposal of classifier's posterior GAN

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

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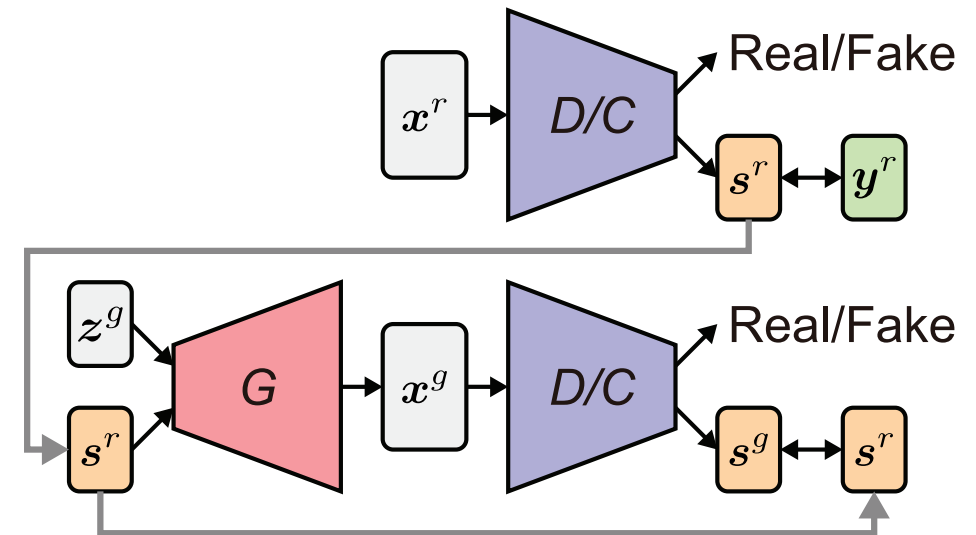- Generates data *selectively* conditioned on the *class-specificity*.

Training data

Smaller than 5   Even

CP-GAN (Ours)

