지적 대화를 위한 깊고 넓은 딥러닝 

김태훈
carpedm20

저는

carpe dm20

UNIST 졸업

DEVSISTERS 병특

딥러닝, TensorFlow

http://carpedm20.github.io/

지적 대화를 위한
깊고 넓은 딥러닝

지적 대화를 위한

깊고 넓은 딥러닝

Deep Learning

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OpenAI

1980년 1997년
CNN, RNN과 같이 흔한 모델이 아니라, 흥미로운 최신 모델들

지적 대화를 위한

깊고 넓은 딥러닝

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지적 대화를 위한

깊고 넓은 딥러닝

1) Deep Convolutional Generative Adversarial Network (DCGAN)

지적 대화를 위한

깊고 넓은 딥러닝

2) NTM, 3) DQN, 4) Visual Analogy

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DCGAN

DCGAN ∉ Supervised Learning

내일의 주가를 예측하고, 평점을 예측하며 사진을 구분할 수 있는 모델들

DCGAN ∈ Unsupervised Learning

Clustering, Anomaly Detection, Generative Models

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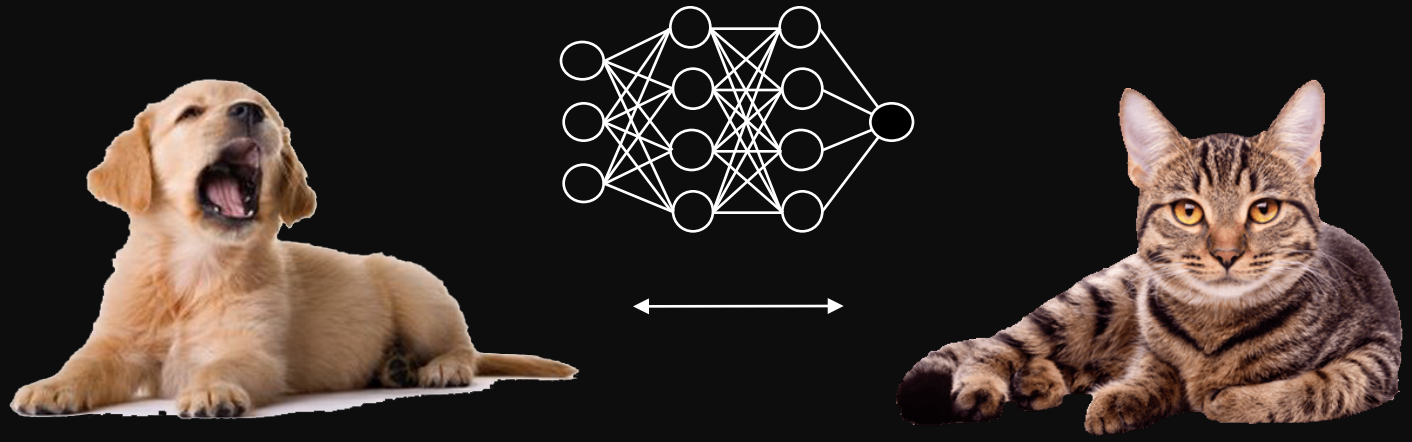
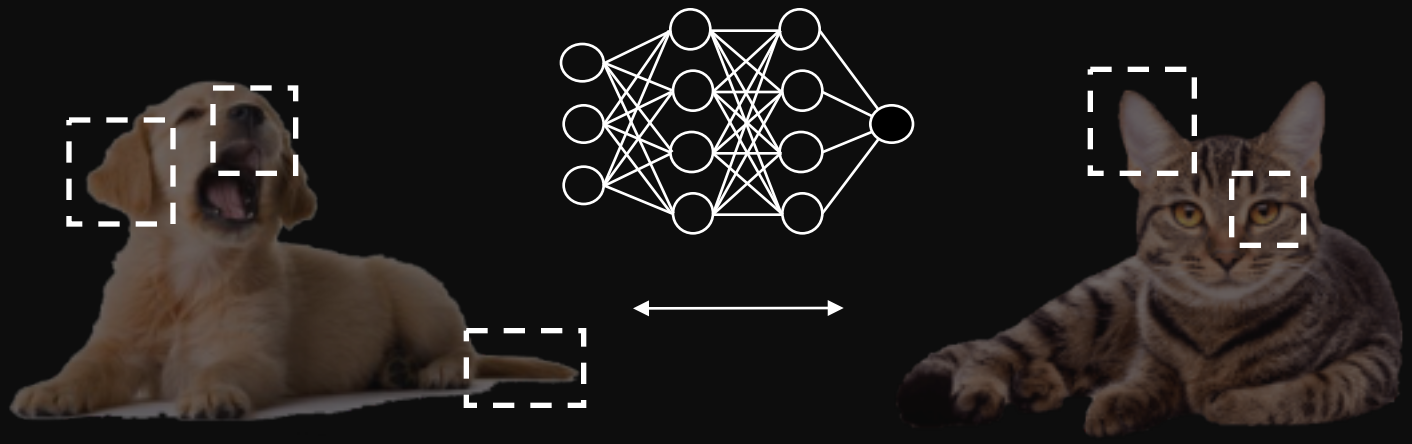
DCGAN ∈ Generative Model

"What I cannot create, I do not understand."

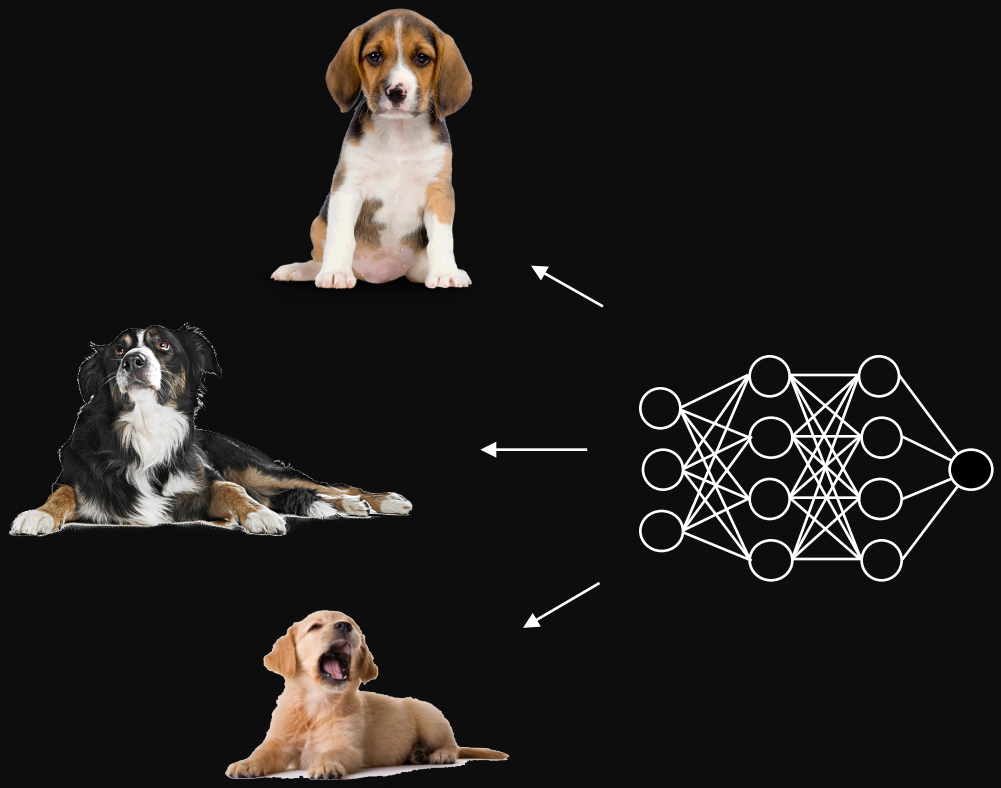
- Richard Feynman



개와 고양이를 구분하는 모델

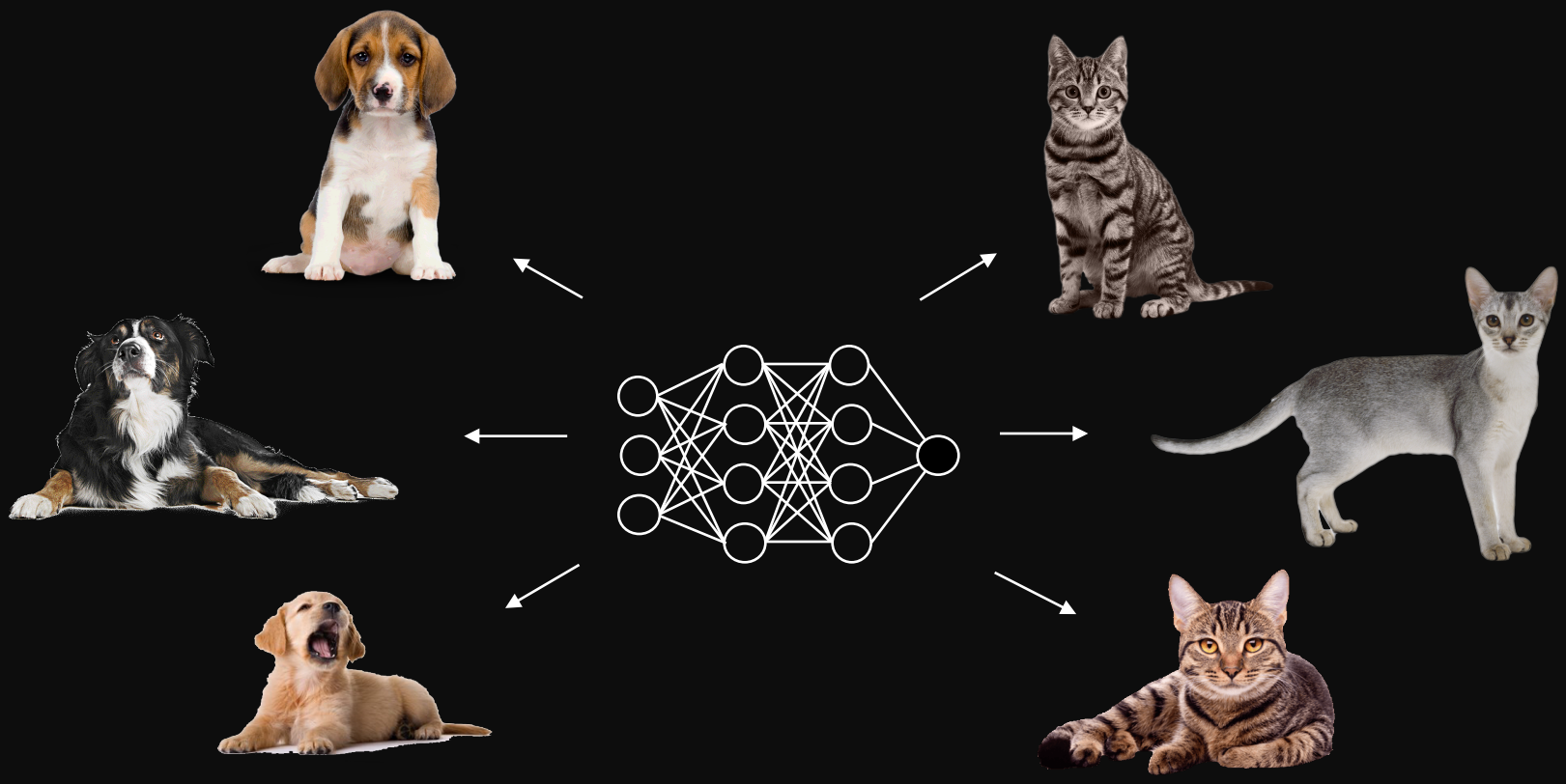


단순히 특징만을 배운 것에 불과

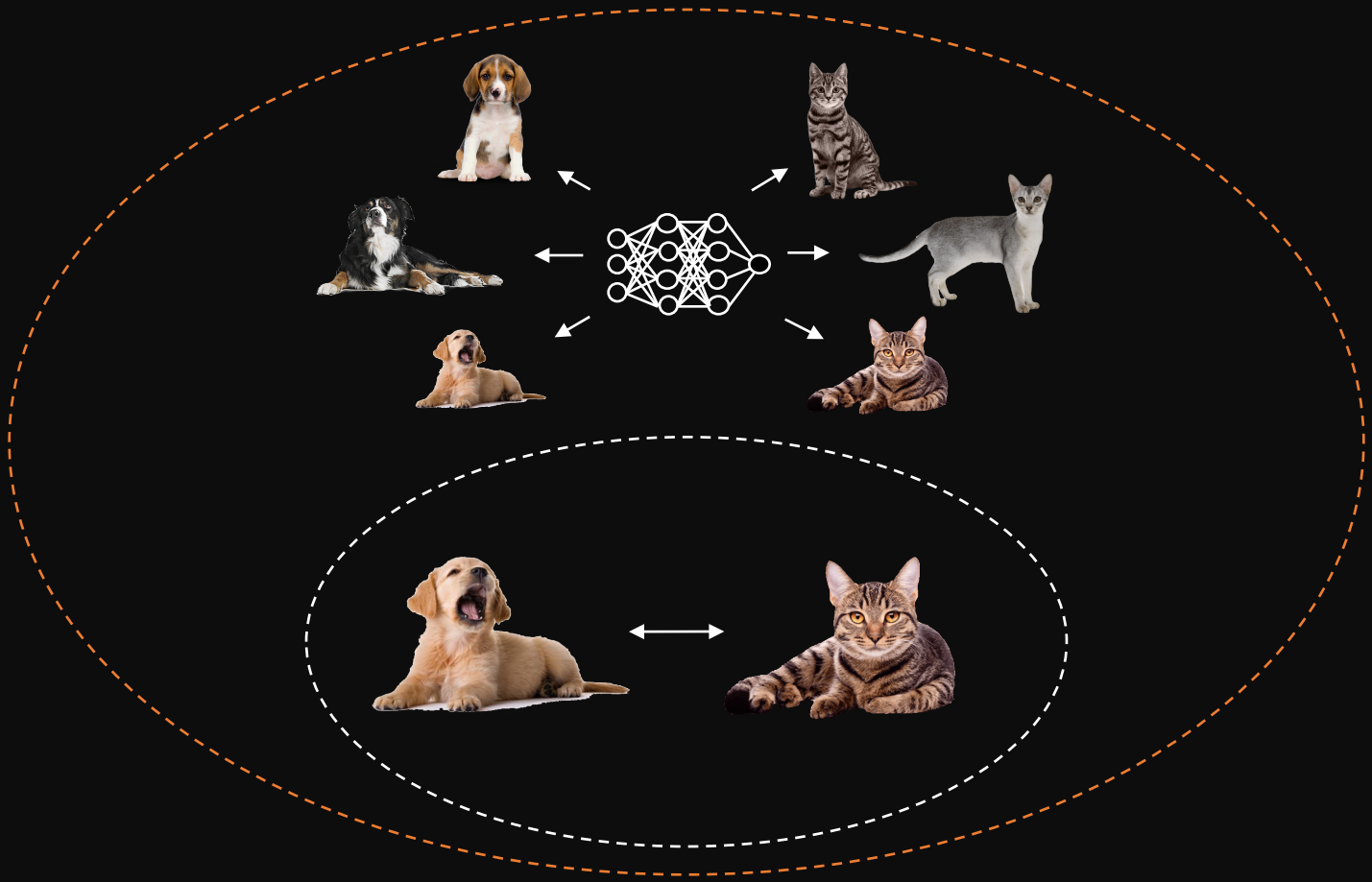


개와 고양이 사진을 만들 수 있는 모델?

Generative Model



분류 모델보다는 개와 고양이를 제대로 이해하고 있다



제대로 이해하고 있다면, 개, 고양이의 분류는 쉬운 문제

이것이 바로

Generative Model이 중요한 이유!

Google DeepMind OpenAI Facebook AI Research

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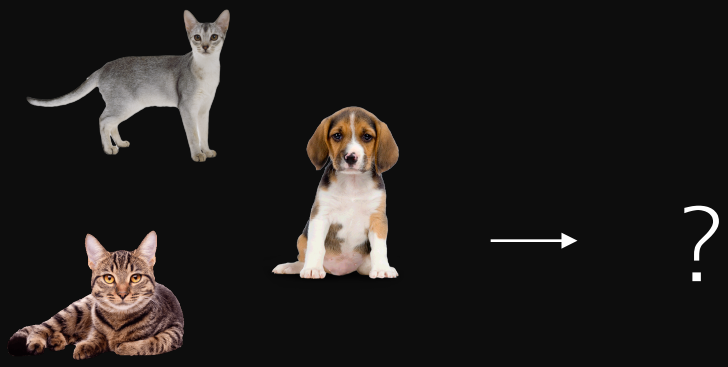


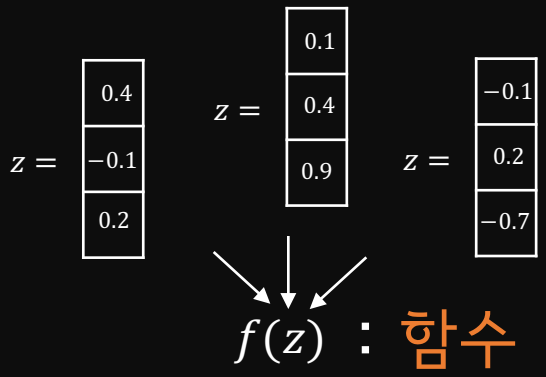
DEVSISTERS

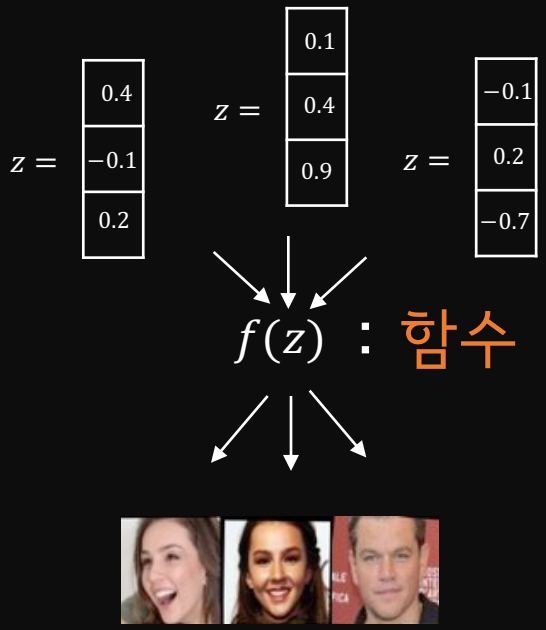
celebA

DCGAN

?

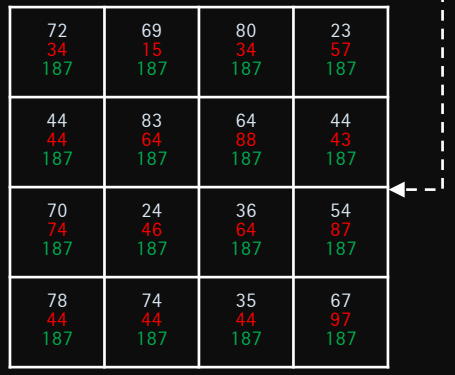
$f(z)$: 함수를 학습


$z =$
0.4
−0.1
0.2
$z =$
0.1
0.4
0.9
$z =$
−0.1
0.2
−0.7
$f(z)$: 함수

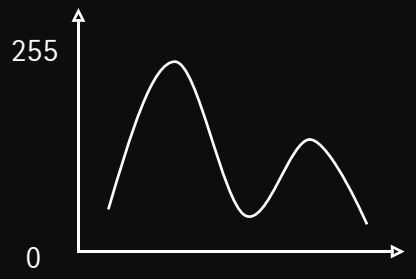

$z =$
0.4
−0.1
0.2
$z =$
0.1
0.4
0.9
$z =$
−0.1
0.2
−0.7
$f(z)$: 함수

$f(z)$: 얼굴 사진을 만드는 궁극의 함수

$f(z)$: 얼굴 사진을 만드는 궁극의 함수



RGB 이미지

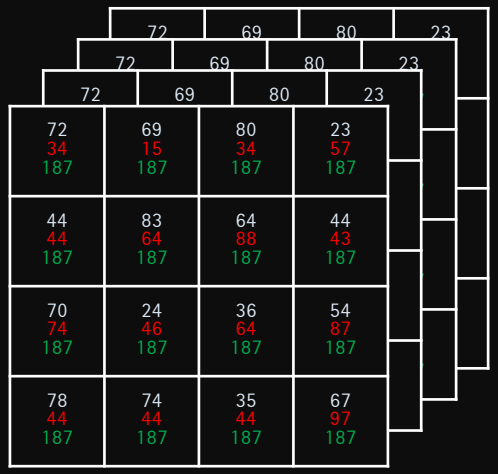


$f(z) = P(y)$: 얼굴 사진을 만드는 궁극의 확률 분포

Probabilistic Distribution

72 34 187	69 15 187	80 34 187	23 57 187
44 44 187	83 64 187	64 88 187	44 43 187
70 74 187	24 46 187	36 64 187	54 87 187
78 44 187	74 44 187	35 44 187	67 97 187

RGB 이미지


72 69 80 23
72 69 80 23
72 69 80 23
72 34 187
69 15 187
80 34 187
23 57 187
44 44 187
83 64 187
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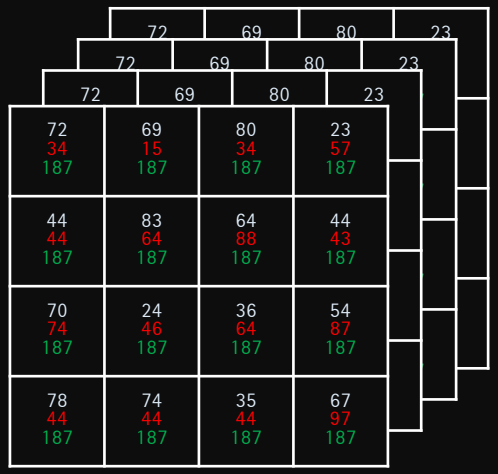
70 74 187
24 46 187
36 64 187
54 87 187
78 44 187
74 44 187
35 44 187
67 97 187

celebA


72 69 80 23
72 69 80 23
72 69 80 23
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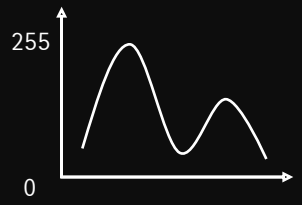
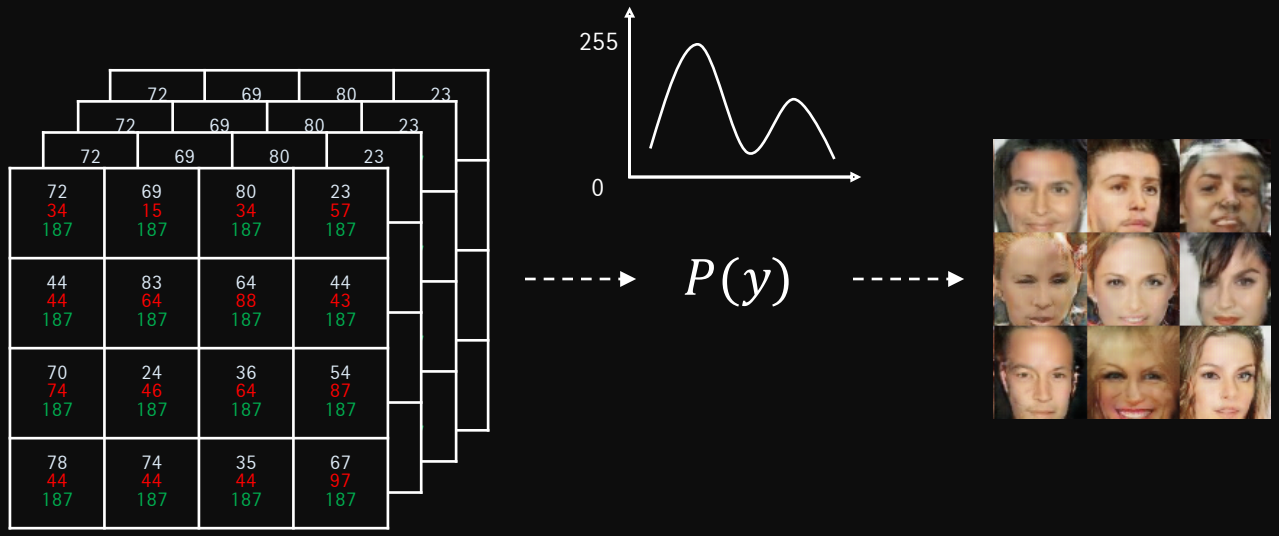
67 97 187

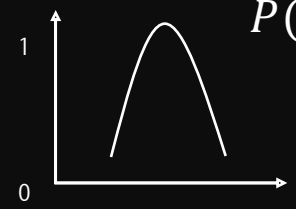

255
0

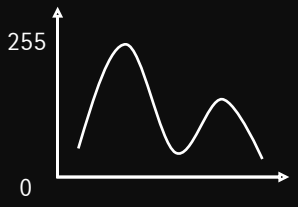
$P(y)$

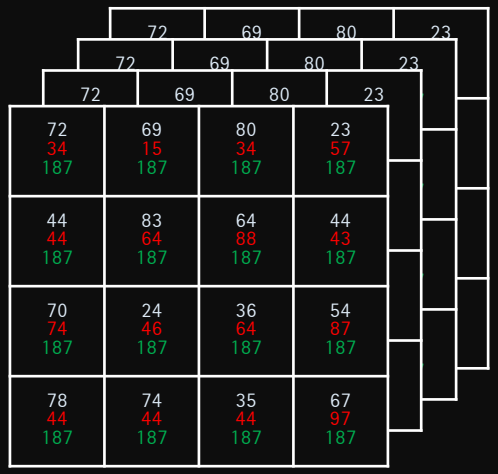
픽셀들의 확률 분포


72 69 80 23
72 69 80 23
72 69 80 23
72 34 187
69 15 187
80 34 187
23 57 187
44 44 187
83 64 187
64 88 187
44 43 187
70 74 187
24 46 187
36 64 187
54 87 187
78 44 187
74 44 187
35 44 187
67 97 187
255
0
$P(y)$

$P(z)$: Gaussian distribution







$P(y|z)$

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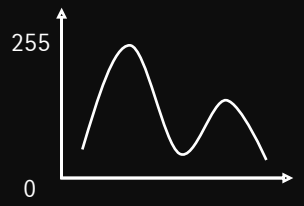
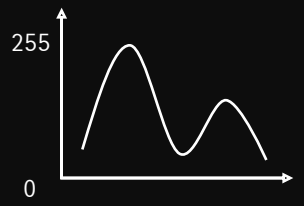


$P(y|z)$



$P(y|z)$

DCGAN

Deep
Convolutional
Generative
Adversarial
Networks

Deep
Convolutional
Generative
Adversarial
Networks

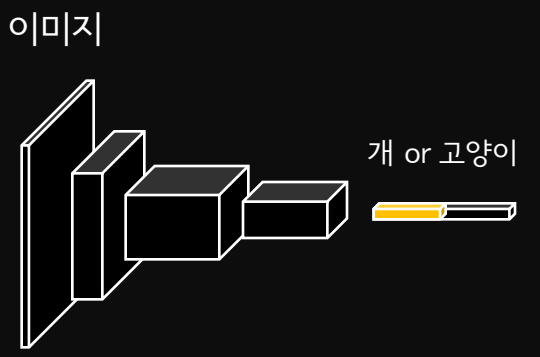
딥러닝
Deep Learning

Deep
Convolutional
Generative
Adversarial
Networks

DEVSISTERS

ConvNet

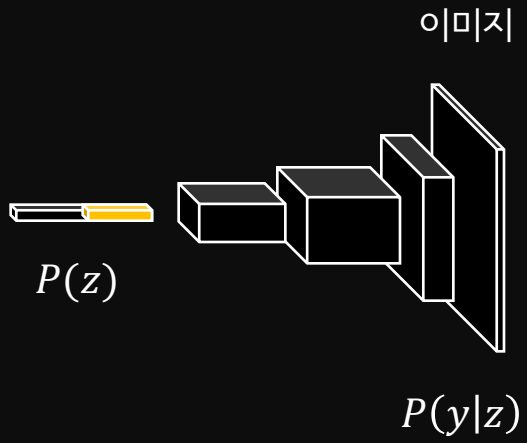
Deep
Convolutional
Generative
Adversarial
Networks



보통 CNN classification은 이게 전부

Deep
Convolutional
Generative
Adversarial
Networks

생성 모델
Generative Model



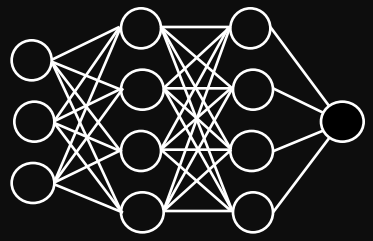
Deep
Convolutional
Generative
Adversarial
Networks

적대적 학습
Adversarial Learning

DEVSISTERS

Deep
Convolutional
Generative
Adversarial
Networks

인공 신경망
Neural Network



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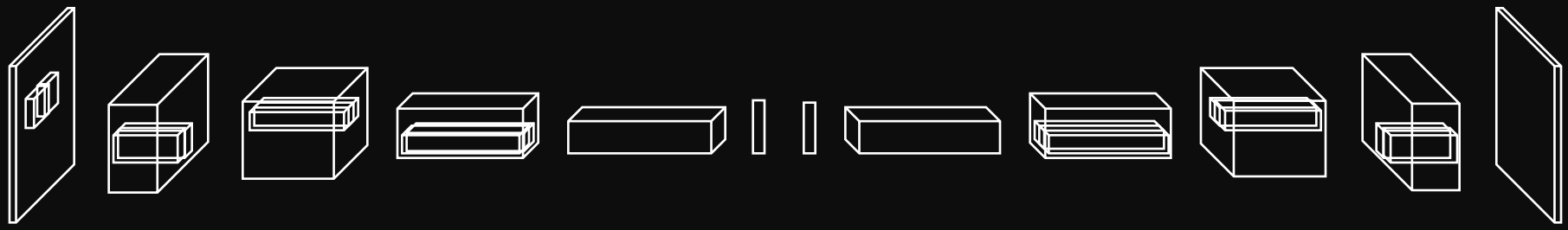
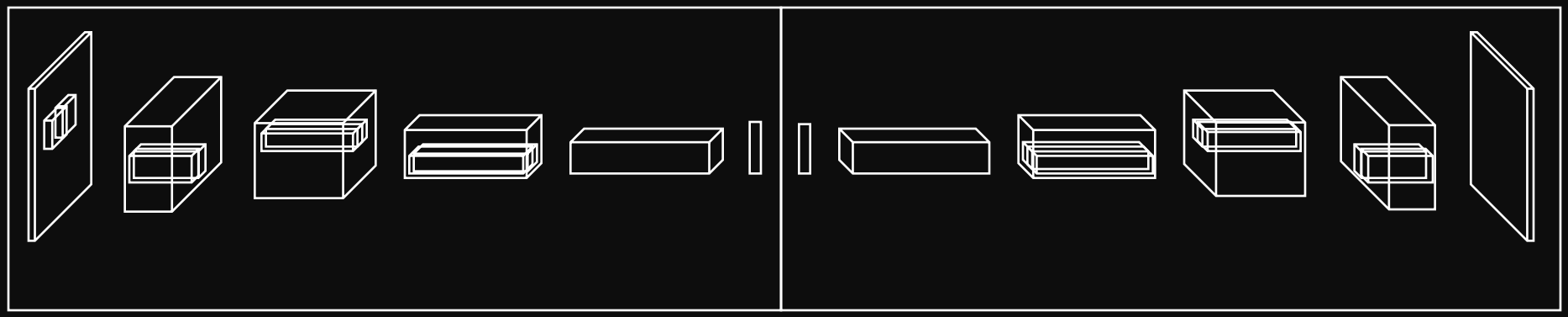
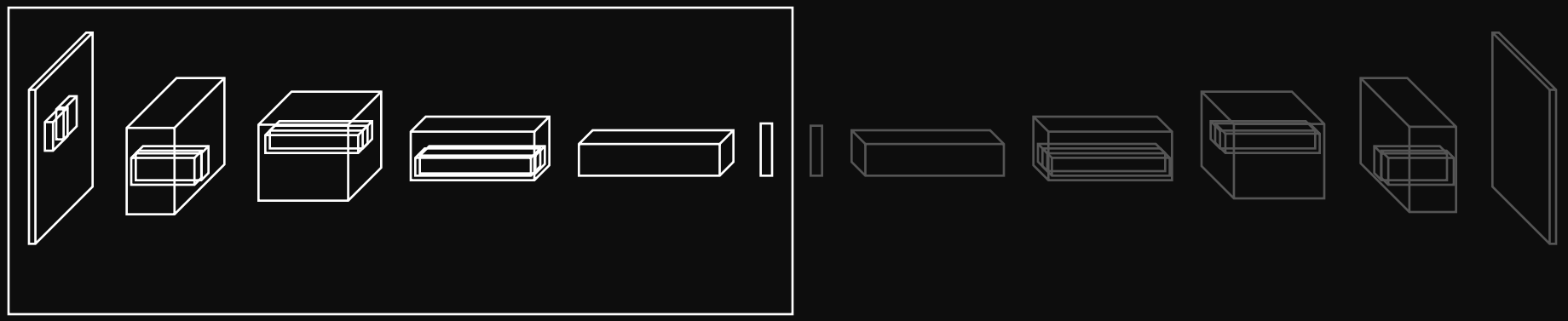
DCGAN



