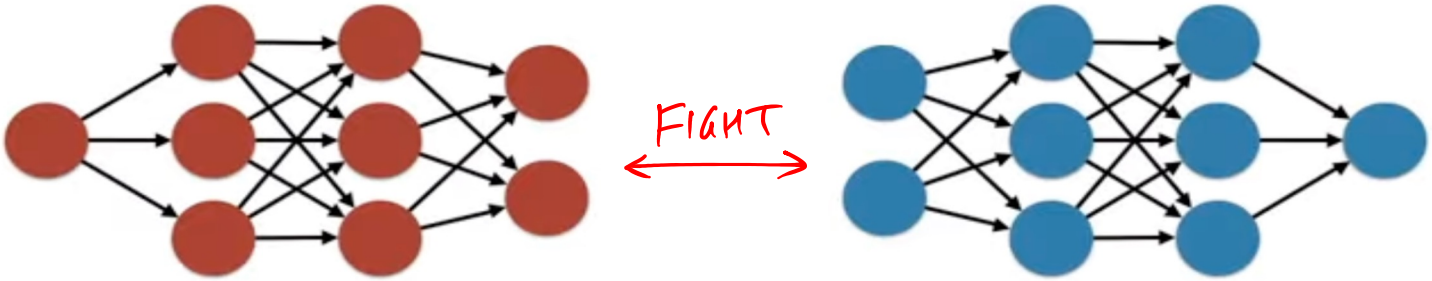
thispersondoesnotexist.com

Generative Adversarial Networks



Generator

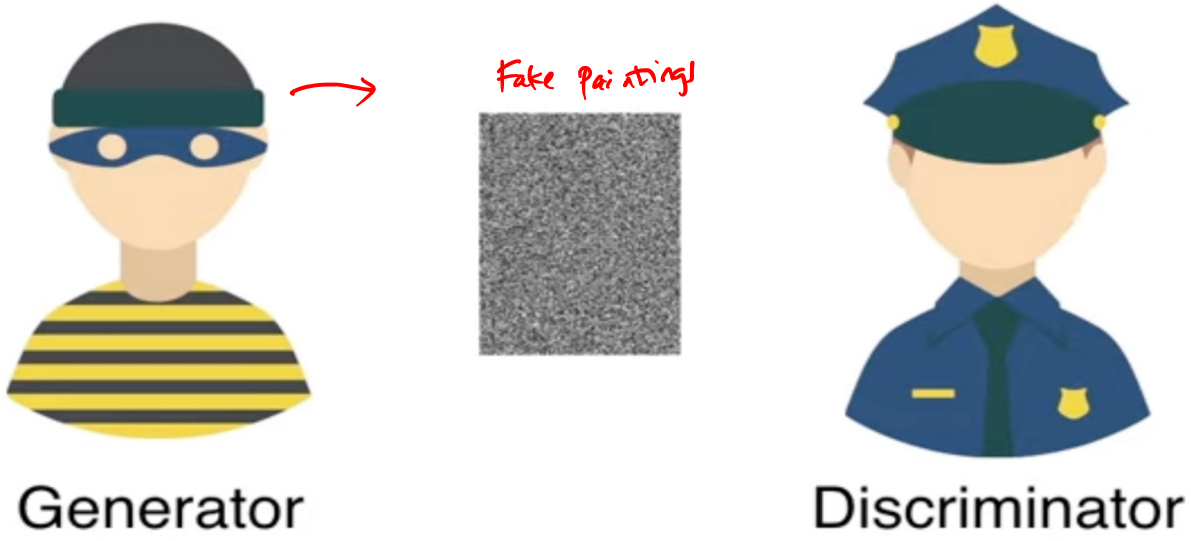
Discriminator

Generative Adversarial Networks

Generator

Discriminator

Generative Adversarial Networks



Generative Adversarial Networks

Generator

Discriminator

Generative Adversarial Networks

Generator

Discriminator

Generative Adversarial Networks

Generator

Discriminator

Generative Adversarial Networks

Generator

A

Discriminator

Generative Adversarial Networks

Generator

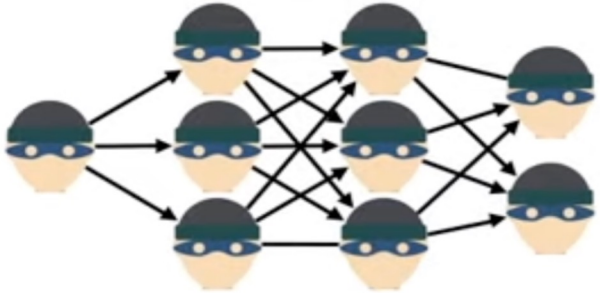
Discriminator

Generative Adversarial Networks

Generative Adversarial Networks

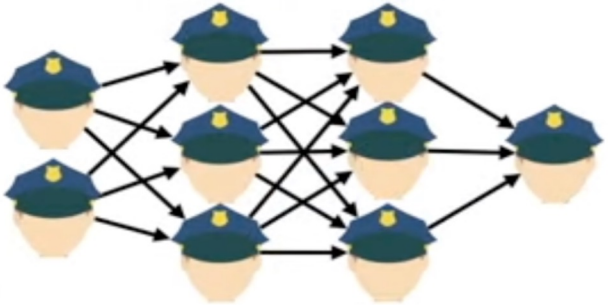
1

Generator



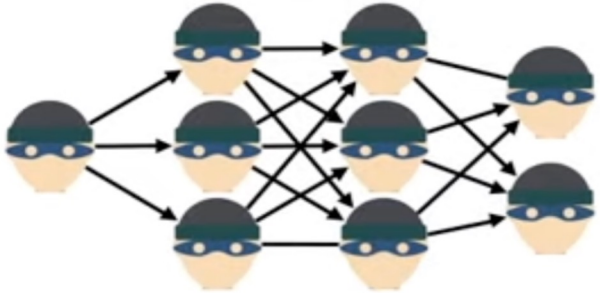
2

Discriminator



Real images

Generator



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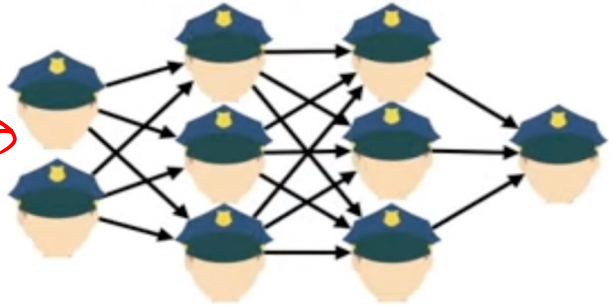
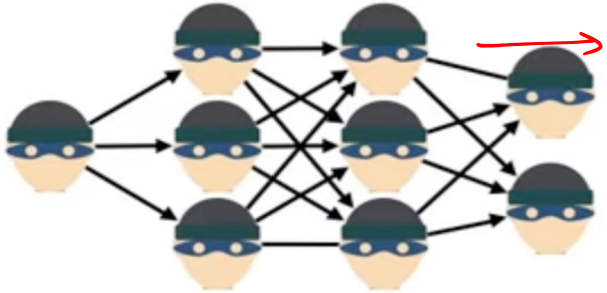
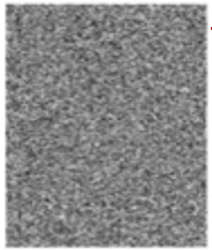


Real

Real images

Generator





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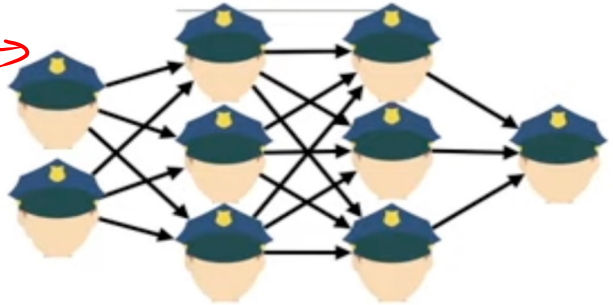
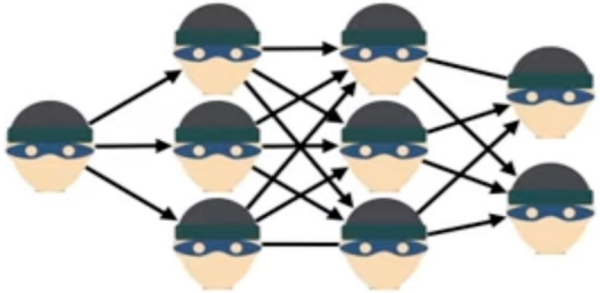


Fake

Real images

Generator



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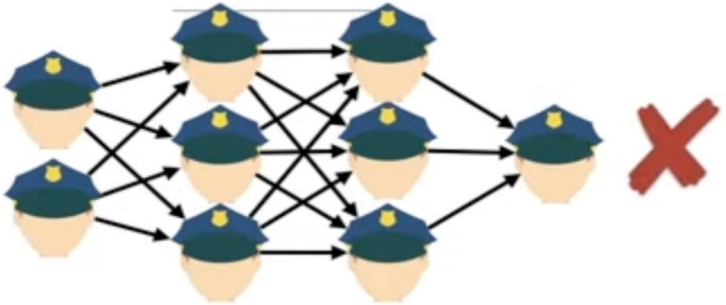
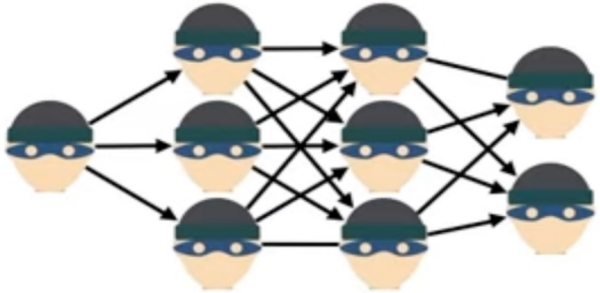


Real images

Generator



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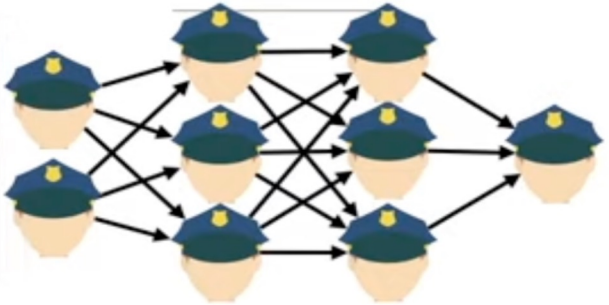
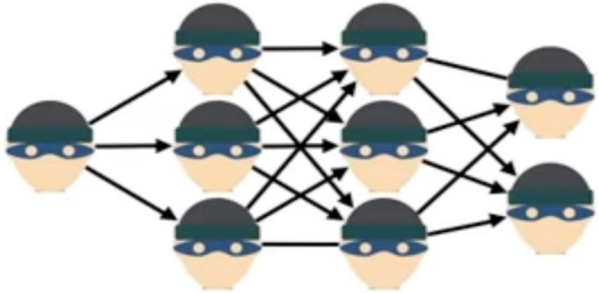


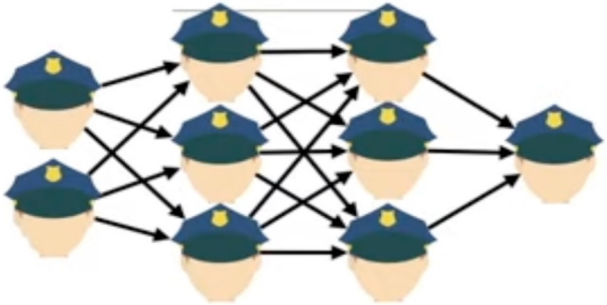
Real images

Generator

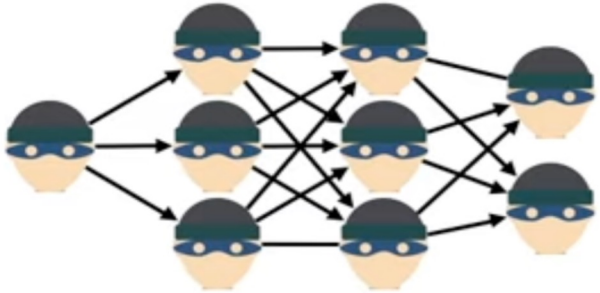


Real images

Discriminator



Generator



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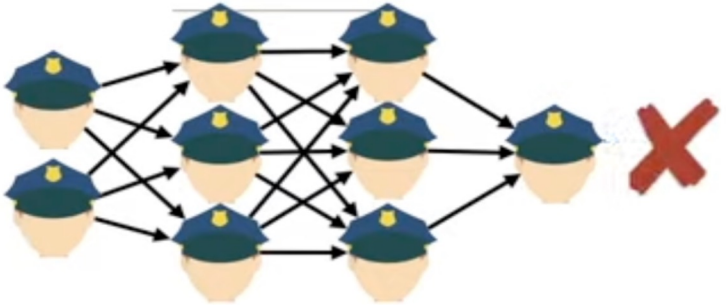
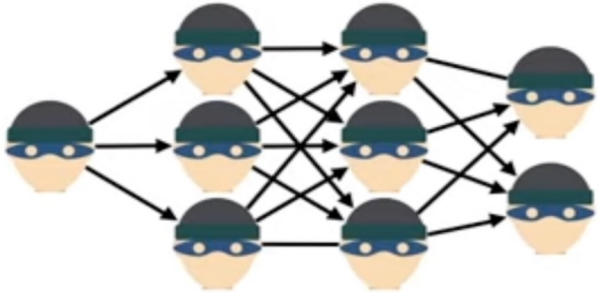


Real images

Generator



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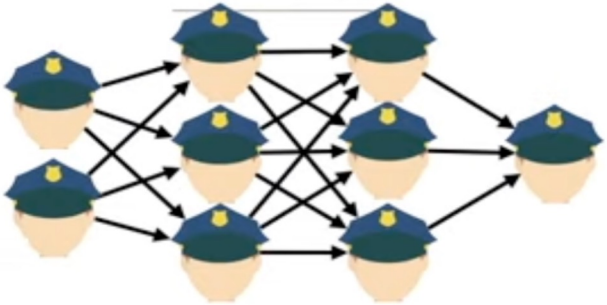
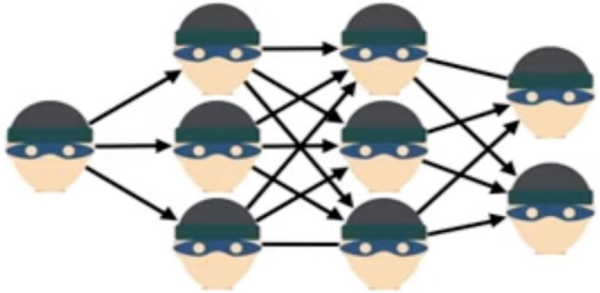


Real images

Generator



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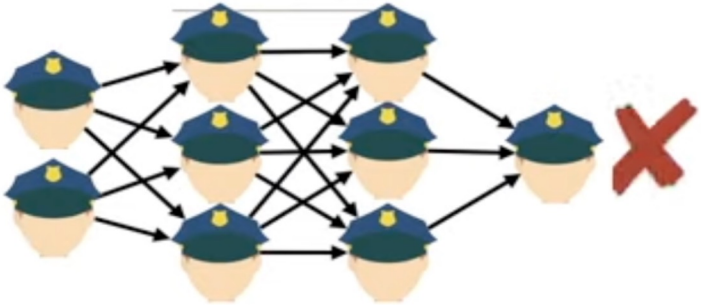
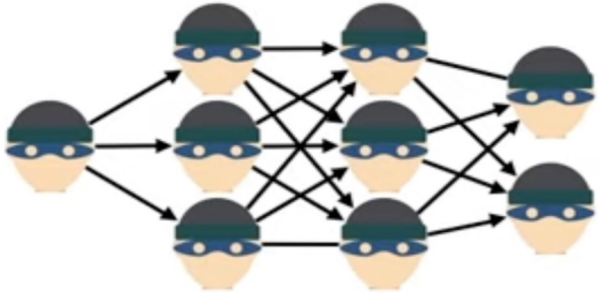


Real images

Generator



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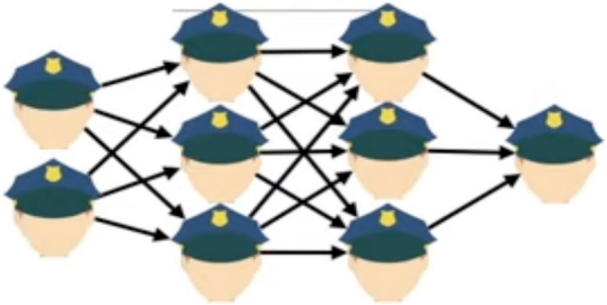
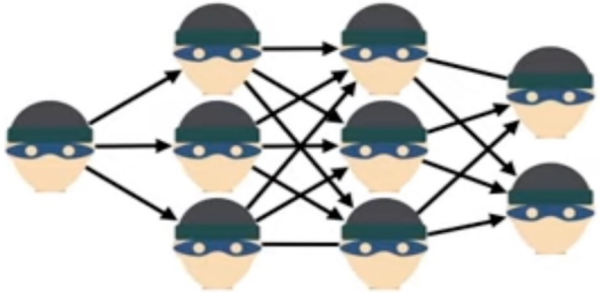


Real images

Generator



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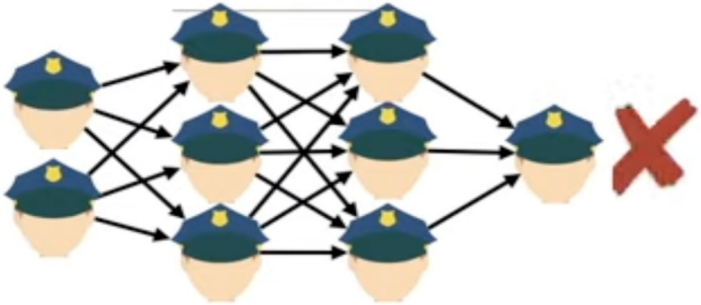
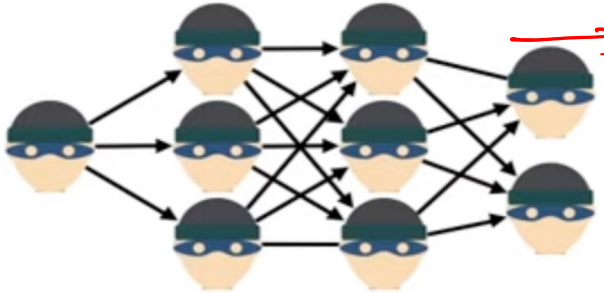


Real images

Generator



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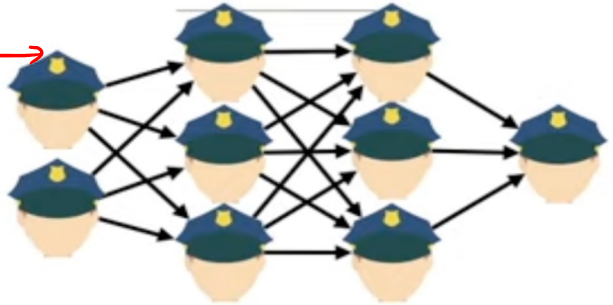
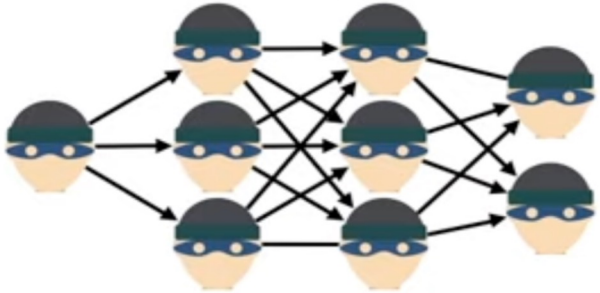


Real images

Generator



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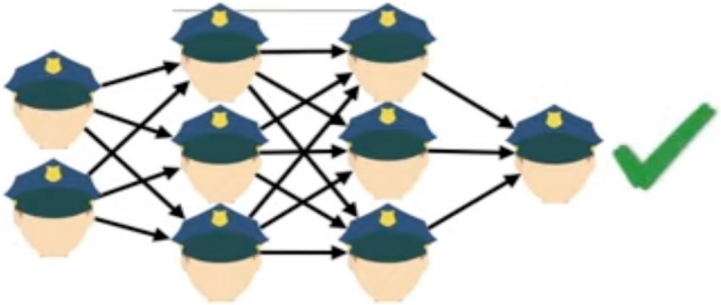


Real images

Build the simplest GAN

Slanted Land

Slanted people

Slanted Land

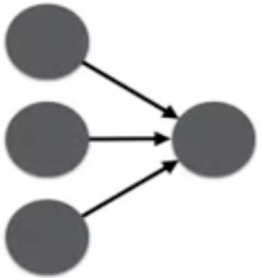
Slanted people

2x2 screens

Slanted Land

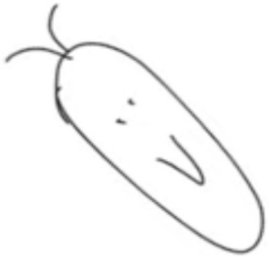
Slanted people

2x2 screens

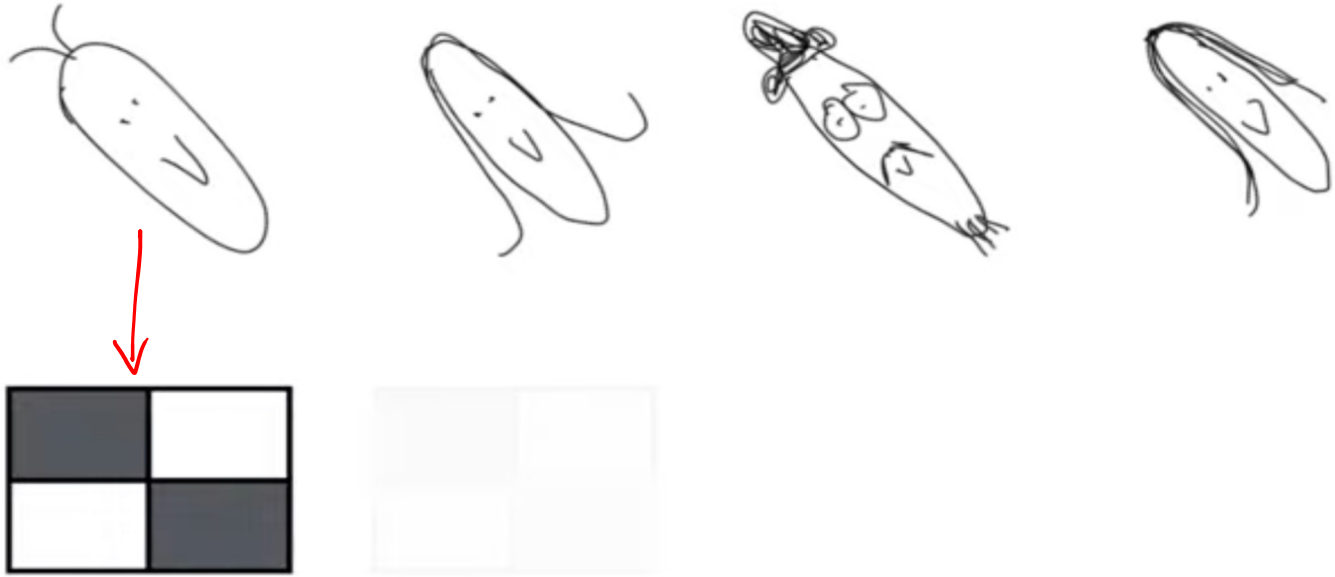


1-layer
Neural networks

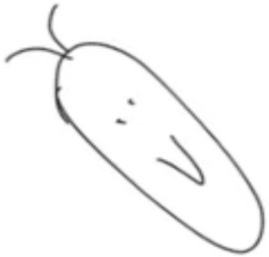
Faces




Faces



Faces

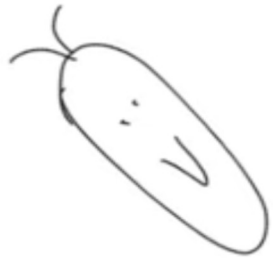


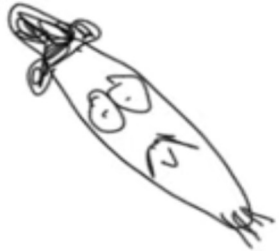



Faces

Faces

Real Faces







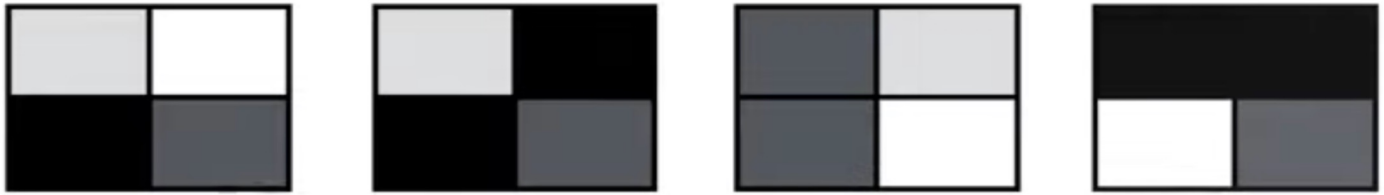


No faces (noise)

No faces (noise)

No faces (noise)

No faces (noise)



