Image colorization

DIGITAL IMAGE PROCESSING AND ANALYSIS PROJECT

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Problem description and motivation

- Input: grayscale image
- Output: color image

- Image colorization can be used for the restoration of historical images
- Traditional methods require a lot of time and expertise
- With advancements in deep learning, image colorization can be automated

Prior work

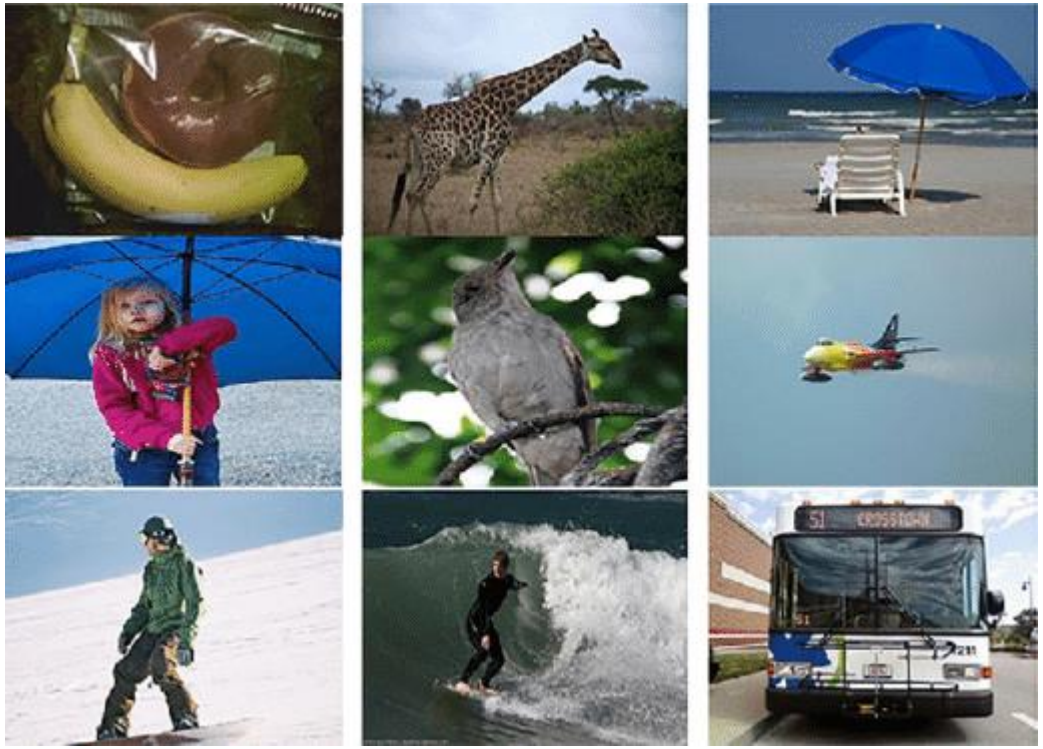
- Most traditional methods depend on user input
  - Scribble-Based Colorization

- Deep learning methods:
  - Convolutional neural networks – Colorful Image Colorization
  - Generative adversarial networks – cGAN, WGAN

COCO 2017 dataset

- Over 200 000 images
- 80 classes

- We used:
  - Train set: approx. 120 000 images
  - Test set: approx. 40 000 images

