Deep Convolutional Generative Adversarial Networks based Uniform Image Processing Architecture

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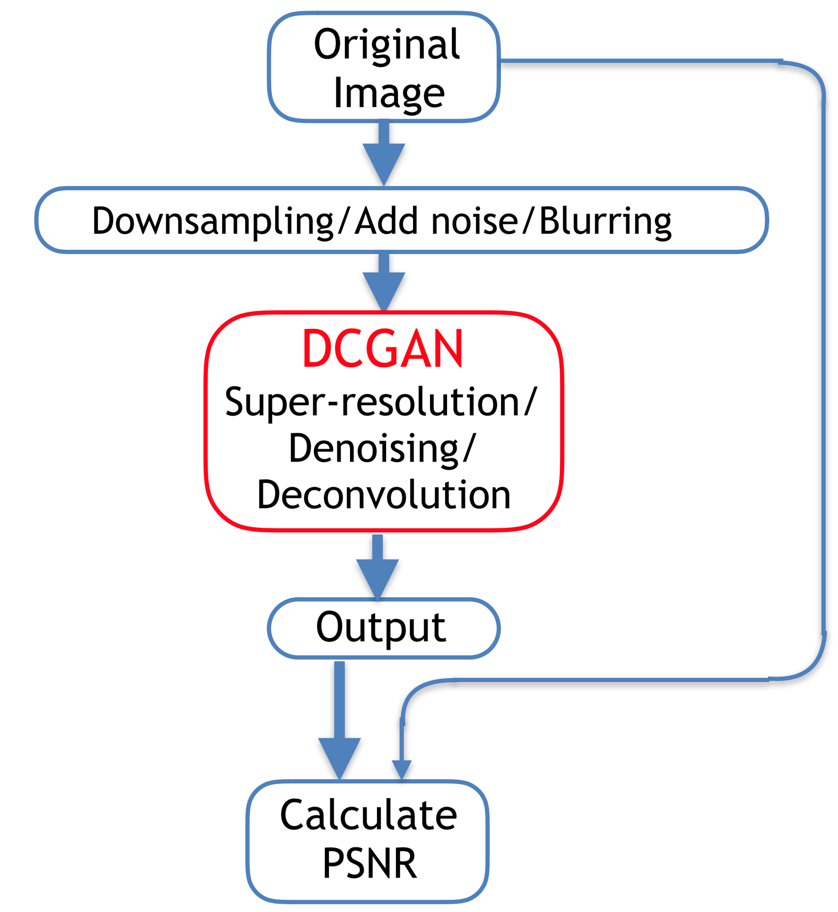
Motivation

Advance of computational power and big datasets brings the opportunity of using deep learning methods to do image processing. We explore the possibilities of using deep convolutional generative adversarial networks (DCGAN) to do various image processing tasks such as super-resolution, denoising and deconvolution. One advantage compared with traditional image processing is that DCGAN allows us to use a single architecture framework to achieve different objectives. In DCGAN, the competition between the generator and the discriminator push the generator to produce images that look more appealing. Also, compared to traditional methods, deep learning methods can learn from big datasets and use trained features to produce images from inputs that lack certain information. For example, with extremely low-resolution human face images as input, DCGAN can complete facial details and produce human faces that look authentic. We evaluated DCGAN on two type of dataset (human face and natural scenes). Our results show similar PSNR as conventional image processing methods and yet finer visual appeal.

