Two-scale Tone Management

- *Two-scale Tone Management for Photographic Look*
  - Bae, Paris, Durand
  - SIGGRAPH 2006

Two-scale Tone Management for Photographic Look

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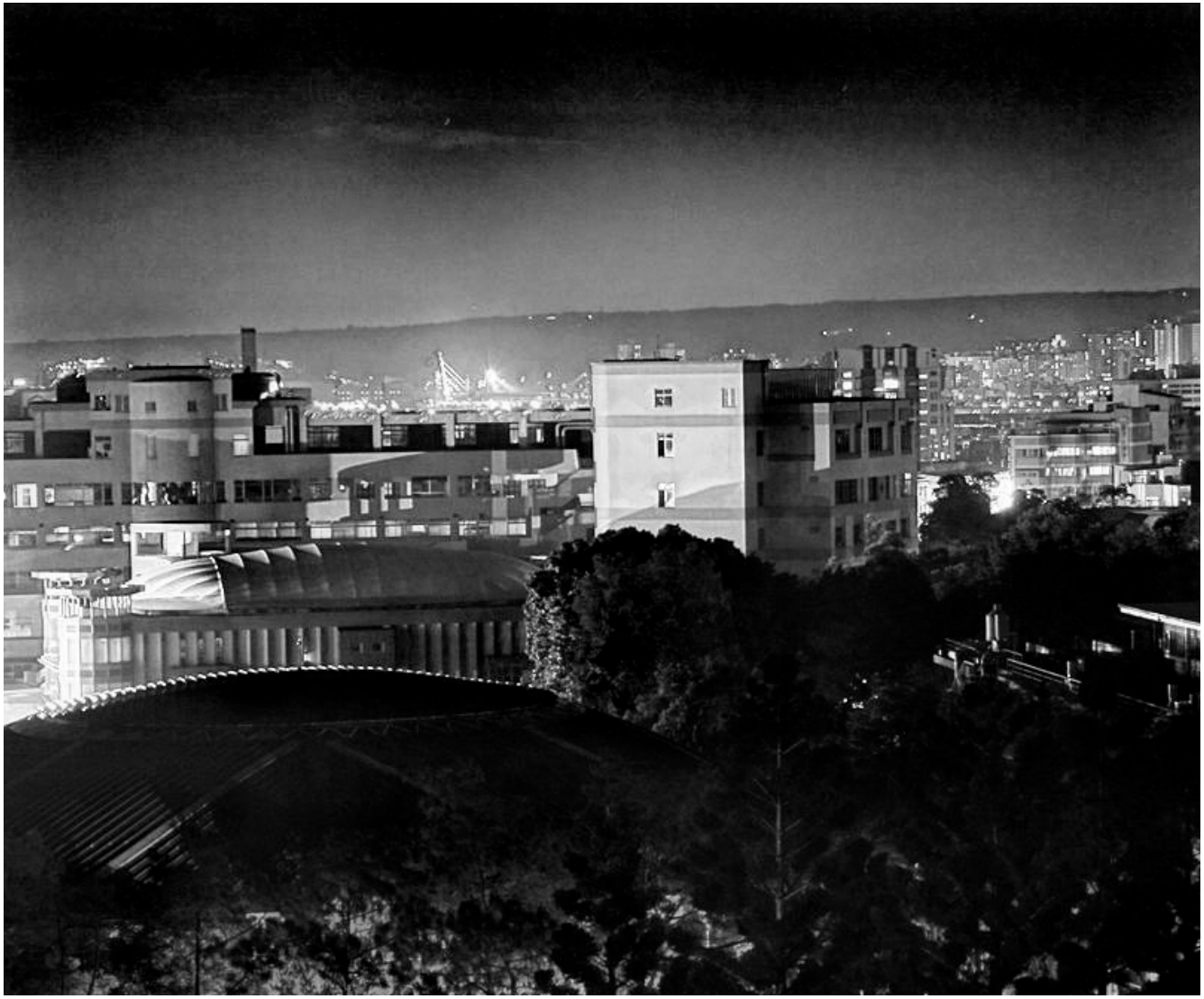
(a) input (b) sample possible renditions: bright and sharp, gray and highly detailed, and contrasted, smooth and grainy

Ansel Adams



Recall Color Transfer (or Histogram Matching)

- Can learn a similar *global* look from the model photograph
- But richness in texture is not learned
  - Texture is *local*

- How to improve it?