A $A \cap B$ B

Classes overlap

A B

Probability density

Classifier's posterior

Generator

$A \cap \neg B$ $A \cap B$ $\neg A \cap B$

Class-specificity controllable

Main idea: Redesign generator input and objective of AC-GAN

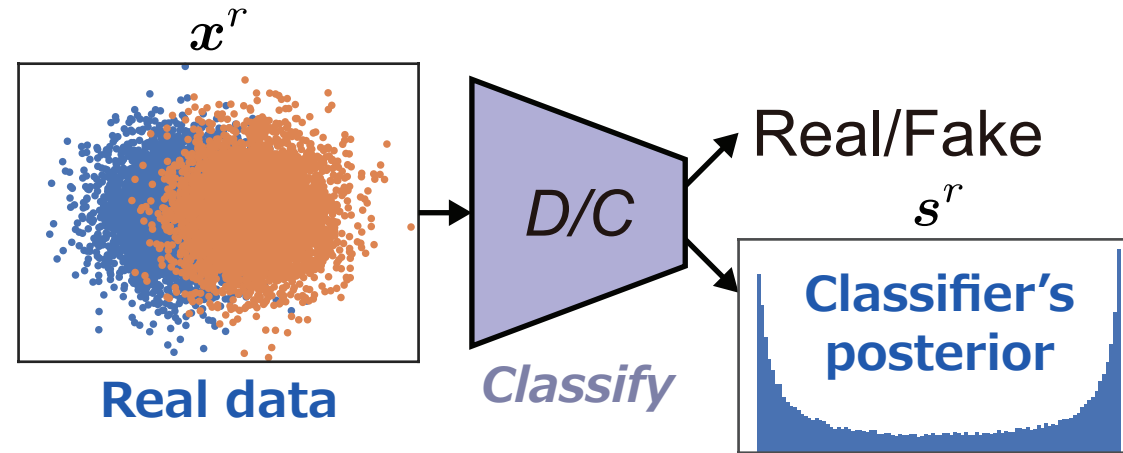We redesign the **generator input** and the **objective function** of AC-GAN.
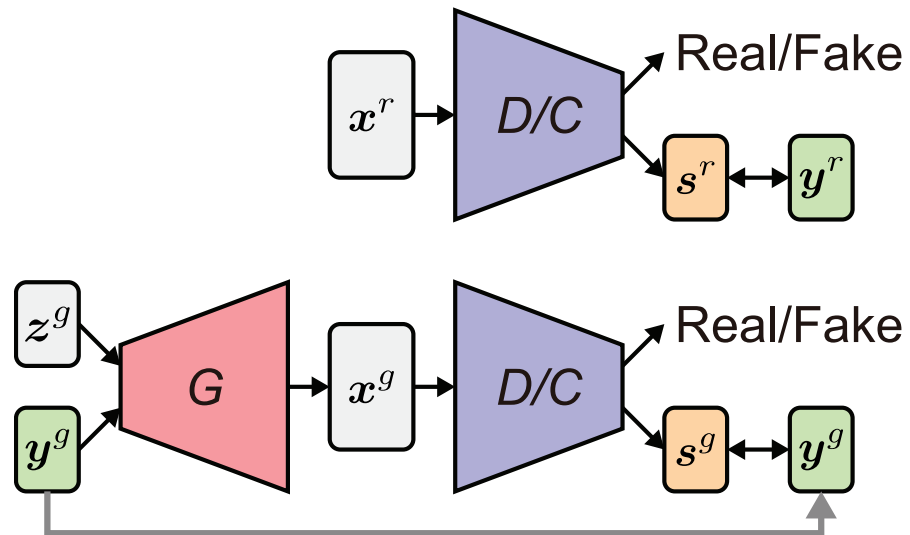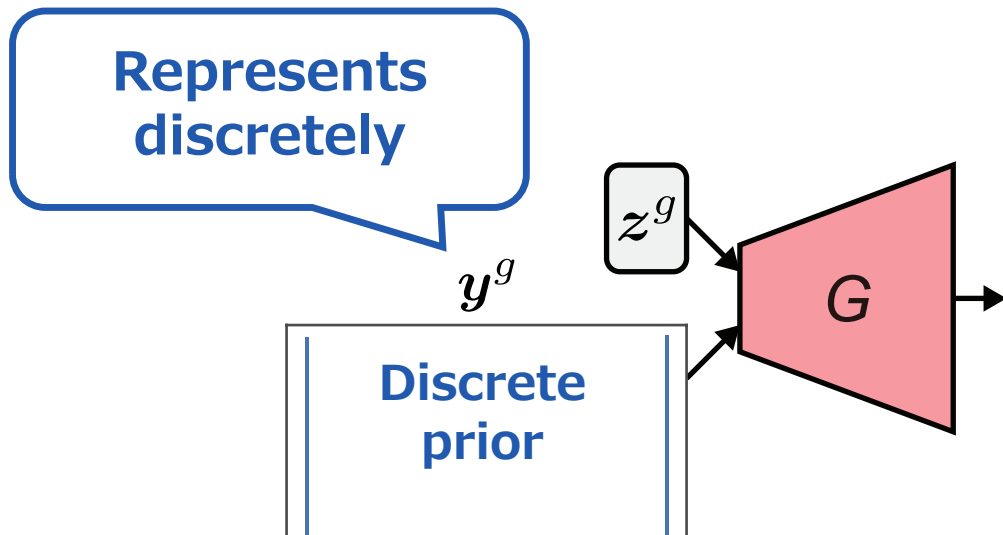
Baseline: AC-GAN