DCGAN



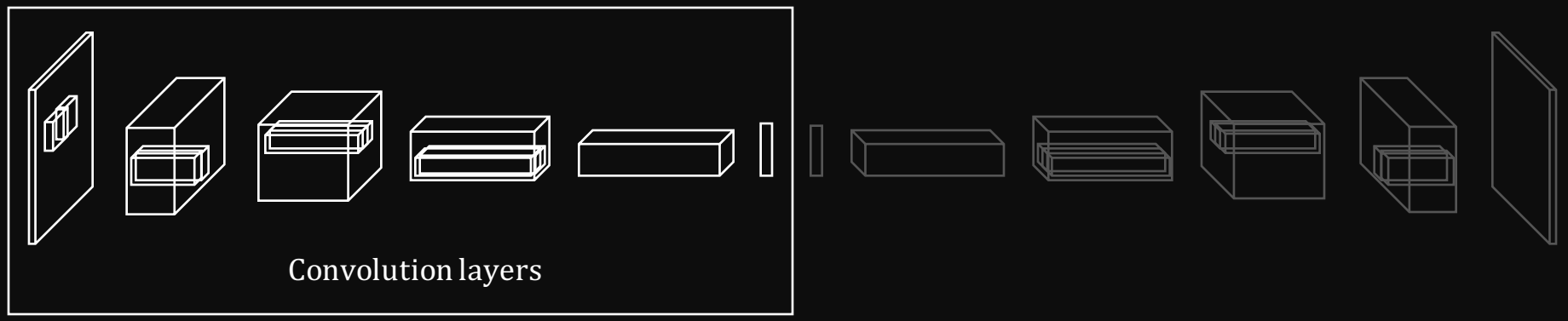
DCGAN



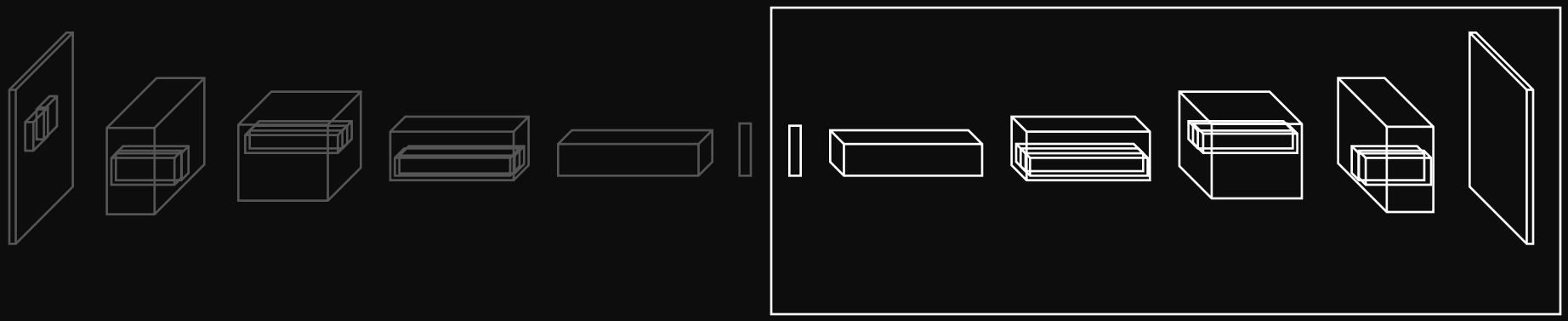
DEVSISTERS

DCGAN

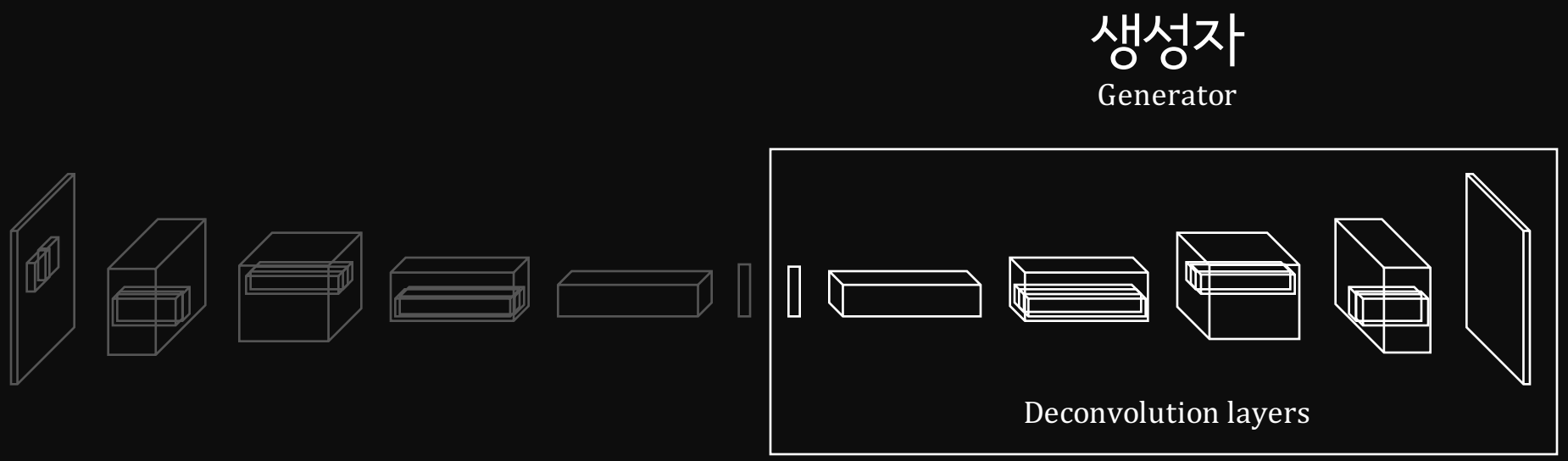
구분자
Discriminator



DCGAN



DCGAN

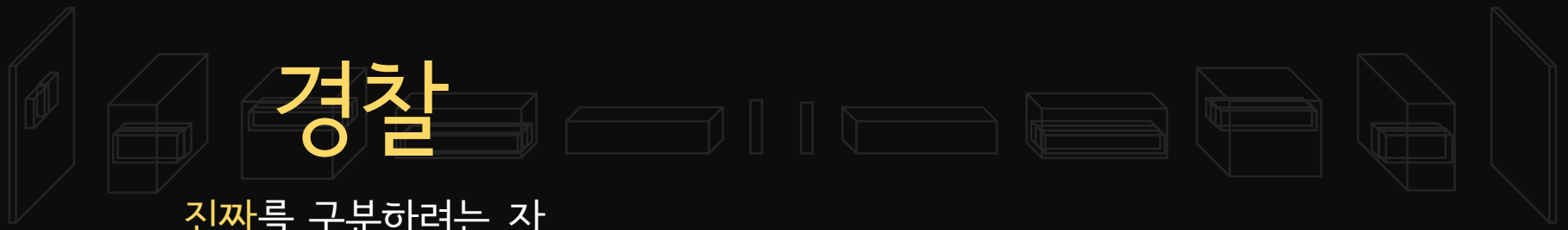


DCGAN

구분자
Discriminator

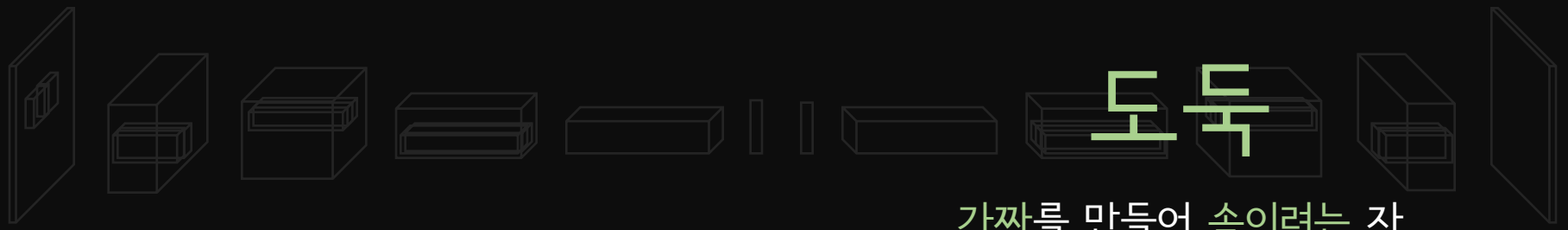
경찰

진짜를 구분하려는 자



DCGAN

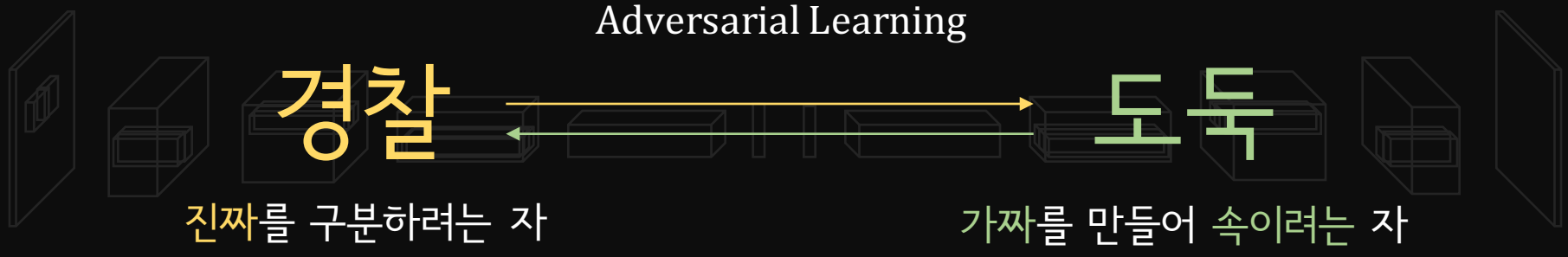
생성자
Generator



도둑

가짜를 만들어 속이려는 자

DCGAN



적대적 학습
Adversarial Learning

DEVSISTERS

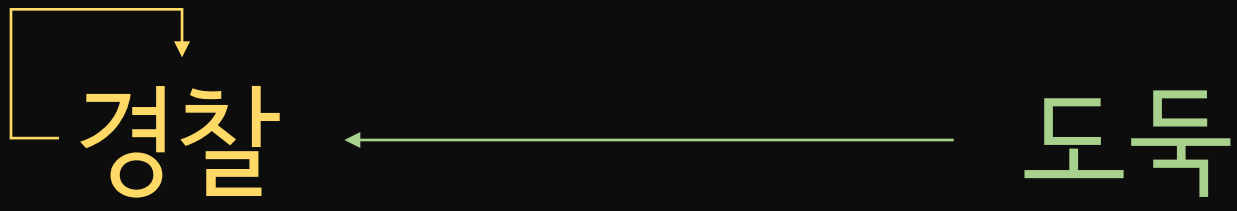
적대적 학습
Adversarial learning

경찰

도둑

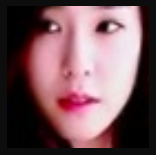
DEVSISTERS

적대적 학습
Adversarial learning

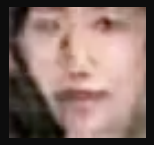


한번에 한번씩 번갈아가며 학습

1. 경찰의 학습



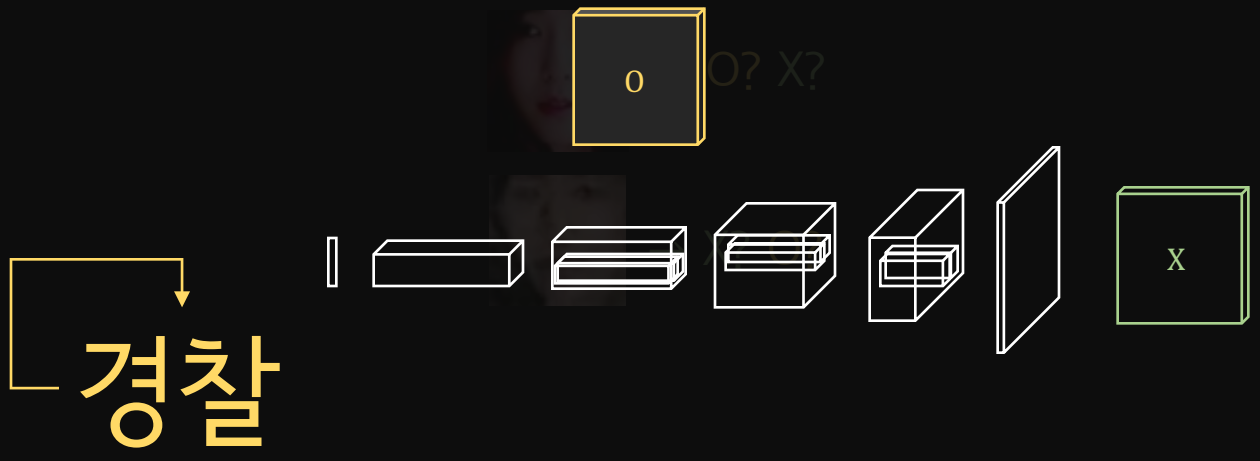
→ O? X?



→ X? O?

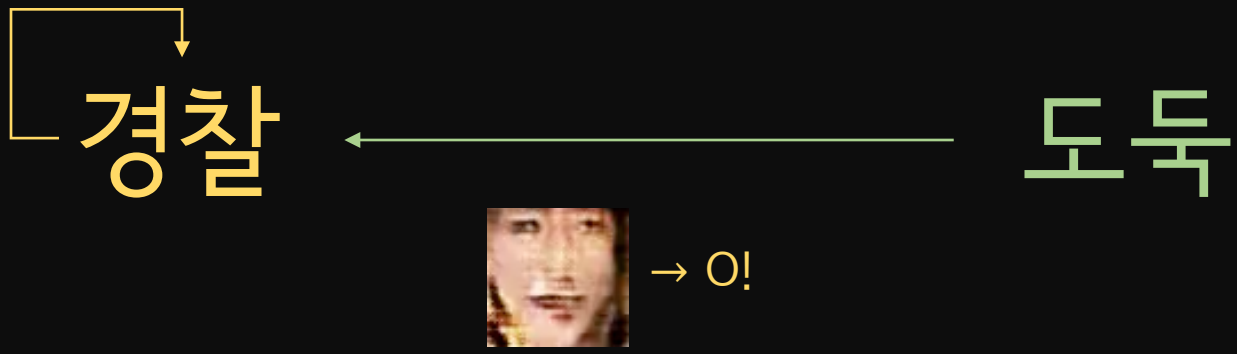
진짜와 가짜를 구분하는 방법을 학습

1. 경찰의 학습

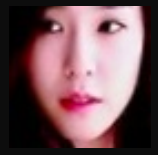


진짜와 가짜를 구분하는 방법을 학습

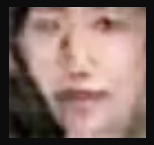
2. 도둑의 학습



경찰을 속이는 사진을 만드는 방법을 학습

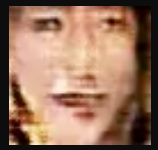


→ O? X?



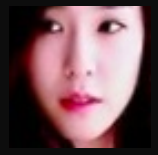
→ X? O?

경찰 ← 도둑

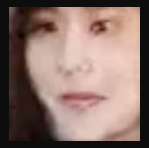


→ O!

경찰은 점점 진짜와 가짜를 구분하게 되고

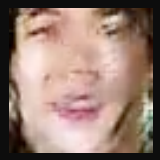


→ O!

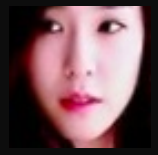


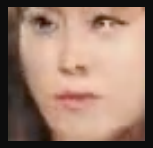
→ X!

경찰 ← 도둑

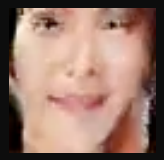


→ O!

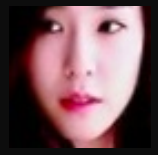

→ O!


→ X?!

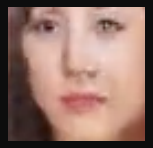
경찰 ← 도둑


→ O!

도둑은 점점 진짜같은 가짜를 잘 만들게 된다



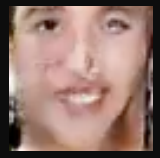
→ O!



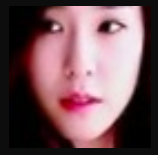
→ X?!

경찰

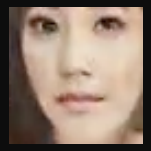
도둑



→ O!



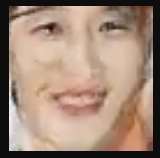
→ O!



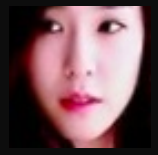
→ O?!

경찰

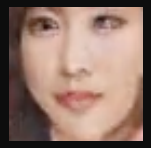
도둑



→ O!



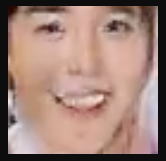
→ O!



→ O?

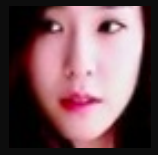
경찰

도둑

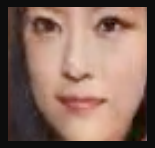


→ O!

DEVSISTERS



→ O!

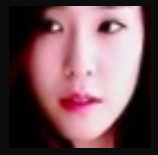


→ O!

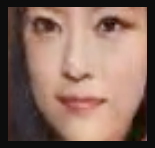
경찰

도둑

→ O!



→ O!

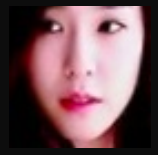


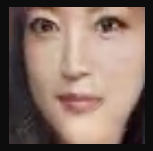
→ O!

경찰

도둑

→ O!


→ O!


→ O!

경찰

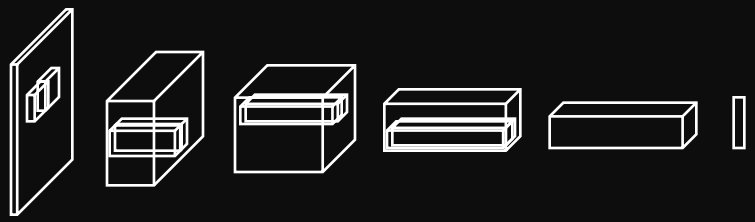
도둑


→ O!

