Art-Photographic Detail Enhancement

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Image Detail Enhancement

- Enhancement of fine-scale intensity variations
- Clarity in conveying shape and structure information
- Common approach
  - Based on base and detail decomposition
  - **Detail scaling** and recombining to base layer

Input

Base layer [Gastal11]

Scaled detail layer

Detail enhancement

Previous Approaches

- Detail enhancement methods with edge-preserving smoothing

Weighted least squares [Farbman08]

Extrema-based multiscale decomposition [Subr09]

Laplacian pyramid [Paris11]

Domain transform method [Gastal11]

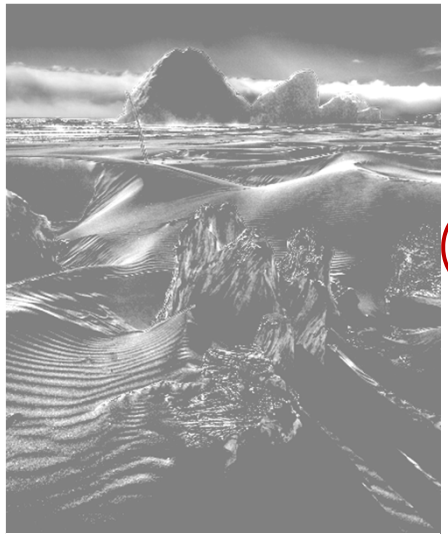
L0 gradient minimization [Xu11]

Previous Approaches

- Detail enhancement methods with edge-preserving smoothing
- Limited enhancement because of dynamic range
  - Increased details bounded by the dynamic range of the display device
  - Impossible to capture sufficient details in very dark or bright regions

Input

Base layer [Xu11]



Scaled detail layer

Limited enhancement

Art Photography

- Aesthetics with exaggerated depiction of fine-scale details
- Hyper-realistic look by combining multiple images carefully
  - Handling lighting conditions of individual regions/objects separately
  - Region-specific control to increase dynamic rage of each region

HDR imaging by Trey Ratcliff
using multiple exposure images

Synthesized by Dave Hill using multiple pictures
of scene components under diff. light conditions

Our Approach

- Single-image detail enhancement inspired by art photography
  - Tone transform model with **base shift** as well as detail scaling
  - Region-specific detail exaggeration: piecewise smooth tone transform
  - Optimization framework aiming to bring out extreme details in each region

Input single image

Output

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

Input

Previous detail enhancement [Xu11]

Our result

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
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Input

Globally smooth scaling s

Tone Transform Model

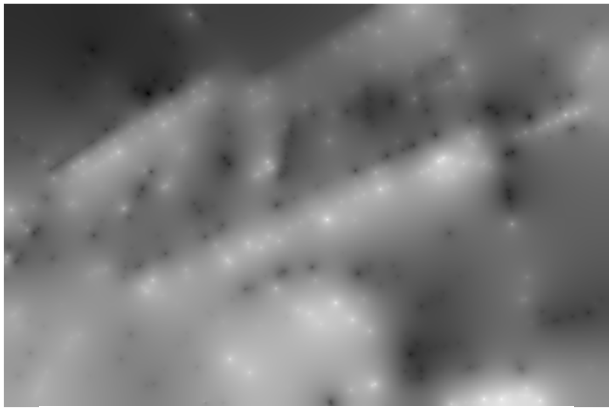
- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input



Globally smooth shift t

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input

Globally smooth transform

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

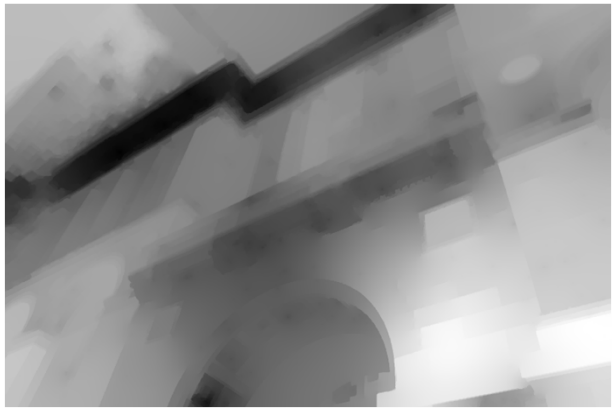
$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input

