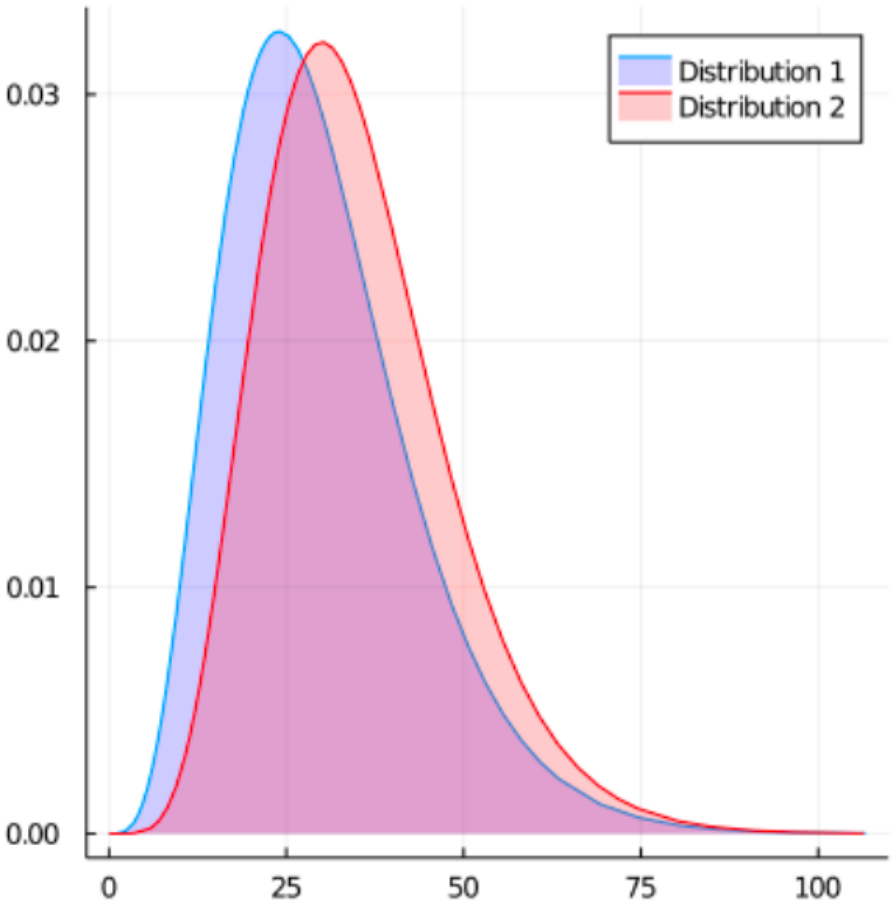
Machine Learning per la Fisica Applicata e la Fisica delle Alte Energie