Training data: Two-class Gaussian distributions with class overlapping

$\boldsymbol{x}^r$

Real data

Classify

D/C

Real/Fake

$\boldsymbol{s}^r$

Classifier's posterior
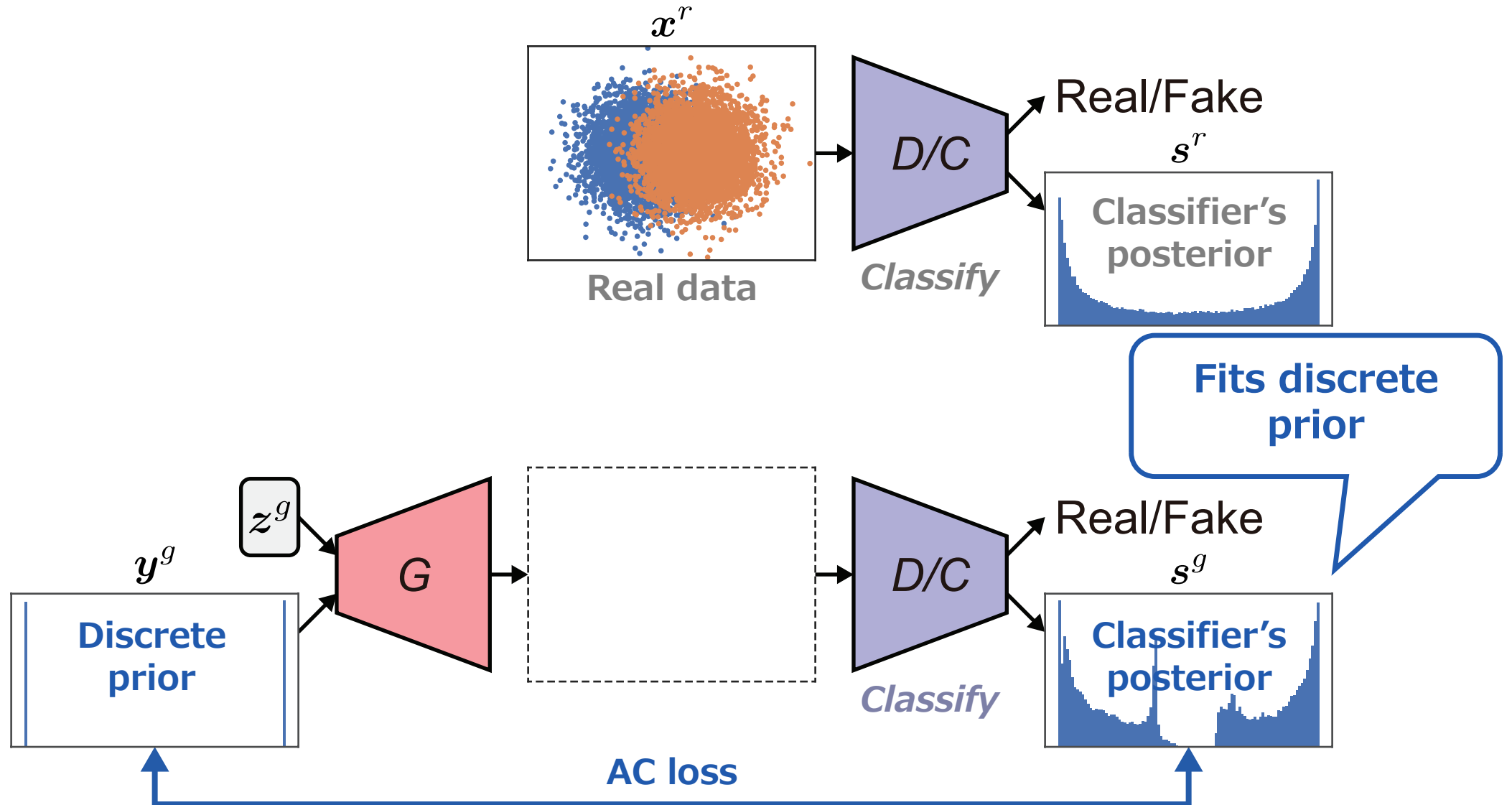
Represents class-overlapping state