Globally smooth transform



Piecewise smooth scaling s

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

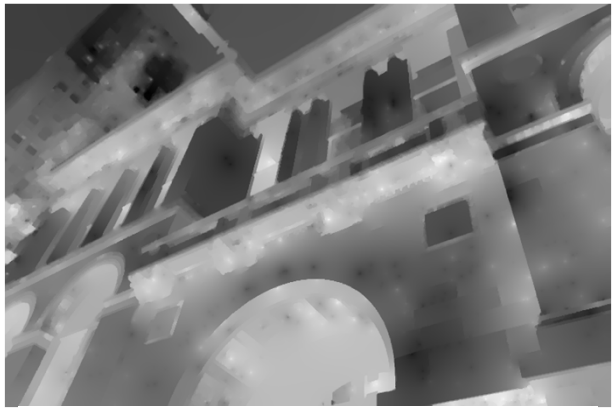
$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input

Globally smooth transform



Piecewise smooth shift t

Tone Transform Model

- Base shifting as well as detail scaling for each pixel
  - For base B and detail $D = I - B$,

$$I'_i = B_i + D'_i = B_i + s_i D_i$$

$$I'_i = B'_i + D'_i = (B_i + t_i) + s_i D_i$$

- Smoothness constraint
  - Smoothly varying s and t for scene structure preservation
  - Piecewise smooth transform for region-based control

Input

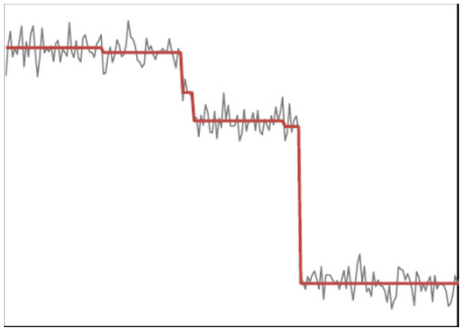
Globally smooth transform

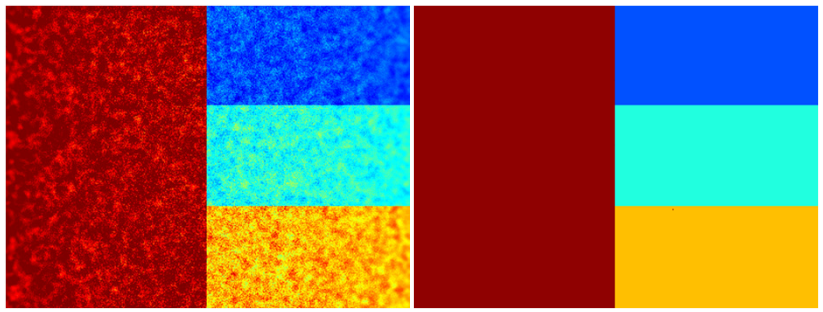
Piecewise smooth transform

Detail and Base Decomposition

- Necessary properties for base layer
  - Piecewise constant within homogeneous region

- Image smoothing via L_0 gradient minimization [Xu11]
  - Best for piecewise constant base layer
  - Global strategy based on sparsity measure
    - Sparsity measure: $C(B) = \#\{i \mid |\partial_x B_i| + |\partial_y B_i| \neq 0\}$
    - Objective function: $\min_B \left\{ \sum_i (B_i - I_i)^2 + \lambda \cdot C(B) \right\}$



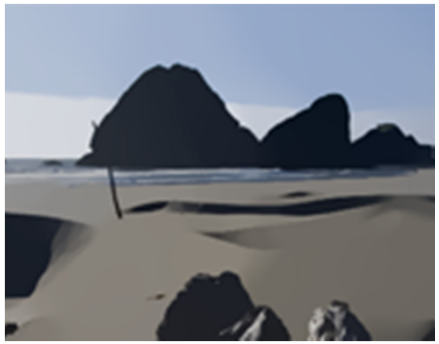


Detail and Base Decomposition

- Necessary properties for base layer
  - Piecewise constant within homogeneous region

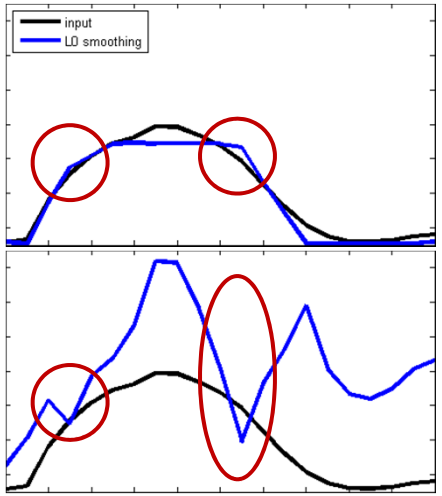
- Image smoothing via L_0 gradient minimization [Xu11]
  - Best for piecewise constant base layer
  - Problems around edges with extreme scaling and shift

