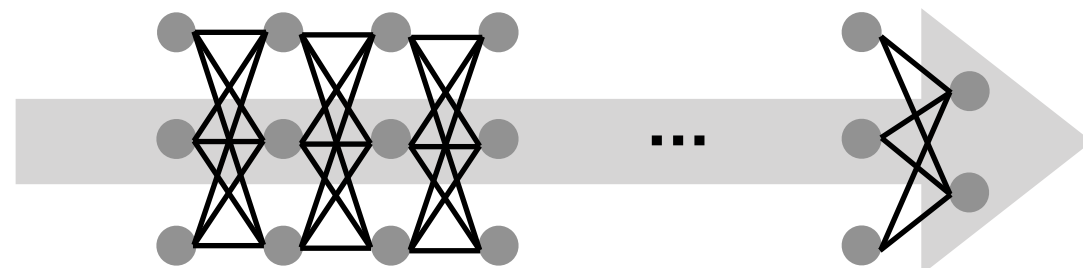
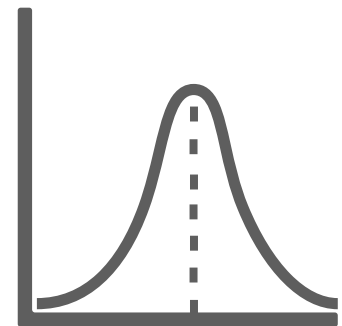