Tone Management

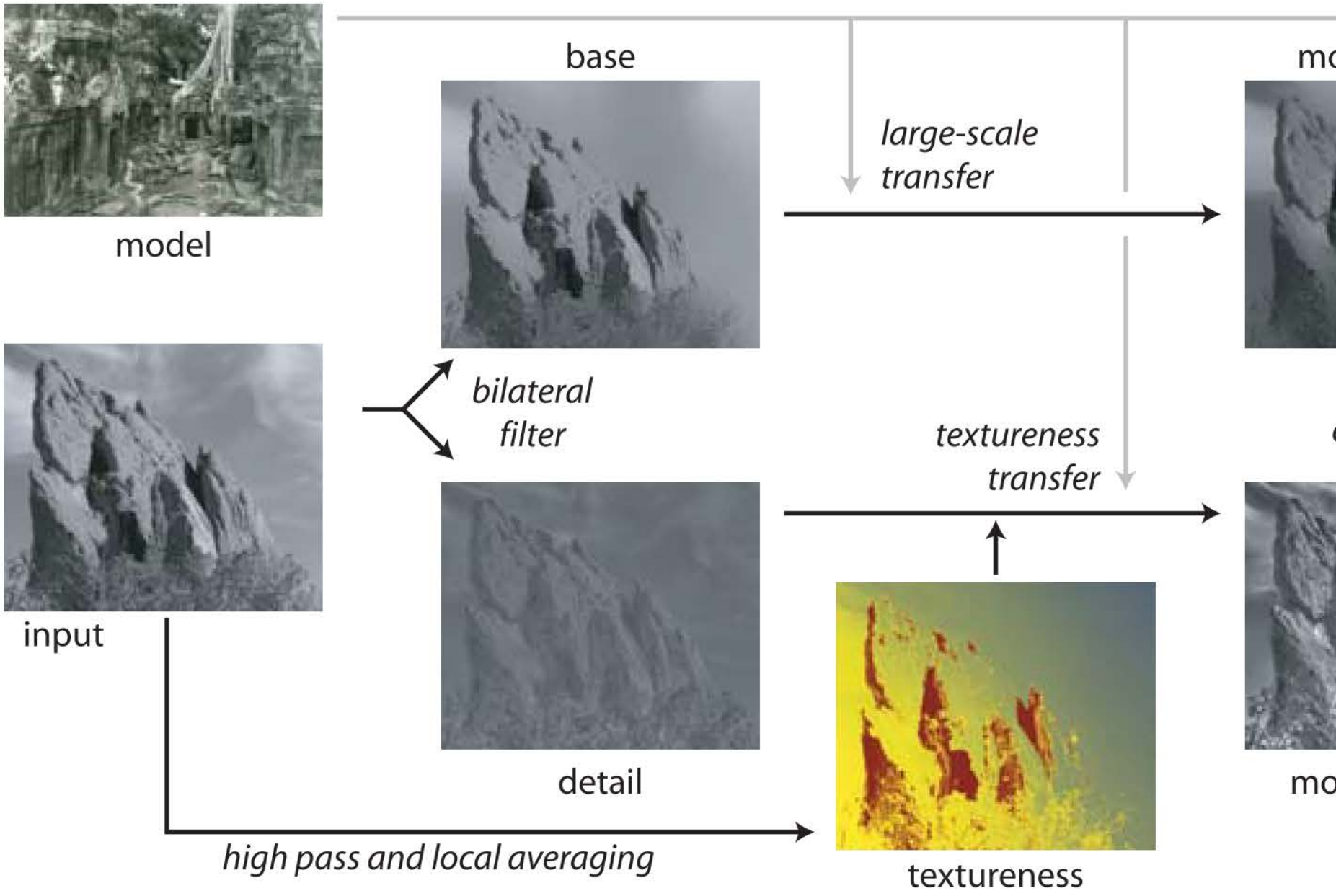
- Photographic look
  - To convey a mood or an aesthetic
  - For both high- and normal-dynamic-range inputs
- Transfer the look of a model photograph to the picture being edited
  - Tonal balance
  - Amount of detail
  - Sepia toning, grainy photograph
- To give hundreds of pictures a consistent look