네트워크와 함께 설명해 보겠습니다

구분자 = 경찰

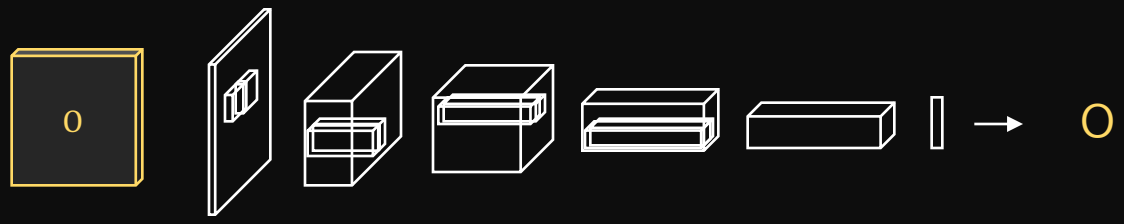
Descriptor



DEVSISTERS

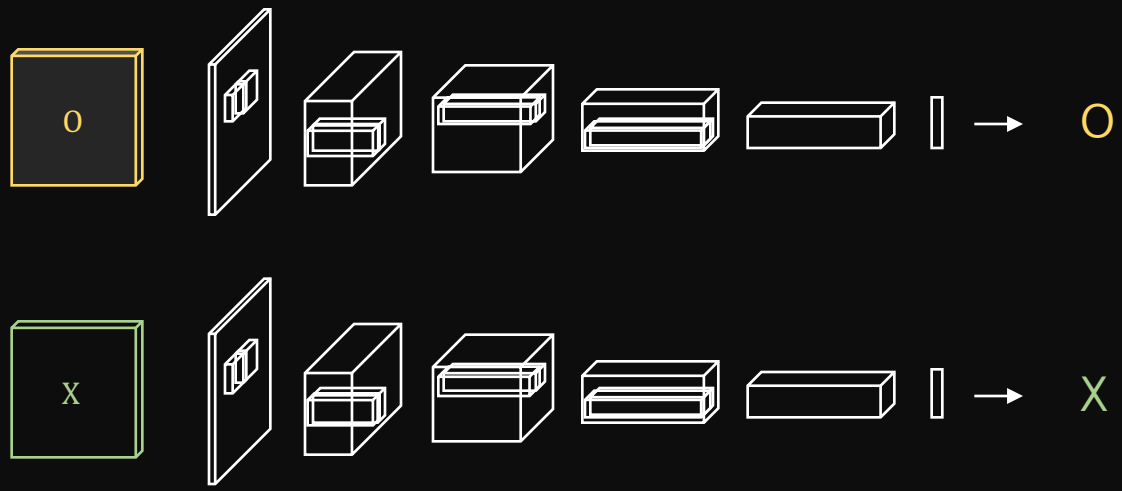
구분자 = 경찰

Descriptor



구분자 = 경찰

Descriptor



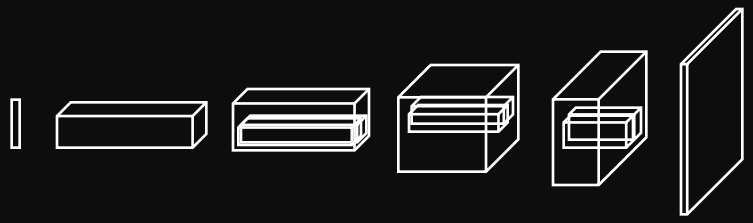
구분자 = 경찰

Descriptor

1, 0로 이루어진 벡터를 예측

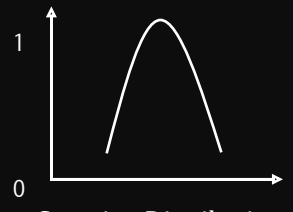
생성자 = 도둑

Generator

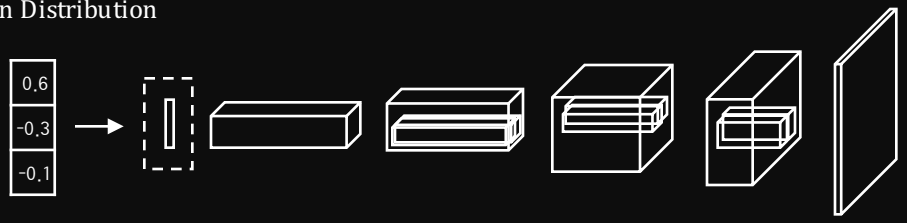


생성자 = 도둑

Generator

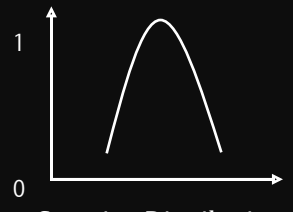


Gaussian Distribution

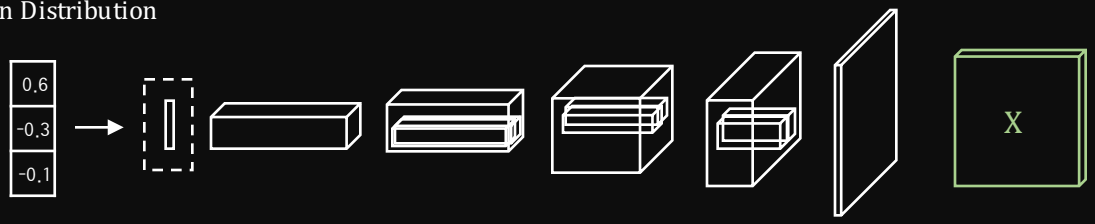


생성자 = 도둑

Generator



Gaussian Distribution

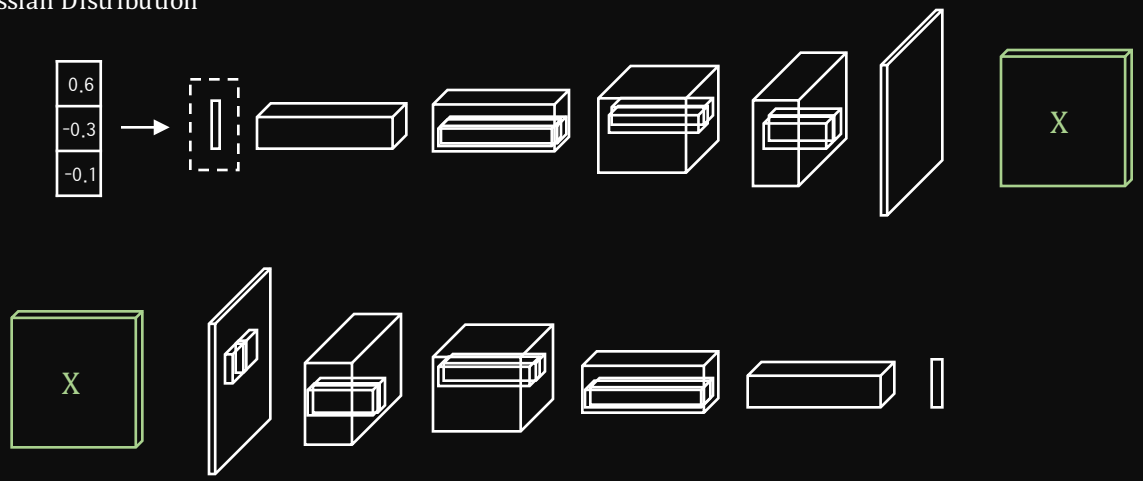


생성자 = 도둑

Generator

평균이 0인 랜덤한 숫자들

Gaussian Distribution

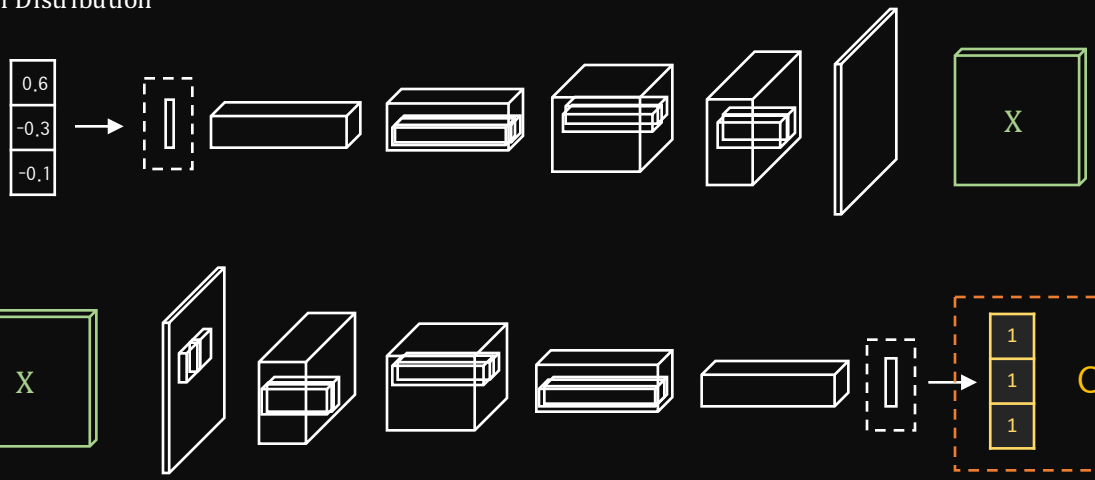


생성자 = 도둑

Generator

평균이 0인 랜덤한 숫자들

Gaussian Distribution



X를 O라고 하도록 학습

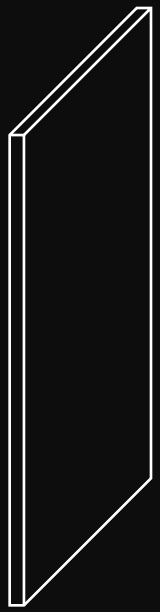
네트워크 구조

Convolution, Deconvolution, Batch Normalization

DEVSISTERS

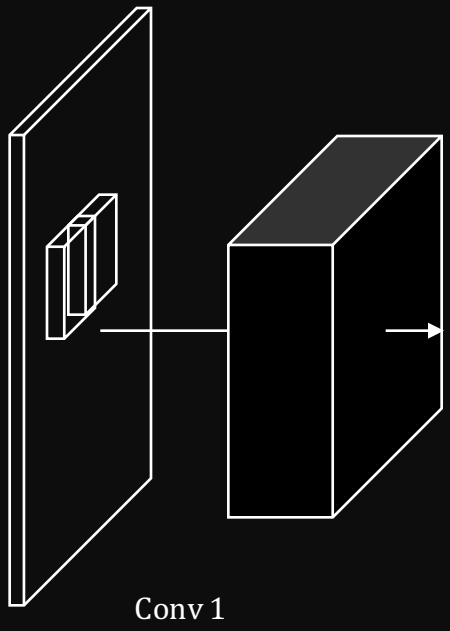
구분자
Discriminator

이미지

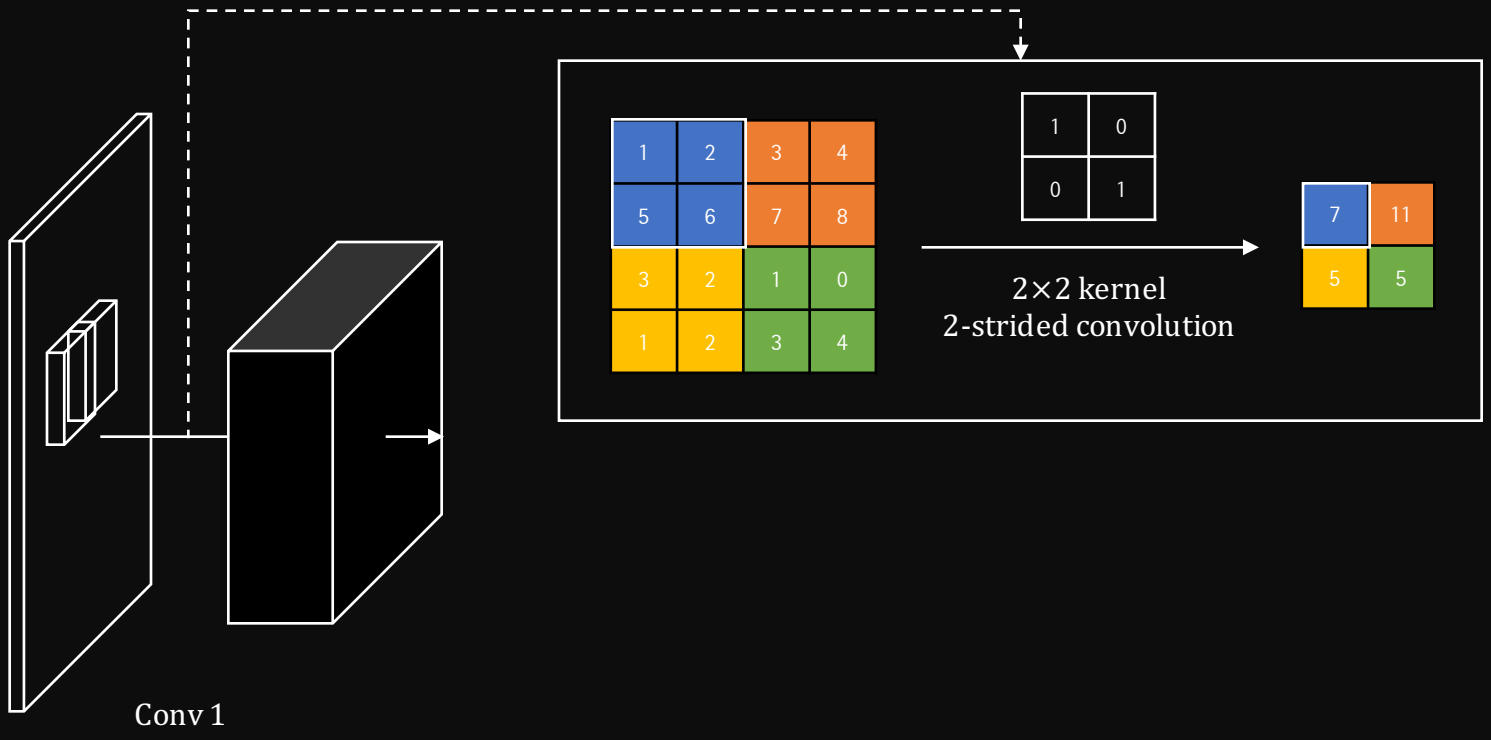


DEVSISTERS

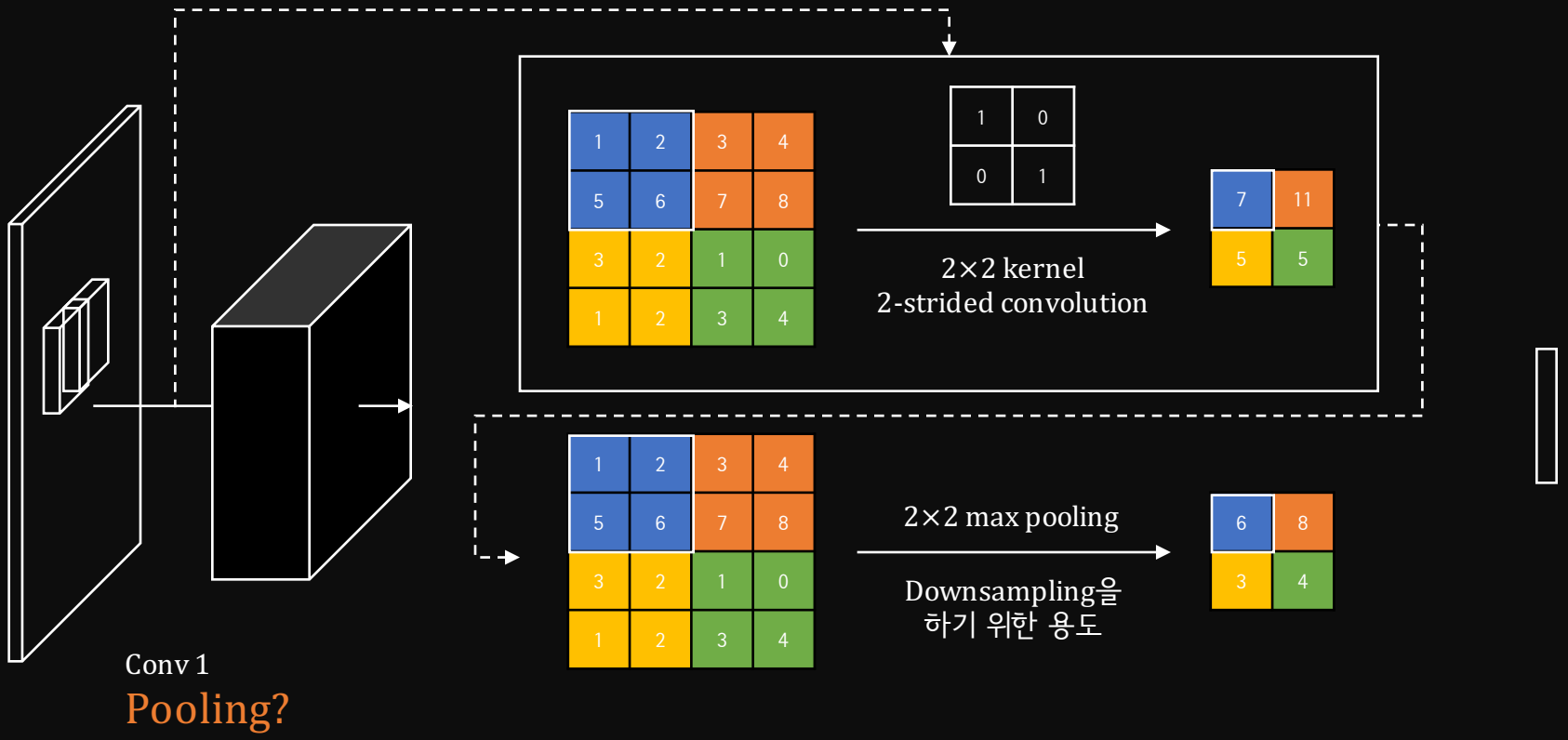
구분자
Discriminator



구분자
Discriminator

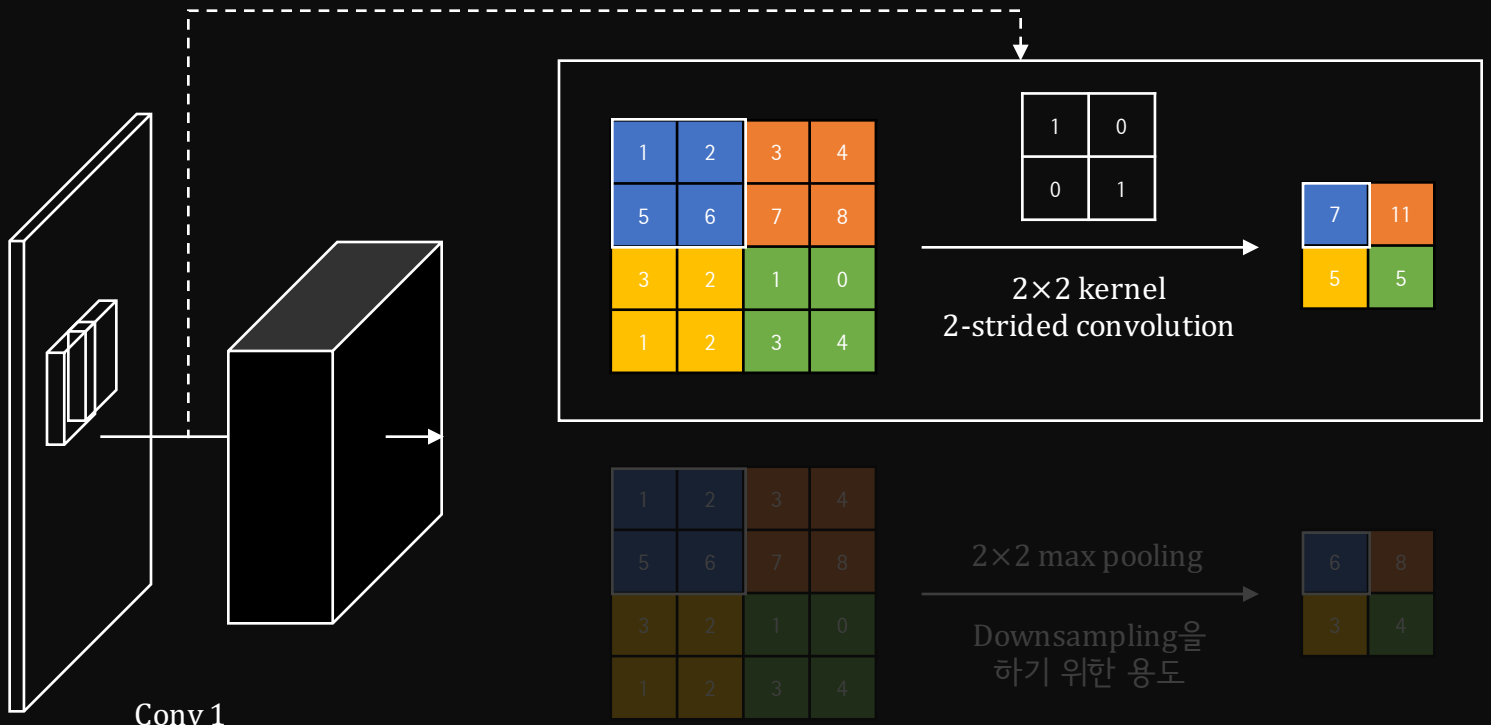


구분자
Discriminator



DEVSISTERS

구분자
Discriminator



Conv 1

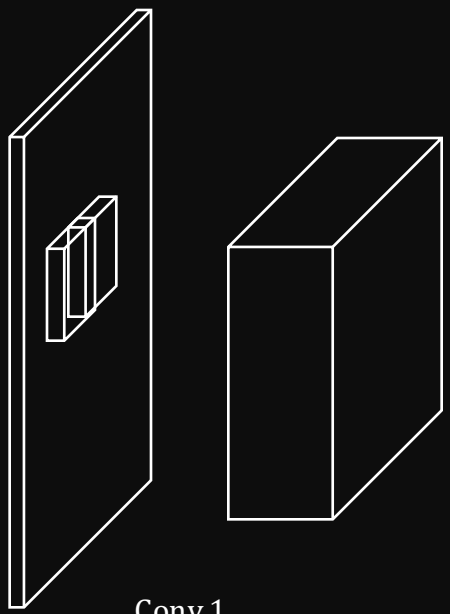
No pooling

4×4의 큰 kernel을 사용해 스스로 최적의 sampling을 배움

DEVSISTERS

구분자
Discriminator

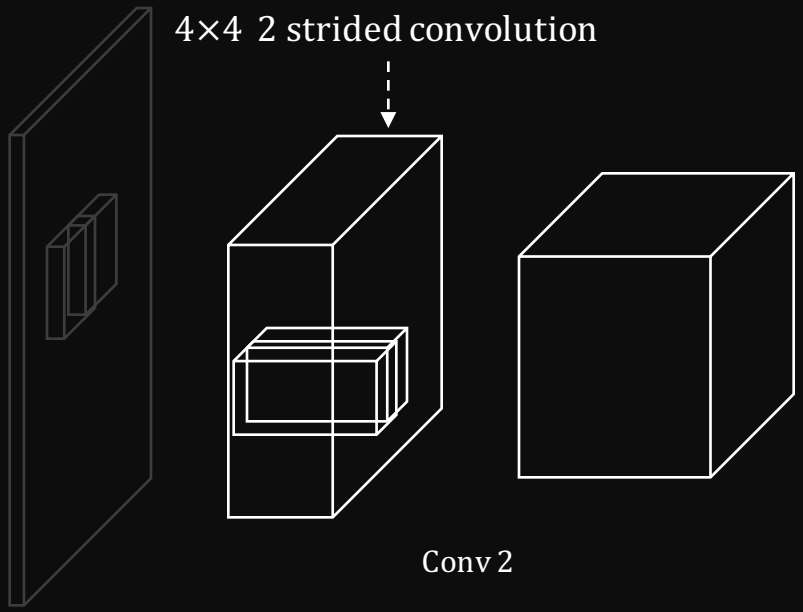
4×4 2 strided convolution



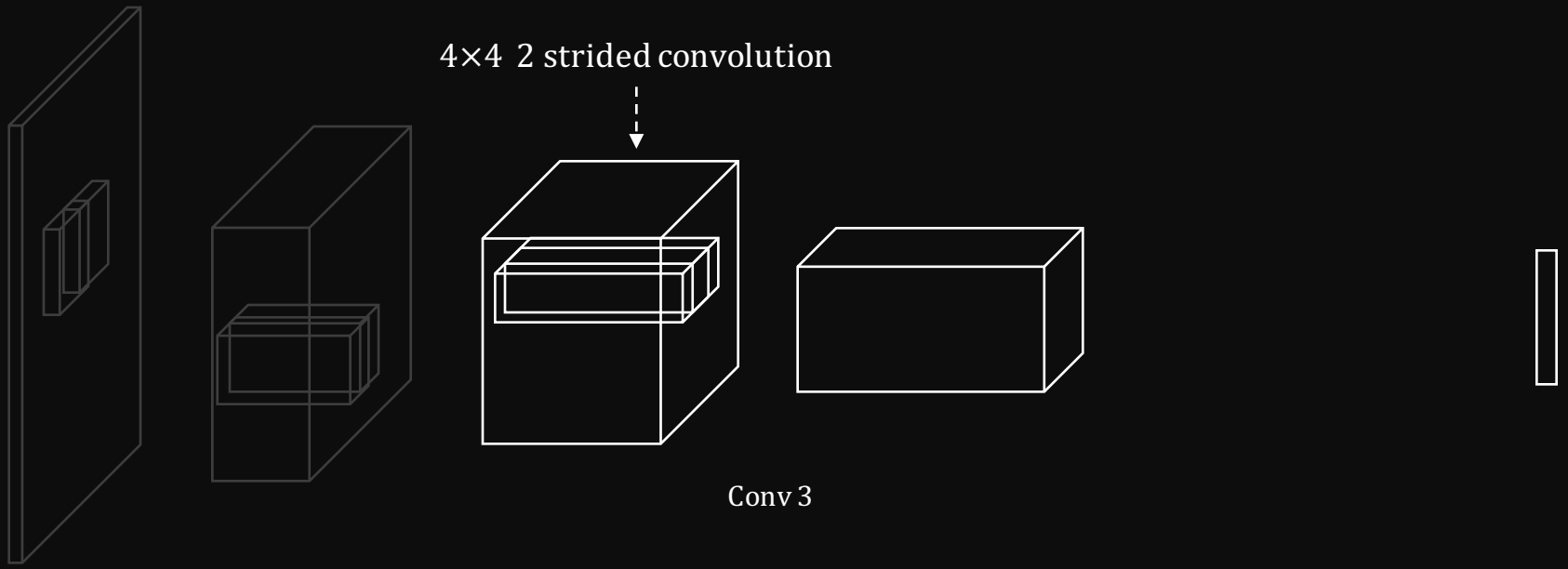
Conv 1

DEVSISTERS

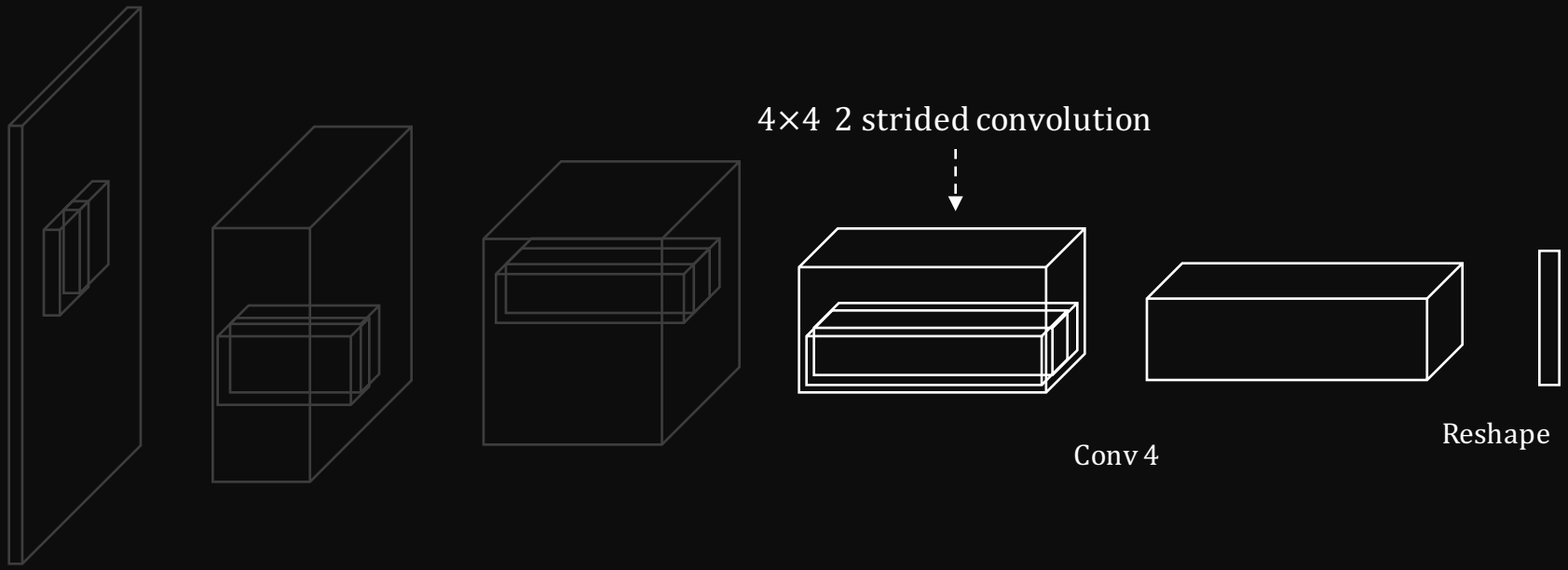
구분자
Discriminator



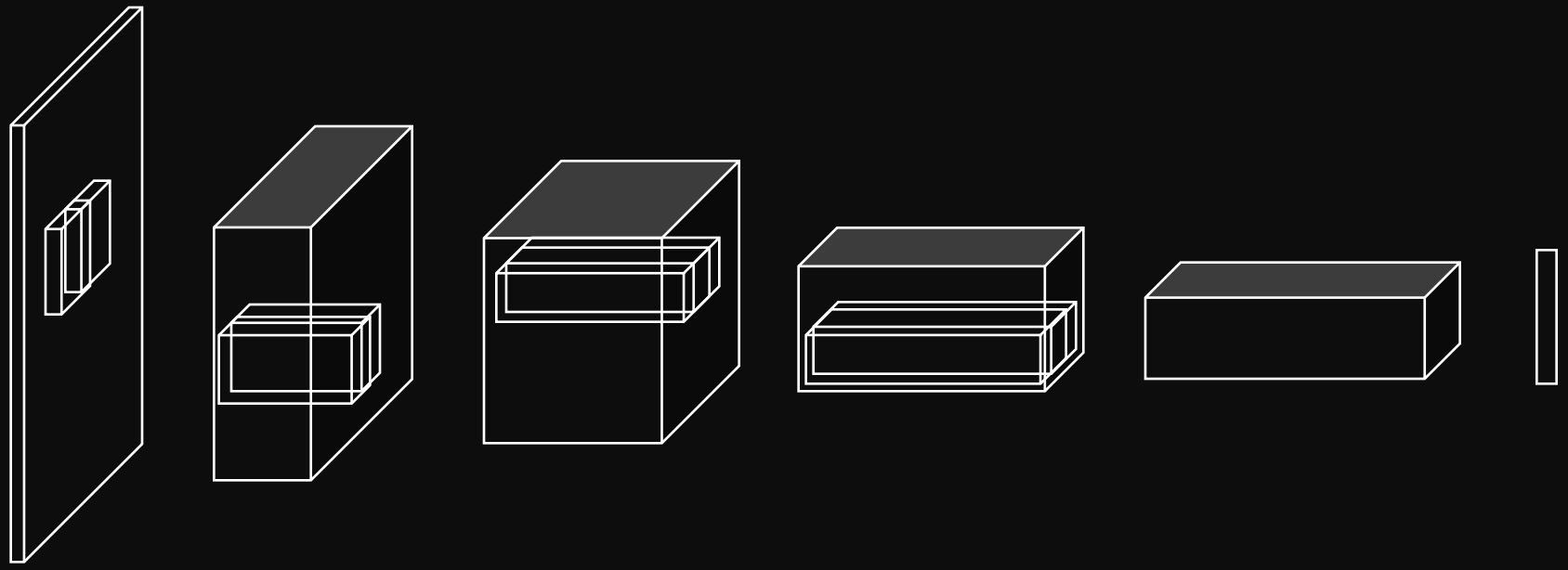
구분자
Discriminator



구분자
Discriminator

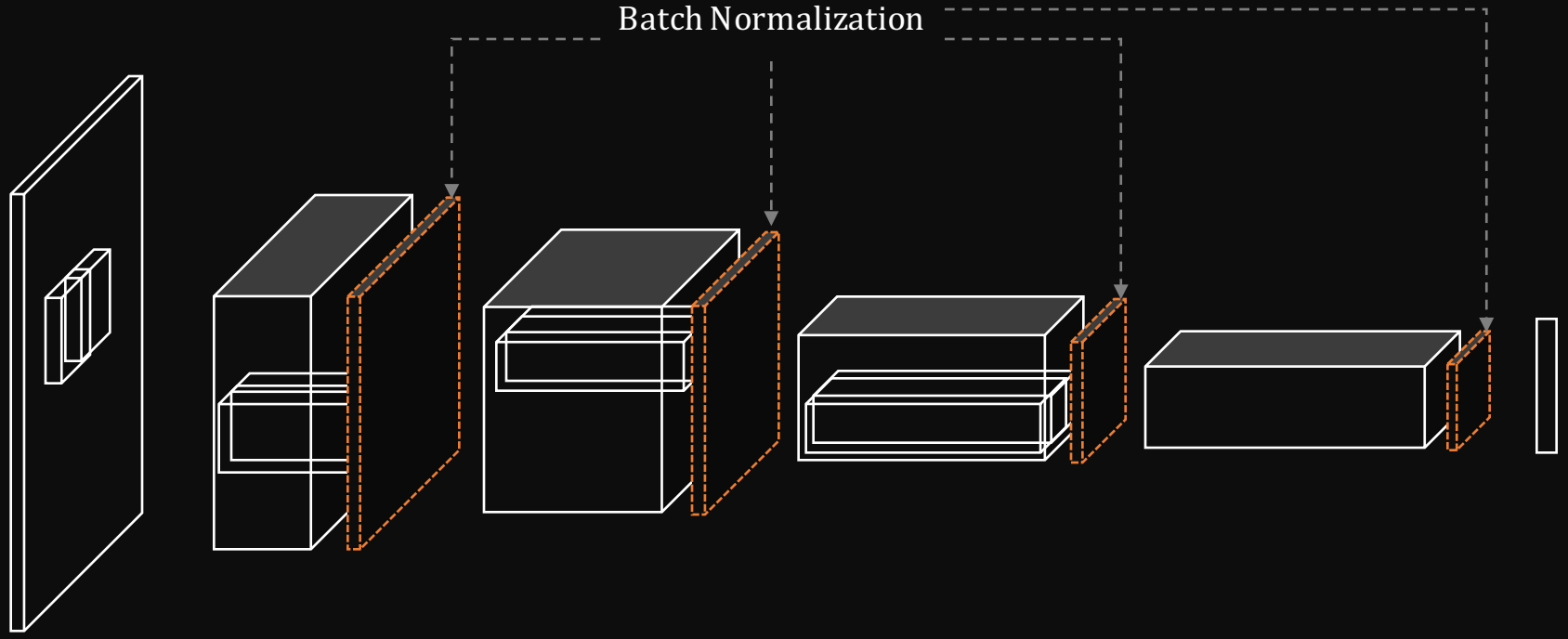


구분자
Discriminator



DEVSISTERS

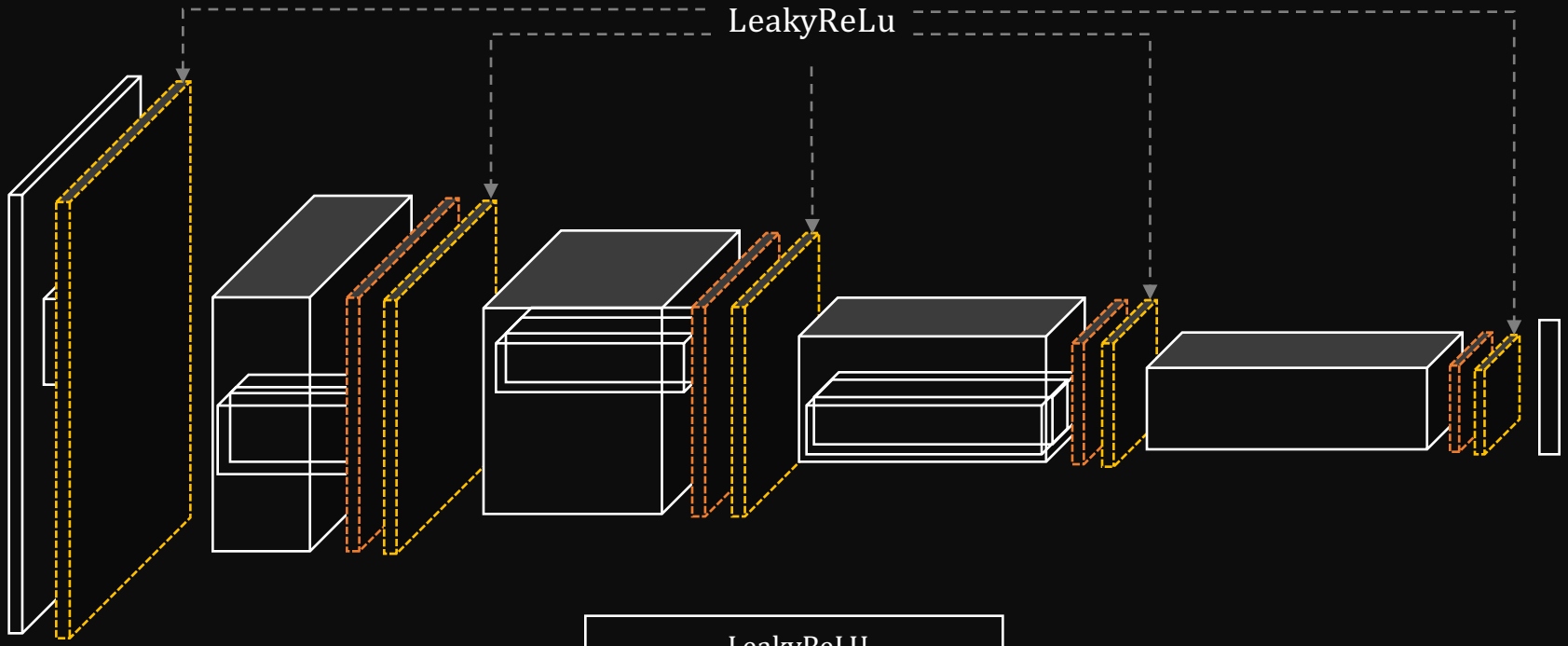
구분자
Discriminator

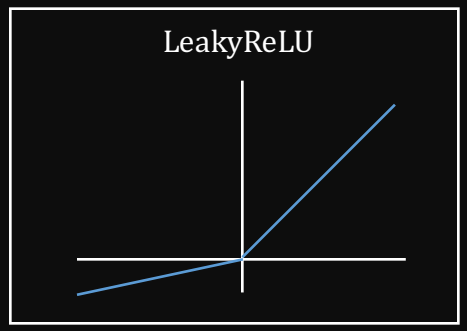


이전 layer의 output을 normalize시켜 학습을 가속시키는 방법

http://sanghyukchun.github.io/88/

구분자
Discriminator





DEVSISTERS

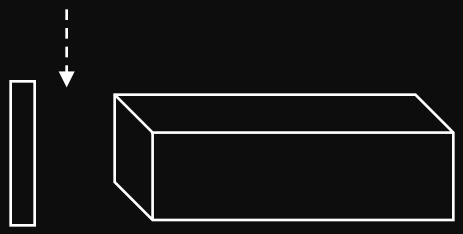
생성자
Generator

이미지

DEVSISTERS

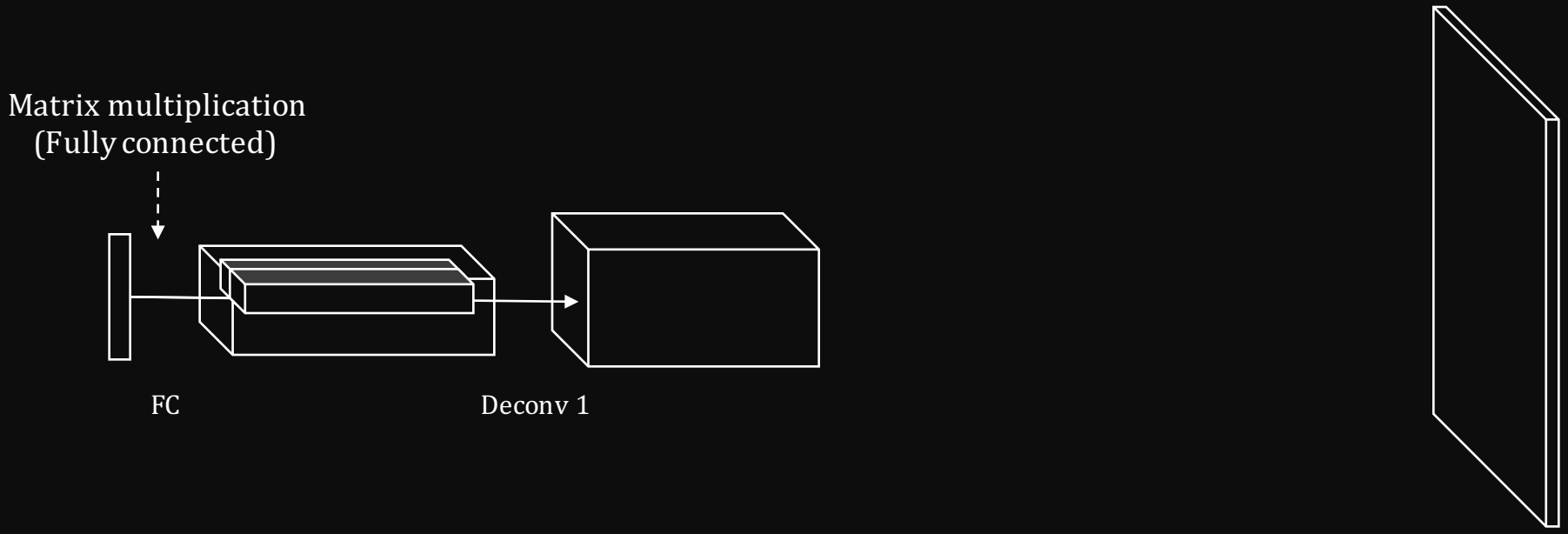
생성자
Generator

Matrix multiplication
(Fully connected)