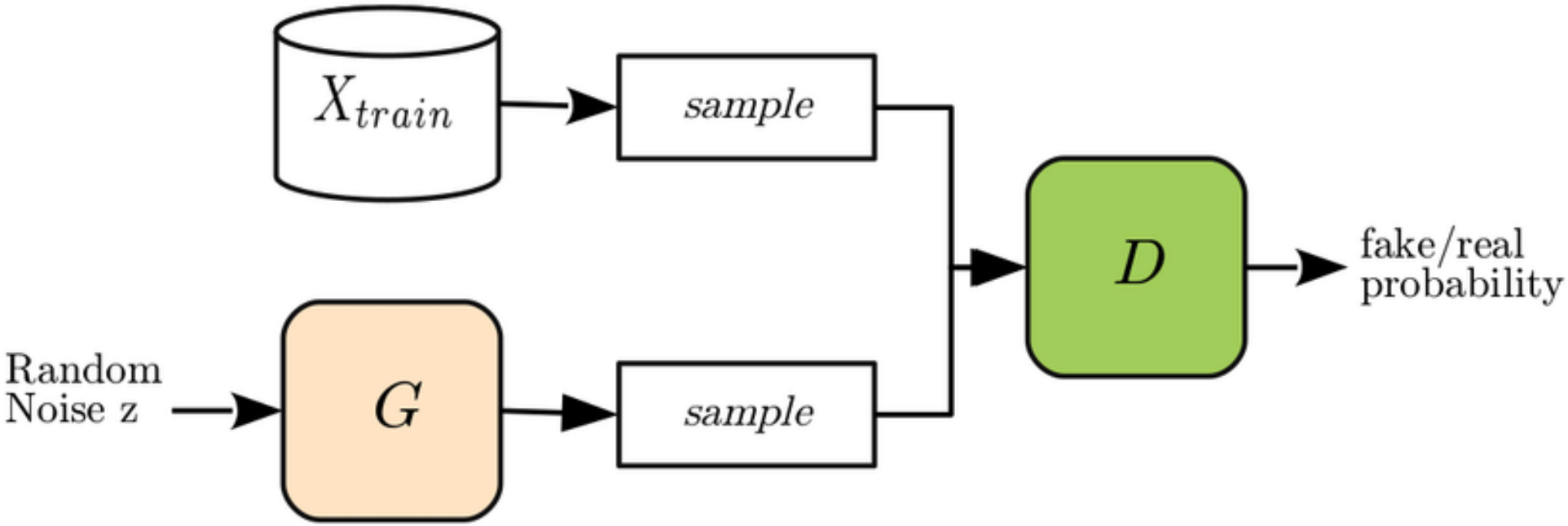


Generative adversarial networks

- Generator – generates images from random input vector
- Discriminator – detects if an image is real or generated
- Zero-sum game

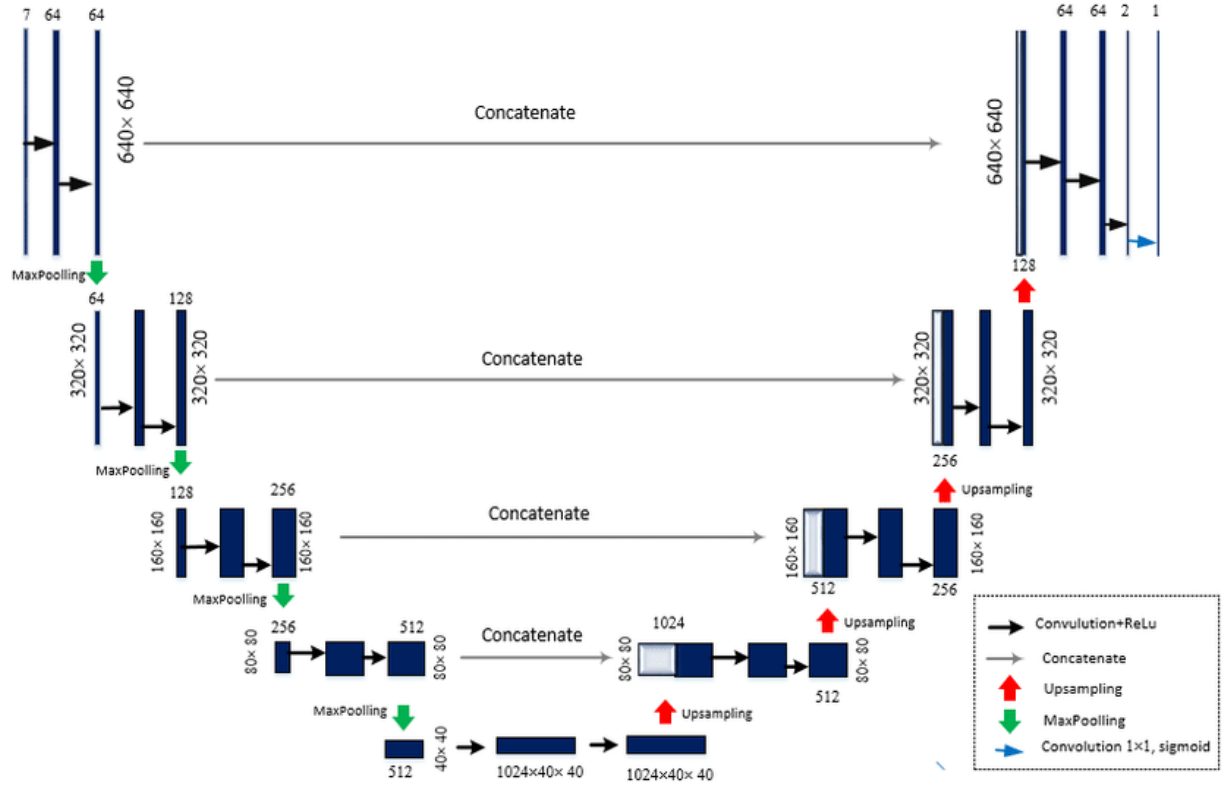
- Conditional GAN (cGAN) – conditional vector as input