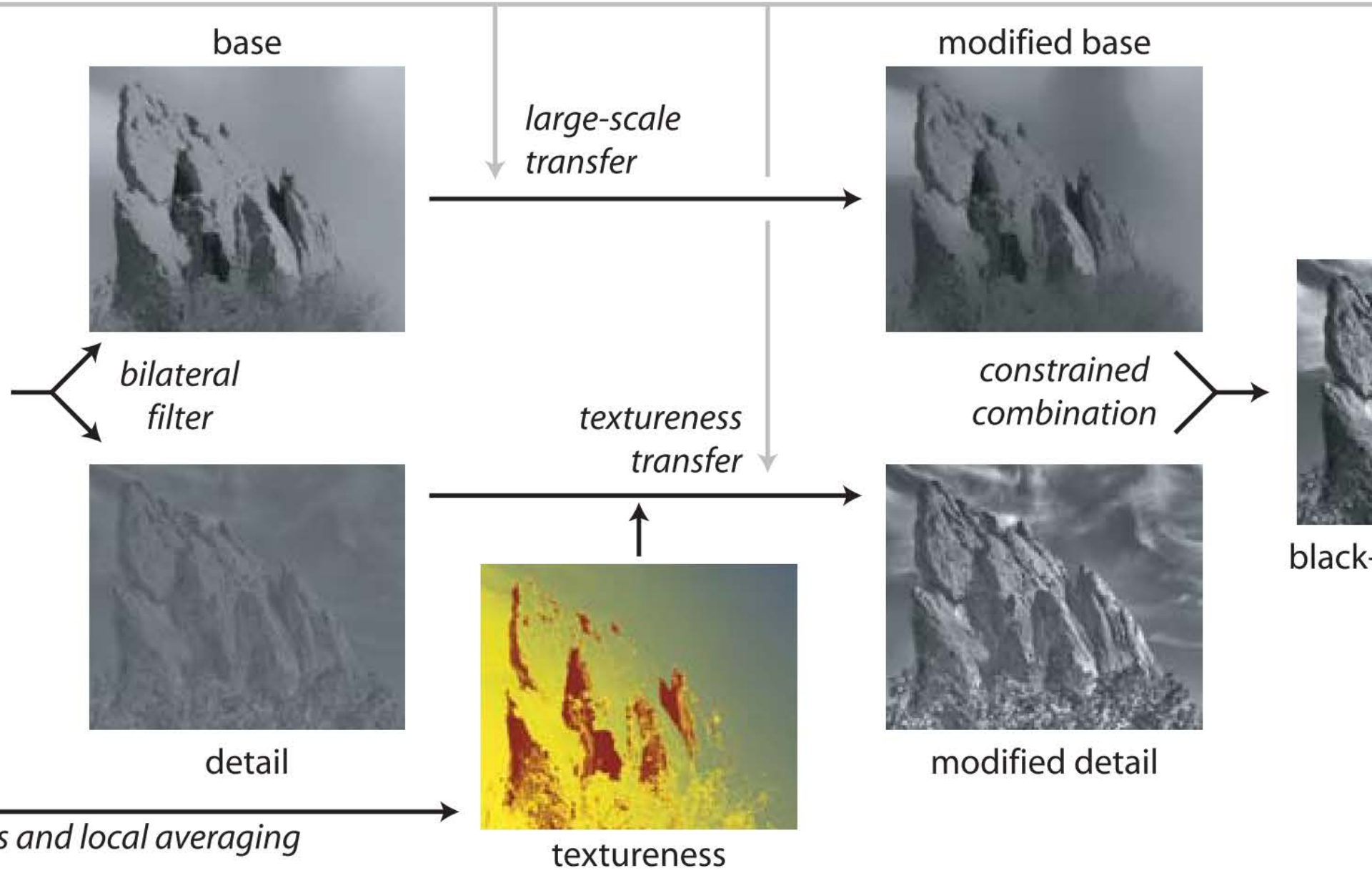
Two-scale Nonlinear Decomposition

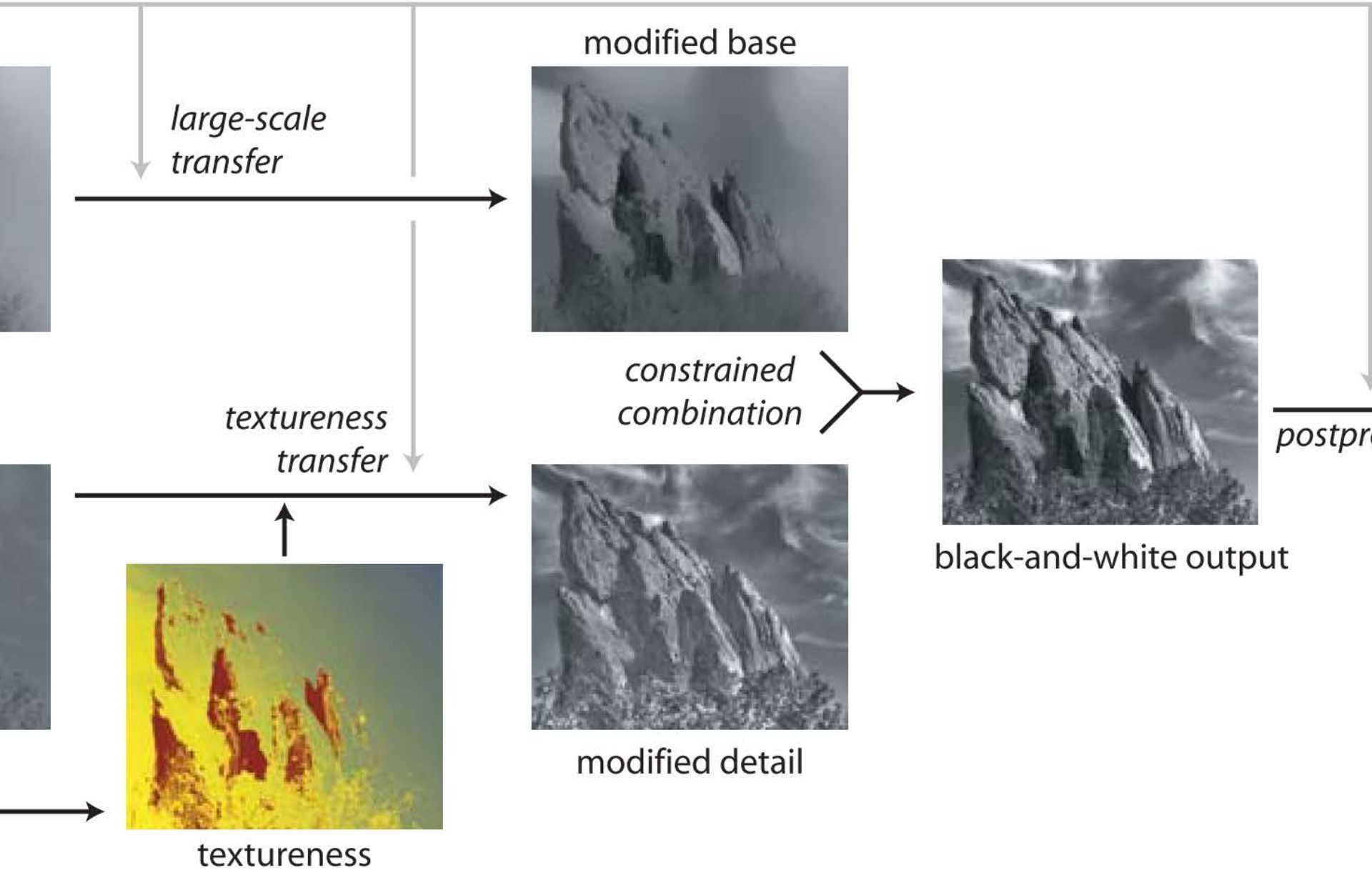
- Large-scale tonal balance management
- Spatial detail variation
- Gradient constraint