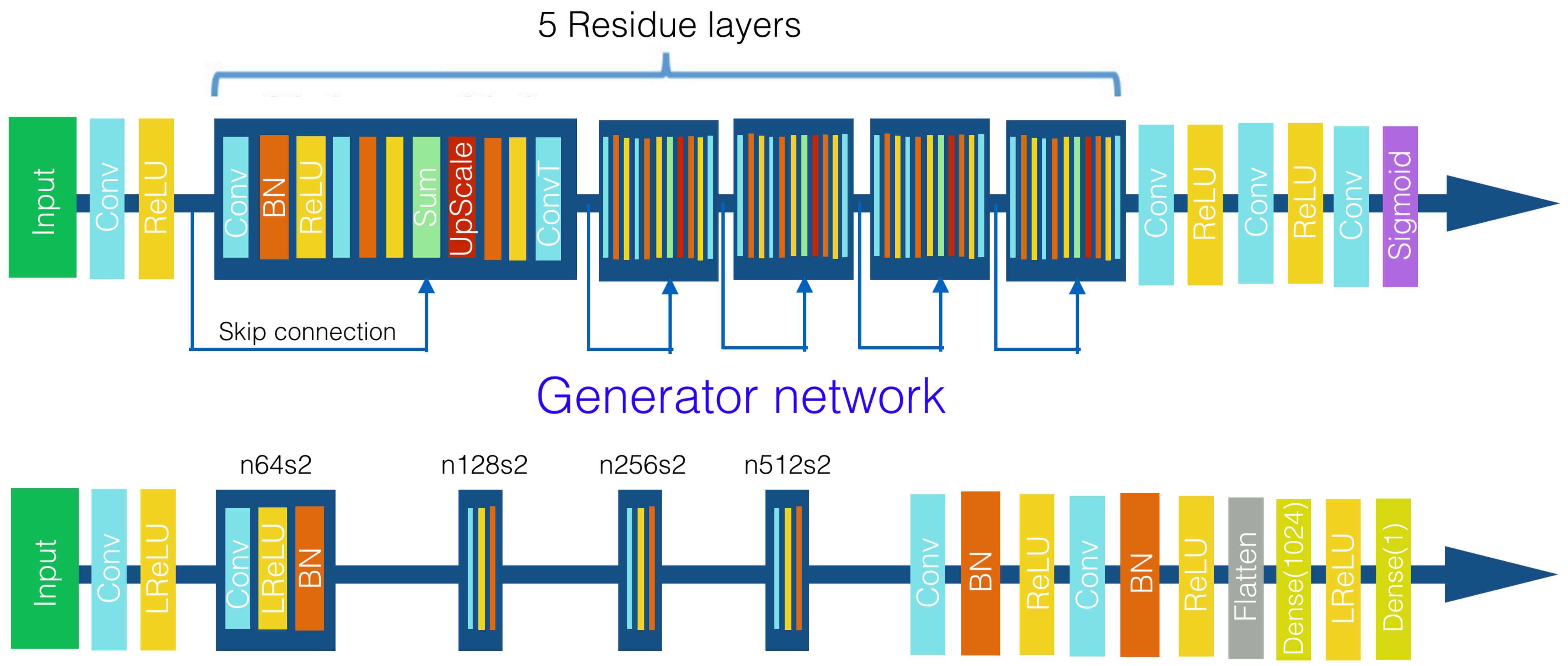
Related Work

- Ledig, C., Theis, L., Huszr, F., Caballero, J., Cunningham, A., Acosta, A., Aitken, A., Tejani, A., Totz, J., Wang, Z. and Shi, W., "Photo-realistic single image super-resolution using a generative adversarial network, in *arXiv preprint arXiv: 1609.04802 (2016)*.
- Liu, Z., Luo, P., Wang, X., & Tang, X. (2015). Deep learning face attributes in the wild. In *Proceedings of the IEEE International Conference on Computer Vision* (pp. 3730-3738).
- Xiao, J., Hays, J., Ehinger, K. A., Oliva, A., & Torralba, A. (2010, June). Sun database: Large-scale scene recognition from abbey to zoo. In *Computer vision and pattern recognition (CVPR), 2010 IEEE conference on* (pp. 3485-3492). IEEE.
- Goodfellow, Ian, et al. "Generative adversarial nets." *Advances in neural information processing systems*. 2014.
- David Garcia, Image super-resolution through deep learning, https://github.com/david-gpu/srez