Input



Base layer using L0 smoothing

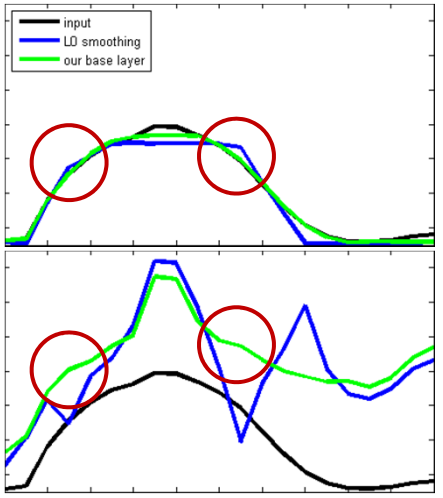
Result



Detail and Base Decomposition

- Necessary properties for base layer
  - Piecewise constant within homogeneous region
  - Matching original edges in boundary region

- Our solution: modified L_0 smoothing [Xu11]
  - 1st step: Original L_0 smoothing: $\min_B \left\{ \sum_i (B_i - I_i)^2 + \lambda \cdot C(B) \right\}$
  - 2nd step: Additional edge matching with adaptive λ
  - 3rd step: Edge adjustment with adaptive Gaussian blur



Input

Base layer using our method

Result

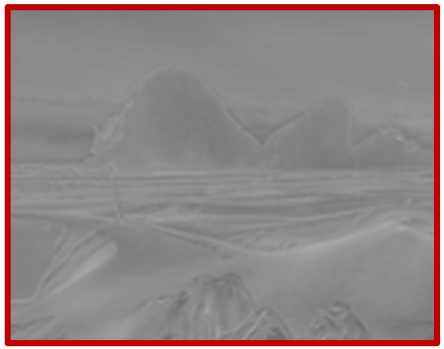
Detail Maximization

$$I_i' = (B_i + t_i) + s_i D_i$$

- Detail measure
  - $\sum_i \|s_i D_i\|^2$

Input

Base layer

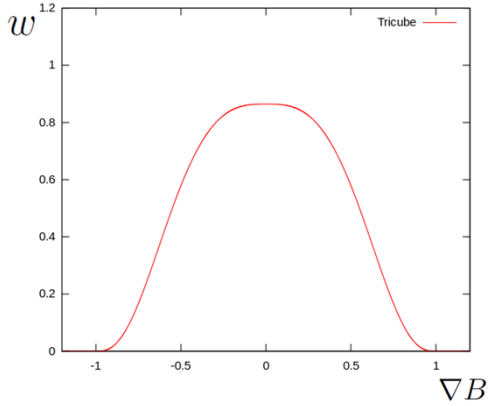


Detail layer

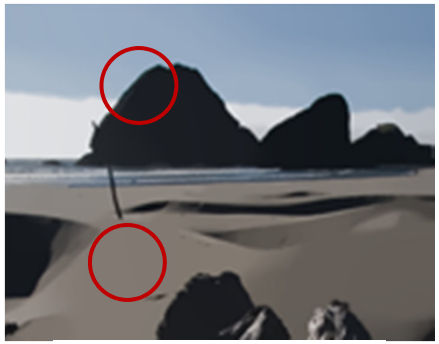
Detail Maximization

$$I'_i = (B_i + t_i) + s_i D_i$$

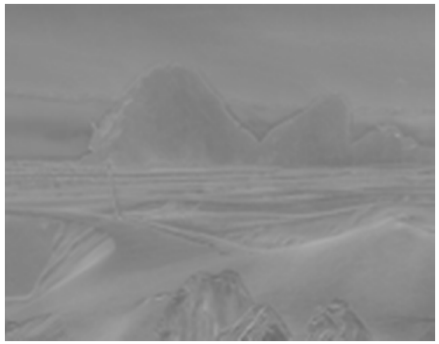
- Detail measure
  - $\sum_i \|s_i D_i\|^2$
- Constraint for piecewise smooth transform
  - $\sum_i w_i \|\nabla s_i\|^2, \sum_i w_i \|\nabla t_i\|^2$ with $w_i = K(\nabla B_i)$



Input



Base layer

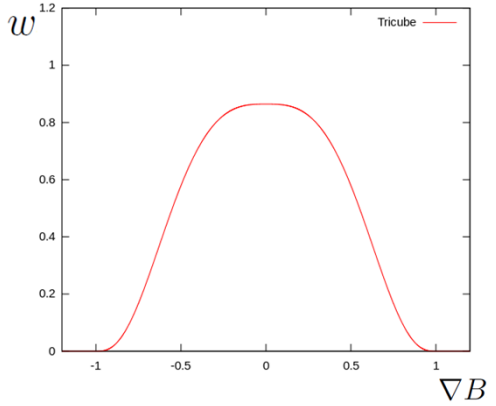


Detail layer

Detail Maximization

$$I'_i = (B_i + t_i) + s_i D_i$$

- Detail measure
  - $\sum_i \|s_i D_i\|^2$
- Constraint for piecewise smooth transform
  - $\sum_i w_i \|\nabla s_i\|^2, \sum_i w_i \|\nabla t_i\|^2$ with $w_i = K(\nabla B_i)$