Tell them apart

Faces

Noise

Tell them apart

Faces

Noise

Tell them apart

Faces

Noise

0 1

Faces

0.75	0
0	0.75

1	0.25
0.25	0.75

1	0
0	1

0.75	0
0.25	0.75

Noise

0.25	0
1	0.75

0.25	1
0.5	0.75

0.75	0.5
0.75	0

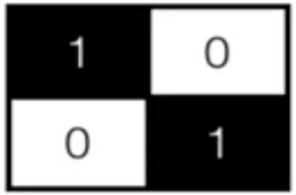
1	1
0	0.75

Building the Discriminator

Binary Classifier : Real / Fake

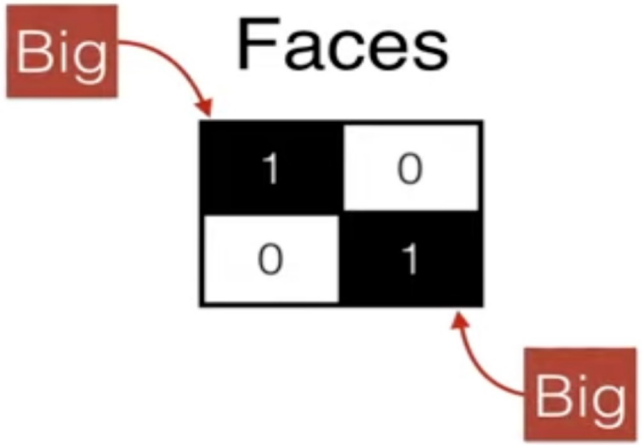
Building the discriminator

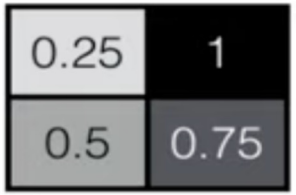
Faces



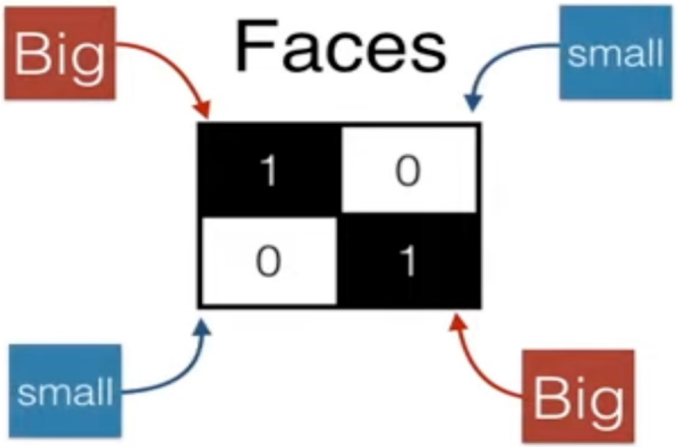
Noise

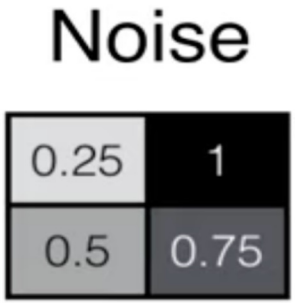
Building the discriminator



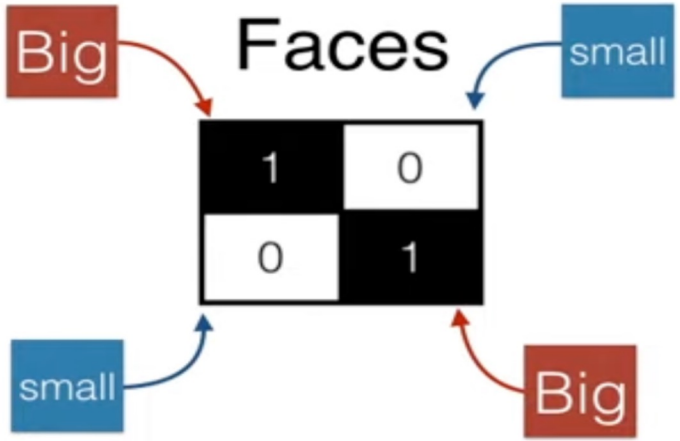


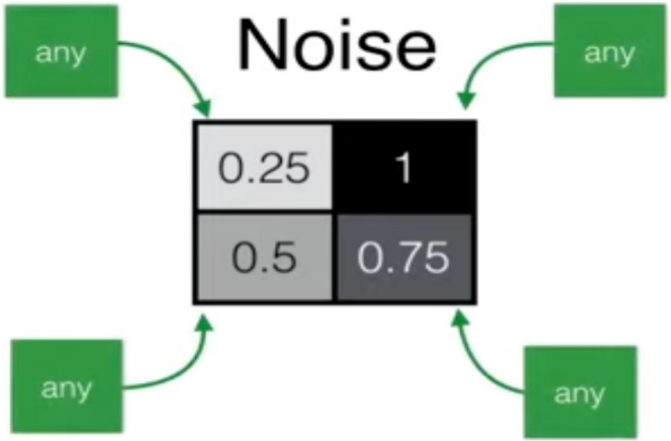
Building the discriminator





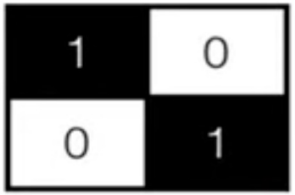
Building the discriminator



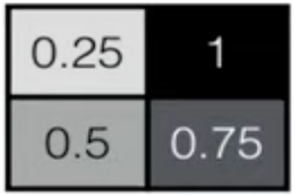


Building the discriminator

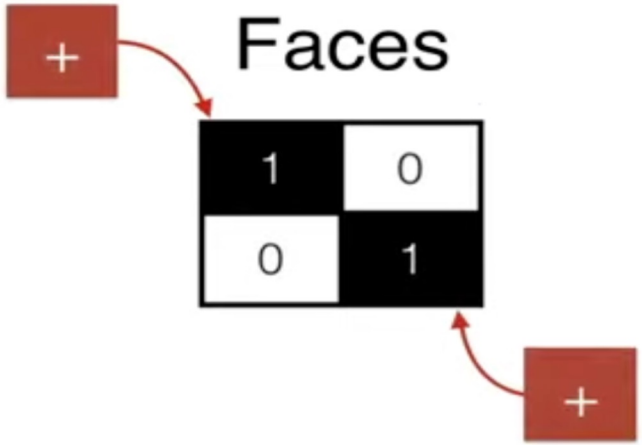
Faces

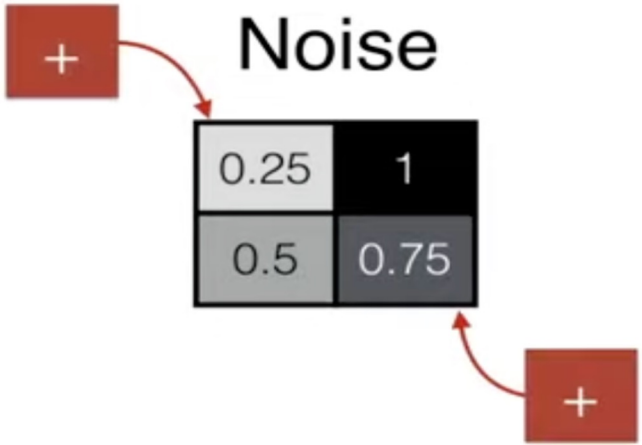


Noise

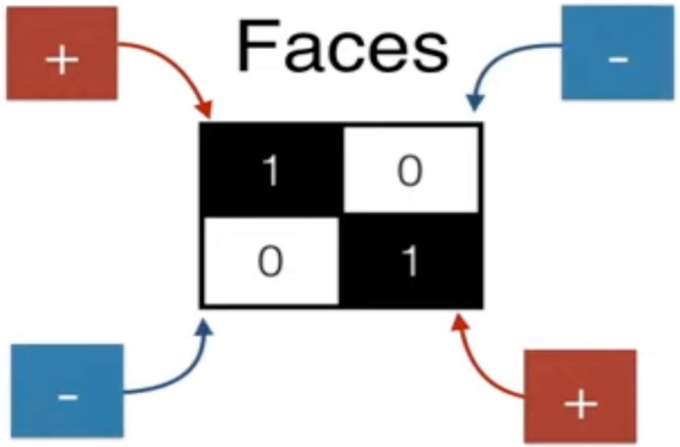


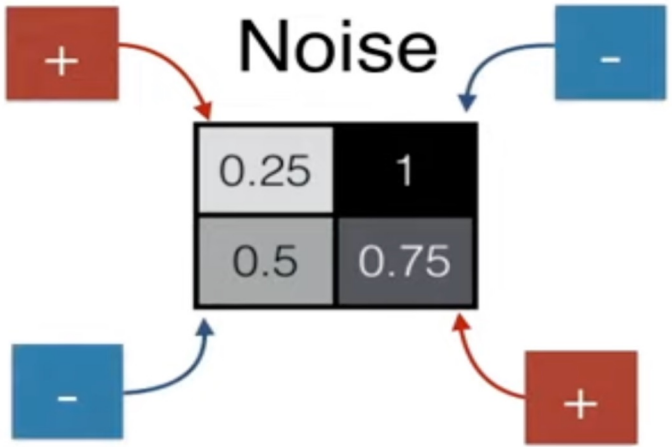
Building the discriminator



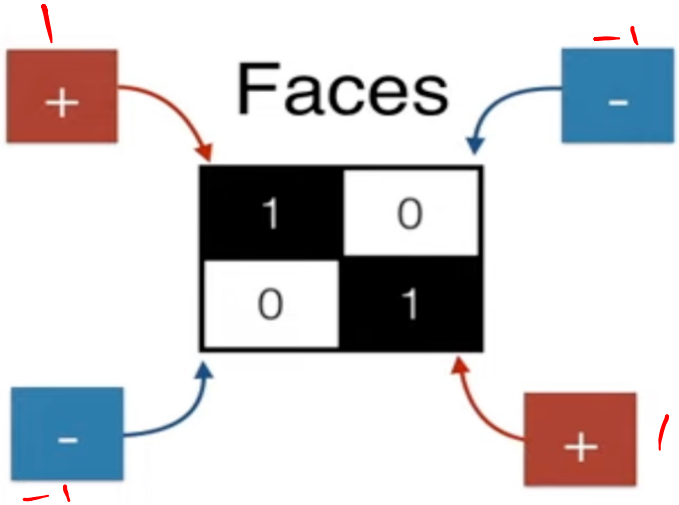


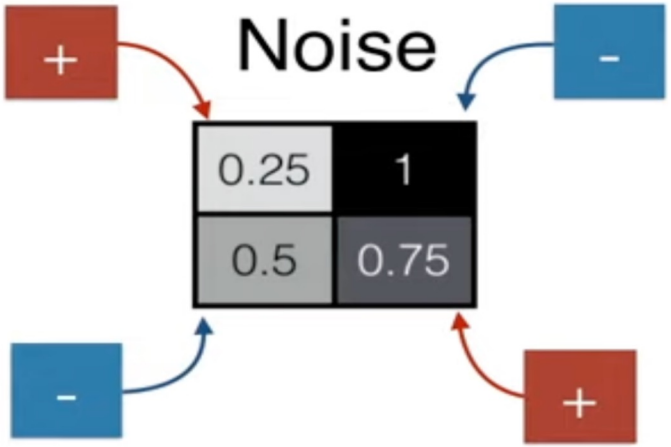
Building the discriminator





Building the discriminator

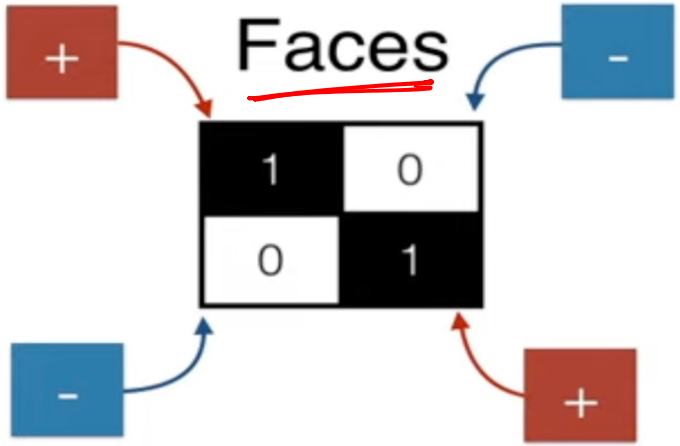


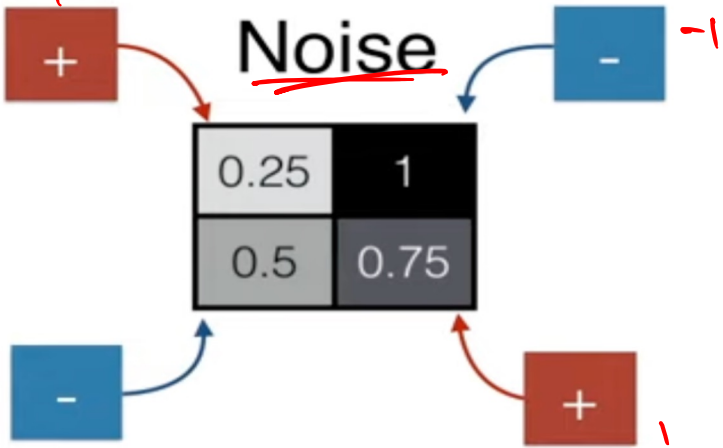


$1*1 + 0*(-1) + 0*(-1) + 1*1$

$= 2$ High

Building the discriminator

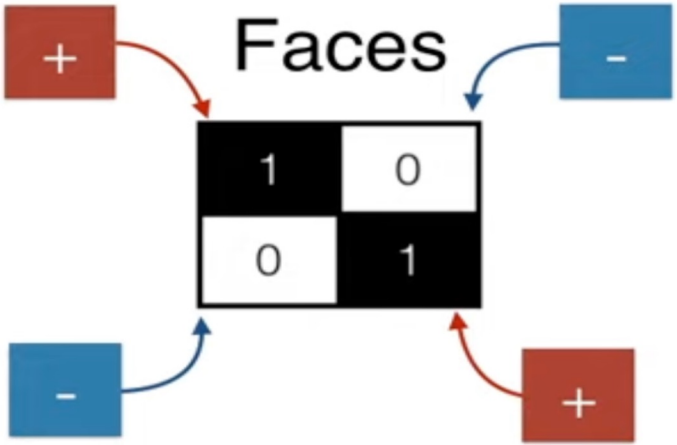


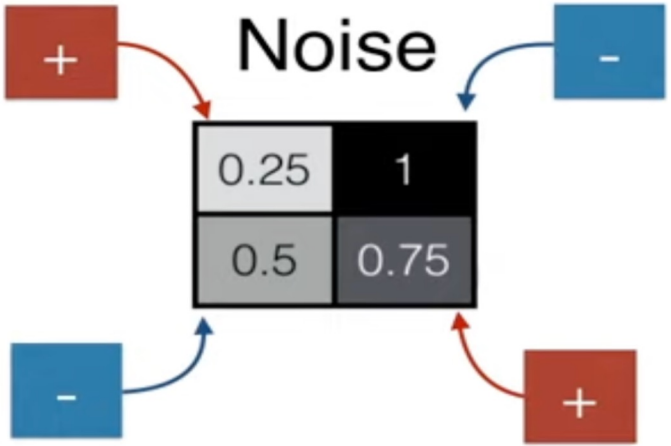


$1*1 + 0*(-1) + 0*(-1) + 1*1$
$= 2$ (High)

$0.25*1 + 1*(-1) + 0.5*(-1) + 0.75*1$
$= -0.5$ (Low)

Building the discriminator



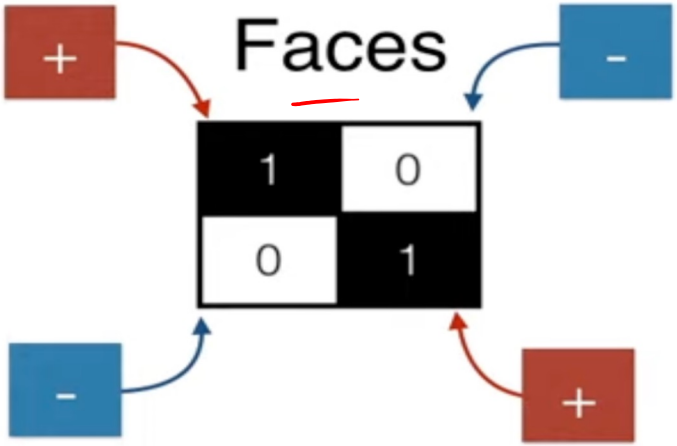


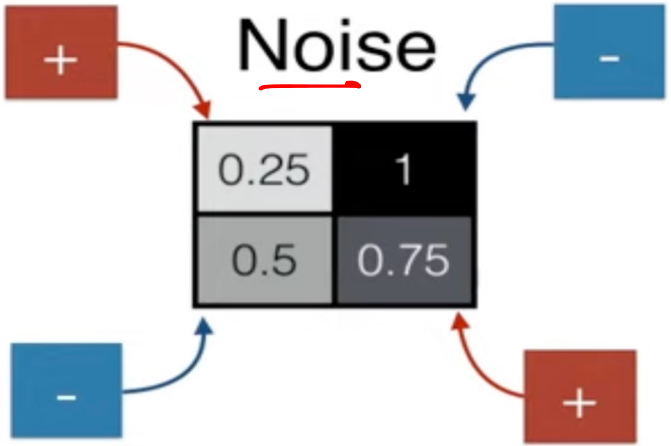
1*1 + 0*(-1) + 0*(-1) + 1*1
= 2

Threshold = 1

0.25*1 + 1*(-1) + 0.5*(-1) + 0.75*1
= -0.5

Building the discriminator





1*1 + 0*(-1) + 0*(-1) + 1*1
= 2

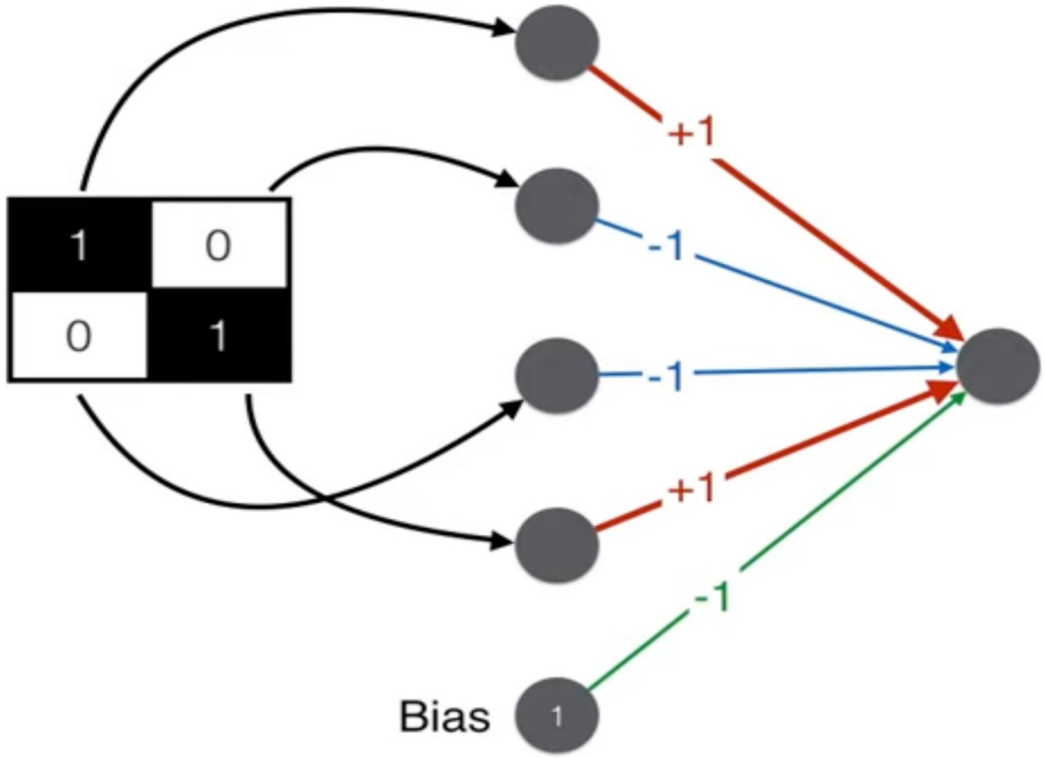
Threshold = 1

0.25*1 + 1*(-1) + 0.5*(-1) + 0.75*1
= -0.5

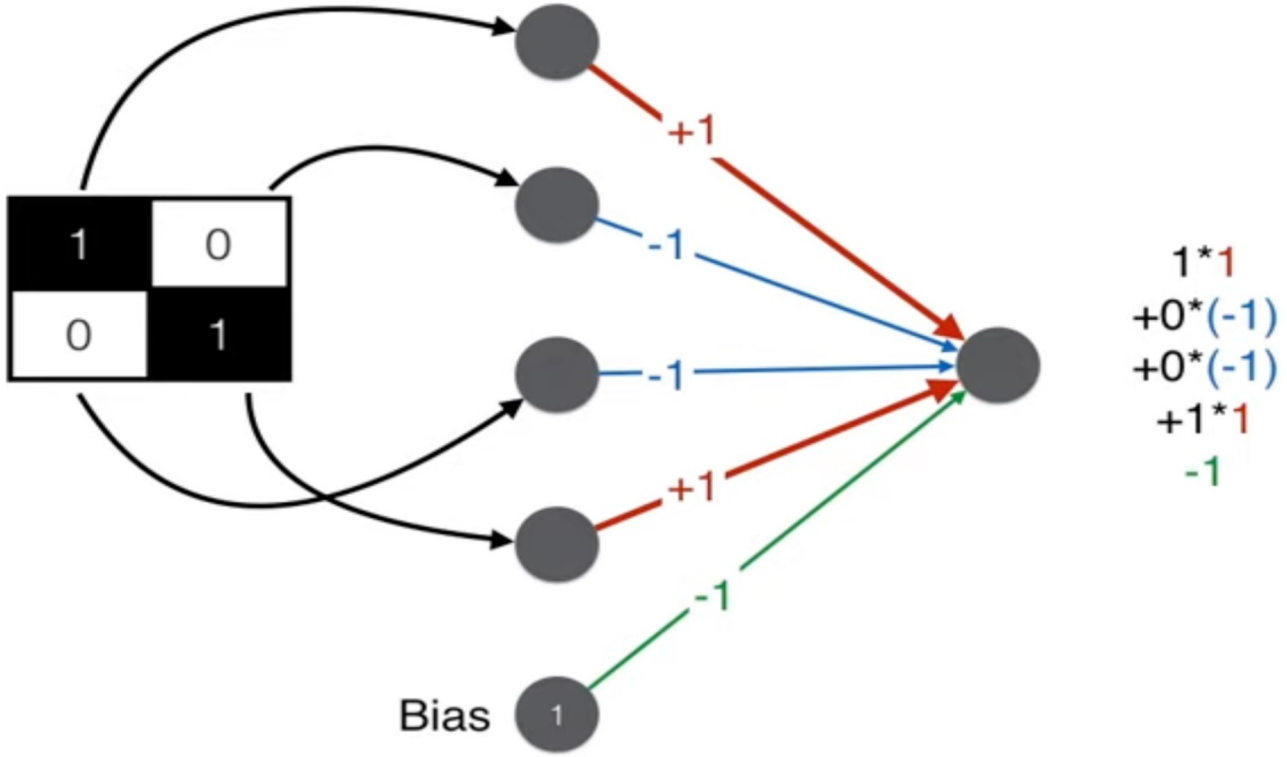
More than 1: face. Less than 1: no face

Discriminator

$1 \cdot 1 + (0 \cdot -1) + (0 \cdot -1) + (1 \cdot 1) + (-1)_{\text{bias}}$



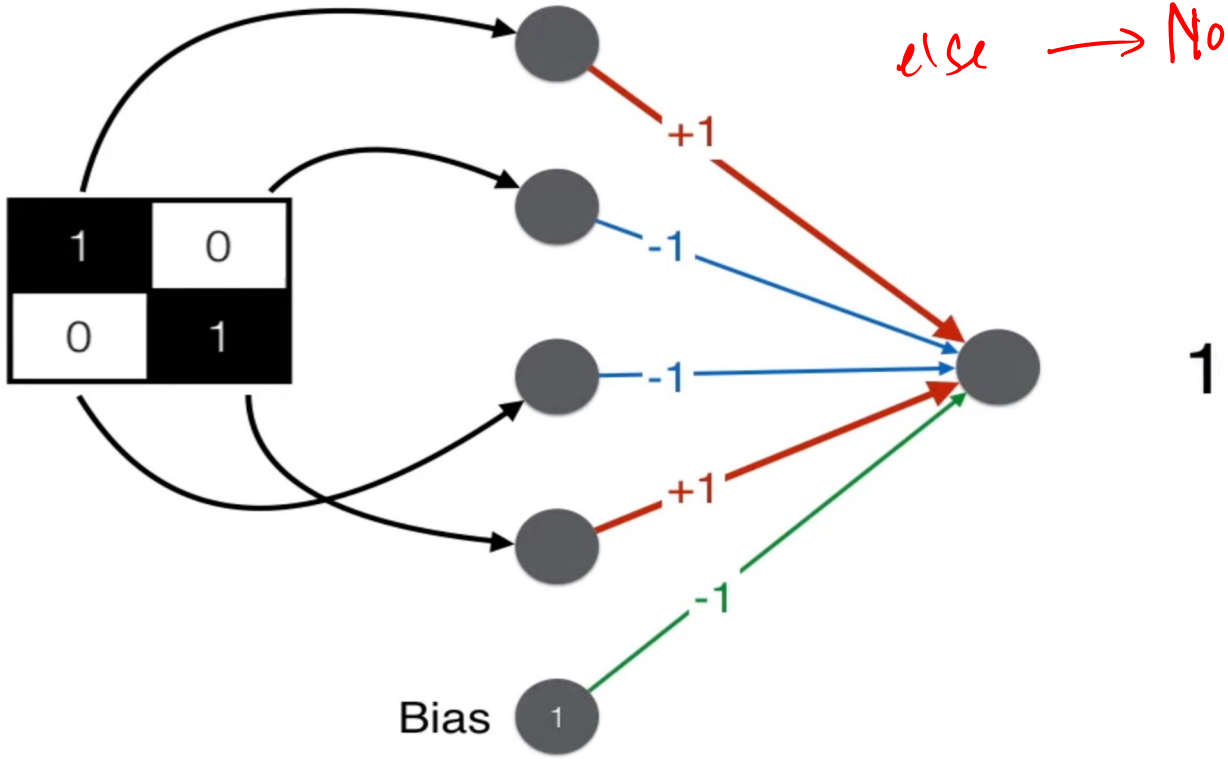
Discriminator



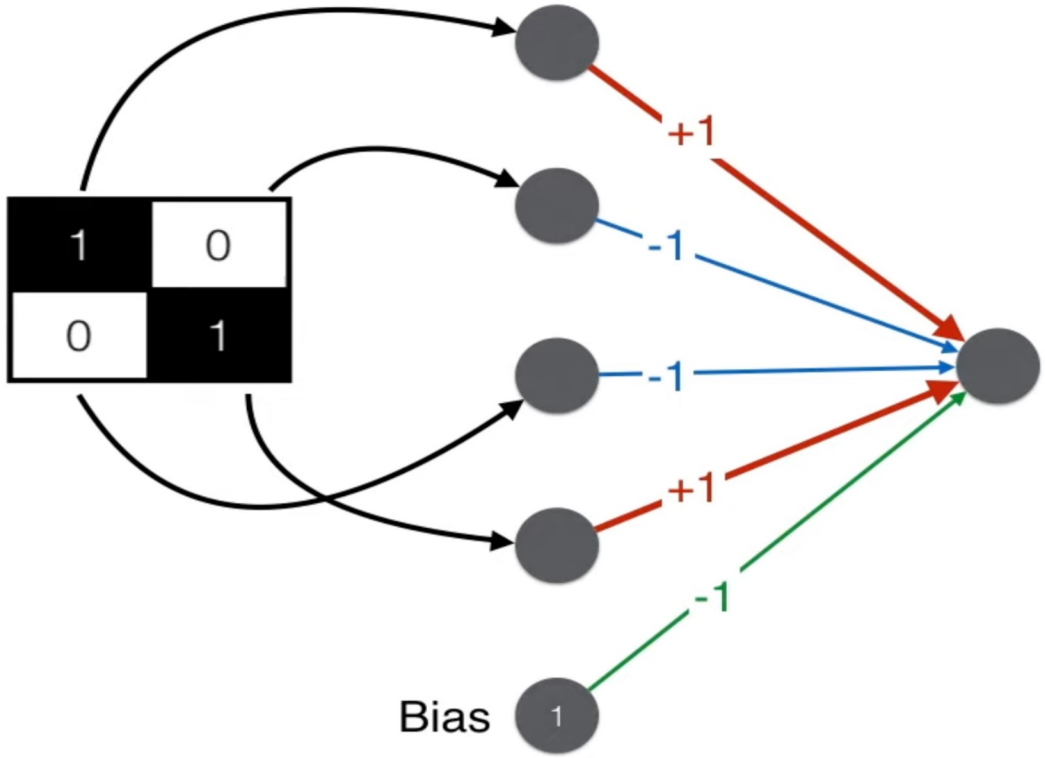
Discriminator

Score ≥ 1 → Face

else → Noise

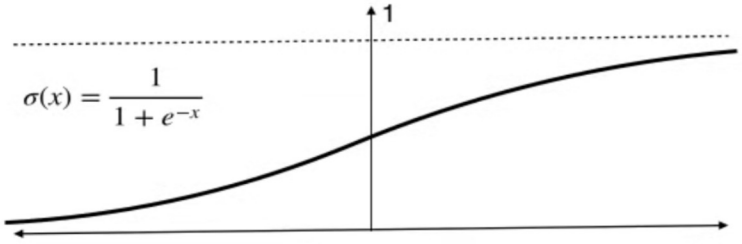


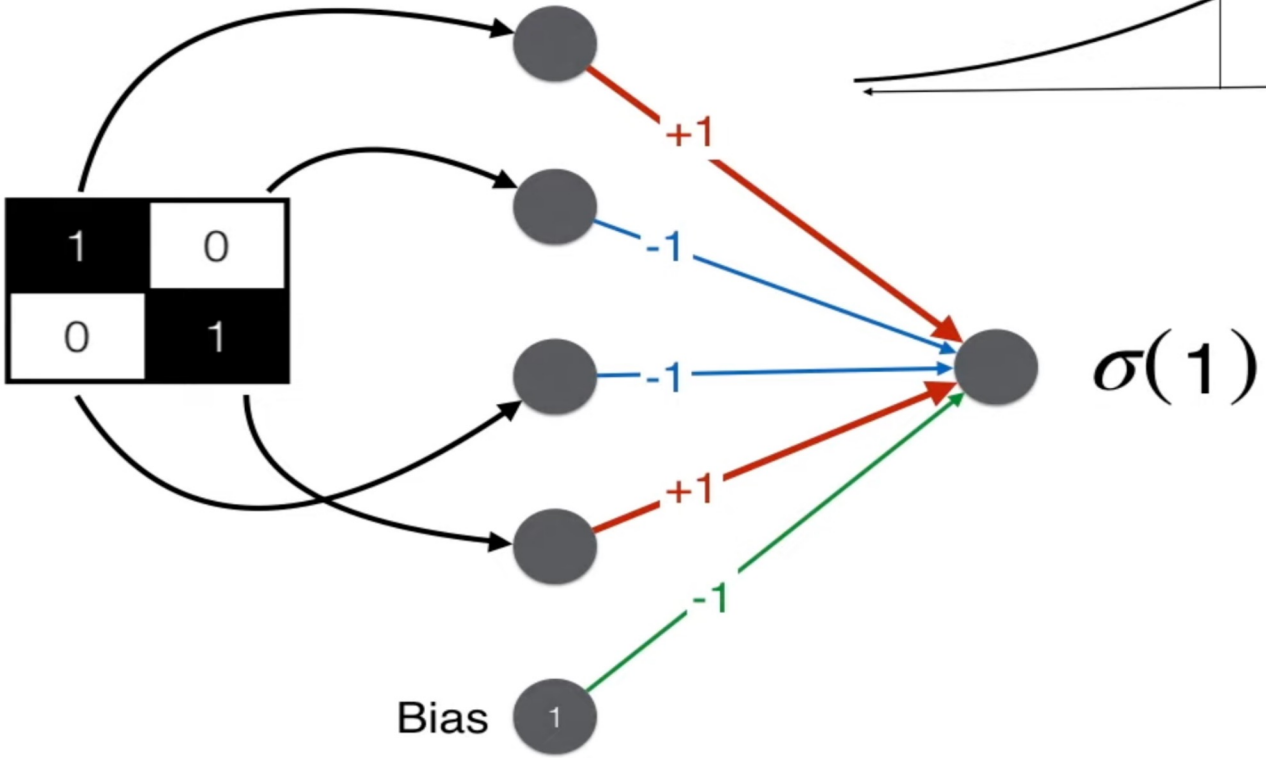
Discriminator



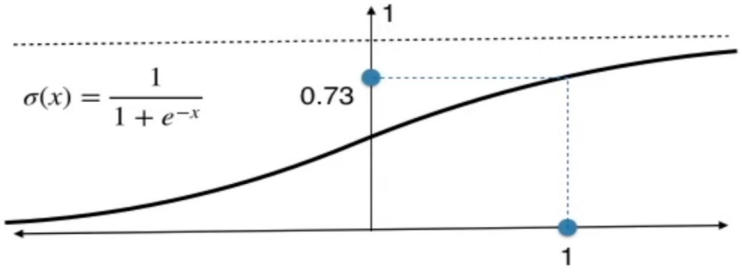
[0-1] → Prob.

