

Image Enhancement Using Deep Learning

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Introduction

Image enhancement - Adjusting images to make them more suitable for display or analysis

Super-resolution - Artificially increasing the level of detail on blurry or low-quality images



Applications

Face Recognition



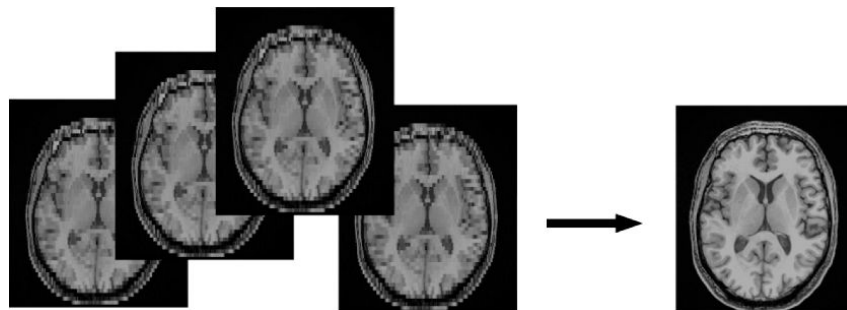
Satellite Mapping



License Plate OCR

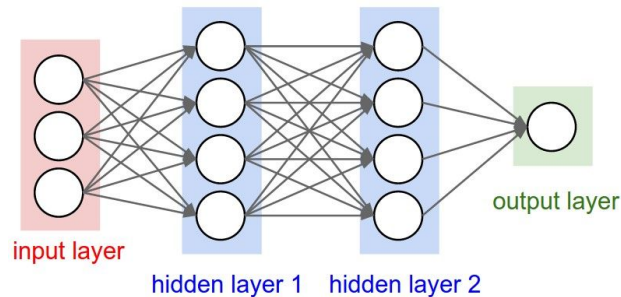


Medical Imaging

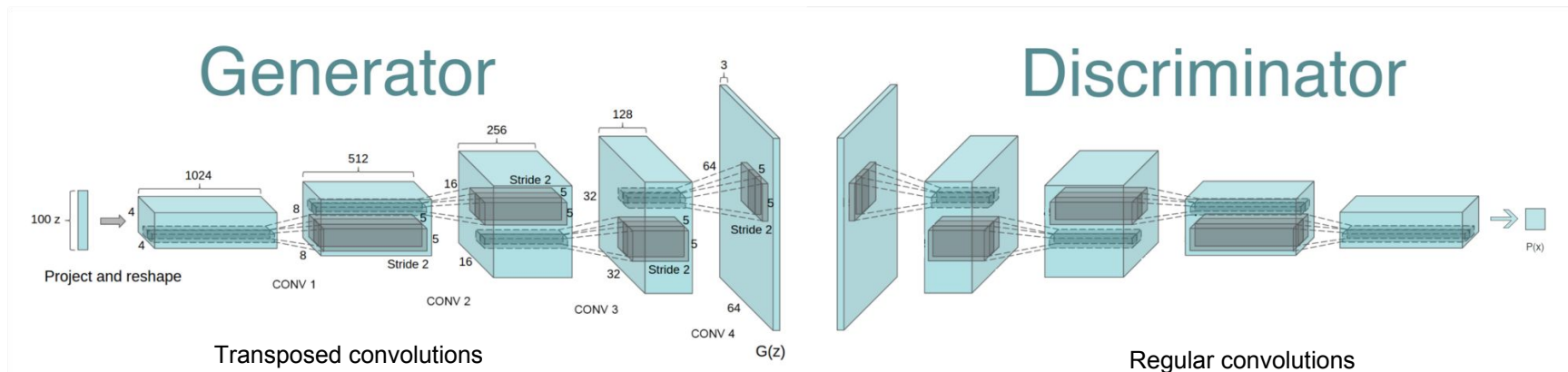


Methods

- Traditional
 - Data-independent, no training required
 - Usually based on fast fourier transforms
 - Forensic software, Adobe Photoshop
- Deep learning
 - Data-dependent, needs training
 - Convolutional neural networks
 - Variational autoencoders
 - **Generative adversarial networks**



Generative Adversarial Networks (GAN)

