



[Home Page](#)

[Title Page](#)

[Contents](#)

[◀](#) [▶](#)

[◀](#) [▶](#)

[Page 1 of 15](#)

[Go Back](#)

[Full Screen](#)

[Close](#)

[Quit](#)

Generative Adversarial Networks

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[Home Page](#)

[Title Page](#)

[Contents](#)

[!\[\]\(6cbaff651e9b7a1a7462c49d18e0be2e_img.jpg\) !\[\]\(1855b11bf6aa350ebef50973960dd134_img.jpg\)](#)

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[Page 2 of 15](#)

[Go Back](#)

[Full Screen](#)

[Close](#)

[Quit](#)

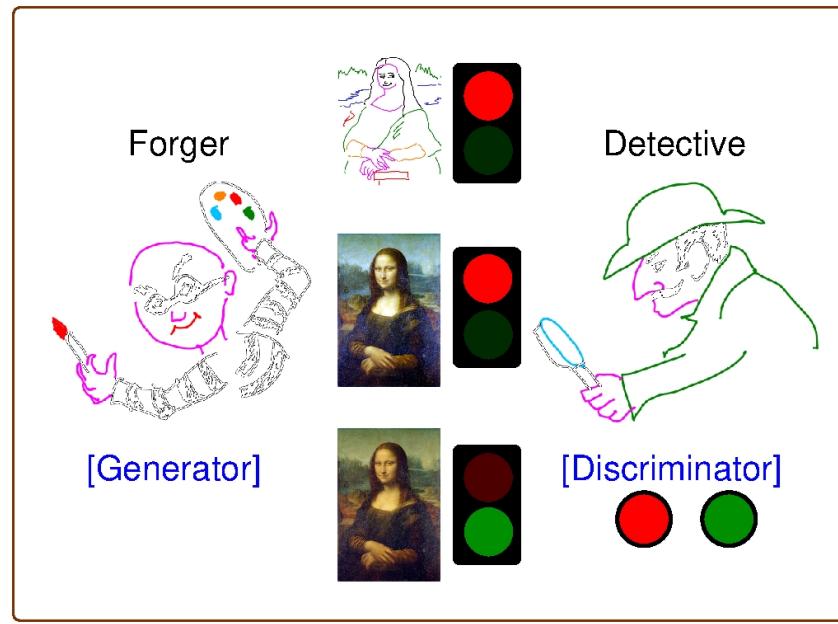
The basic GAN concept

https://upload.wikimedia.org/wikipedia/commons/f/fe/Ian_Goodfellow.jpg



- **Ian J. Goodfellow [1987-]**
- **[I. J. Goodfellow *et al.*, NIPS'14]**
- **[J. Schmidhuber'91], [O. Neimitalo'10], [Li, Gauci, Gross'13]**

https://upload.wikimedia.org/wikipedia/commons/e/ec/Mona_Lisa%2C_by_Leonardo_da_Vinci%2C_from_C2RMF_retouching.jpg





[Home Page](#)

[Title Page](#)

[Contents](#)

[Page 3 of 15](#)

[Go Back](#)

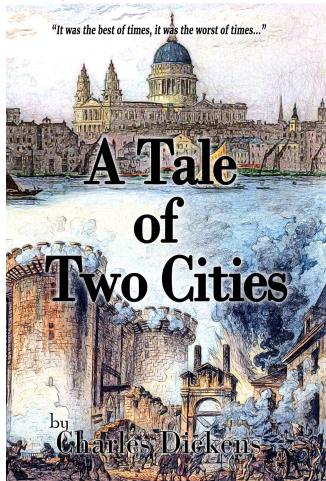
[Full Screen](#)

[Close](#)

[Quit](#)

A Tale of Two (Atro)Cities!