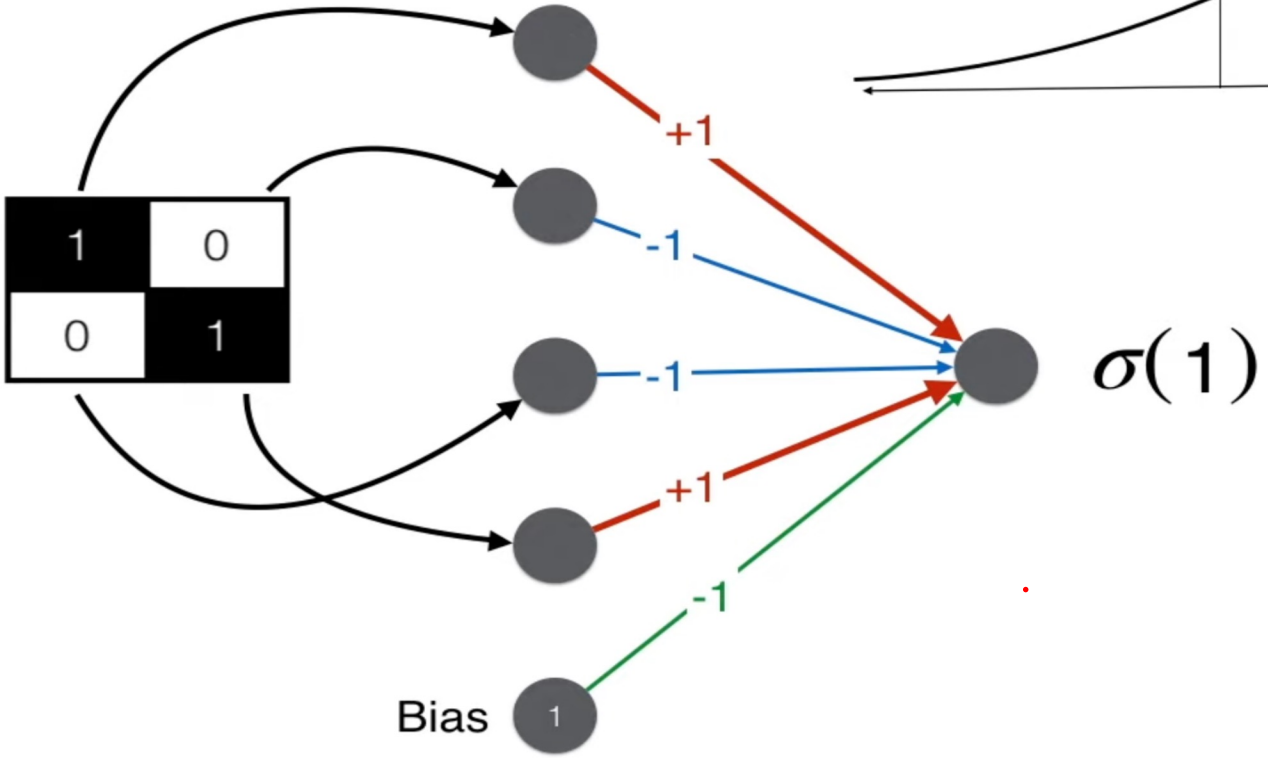
Discriminator



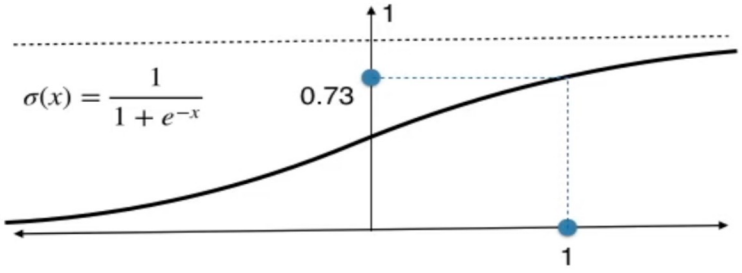


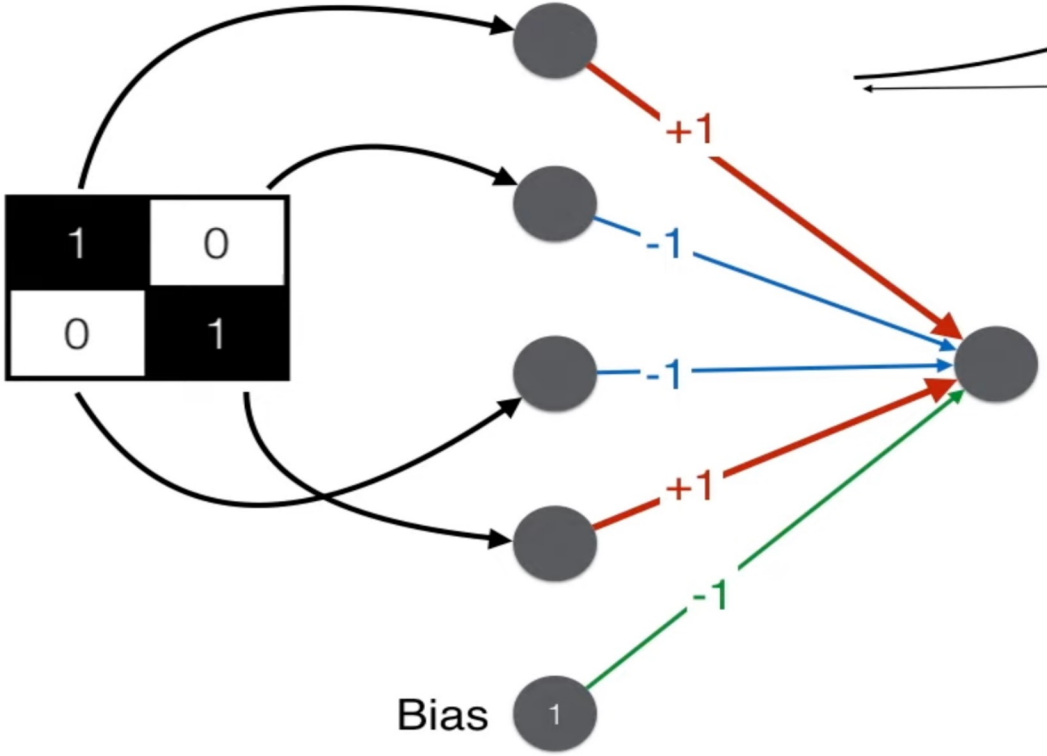
Discriminator





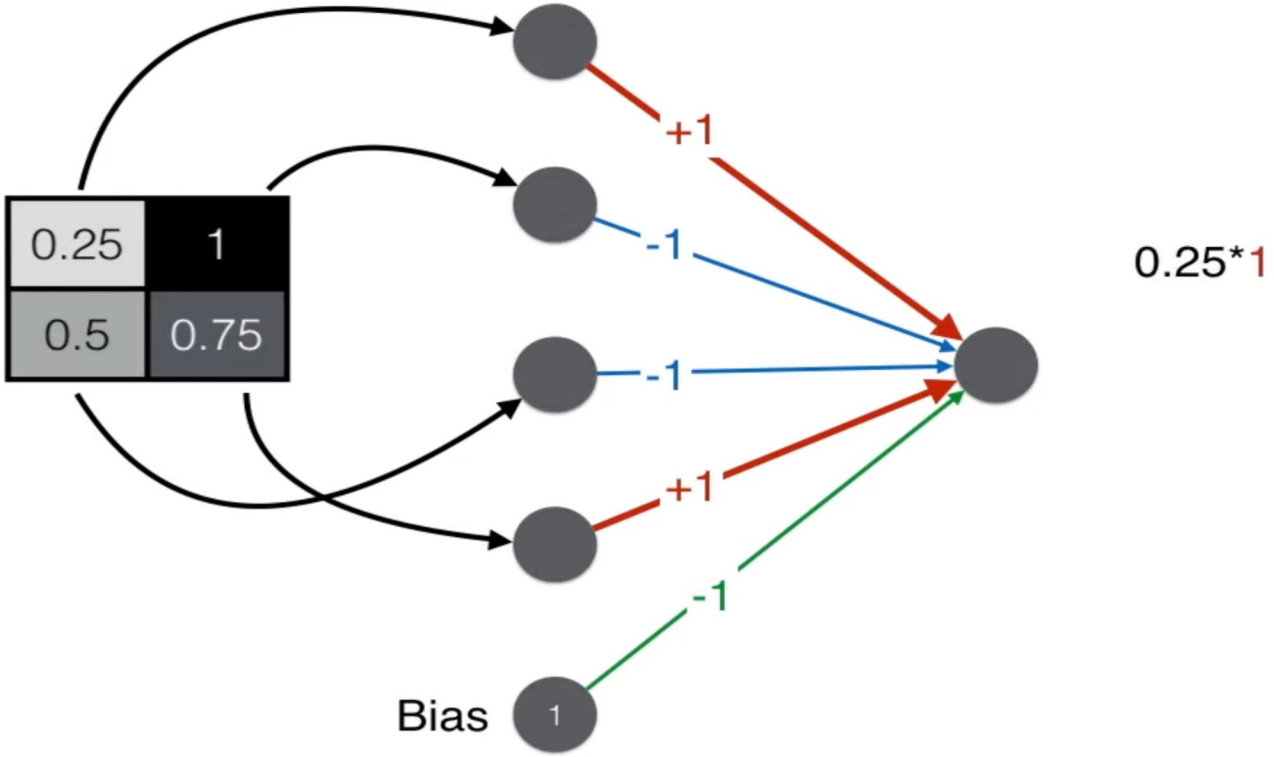
Discriminator



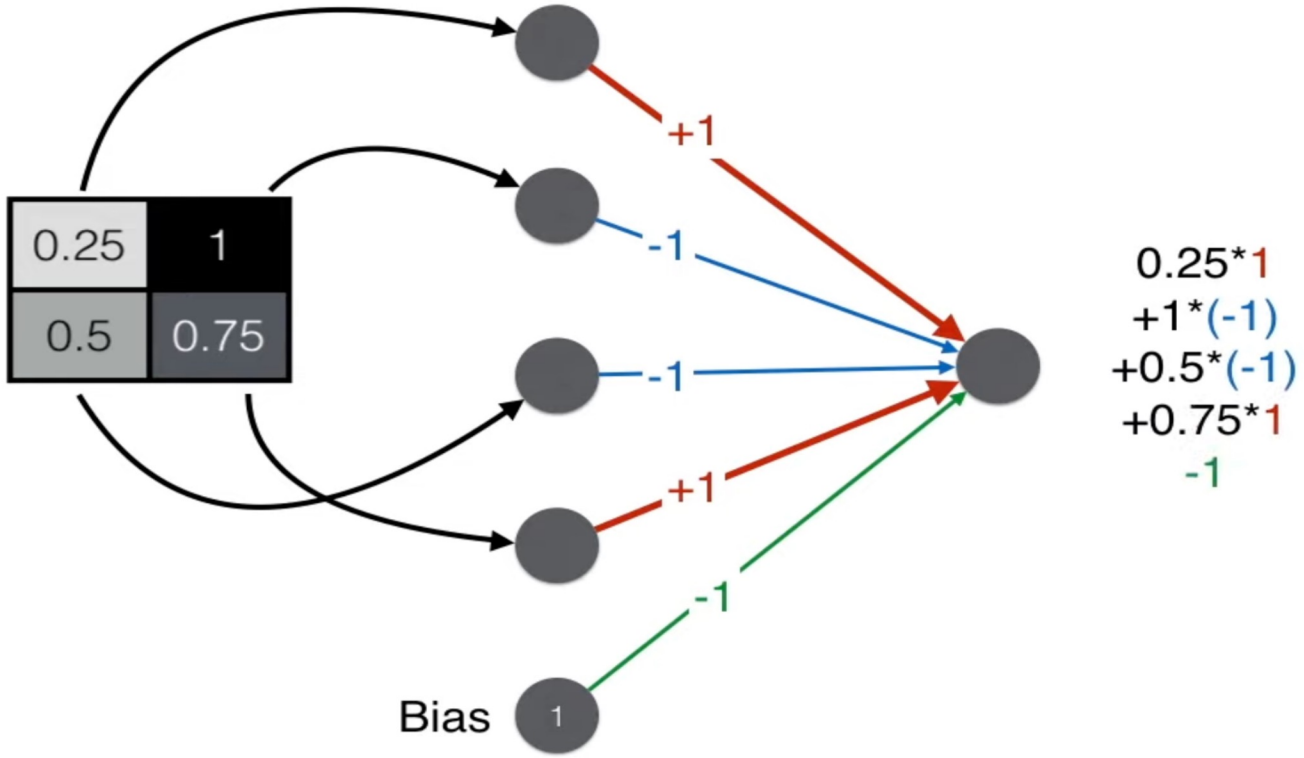


$\sigma(1) = 0.73$

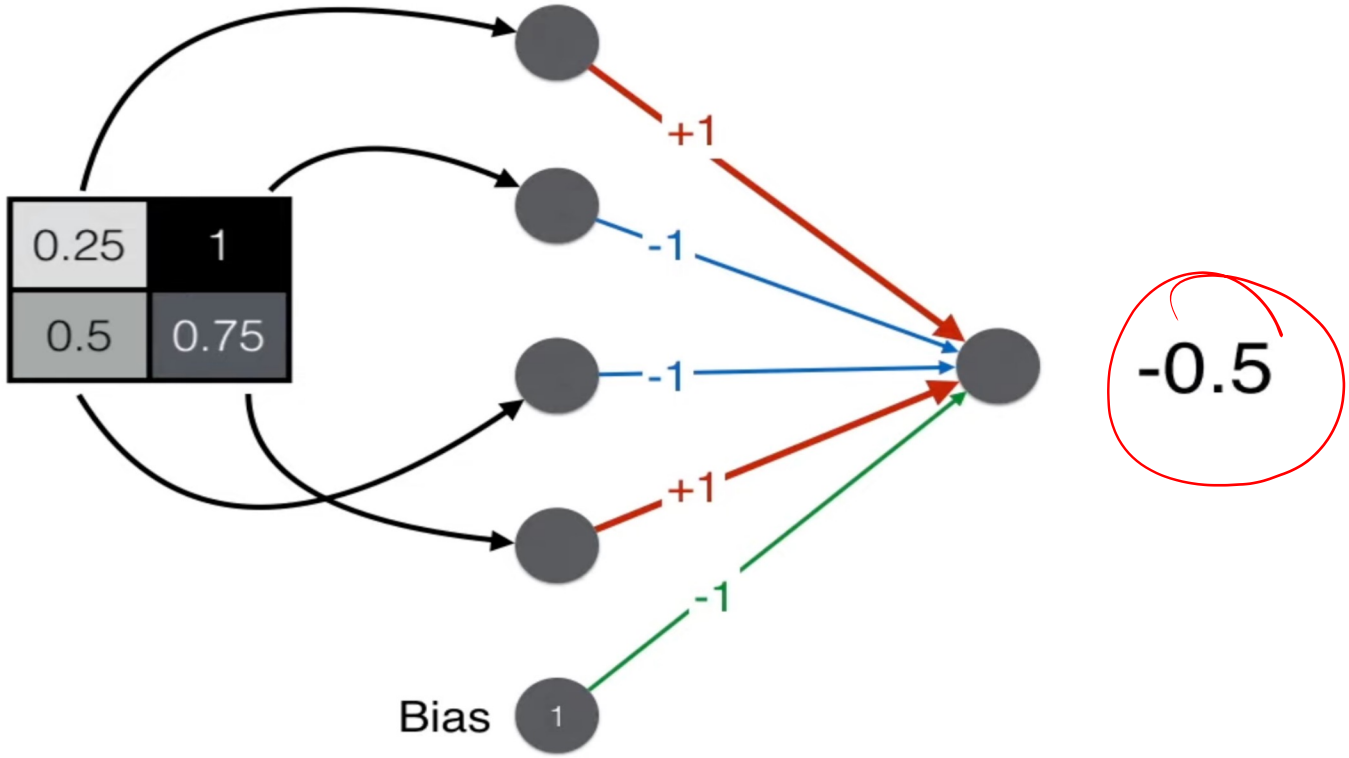
Discriminator



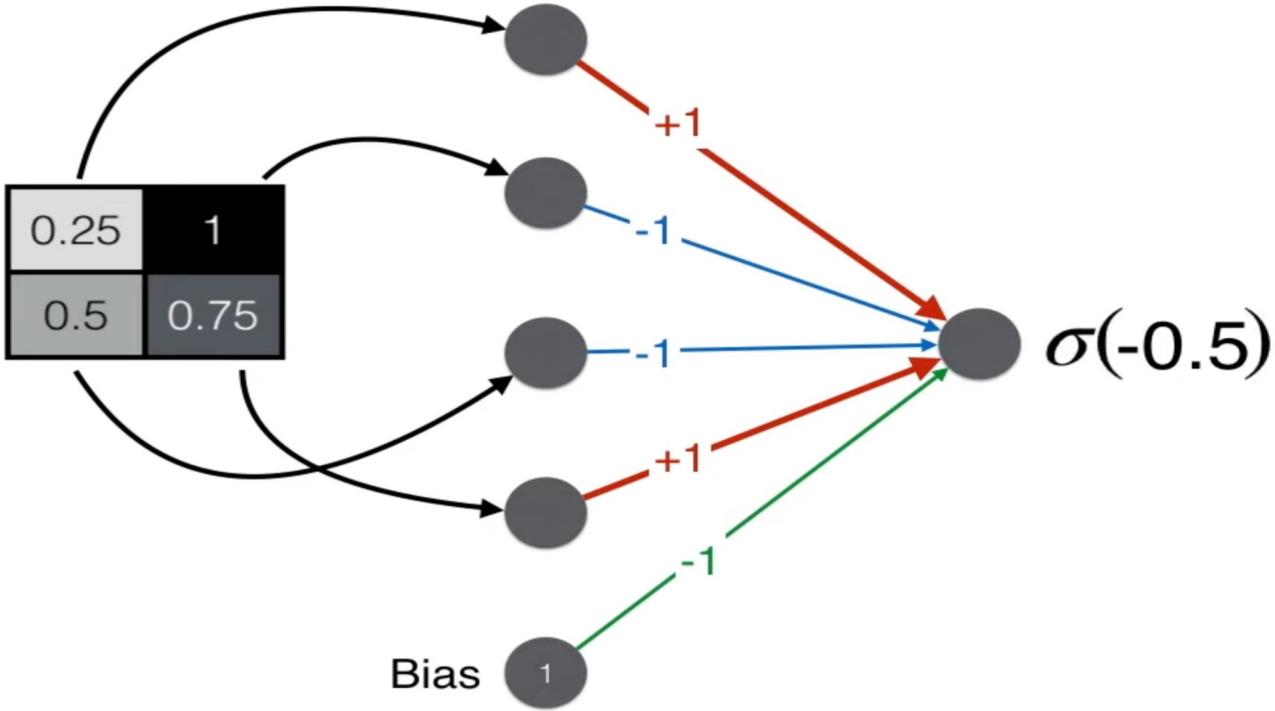
Discriminator



Discriminator

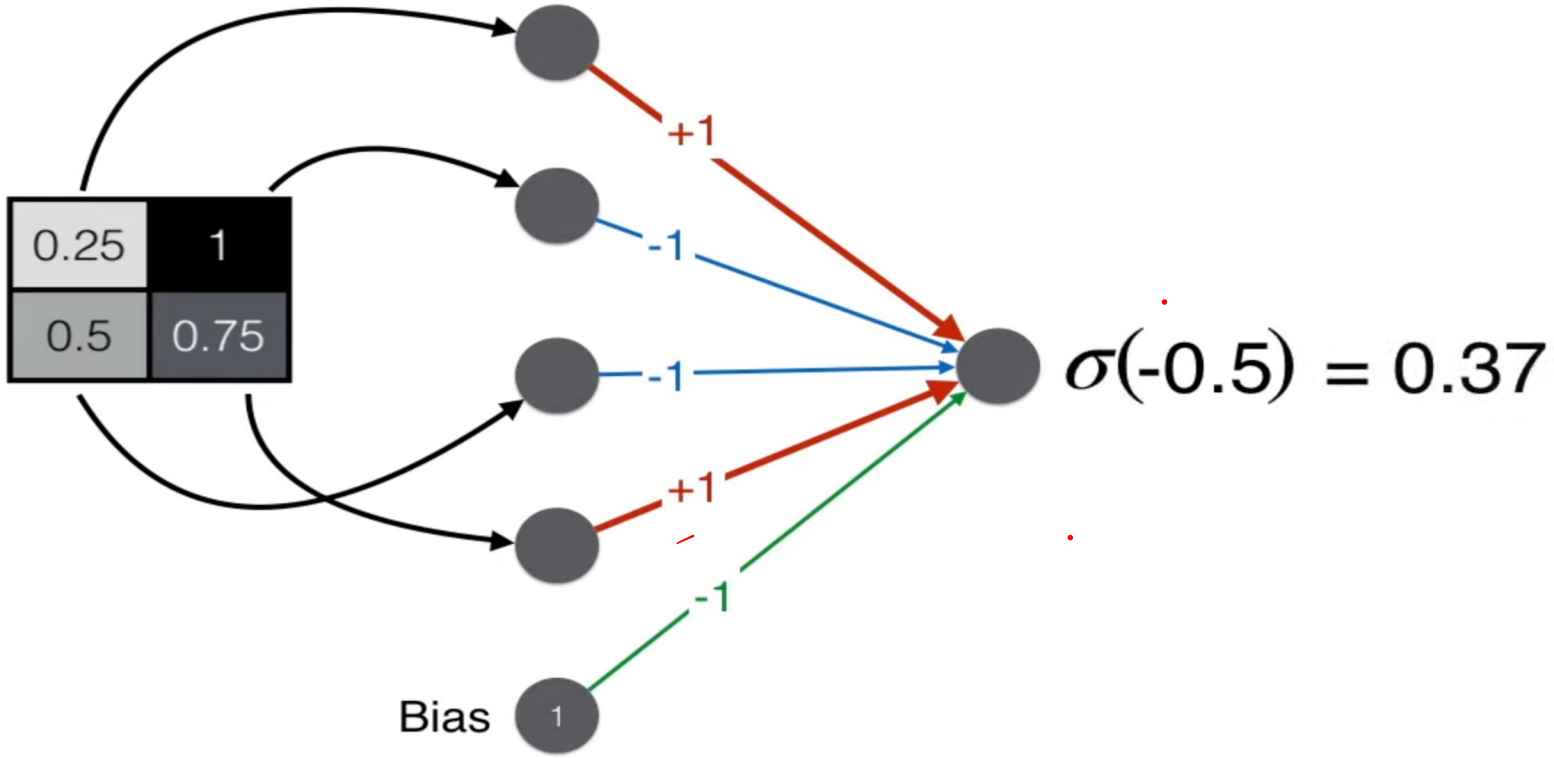


Discriminator



Discriminator

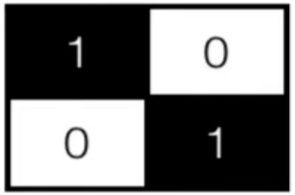
Basic Binary Classifier



Building the Generator

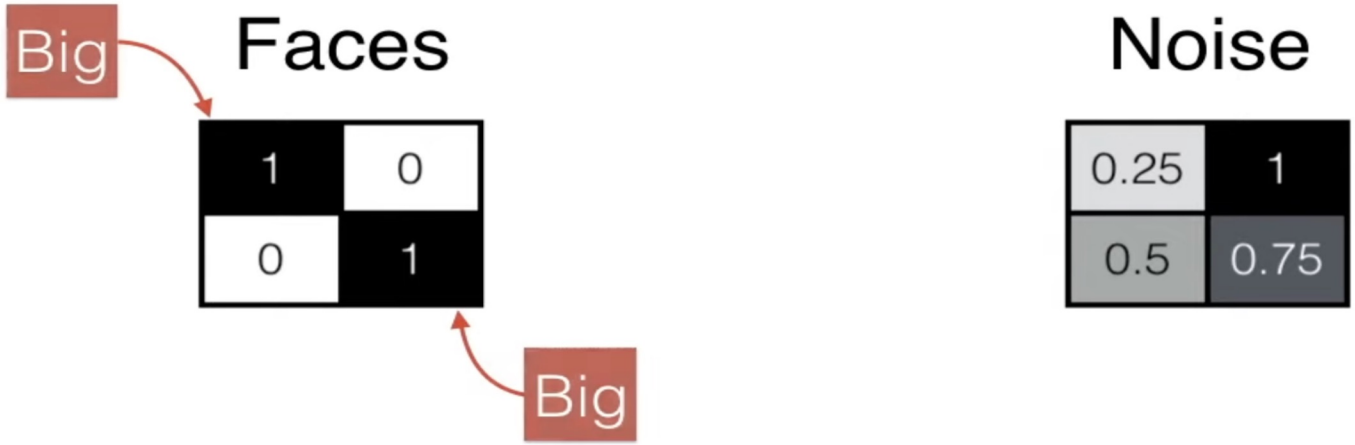
Building the generator

Faces

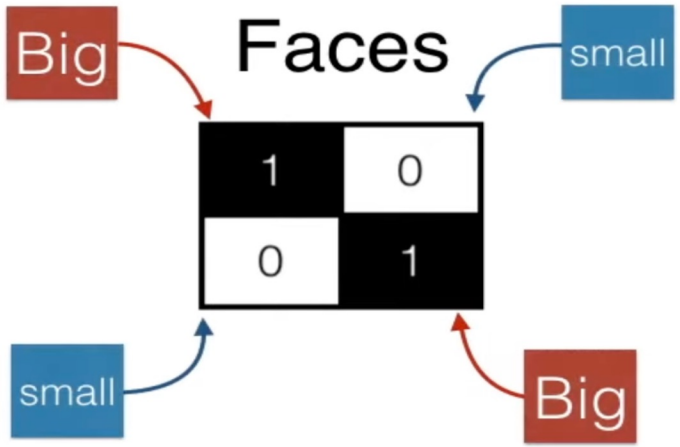


Noise

Building the generator



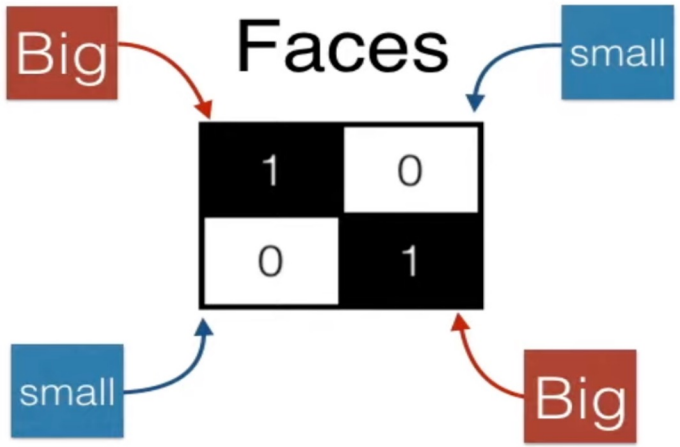
Building the generator

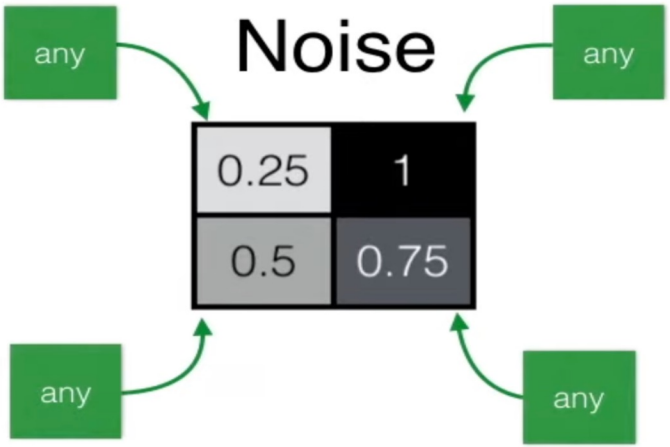


Noise

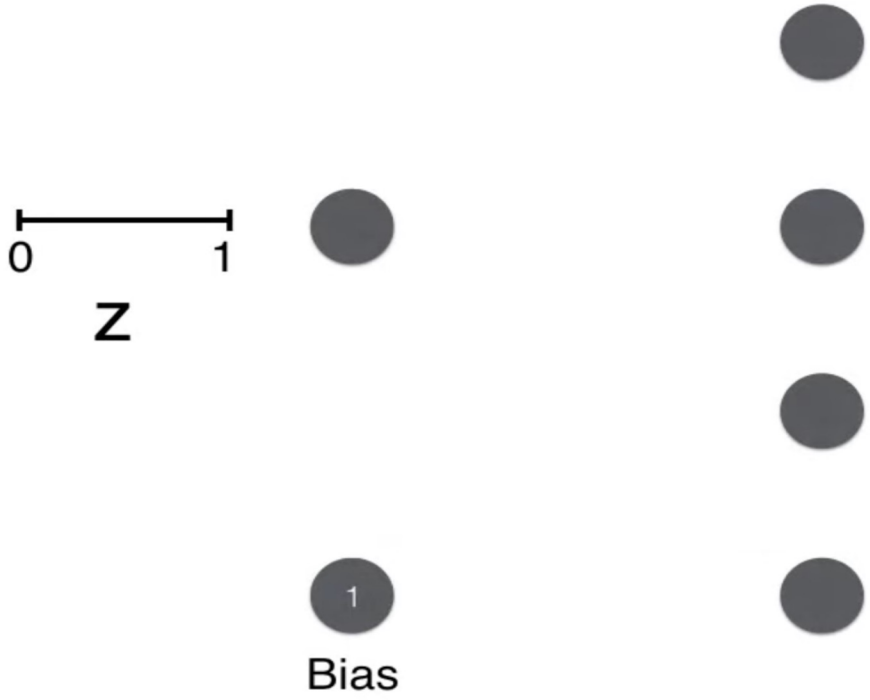
0.25	1
0.5	0.75

Building the generator

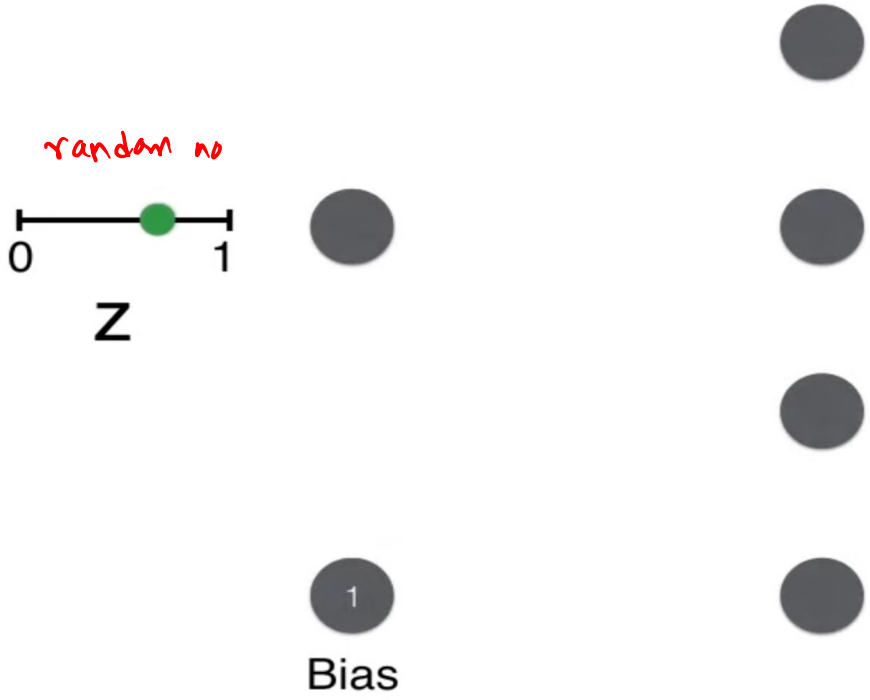




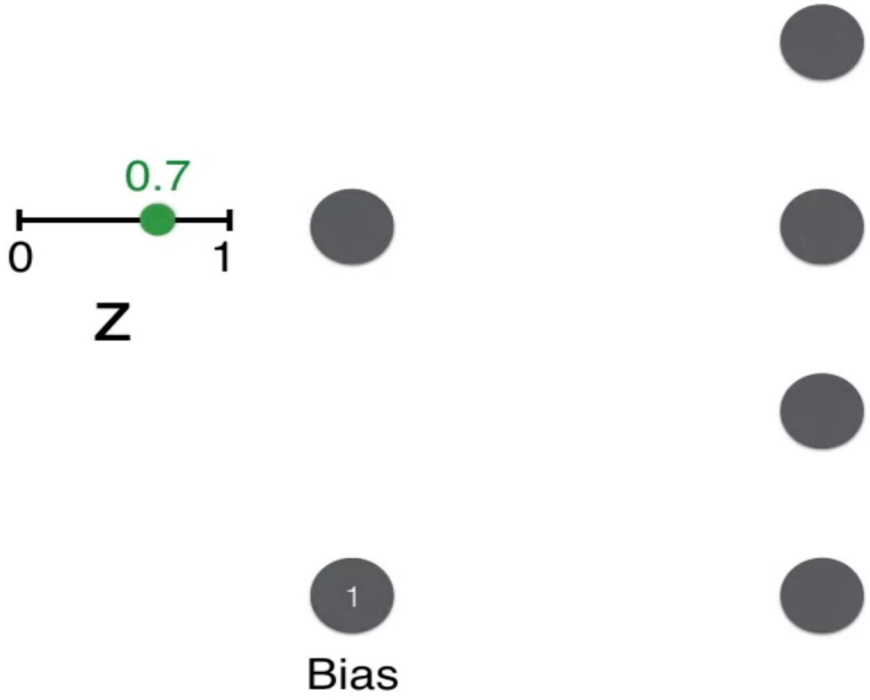
Generator



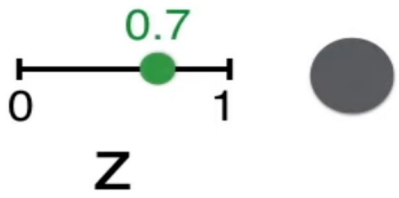
Generator

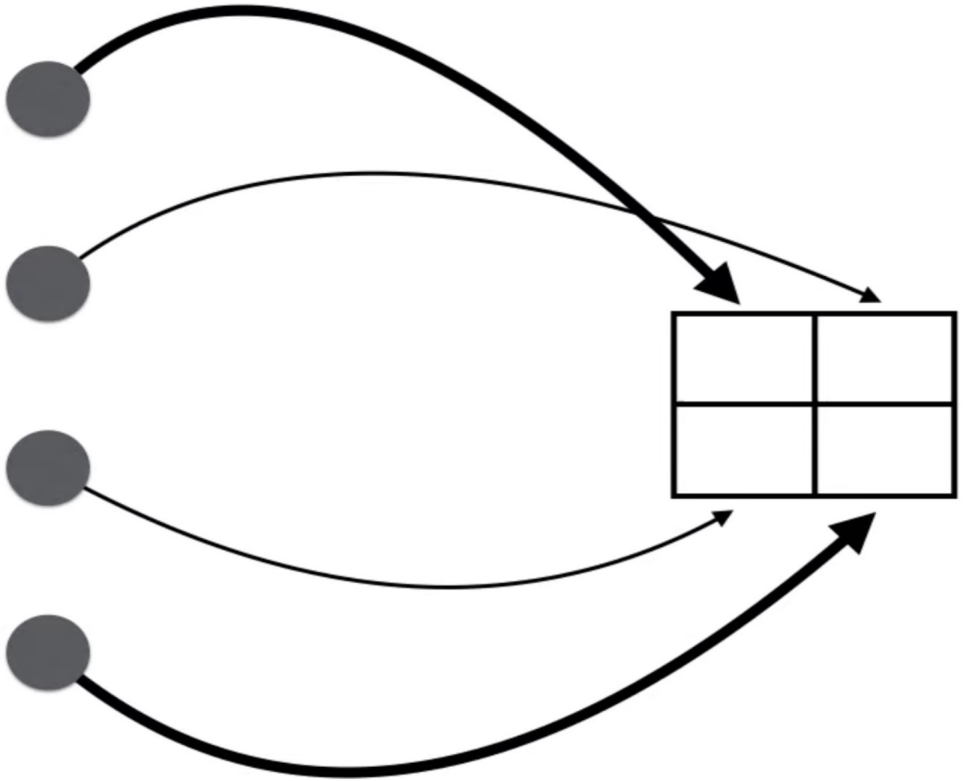


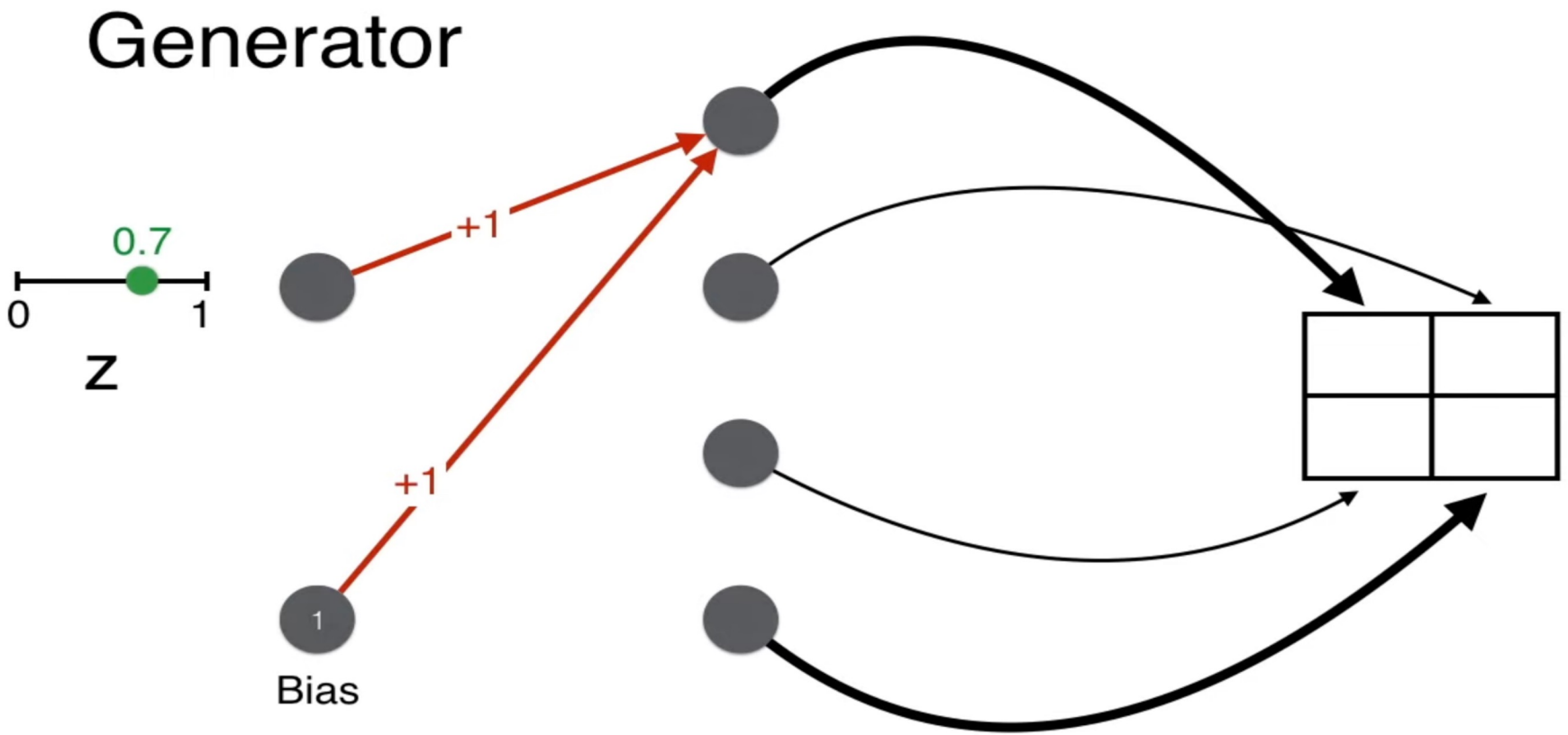
Generator

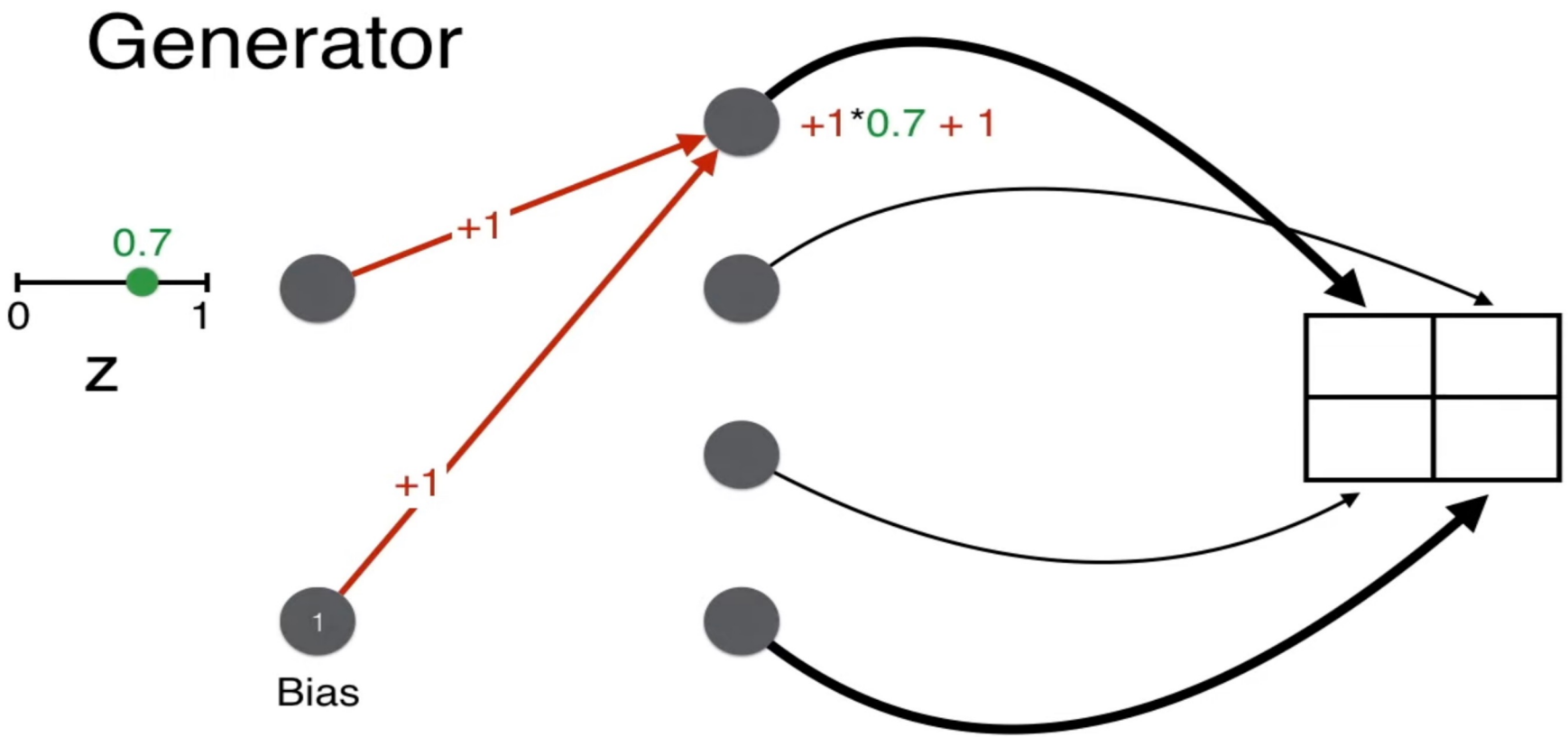


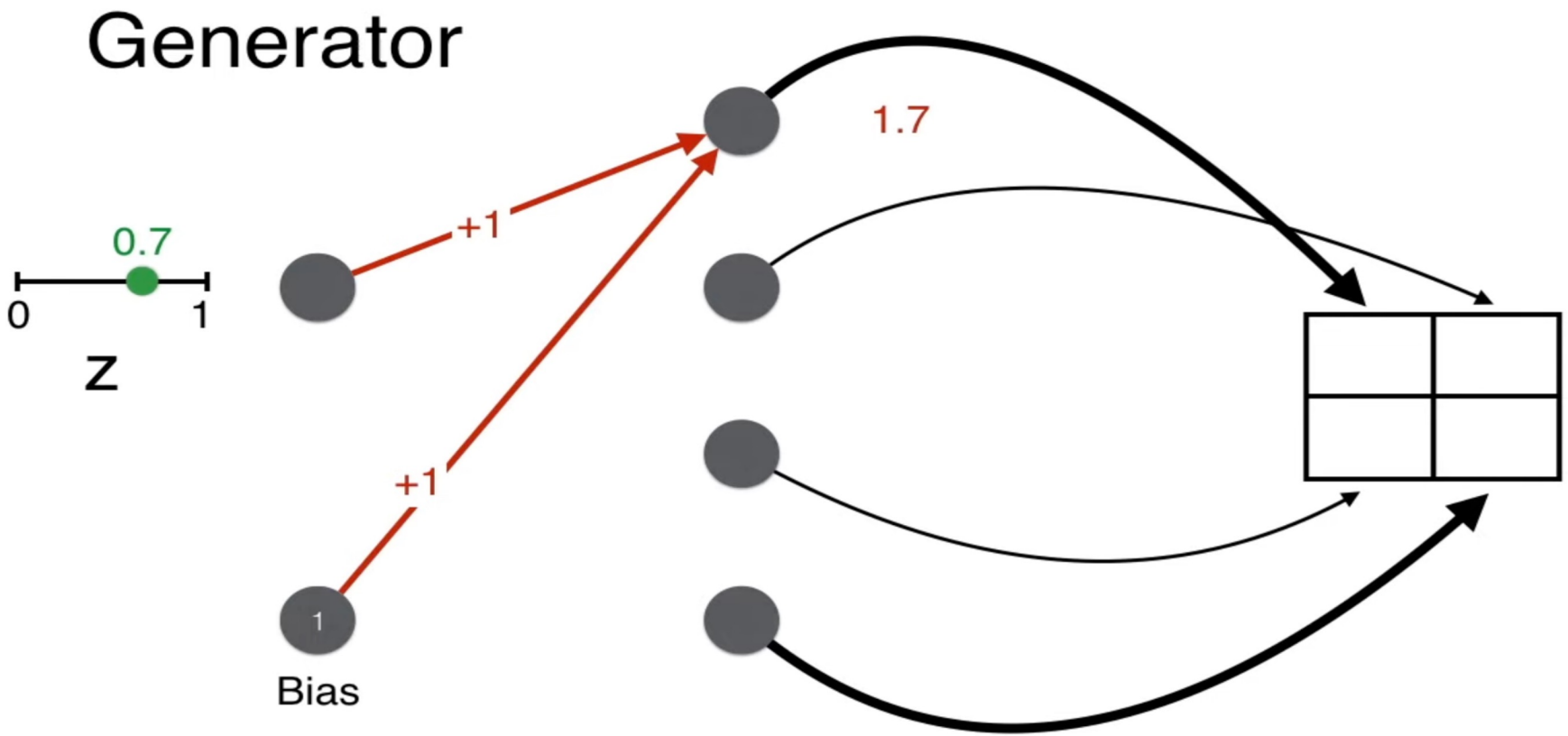
Generator



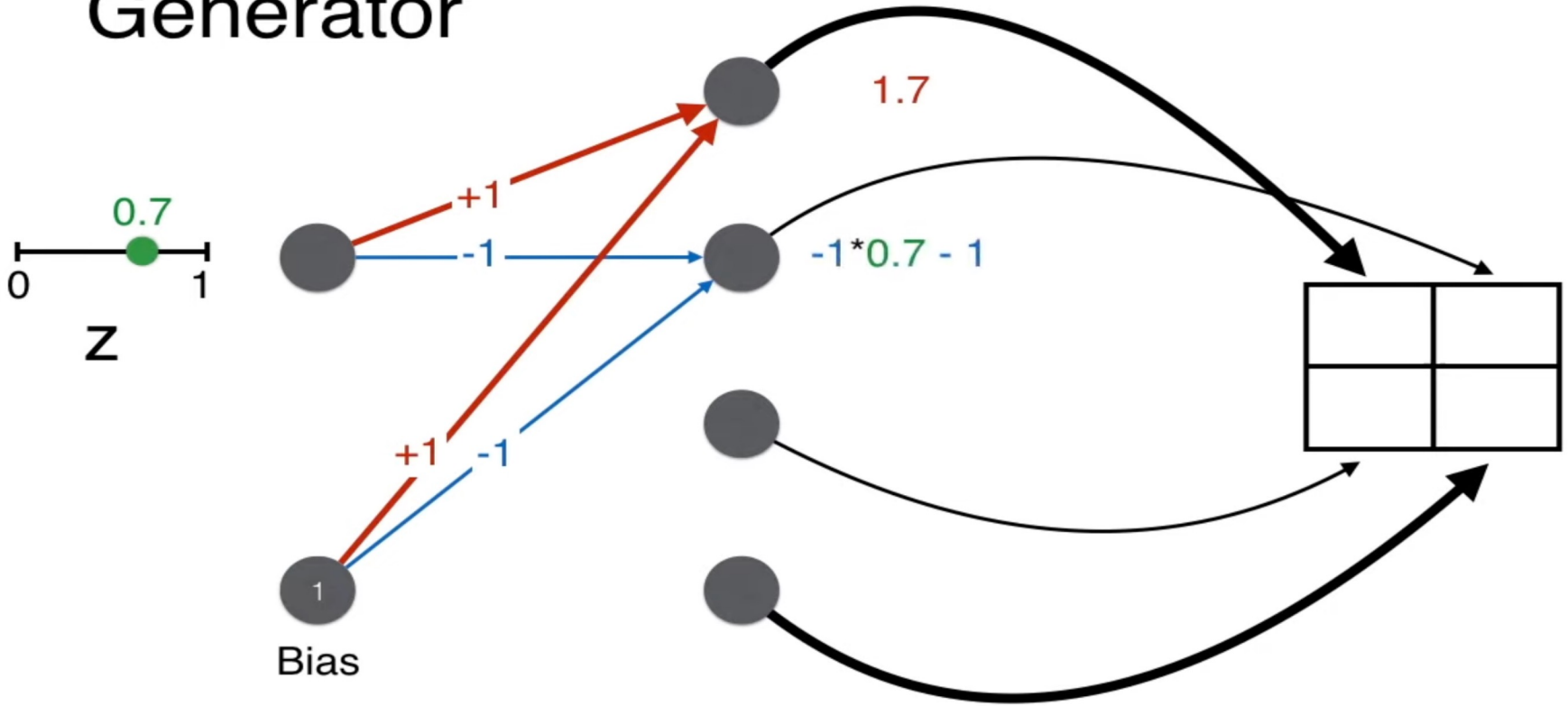



Generator
0.7
0
1
Z