- Objective function
  - Minimizing

$$f(s,t) = -\sum_i \|s_i D_i\|^2 + r_1 \sum_i w_i \|\nabla s_i\|^2 + r_2 \sum_i w_i \|\nabla t_i\|^2,$$

  - with range constraint $0 \le I'_i = (B_i + t_i) + s_i D_i \le 1$

Detail Maximization

- Detail control via interpolation
  - $I_\mu = \mu I' + (1-\mu)I = (\mu s + (1-\mu))D + B + \mu t$

μ=0.25

μ=0.5

μ=0.75

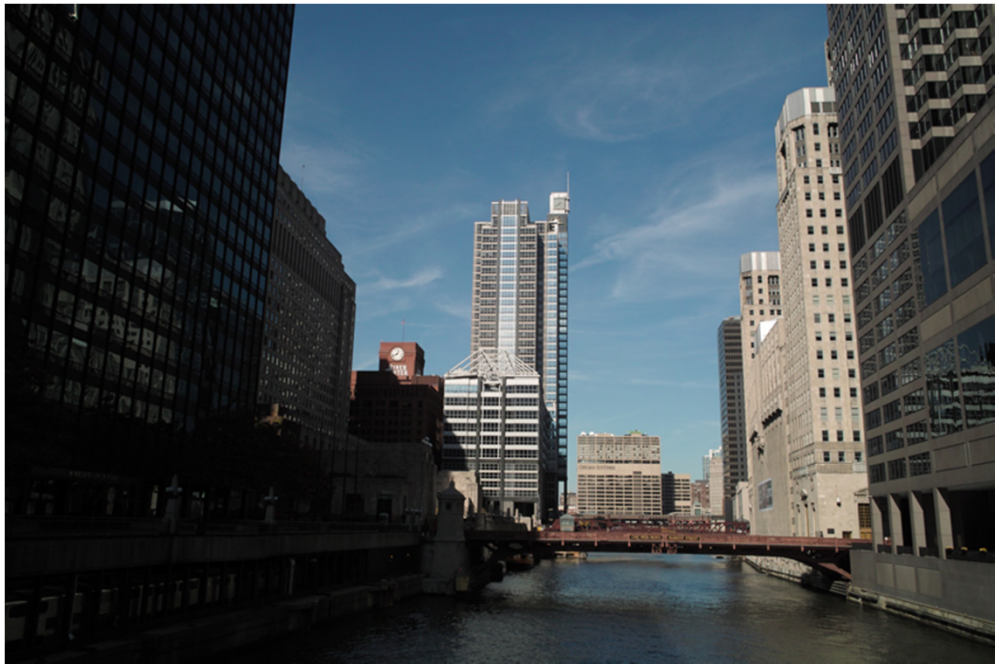
μ=0.0
(input)

μ=1.0
(max.)