<https://m.media-amazon.com/images/I/91-J0ie5SmL..SL1500..jpg>



- Generative Models: **sampling**: new point in input space (\sim GMM)
- Gen: new samples, Disc: real/fake
- 0-Sum Adv game, till Disc fooled 50%
- Disc can be discarded post-training
- GANs use both bow-tie & contractive
 - Bow-tie: o/p, i/p same dim: **Generator**
 - Simple Example: Auto-Encoder
 - Contractive: 2-class classifier: **Discriminator**
 - Simple Example: Convolutional NN (Oxymoron)
 - Neither ‘convolution’, nor ‘neural network’ [00:48]



Home Page

Title Page

Contents



Page 4 of 15

Go Back

Full Screen

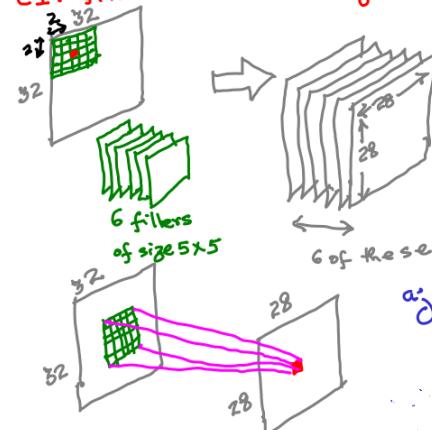
Close

Quit

Contractive: Discriminator

LeNet-5 DETAILS

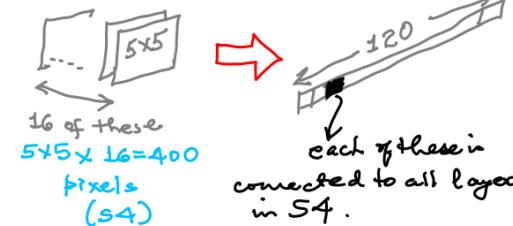
C1: first convolutional layer



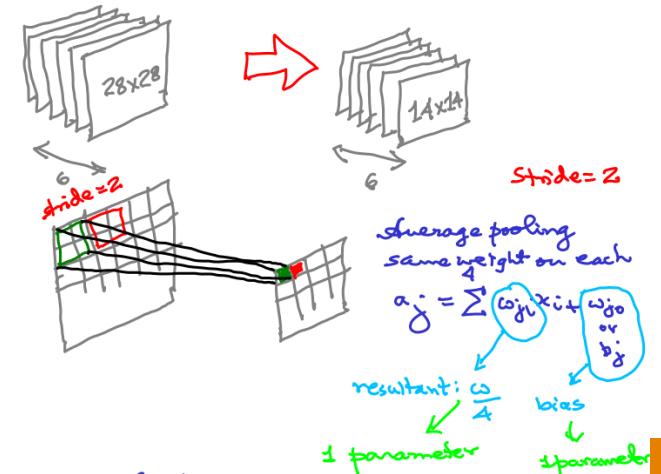
$$a_j = \sum_{i=1}^{25} w_{ji}^{(1)} x_i + b_j$$

⑤ "C5" 5th Layer, C \Rightarrow convolution

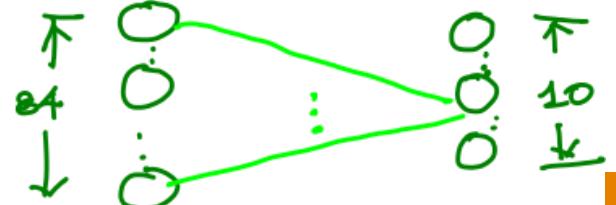
"Flattening"



Second layer (S2) "Sub-sampling" or Average Pooling layer



⑥ Output layer





[Home Page](#)

[Title Page](#)

[Contents](#)

[Page 5 of 15](#)