+1
+1
1
Bias

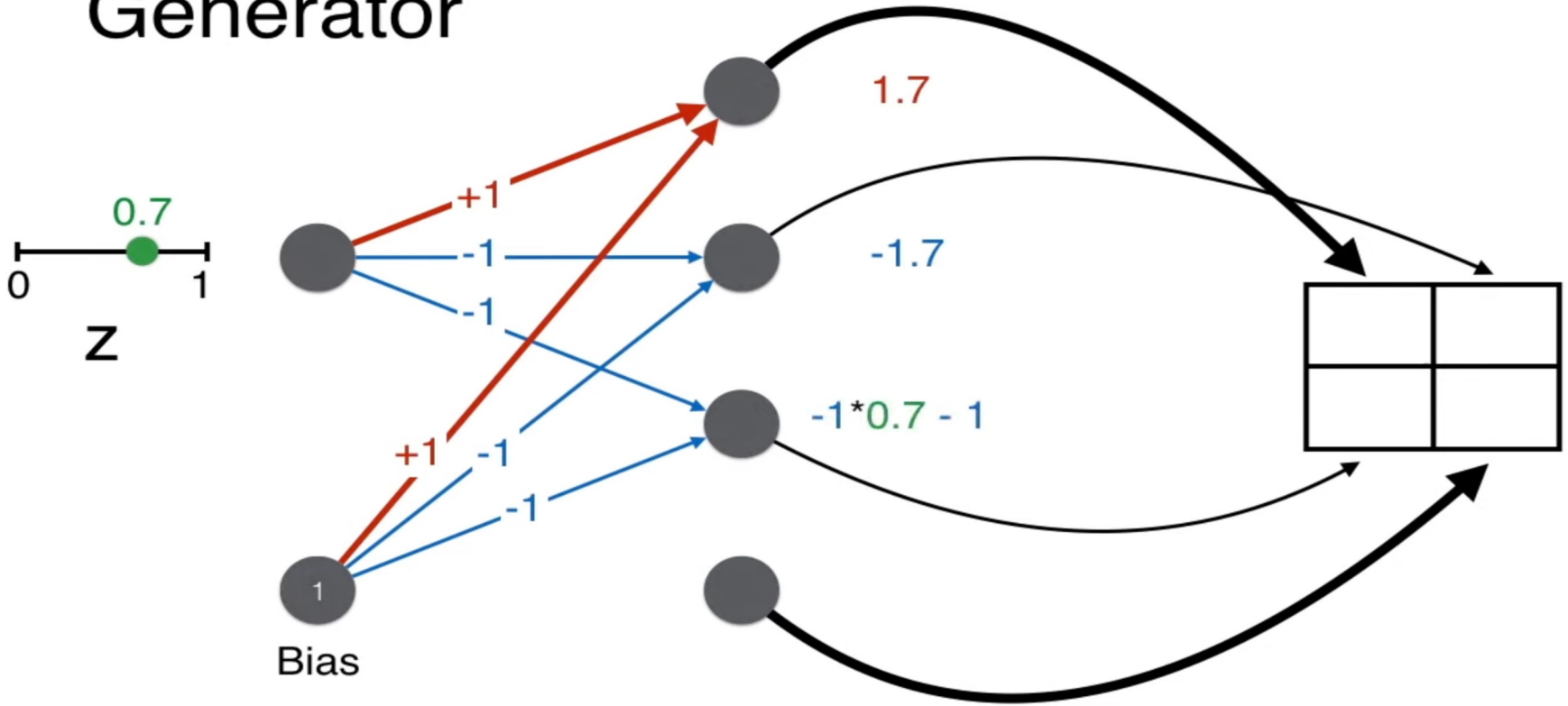

Generator
0.7
0
1
Z
+1
+1
1
Bias
+1*0.7 + 1


Generator
0.7
0
1
Z
+1
+1
1
Bias
1.7

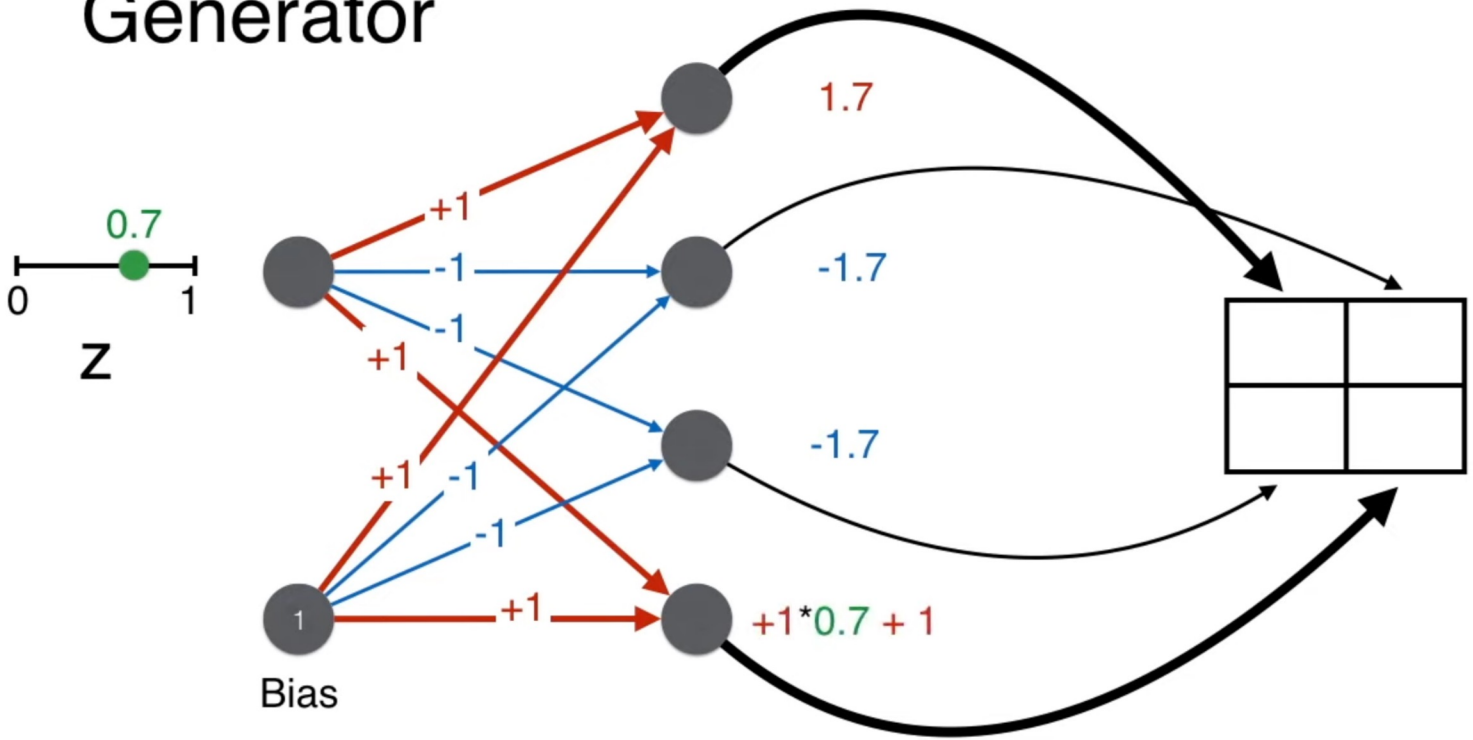
Generator



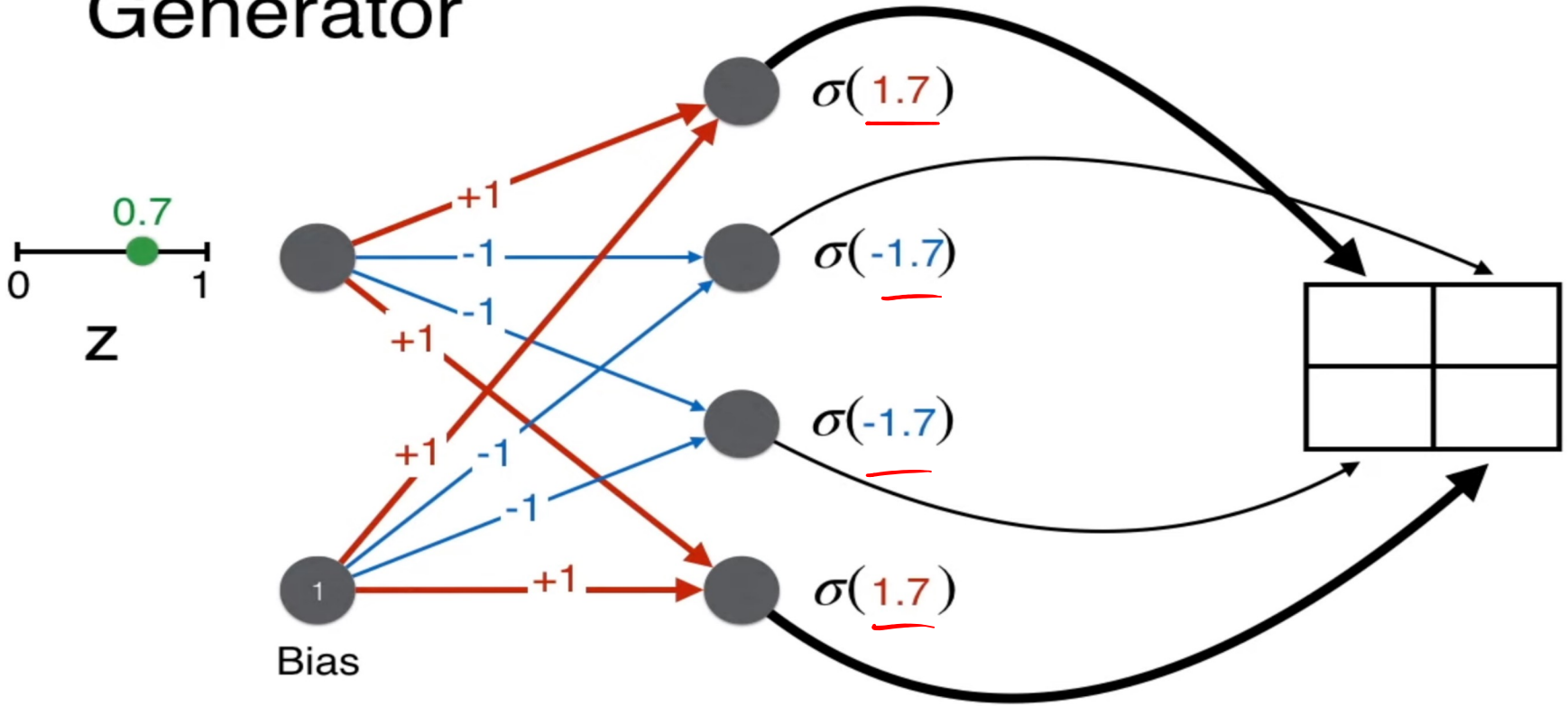
Generator



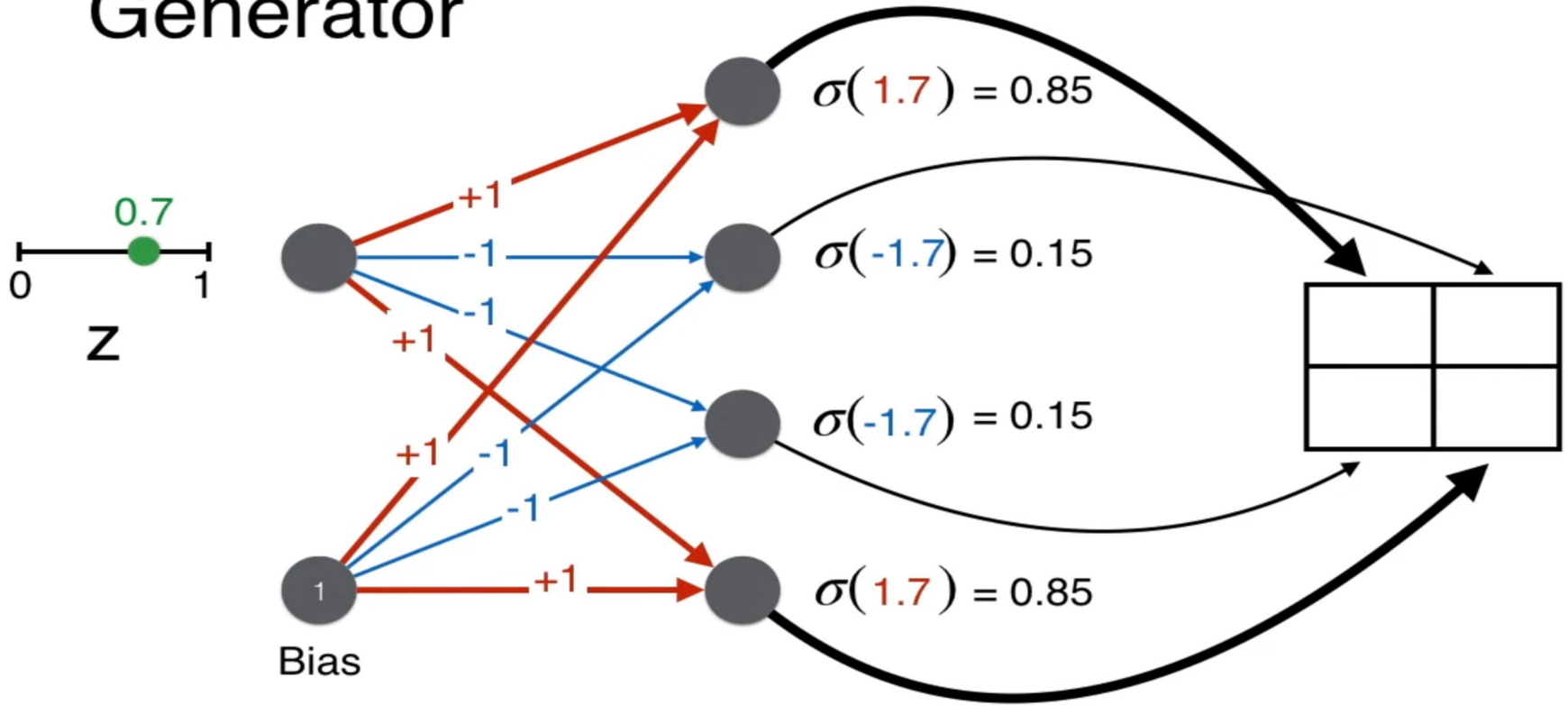
Generator



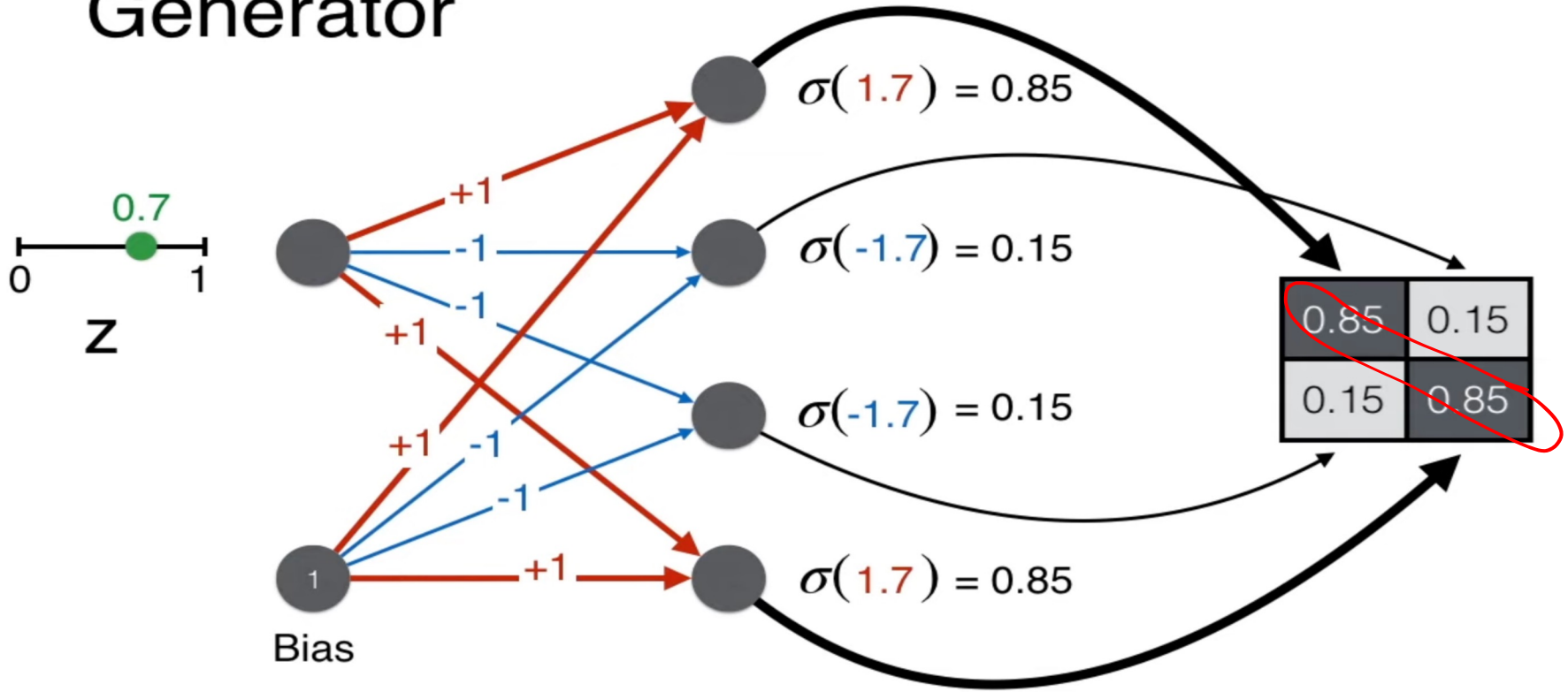
Generator



Generator



Generator


0.7
0
1
Z
+1
-1
-1
+1
+1
-1
-1
+1
1
Bias
σ(1.7) = 0.85
σ(-1.7) = 0.15
σ(-1.7) = 0.15
σ(1.7) = 0.85
0.85
0.15
0.15
0.85

The training process: Error functions

COST

Log-loss error function

Log-loss error function

Actual Label: 1
Prediction: 0.1

Log-loss error function

Label: 1
Prediction: 0.1

Error: large

Log-loss error function

Label: 1
Prediction: 0.1

Error: large

Actual Label: 1
Prediction: 0.9

Log-loss error function

Label: 1
Prediction: 0.1

Error: large

Label: 1
Prediction: 0.9

Error: small

Log-loss error function

Label: 1
Prediction: 0.1

Error: large

$$-\ln(0.1) = 2.3$$

Label: 1
Prediction: 0.9

Error: small

Log-loss error function

Label: 1
Prediction: 0.1

Error: large

Large

$$-\ln(0.1) = 2.3$$

Label: 1
Prediction: 0.9

Error: small

Small

$$-\ln(0.9) = 0.1$$

Log-loss error function

Error = -ln(prediction)

Label: 1
Prediction: 0.1

Error: large $-\ln(0.1) = 2.3$

Label: 1
Prediction: 0.9