Results

Results

Results



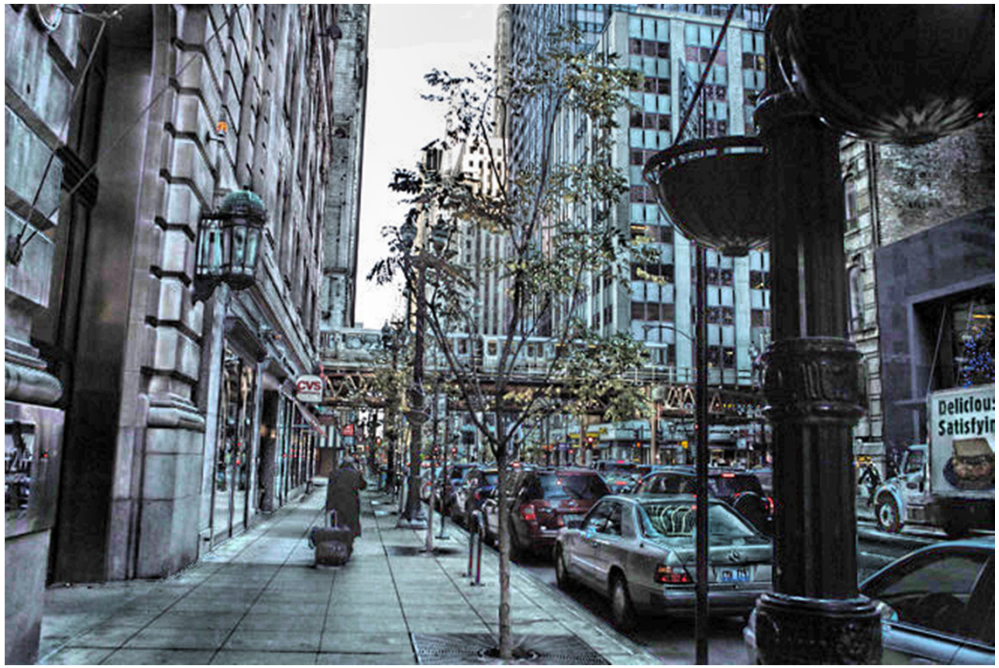
Results

Results

Results

Results

Results



Results

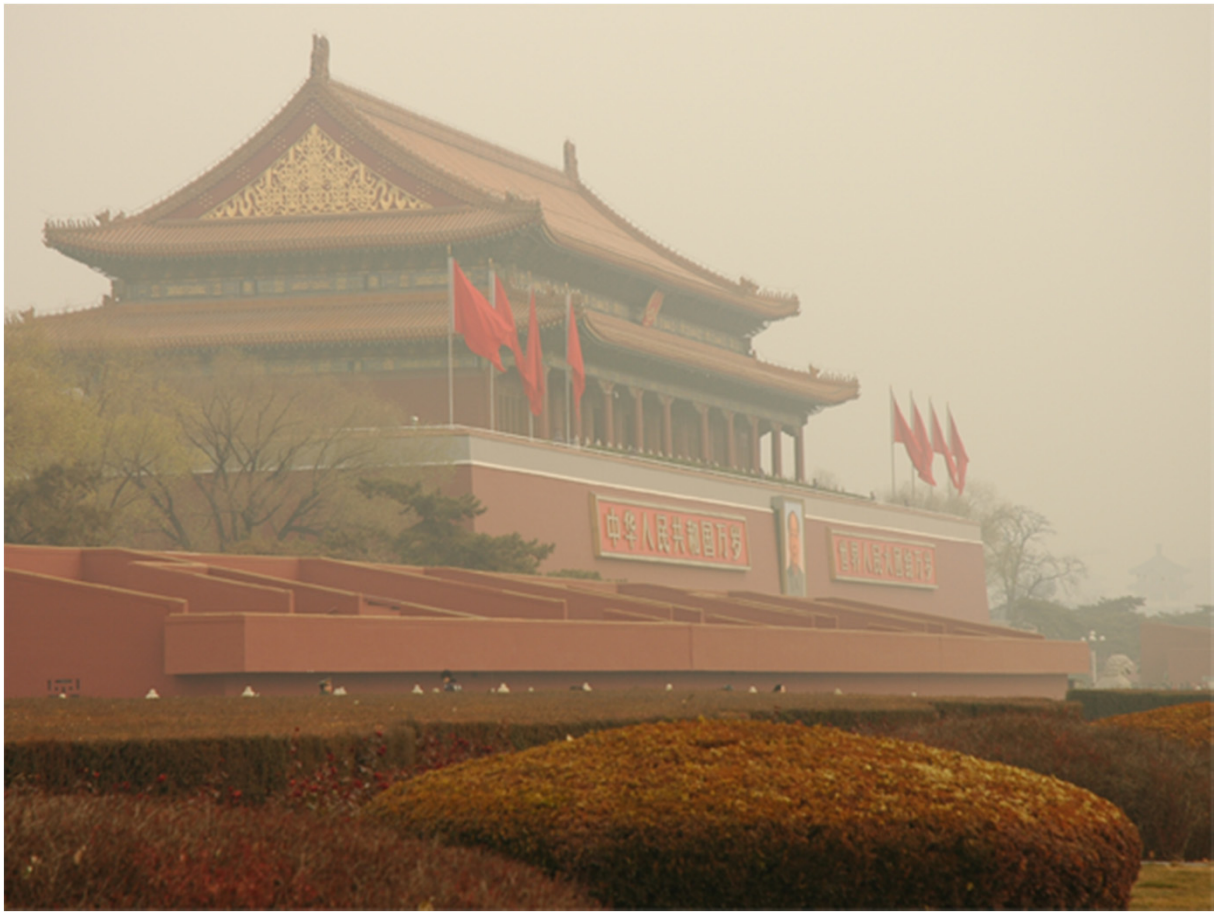

祭
禮


TOSHIBA
