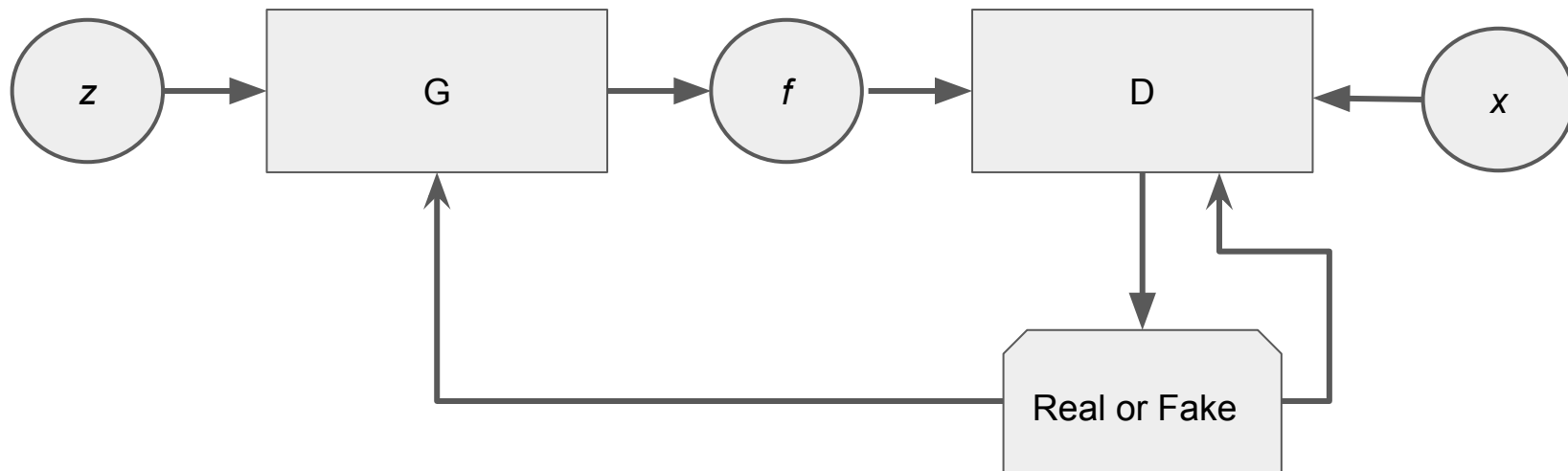


Генеративно-состязательные сети

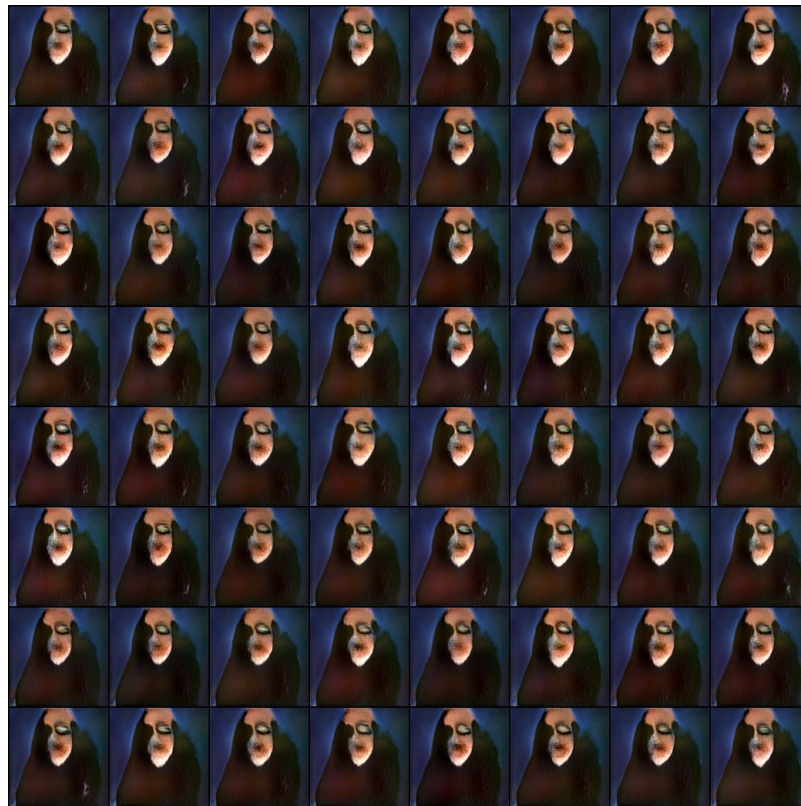
Концепция и трюки

Концепция GAN



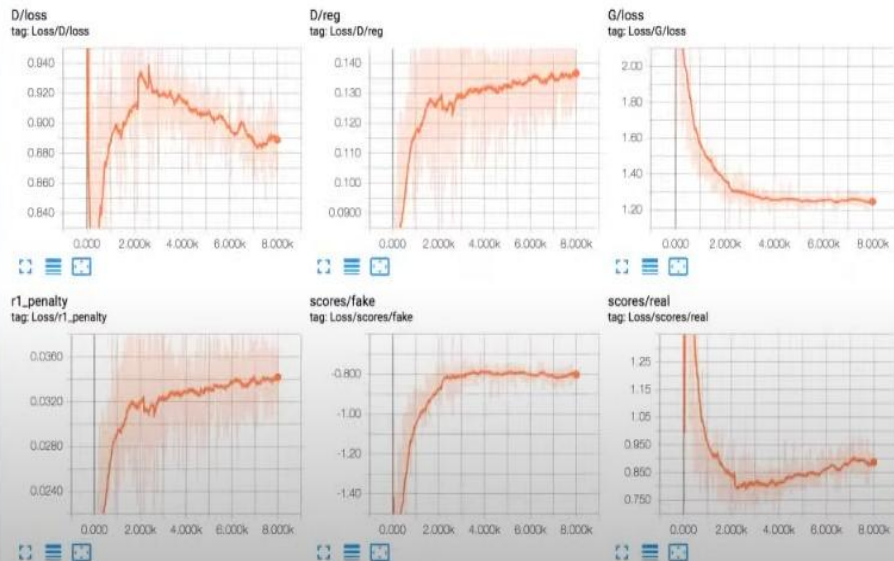
GAN collaps

- mode collaps
- mode dropping
- divergence
- OOM



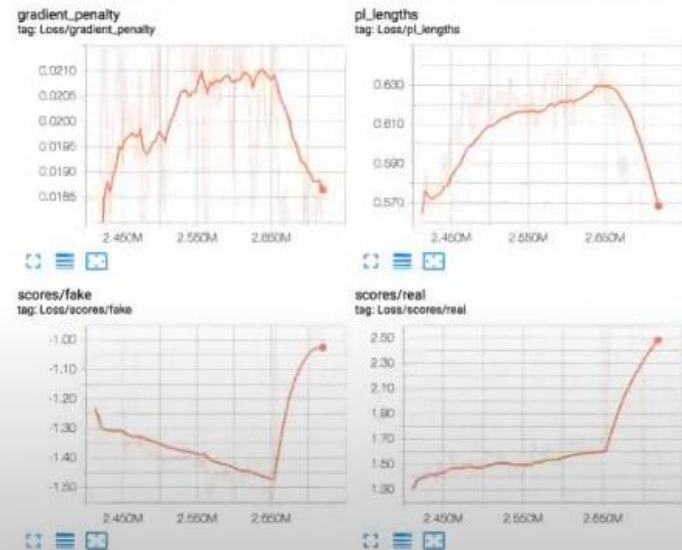
GAN collaps

(Almost) typical run



Collapse

Loss



GAN losses: standart

$$E_x[\log(D(x))] + E_z[\log(1 - D(G(z)))]$$

1) D loss $\nabla_{\theta_d} \frac{1}{m} \sum_{i=1}^m \left[\log D(\mathbf{x}^{(i)}) + \log(1 - D(G(\mathbf{z}^{(i)}))) \right]$

2) G loss $\nabla_{\theta_g} \frac{1}{m} \sum_{i=1}^m \log(1 - D(G(\mathbf{z}^{(i)})))$