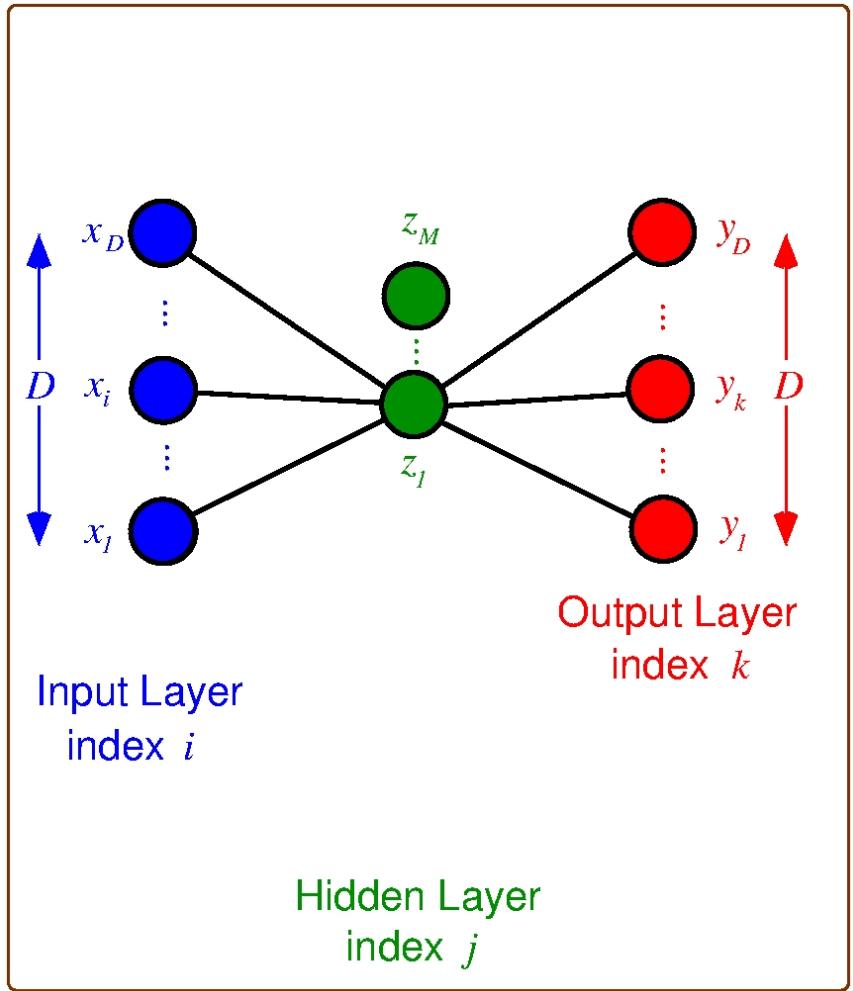
[Go Back](#)

[Full Screen](#)

[Close](#)

[Quit](#)

Bow-tie: Autoencoder





[Home Page](#)

[Title Page](#)

[Contents](#)

[◀](#) [▶](#)

[◀](#) [▶](#)

[Page 6 of 15](#)

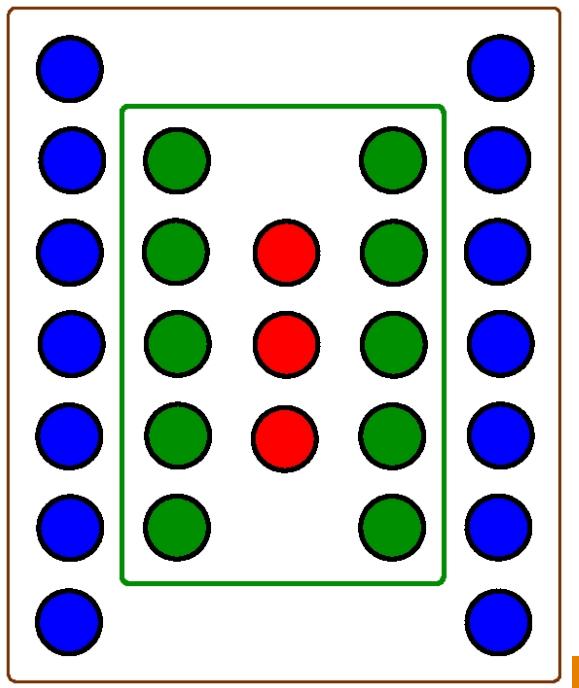
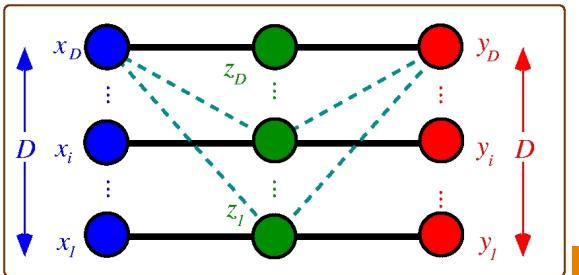
[Go Back](#)

[Full Screen](#)

[Close](#)

[Quit](#)

Bow-tie: Autoencoder (contd) ▶





[Home Page](#)

[Title Page](#)

[Contents](#)



[Page 7 of 15](#)