ENTER
TO WIN AT
FACEBOOK.COM/BUDLIGHT
News Corporation
FOX
SONY
JVC

Results

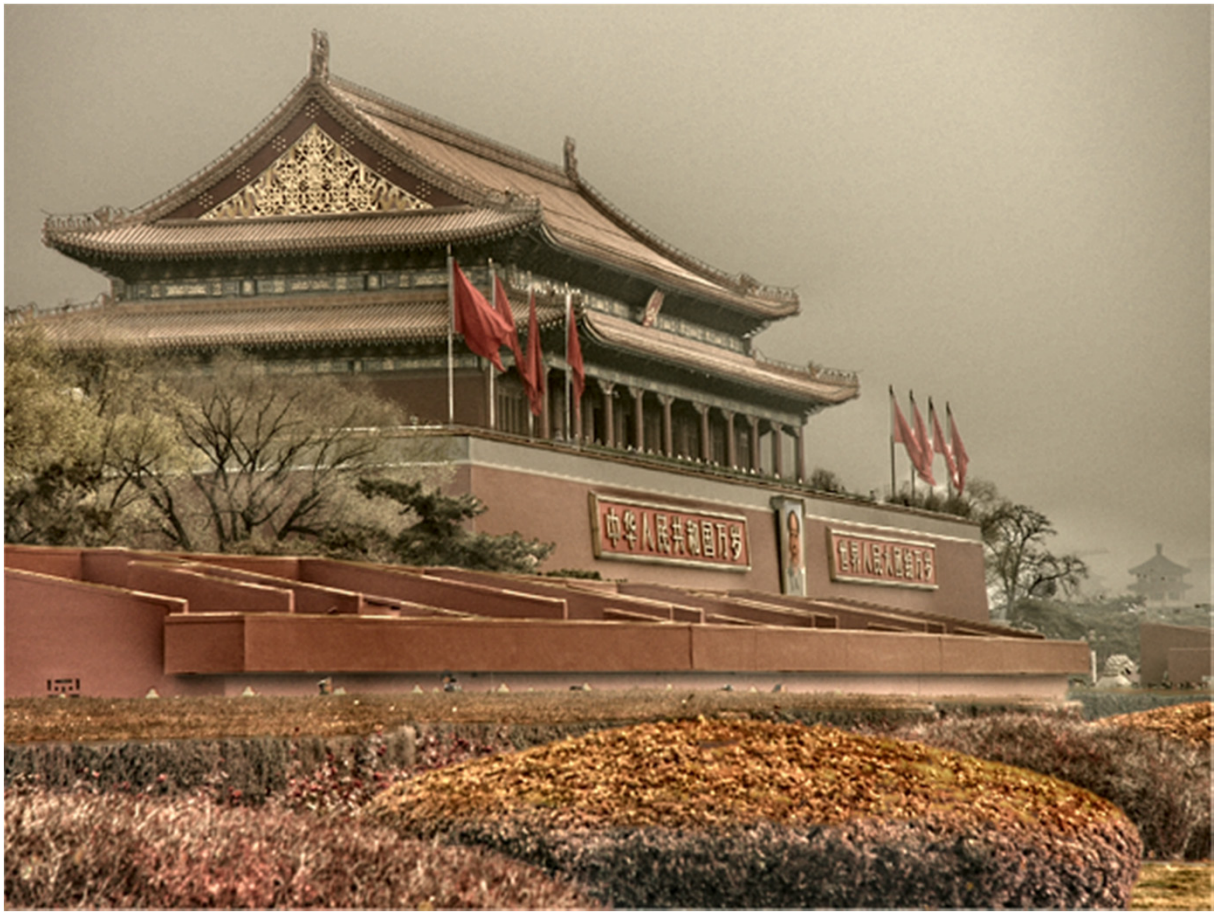
Results

- Image dehazing



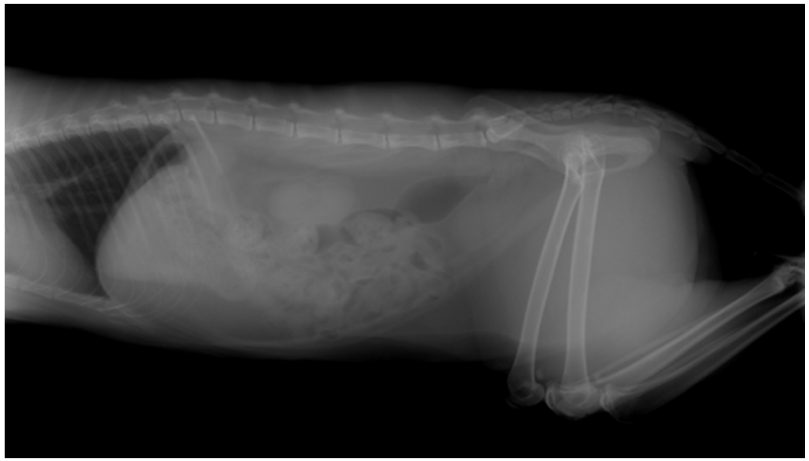