GAN losses: non-saturating loss

$$\max \log(D(G(z)))$$

GAN losses: Wasserstein loss

D loss
$$\min_D - \left(\mathbb{E}_{x \sim p_X} [D(x)] - \mathbb{E}_{z \sim p_Z} [D(G(z))] \right).$$

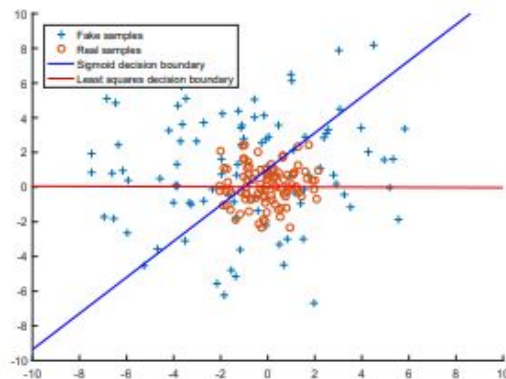
G loss
$$\min_G - \left(\mathbb{E}_{z \sim p_Z} [D(G(z))] \right).$$

- вместо sigmoid у D липшецева непрерывная функция
- осмысленная функция потерь коррелирующая с качеством образцов и сходимостью генератора
- повышенная стабильность процесса оптимизации
- нужно обрезать веса
- не использовать BN

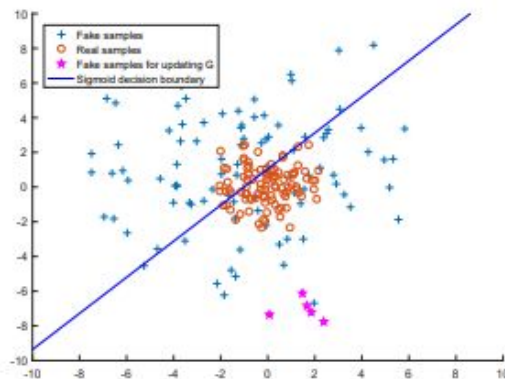
GAN Least Squares Loss

$$\min_D V_{LS}(D) = \frac{1}{2} \mathbb{E}_{\mathbf{x} \sim p_{data}(\mathbf{x})} \left[(D(\mathbf{x}) - b)^2 \right] + \frac{1}{2} \mathbb{E}_{\mathbf{z} \sim p_{data}(\mathbf{z})} \left[(D(G(\mathbf{z})) - a)^2 \right]$$

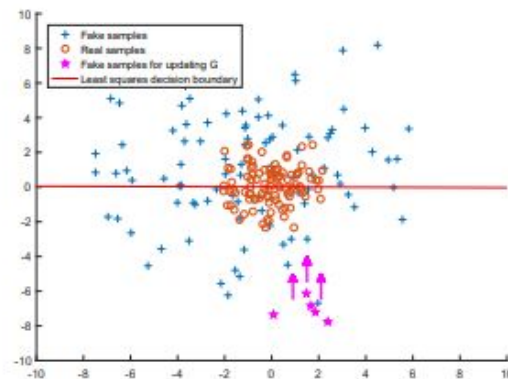
$$\min_G V_{LS}(G) = \frac{1}{2} \mathbb{E}_{\mathbf{z} \sim p_{\mathbf{z}}(\mathbf{z})} \left[(D(G(\mathbf{z})) - c)^2 \right]$$



(a)



(b)



(c)

GAN Hinge Loss

$$L_D = -\mathbb{E}_{(x,y) \sim p_{data}}[\min(0, -1 + D(x, y))] - \mathbb{E}_{z \sim p_z, y \sim p_{data}}[\min(0, -1 - D(G(z), y))]$$