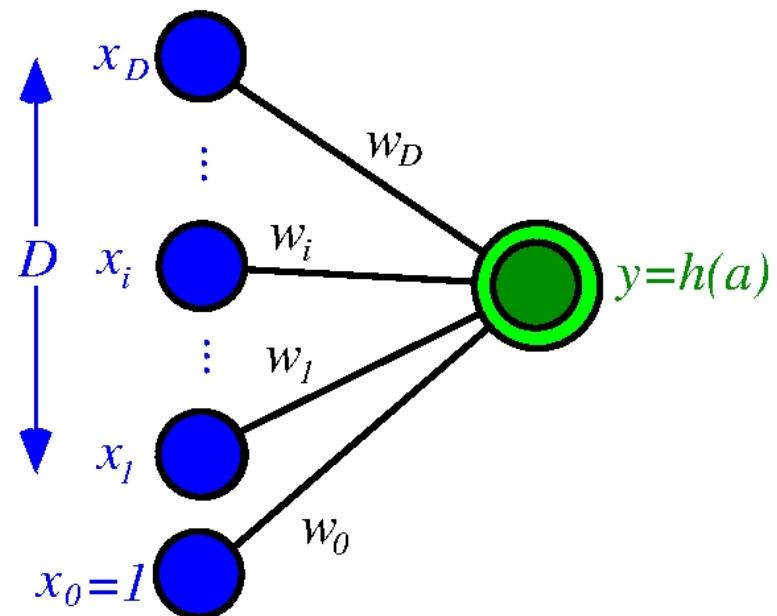
[Go Back](#)

[Full Screen](#)

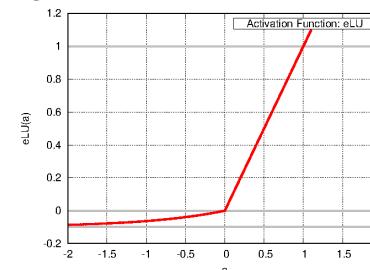
[Close](#)

[Quit](#)

Serrano's Perceptron-like NNs!



- A single-layer NN
- #neurons? [04:00]
- $h(a)$? $\sigma(a)$
- $y_i = \mathbf{w}^T \mathbf{x}_i + b$ or w_0
- b/w_0 : bias/thresh



- Activation fn: σ , $tanh$, ReLU, Leaky ReLU, eLU
- $\text{LeakyReLU}(a, \alpha) \triangleq \max(\alpha a, a)$, $\alpha \in (0, 1)$
- $eLU(a, \alpha) \triangleq \begin{cases} a, & a > 0 \\ \alpha(e^a - 1), & a \leq 0 \end{cases}$ [00:50]



Home Page

Title Page

Contents



Page 8 of 15

Go Back

Full Screen

Close

Quit

Angels & Demons: \s & Noise

https://d28hgpr18am2if.cloudfront.net/book_images/onix/cvr9780743493468/angels-demons-9780743493468_xlg.jpg

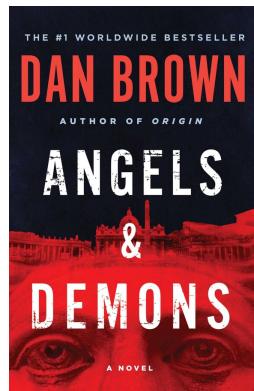
Acceptable backslashes (2×2 images):

0.75	0.00
0.00	0.75
1.00	0.25
0.25	0.75

1.00	0.00
0.00	1.00
0.75	0.00
0.25	0.75

0.25	0.00
1.00	0.75
0.25	1.00
0.50	0.75

0.75	0.50
0.75	0.00
1.00	1.00
0.00	0.75



• Building the Discriminator, by hand

• 1 possible fn: \sum Main Diag - \sum Other

$$\begin{array}{|c|c|} \hline 1.00 & 0.00 \\ \hline 0.00 & 1.00 \\ \hline \end{array} = +2.00 \quad \begin{array}{|c|c|} \hline 0.25 & 1.00 \\ \hline 0.50 & 0.75 \\ \hline \end{array} = -0.50$$