DCGAN Model and Image Processing Pipeline



DCGAN Architecture

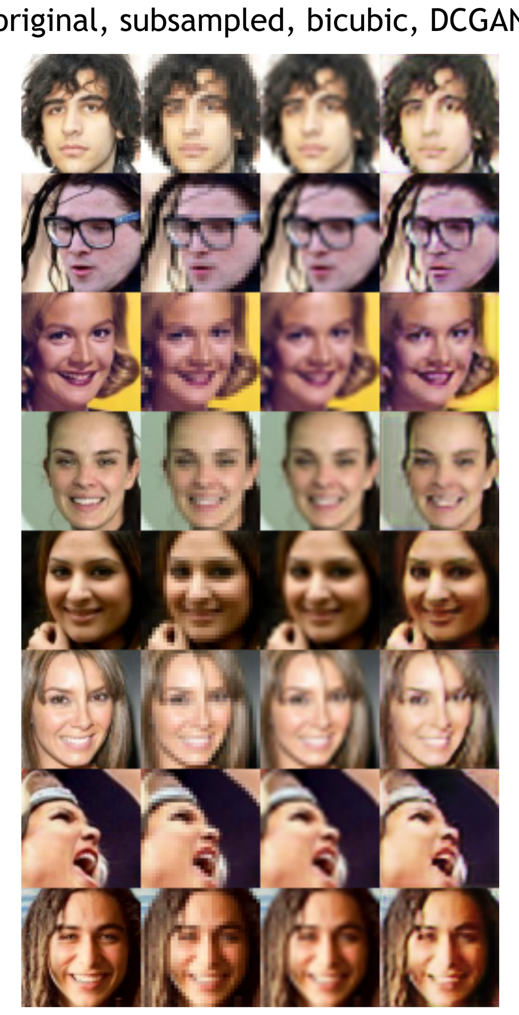


Generator network

Discriminator network

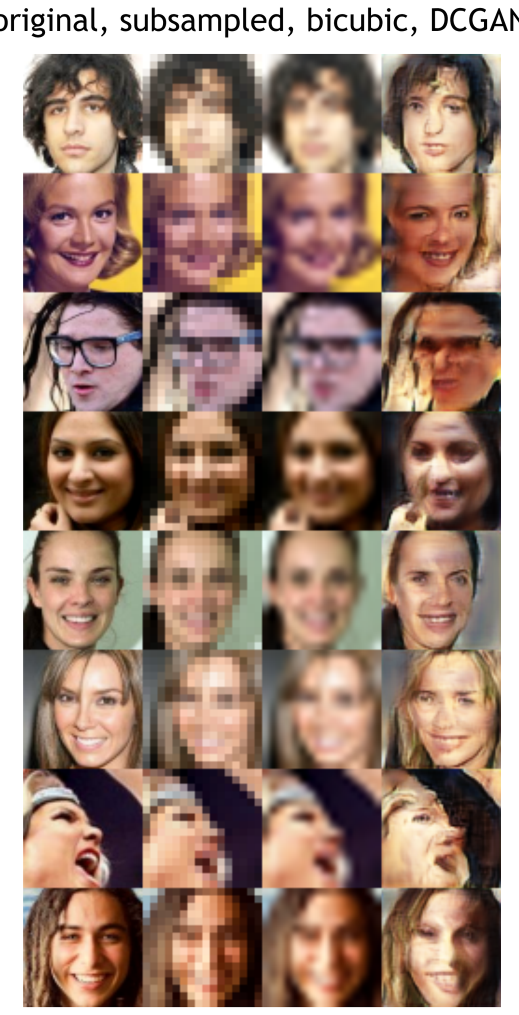
Experimental Results

human faces SR 2x
original, subsampled, bicubic, DCGAN