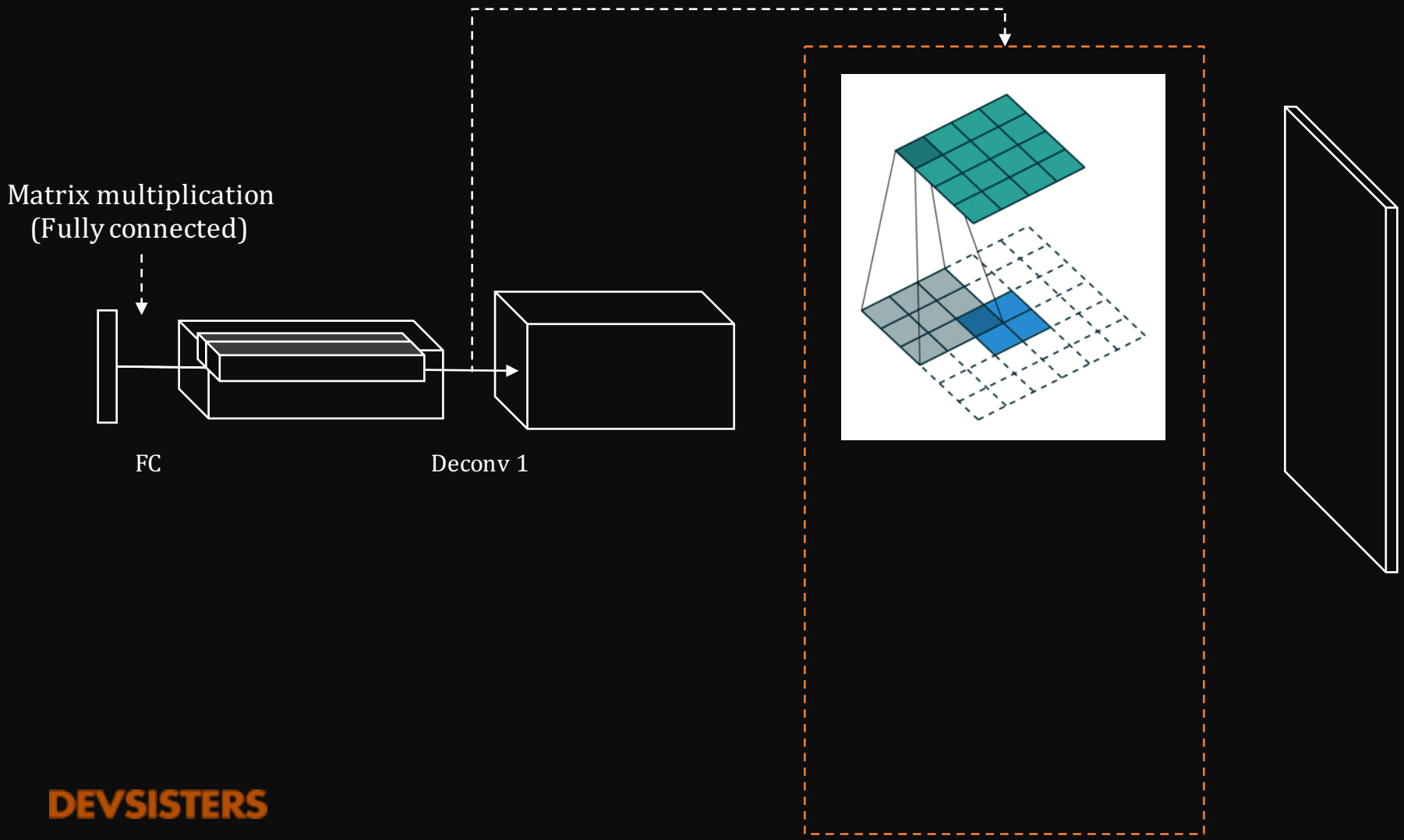


FC

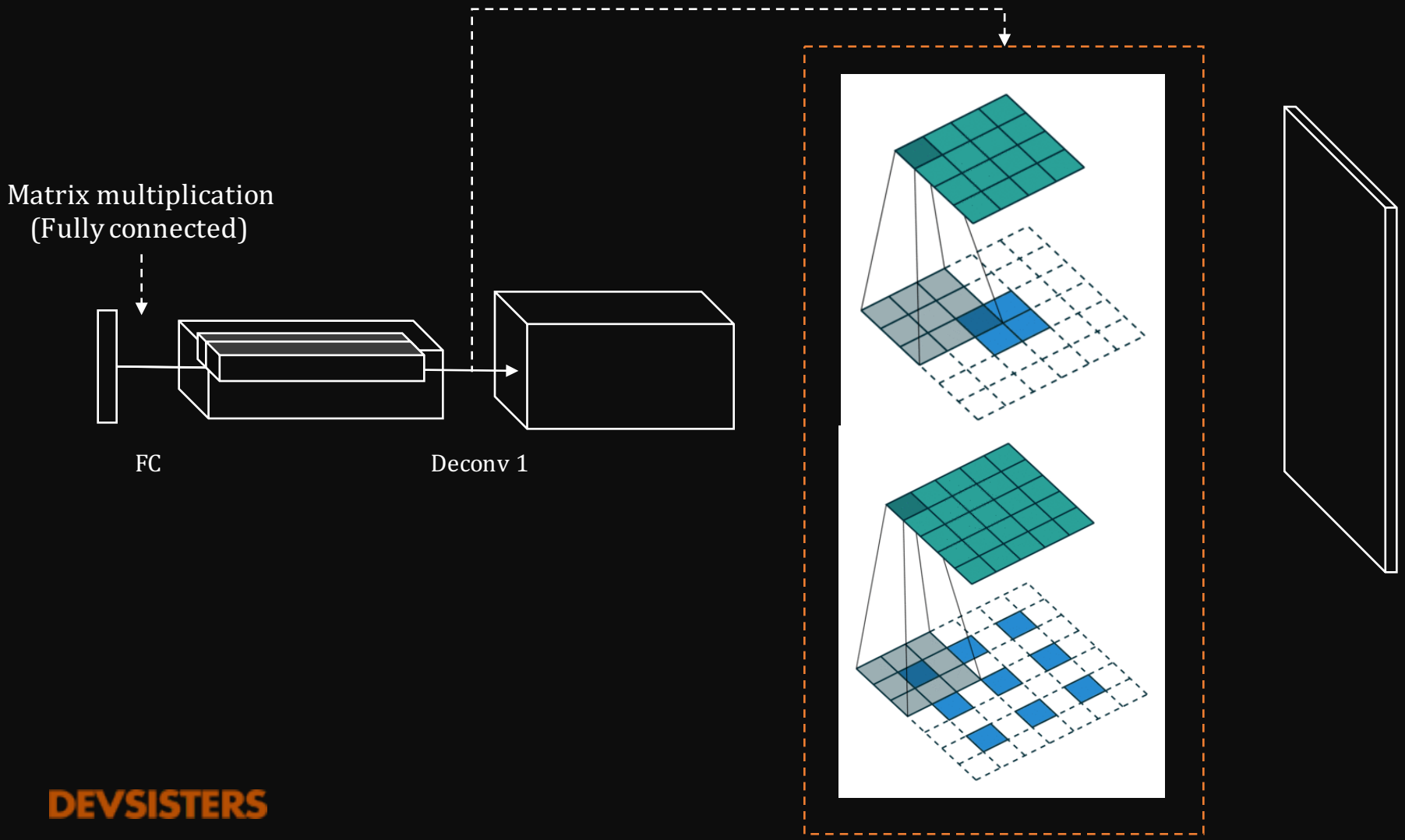
생성자
Generator



생성자
Generator

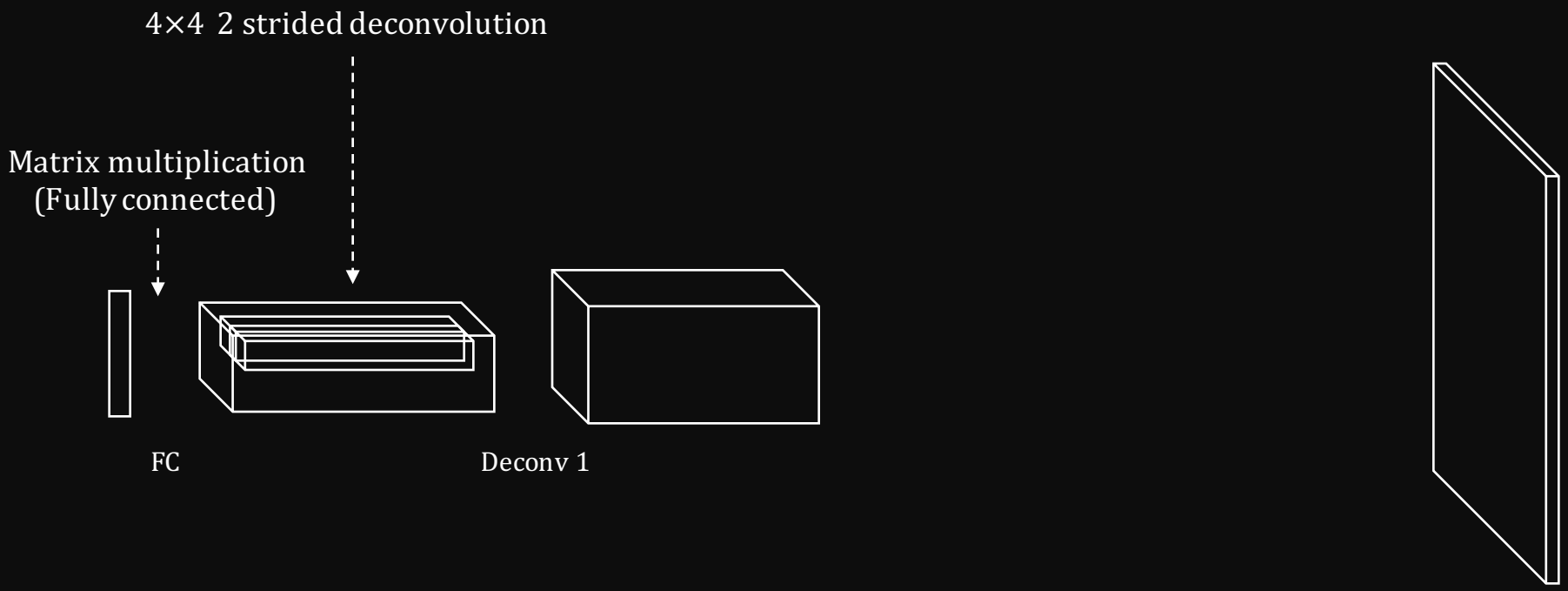


생성자
Generator

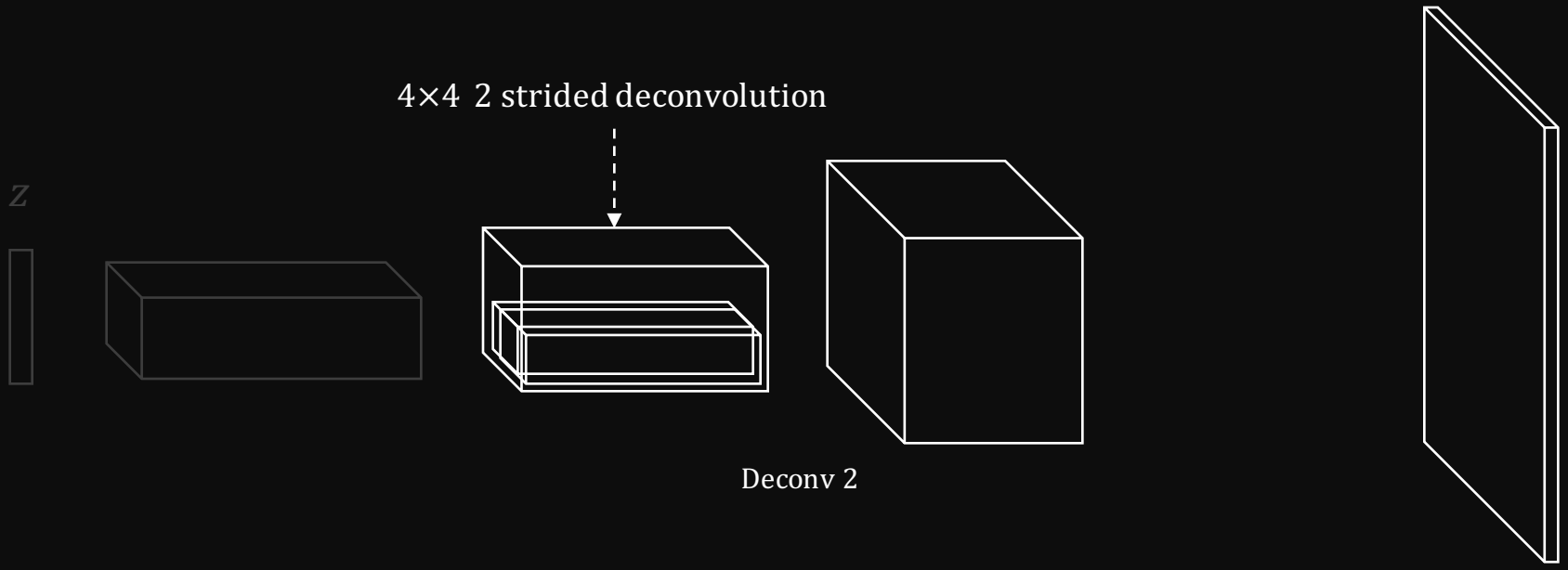


DEVSISTERS

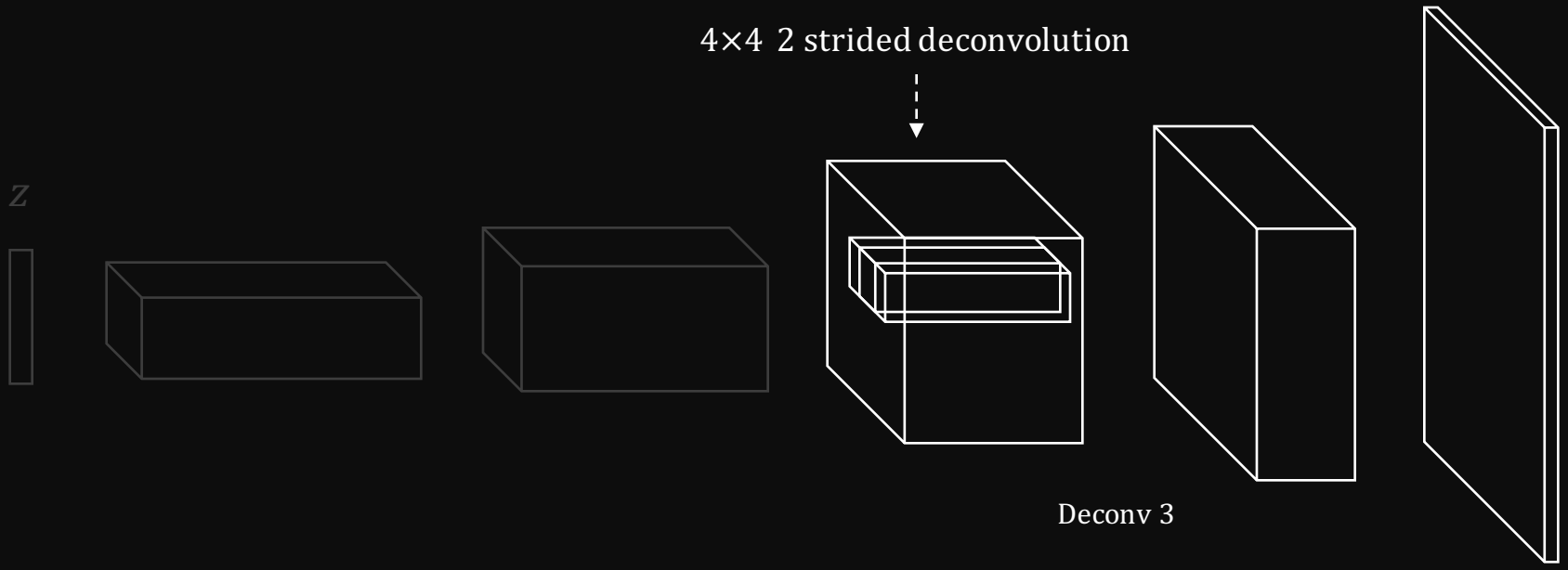
생성자
Generator



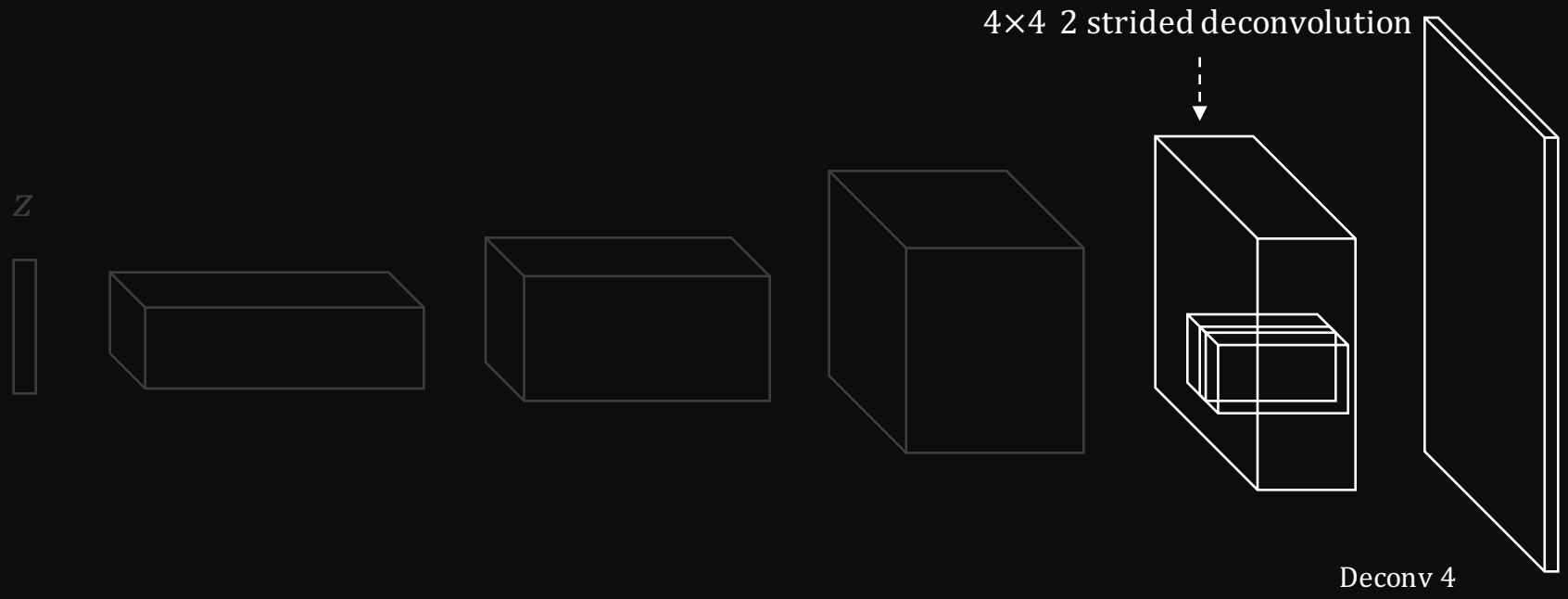
생성자
Generator



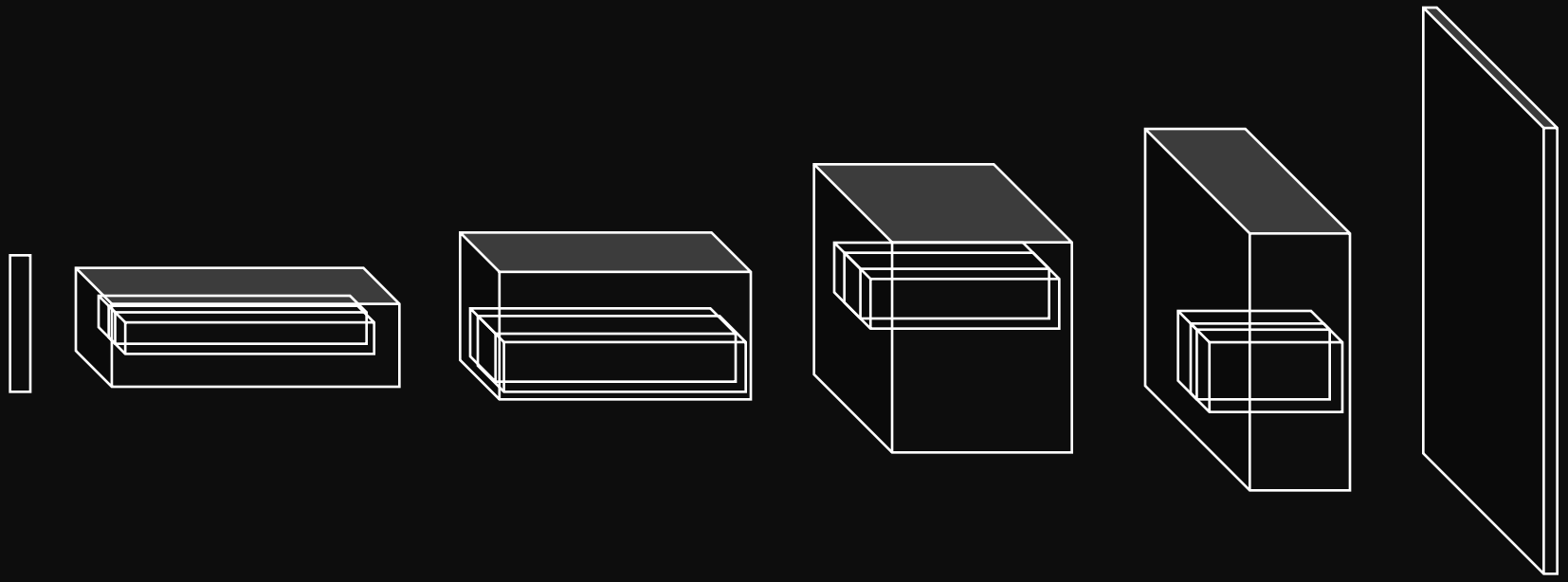
생성자
Generator



생성자
Generator

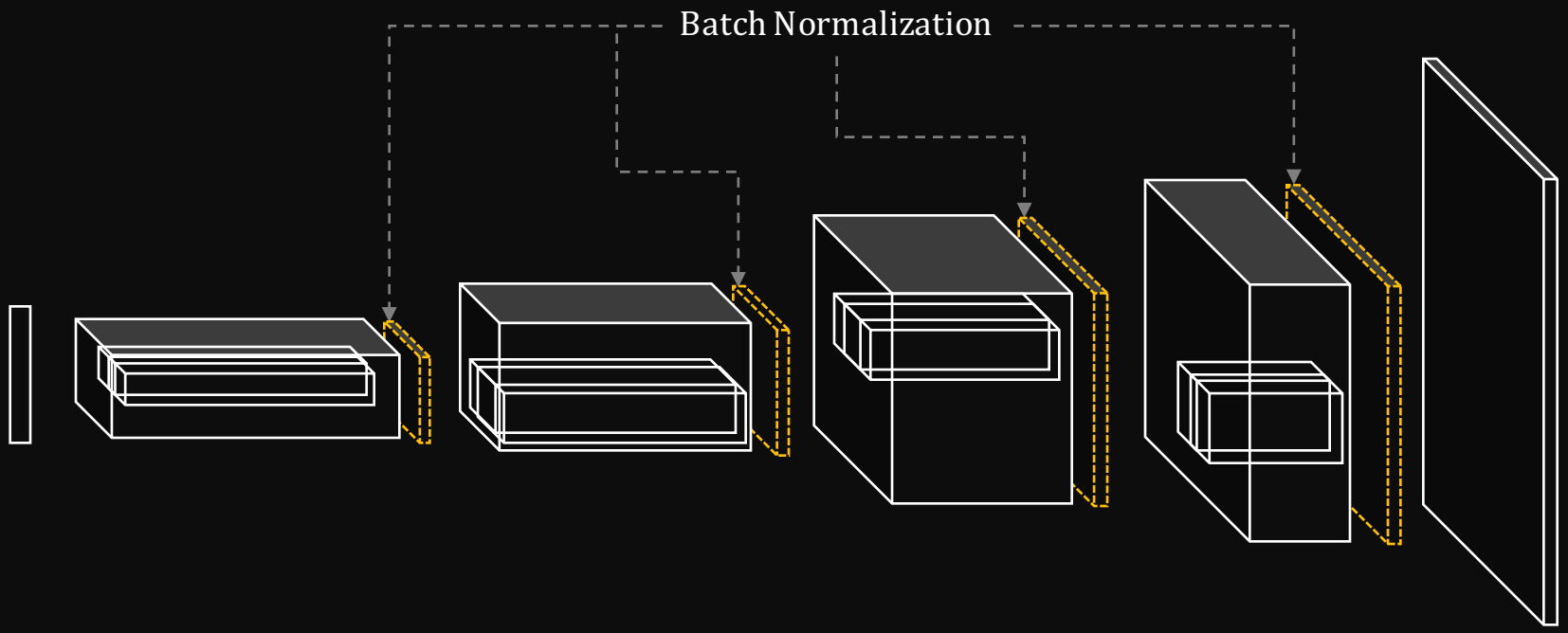


생성자
Generator

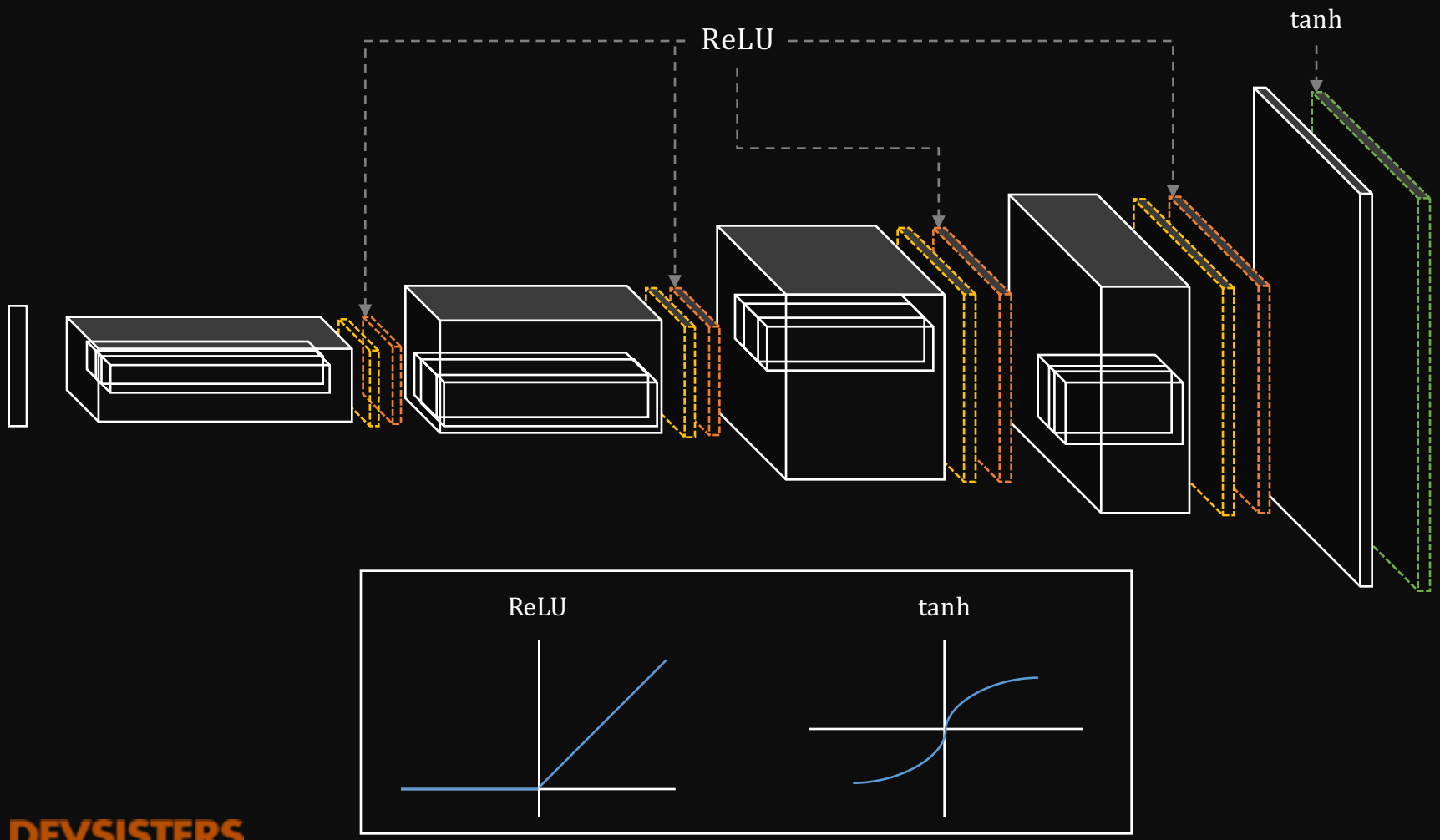


DEVSISTERS

생성자
Generator



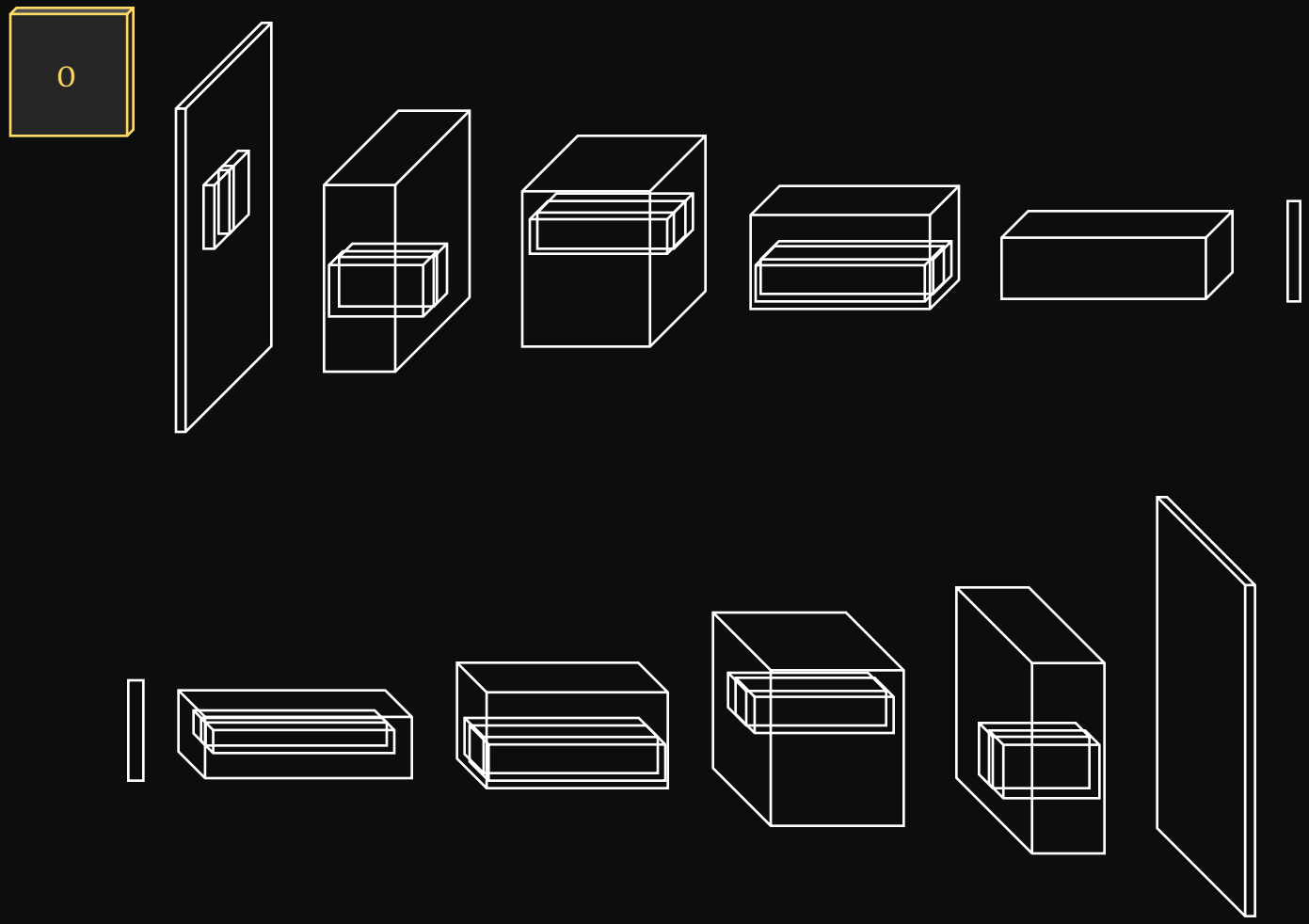
생성자
Generator



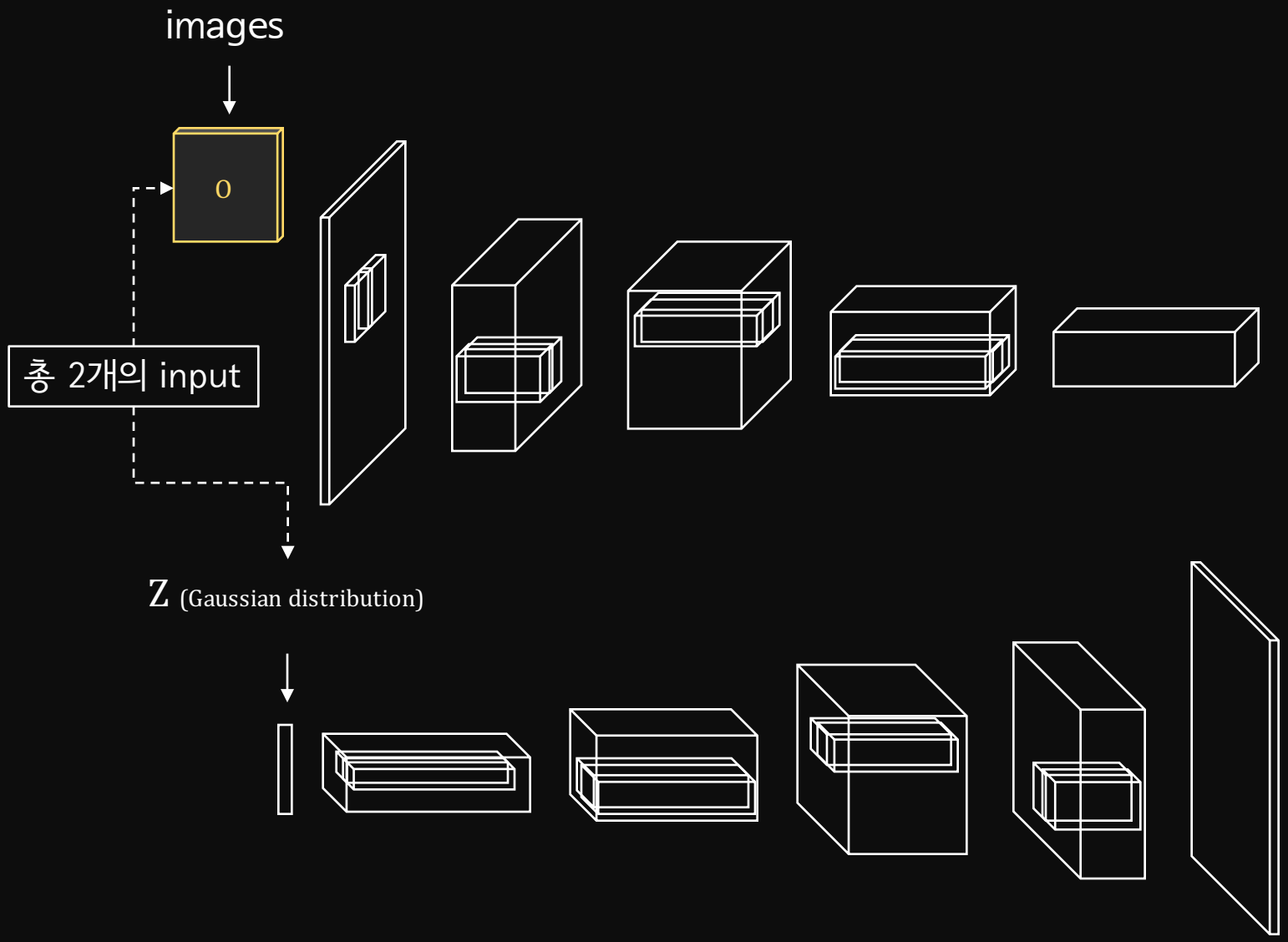
총 정리

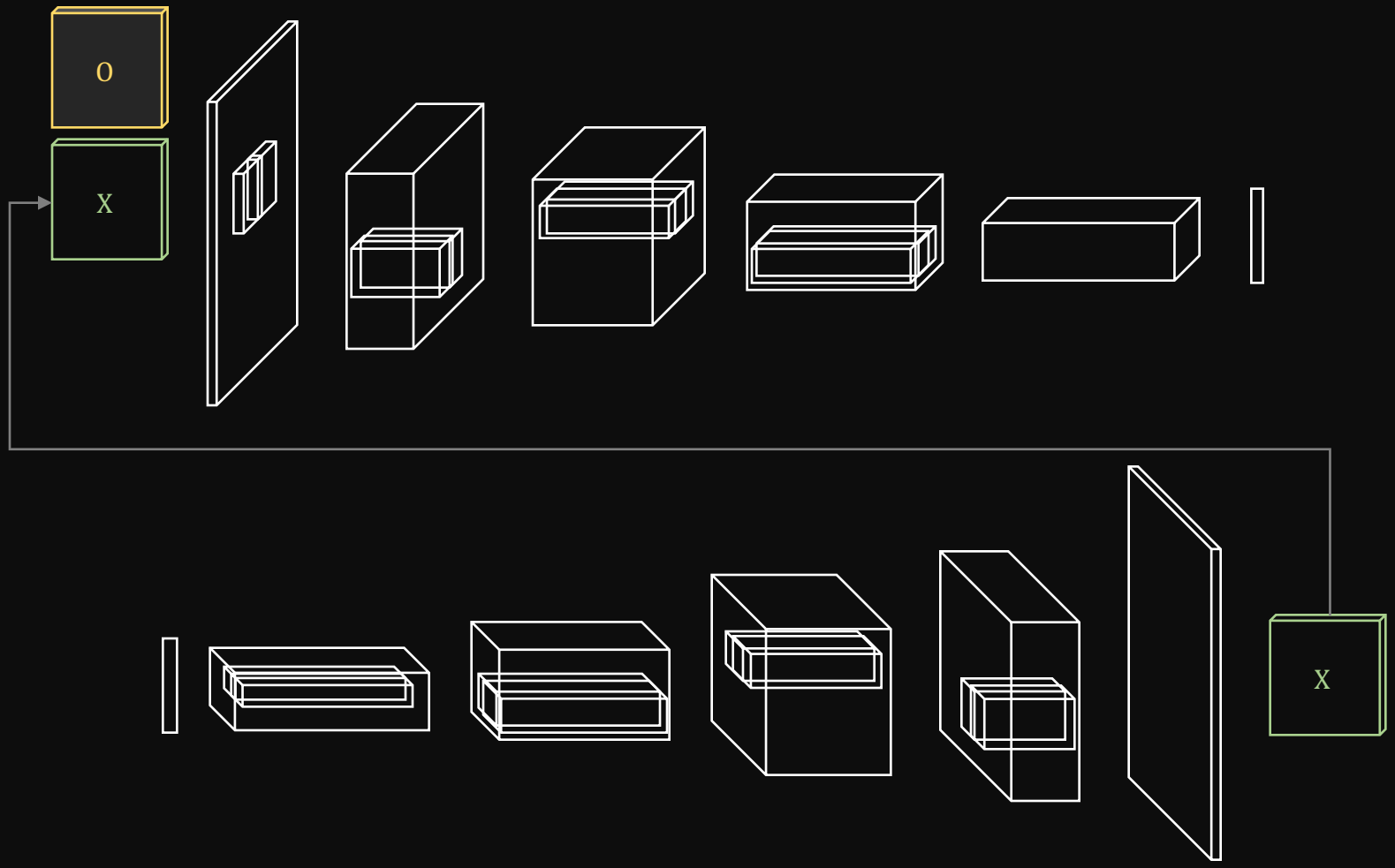
(탕탕)

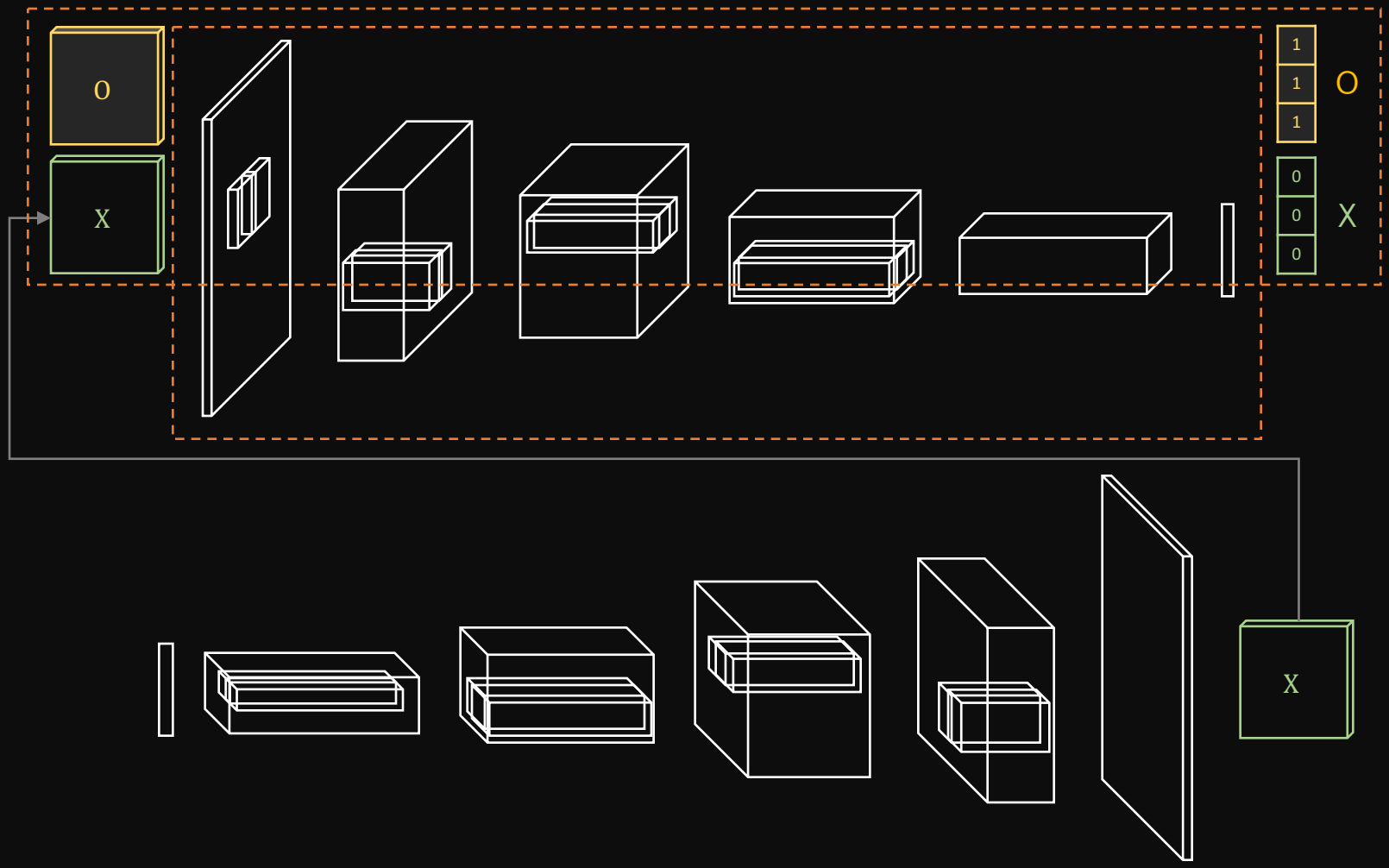
DEVSISTERS

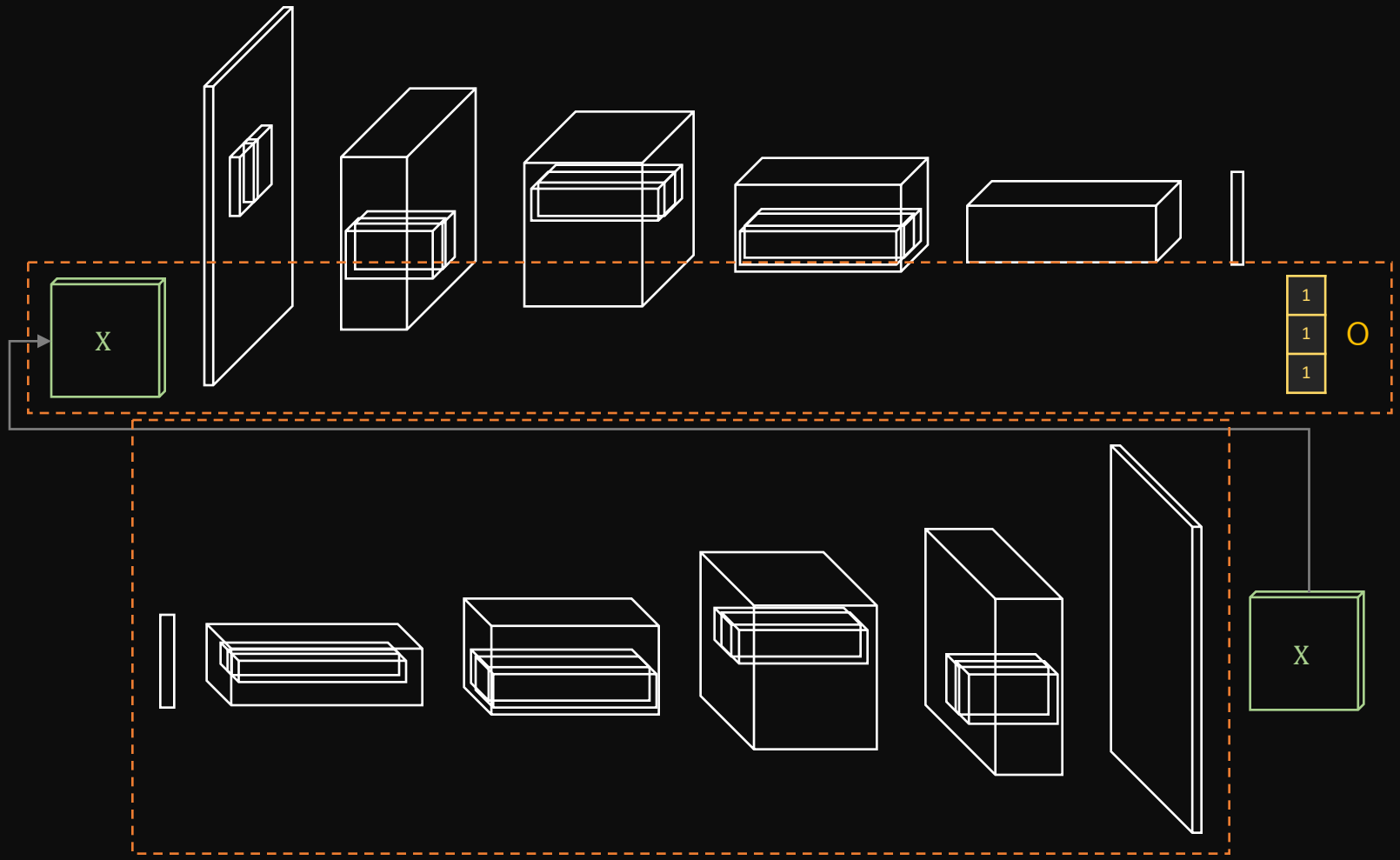


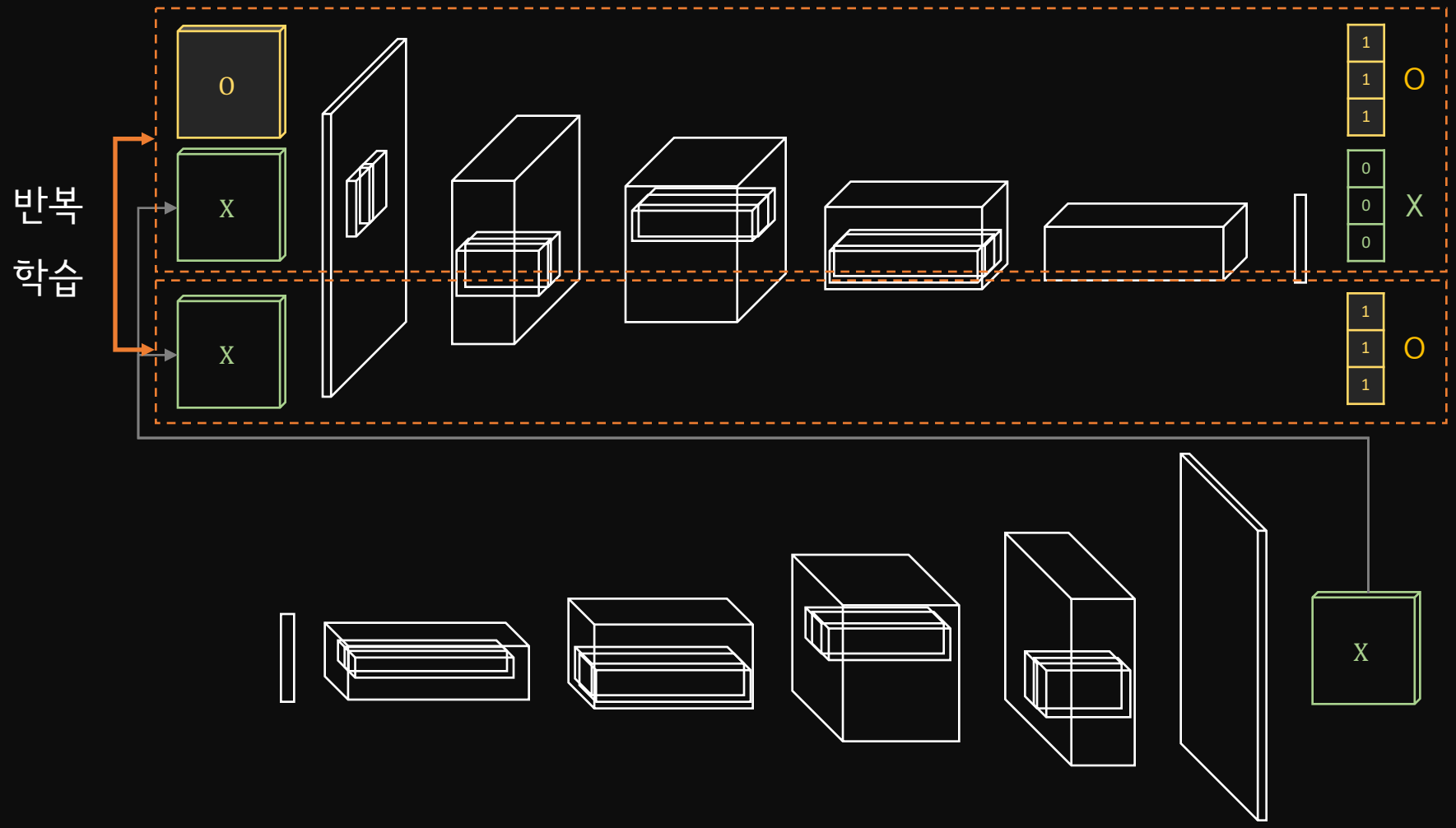
DEVSISTERS


images
0
총 2개의 input
Z (Gaussian distribution)


0
x
x


O
X
1
1
1
O
0
0
0
X
X

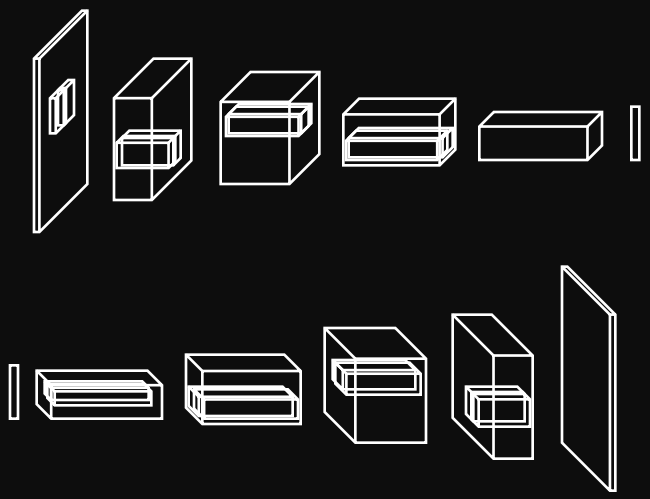

x
1
1
1
O
x



DEVSISTERS

```
import tensorflow as tf
```

입력값
Inputs



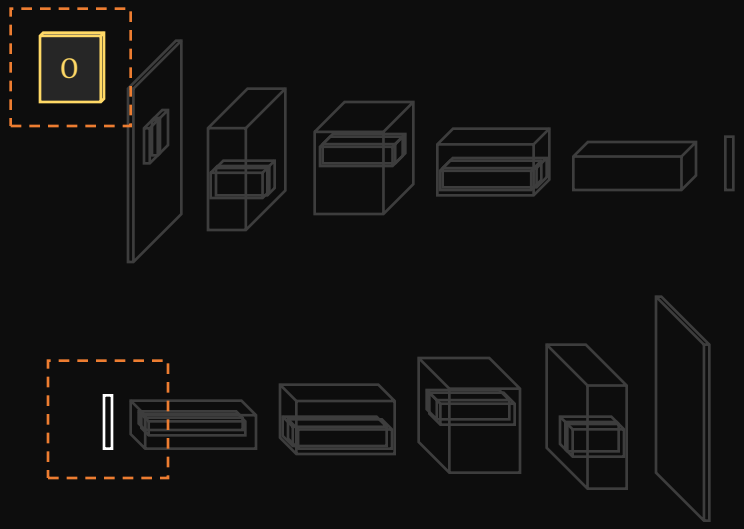
DEVSISTERS

입력값
Inputs

```
images = tf.placeholder(tf.float32, [32, 84, 84, 3])
```

입력값
Inputs

```
images = tf.placeholder(tf.float32, [32, 84, 84, 3])

z = tf.placeholder(tf.float32, [32, 100], name='z’)