Error: small $-\ln(0.9) = 0.1$

Log-loss error function

Actual Label: 0

Prediction: 0.1

Log-loss error function

Label: 0
Prediction: 0.1

Error: small

Log-loss error function

Label: 0
Prediction: 0.1

Error: small

Label: 0
Prediction: 0.9

Error: large

Log-loss error function

Error = -ln(1 - prediction)

Label: 0
Prediction: 0.1

Error: small

Label: 0
Prediction: 0.9

Error: large

Log-loss error function

Error = -ln(1 - prediction)

Label: 0
Prediction: 0.1

Error: small

$-\ln(1-0.1)$

$= -\ln(0.9) = 0.1$

Label: 0
Prediction: 0.9

Error: large

Log-loss error function

Error = -ln(1 - prediction)

Label: 0
Prediction: 0.1

Error: small $-\ln(0.9) = 0.1$

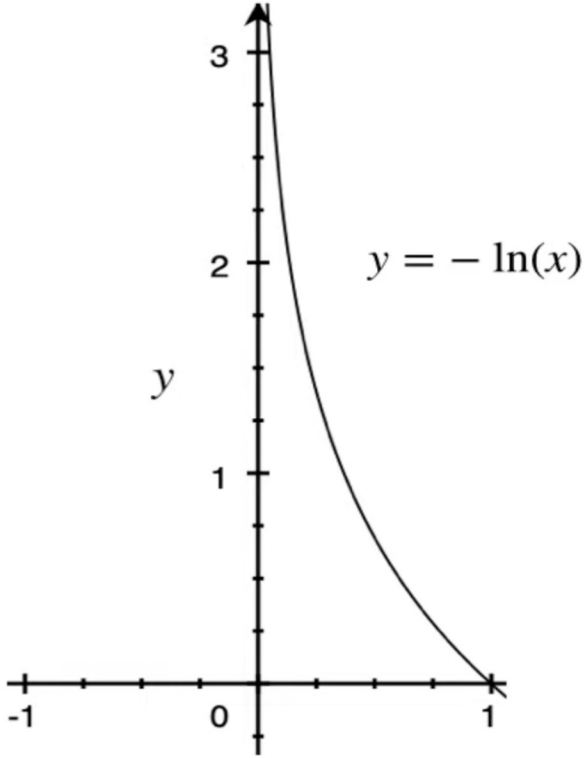
Label: 0
Prediction: 0.9

Error: large $-\ln(0.1) = 2.3$

Summary

If we want a prediction to be 1:

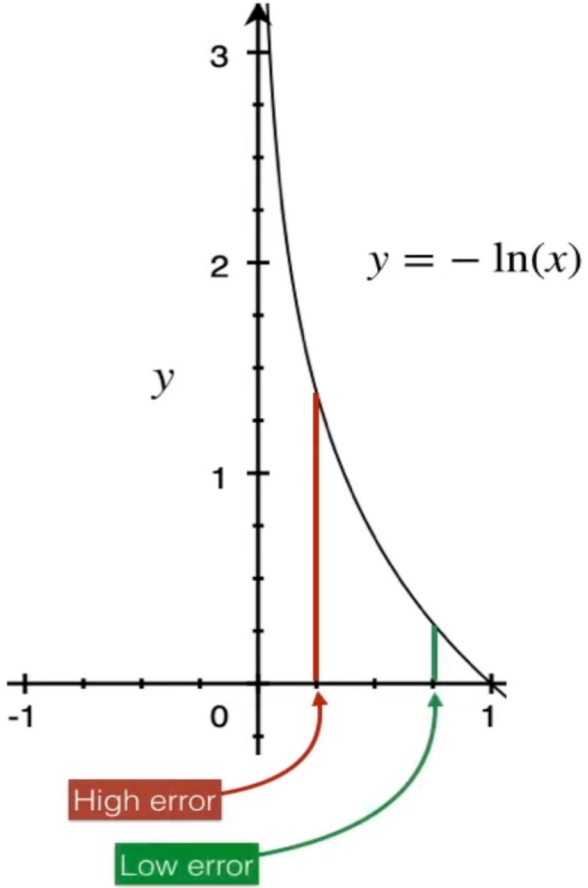
Log-loss = -ln(prediction)



Summary

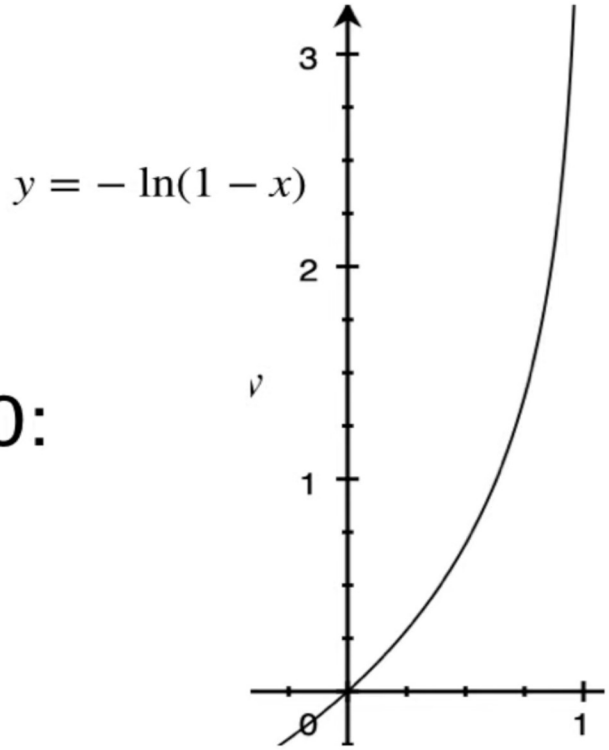
If we want a prediction to be 1:

Log-loss = -ln(prediction)



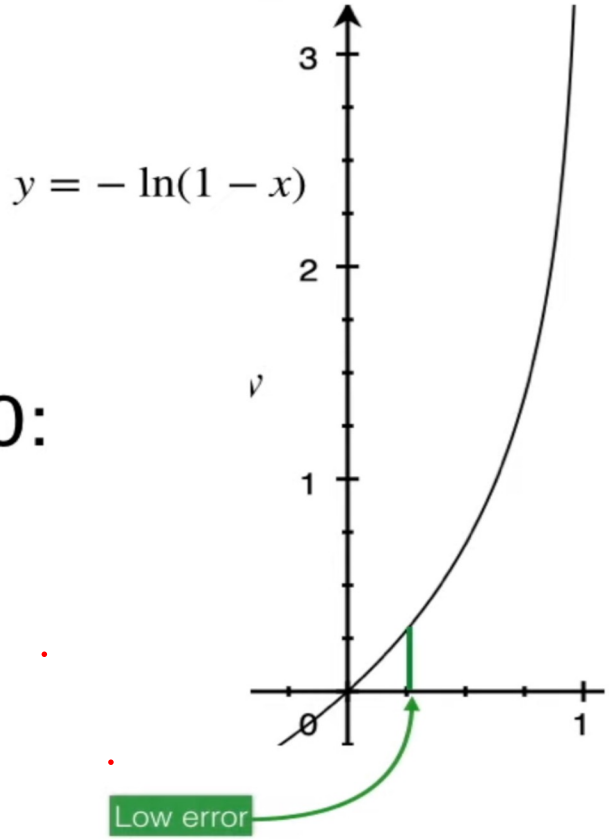
Summary

If we want a prediction to be 0:
Log-loss = -ln(1-prediction)



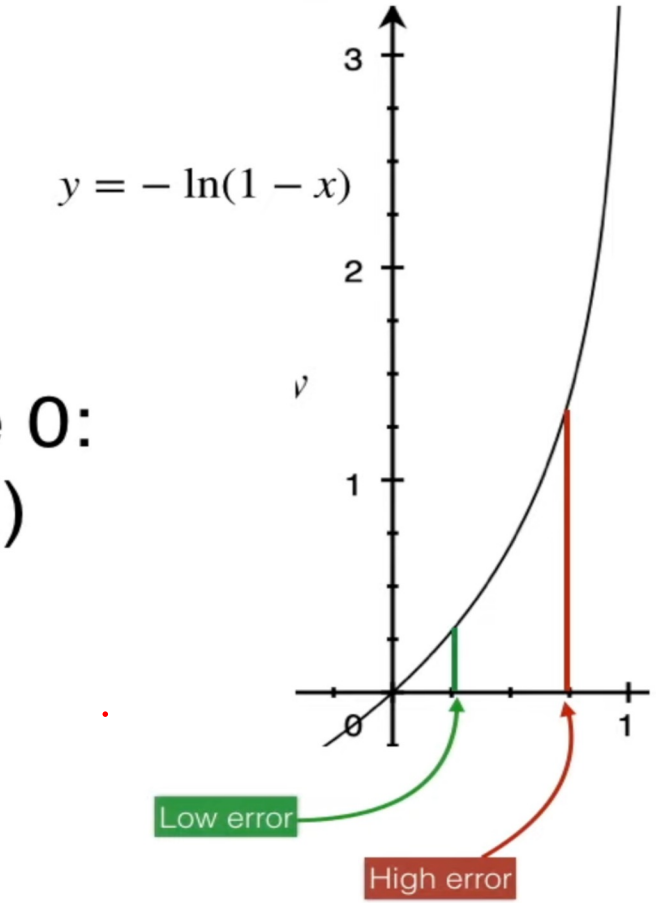
Summary

If we want a prediction to be 0:
Log-loss = -ln(1-prediction)



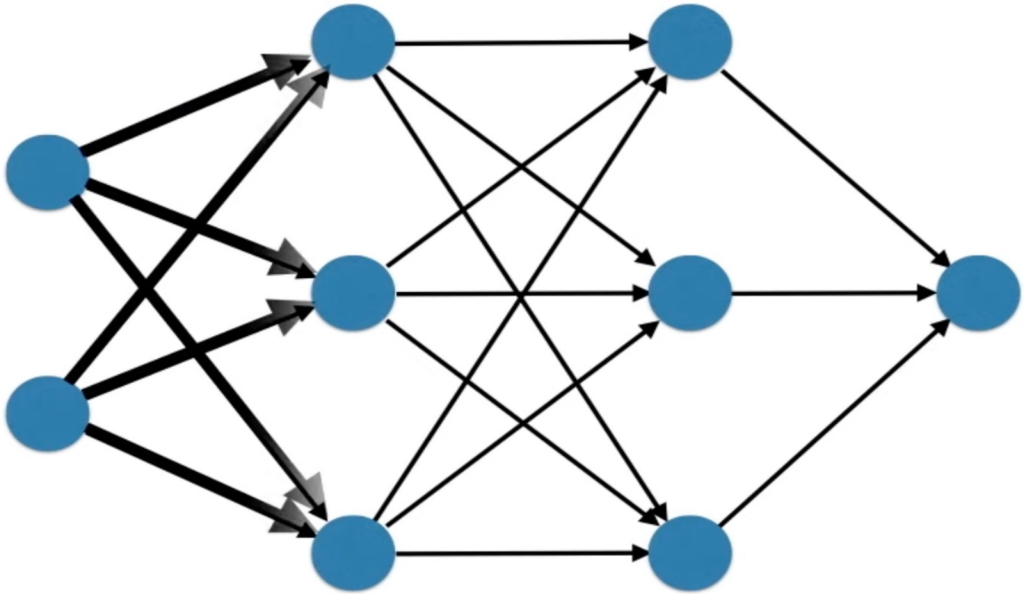
Summary

If we want a prediction to be 0:
Log-loss = -ln(1-prediction)