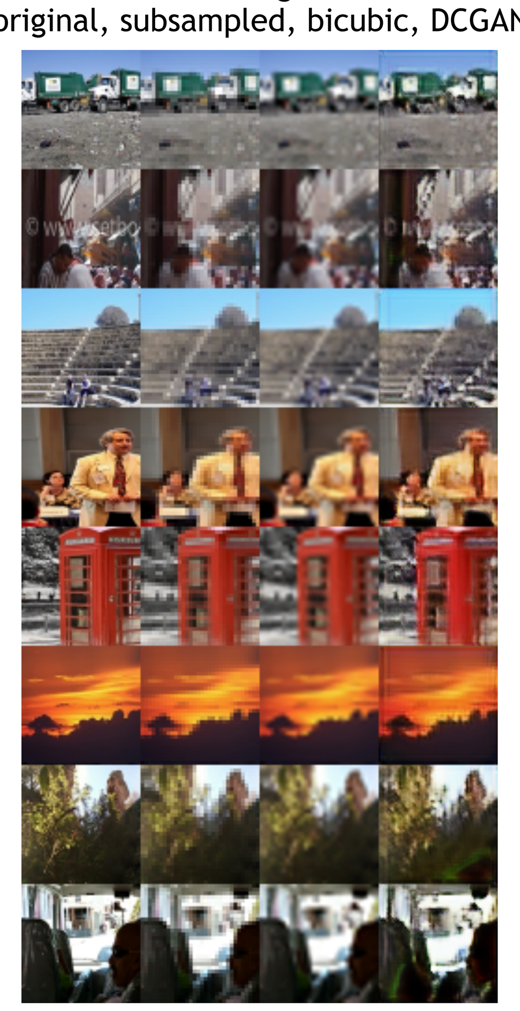
Method	PSNR mean (dB)	PSNR std
bicubic	26.5124	2.0854
DCGAN	24.7346	1.4364

human faces SR 4x
original, subsampled, bicubic, DCGAN



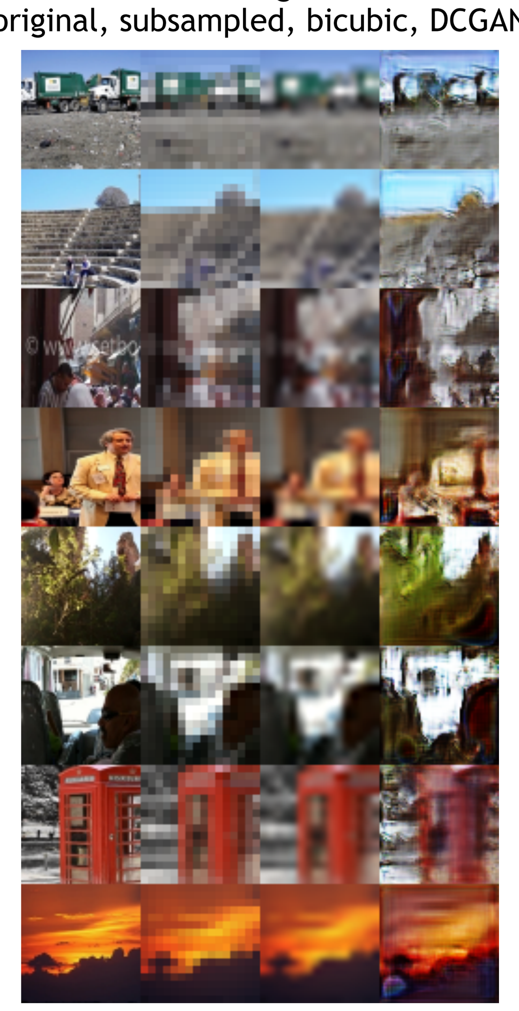
Method	PSNR mean (dB)	PSNR std
bicubic	21.3604	1.5173
DCGAN	17.1314	1.8369