• Backslash: high response, noise: low



Home Page

Title Page

Contents



Page 9 of 15

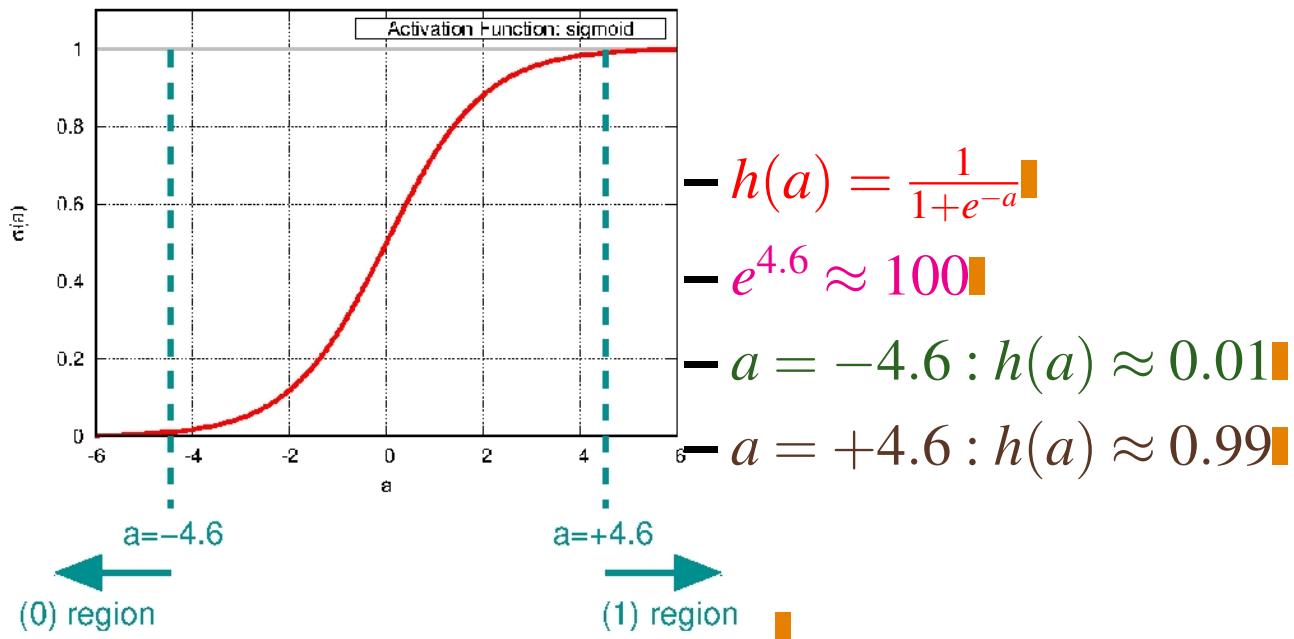
Go Back

Full Screen

Close

Quit

- To translate the fn into a NN: \sum weights +1, -1
- To translate the score $\in (-\infty, +\infty)$ into a prob:





Home Page

Title Page

Contents



Page 10 of 15

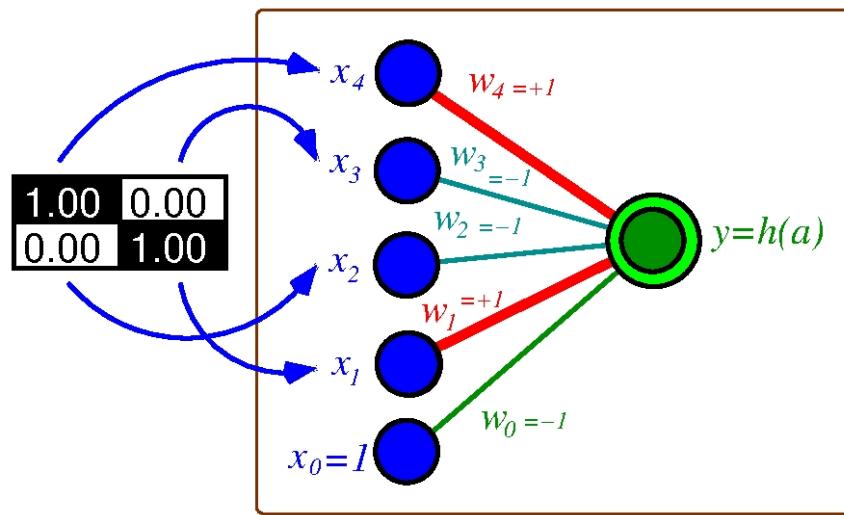
Go Back

Full Screen

Close

Quit

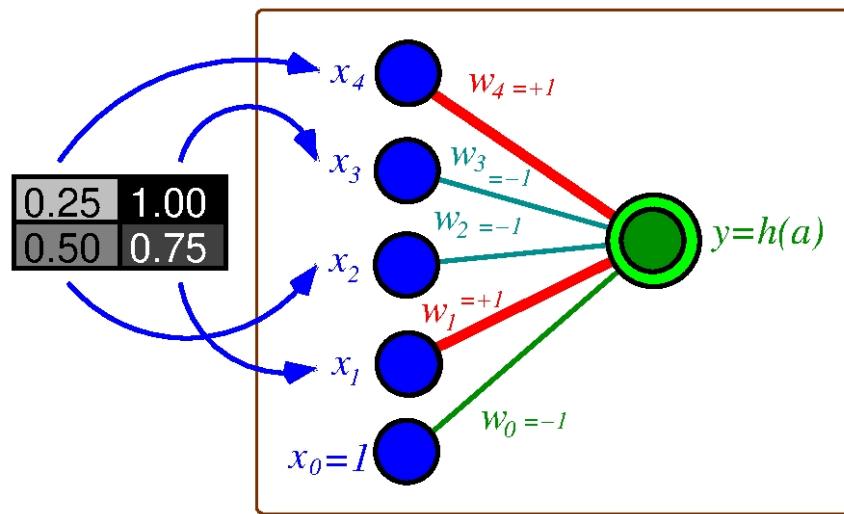
Discriminator: Backslash & Noise



- $a = 1.00(+1) + 0.00(-1) + 0.00(-1) + 1.00(+1) + 1(-1) = +1.00$

- $\sigma(+1.00) = 0.73$

- $\sigma(\cdot) : \uparrow \# \rightarrow \uparrow prob$



- $a = 0.25(+1) + 1.00(-1) + 0.50(-1) + 0.75(+1) + 1(-1) = -0.50$

- $\sigma(-1.50) = 0.37$

- $\sigma(\cdot) : \downarrow \# \rightarrow \downarrow prob$



[Home Page](#)

[Title Page](#)

[Contents](#)

[◀](#) [▶](#)

[◀](#) [▶](#)

[Page 11 of 15](#)

[Go Back](#)

[Full Screen](#)

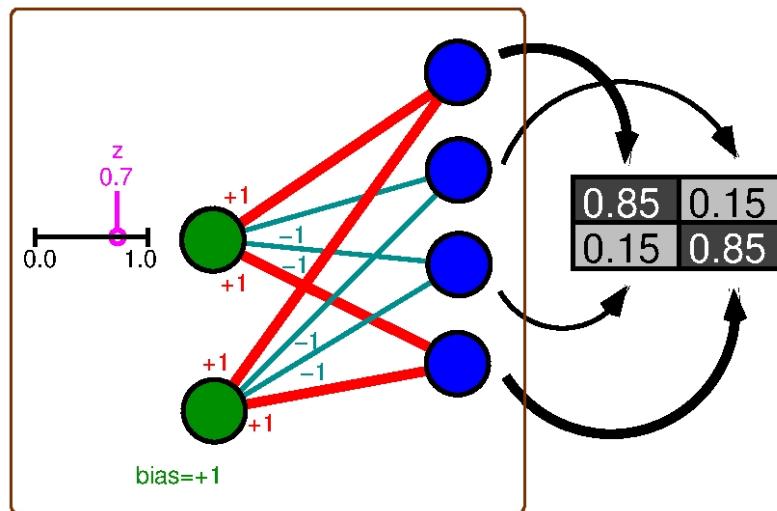
[Close](#)

[Quit](#)

Building the Generator

- High (+1) wt: main diag (#1, #4), Low (-1): other

$$\begin{aligned}\rightarrow a_4 &= 0.70(+1) + \\ &\quad 1.00(+1) = +1.7 \\ \rightarrow a_3 &= 0.70(-1) + \\ &\quad 1.00(-1) = -1.7 \\ \rightarrow a_2 &= 0.70(-1) + \\ &\quad 1.00(-1) = -1.7 \\ \rightarrow a_1 &= 0.70(+1) + \\ &\quad 1.00(+1) = +1.7\end{aligned}$$



- $\begin{cases} \sigma(+1.7) = 0.85, \sigma(-1.7) = 0.15 \\ \sigma(-1.7) = 0.15, \sigma(+1.7) = 0.85 \end{cases}$