Baseline: AC-GAN

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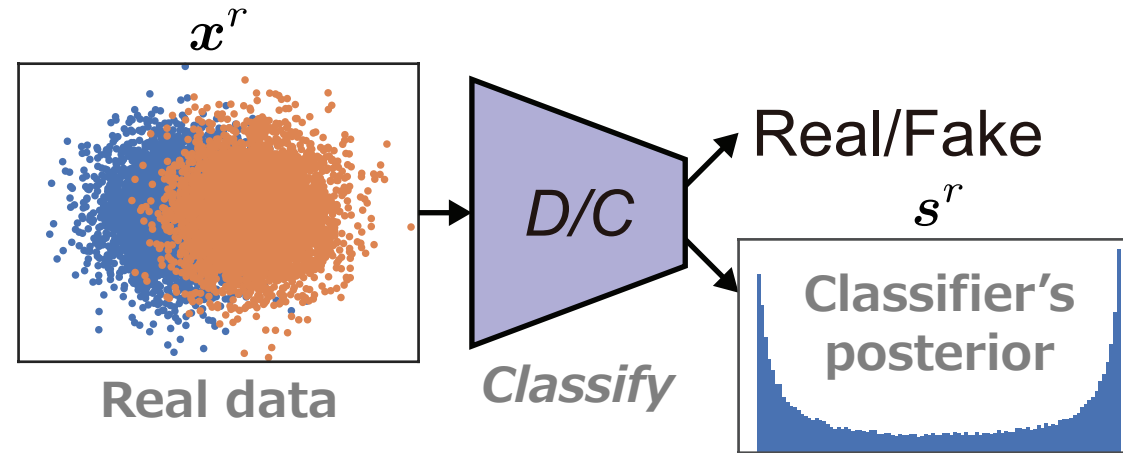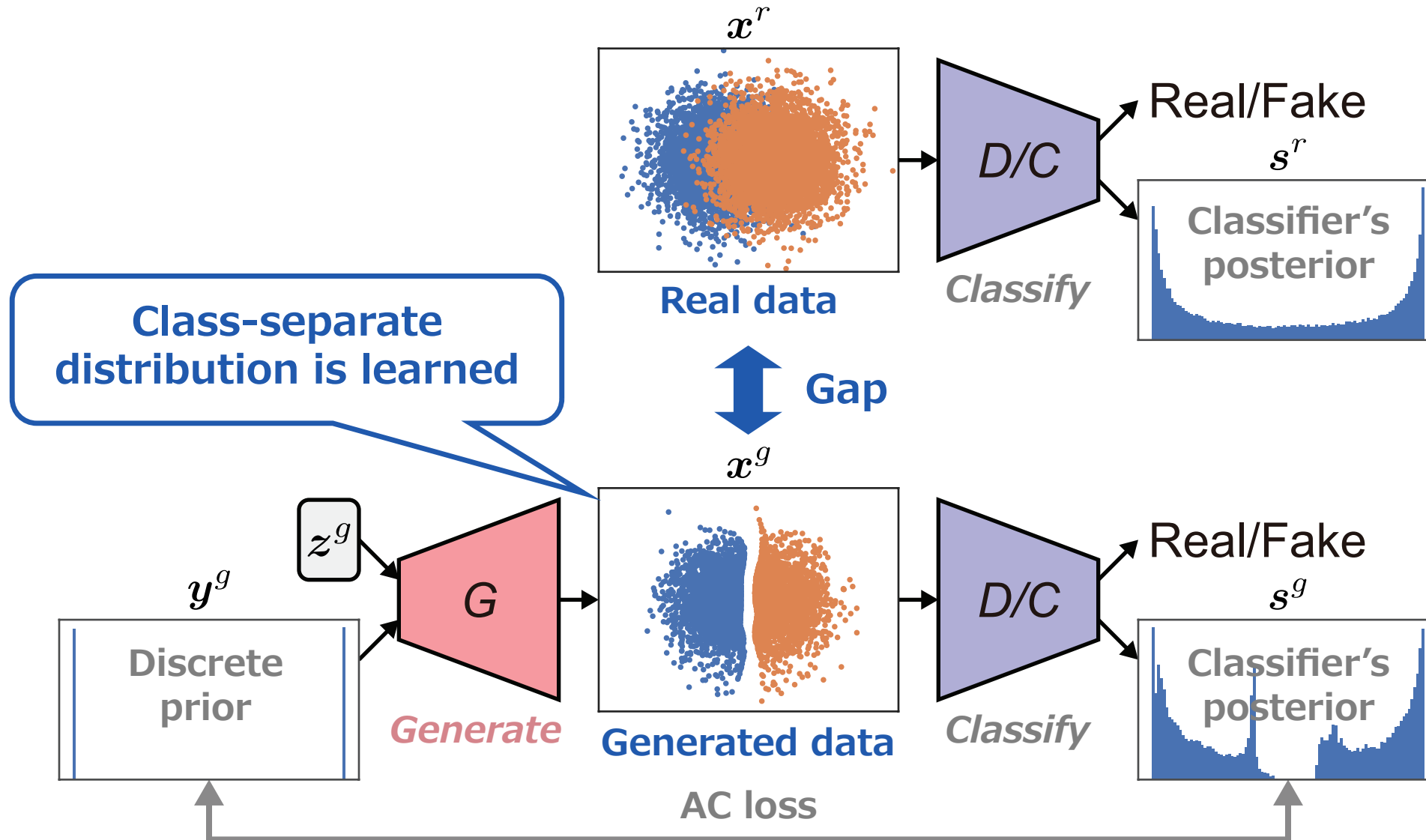
Baseline: AC-GAN