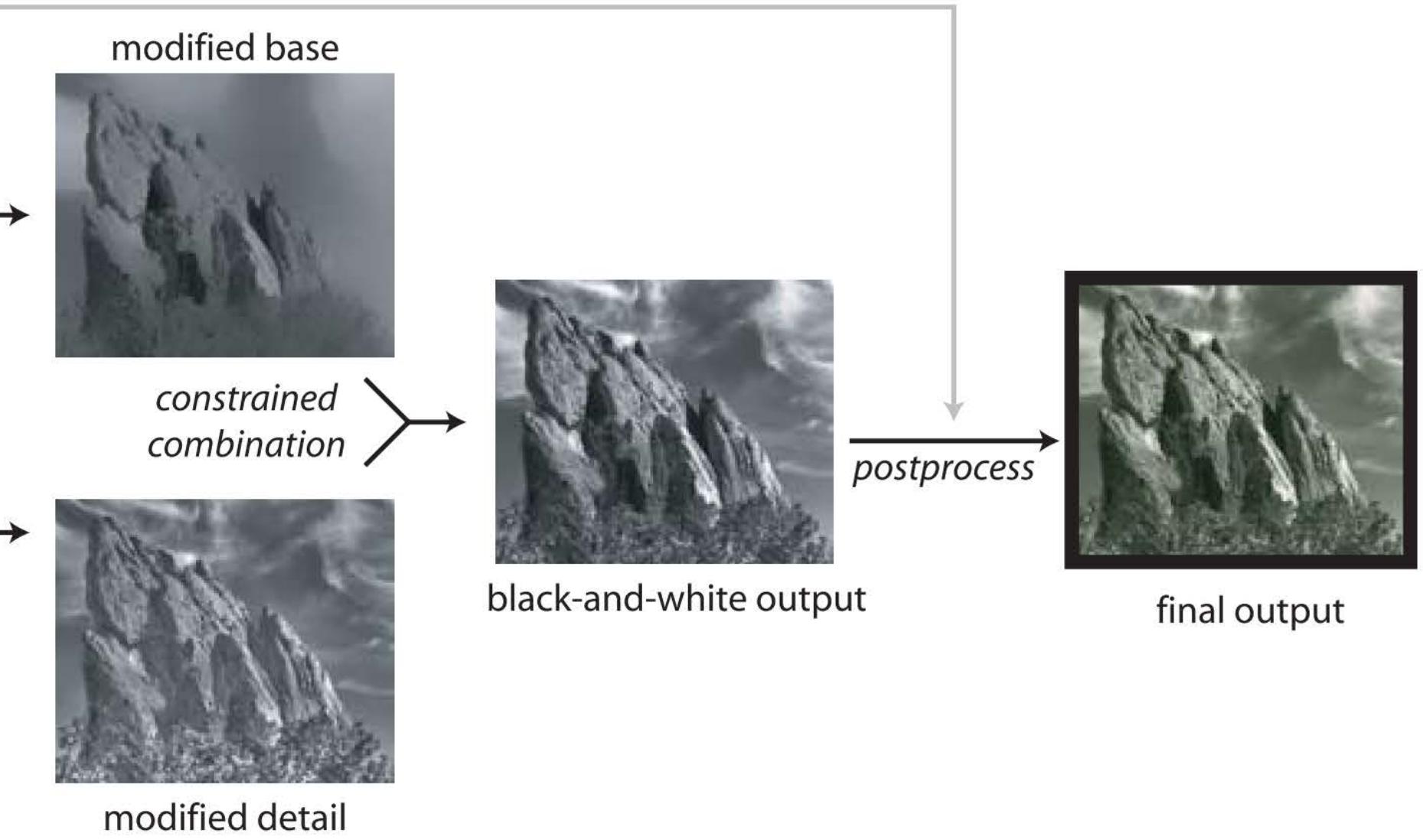
Using Techniques We Have Learned So Far

- Histogram matching
- Bilateral filtering
  - Joint (or cross) bilateral filtering
  - and a technique we will learn next week: gradient domain, Poisson reconstruction

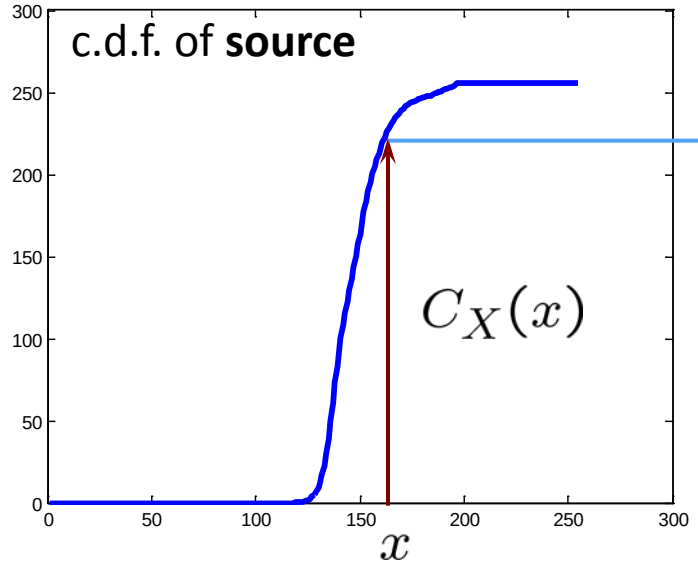

model
base
large-scale
transfer
input
bilateral
filter
textureness
transfer
detail
high pass and local averaging
textureness

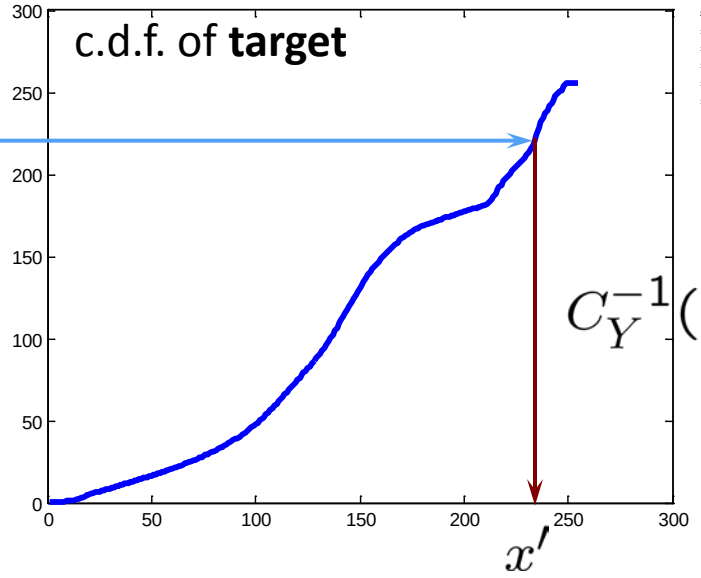

base
large-scale
transfer
modified base
bilateral
filter
constrained
combination
textureness
transfer
detail
modified detail
s and local averaging
textureness

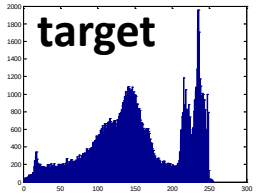

modified base
large-scale
transfer
constrained
combination
black-and-white output
textureness
transfer
modified detail
textureness

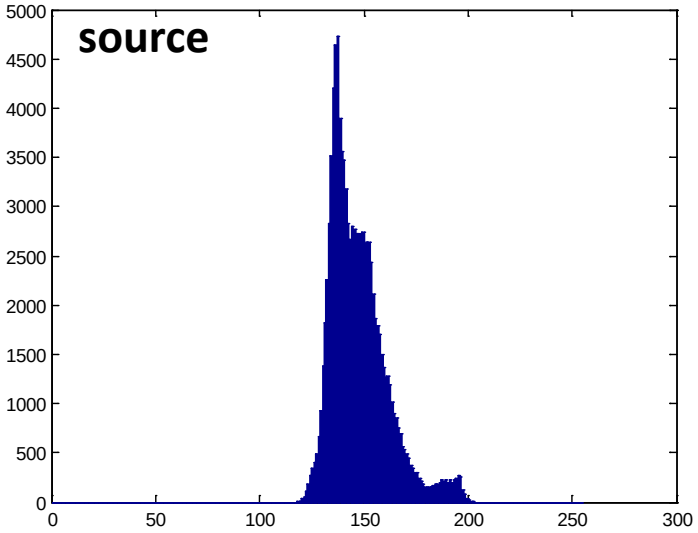

modified base
constrained
combination
modified detail
black-and-white output
postprocess
final output