Generative adversarial networks



Generative adversarial networks

- We used:
  - Generator: U-Net
  - Discriminator: CNN



Quality metrics

- Inception Score (IS)

$$\mathrm{IS}(G) = \exp\left(\mathbb{E}_{\mathbf{x} \sim p_g} D_{KL}(p(y|\mathbf{x}) \parallel p(y)) \right)$$

- Fréchet Inception Distance (FID)

$$FID = \|\mu_r - \mu_g\|^2 + Tr(\Sigma_r + \Sigma_g - 2(\Sigma_r \Sigma_g)^{1/2})$$

Experiments

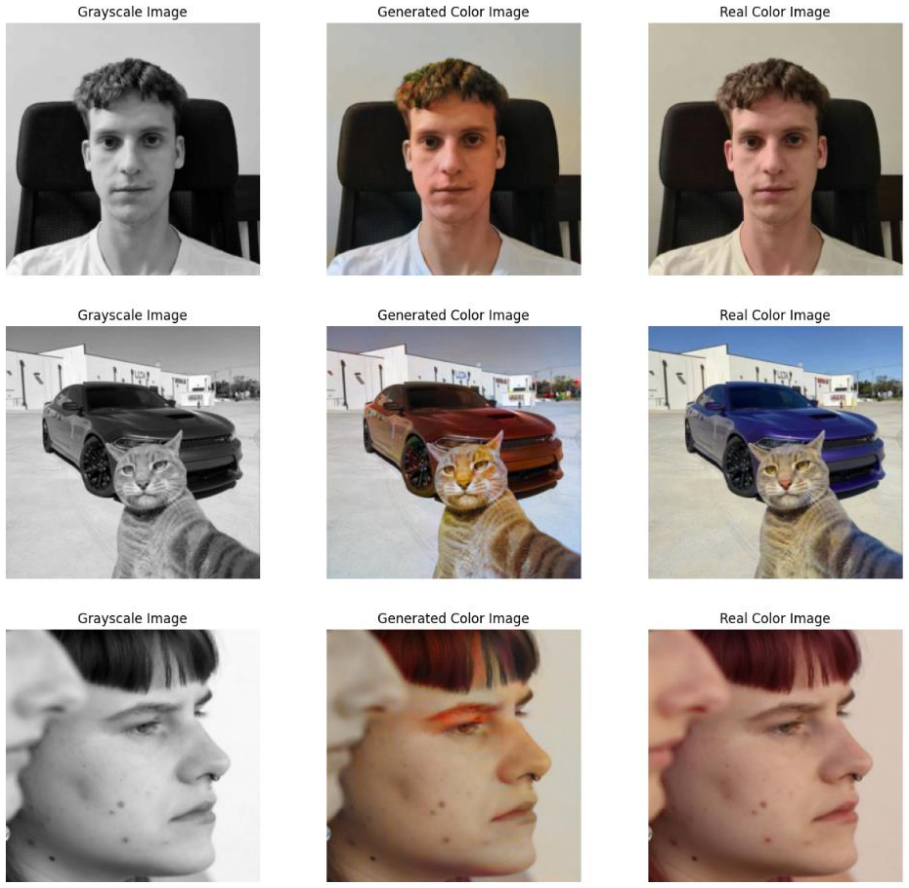
Experiment setup

- Input images were converted into CIELAB color space
- Generator gets grayscale image (L component) as input, generates A and B components
- Discriminator detects if the image is real or generated

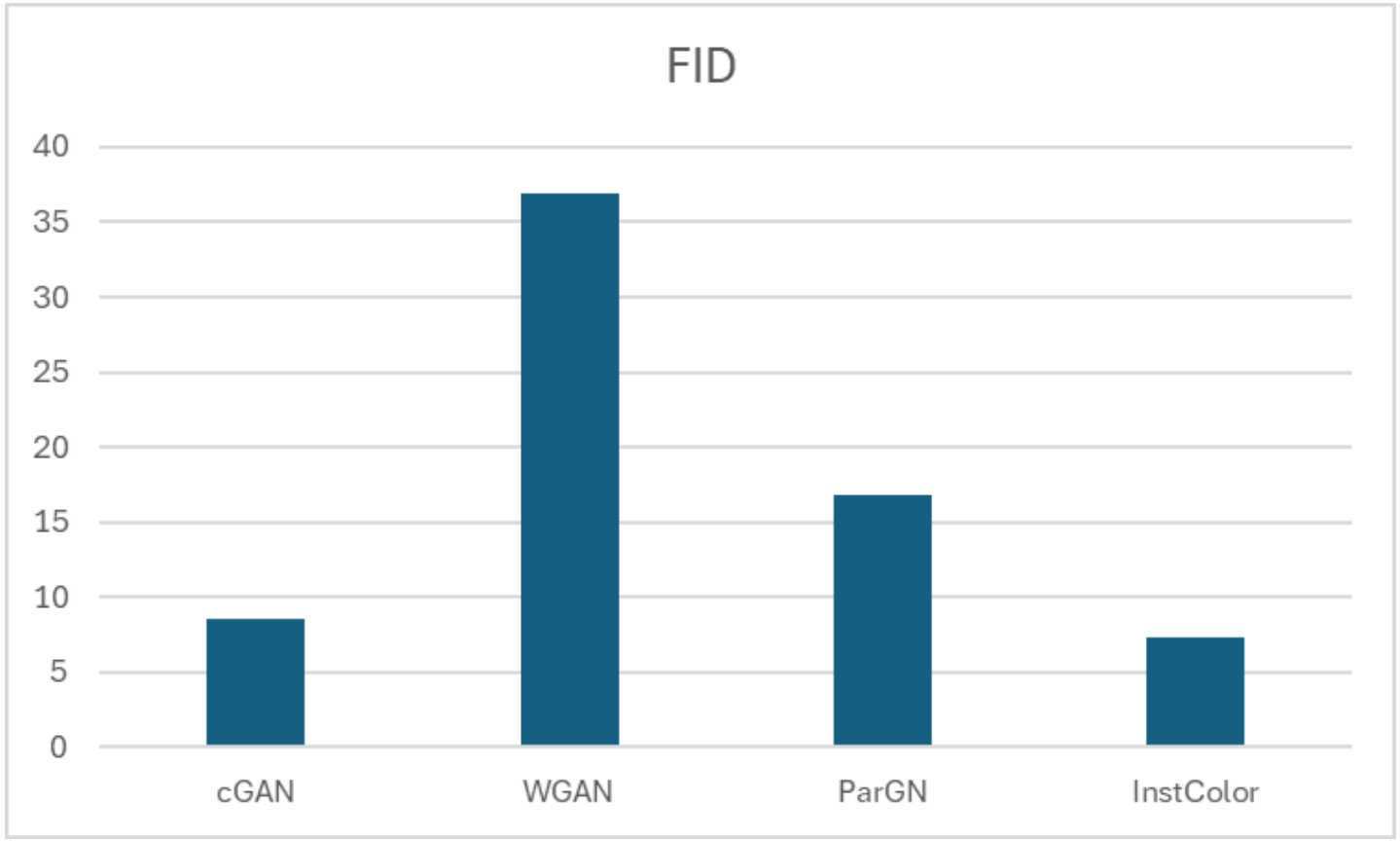
- Model training:
  - 200 epochs
  - Optimizer: Adam

