Training Image Estimators without Image Gound-Truth

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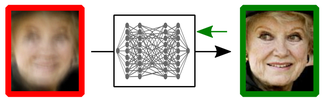
https://projects.ayanc.org/unsupimg

Overview

Motivation

Practical Measurements (Incomplete / Imperfect)

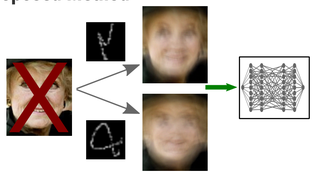
High-quality Images



Standard supervised training requires a large training set with ground-truth data.

But these are hard to measure.

Proposed Method



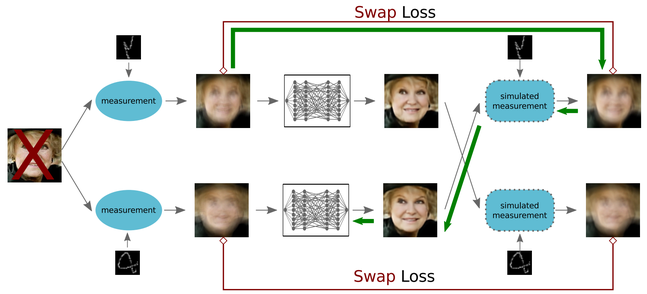
Train on pairs of different measurements of same image, **without ground-truth for image !**

Noise2Noise [Lehtinen et al., 2018]: Train denoisers with noisy pairs.

Our Approach:
- Estimators for general linear measurement models. Useful for *compressive sensing, deblurring, inpainting, ...*
- Trains on pairs with different measurement parameters.
- Supports blind training when these parameters unknown.

- Linear Measurement Model: $y = \theta x + \epsilon$; θ is low-rank and non-invertible.
- Train a network f to estimate image $\hat{x} = f(y)$ *from a single measurement*.
- Train on measurement pairs y_1 & y_2, made with parameters θ_1 & θ_2. ($[\theta_1^T, \theta_2^T]^T$ together is also non-invertible)
- Unsupervised: x is unknown during training. Blind Unsupervised: θ_1 & θ_2 also unknown.

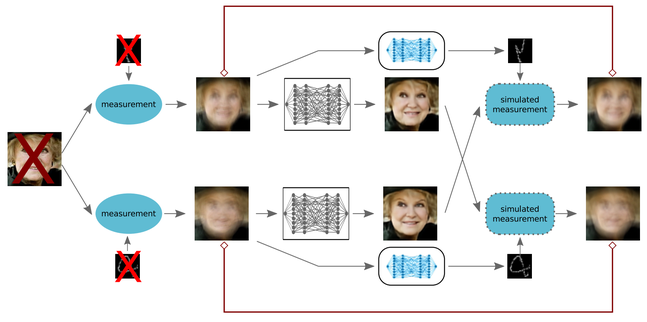
Unsupervised Training



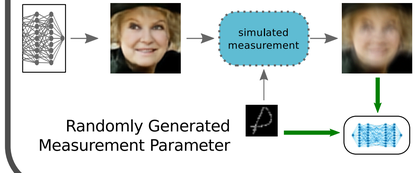
$$L(f) = \|\theta_2\ f(y_1) - y_2\| + \|\theta_1\ f(y_2) - y_1\|$$

- Show that this provides "full supervision" if measurement parameter pairs are random, and *diverse*: $\mathbb{E}\left(\theta\theta^T\right)$ is full-rank.

Blind Unsupervised Training



- Use a second *parameter estimation* network. But how do we train this ?
- Train both networks simultaneously, using image network outputs to create ***a synthetic proxy training set.***



- Generate measurements for which we know true parameter and image.
- Use to train paramater network, & augment training of image network.

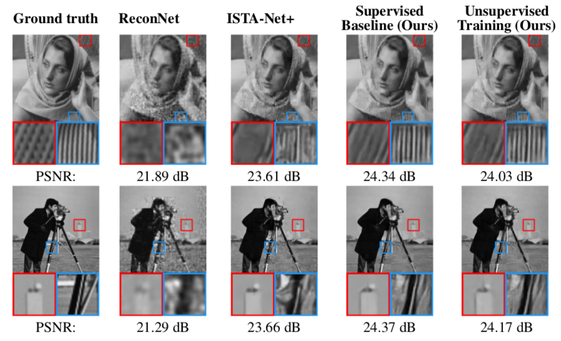
Experimental Results

Compressive Sensing

- Patch-wise Compressive Measurement: Linear low-rank matrices applied to 33x33 patches.
- Compression ratio = No. of measurements per patch / pixels in patch.
- Make two measurements using same matrix applied to randomly shifted patches.

Method	Supervised	BSD68			Set11		
		1%	4%	10%	1%	4%	10%
ISTA-Net+	✓	19.14	22.17	25.33	17.34	21.31	26.64
Supervised Baseline (Ours)	✓	**19.74**	**22.94**	**25.57**	**17.88**	**22.61**	**26.74**
Unsupervised Training (Ours)	✗	19.67	22.78	25.40	17.84	22.20	26.33

Reconstruction Quality in PSNR (dB)



Blind Face Image Motion Deblurring

- Blind motion deblurring task for face images: blur kernel unknown at test time.
- Make measurements with different blur kernels.
- Consider both non-blind vs blind training: i.e., kernels known vs unknown during training.

Method	Supervised	Helen		CelebA	
		PSNR	SSIM	PSNR	SSIM
Xu *et al.*	✗	20.11	0.711	18.93	0.685
Shen *et al.*	✓	25.99	0.871	25.05	0.879
Supervised Baseline (Ours)	✓	**26.13**	**0.886**	**25.20**	**0.892**
Unsupervised Non-blind (Ours)	✗	25.95	0.878	25.09	0.885
Unsupervised Non-blind (Ours) *without proxy loss*	✗	25.47	0.867	24.64	0.873
Unsupervised Blind (Ours)	✗	25.93	0.876	25.06	0.883