```



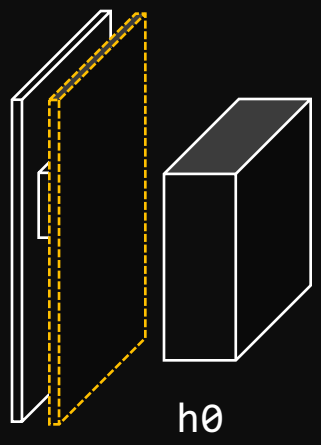
DEVSISTERS

구분자
Discriminator

DEVSISTERS

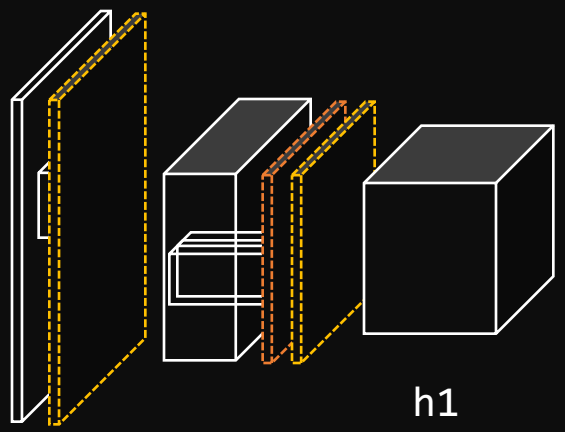
구분자
Discriminator

```
h0 = conv2d(images, 64, 4, 4, 2, 2)
```



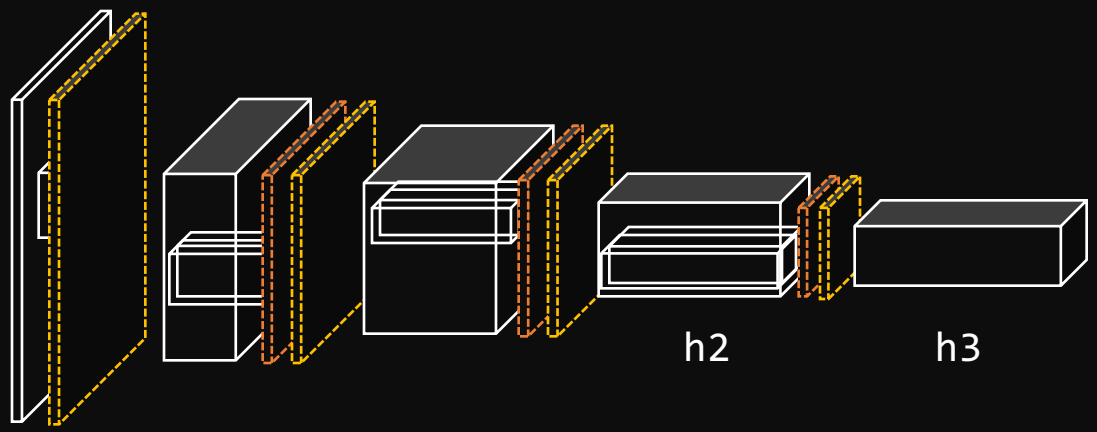
구분자
Discriminator

```
h1_logits = batch_norm(conv2d(h0, 64 * 2, 4, 4, 2, 2))

h1 = lrelu(h1_logits)
```



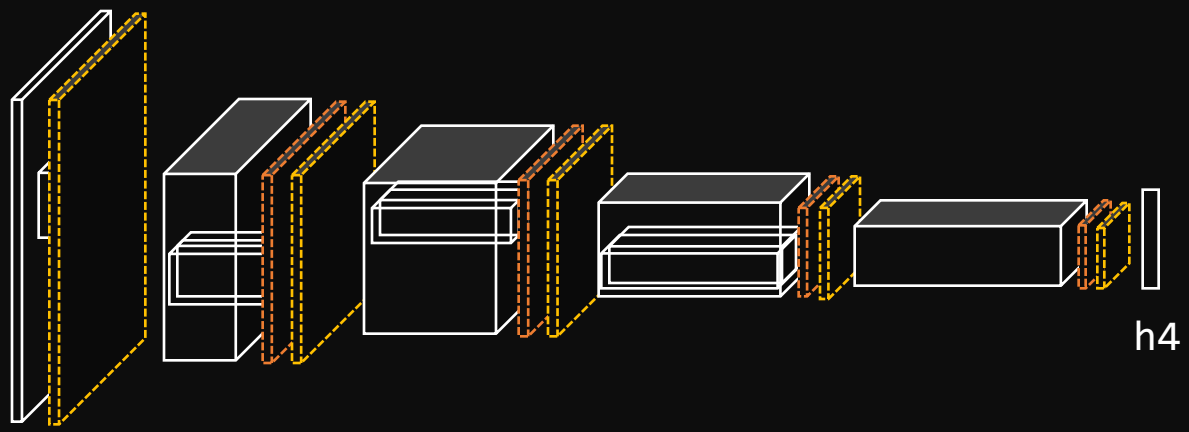
구분자
Discriminator

```
h2_logits = batch_norm(conv2d(h1, 64 * 4, 4, 4, 2, 2))

h2 = lrelu(h2_logits)

h3_logits = batch_norm(conv2d(h2, 64 * 8, 4, 4, 2, 2))

h3 = lrelu(h3_logits)
```



구분자
Discriminator

```
h4 = linear(tf.reshape(h3, [32, -1])
```

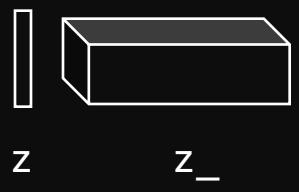


DEVSISTERS

생성자
Geneartor

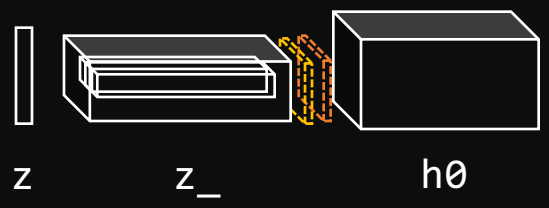
생성자
Geneartor

```
z_ = linear(z, 64*8*4*4)

h0_logits = tf.reshape(z_, [-1, 4, 4, 64 * 8])
```



생성자
Geneartor

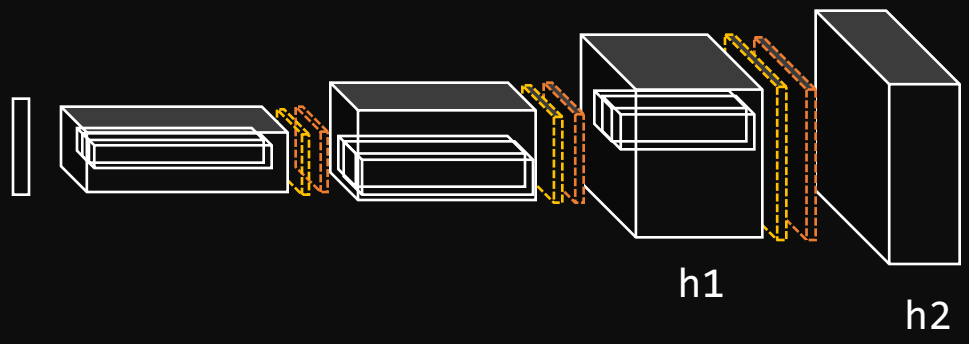
```
z_ = linear(z, 64*8*4*4)

h0_logits = tf.reshape(z_, [-1, 4, 4, 64 * 8])

h0 = tf.nn.relu(batch_norm(h0_logits))
```



DEVSISTERS

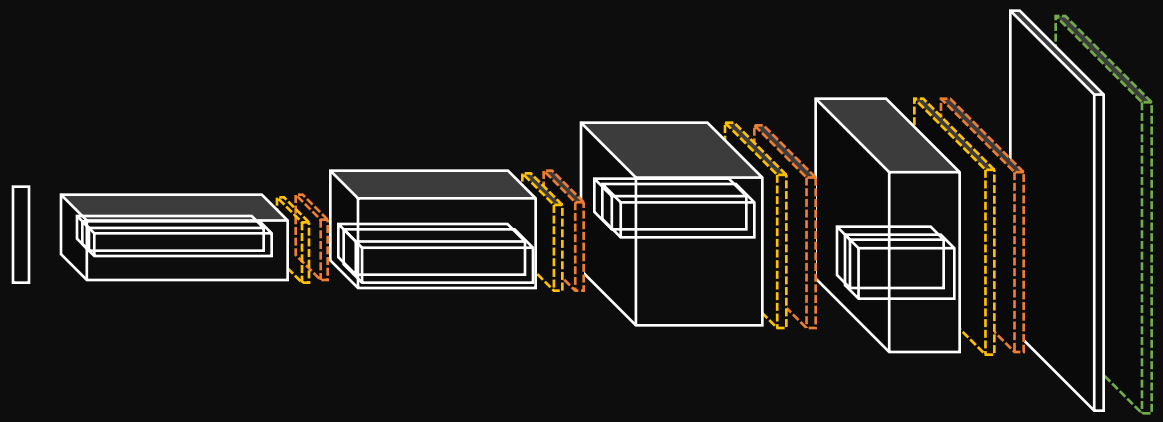
생성자
Geneartor

```
h1_logits = tf.nn.relu(deconv2d(h0, [32, 8, 8, 64*4])

h1 = batch_norm(h1_logits))

h2_logits = tf.nn.relu(deconv2d(h1, [32, 8, 8, 64*4])

h2 = batch_norm(h2_logits))
```