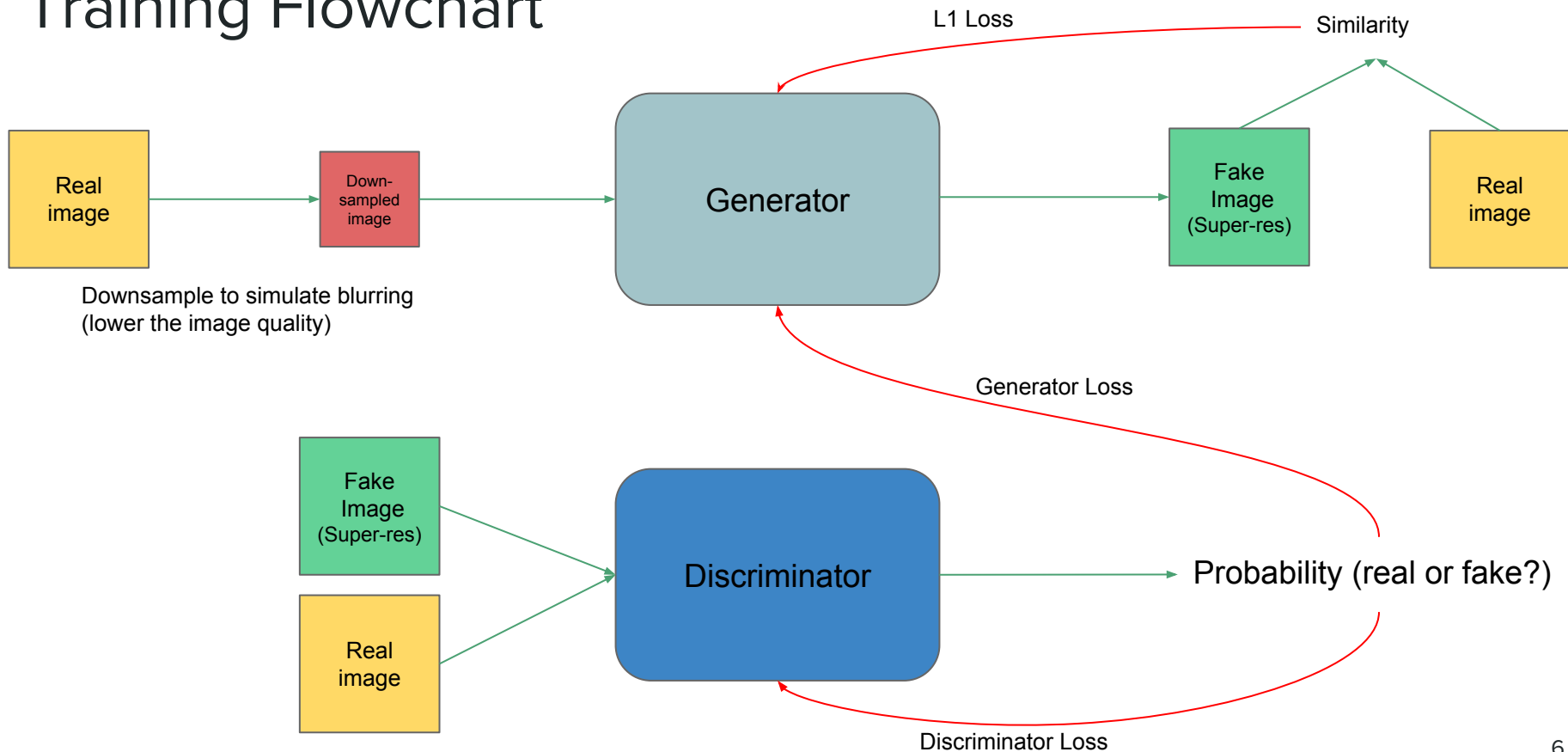


Learns to create fake images that can fool the Discriminator

Learns to distinguish between real and fake images

Goal is to create super-resolution images that look as real as possible and similar to the original image

Training Flowchart



Training Notes

- Multiple loss functions to optimize and balance
 - Generator L1 loss
 - How much does the generated image match the original
 - Generator Cross-entropy loss
 - How realistic the generated image looks (can it fool the Discriminator?)
 - Discriminator loss
 - How well the discriminator correctly classifies an image as real or fake
- Training will fail if the Discriminator overpowers Generator
 - Discriminator provides no useful information for Generator to learn
 - Very common problem with GANs
 - Must optimize hyperparameters or alter the model architecture
- Decent results achieved after several thousand iterations

Dataset

MNIST Digits

60k images



16x16 pixels
Downsampled to 4x4

Celebrity Faces

200k images



64x64 pixels
Downsampled to 16x16

Flowers

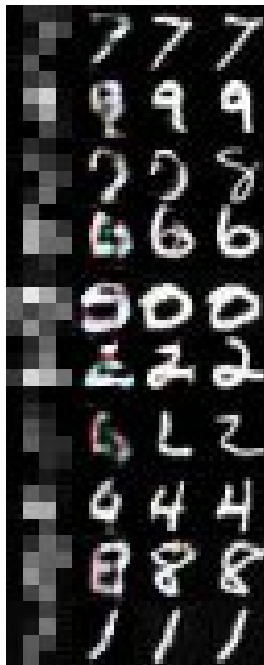
8k images



Results

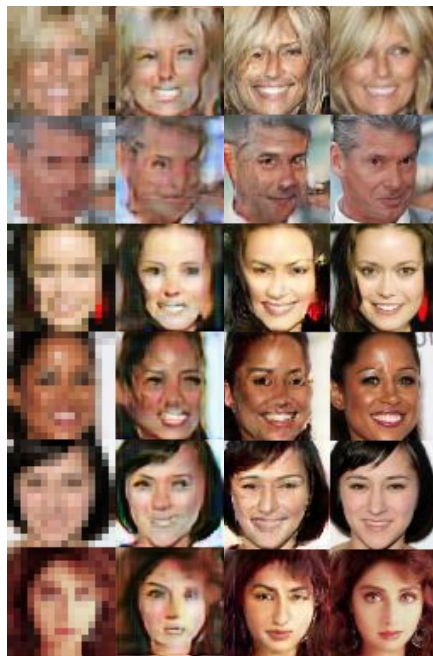
Digits

4x4 | 1k iterations | 20k iterations | Truth



Faces

16x16 | 1k iterations | 8k iterations | Truth



Flowers

16x16 | 1k iterations | 5k iterations | Truth



References

- Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks - <https://arxiv.org/abs/1511.06434>
- http://www.mathcs.emory.edu/~nagy/courses/fall06/ID_lecture1.pdf
- A hybrid MLP-PNN architecture for fast image superresolution - https://www.researchgate.net/publication/1957977_A_hybrid_MLP-PNN_architecture_for_fast_image_superresolution
- <https://www.mathworks.com/discovery/image-enhancement.html>
- <https://people.mpi-inf.mpg.de/~kkim/supres/supres.htm>
- A PCA-Based Super-Resolution Algorithm For Short Image Sequences - <https://arxiv.org/ftp/arxiv/papers/1201/1201.3821.pdf>
- <http://www.ifp.illinois.edu/~jyang29/papers/chap1.pdf>
- <https://github.com/david-gpu/srez>
- <https://github.com/reedscot/icml2016>