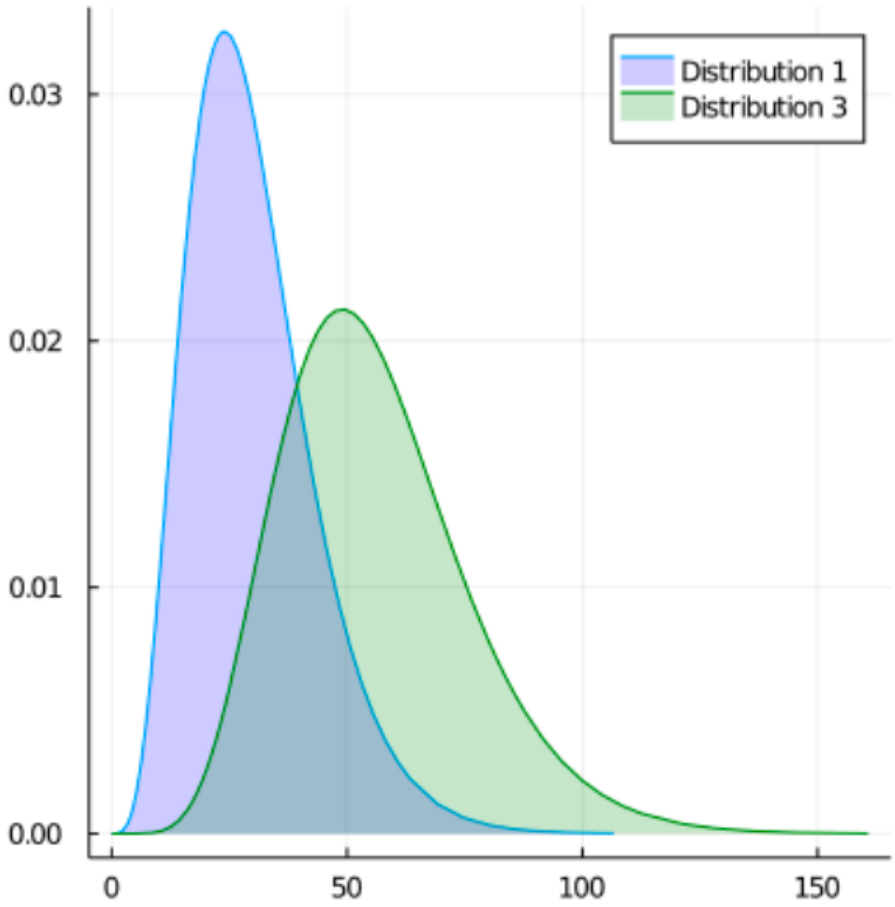
Lezione 24: Generative Adversarial Neural Networks