# Classification Model

# How does it work?



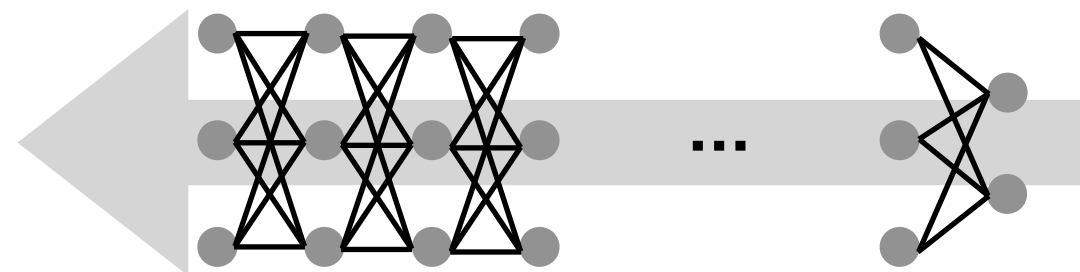
**Forward path**



**Penguin: 0.01**

**Iteration**

**Difference  
measurement  
(Loss)**

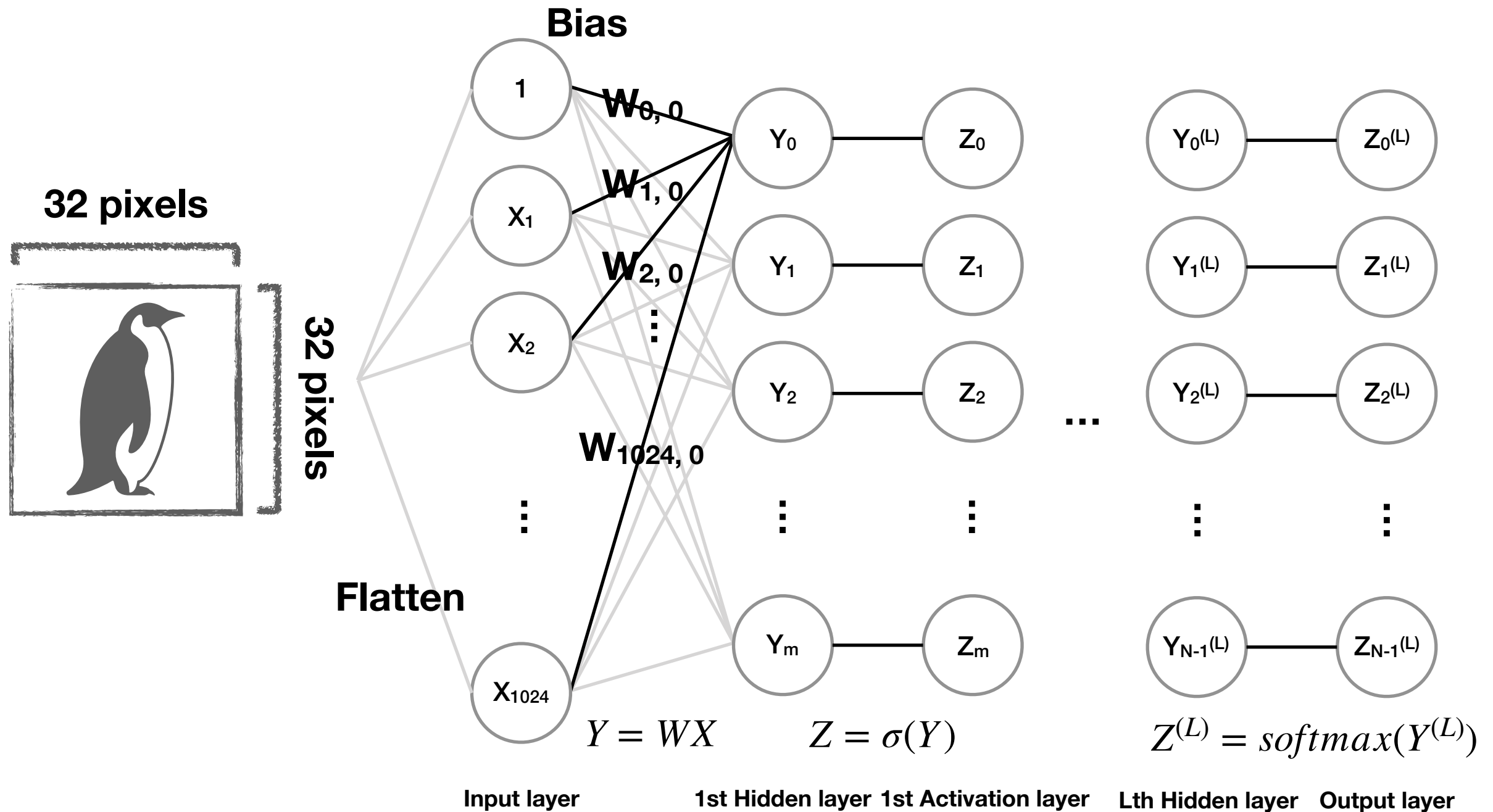


**Backward path  
(Gradient Back-propagation)**

$\nabla_{\theta} L$