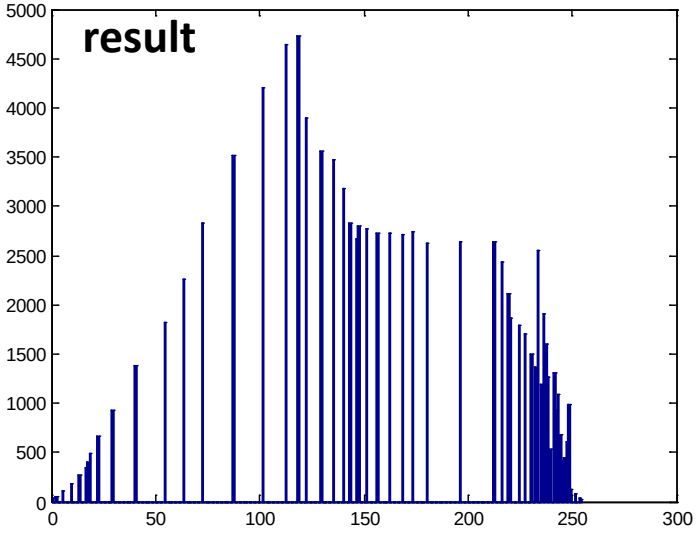
Histogram Matching



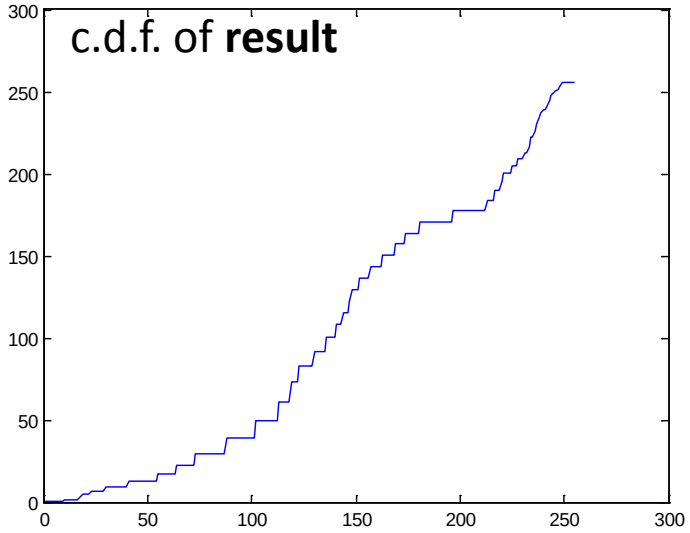


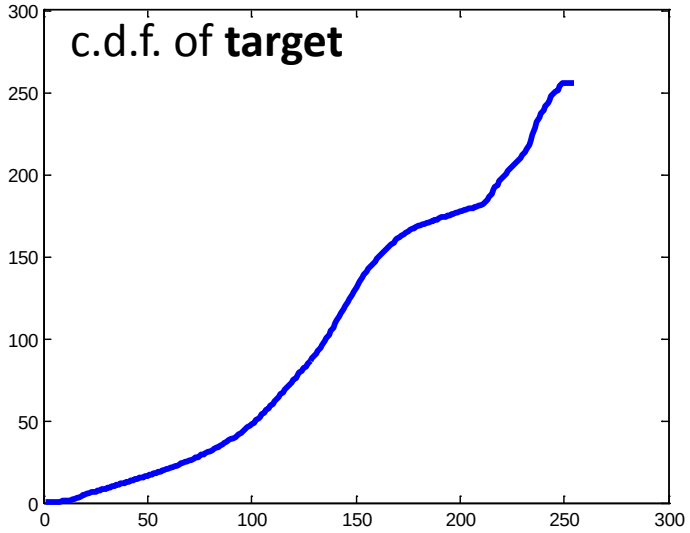


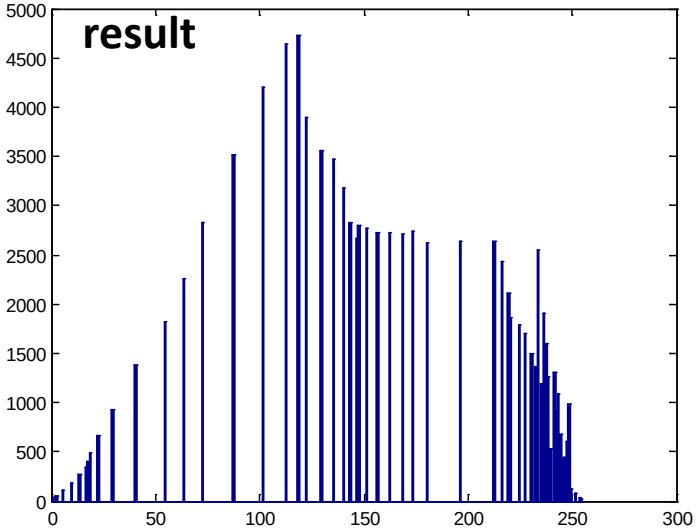




Histogram Matching







Poisson Reconstruction

Given a 2D field of 2D vectors $\mathbf{v}$, one can build an image I with a gradient ∇I as close as possible to $\mathbf{v}$, in the least square sense.

$$\Delta I = \text{div}(\mathbf{v})$$

There might not exist an image I such that $\nabla I = \mathbf{v}$

Bilateral Filtering

$$bf(I)_{\mathbf{p}} = \frac{1}{k} \sum_{\mathbf{q} \in I} g_{\sigma_s}(\|\mathbf{p} - \mathbf{q}\|) g_{\sigma_r}(\|I_{\mathbf{p}} - I_{\mathbf{q}}\|) I_{\mathbf{q}}$$

$$k = \sum_{\mathbf{q} \in I} g_{\sigma_s}(\|\mathbf{p} - \mathbf{q}\|) g_{\sigma_r}(\|I_{\mathbf{p}} - I_{\mathbf{q}}\|)$$

$$g_\sigma(x) = \exp(-x^2/\sigma^2)$$

$$\sigma_s = \min(\text{width}, \text{height})/16$$

$$\sigma_r = p_{90}(\|\nabla I\|)$$

[1]For an image I, $p_n(I)$ is the intensity value such that n% of the values of I are under it, *e.g.* $p_{50}(I)$ is the median. Percentiles are robust to outliers.