Experiment results

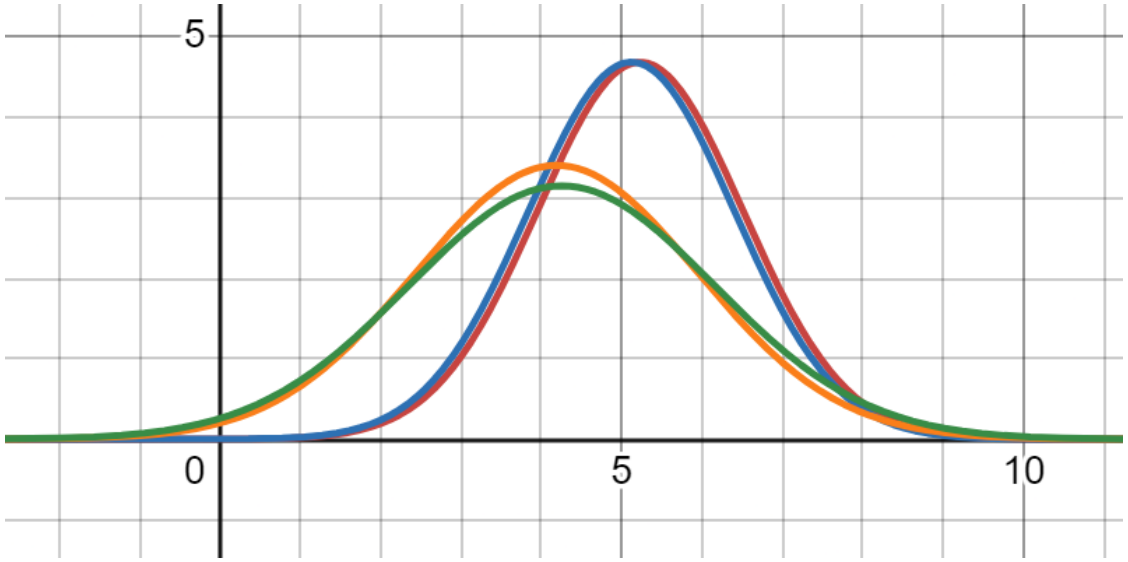
Experiment results



Comparison with prior work - FID



Comparison with prior work - IS



Blue (Real), Red (Generated) - cGAN

Green (Real), Orange (Generated) - WGAN

Conclusion

- cGAN architecture can be used to successfully colorize images
- Quality of colorization depends on the used dataset

- Future work:
  - Train model on bigger datasets (ImageNet)
  - Try different architectures (WGAN, diffusion models)

Thanks for your attention!