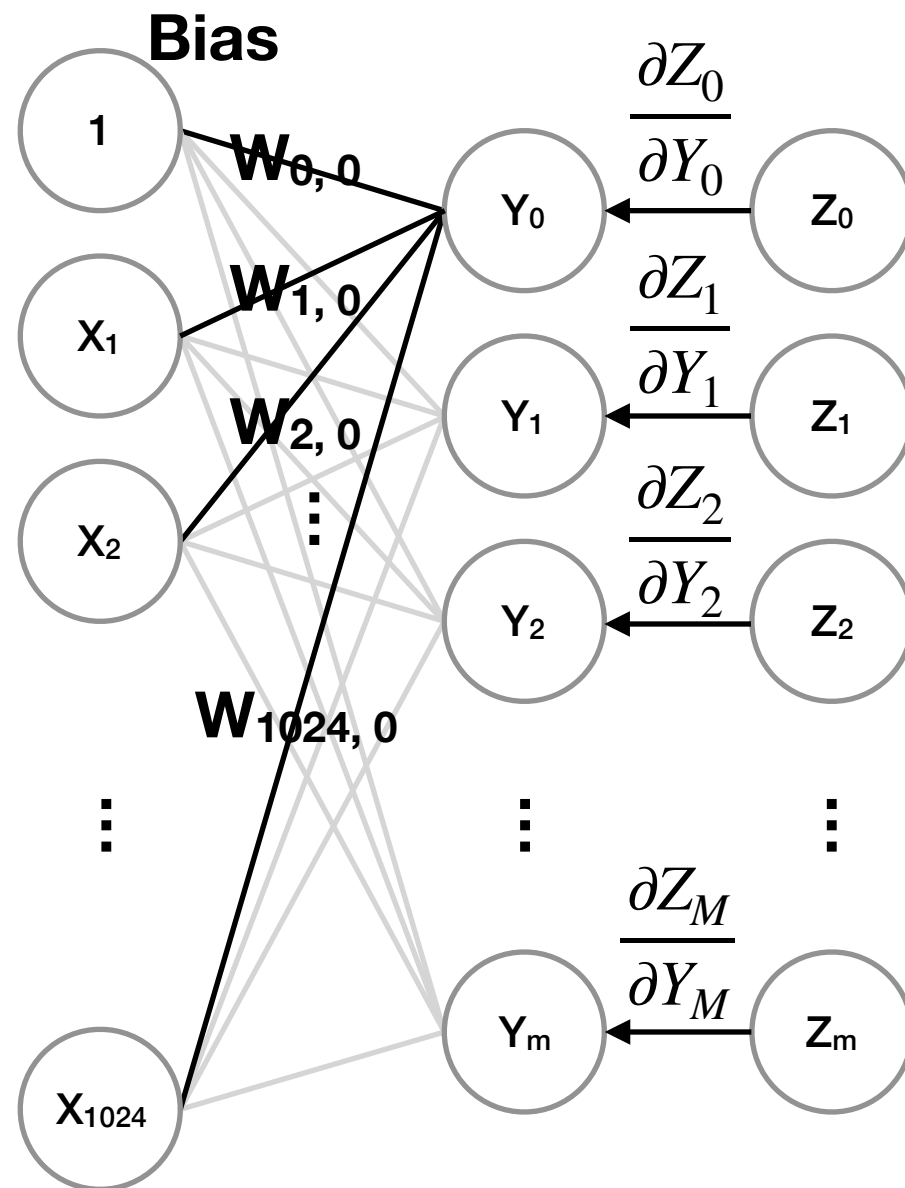
**Penguin: 1.0**

# Forward path



**Densely connected**  
(fully connected)

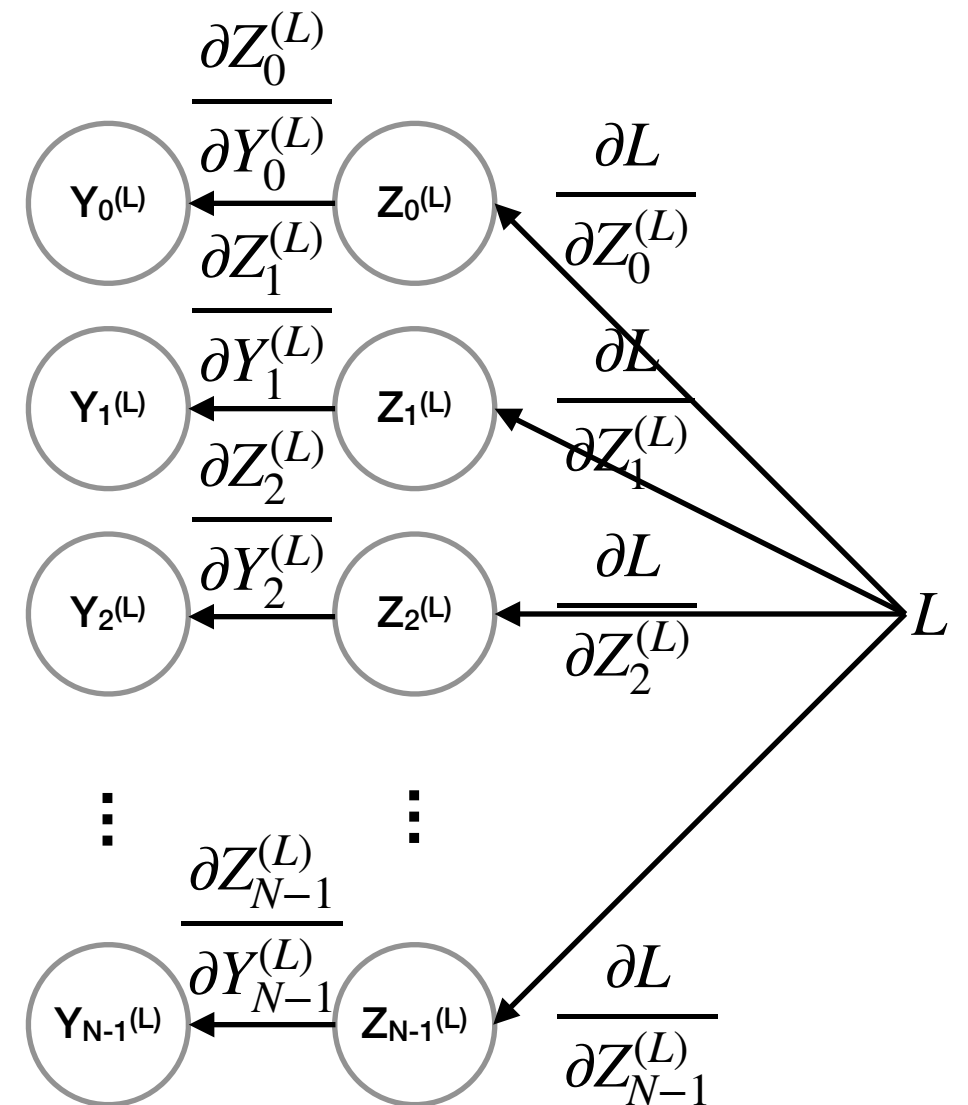
# Backward path



$$\frac{\partial L}{\partial W_{0,0}} = \frac{\partial L}{\partial Y_0} \frac{\partial Y_0}{\partial W_{0,0}}$$