Training data: Two-class Gaussian distributions with class overlapping

Baseline: AC-GAN

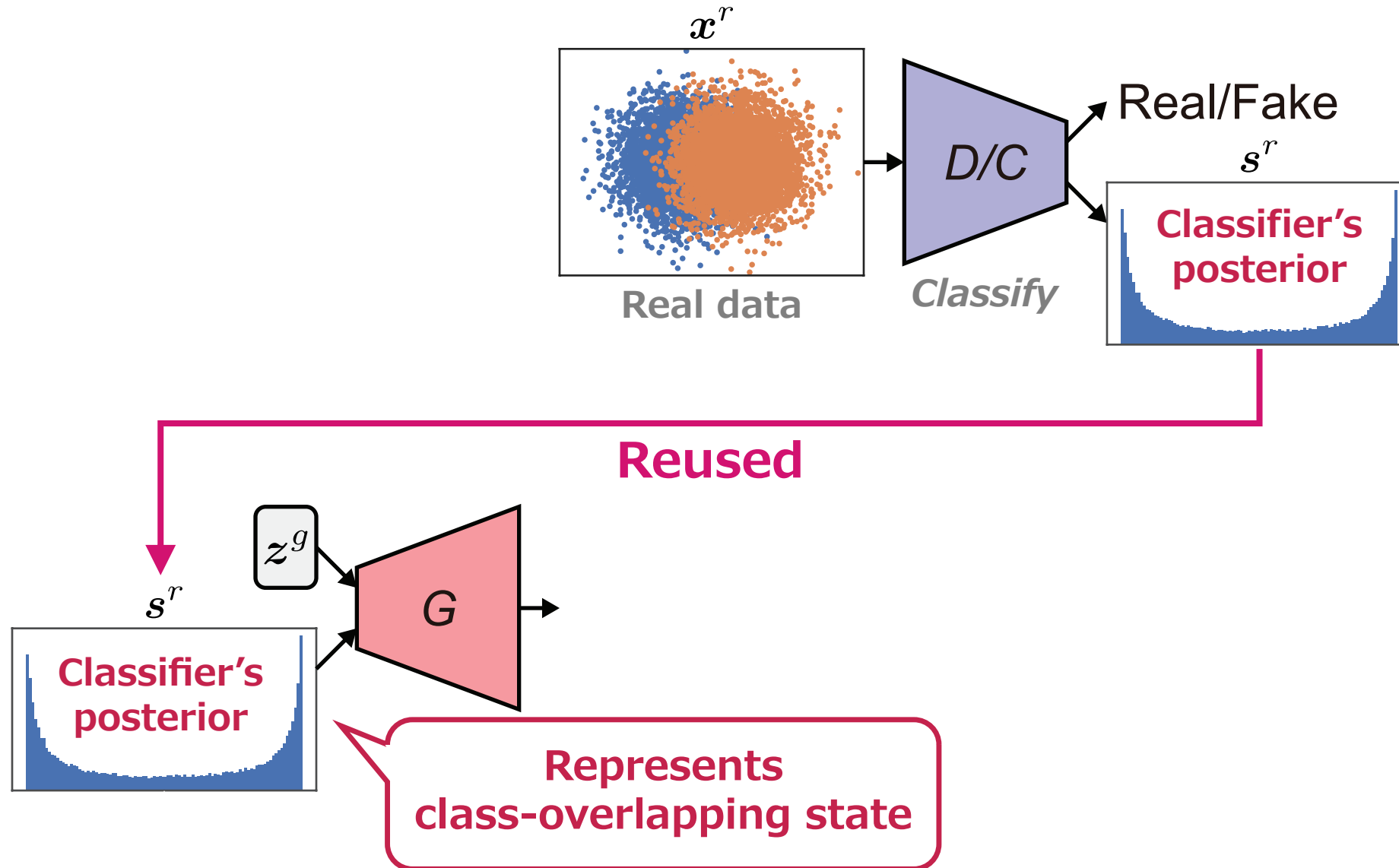