natural images SR 2x
original, subsampled, bicubic, DCGAN



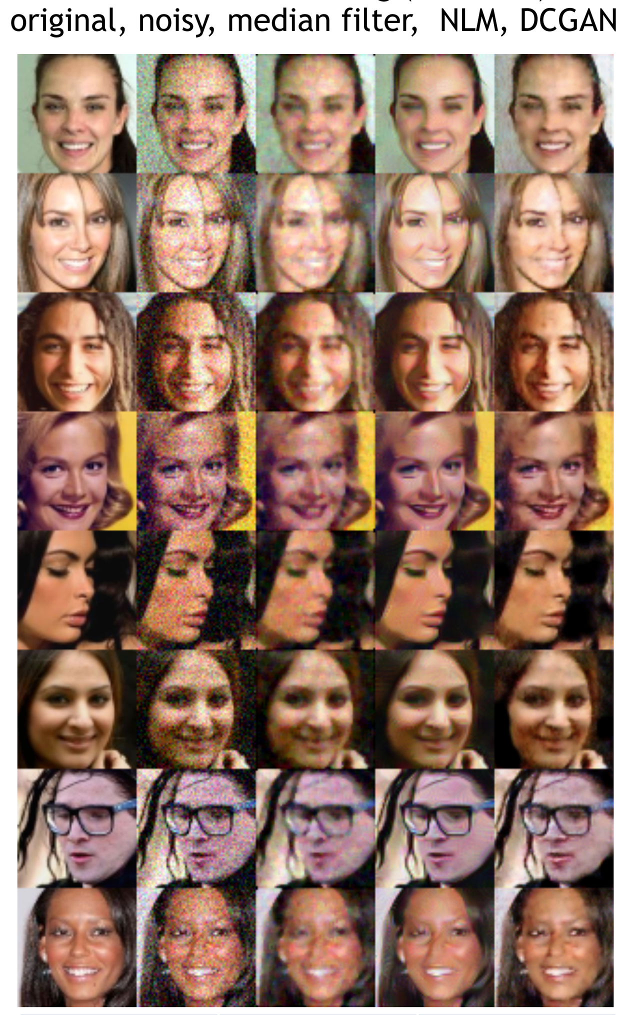
Method	PSNR mean (dB)	PSNR std
bicubic	23.4309	3.0286
DCGAN	21.7034	2.0999

natural images SR 4x
original, subsampled, bicubic, DCGAN



Method	PSNR mean (dB)	PSNR std
bicubic	20.2359	2.5090
DCGAN	16.6750	1.1949

human faces denoising (std = 0.1)
original, noisy, median filter, NLM, DCGAN



Method	PSNR mean (dB)	PSNR std
median filter	23.5595	1.2906
NLM	26.7011	0.9317
DCGAN	26.2448	0.9219

natural images denoising (std = 0.1)
original, noisy, median filter, NLM, DCGAN

Method	PSNR mean (dB)	PSNR std
median filter	20.9344	1.2277
NLM	24.5626	1.6664
DCGAN	23.1454	0.7862

Future Work

- **Training Set categorization**

  Currently our work uses a mixed training image data set. The super resolution result could potentially be improved with a characteristic specific training data. For example, when performing SR on a smiley face (or a profile) image, it would be advantageous to use training data set composed of such smiley faces (or profiles) so that the CNN engine could capture more categorized features.
- **Combining Super Resolution and Denoising**

  Currently our work only discussed the proposed model on image SR and denoising separately. However, for real applications, we often have to deal with noisy low resolution images. With conventional interpolation and denoising, both image processing methods would interfere with each other. Therefore, it might be great incentives to further investigate the combined SR and denoising effects on degraded images.
- **DCGAN on Image Deconvolution**

  Image deconvolution is traditionally considered as challenging problems in practice not only because it is mathematically difficult to solve but due to the toughness on estimating the blurring PSF. Theoretically, deconvolution problems can be mathematically transformed into convolutional problems. Therefore, it is interesting to explore the possibilities on blind deconvolution with our proposed DCGAN image processing framework.