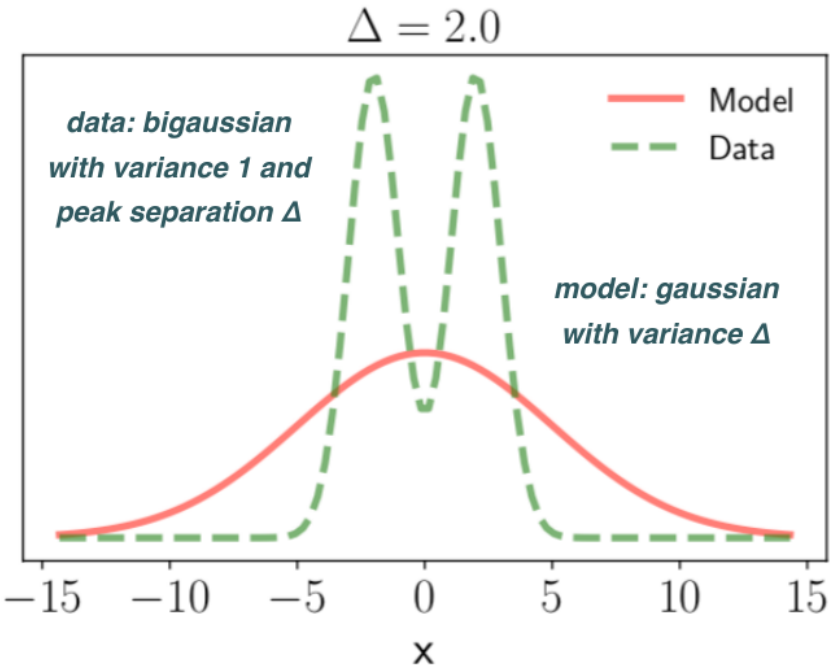
Emanuele R. Nocera

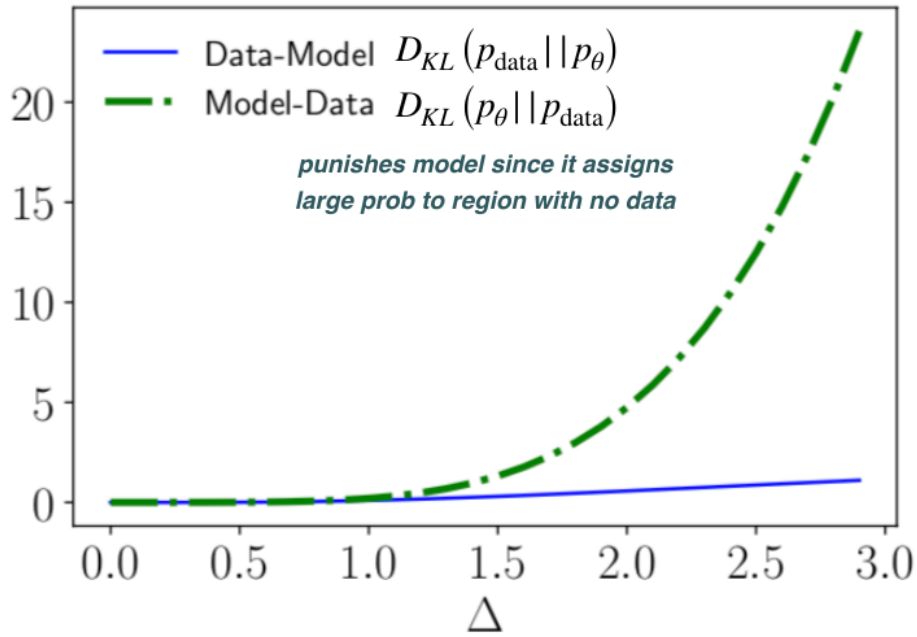
10 gennaio 2023

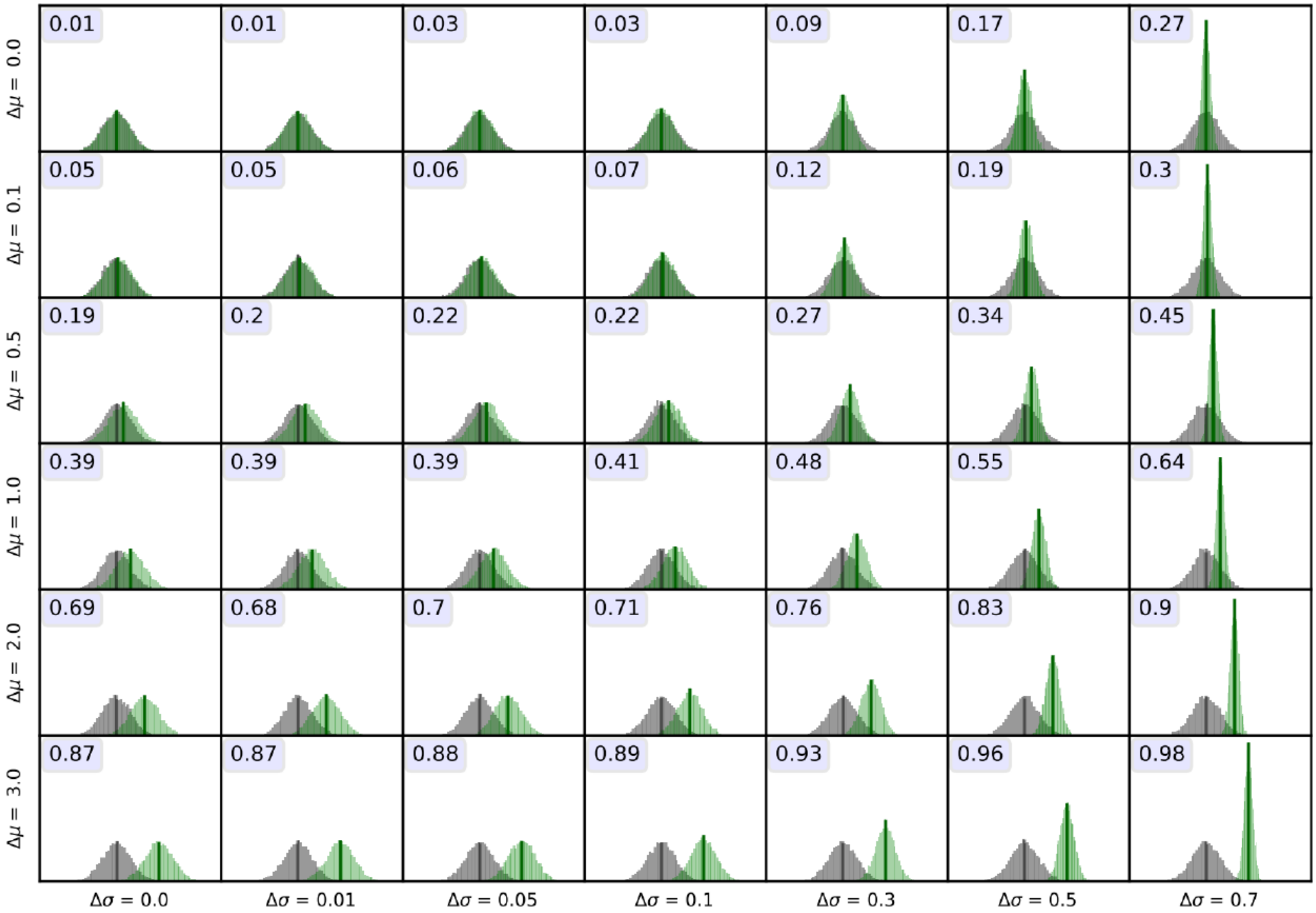
UNIVERSITÀ DI TORINO

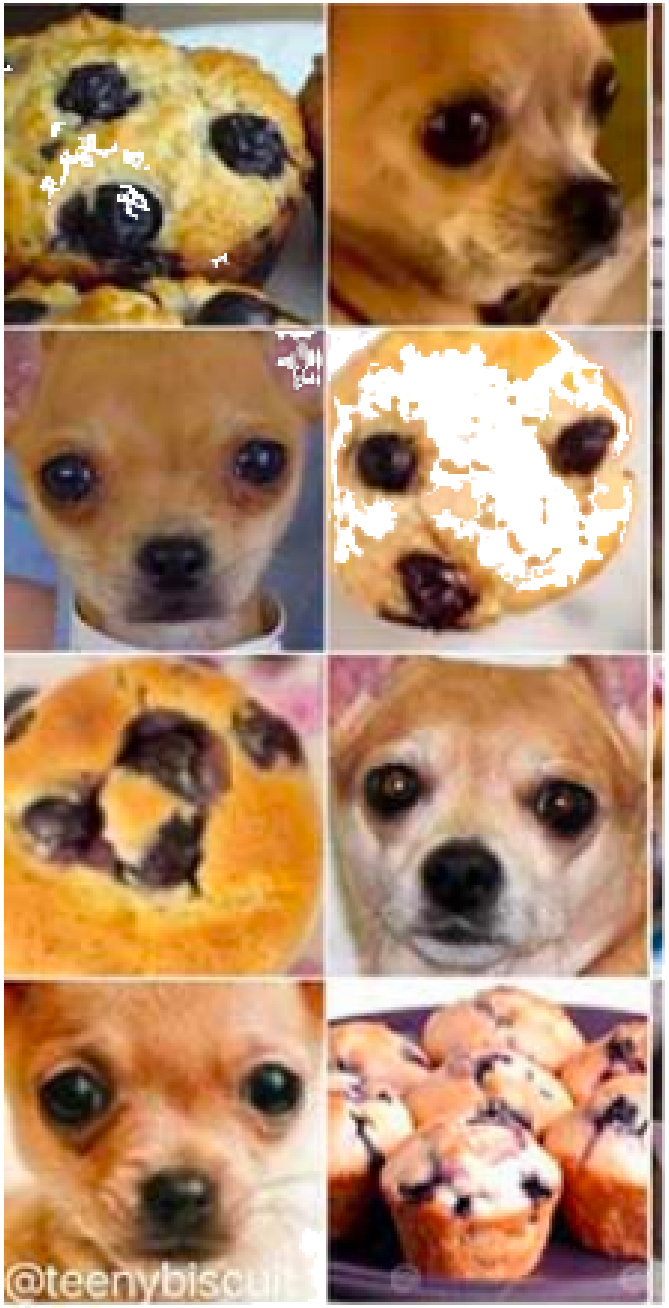

Distribution 1
Distribution 2
0.03
0.02
0.01
0.00
0
25
50
75
100


Distribution 1
Distribution 3
0.03
0.02
0.01
0.00
0
50
100
150

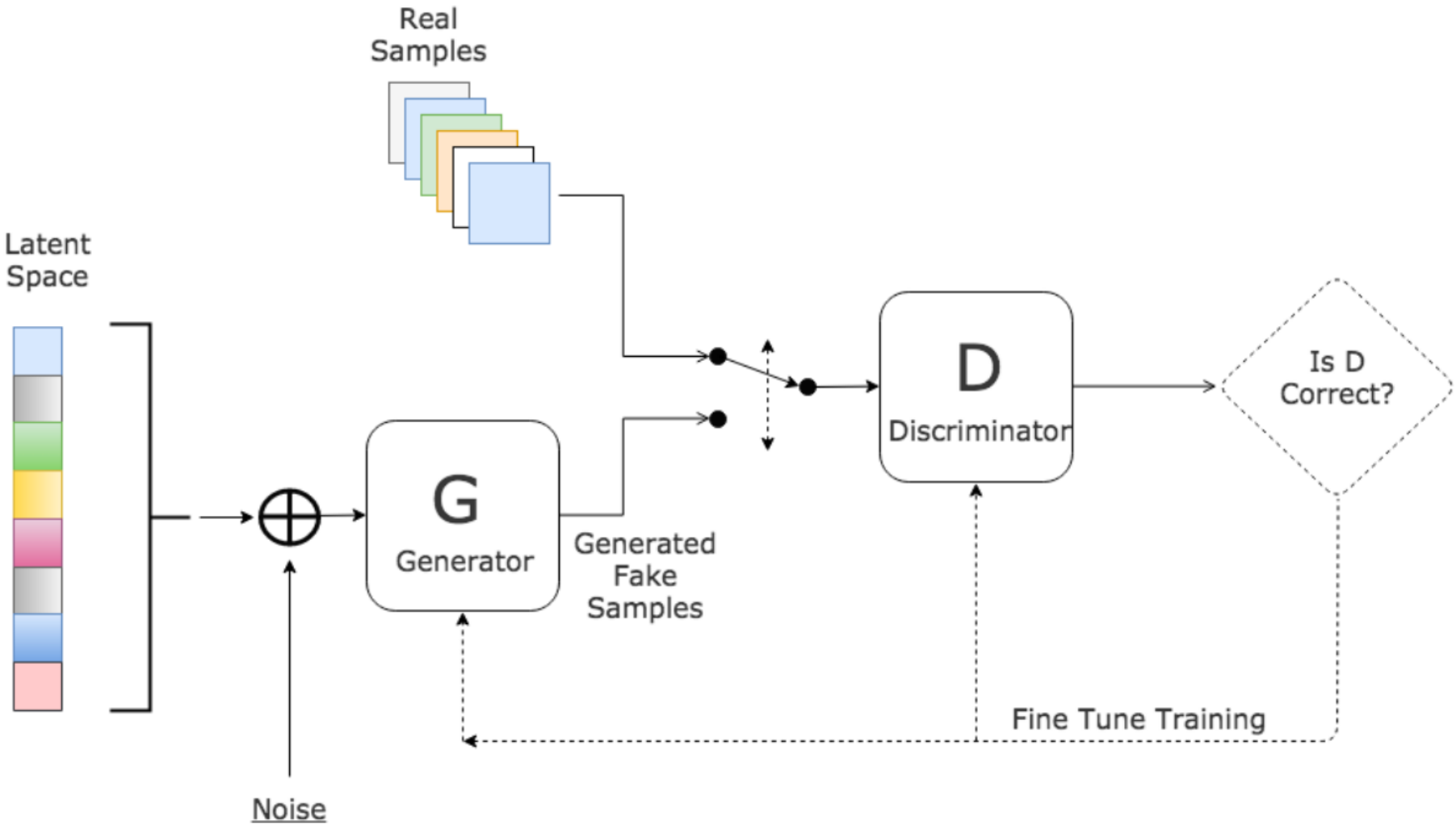

$\Delta = 2.0$
data: bigaussian with variance 1 and peak separation Δ
model: gaussian with variance Δ
Model
Data
−15
−10
−5
0
5
10
15
x


Data-Model $D_{KL}\left(p_{\text{data}}||p_\theta\right)$