$$L_G = -\mathbb{E}_{z \sim p_z, y \sim p_{data}} D(G(z), y)$$

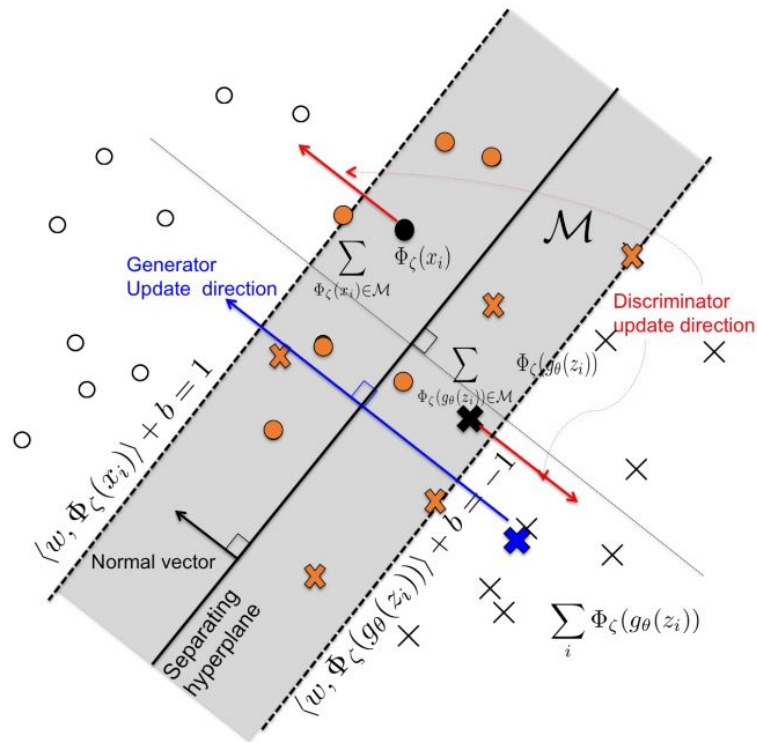
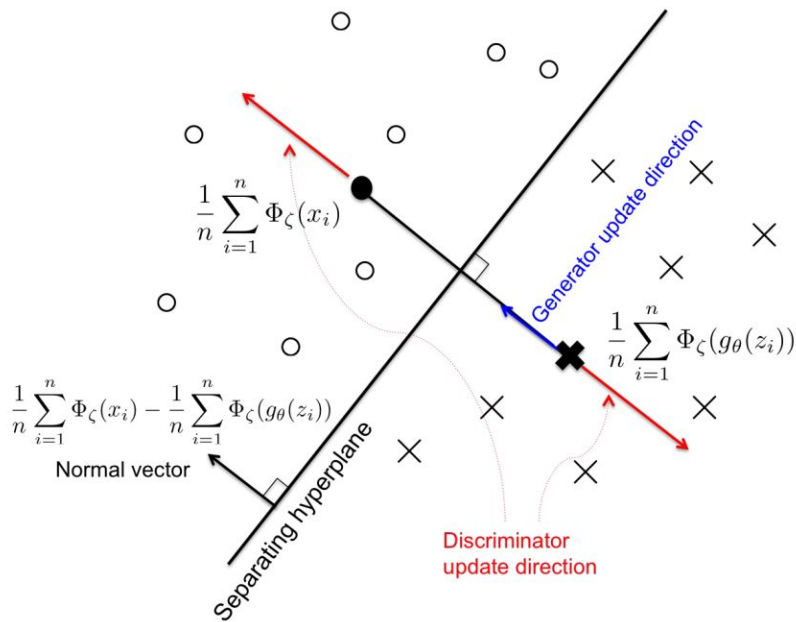


Figure 2: Geometry of the mean feature matching GAN.

DRAGAN

$$\lambda \cdot \mathbb{E}_{x \sim P_{real}, \delta \sim N_d(0, cI)} [\|\nabla_{\mathbf{x}} D_{\theta}(x + \delta)\|^2]$$

$$\lambda \cdot \mathbb{E}_{x \sim P_{real}, \delta \sim N_d(0, cI)} [\max(0, \|\nabla_{\mathbf{x}} D_{\theta}(x + \delta)\|^2 - k)]$$

История

- 1) 2014 64px Generative Adversarial Nets; Ian J. Goodfellow
- 2) 2016 128 px DCGAN
- 3) 2018 1024px ProGan
- 4) 2019 BigGan
- 5) StyleGAN 1-2-3
- 6) Stable Diffusion