생성자
Geneartor

```
h3 = tf.nn.tanh(deconv2d(h2, [32, 8, 8, 64*4])
```



DEVSISTERS

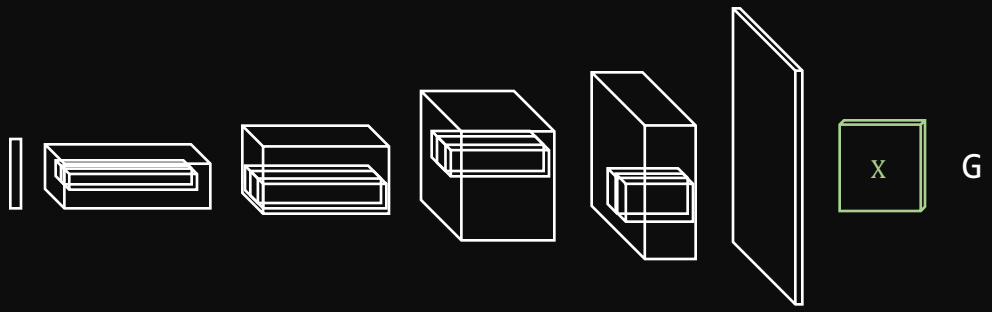
적대적 학습

Adversarial Learning

DEVSISTERS

적대적 학습
Adversarial Learning

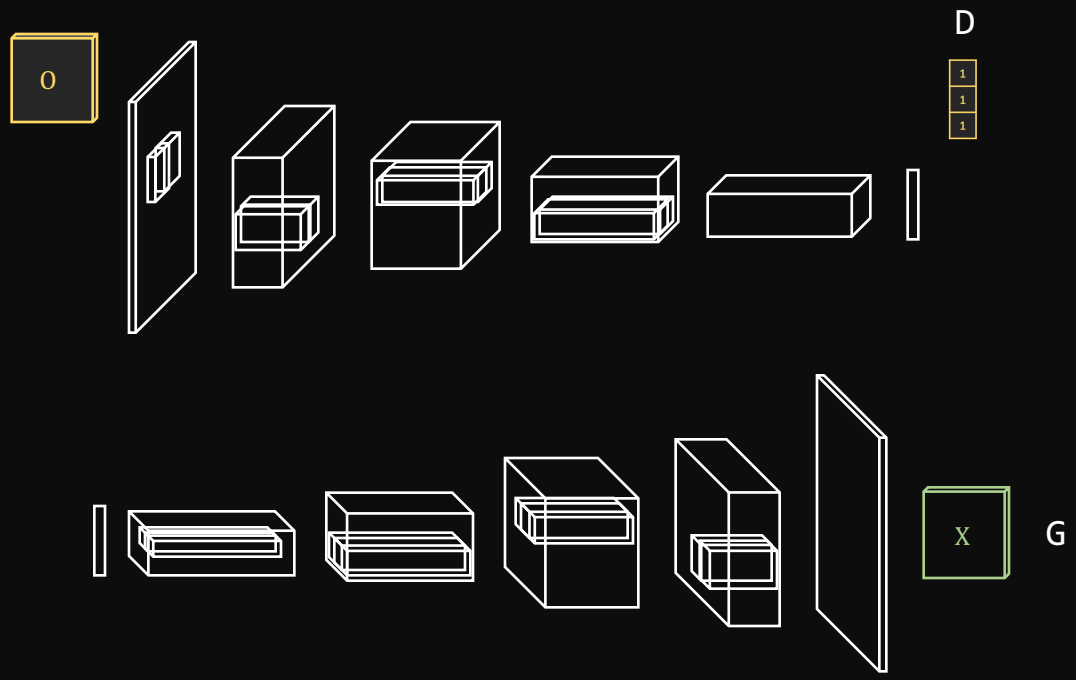
```
G = generator(z)
```



DEVSISTERS

적대적 학습
Adversarial Learning

```
G = generator(z)

D = discriminator(images)
```

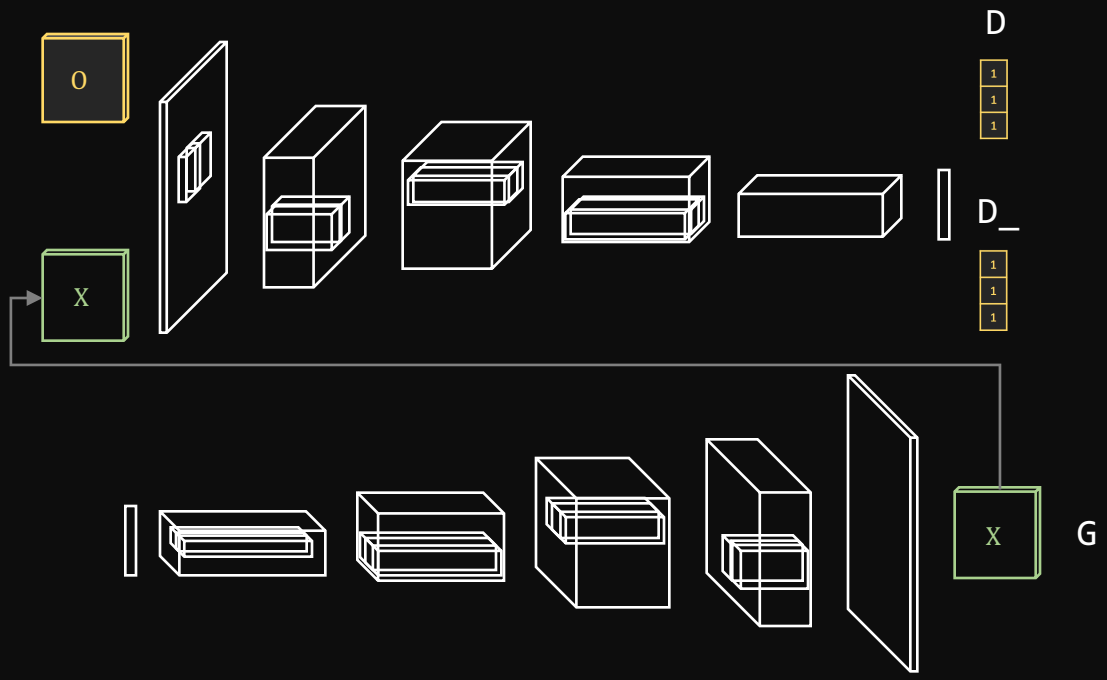


DEVSISTERS

적대적 학습

Adversarial Learning

```
G = generator(z)

D = discriminator(images)

D_ = discriminator(G, reuse=True)
```



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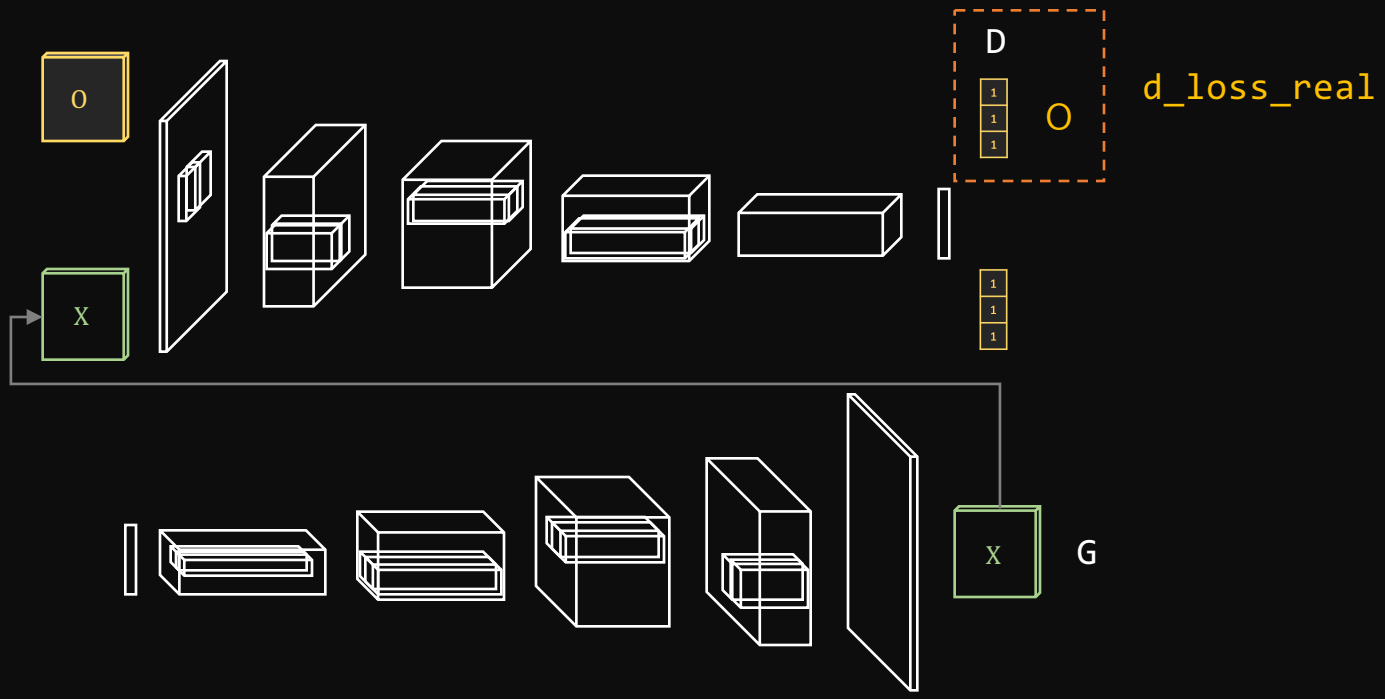
적대적 학습

Adversarial Learning

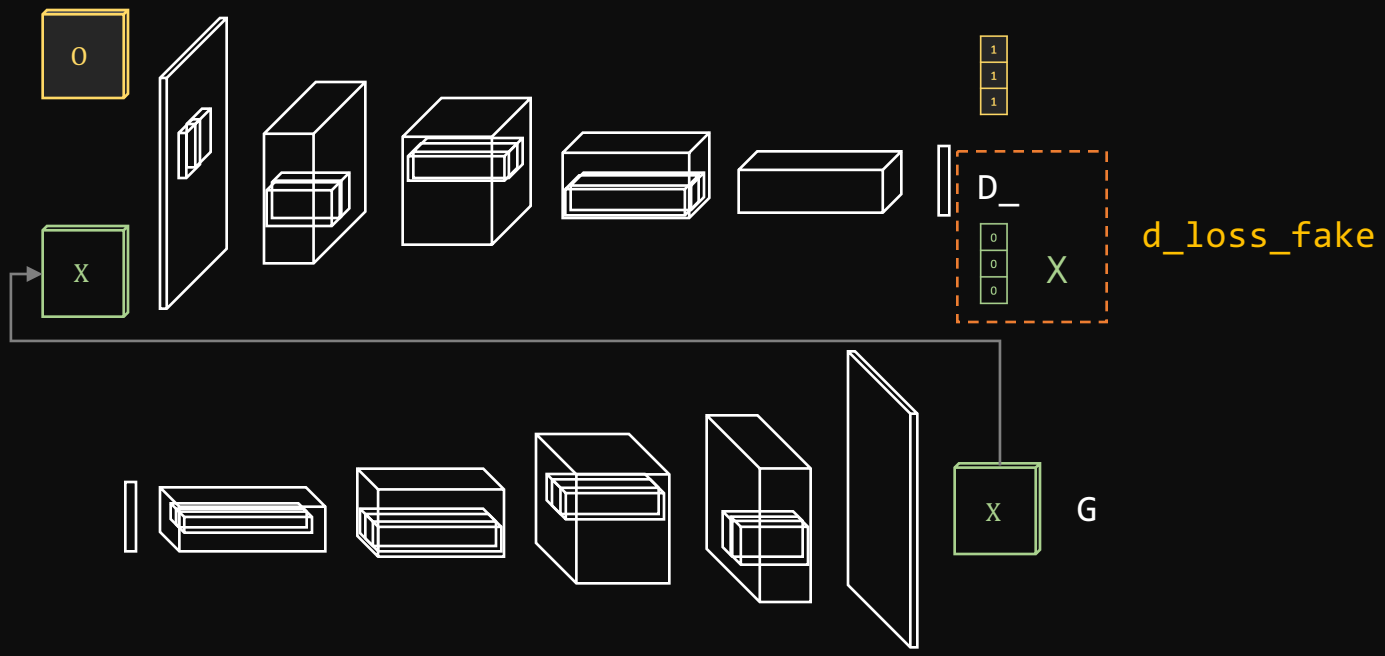
```
d_loss_real = tf.reduce_mean(
    tf.nn.sigmoid_cross_entropy_with_logits(D, tf.ones_like(D)))
```



적대적 학습

Adversarial Learning

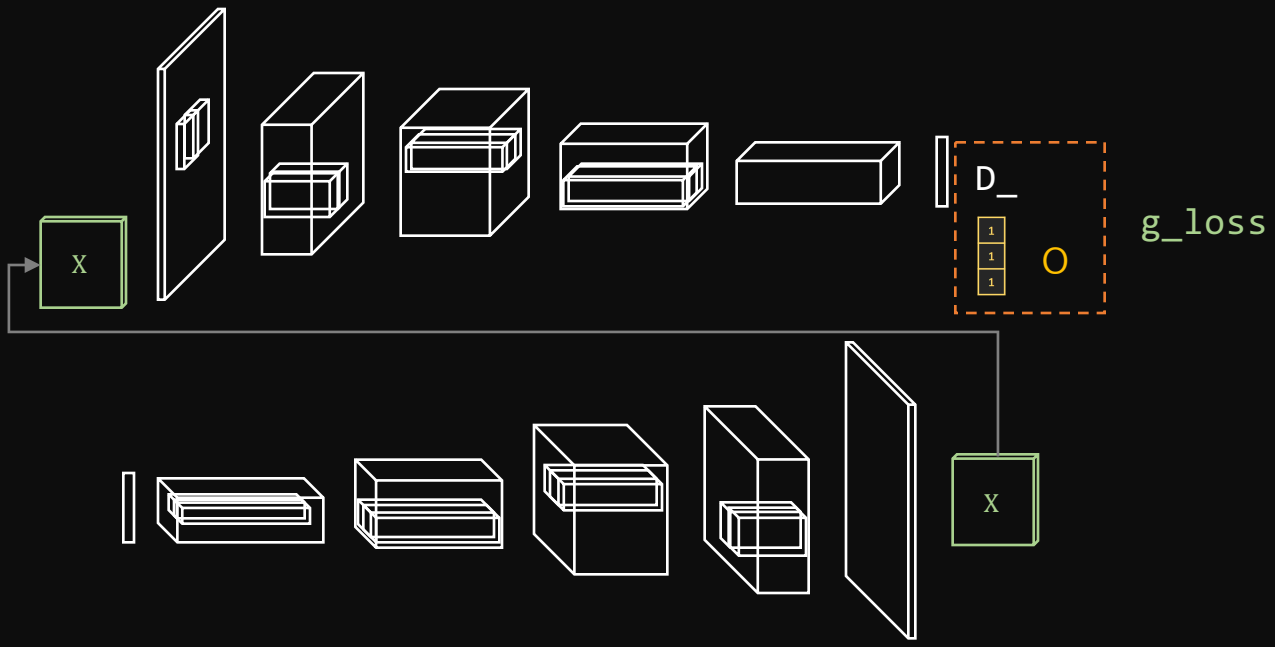
```
d_loss_real = tf.reduce_mean(
    tf.nn.sigmoid_cross_entropy_with_logits(D, tf.ones_like(D)))
d_loss_fake = tf.reduce_mean(
    tf.nn.sigmoid_cross_entropy_with_logits(D_, tf.zeros_like(D_)))
```



DEVSISTERS

적대적 학습
Adversarial Learning

```
g_loss = tf.reduce_mean(
    tf.nn.sigmoid_cross_entropy_with_logits(D_logits_, tf.ones_like(D_)))
```



DEVSISTERS

적대적 학습

Adversarial Learning

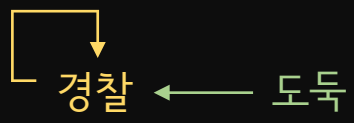
```
d_loss = d_loss_real + d_loss_fake
```

적대적 학습
Adversarial Learning

```
d_loss = d_loss_real + d_loss_fake


d_optim = tf.train.AdamOptimizer(0.0002).minimize(d_loss)

g_optim = tf.train.AdamOptimizer(0.0002).minimize(g_loss)
```

적대적 학습
Adversarial Learning

```
d_loss = d_loss_real + d_loss_fake


d_optim = tf.train.AdamOptimizer(0.0002).minimize(d_loss)

g_optim = tf.train.AdamOptimizer(0.0002).minimize(g_loss)


while True:

    sess.run(d_optim, { images: batch_images, z: batch_z })

    sess.run(g_optim, { z: batch_z })
```



학습 결과

MNIST

(Real)

MNIST
(Fake)

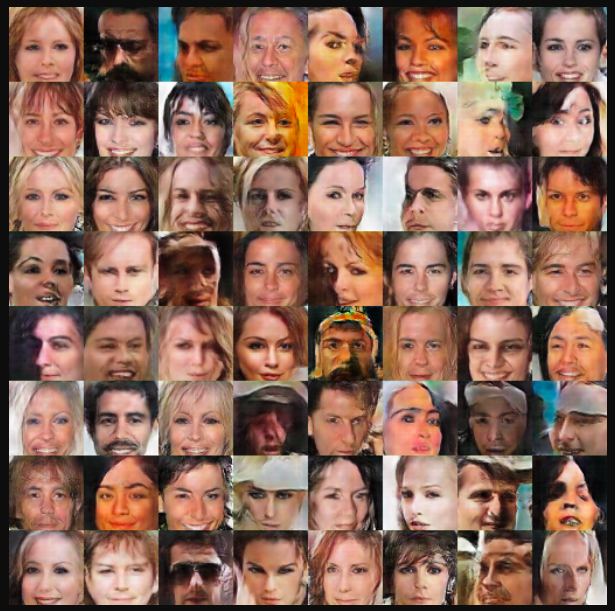
MNIST
(Fake)

MNIST
(Fake)

CelebA

(Real)

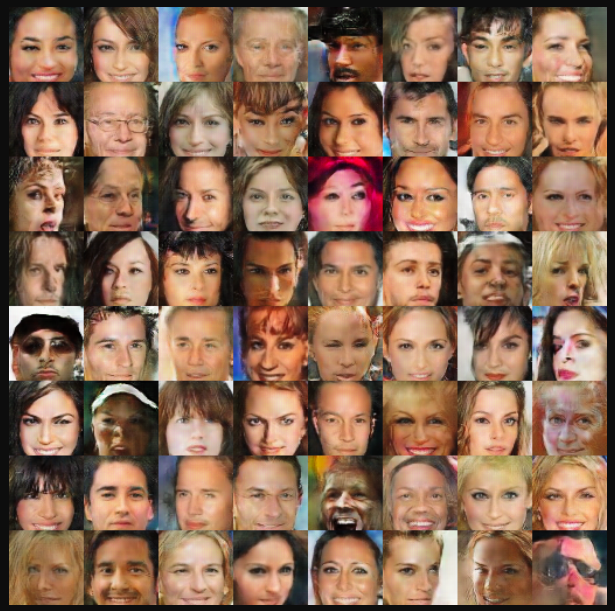
DEVSISTERS



CelebA

(Fake)

DEVSISTERS



CelebA

(Fake)

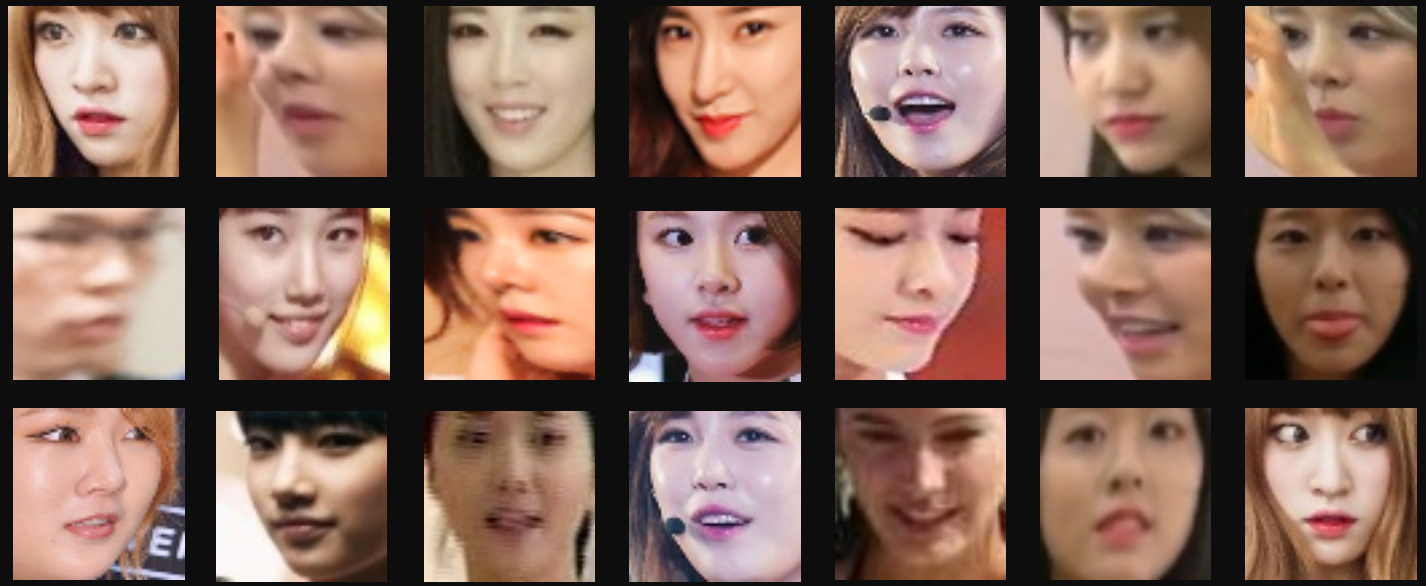
DEVSISTERS

한국인 얼굴 데이터

DEVSISTERS

한국인 얼굴 데이터

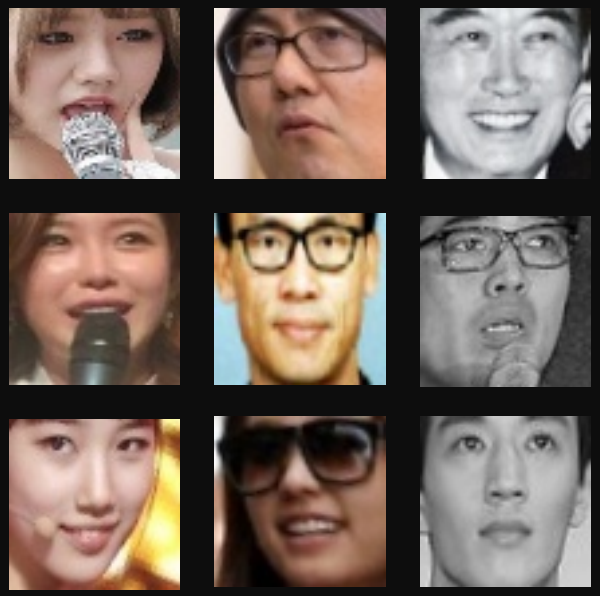
(Real)



한국인 얼굴 데이터

(Real)

마이크 안경 흑백



한국인 얼굴 데이터
(Real)

DEVSISTERS

한국인 얼굴 데이터

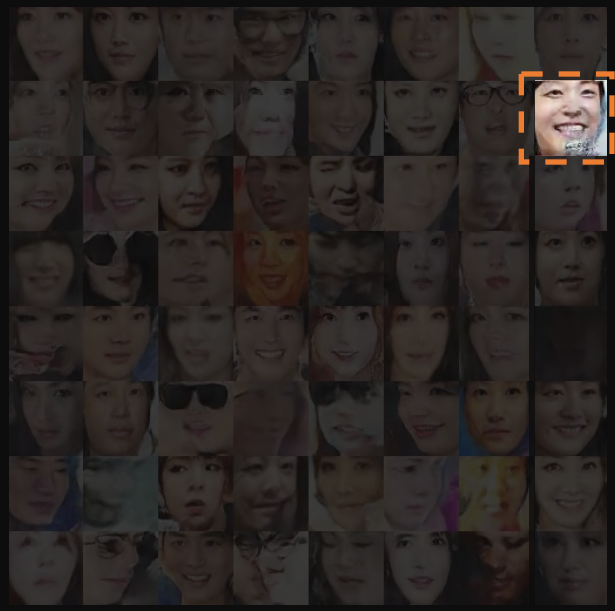
(Fake)

DEVSISTERS

한국인 얼굴 데이터

(Fake)

DEVSISTERS



한국인 얼굴 데이터

(Fake)

DEVSISTERS

한국인 얼굴 데이터

(Fake)

DEVSISTERS

한국인 얼굴 데이터
(Fake)

DEVSISTERS

한국인 얼굴 데이터
(Fake)

DEVSISTERS

한국인 얼굴 데이터

(Fake)

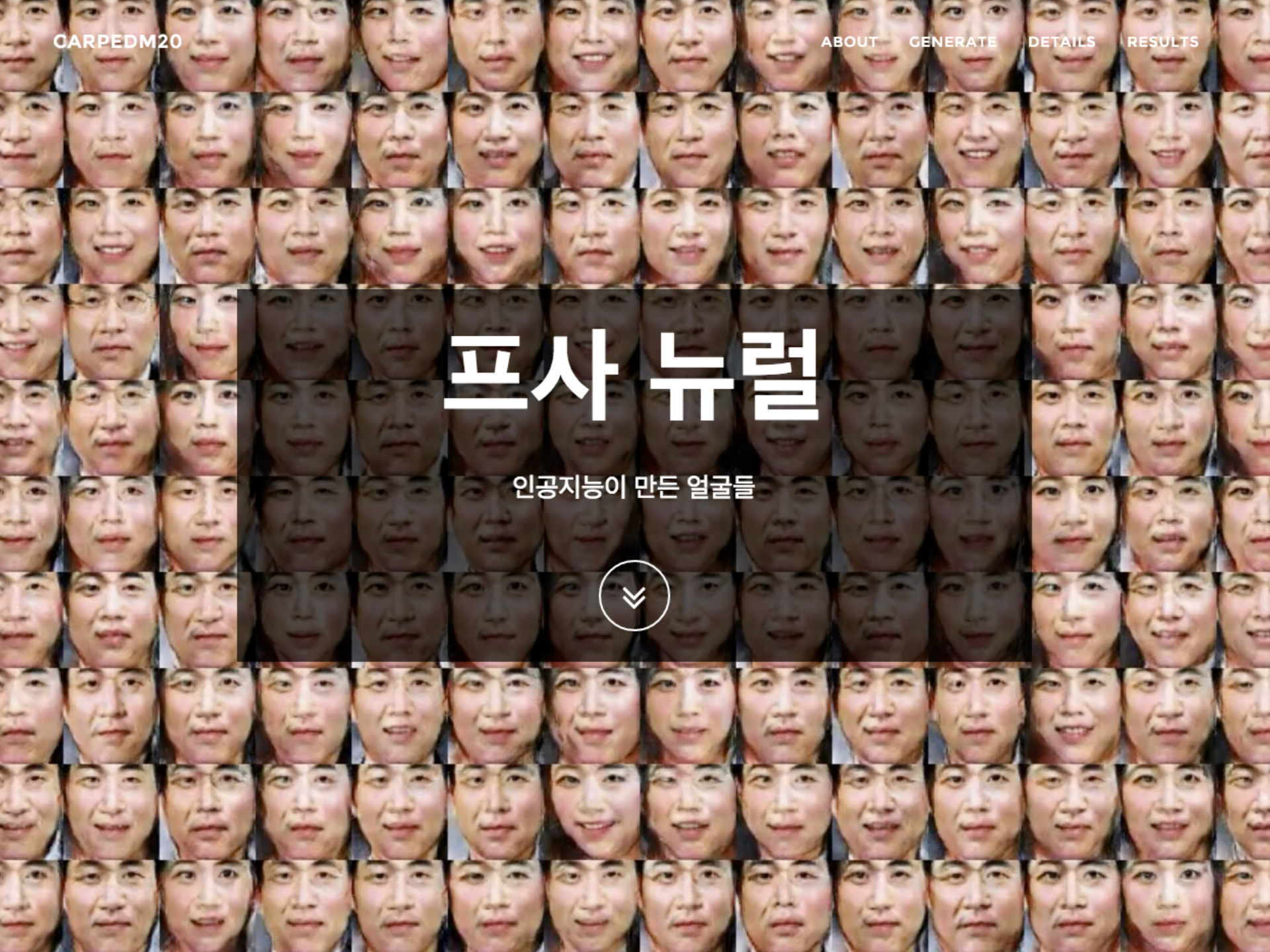
DEVSISTERS

한국인 얼굴 데이터
(Fake)

DEVSISTERS

한국인 얼굴 데이터
(Fake)

DEVSISTERS



프사 뉴럴

인공지능이 만든 얼굴들

https://github.com/carpedm20/DCGAN-tensorflow

http://carpedm20.github.io/faces/

Resources

- OpenAI's "Generative Models" blog post
- **Image Completion with Deep Learning in TensorFlow**
- A Beginner's Guide to Variational Methods: Mean-Field Approximation

DEVSISTERS

Algorithm Learning

Algorithm Learning

알고리즘의 입력과 출력을 보고 알고리즘을 배울 수 있을까?

3, 1, 2, 5 → 1, 2, 3, 5

Algorithm Learning

알고리즘의 입력과 출력을 보고 알고리즘을 배울 수 있을까?

3, 1, 2, 5 → 1, 2, 3, 5
9, 2, 4, 1 → 1, 2, 4, 9
7, 2, 6, 9 → 2, 6, 7, 9
9, 2, 4, 0 → 0, 2, 4, 9
…

Neural Turing Machine

Neural Turing Machine

뉴럴 네트워크로 튜링 머신을 만들 수 있다면?