$$W_{0,0} = W_{0,0} - \rho \frac{\partial L}{\partial W_{0,0}}$$

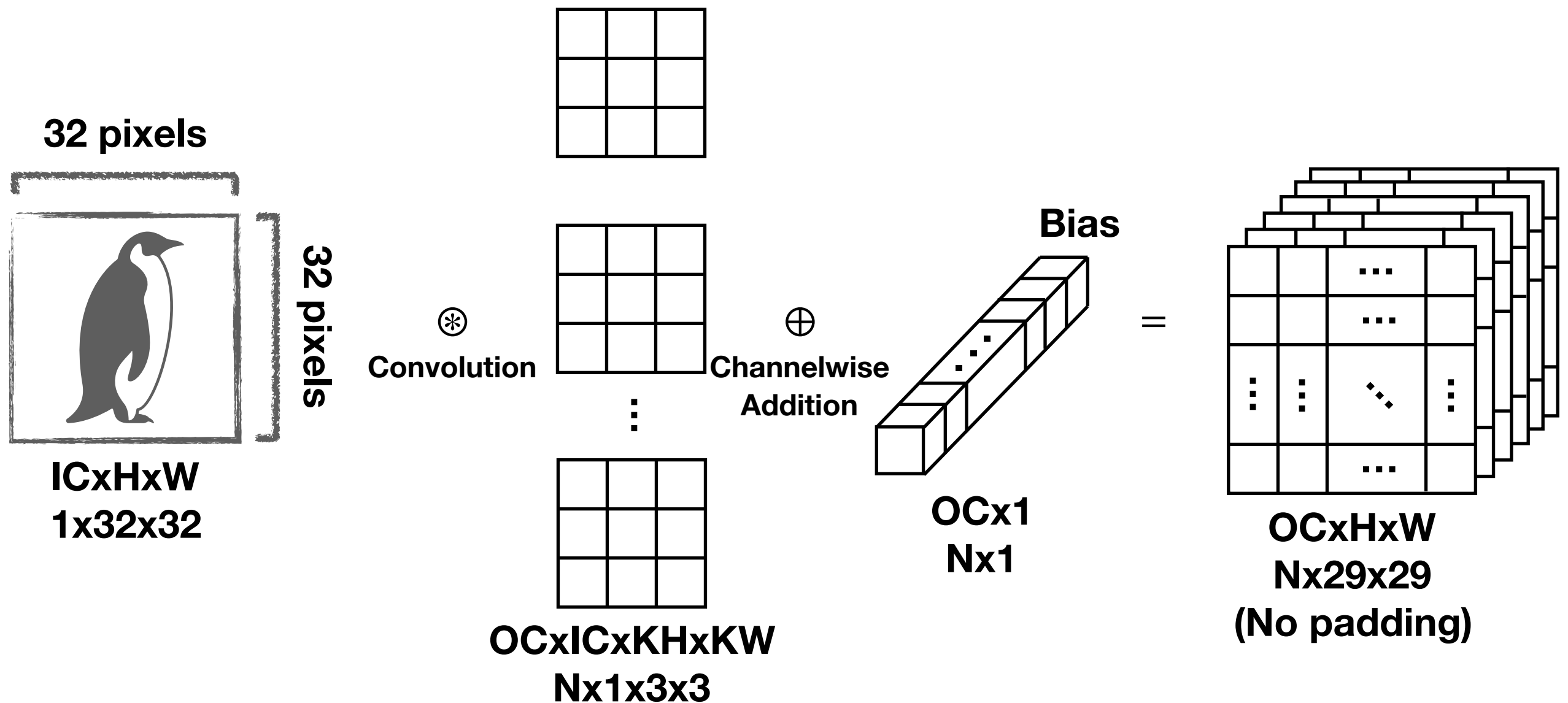
...