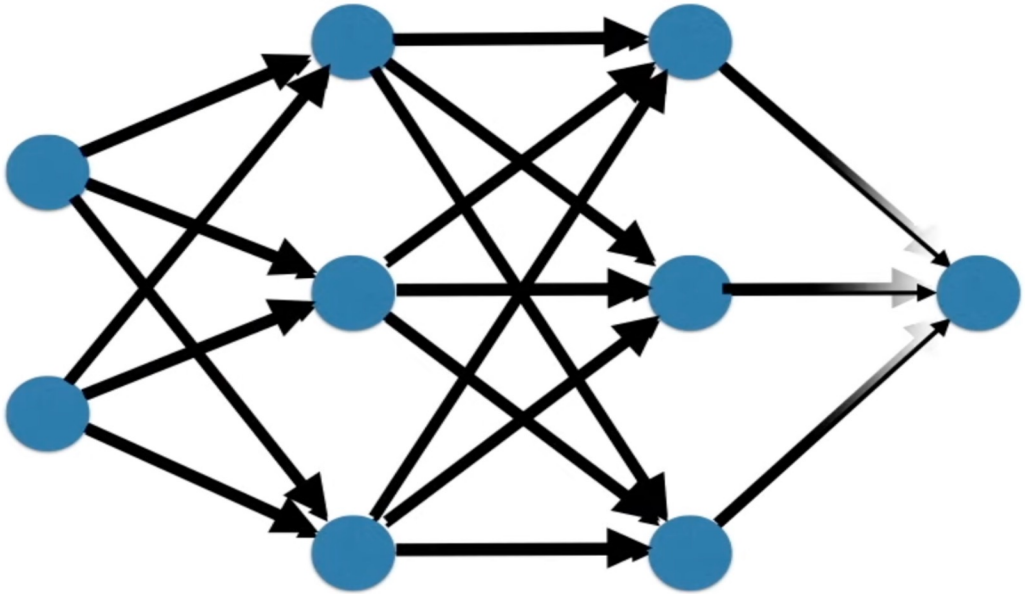


The training process: Backpropagation

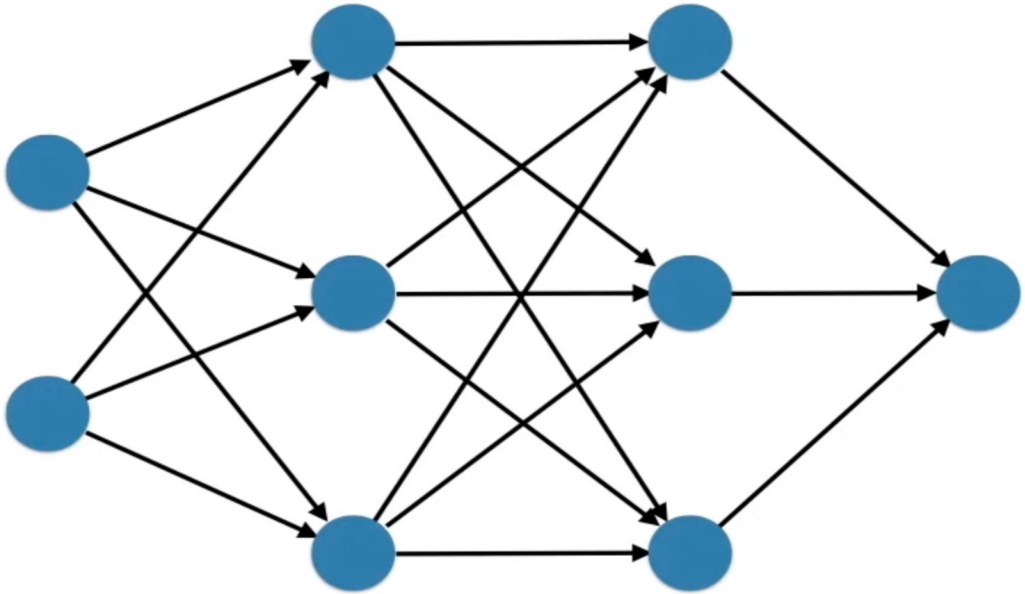
Backpropagation



Backpropagation

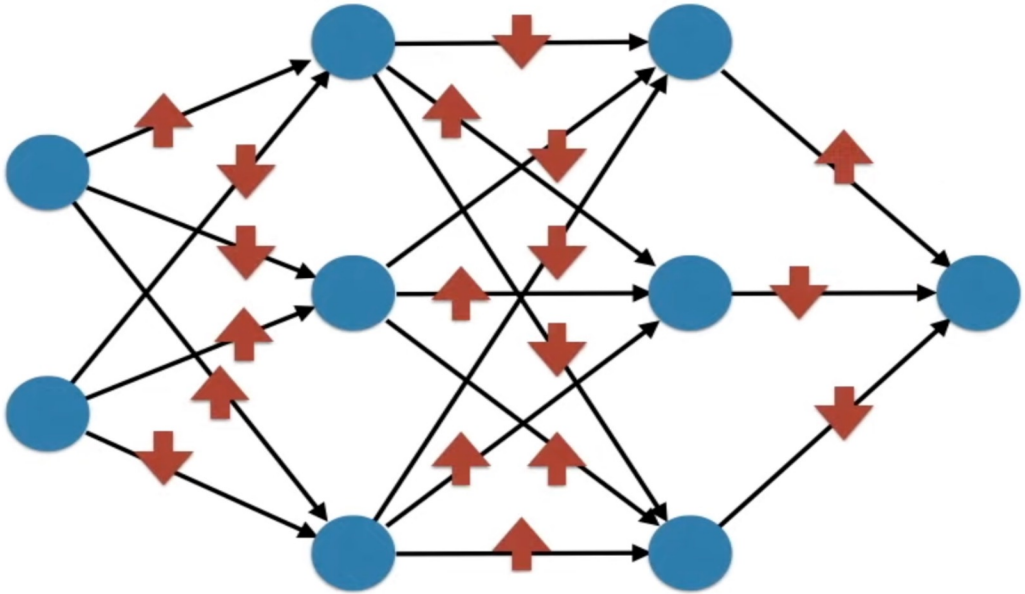


Backpropagation



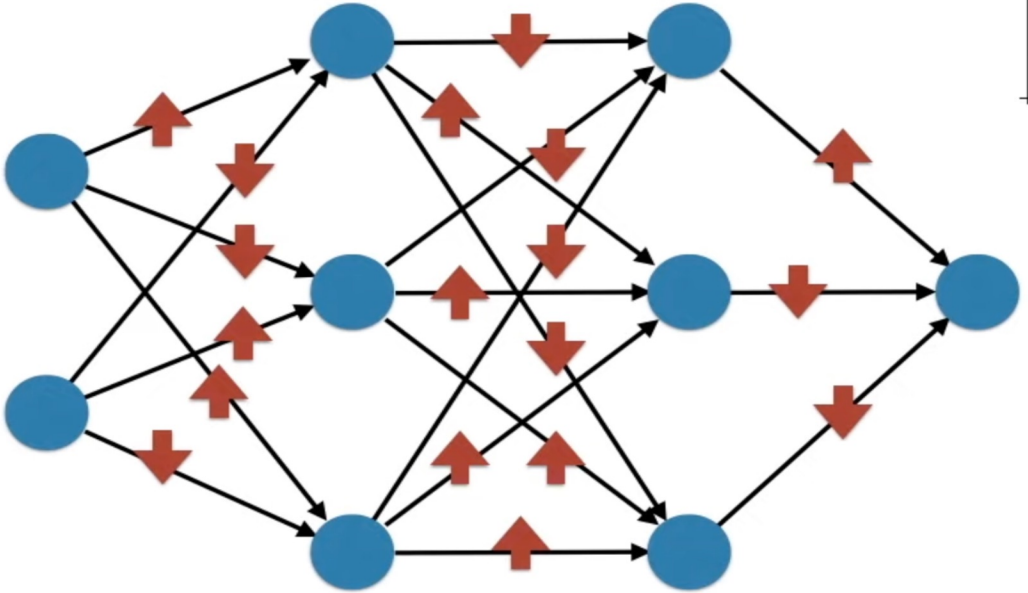
Prediction
Error

Backpropagation



Prediction
Error

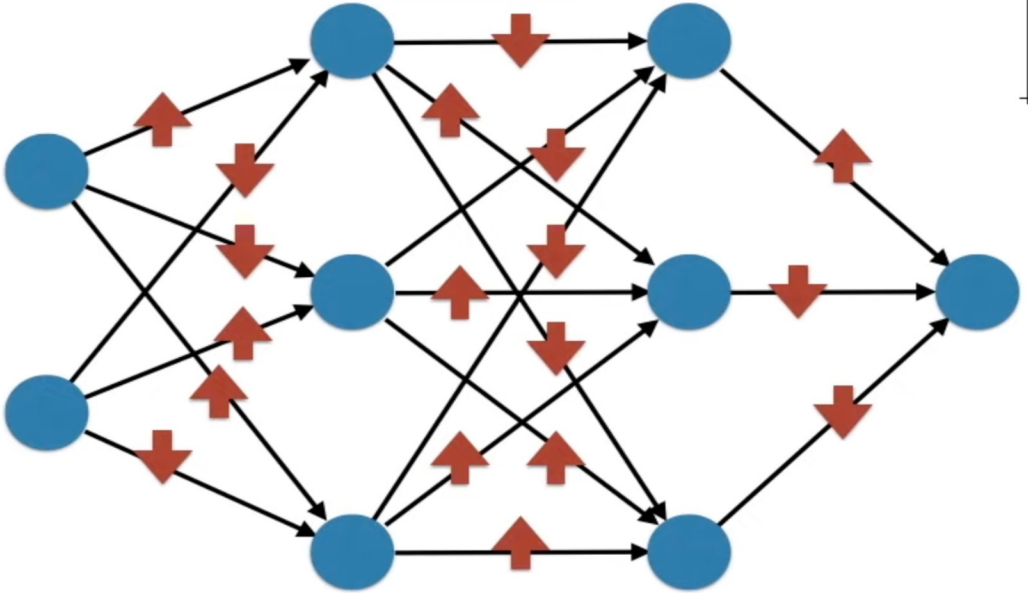
Backpropagation

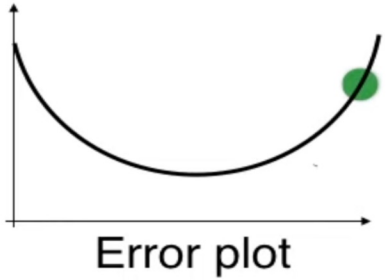


Prediction

Error

Backpropagation

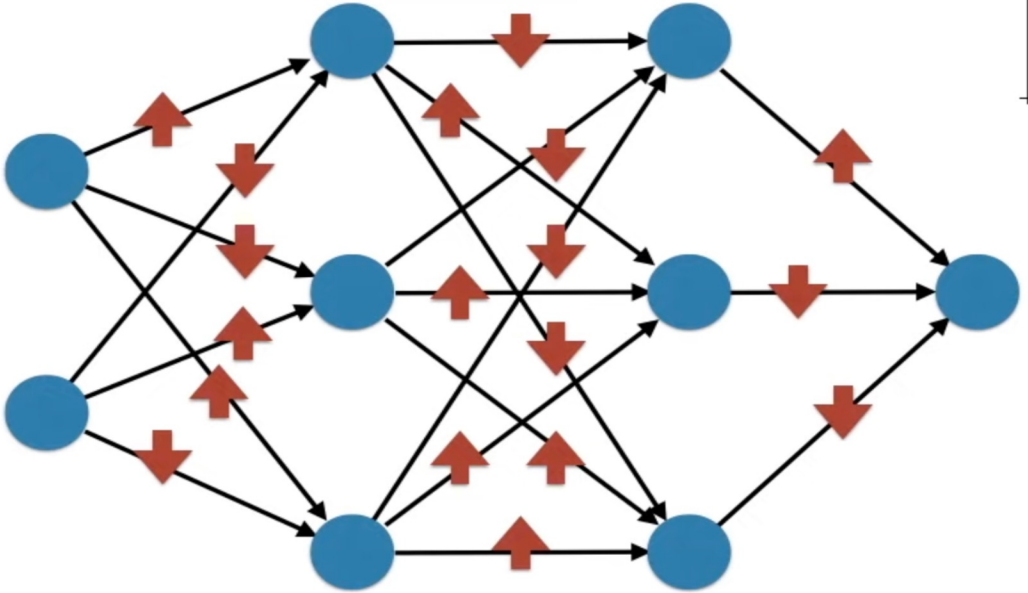


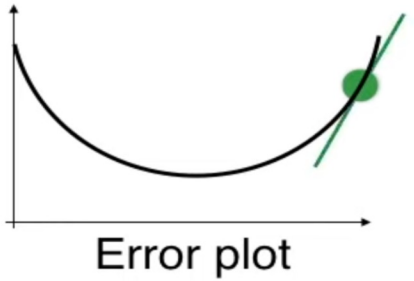


Prediction

Error

Backpropagation

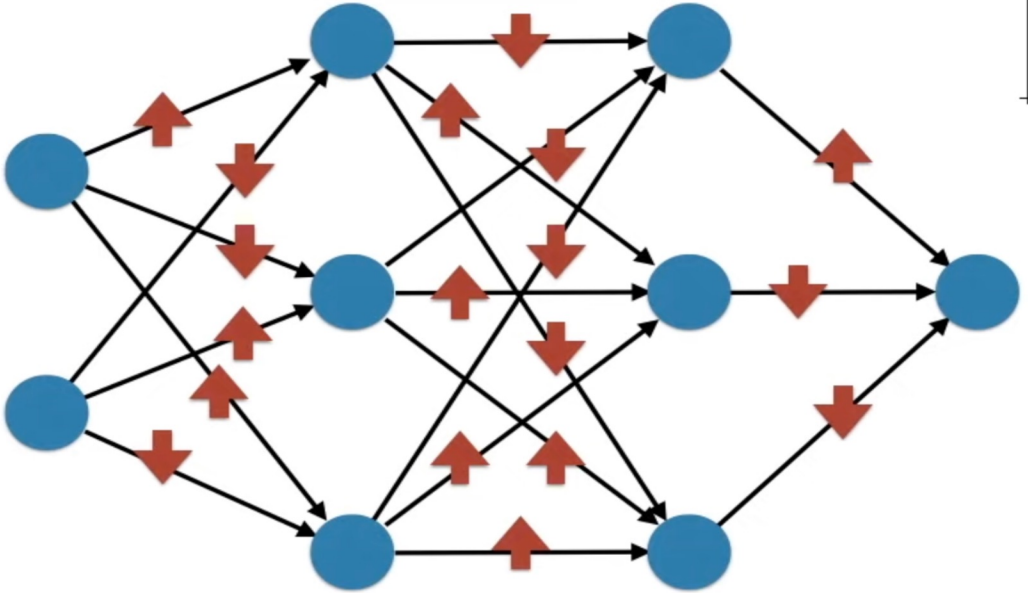


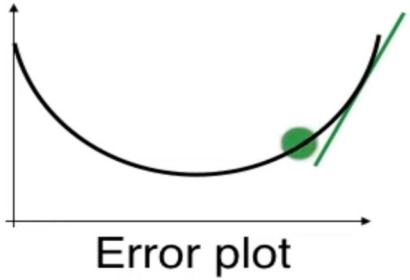


Prediction

Error

Backpropagation

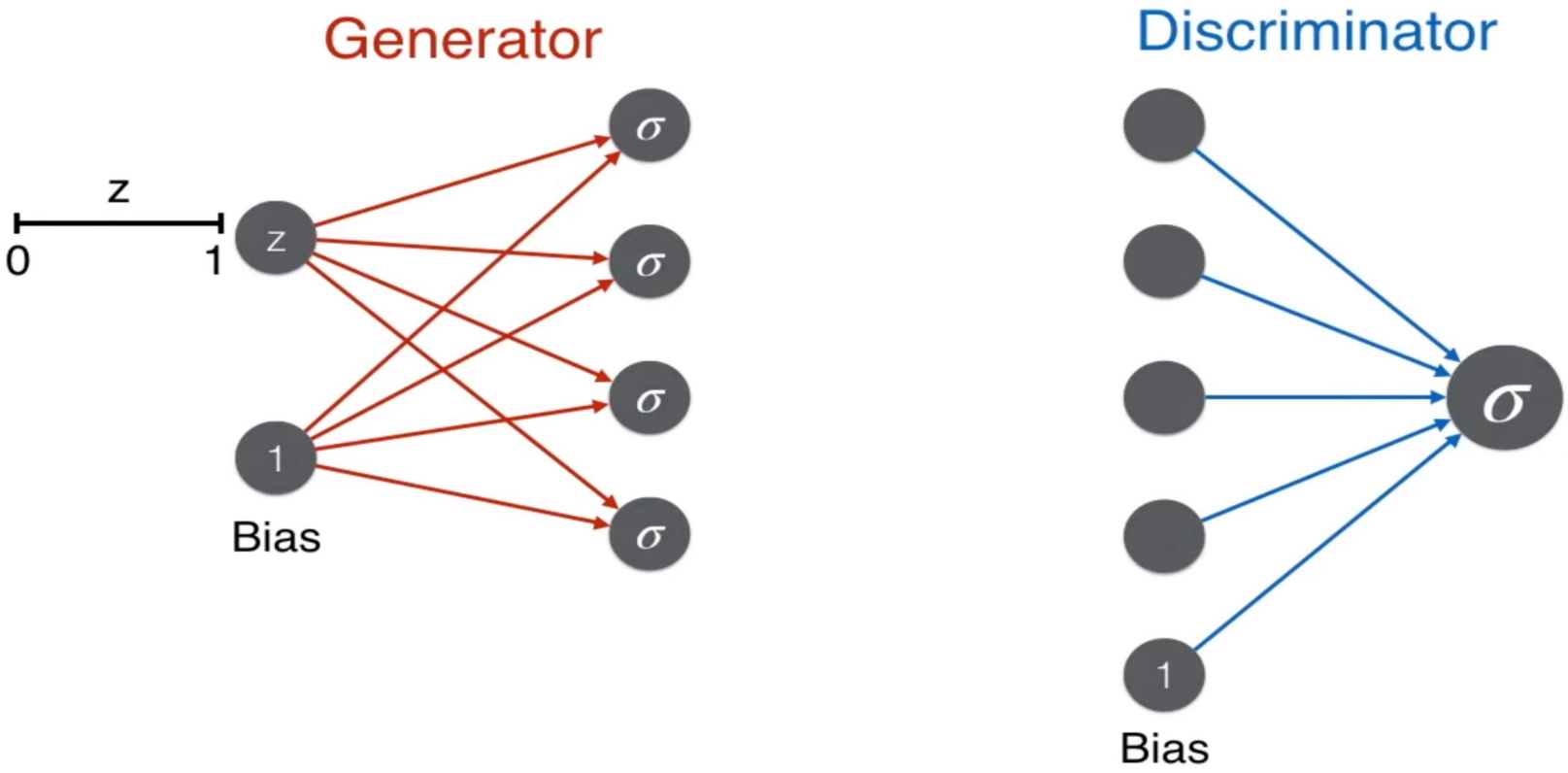


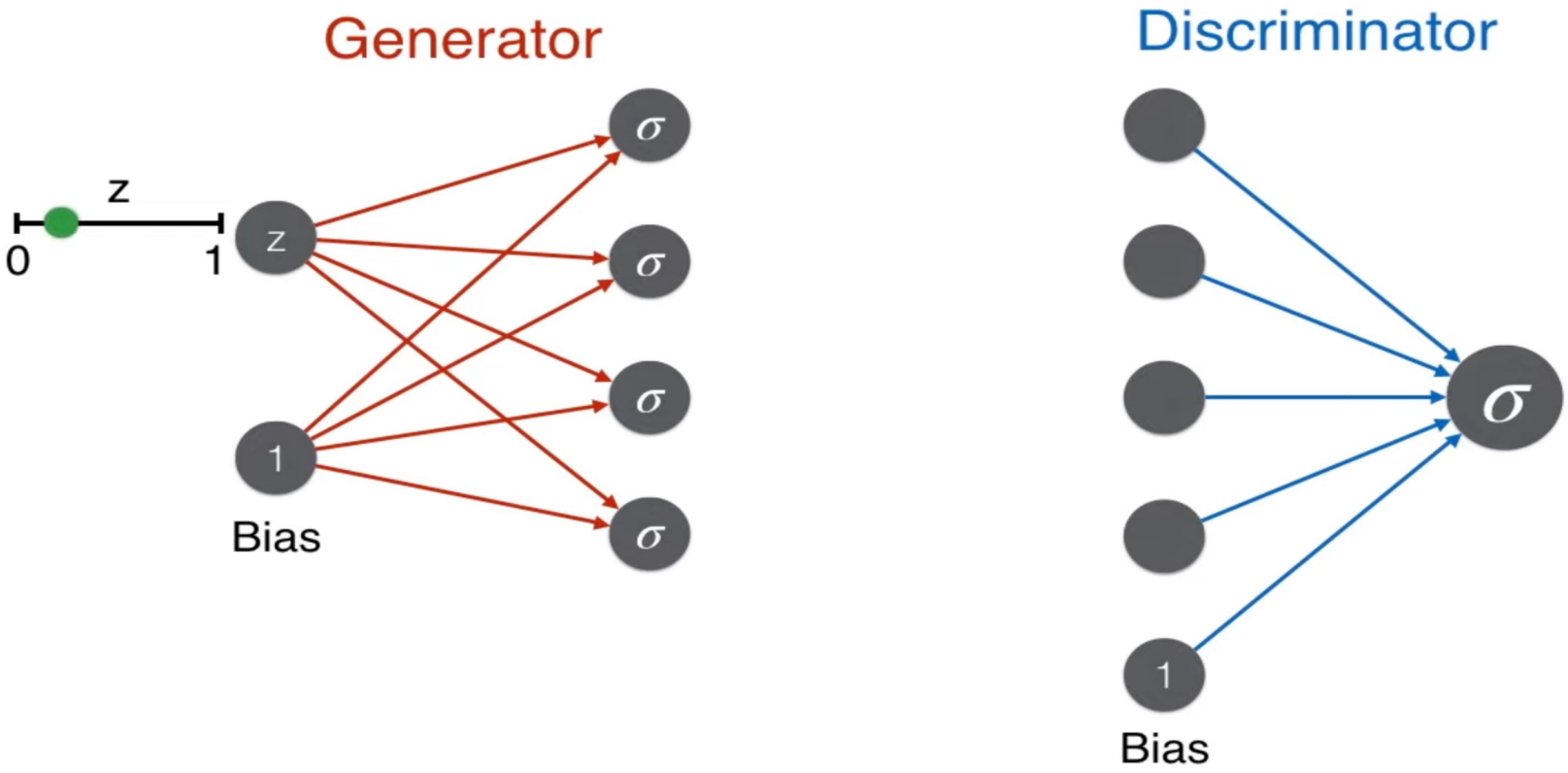


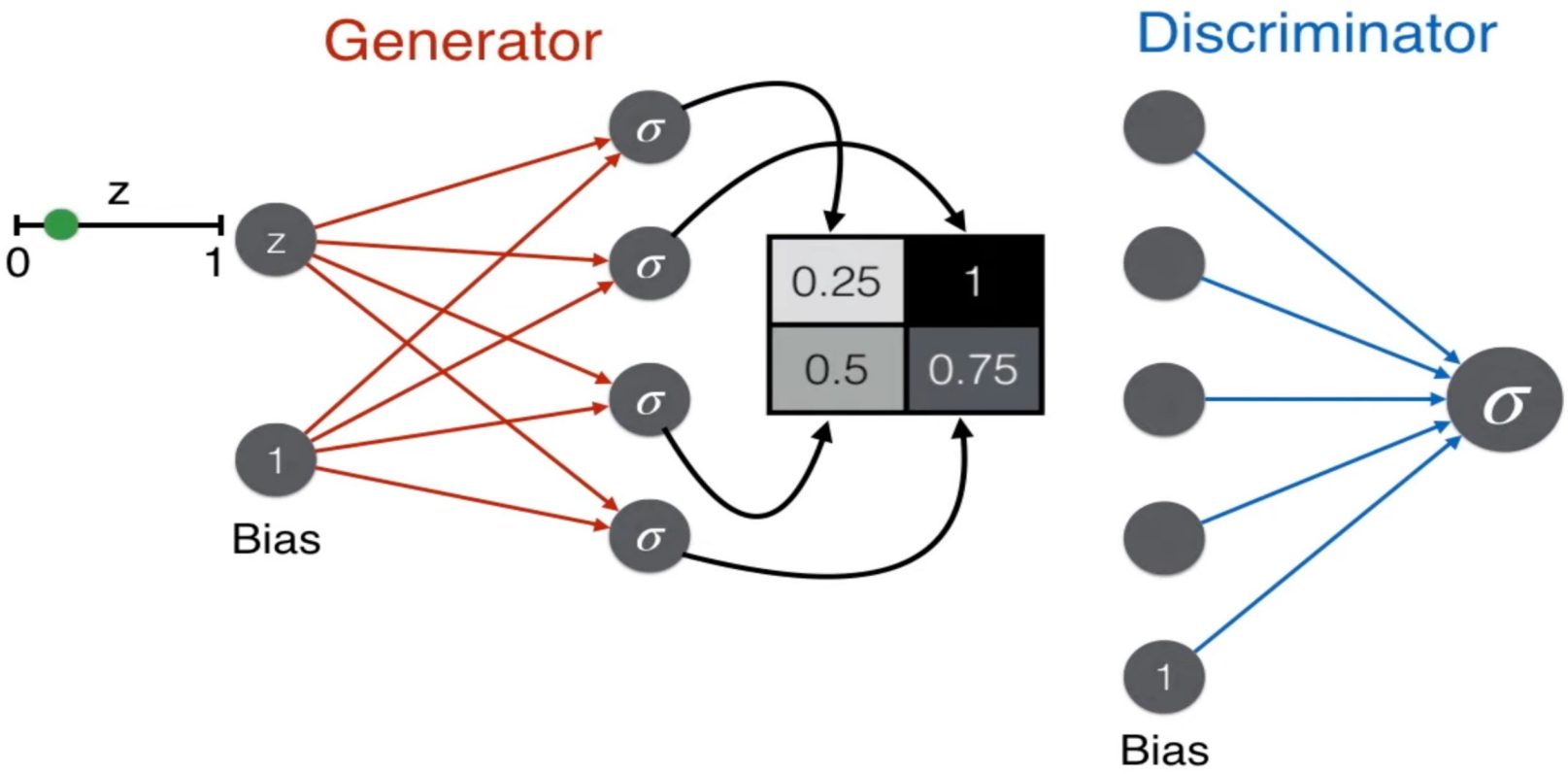
Prediction

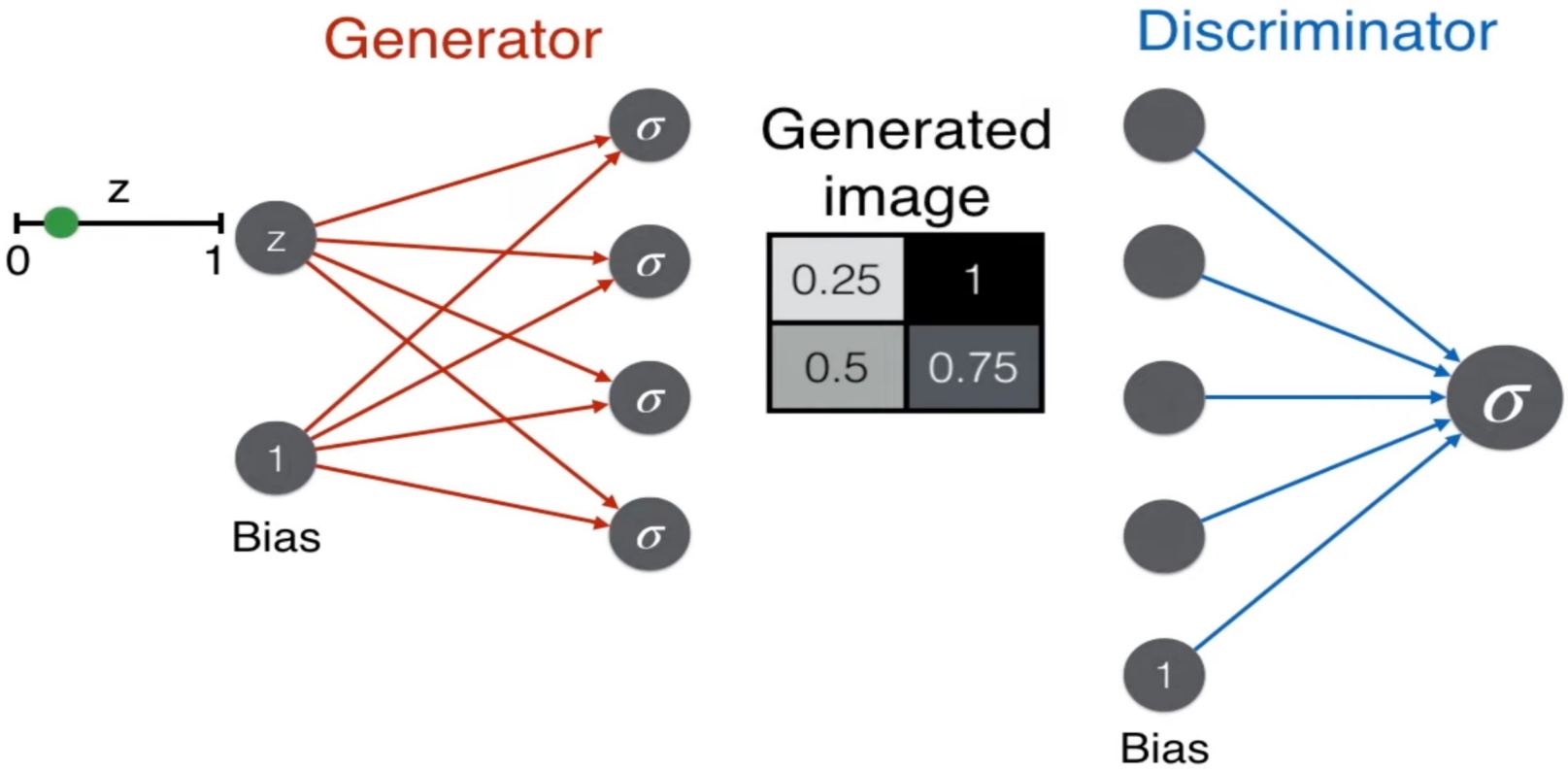
Error

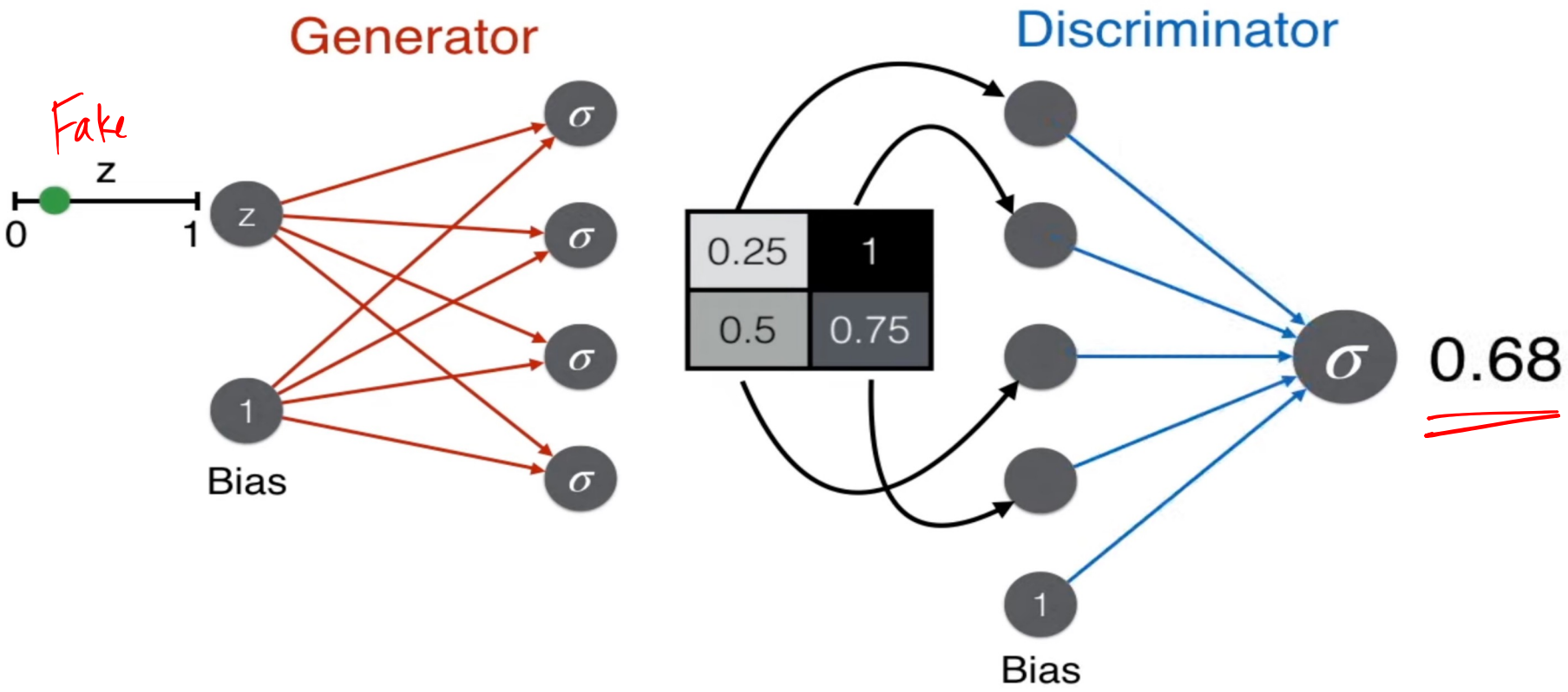
Training the generator and the discriminator