Model-Data $D_{KL}\left(p_\theta||p_{\text{data}}\right)$
punishes model since it assigns large prob to region with no data
20
15
10
5
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Δ


0.01
0.01
0.03
0.03
0.09
0.17
0.27
0.05
0.05
0.06
0.07
0.12
0.19
0.3
0.19
0.2
0.22
0.22
0.27
0.34
0.45
0.39
0.39
0.39
0.41
0.48
0.55
0.64
0.69
0.68
0.7
0.71
0.76
0.83
0.9
0.87
0.87
0.88
0.89
0.93
0.96
0.98
Δμ = 0.0
Δμ = 0.1
Δμ = 0.5
Δμ = 1.0
Δμ = 2.0
Δμ = 3.0
Δσ = 0.0
Δσ = 0.01
Δσ = 0.05
Δσ = 0.1
Δσ = 0.3
Δσ = 0.5
Δσ = 0.7


@teenybiscuit

Generative Adversarial Network



for *epochs* $1, \cdots, N$ **do**

  for *discriminator steps* $1, \cdots, k$ **do**

    - Sample minibatch of size m from the real input sample: $\{x_r^{(1)}, \cdots, x_r^{(m)}\}$
    - Sample minibatch of size m from the latent space: $\{z^{(1)}, \cdots, z^{(m)}\}$
    - Perform gradient **ascent** on discriminator:

$$\nabla_\phi V(G_\theta, D_\phi) = \frac{1}{m} \nabla_\phi \sum_{i=1}^{m} \log D_\phi \left(x_r^{(i)} \right) + \frac{1}{m} \nabla_\phi \sum_{i=1}^{m} \log \left(1 - D_\phi \left(G_\theta \left(z^{(i)} \right) \right) \right)$$

  end

  for *generator steps* $1, \cdots, l$ **do**

    - Sample minibatch of size m from the latent space: $\{z^{(1)}, \cdots, z^{(m)}\}$
    - Perform gradient **descent** on generator:

$$\nabla_\theta V(G_\theta, D_\phi) = \frac{1}{m} \nabla_\theta \sum_{i=1}^{m} \log \left(1 - D_\phi \left(G_\theta \left(z^{(i)} \right) \right) \right)$$

  end

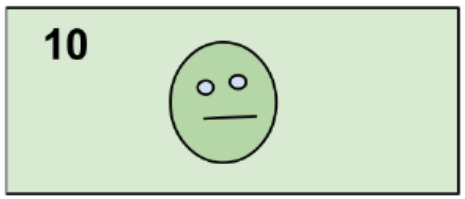
end

initial training

Generated Data | **Discriminator** | **Real Data**

FAKE **REAL**

intermediate training



FAKE **REAL**

long training

REAL **REAL**

convergence!!

Un mio parente

Un po' di arte