$$L = - \sum_{k=0}^{N-1} t_k \log Z_k = - \log Z_i$$

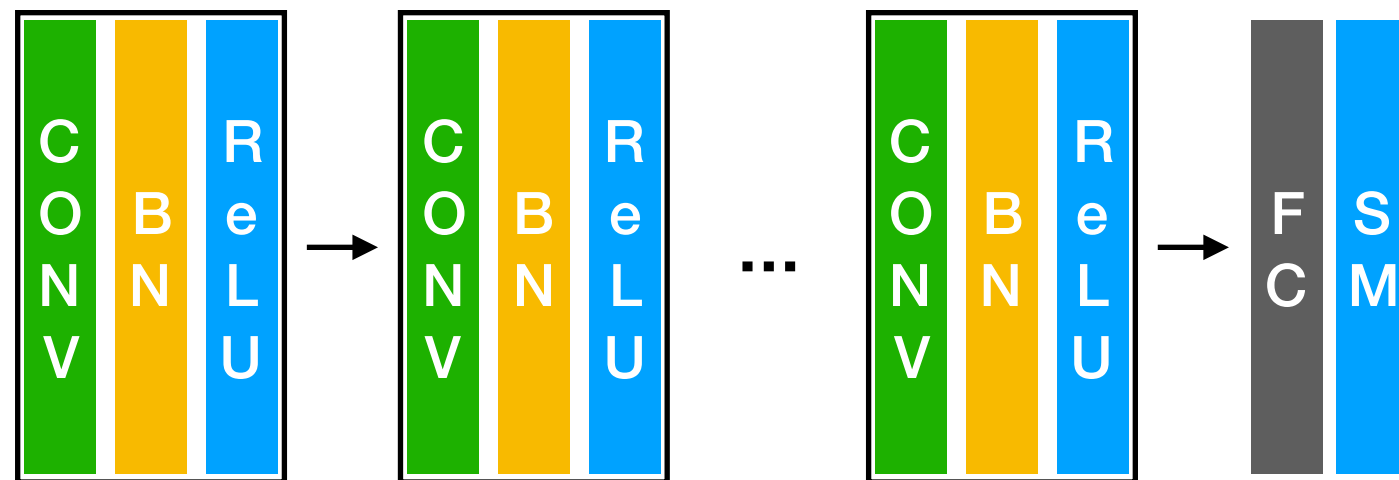
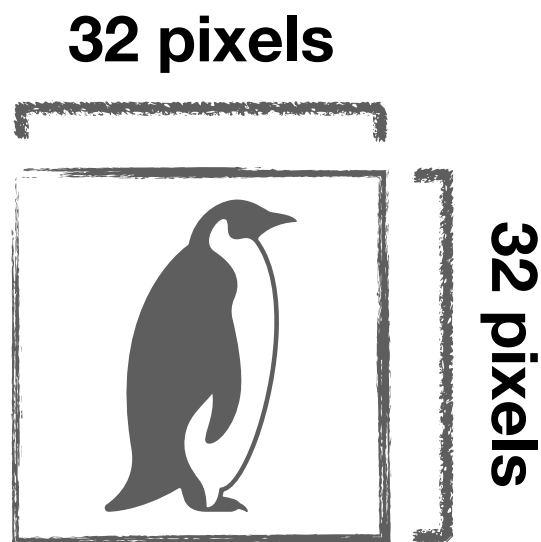
**Cross-entropy loss**

# Convolution\*



H: Height  
 W: Width  
 OC: Output Channel  
 IC: Input Channel  
 KH: Kernel Height  
 KW: Kernel Width

# Convolutional neural network



BN: Batch Normalization  
CONV: CONVolution  
FC: Fully Connected layer  
ReLU: Rectified Linear Unit  
SM: SoftMax activation layer

# Practice

# MNIST database



**Training set: 60,000 images and labels**  
**Test set: 10,000 images and labels**

**The MNIST database (Modified National Institute of Standards and Technology database) is a large database of handwritten digits that is commonly used for training various image processing systems.**