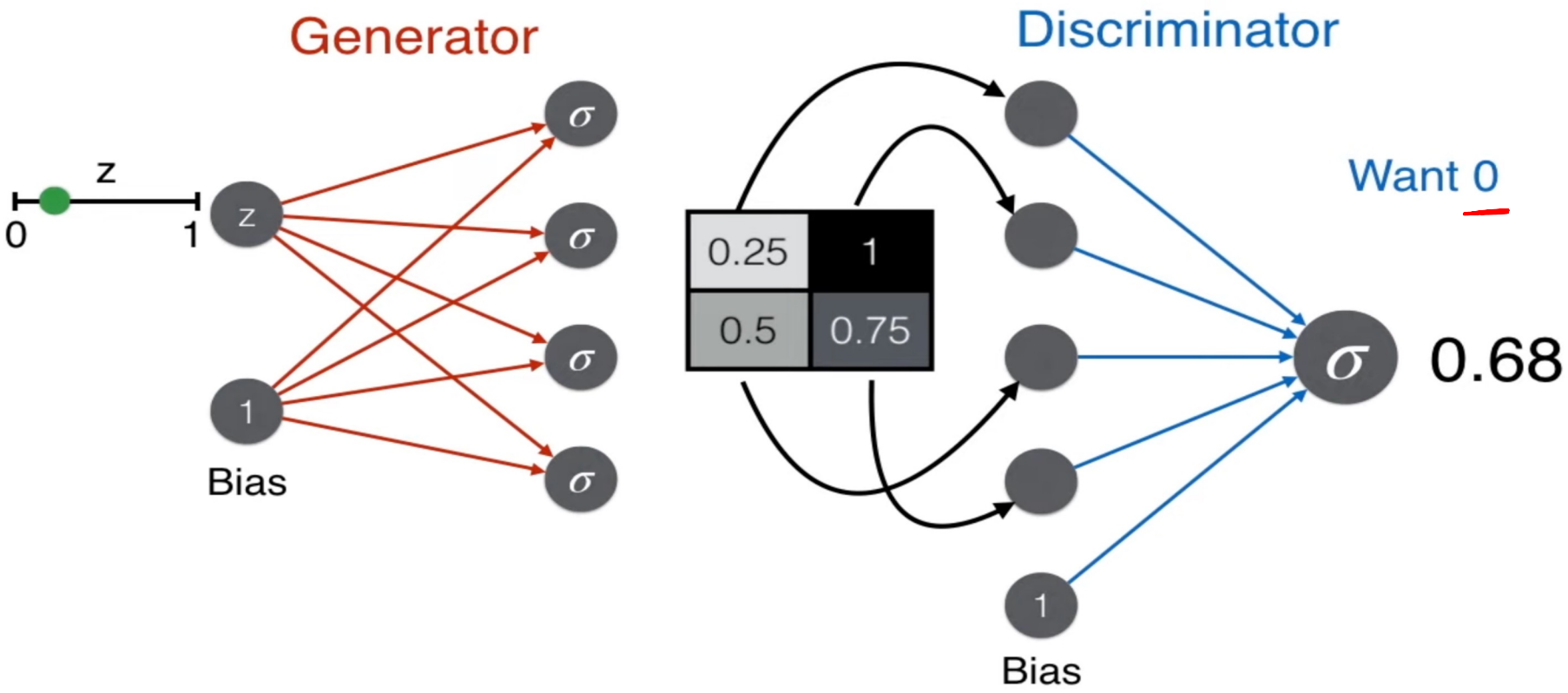

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Discriminator
σ
1
Bias

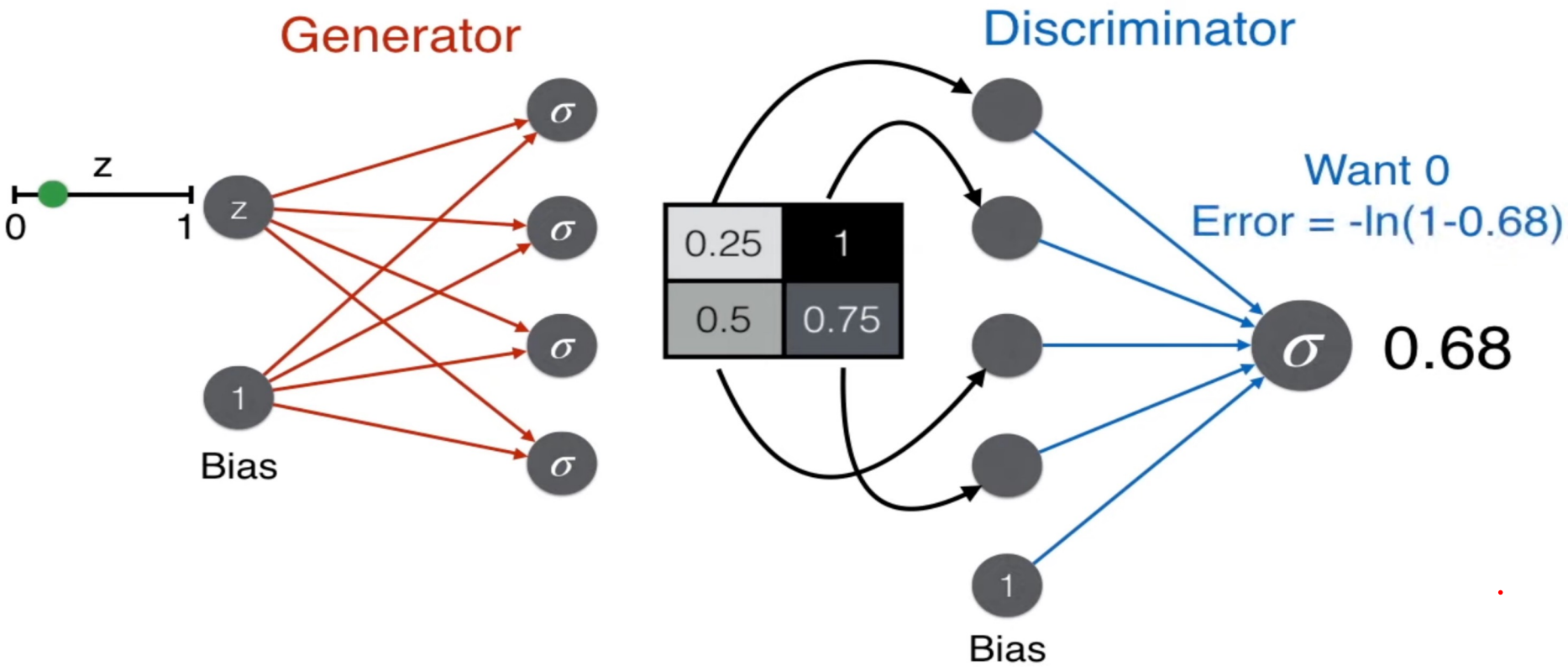

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Discriminator
σ
1
Bias

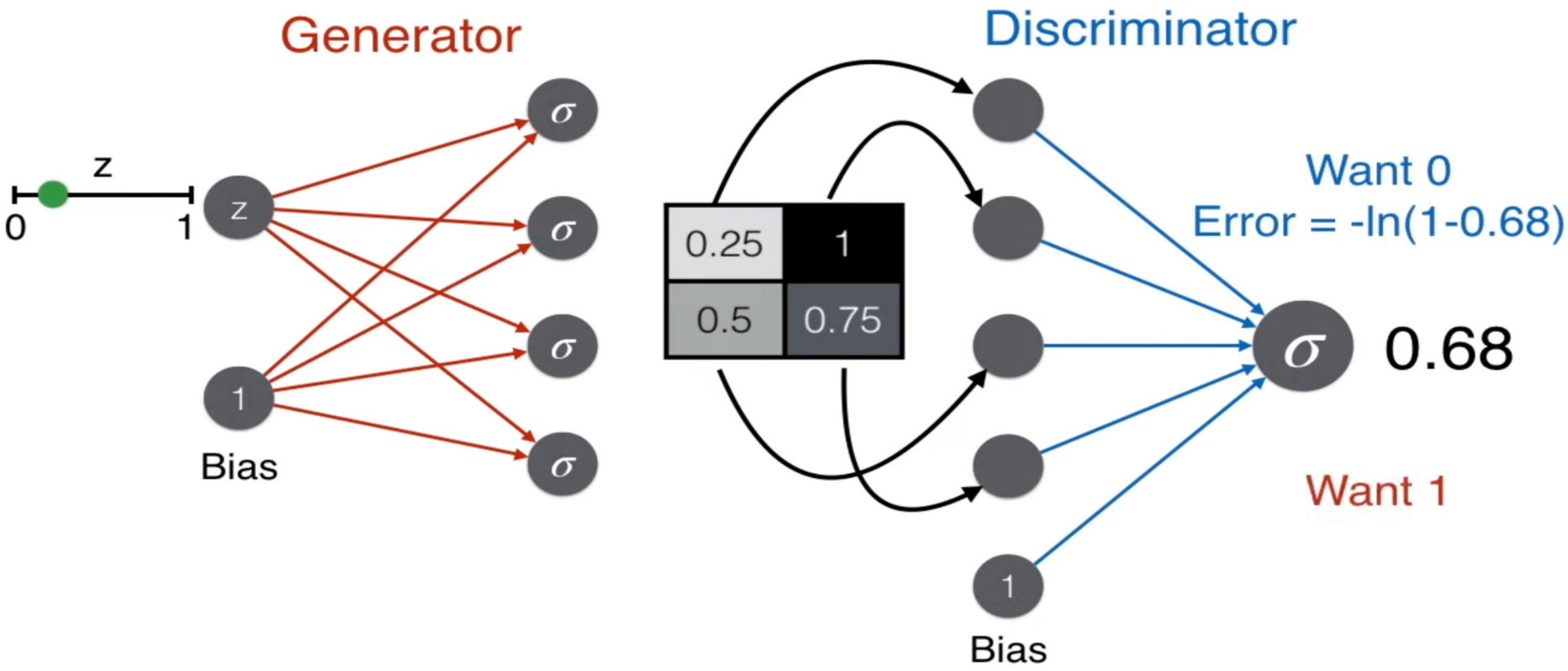

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
0.25
1
0.5
0.75
σ
1
Bias

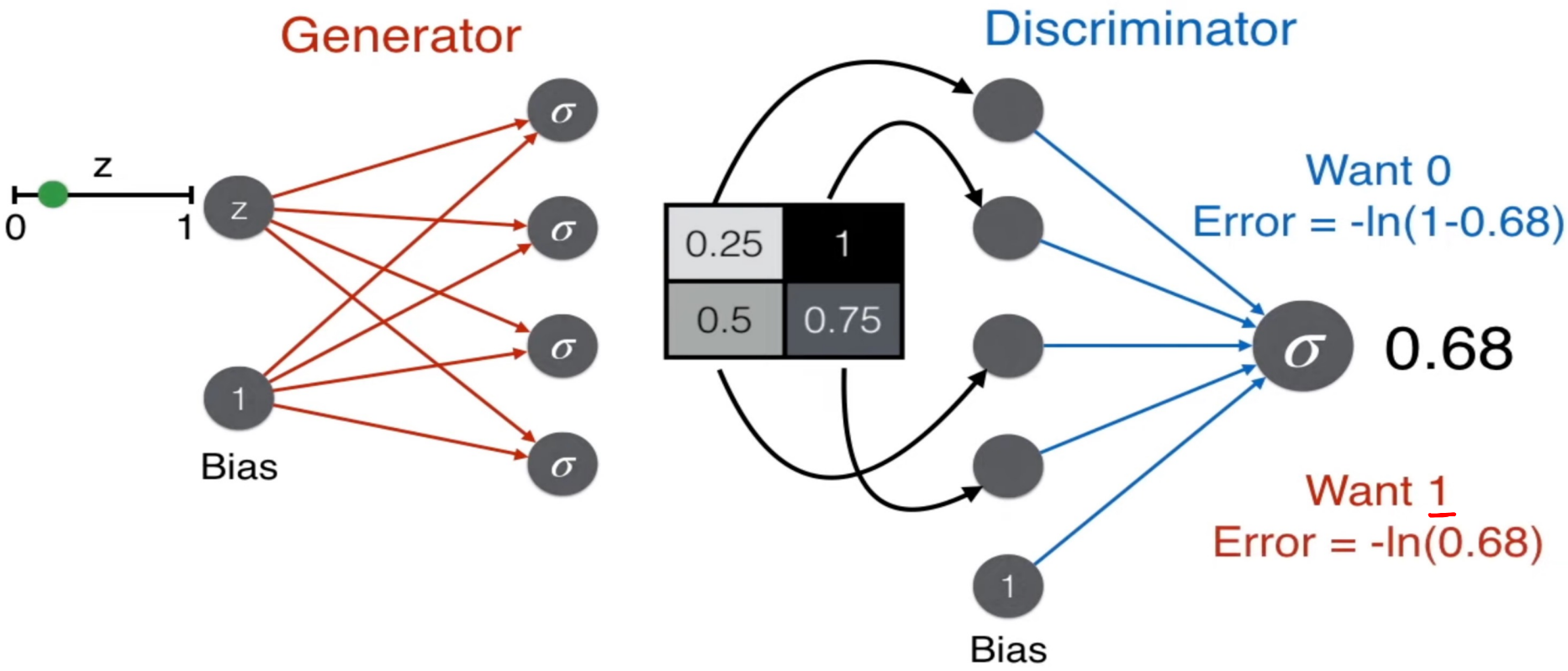

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Generated image
0.25
1
0.5
0.75
Discriminator
σ
1
Bias

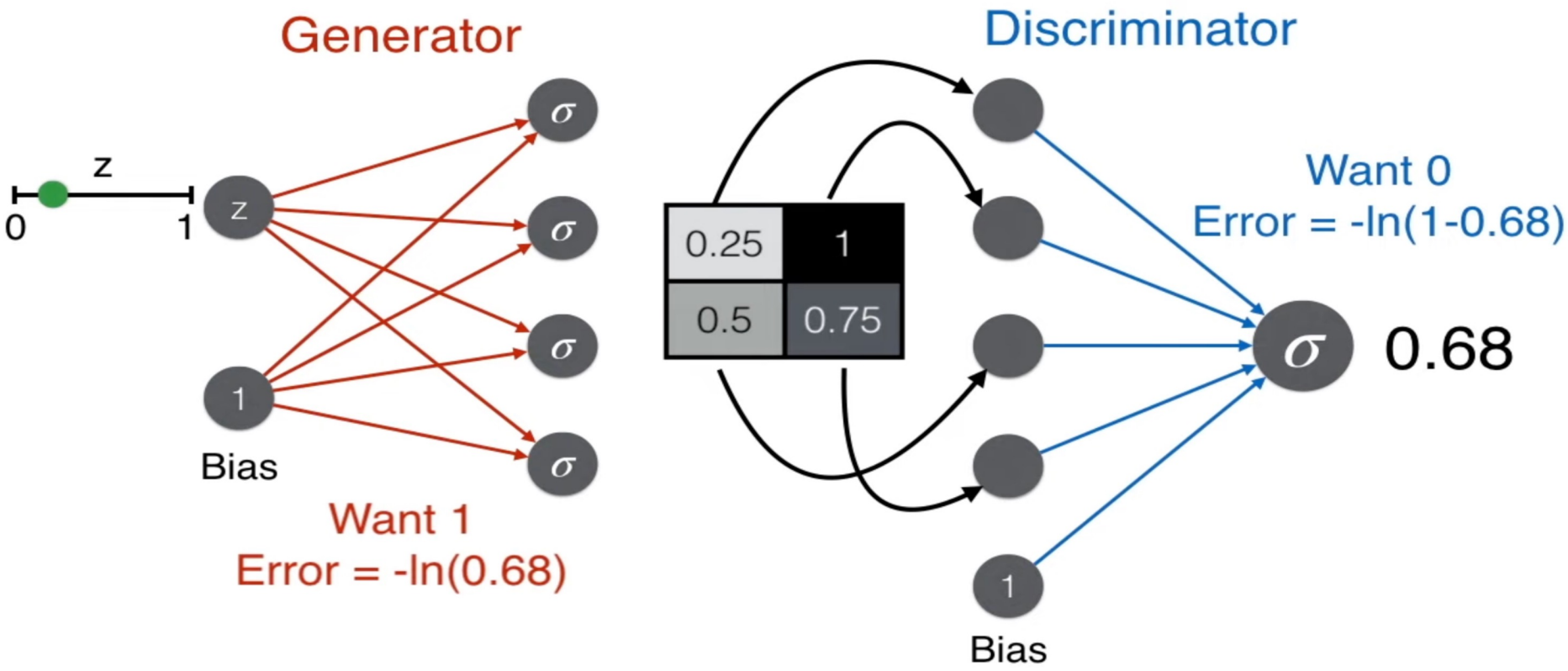

Generator
Discriminator
Fake
z
0
1
z
1
Bias
σ
σ
σ
σ
0.25
1
0.5
0.75
σ
0.68
1
Bias

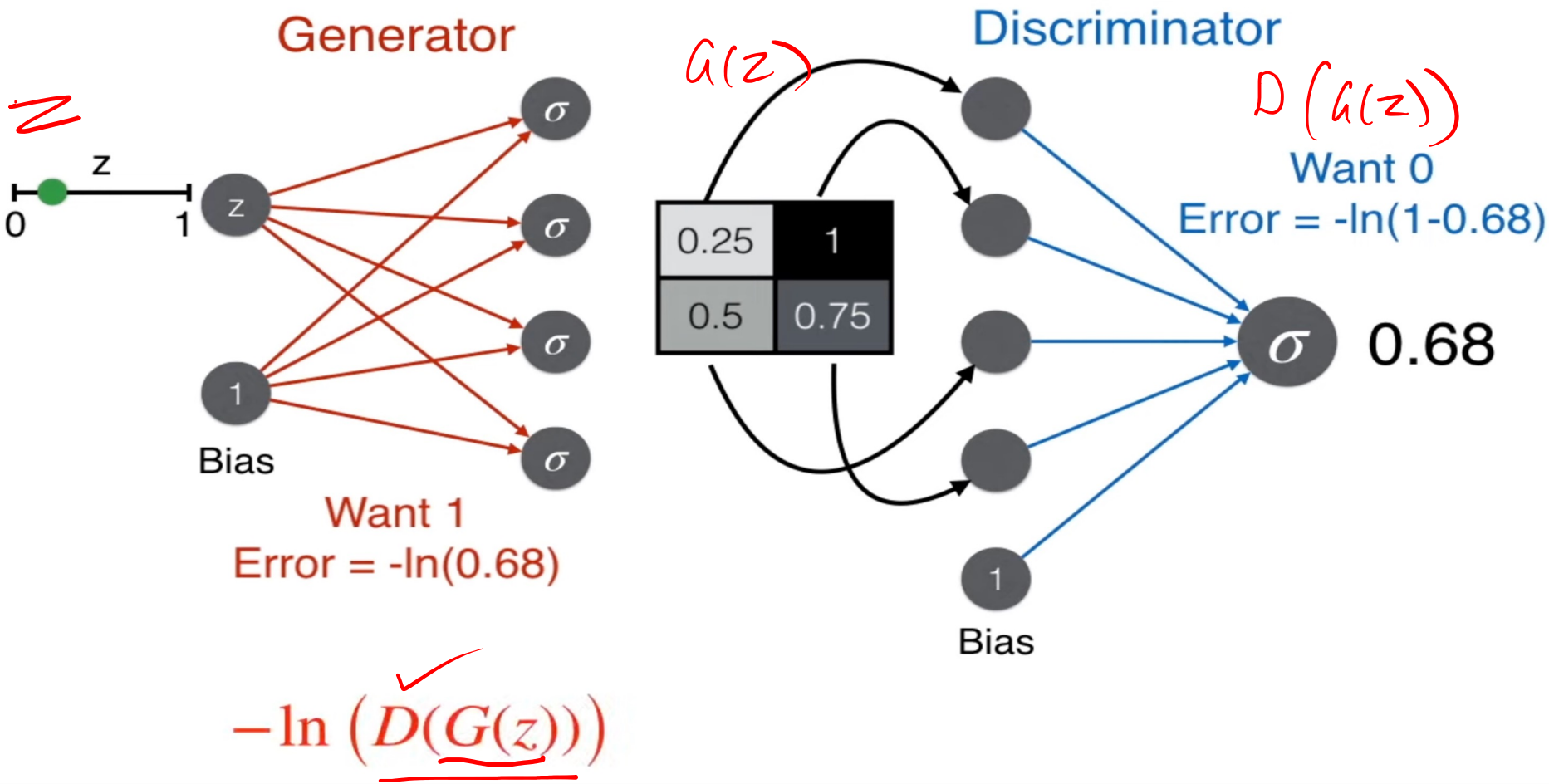

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
0.25
1
0.5
0.75
Want 0
σ
0.68
1
Bias

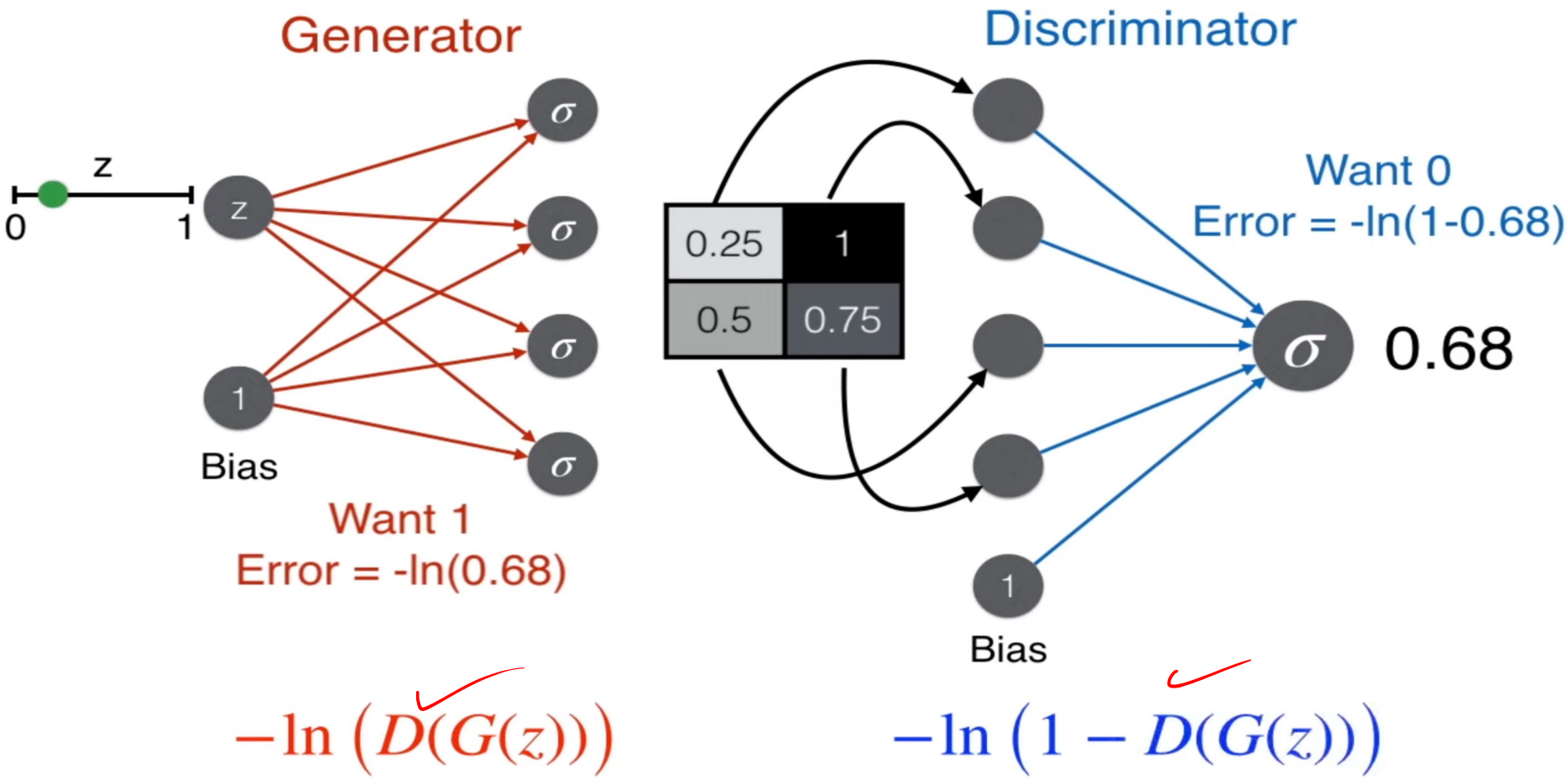

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Discriminator
0.25
1
0.5
0.75
1
Bias
σ
Want 0
Error = -ln(1-0.68)
0.68


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Discriminator
0.25
1
0.5
0.75
1
Bias
σ
0.68
Want 0
Error = -ln(1-0.68)
Want 1

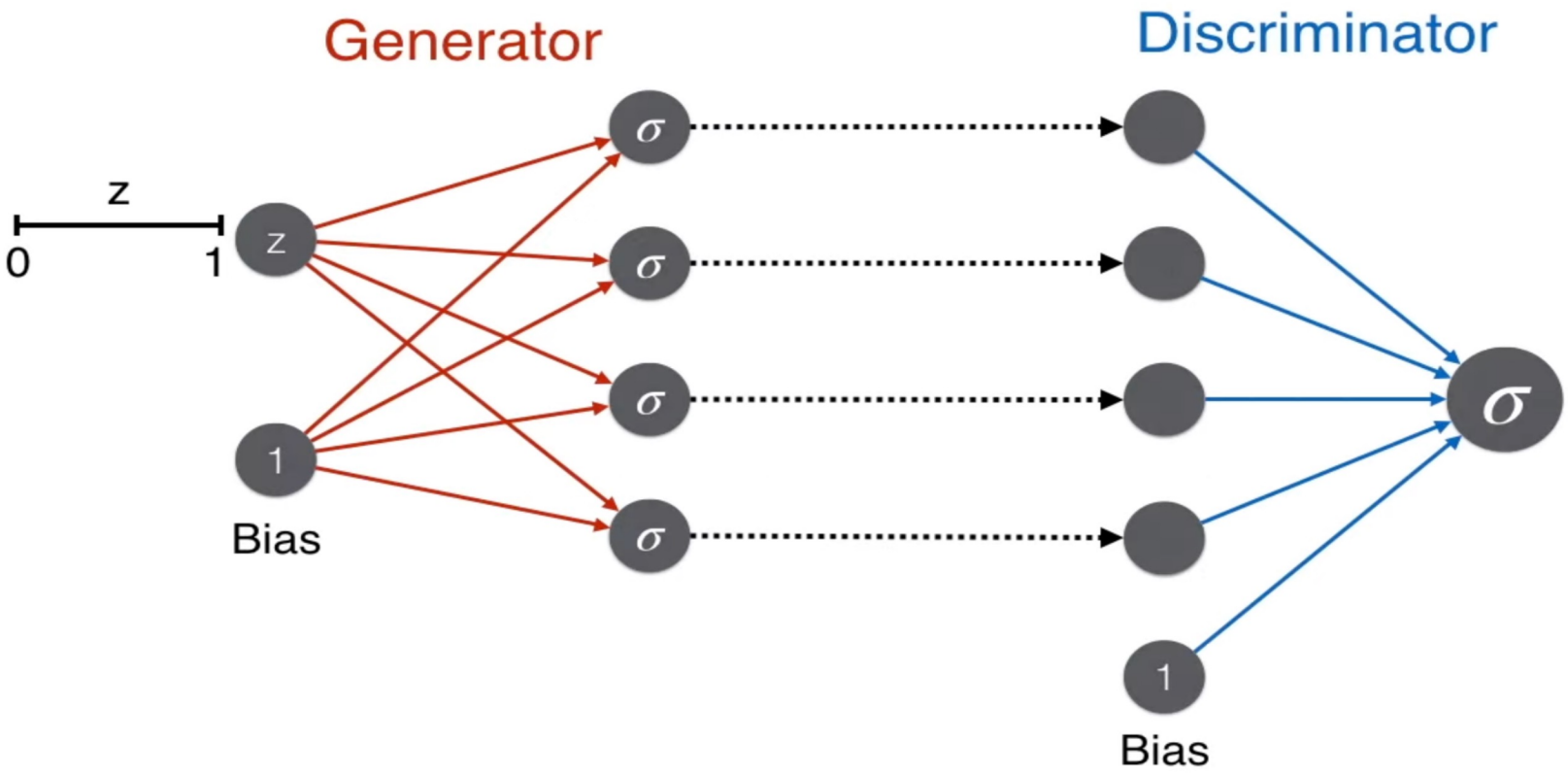

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
0.25
1
0.5
0.75
σ
0.68
Want 0
Error = -ln(1-0.68)
Want 1
Error = -ln(0.68)
1
Bias

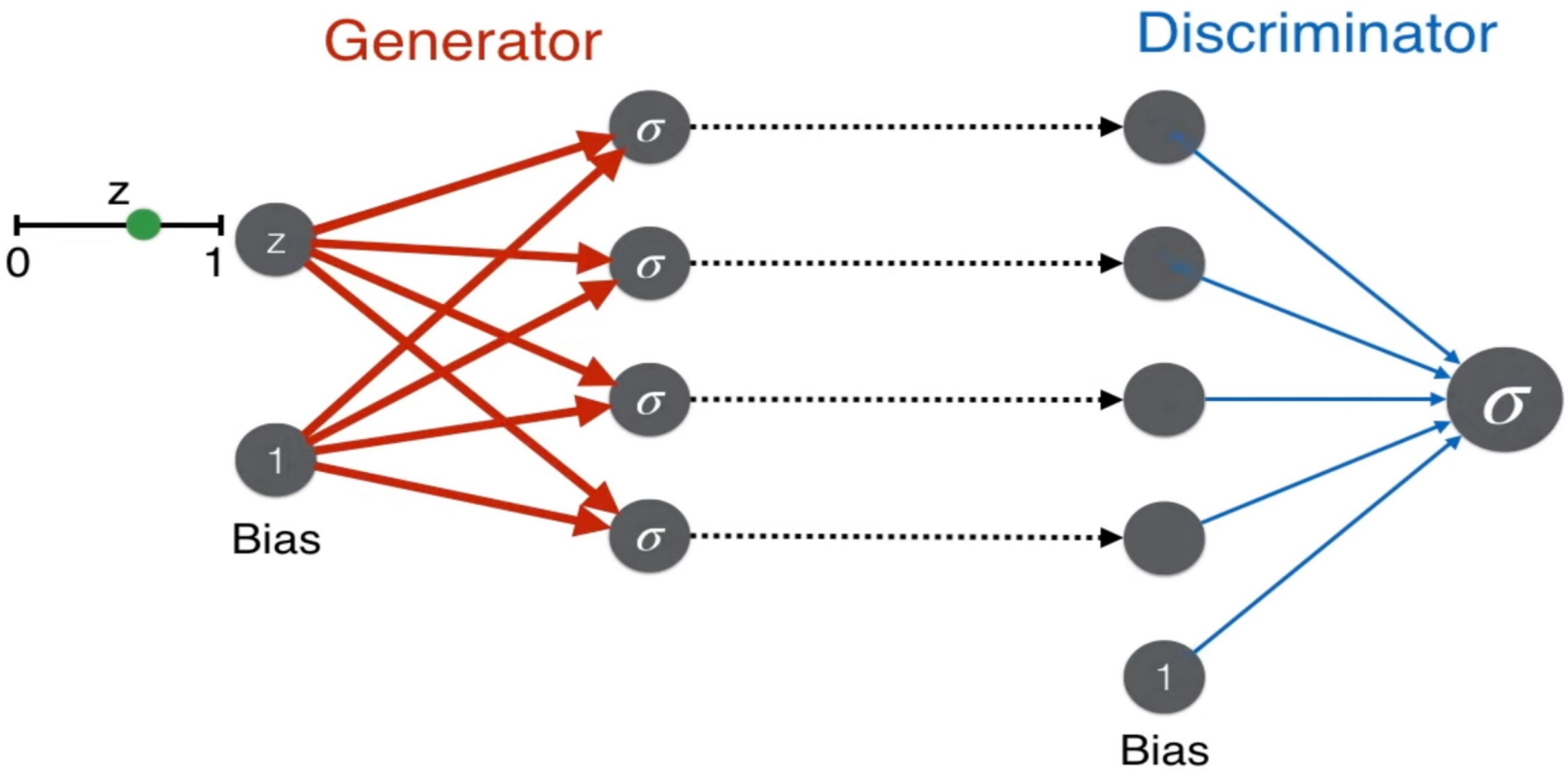

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Want 1
Error = -ln(0.68)
Discriminator
0.25
1
0.5
0.75
1
Bias
σ
0.68
Want 0
Error = -ln(1-0.68)

