Self-Attention Generative Adversarial Networks

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Introduction

- Image synthesis
  - Remarkable progress: Emergence of GANs
  - GANs based on deep convolutional networks
    - SOTA ImageNet GAN Miyato and Koyama,2018
    - Self-attention
  - Self-Attention Generative Adversarial Networks(SAGANs)
    - Enforcing good conditioning of GAN generators
      using the spectral normalization technique
    - Inception Score (IS) from 36.8 to **52.52**
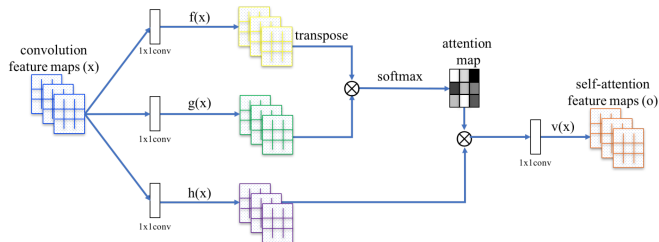   and reducing Frechet Inception Distance (FID) from 27.62 to **18.65**

Self-Attention Generative Adversarial Networks

Self-Attention Module

$$\beta_{j,i} = \frac{exp(s_{ij})}{\sum_{i=1}^{N} exp(s_{ij})}, \;\; where \; s_{ij} = \mathbf{f}(\mathbf{x}_i)^T \mathbf{g}(\mathbf{x}_j) \tag{1}$$

$$\mathbf{o} = (\mathbf{o_1}, \mathbf{o_2}, ..., \mathbf{o_j}, ..., \mathbf{o_N}) \in \mathbb{R}_{CxN},$$

$$where, \mathbf{o}_j = \mathbf{v}\left(\sum_{i=1}^{N} \beta_{j,i}\mathbf{h}(\mathbf{x}_i)\right), \;\; \mathbf{h(x_i)} = \mathbf{W_h x_i}, \;\; \mathbf{v(x_i)} = \mathbf{W_v x_i} \tag{2}$$

$$\mathbf{y_i} = \gamma\mathbf{o_i} + \mathbf{x_i} \tag{3}$$

Self-Attention Generative Adversarial Networks

Hinge version of the adversarial loss

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

$$L_G = -\mathbb{E}_{z_{p_z}, y \sim p_{data}} D(G(z), y), \tag{4}$$

Techniques to Stabilize the Training of GANs

- Spectral normalization in the generator as well as in the discriminator
- The two-timescale update rule (TTUR)
  - Spectral normalization (SN) for both generator and discriminator
    - Restricting the spectral norm of each layer
    - Does not require extra hyper-parameter tuning
    - Computational cost is relatively small
  - Imbalanced learning rate for generator and discriminator updates
    - Regularization of the discriminator often slows down the GAN's learning process
    - Using separate learning rates (TTUR)
    - Produce better results given the same wall-clock time

- Evaluation metrics
  - Inception Score (IS) and Frechet Inception Distance (FID)
- Network structures and implementation details
  - Evaluating the proposed stabilization techniques
  - Self-attention mechanism
  - Comparison with the state-of-the-art

Conclusion

- Self-Attention Generative Adversarial Networks (SAGANs)
  - The self-attention module
  - Spectral normalization and TTUR