Large-Scale Tonal Distribution

Bilateral Decomposition (log-Domain)

- Base layer

$$B = bf(I)$$

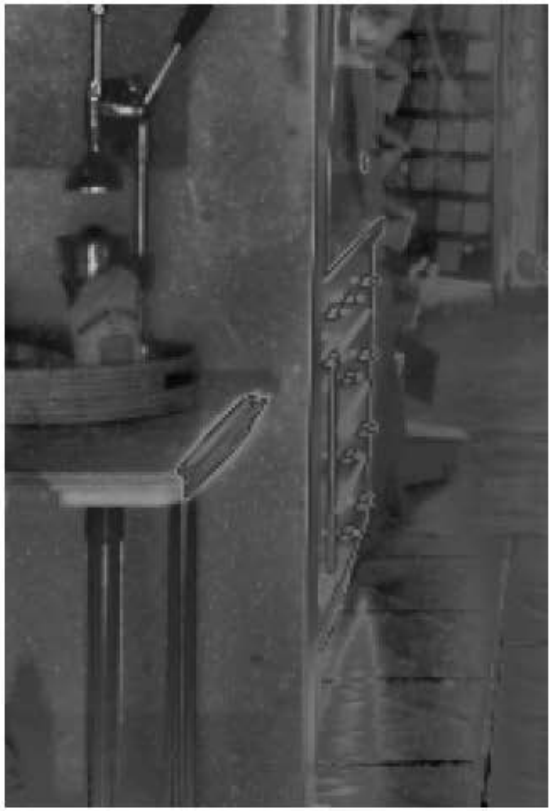
- Detail layer

$$D = I - B$$

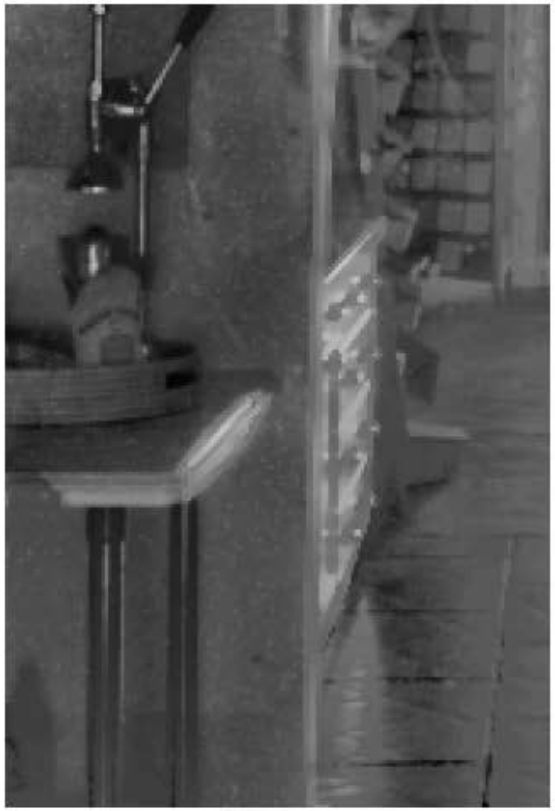
Uncertainty

- The bilateral filter can cause gradient reversals in the detail layer near smooth edges.

(a) input image



(b) uncorrected detail



(c) corrected detail

Gradient Reversal Removal

- Uncertainty
- We want a reliable halo-free detail layer

build the gradient field $\mathbf{v} = (x_{\mathbf{v}}, y_{\mathbf{v}})$

$$x_{\mathbf{v}} = \begin{cases} 0 & \text{if} \quad \text{sign}\,(\partial D/\partial x) \neq \text{sign}\,(\partial I/\partial x) \\ \partial I/\partial x & \text{if} \quad |\partial D/\partial x| > |\partial I/\partial x| \\ \partial D/\partial x & \text{otherwise} \end{cases}$$

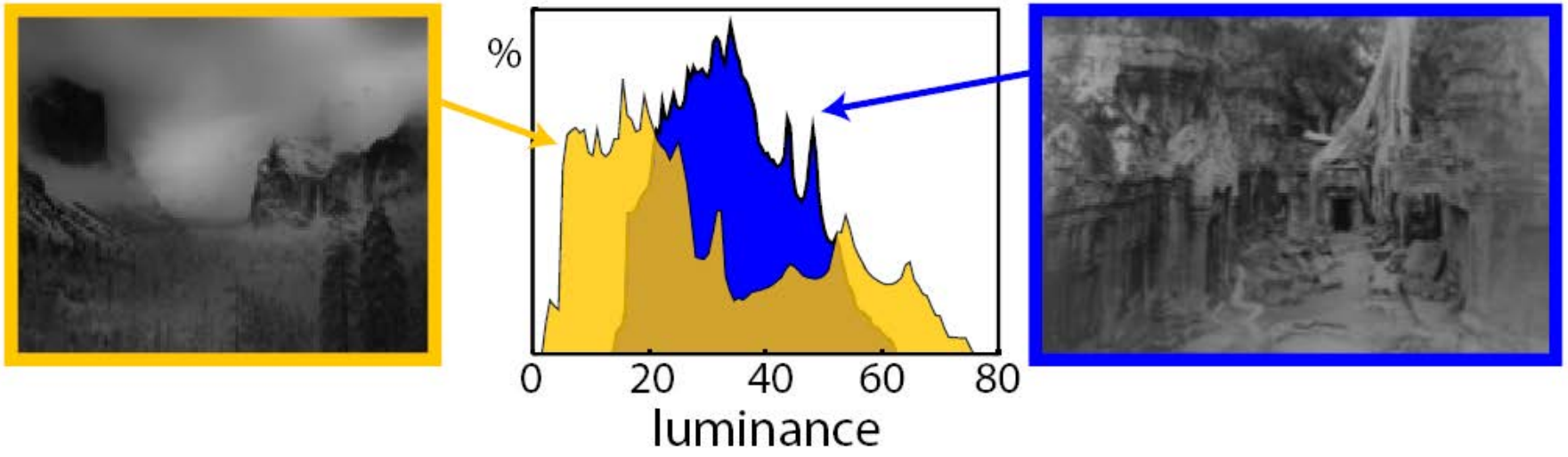
the corrected detail layer is obtained by solving the corresponding Poisson equation.

update the base layer $B = I - D$

Tonal Balance

- Perform histogram matching and transfer the histogram of model base layer onto the new base layer

the luminance histogram of the base component is a good indicator of tonal balance