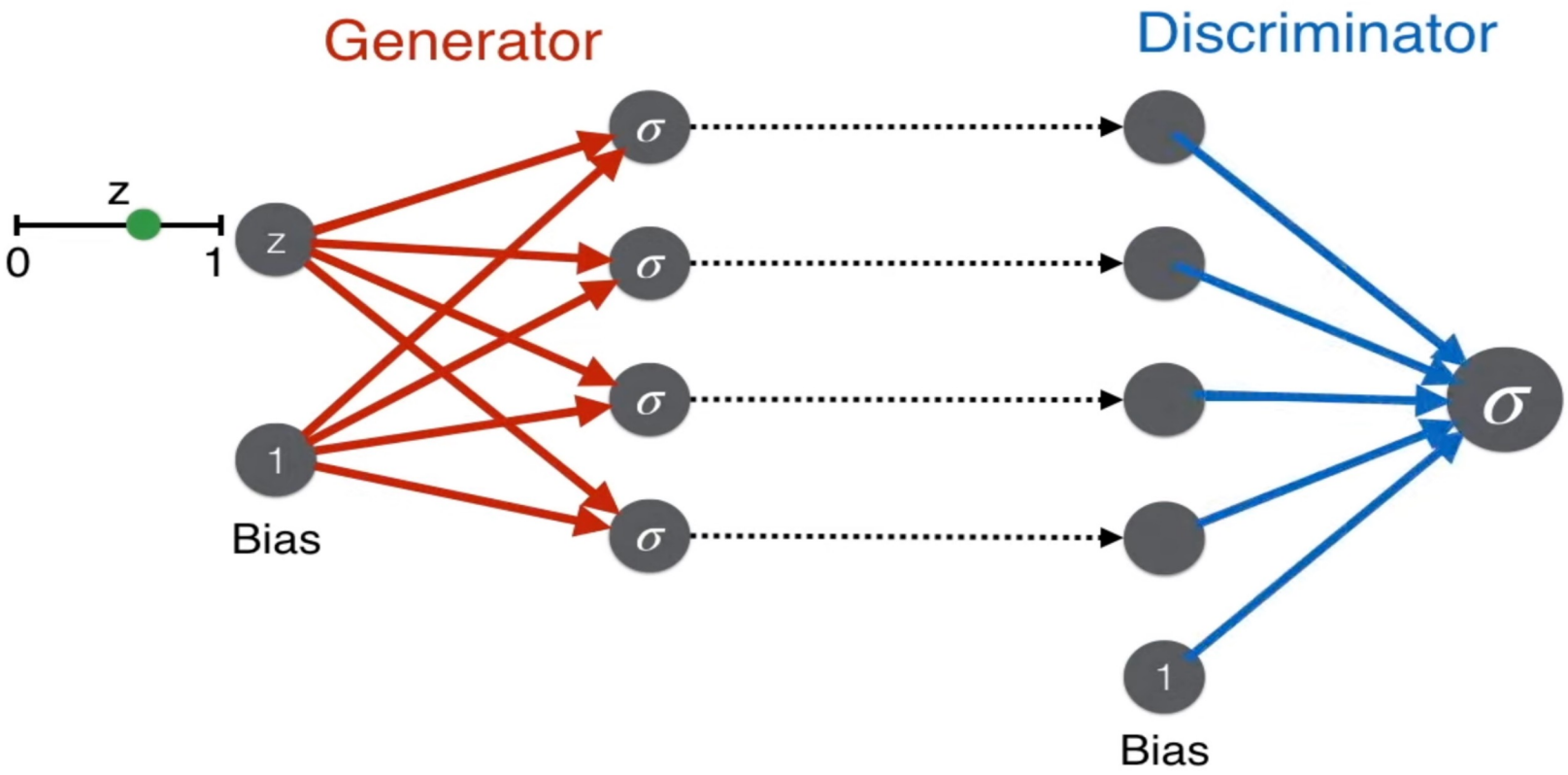

Generator
z
z
0
1
z
1
Bias
Want 1
Error = -ln(0.68)
G(z)
0.25
1
0.5
0.75
Discriminator
D(G(z))
Want 0
Error = -ln(1-0.68)
0.68
1
Bias
$-\ln\left(D(G(z))\right)$

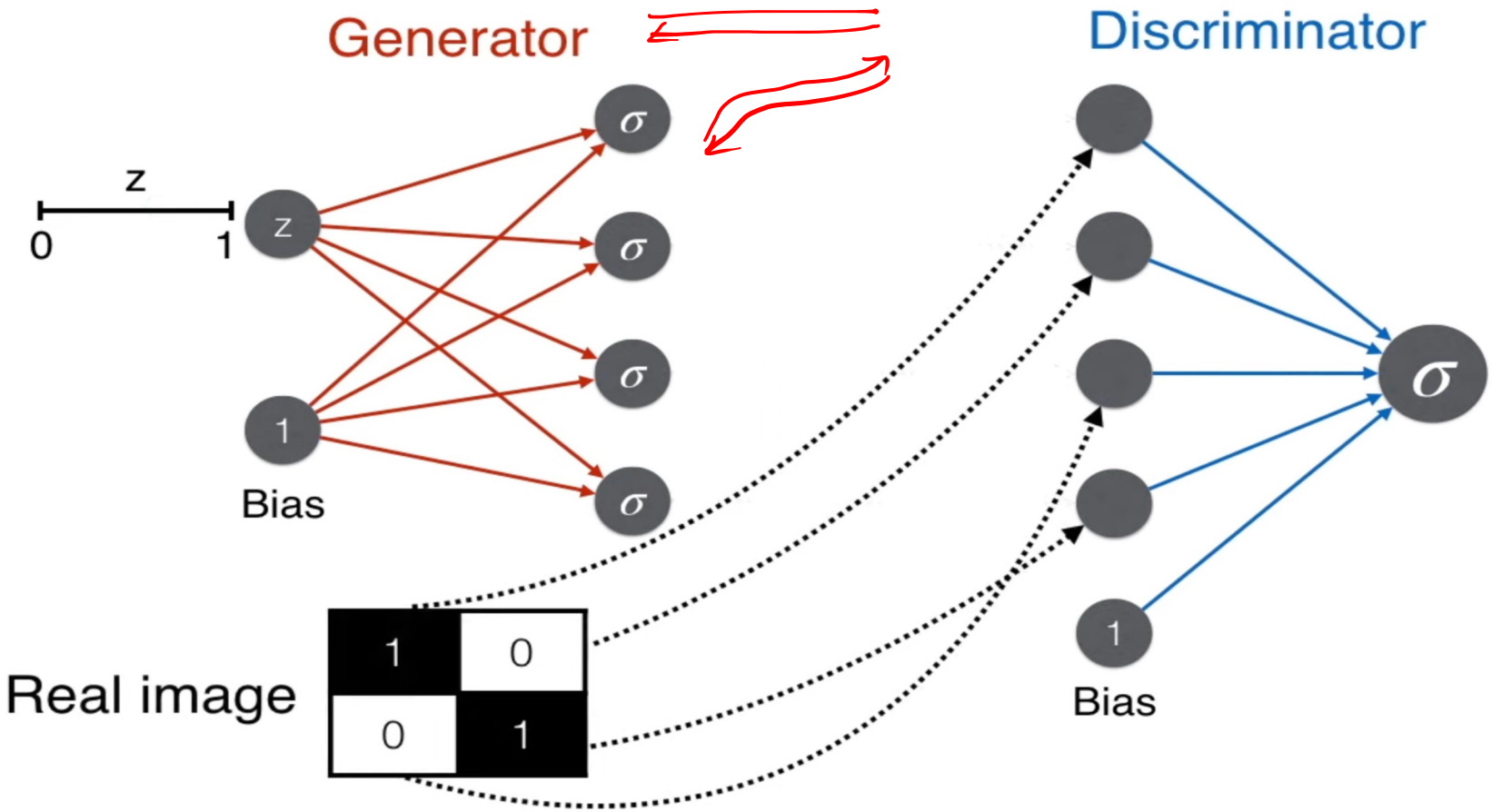

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ
Want 1
Error = -ln(0.68)
Discriminator
0.25
1
0.5
0.75
1
Bias
σ
0.68
Want 0
Error = -ln(1-0.68)
$-\ln\left(D(G(z))\right)$
$-\ln\left(1-D(G(z))\right)$

Repeat many times…

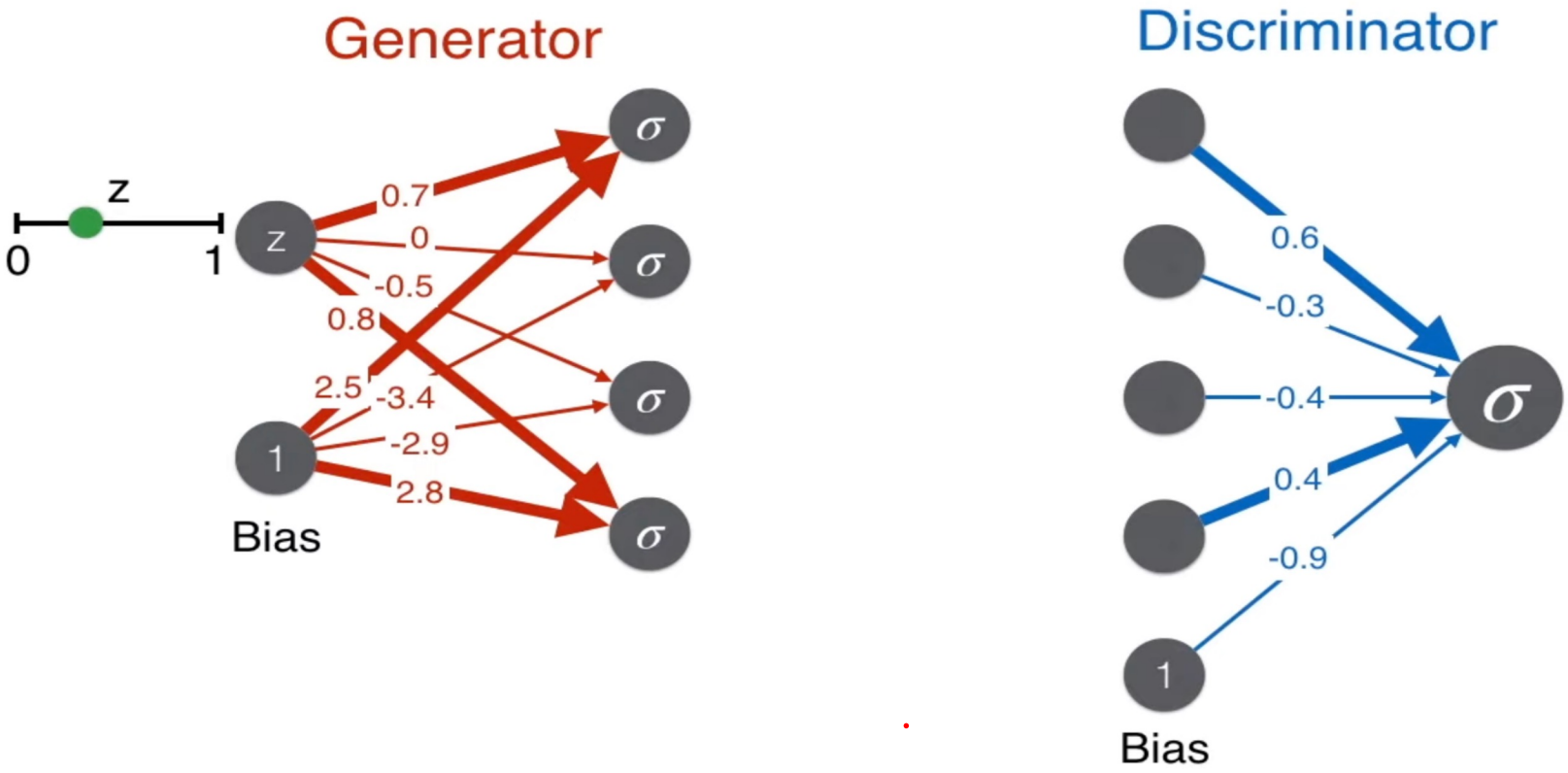

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
σ
1
Bias

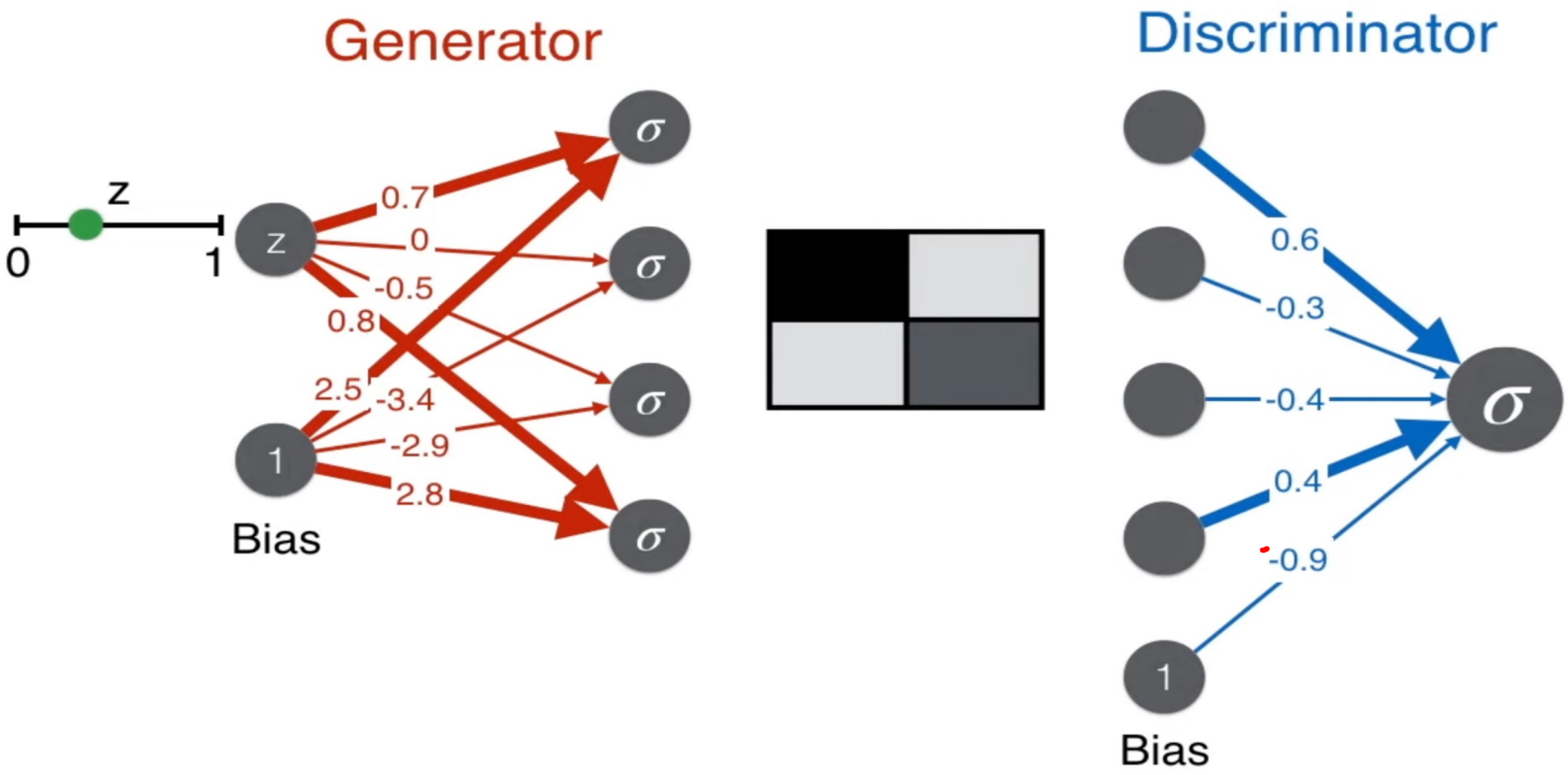

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
σ
1
Bias


Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
σ
1
Bias

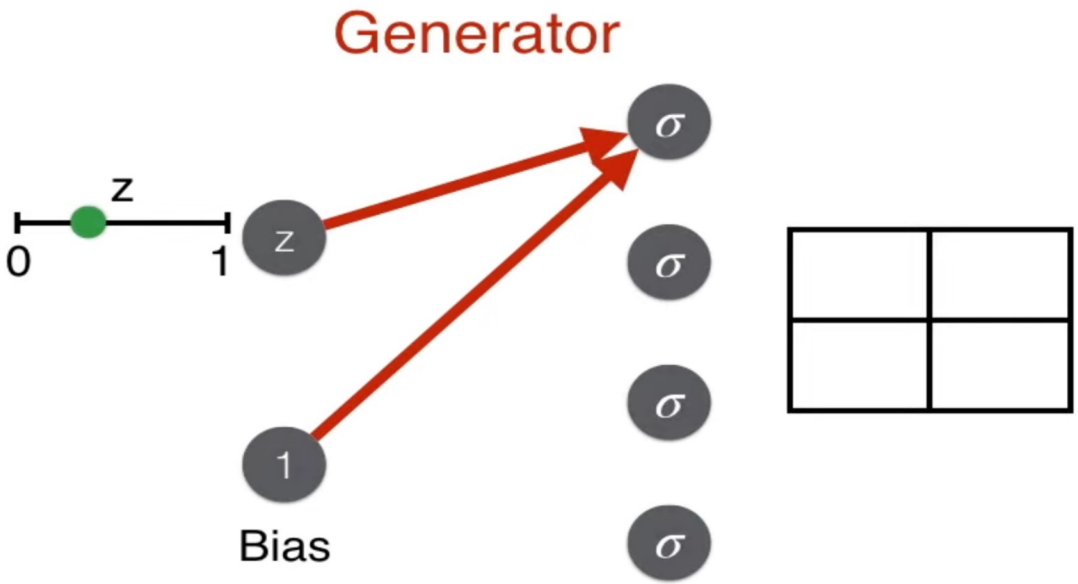

Generator
Discriminator
z
0
1
z
1
Bias
σ
σ
σ
σ
σ
1
Bias
Real image
1
0
0
1

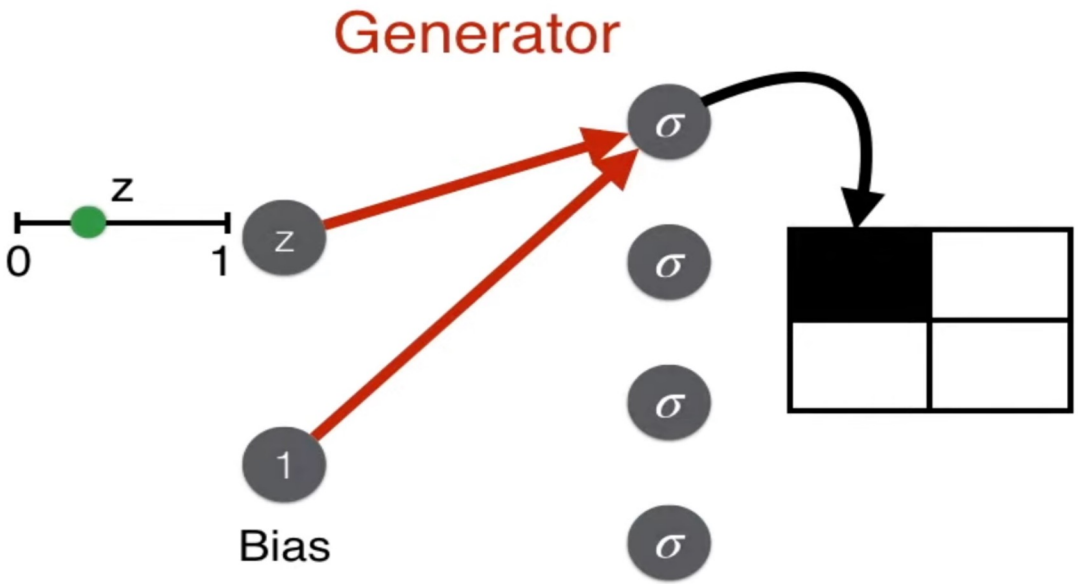
After many of these iterations (epochs)

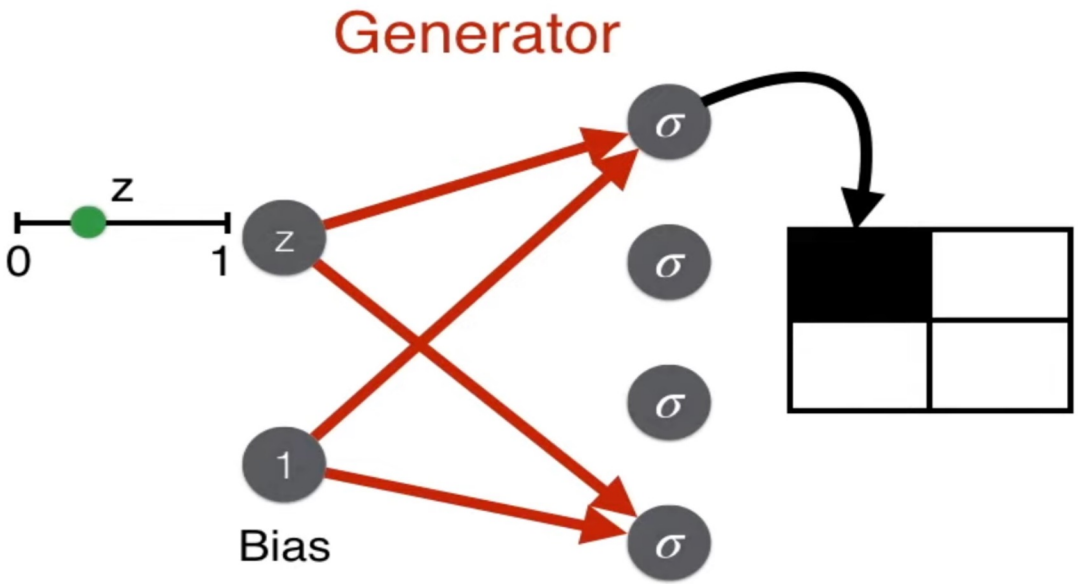

Generator
z
0
1
z
0.7
0
-0.5
0.8
2.5
-3.4
-2.9
2.8
1
Bias
σ
σ
σ
σ
Discriminator
0.6
-0.3
-0.4
0.4
-0.9
1
Bias
σ

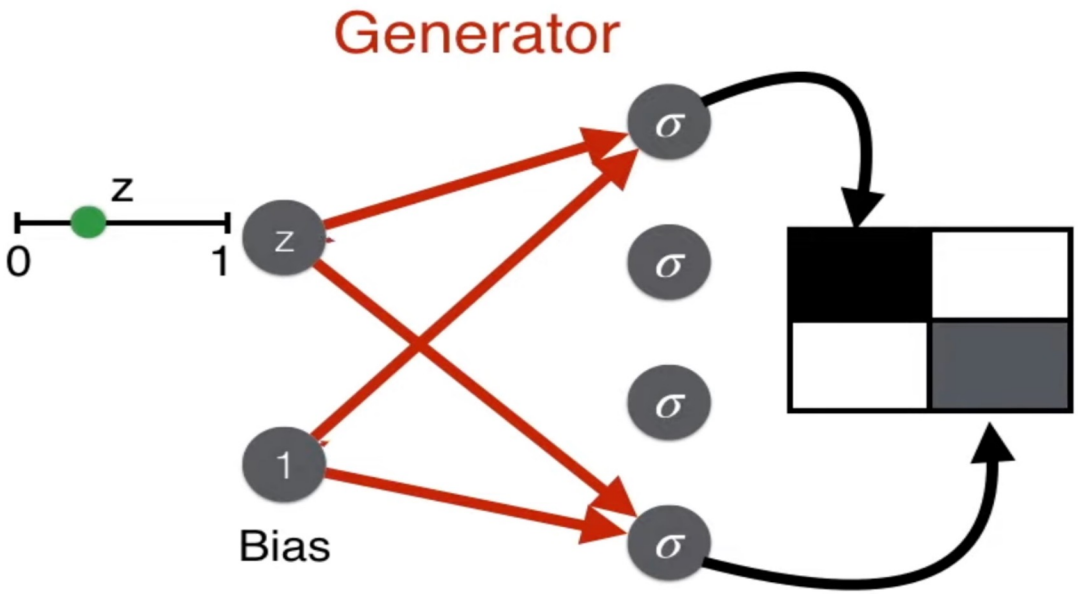

Generator
Discriminator
z
0
1
z
1
0.7
0
-0.5
0.8
2.5
-3.4
-2.9
2.8
Bias
σ
σ
σ
σ
0.6
-0.3
-0.4
0.4
-0.9
1
Bias
σ

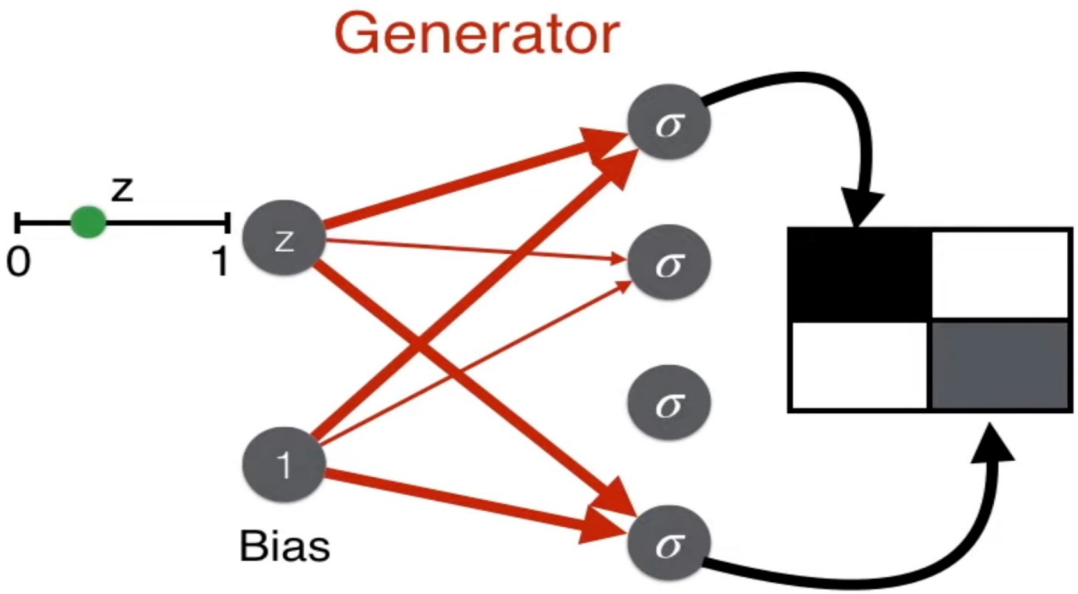
Generator

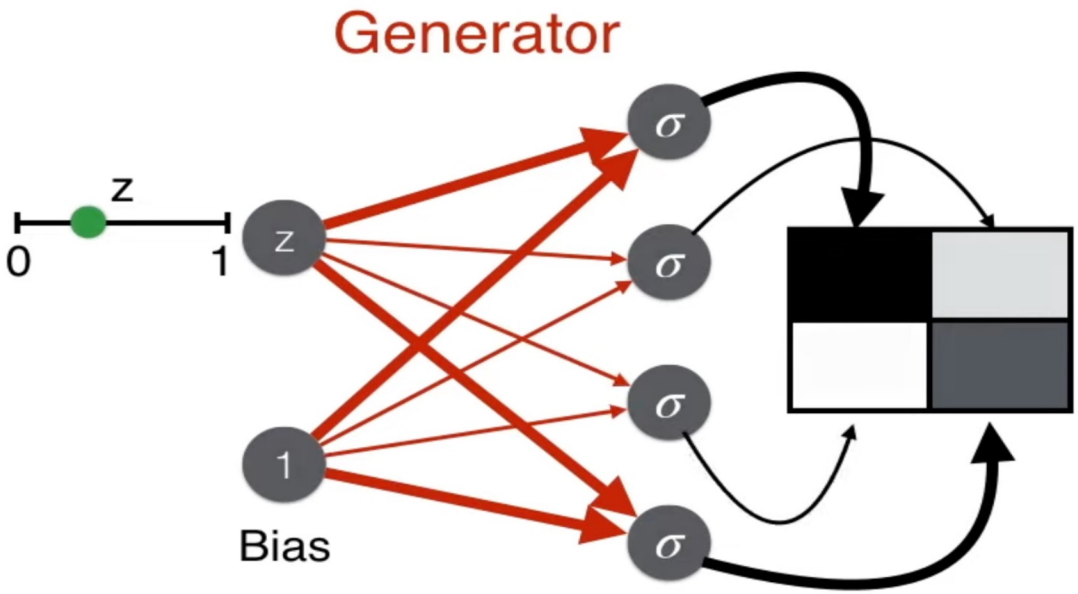

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ

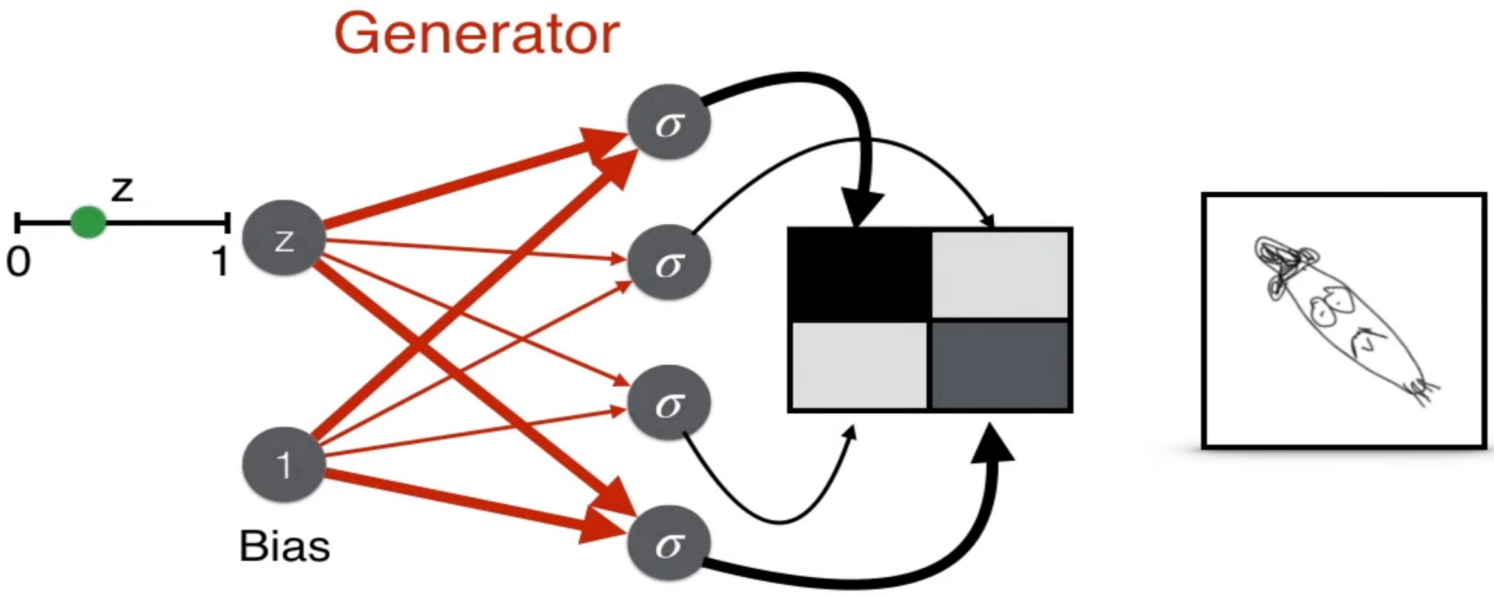

Generator
z
0
1
z
1
Bias
σ
σ
σ
σ


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ


Generator
z
0
1
z
1
Bias
σ
σ
σ
σ