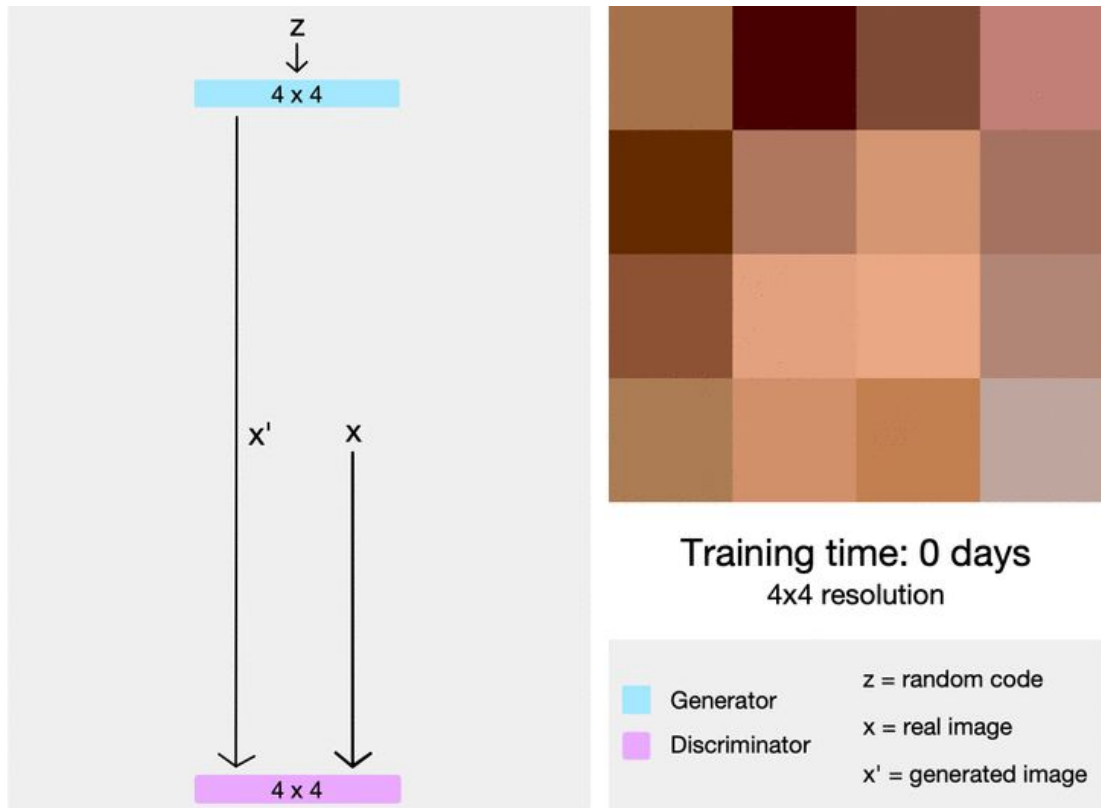
Регуляризация

$$R_1 = \frac{\gamma}{2} \mathbb{E}_{x \sim p_d} [\| \nabla D(x) \|^2]$$

$$R_2 = \frac{\gamma}{2} \mathbb{E}_{\hat{x} \sim p_g} [\| \nabla D(x) \|^2]$$

$$R_{\text{LC}} = \mathbb{E}_{x \sim p_d} [\| D(x) - \alpha_F \|^2] + \mathbb{E}_{\hat{x} \sim p_g} [\| D(G(\hat{x})) - \alpha_R \|^2]$$