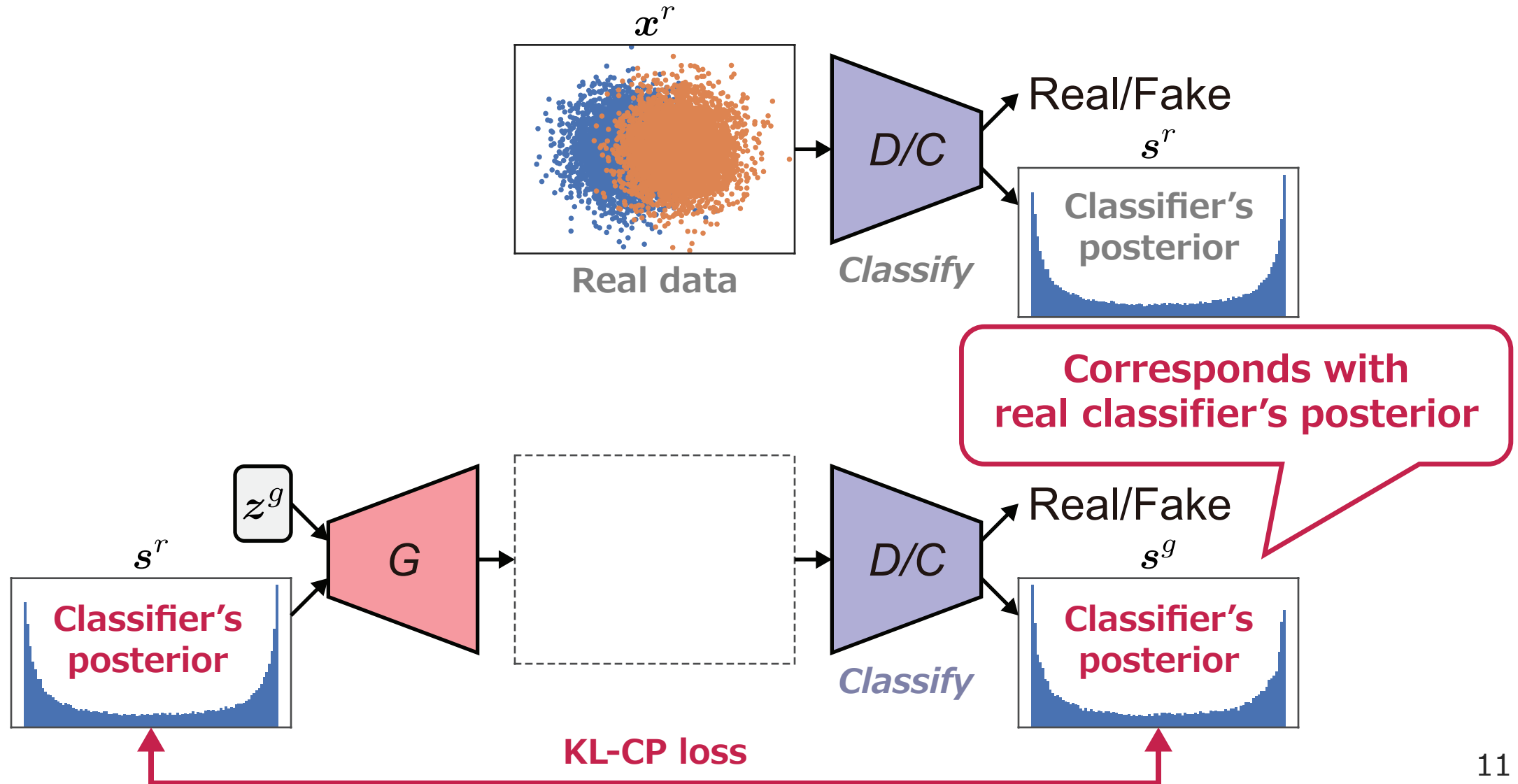**Training data:** Two-class Gaussian distributions with class overlapping