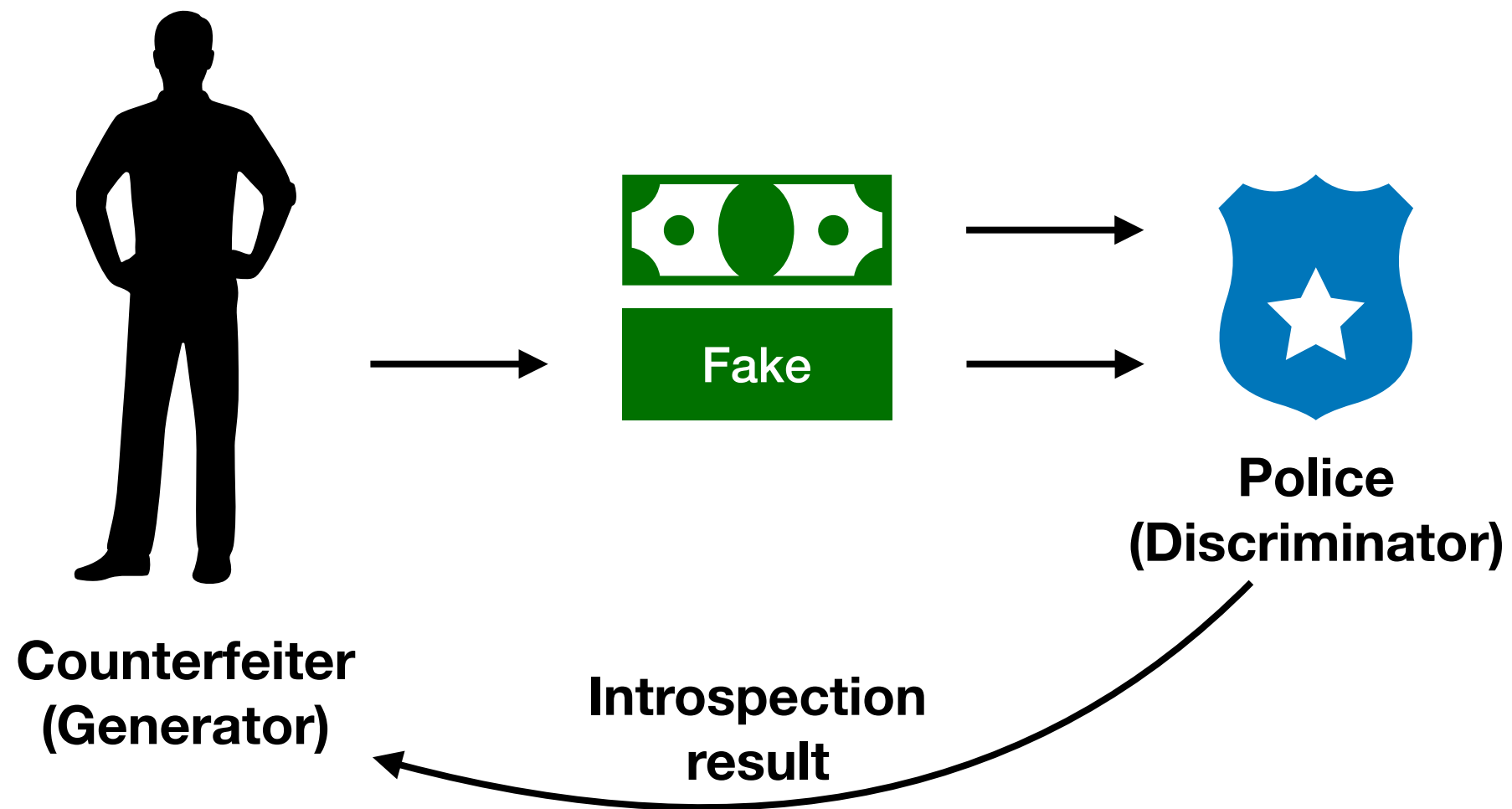
# Generative Model

# Various generative models

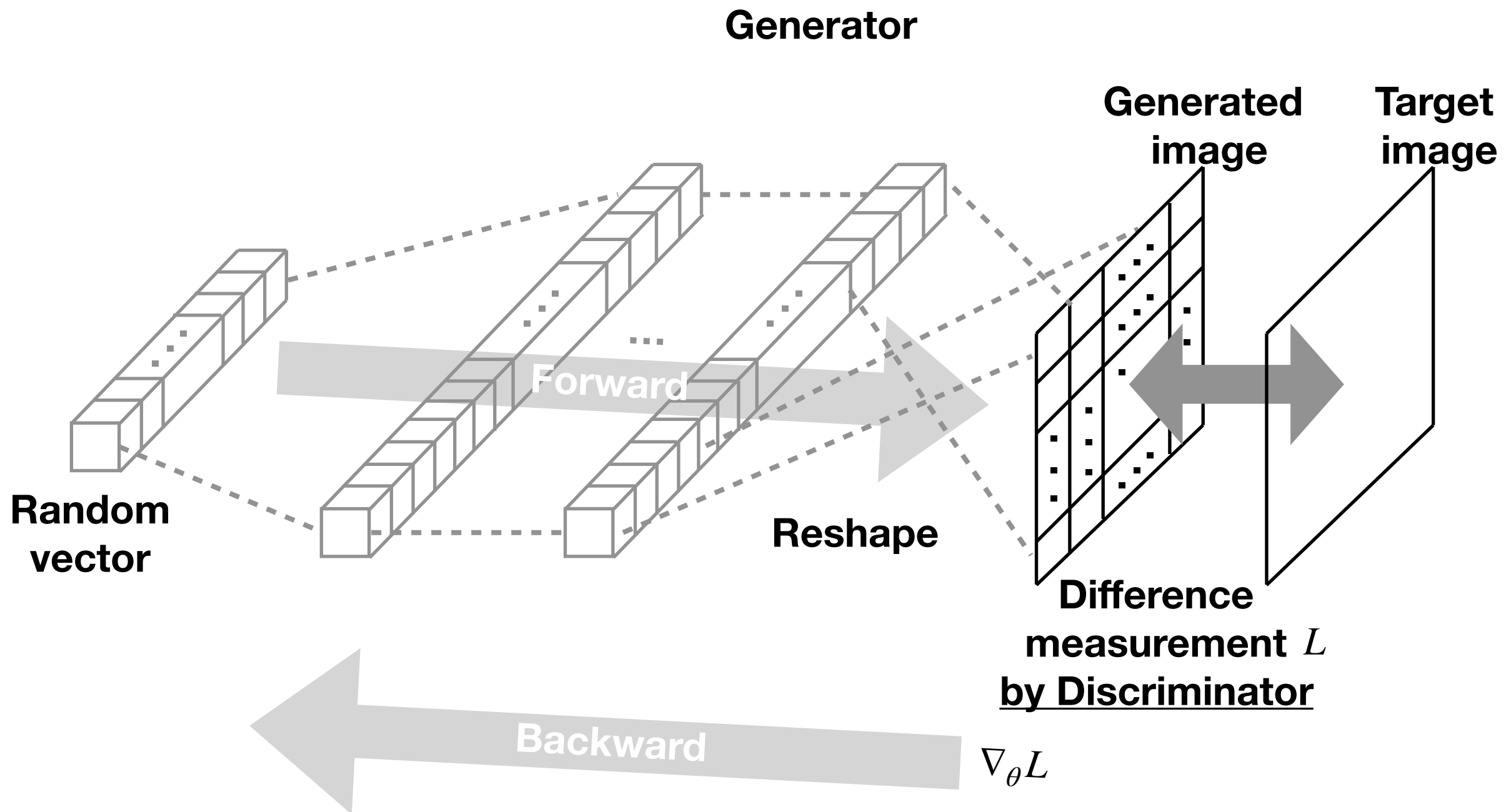
- Hidden Markov Model (HMM)
- Restricted Boltzmann Machine (RBM)
- Variational Auto-Encoder (VAE)
- Recurrent Neural Network (RNN)
- **Generative Adversarial Network (GAN)**