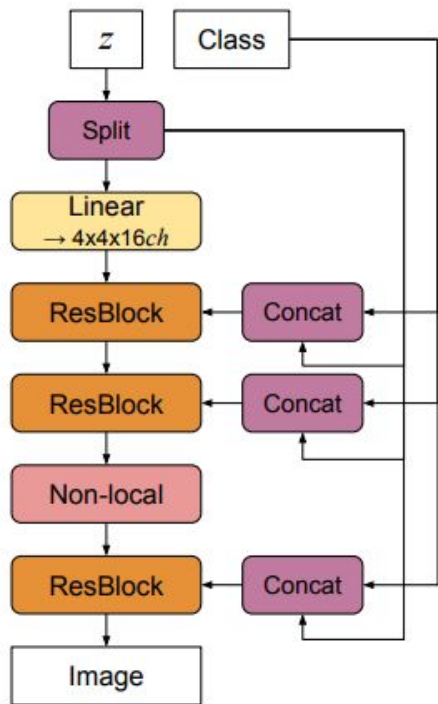
Progressive Training



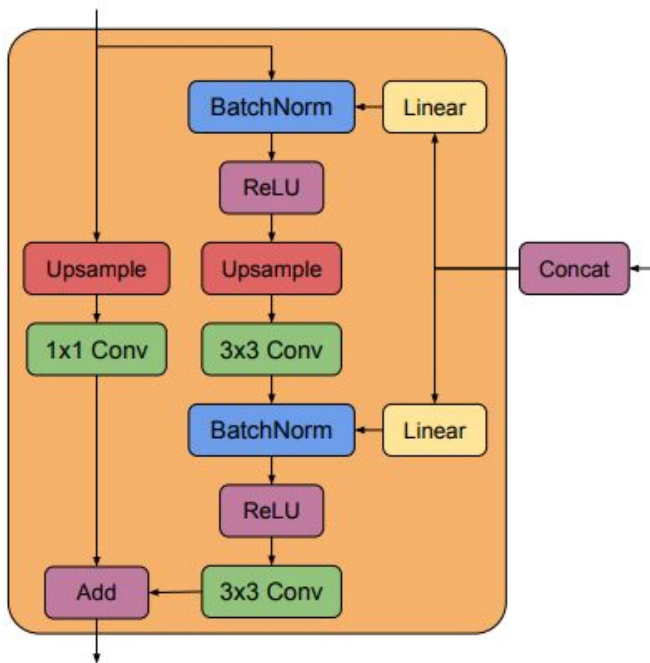
BigGAN

- генерация изображений из разных доменов
- Self-attention блоки
- conditional batch norm
- большие батчи
- нет пирамиды

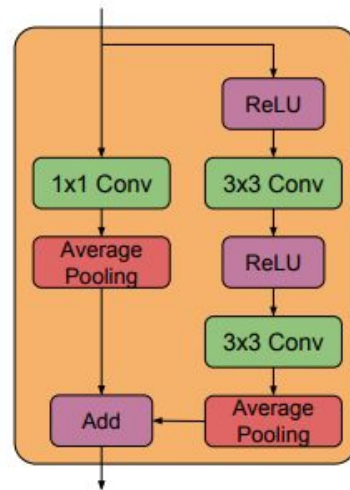
BigGAN



(a)