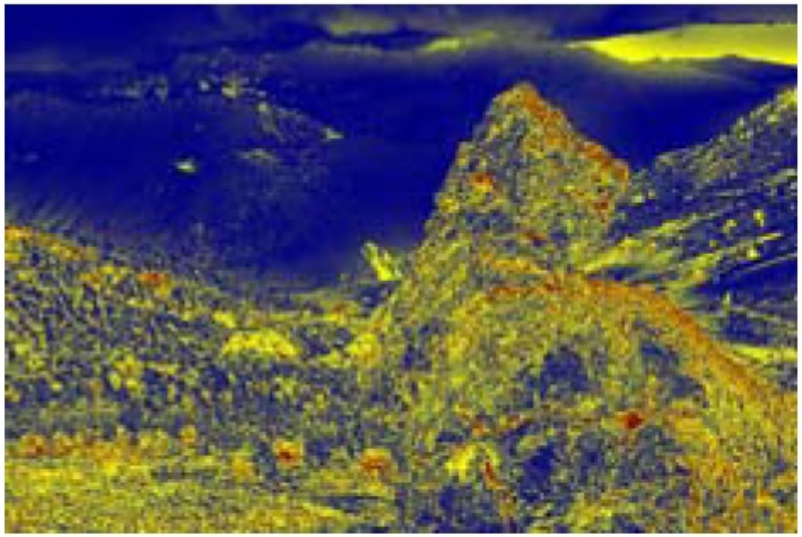


Detail and Texture Management

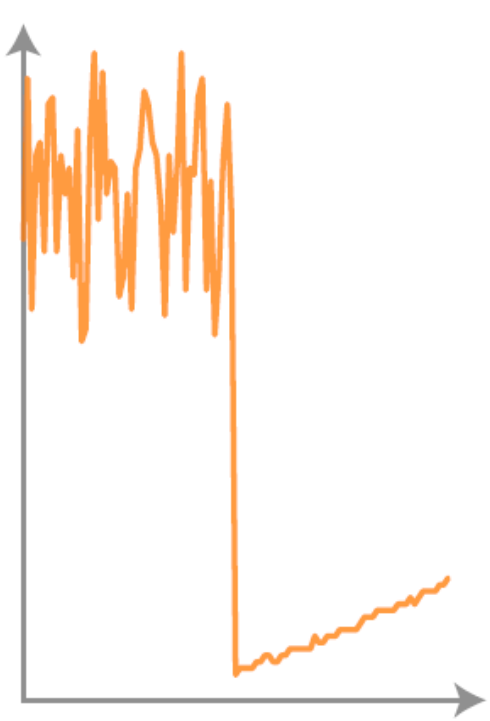
High Frequencies of Input

(a) input

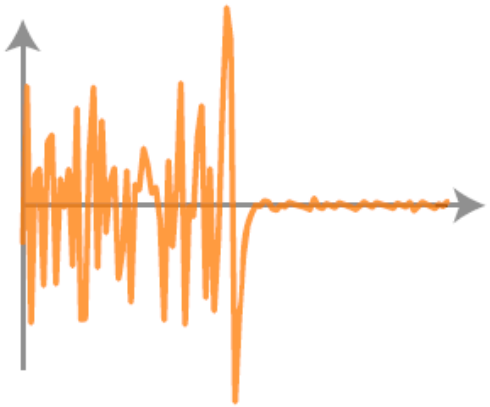
(b) high frequencies of input



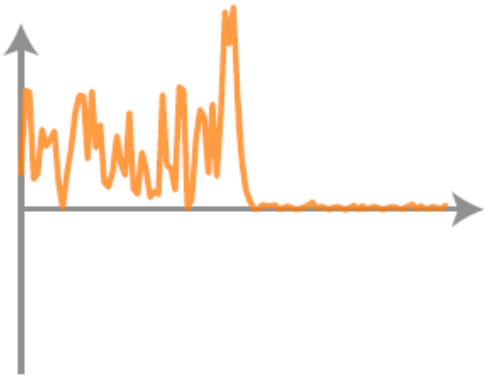
Detail and Texture Management



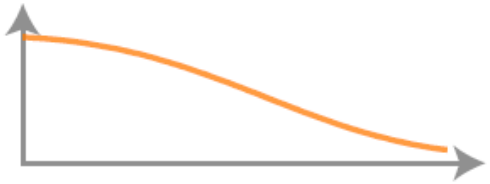
(a) input I



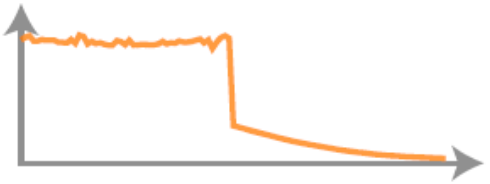
(b) high frequencies H



(c) absolute values $|H|$



(d) activity/power map: low pass of $|H|$



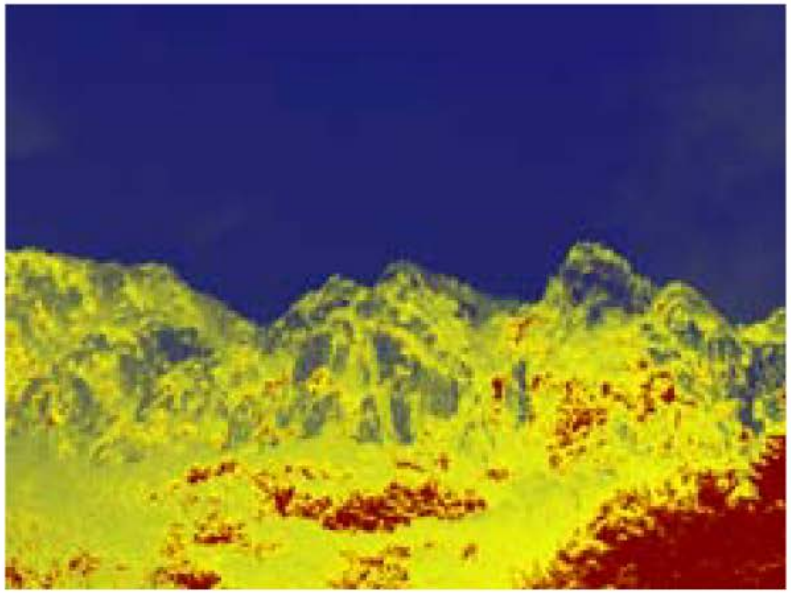
(e) textureness: cross bilateral filter of $|H|$ and I