**GAN**

# What is GAN?

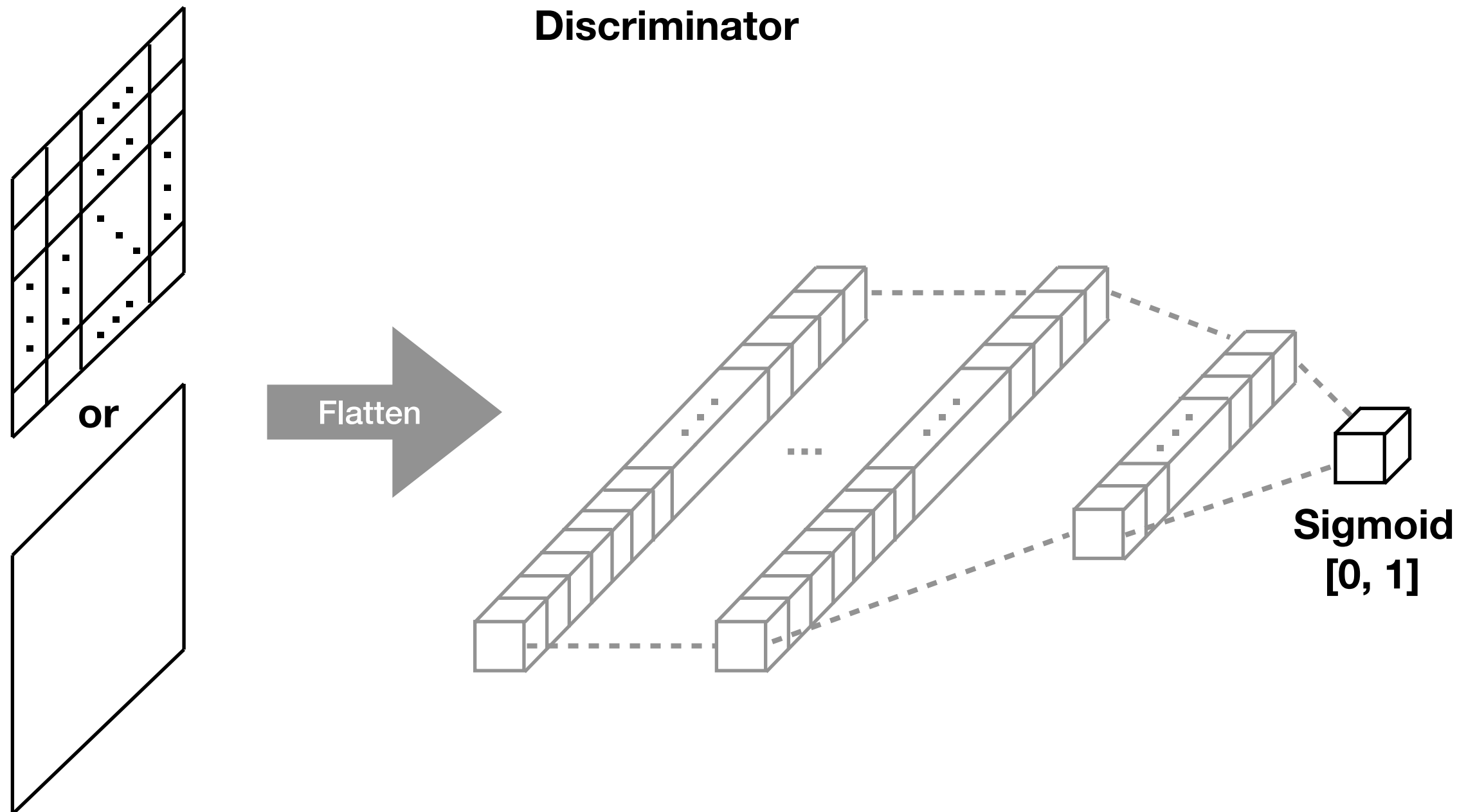


# How does GAN work?



E.g. image generation model

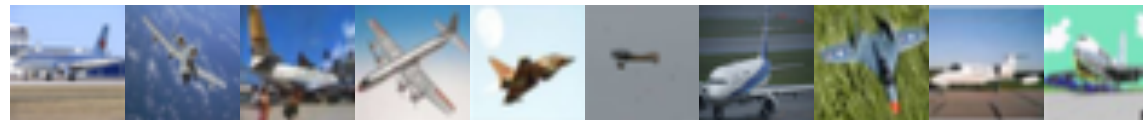
# How does GAN work?