Results

- Image dehazing

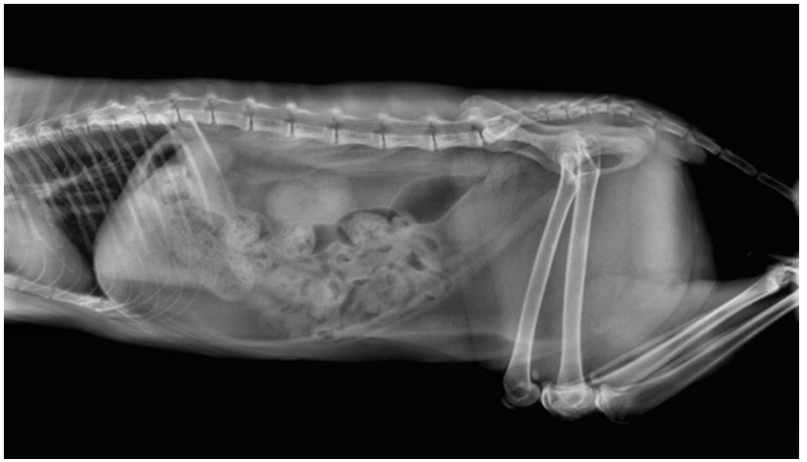


Results

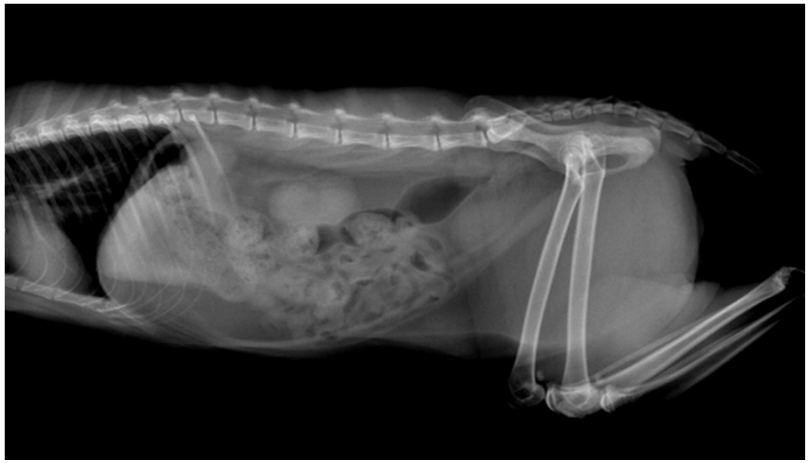
- Medical image enhancement



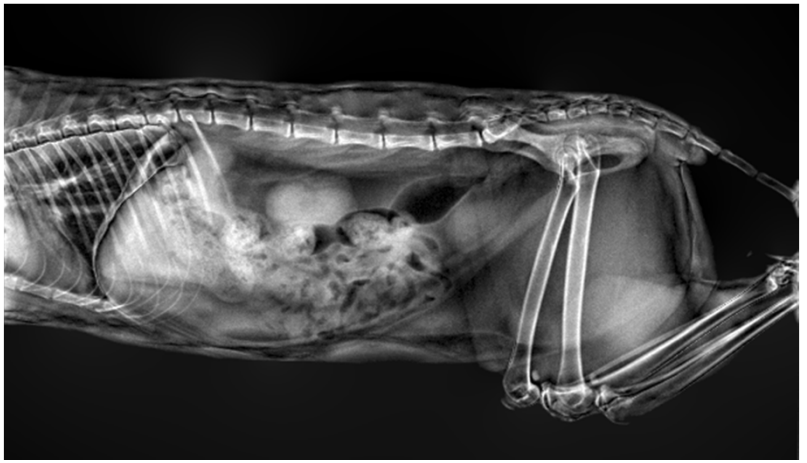