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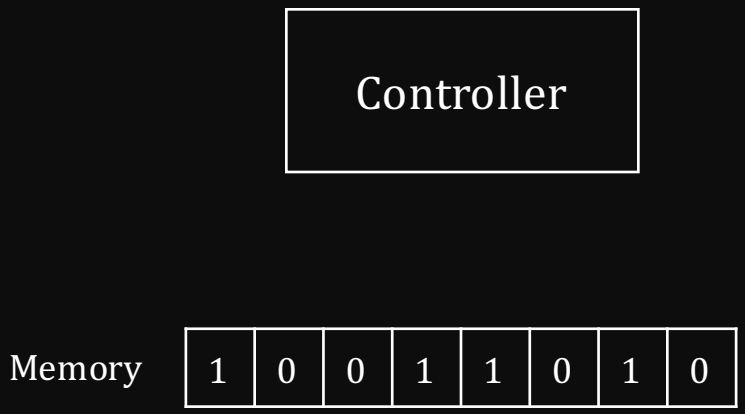
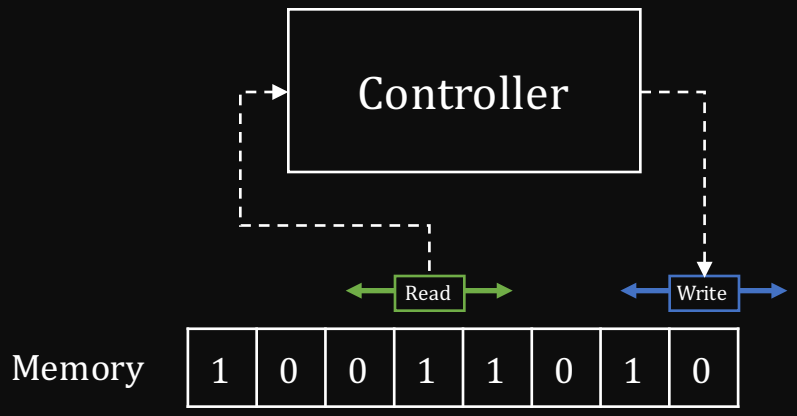
튜링 머신
Turing machine



튜링 머신
Turing machine



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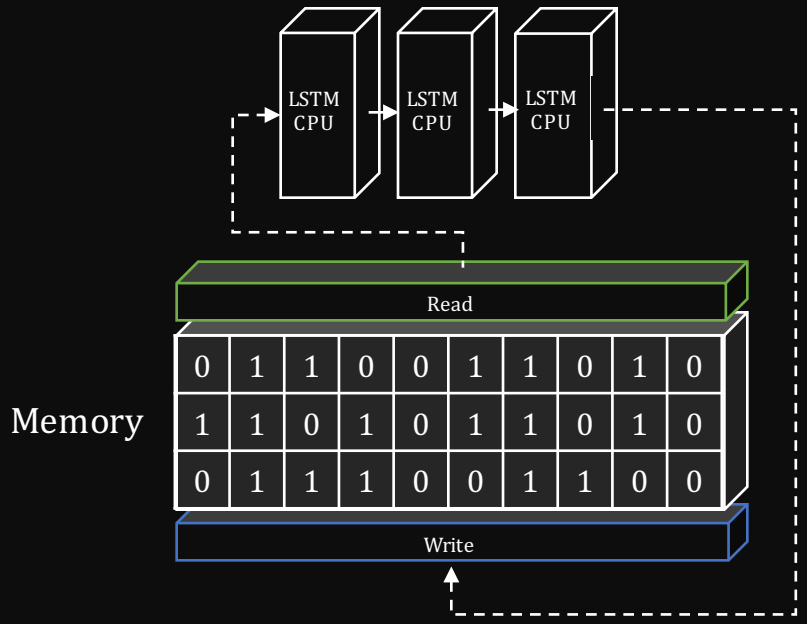
뉴럴 튜링 머신

Neural Turing machine



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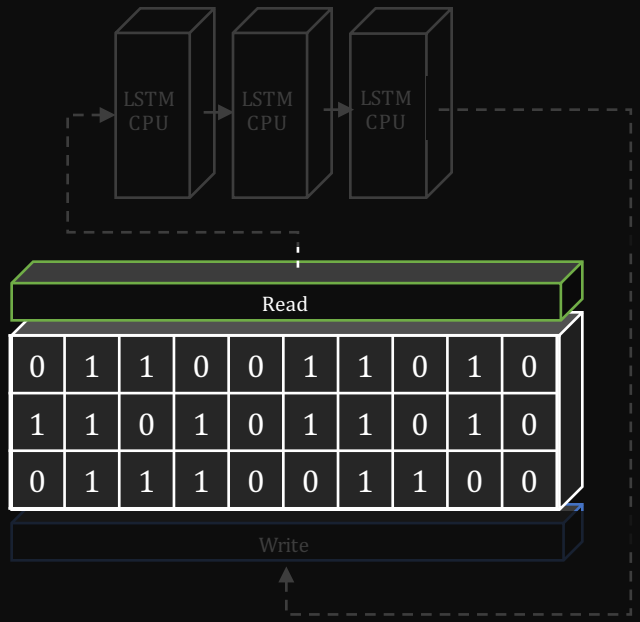
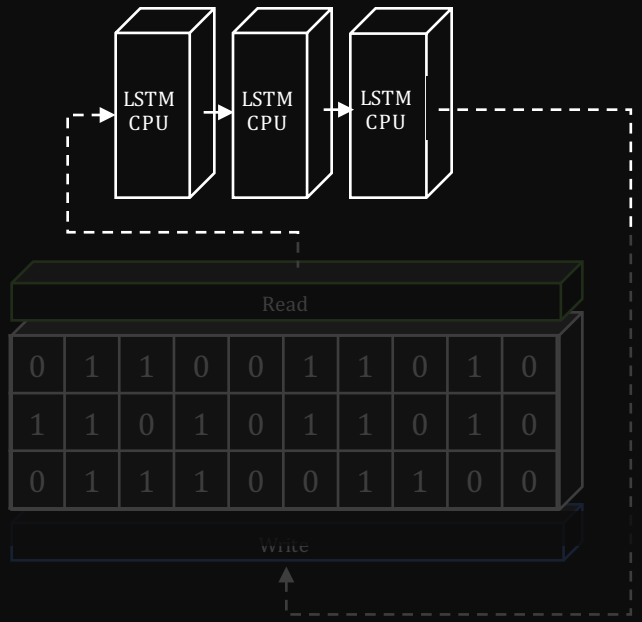
실행 과정

1. 읽고

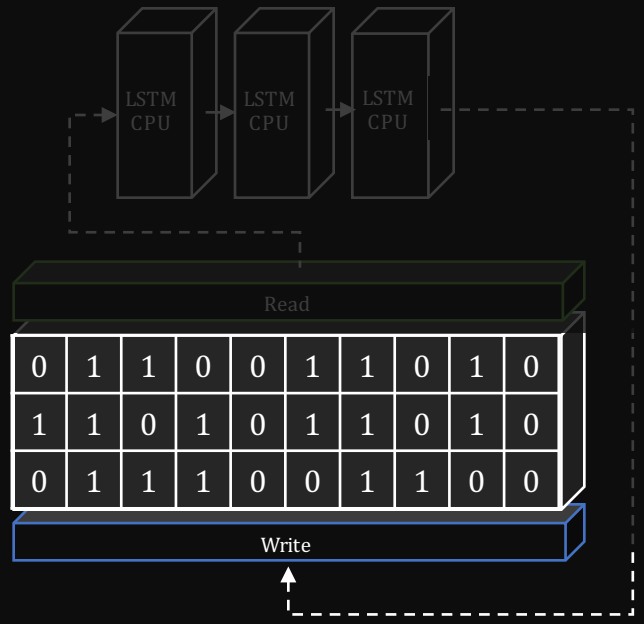

LSTM
CPU
LSTM
CPU
LSTM
CPU
Read
0 1 1 0 0 1 1 0 1 0
1 1 0 1 0 1 1 0 1 0
0 1 1 1 0 0 1 1 0 0
Write

실행 과정

2. 처리하고


LSTM
CPU
LSTM
CPU
LSTM
CPU
Read
0 1 1 0 0 1 1 0 1 0
1 1 0 1 0 1 1 0 1 0
0 1 1 1 0 0 1 1 0 0
Write

실행 과정


LSTM
CPU
LSTM
CPU
LSTM
CPU
Read
0 1 1 0 0 1 1 0 1 0
1 1 0 1 0 1 1 0 1 0
0 1 1 1 0 0 1 1 0 0
Write

3. 쓴다

t=1

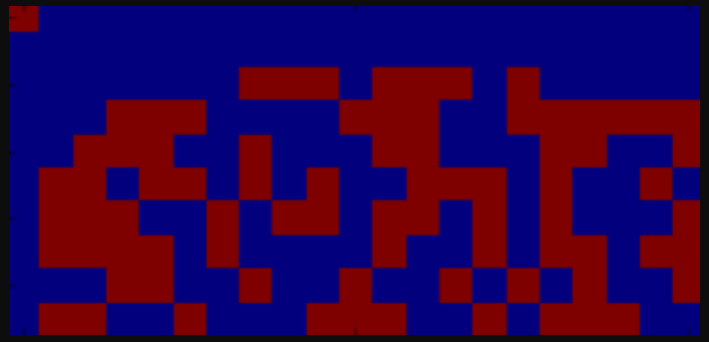
Start symbol

t=2

하나씩 읽어 메모리에 저장

t=3

하나씩 읽어 메모리에 저장



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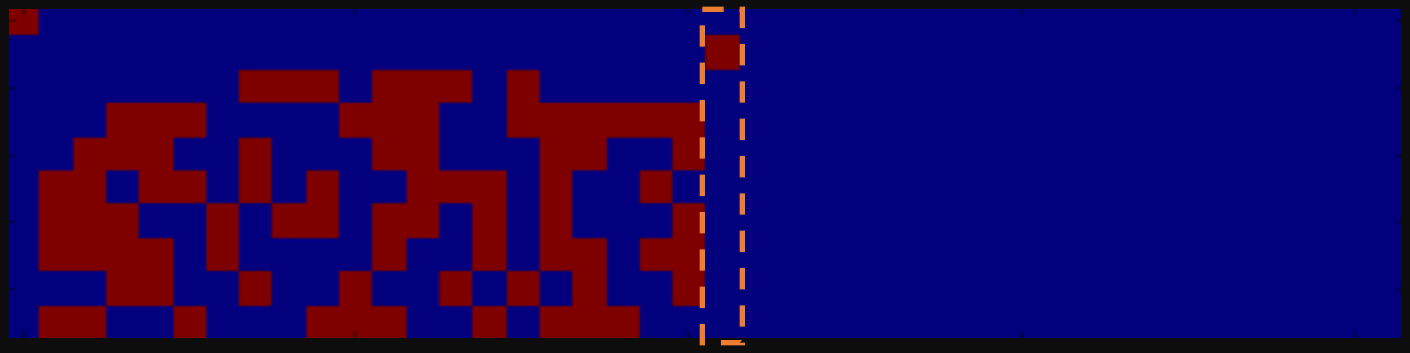
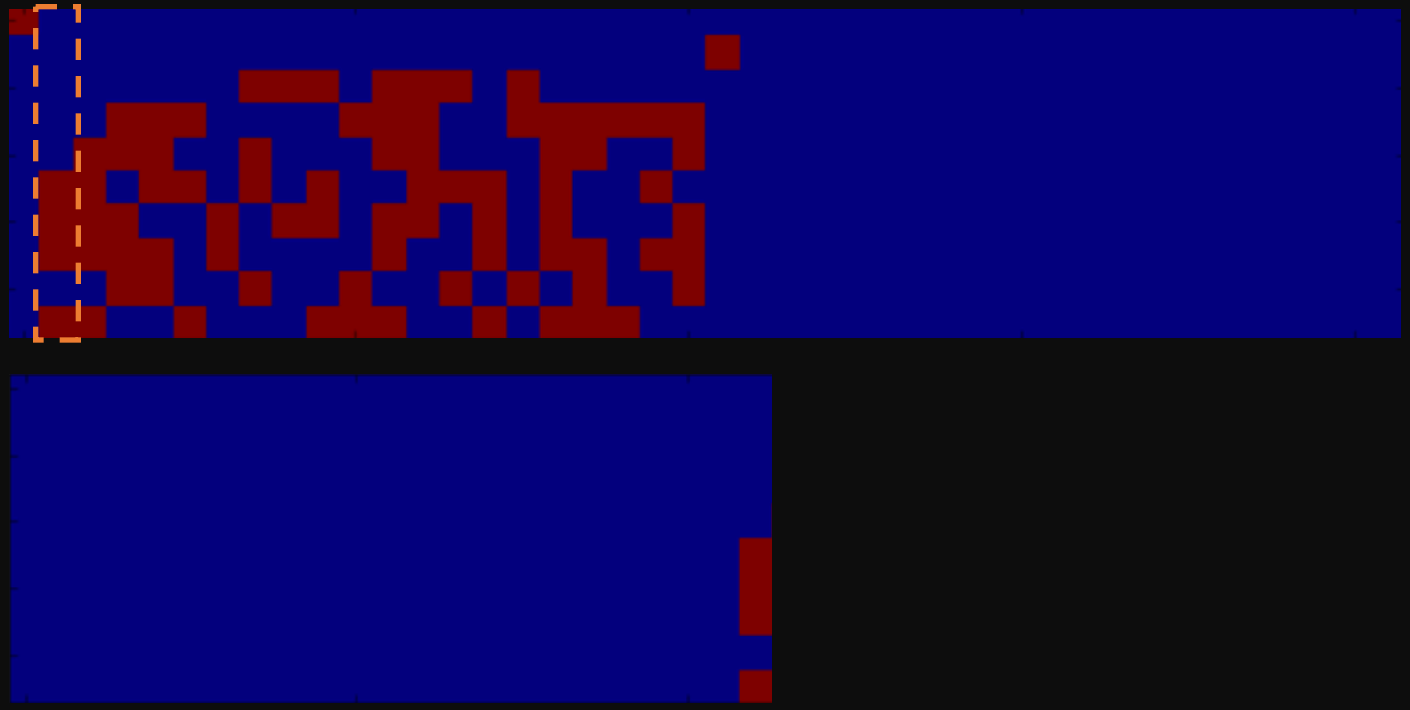
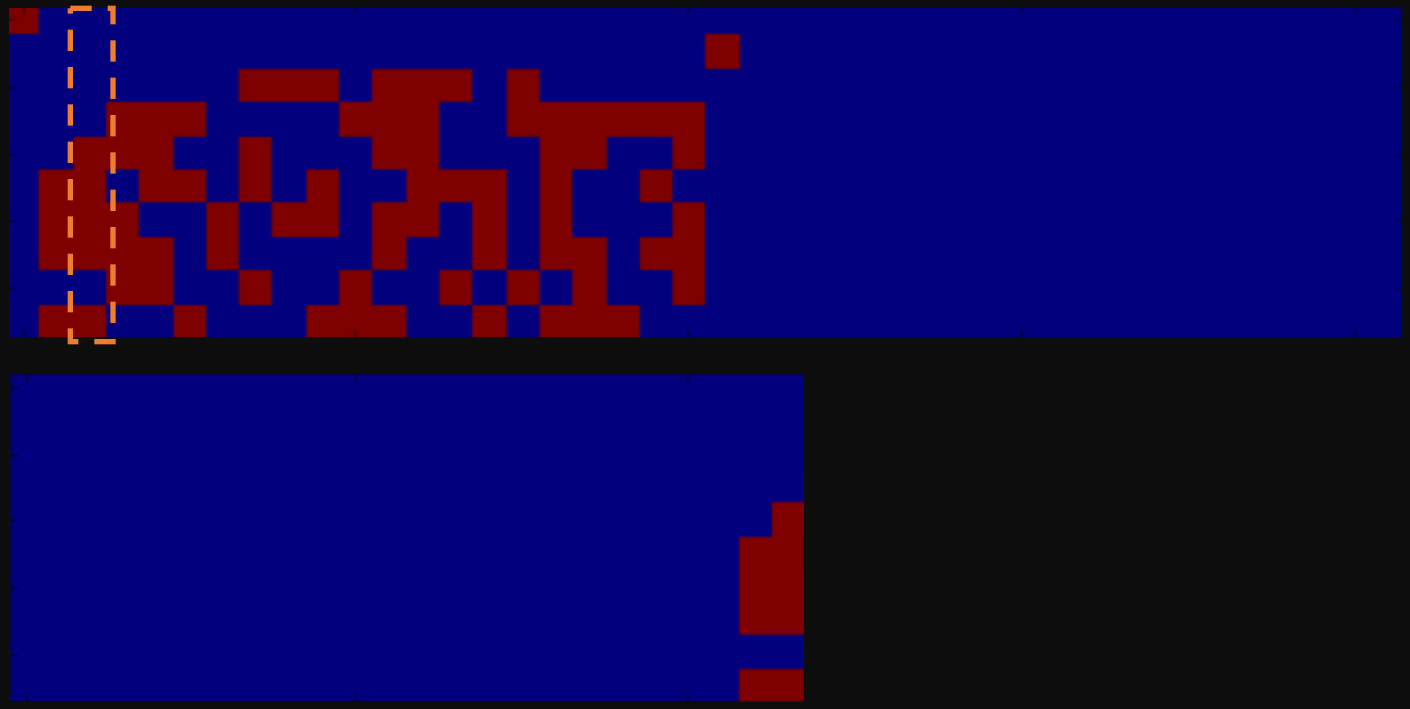


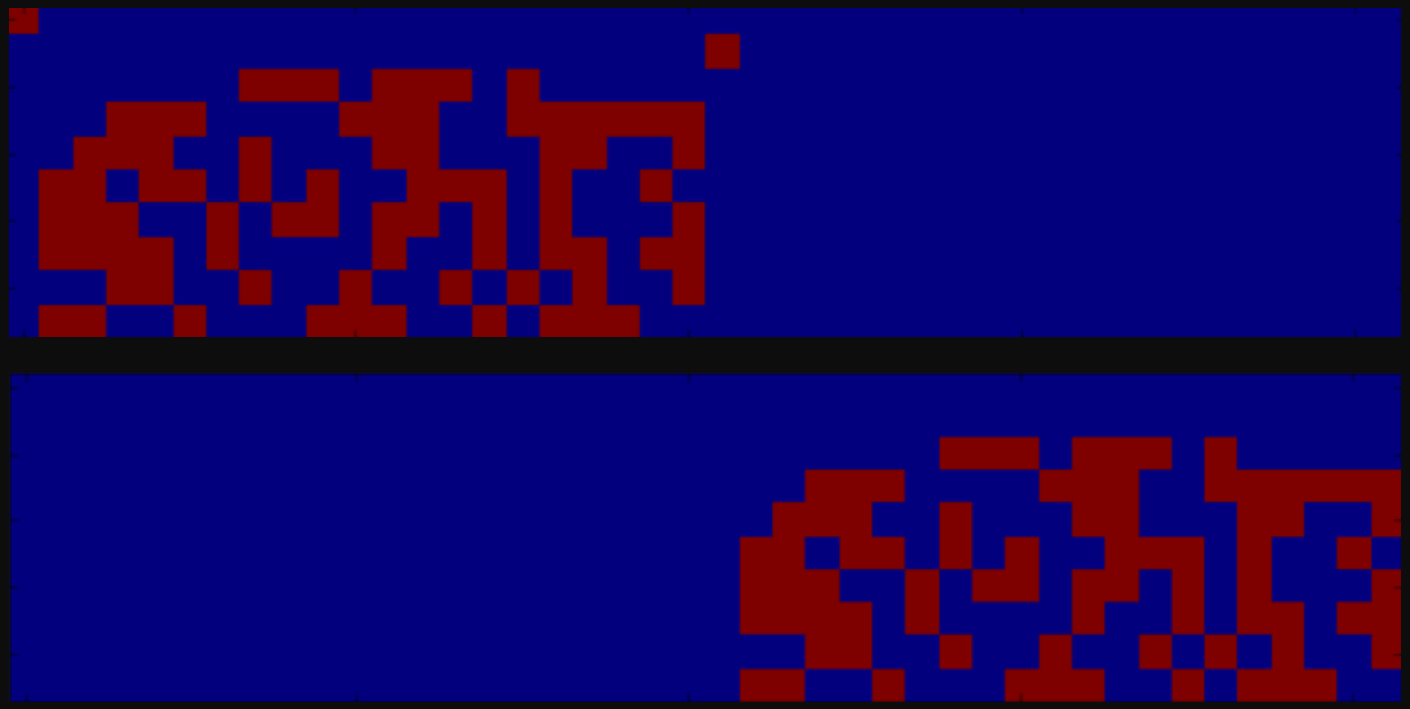
End symbol



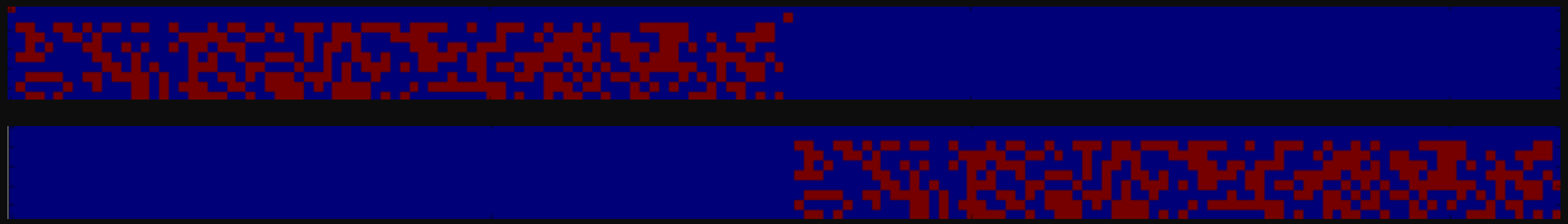
메모리에서 하나씩 읽어서 출력



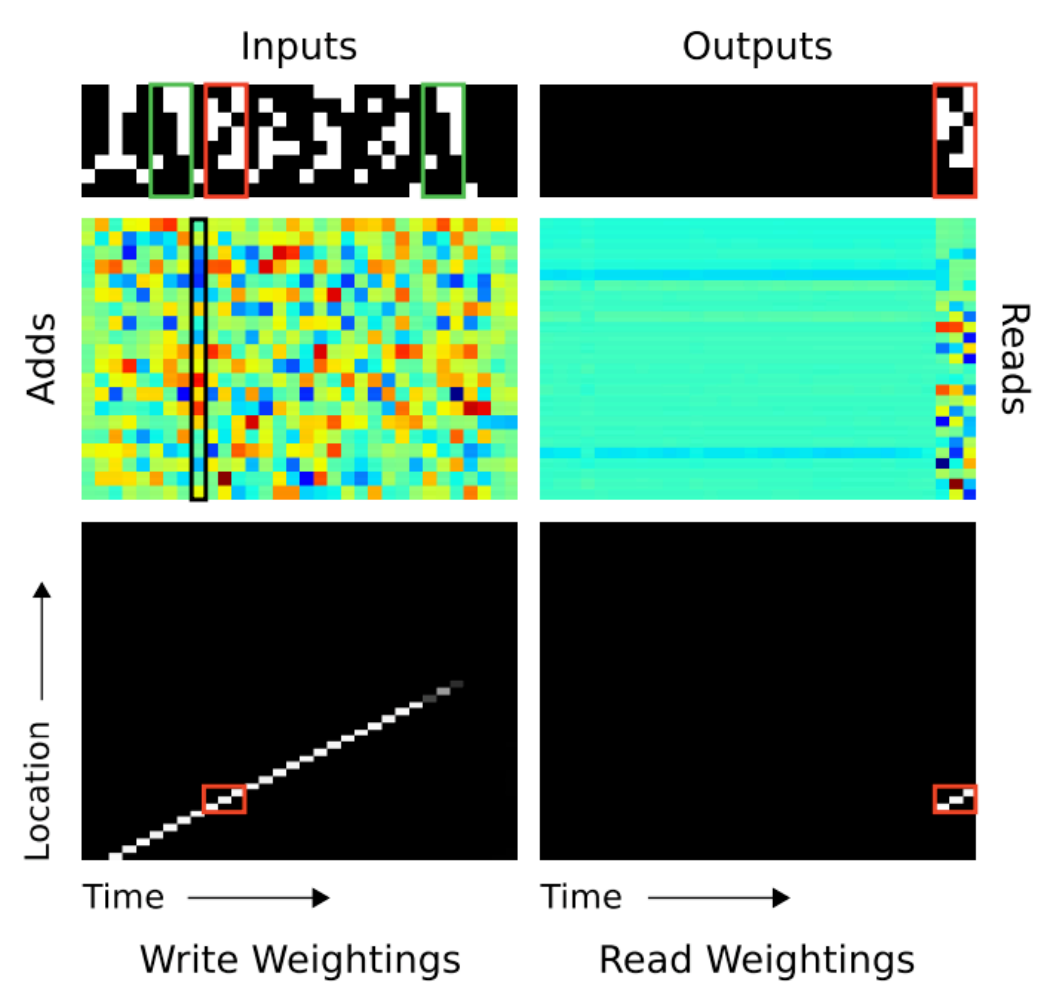
메모리에서 하나씩 읽어서 출력



DEVSISTERS



학습에 보지 않았던 긴 input


Inputs
Outputs
Adds
Reads
Location
Time
Time
Write Weightings
Read Weightings

https://github.com/carpedm20/NTM-tensorflow

Resources

- Neural Turing Machine (in Chinese)
- Fancy Addressing for Neural Turing Machines
- Neural Turing Machines implementation
- Neural Turing Machines - A First Look

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Deep Q Learning

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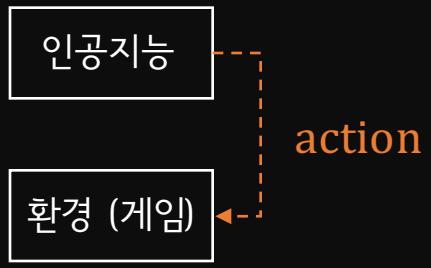
Deep Q Learning
∈ Reinforcement Learning



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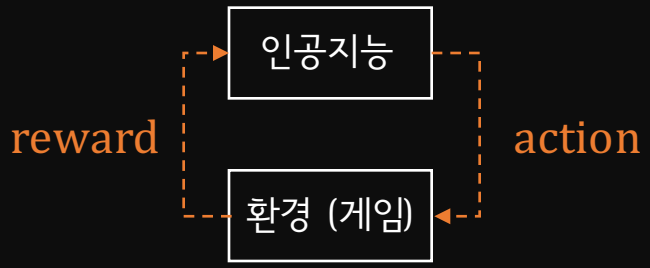
Deep Q Learning
∈ Reinforcement Learning



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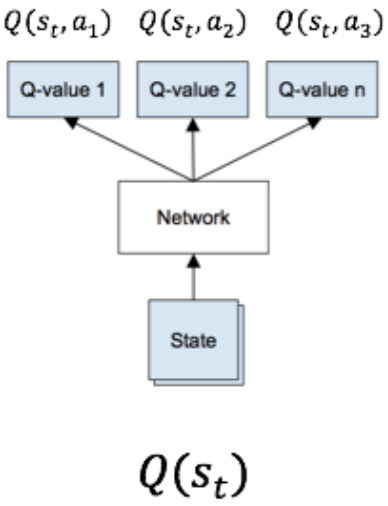
Deep Q Learning
∈ Reinforcement Learning

"AI = Reinforcement Learning + Deep Learning"

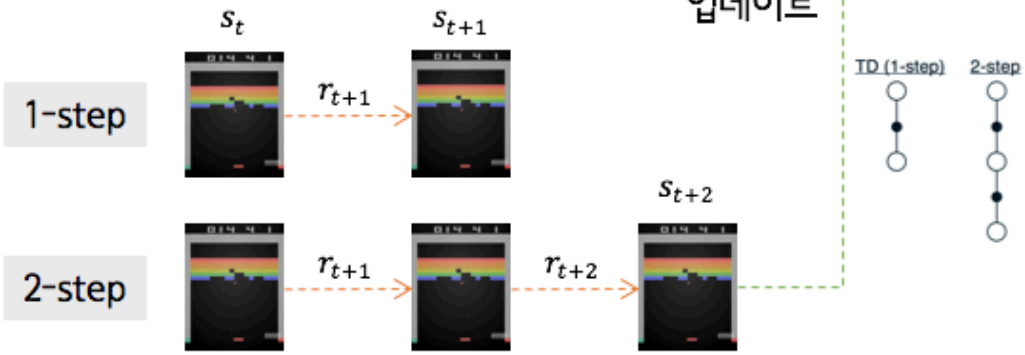
- David Silver

n-step Q-learning



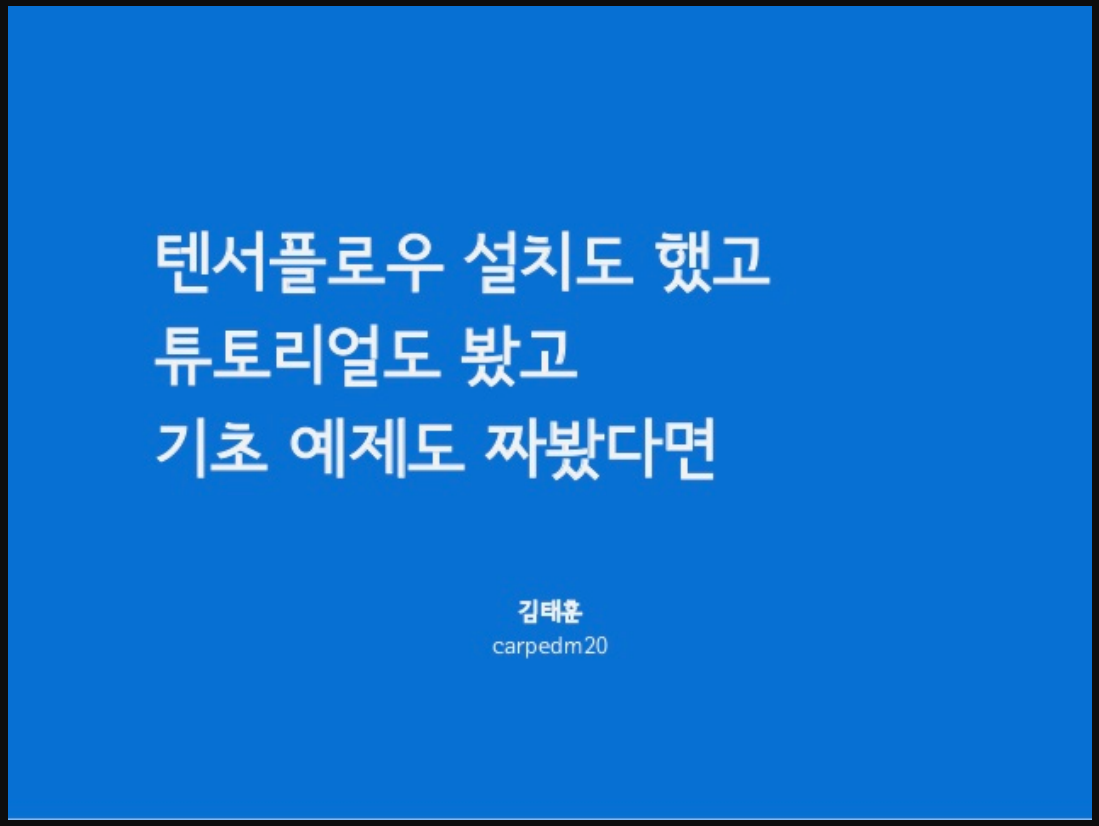
$$Q(s_t, a_t) \leftarrow \underbrace{Q(s_t, a_t)}_{\text{old value}} + \underbrace{\alpha}_{\text{learning rate}} \cdot \Big(\overbrace{\underbrace{r_{t+1}}_{\text{reward}} + \underbrace{\gamma}_{\text{discount factor}} \cdot \underbrace{\max_a Q(s_{t+1}, a)}_{\text{estimate of optimal future value}}}^{\text{learned value}} - \underbrace{Q(s_t, a_t)}_{\text{old value}} \Big)$$