Textureness:
Local Amount of High Frequency Content

$$T(I)_{\mathbf{p}} = \frac{1}{k} \sum_{\mathbf{q} \in |H|} g_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|)\, g_{\sigma_r}\left(\left|I_{\mathbf{p}} - I_{\mathbf{q}}\right|\right)\, |H|_{\mathbf{q}}$$

$$\text{with:} \quad k = \sum_{\mathbf{q} \in I} g_{\sigma_s}(\|\mathbf{p}-\mathbf{q}\|)\, g_{\sigma_r}\left(\left|I_{\mathbf{p}} - I_{\mathbf{q}}\right|\right)$$

(a) input



(b) textureness

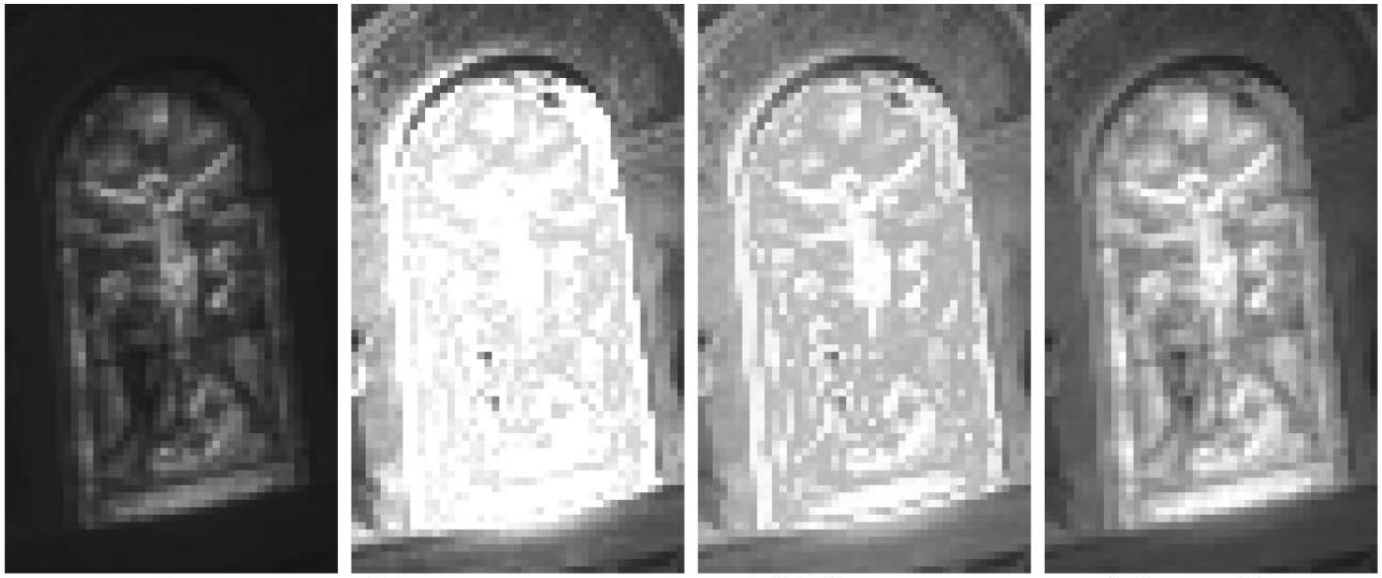
Textureness Transfer

- The input I and model M have textureness maps $T(I)$ and $T(M)$. Using histogram transfer to enforce the histogram of $T(M)$ onto $T(I)$ to build the desired textureness map T'
- Modify the detail layer
  - Scale the values of the detail layer by a ratio

$$\rho_{\mathbf{p}} = \max\left(0, \frac{T'_{\mathbf{p}} - T(B')_{\mathbf{p}}}{T(D)_{\mathbf{p}}}\right)$$

output $O = B' + \rho D$.

Fine Tuning



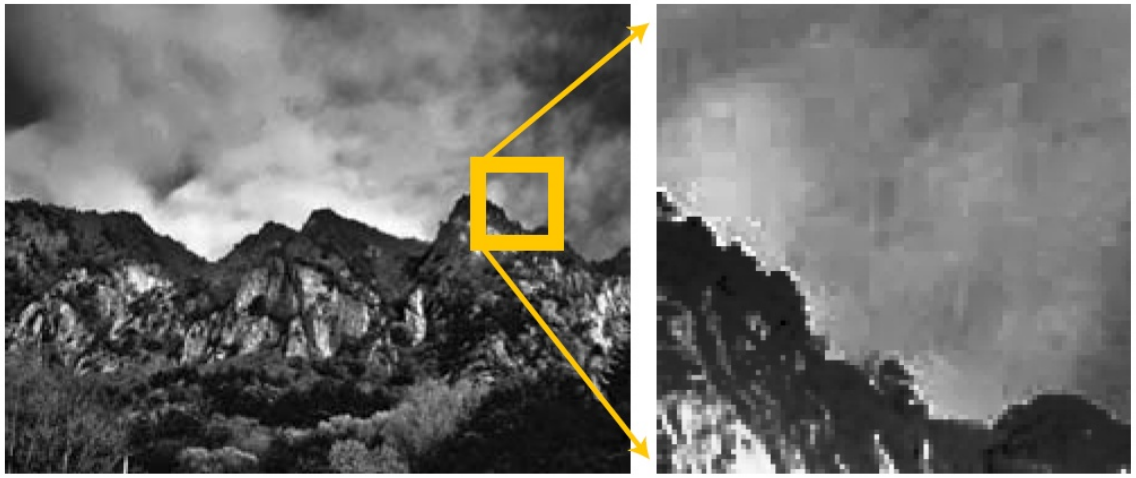
(a) input (b) unconstrained (c) histogram matching (d) gradient constraint

$$x_{\mathbf{v}} = \begin{cases} \alpha\, \partial I/\partial x & \text{if} \quad |\partial O/\partial x| < \alpha\, |\partial I/\partial x| \\ \beta\, \partial I/\partial x & \text{if} \quad |\partial O/\partial x| > \beta\, |\partial I/\partial x| \\ \partial O/\partial x & \text{otherwise} \end{cases}$$

Film grain: extract the grain from the model; generate a grain layer by texture synthesis

Discussion

- JPEG artifacts



- A one megapixel image takes six seconds on a 2.6GHz PC
- Portraits
  - Skin defects are emphasized