Proposal: CP-GAN

Training data: Two-class Gaussian distributions with class overlapping

Proposal: CP-GAN

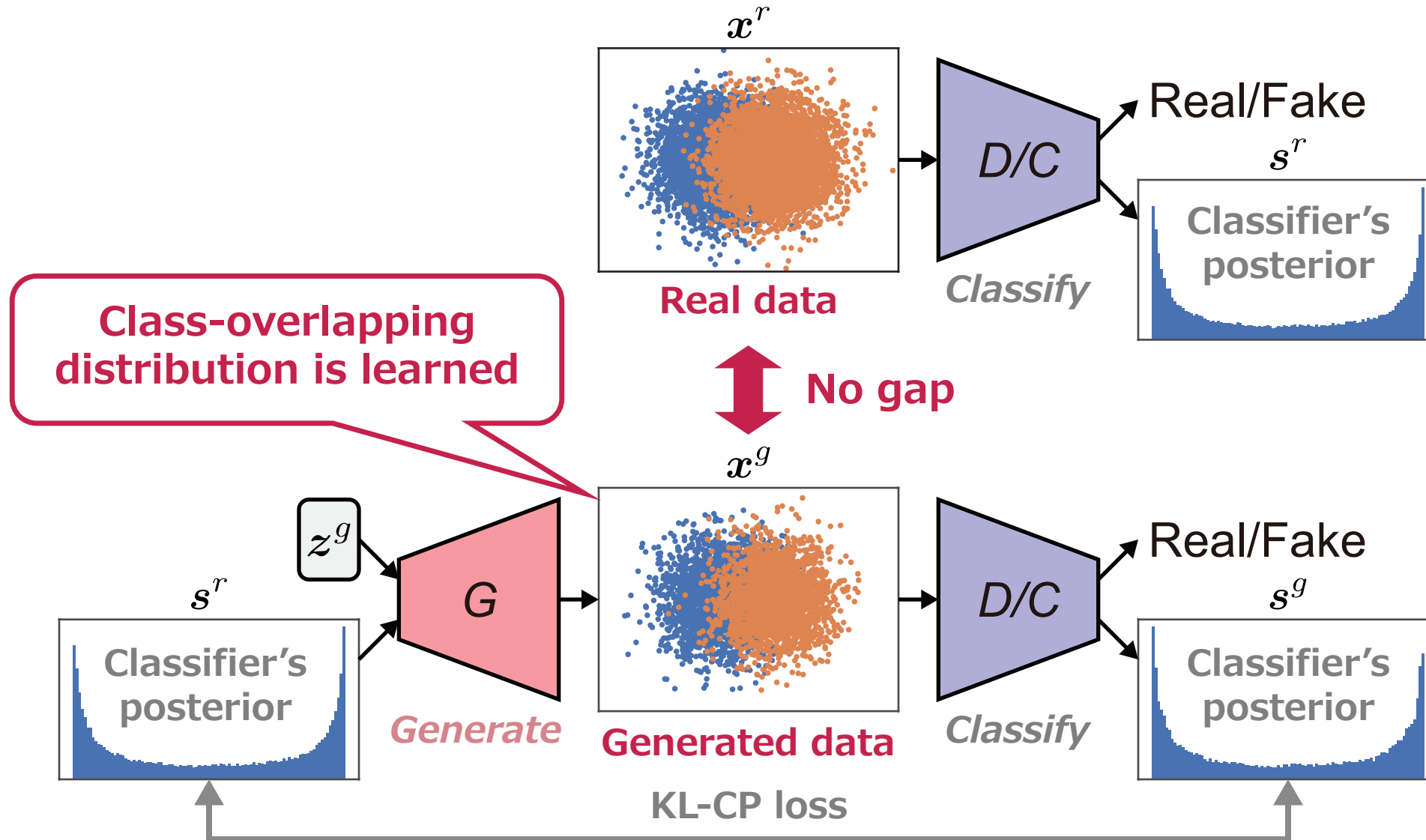**Training data:** Two-class Gaussian distributions with class overlapping

Proposal: CP-GAN

Training data: Two-class Gaussian distributions with class overlapping

Class-overlapping distribution is learned

No gap

KL-CP loss

Experiment I: Controlled class-overlapping data

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

$$\{9, 0, 1\} \in A$$
$$\{1, 2, 3\} \in B$$
$$\{3, 4, 5\} \in C$$
$$\{5, 6, 7\} \in D$$
$$\{7, 8, 9\} \in E$$
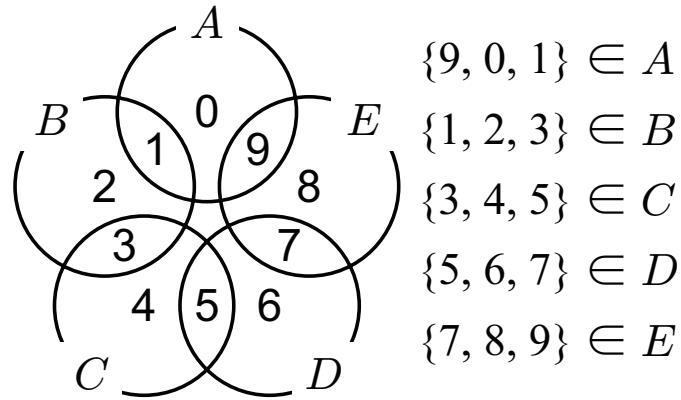
0: Airplane	5: Dog
1: Automobile	6: Frog
2: Bird	7: Horse
3: Cat	8: Ship
4: Deer	9: Truck

Expected states	A	$A \cap B$	B	$B \cap C$	C	$C \cap D$	D	$D \cap E$	E	$E \cap A$	FID↓	DMA↑
AC-GAN [1]											13.7	36.6
cGAN [3]											16.9	32.3
CFGAN [5]											15.8	50.9
CP-GAN											**12.5**	**95.0**

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

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

[1] Odena et al. ICML 2017. [3] Miyato & Koyama. ICLR 2018. [4] Krizhevsky. 2009.
[5] Kaneko et al. CVPR 2017. [6] Heusel et al. NIPS 2017.