업데이트



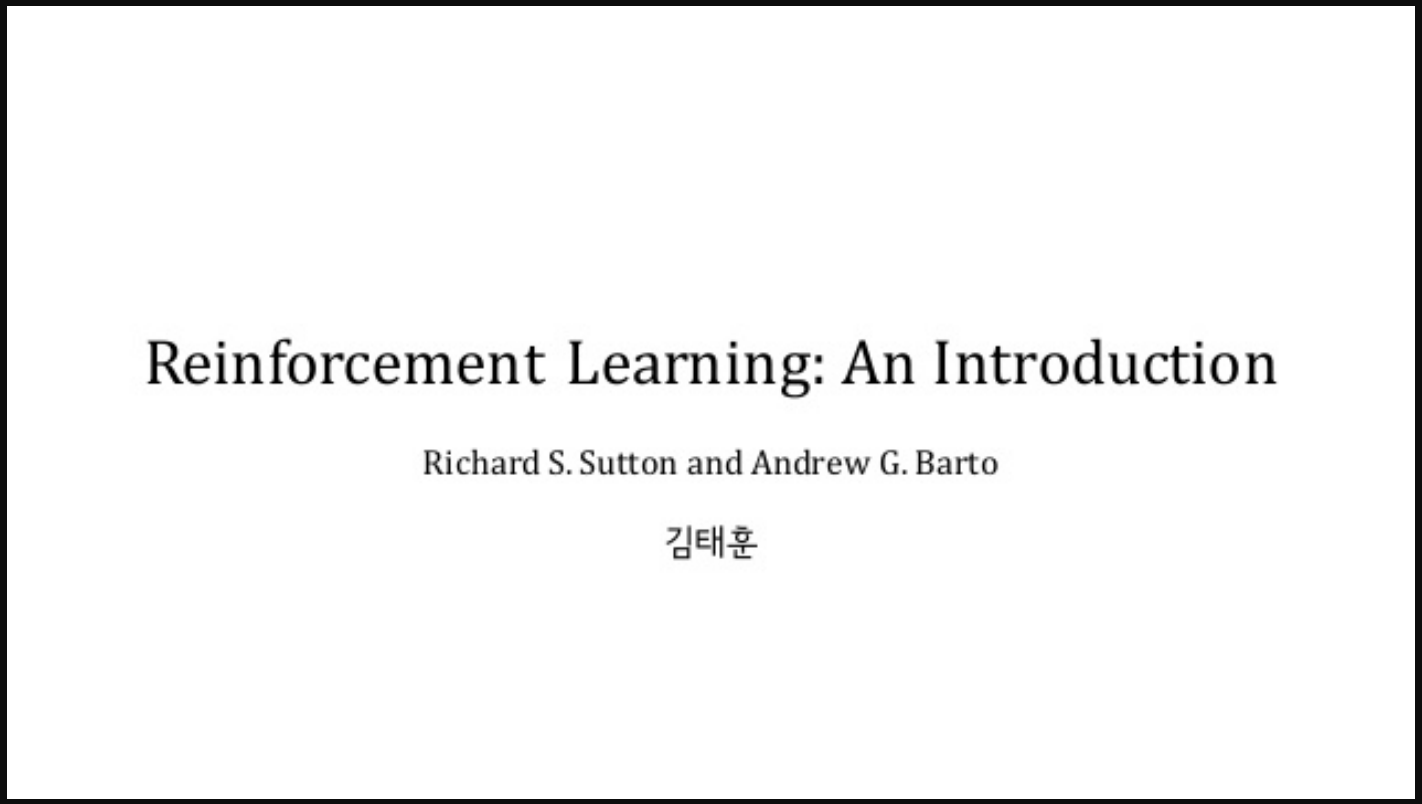
See David Silver's course & Sutton's book for more information

더 자세한건…



http://www.slideshare.net/carpedm20/ss-63116251

더 자세한건…



http://www.slideshare.net/carpedm20/reinforcement-learning-an-introduction-64037079

https://github.com/carpedm20/deep-rl-tensorflow

https://github.com/devsisters/DQN-tensorflow/

Resources

- David Silver's ICML "Reinforcement Learning tutorial"
- Demystifying Deep Reinforcement Learning
- Playing Atari With Deep Reinforcement Learning

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Deep Visual Analogy-Making

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Deep Visual Analogy-Making

이미지 버전의 '왕 - 남자 + 여자 = 여왕' (word2vec)

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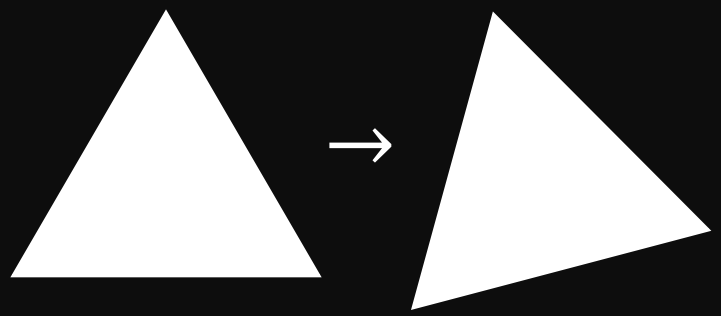
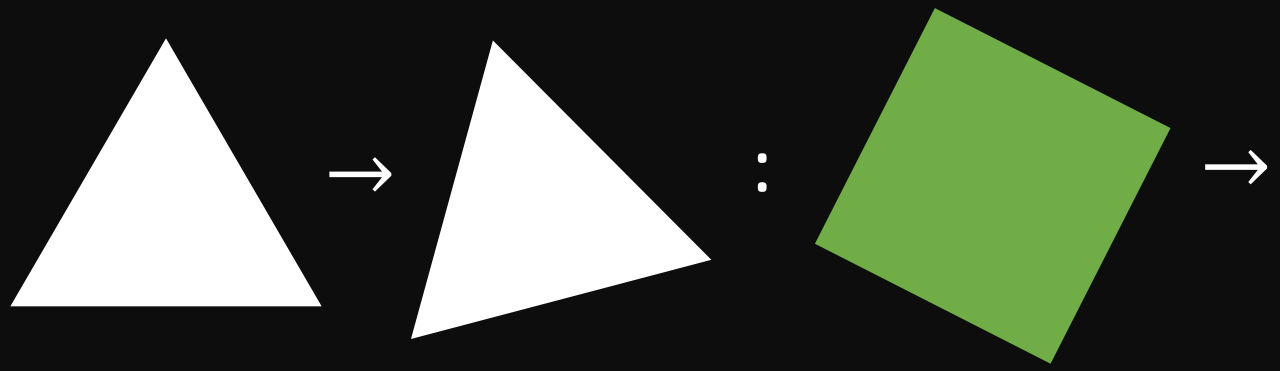
A → B

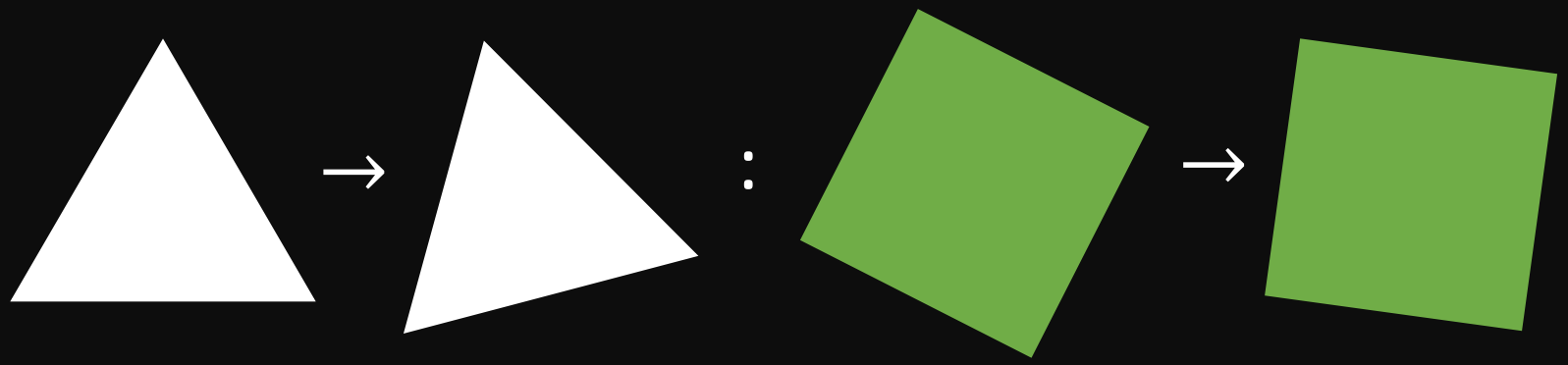


A → B : C → ?



A에서 B의 변화를 C에 적용하면?

A → B : C → ?

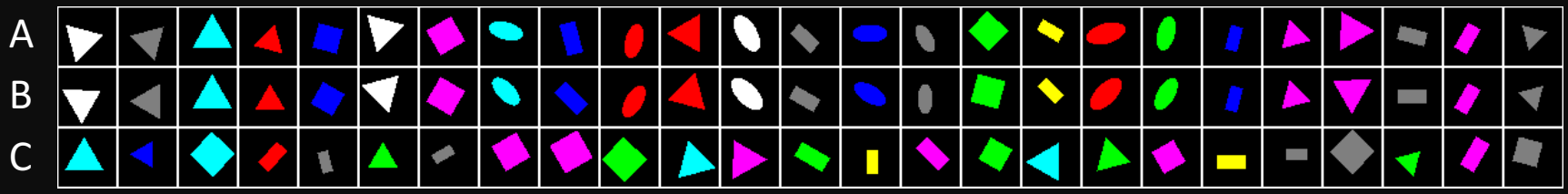


A에서 B의 변화를 C에 적용하면?

A → B : C → ?

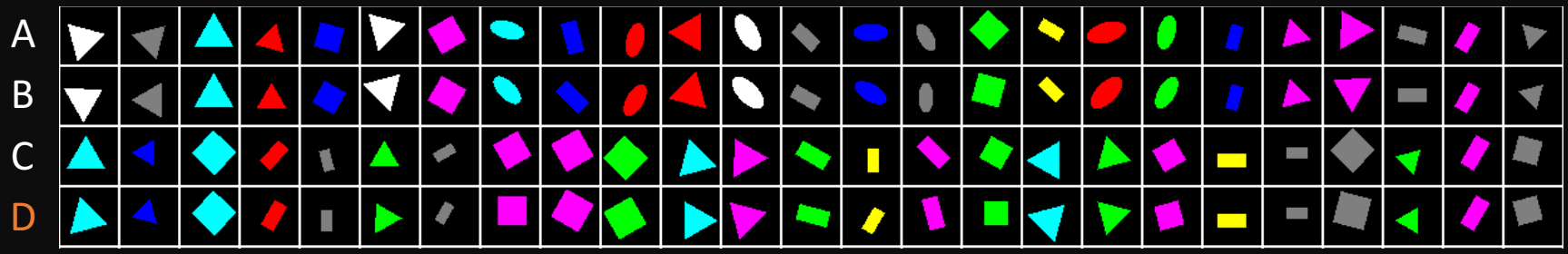
DEVSISTERS

A → B : C → ?



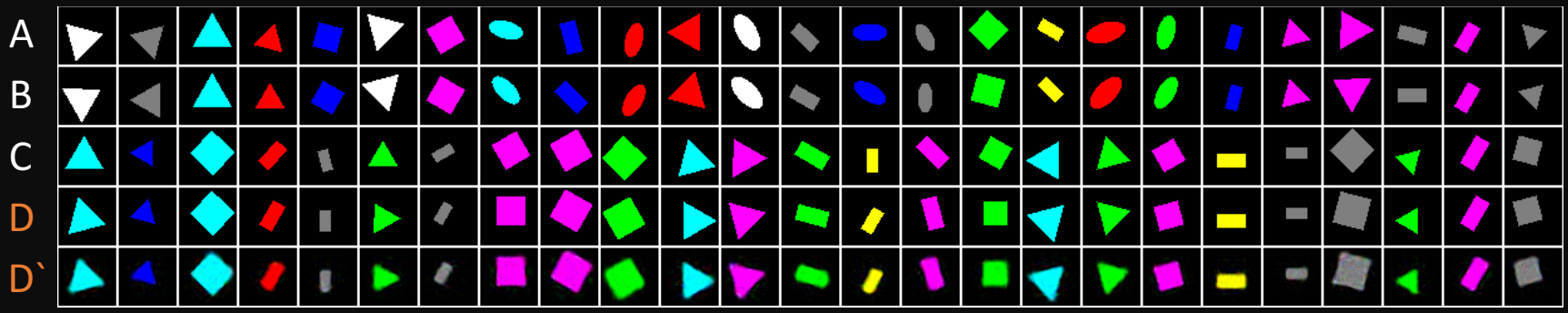
회전한 이미지를 보고

A → B : C → ?



회전 1번

A → B : C → ?



회전 2번

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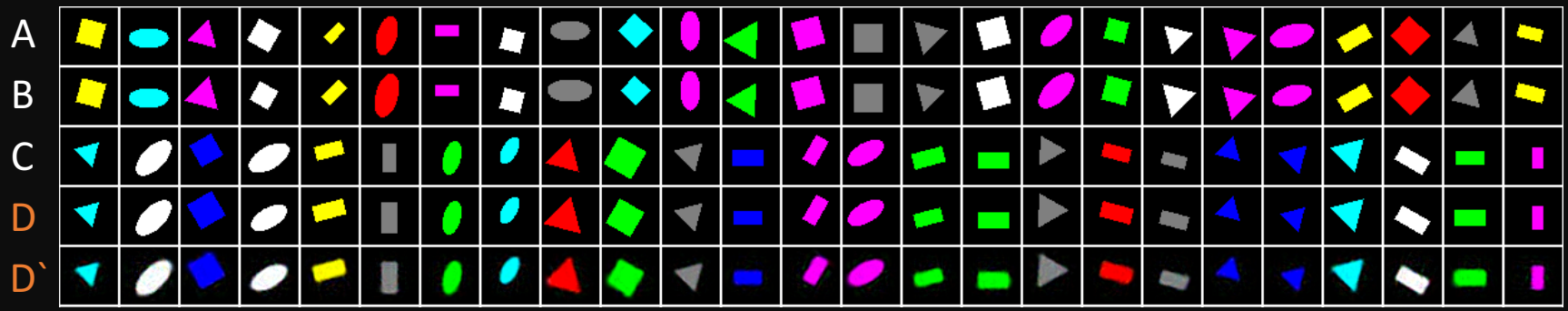
A → B : C → ?



확대, 축소

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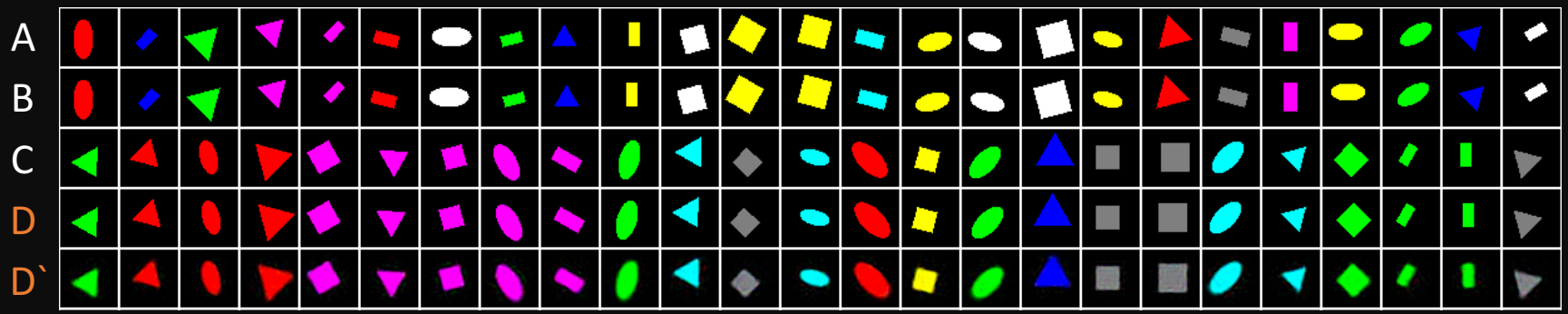
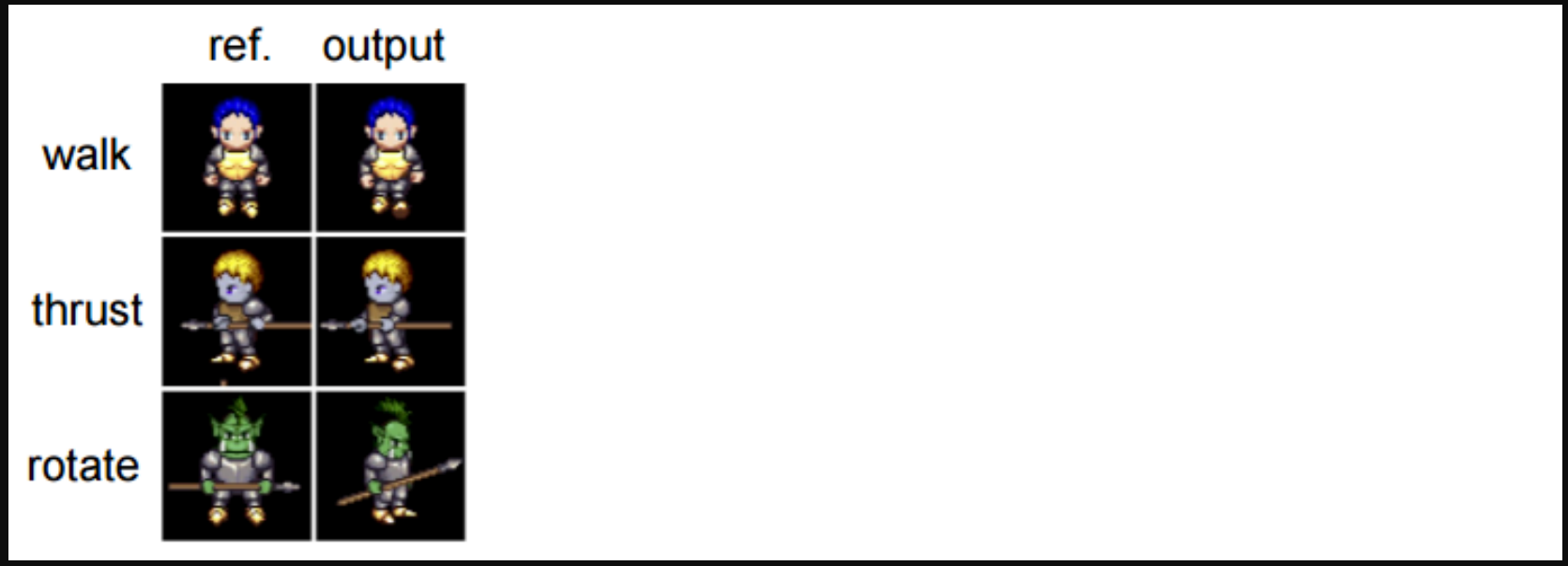
A → B : C → ?

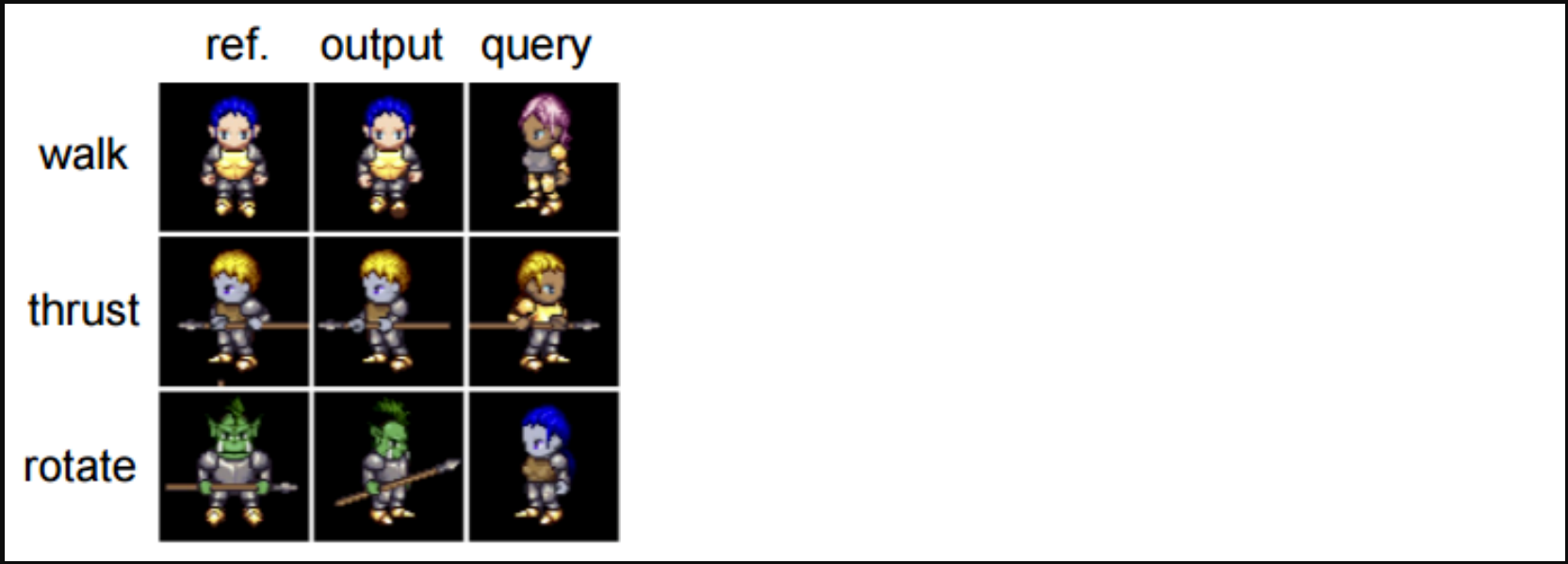


x, y 축 이동

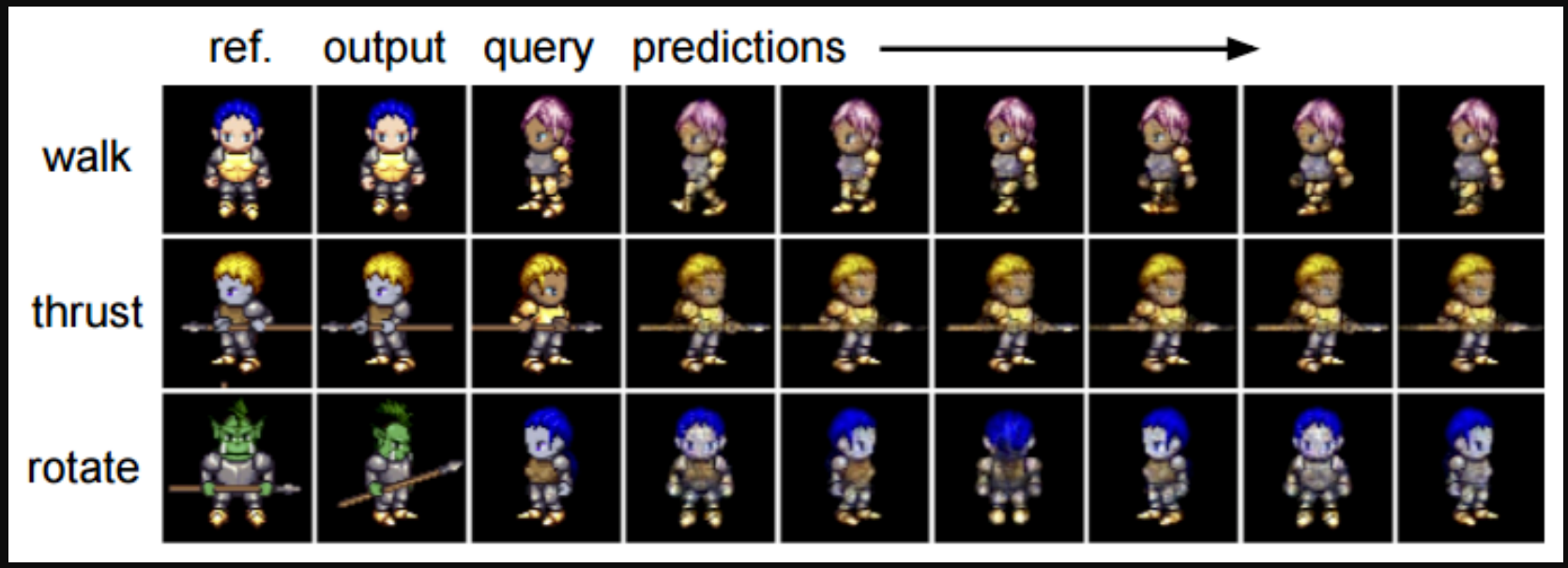
A → B : C → ?



A → B : C → ?



A → B : C → ?



https://github.com/carpedm20/visual-analogy-tensorflow

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지금까지 제가 구현한 논문은

- Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks
- Deep Visual Analogy-Making
- Pixel Recurrent Neural Networks

Computer Vision

DEVSISTERS

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Computer Vision

- End-To-End Memory Networks
- Neural Variational Inference for Text Processing
- Character-Aware Neural Language Models
- Teaching Machines to Read and Comprehend

Natural Language Processing

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- Playing Atari with Deep Reinforcement Learning
- Human-level control through deep reinforcement learning
- Deep Reinforcement Learning with Double Q-learning
- Dueling Network Architectures for Deep Reinforcement Learning
- Language Understanding for Text-based Games Using Deep Reinforcement Learning
- Asynchronous Methods for Deep Reinforcement Learning
- Continuous Deep q-Learning with Model-based Acceleration

Reinforcement Learning

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Reinforcement Learning

- Neural Turing Machines

Algorithm Learning

재미있었던 논문은

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- Continuous Deep q-Learning with Model-based Acceleration

Reinforcement Learning

- Neural Turing Machines

Algorithm Learning

각 모델들은

- 이미지(사람의 얼굴 사진)을 이해하고 스스로 만드는 모델
- 이미지 버전의 '왕 - 남자 + 여자 = 여왕'
- 이미지를 이해하고 픽셀 하나씩 만들어가는 모델 — Computer Vision

- Question Answering, Language Model
- Neural Variational Inference for Text Processing
- Character-level Language Models with CNN
- Question Answering — Natural Language Processing

- Atari 게임을 화면의 픽셀만 보고 배우는 딥러닝 모델 (최초)
- Atari 게임을 화면의 픽셀만 보고 배우는 딥러닝 모델 (Nature 논문)
- Double Q-Learning로 Atari 게임을 더 잘 플레이하는 모델
- Dueling Network로 Atari 게임을 더 잘 플레이하는 모델
- 텍스트 게임을 강화학습으로 배우는 모델
- Asynchronous 학습으로 빠르게 로 Atari 게임을 학습하는 모델
- Atari 게임과 같이 discrete한 action이 아닌 환경을 잘 학습하는 모델 — Reinforcement Learning

---

- 뉴럴 튜링 머신 — Algorithm Learning

모든 코드는 Github에

- https://github.com/carpedm20/DCGAN-tensorflow ★ 580+
- https://github.com/carpedm20/visual-analogy-tensorflow ★ 210+
- https://github.com/carpedm20/pixel-rnn-tensorflow/ ★ 80+

- https://github.com/carpedm20/MemN2N-tensorflow ★ 180+
- https://github.com/carpedm20/variational-text-tensorflow ★ 330+
- https://github.com/carpedm20/lstm-char-cnn-tensorflow ★ 170+
- https://github.com/carpedm20/attentive-reader-tensorflow ★ 100+

- https://github.com/devsisters/DQN-tensorflow ★ 410+
- https://github.com/devsisters/DQN-tensorflow
- https://github.com/carpedm20/deep-rl-tensorflow ★ 370+
- https://github.com/carpedm20/deep-rl-tensorflow
- https://github.com/carpedm20/text-based-game-rl-tensorflow ★ 20+
- https://github.com/devsisters/async-rl-tensorflow
- https://github.com/carpedm20/NAF-tensorflow/ ★ 40+

- https://github.com/carpedm20/NTM-tensorflow ★ 330+

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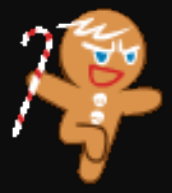
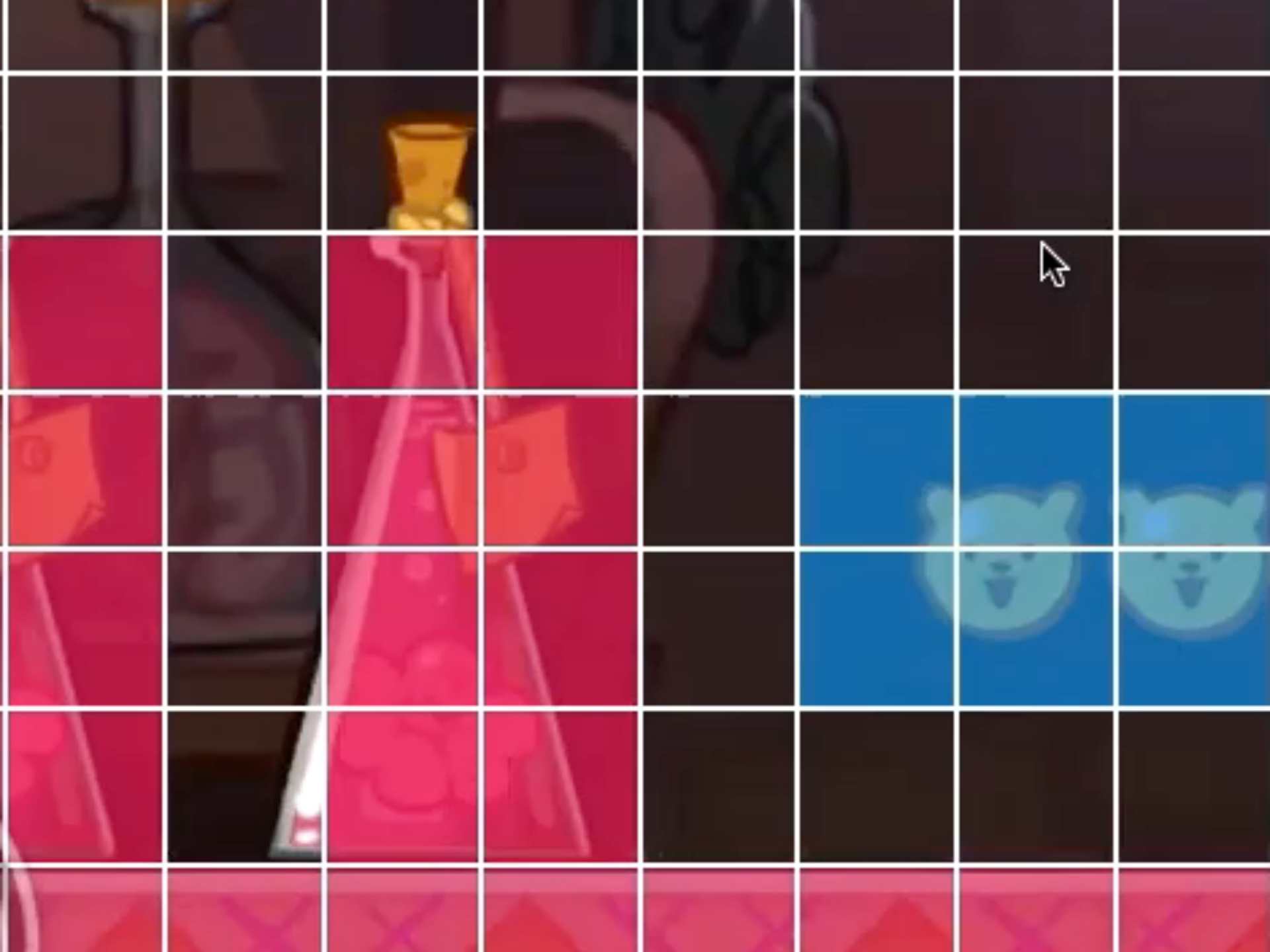
마지막으로..



DEVSISTERS



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http://carpedm20.github.io/

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오픈 세션 205

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