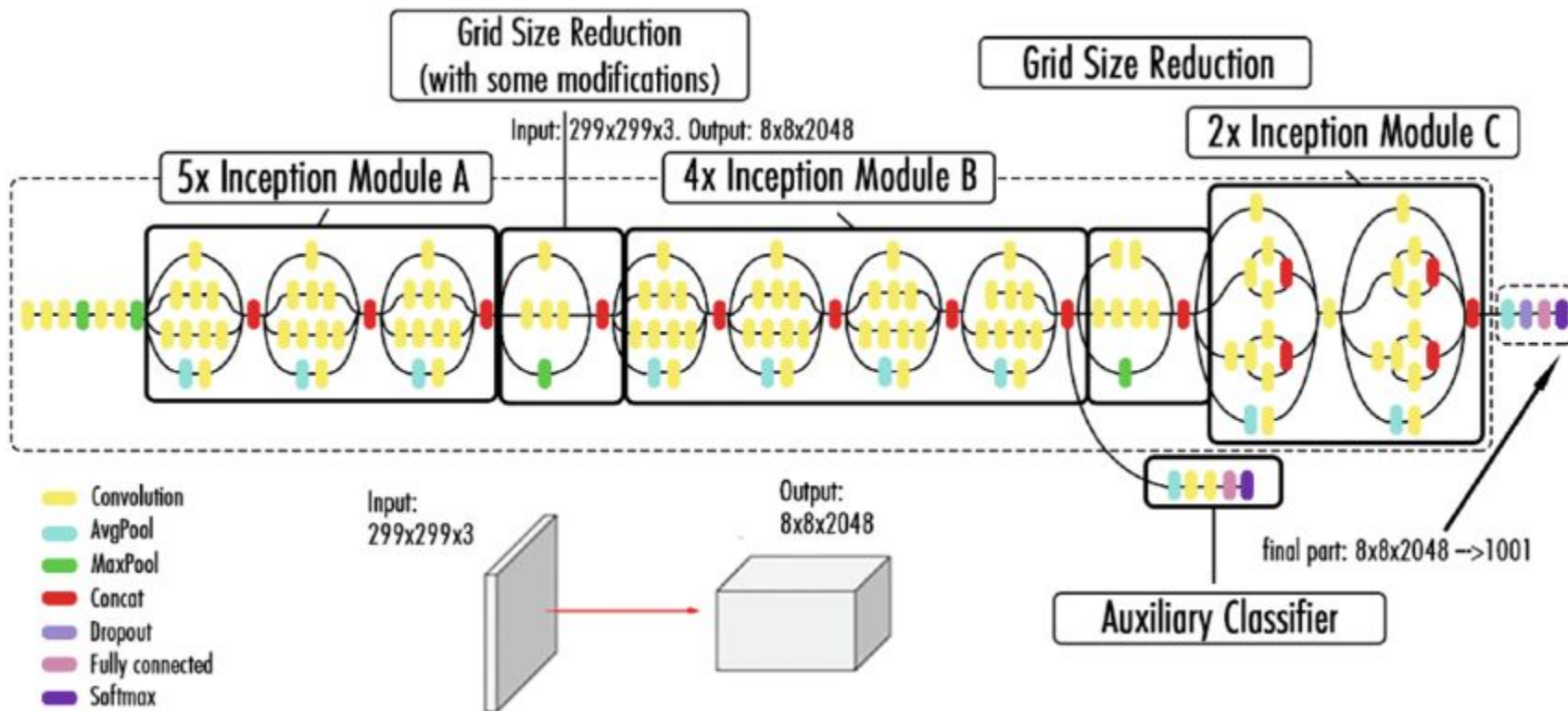


(b)



(c)

InceptionV3



Метрики

Inception score

$$IS(p_{gen}, p_{dis}) := \exp\left(\mathbb{E}_{x \sim p_{gen}} \left[D_{KL} \left(p_{dis}(\cdot|x) \parallel \int p_{dis}(\cdot|x) p_{gen}(x) dx \right) \right]\right)$$

FID

$$d^2 = \|\mu_1 - \mu_2\|^2 + \text{Tr}(C_1 + C_2 - 2 \cdot \text{sqrt}(C_1 \cdot C_2))$$

PSNR

$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right)$$

Почему FID не стабилен?

<https://arxiv.org/abs/2201.13019>

Structural Similarity Index

$$\mu_x = \frac{1}{N} \sum_{i=1}^N x_i$$

$$\sigma_x = \left(\frac{1}{N-1} \sum_{i=1}^N (x_i - \mu_x)^2 \right)^{1/2}$$

$$l(\mathbf{x}, \mathbf{y}) = \frac{2 \mu_x \mu_y + C_1}{\mu_x^2 + \mu_y^2 + C_1}$$

$$c(\mathbf{x}, \mathbf{y}) = \frac{2 \sigma_x \sigma_y + C_2}{\sigma_x^2 + \sigma_y^2 + C_2}$$

$$s(\mathbf{x}, \mathbf{y}) = \frac{\sigma_{xy} + C_3}{\sigma_x \sigma_y + C_3}.$$

$$c_1 = K_1 L$$

$$\text{SSIM}(\mathbf{x}, \mathbf{y}) = [l(\mathbf{x}, \mathbf{y})]^\alpha \cdot [c(\mathbf{x}, \mathbf{y})]^\beta \cdot [s(\mathbf{x}, \mathbf{y})]^\gamma$$

$$\text{SSIM}(\mathbf{x}, \mathbf{y}) = \frac{(2 \mu_x \mu_y + C_1) (2 \sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1) (\sigma_x^2 + \sigma_y^2 + C_2)}$$

Доп материалы

<https://www.youtube.com/watch?v=oEU-LNeA1Nc>

<https://github.com/Yangyangii/GAN-Tutorial>

<https://github.com/ChristophReich1996/Dirac-GAN>

<https://arxiv.org/pdf/1606.03498v1.pdf>

https://pytorch.org/hub/facebookresearch_pytorch-gan-zoo_pgan/