Experiment II: Real-world class-overlapping data

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

Knitwear ? Sweater

Expected states	T-Shirt	Shirt	Knitwear	Chiffon	Sweater	Hoodie	Windbreaker	Jacket	Down Coat	Suit	Shawl	Dress	Vest	Underwear
AC-GAN [1] FID: 9.3	49.5	49.2	23.7	52.4	5.9	27.0	23.8	**70.4**	81.3	60.5	35.0	60.7	54.3	54.7
cGAN [3] FID: 11.4	44.8	48.0	25.7	37.6	**34.0**	35.8	52.5	64.8	73.1	44.9	74.9	52.6	41.8	62.4
CP-GAN FID: 6.8	**51.4**	**60.2**	**42.2**	**55.7**	33.6	**48.6**	**86.3**	67.9	**92.7**	67.6	**91.9**	**74.2**	**70.6**	**68.1**

FID (Fréchet Inception distance) [6], **DMA** (Class-distinct accuracy; numbers below images)

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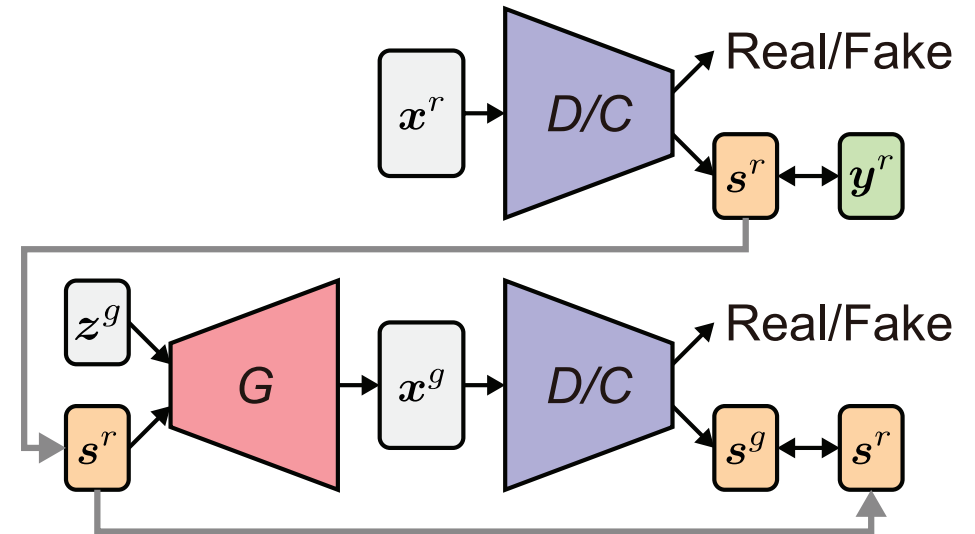✓ Generates **class-distinct images selectively**.

[1] Odena et al. ICML 2017. [3] Miyato & Koyama. ICLR 2018. [6] Heusel et al. NIPS 2017. [7] Xiao et al. CVPR 2015.

Thank you!

Our code is publicly available at

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

AC-GAN (Previous)
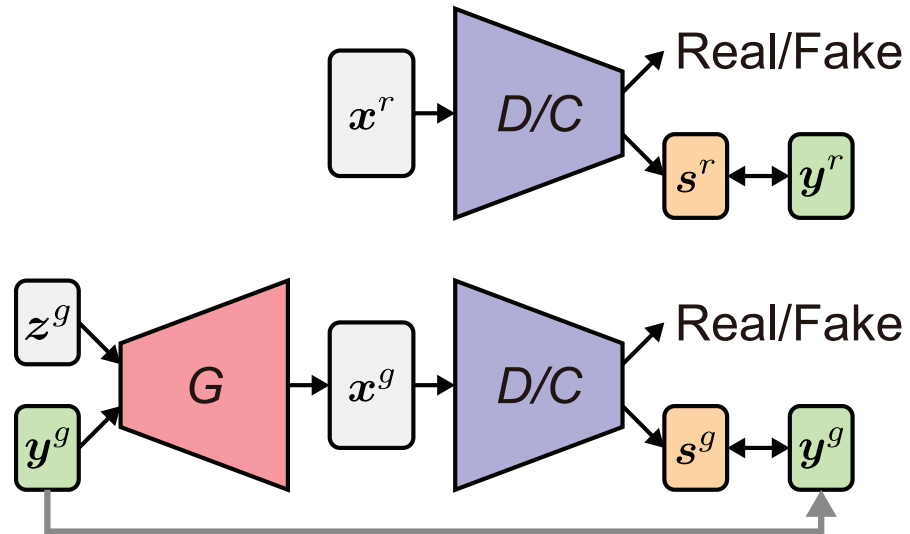
CP-GAN (Ours)

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