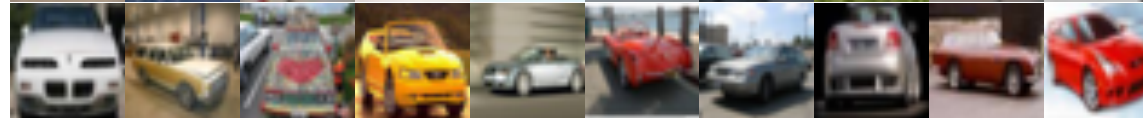
# Practice

# CIFAR10

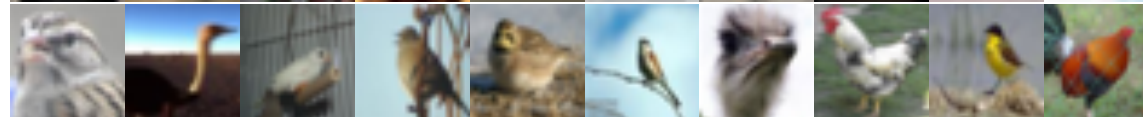
airplane



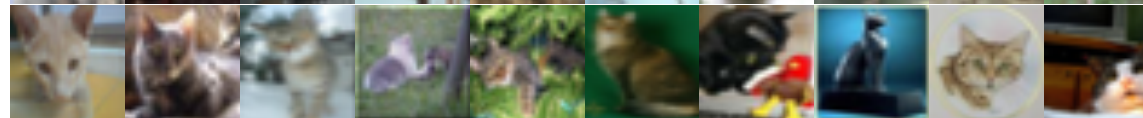
automobile



bird



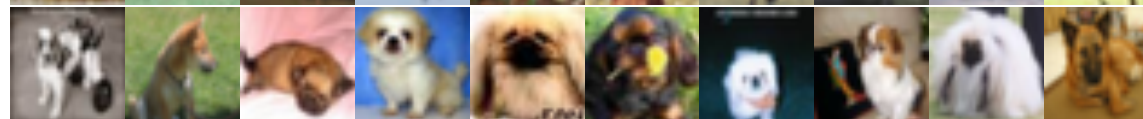
cat



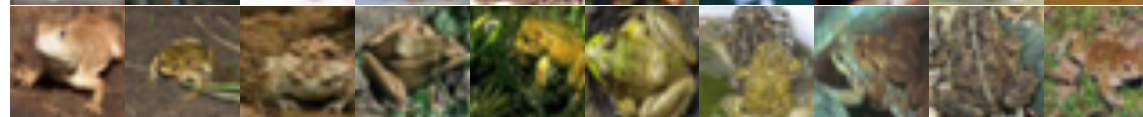
deer



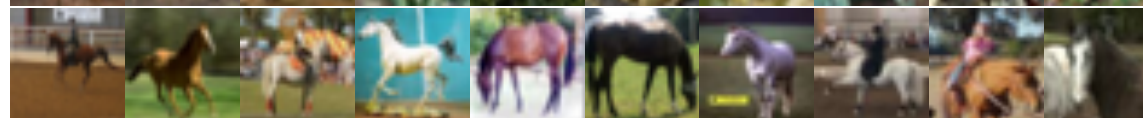
dog



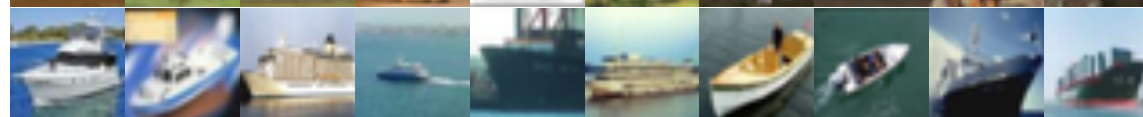
frog



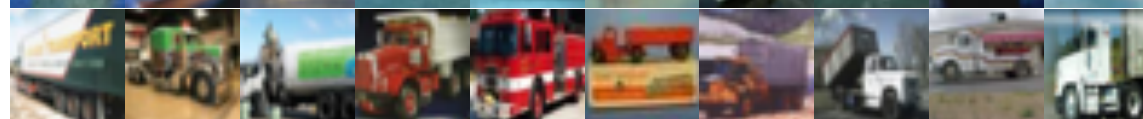
horse



ship



truck



Credit. Learning Multiple Layers of Features from Tiny Images, Alex Krizhevsky, 2009.

**The CIFAR-10 dataset consists of 60,000 32x32 color images in 10 classes, with 6,000 images per class. There are 50,000 training images and 10,000 test images.**