Input



Local histogram equalization



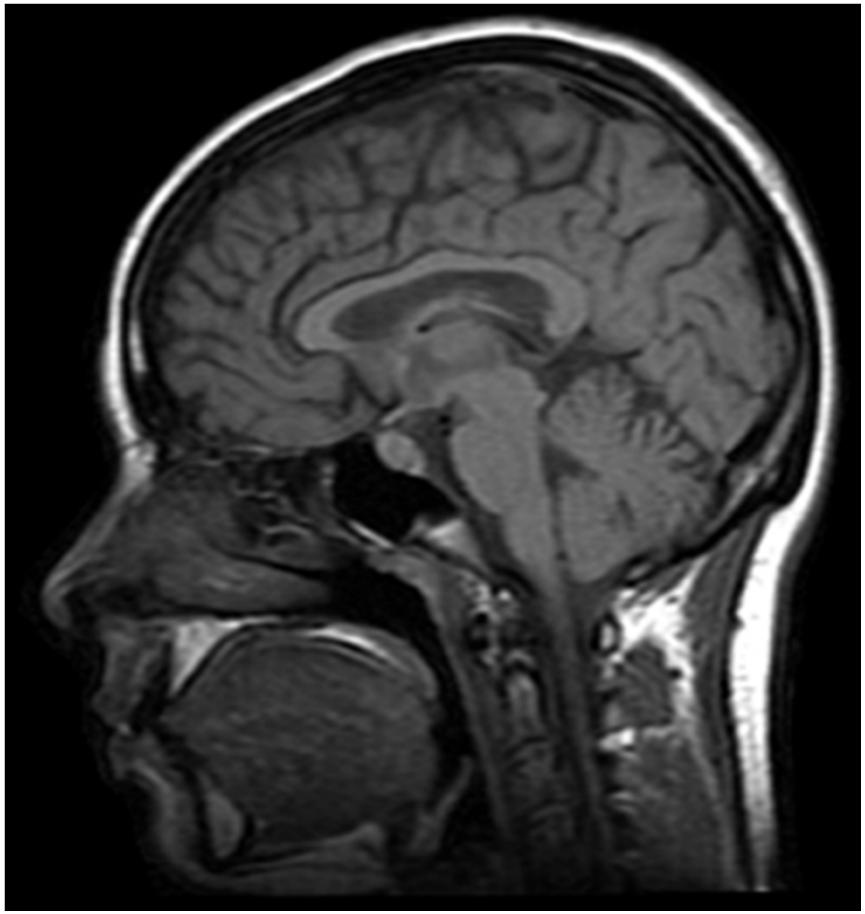
Photoshopped (sharpen filter)

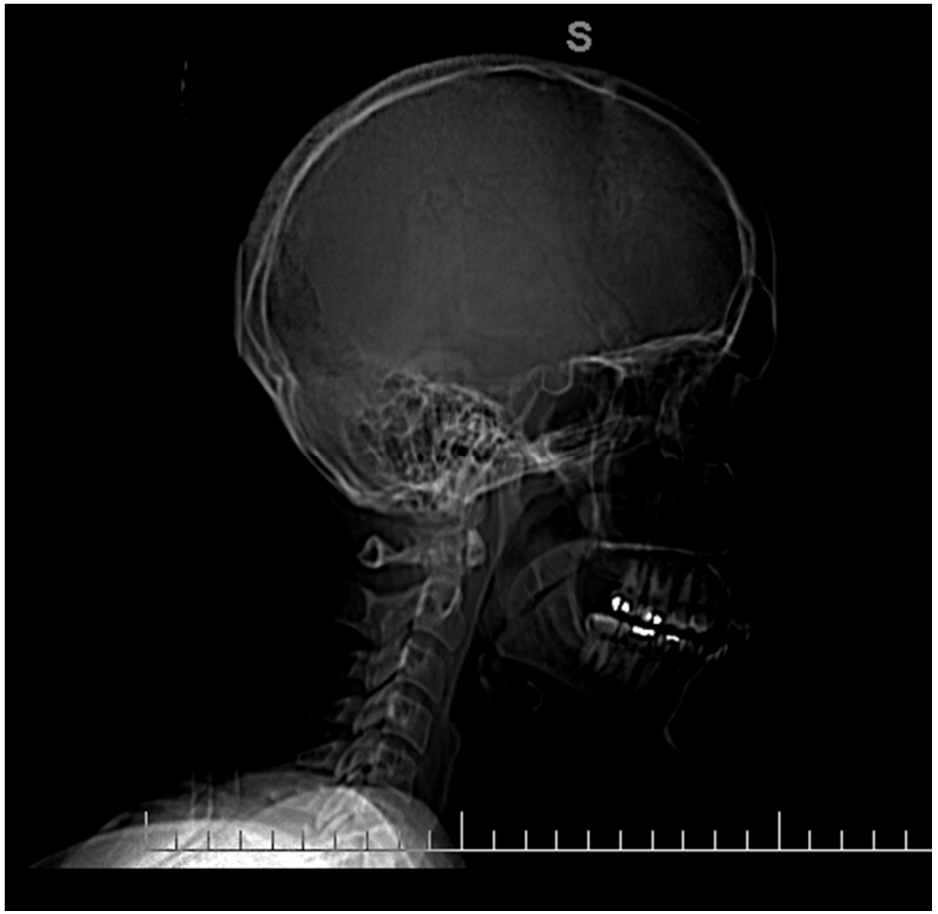


Our result

Results

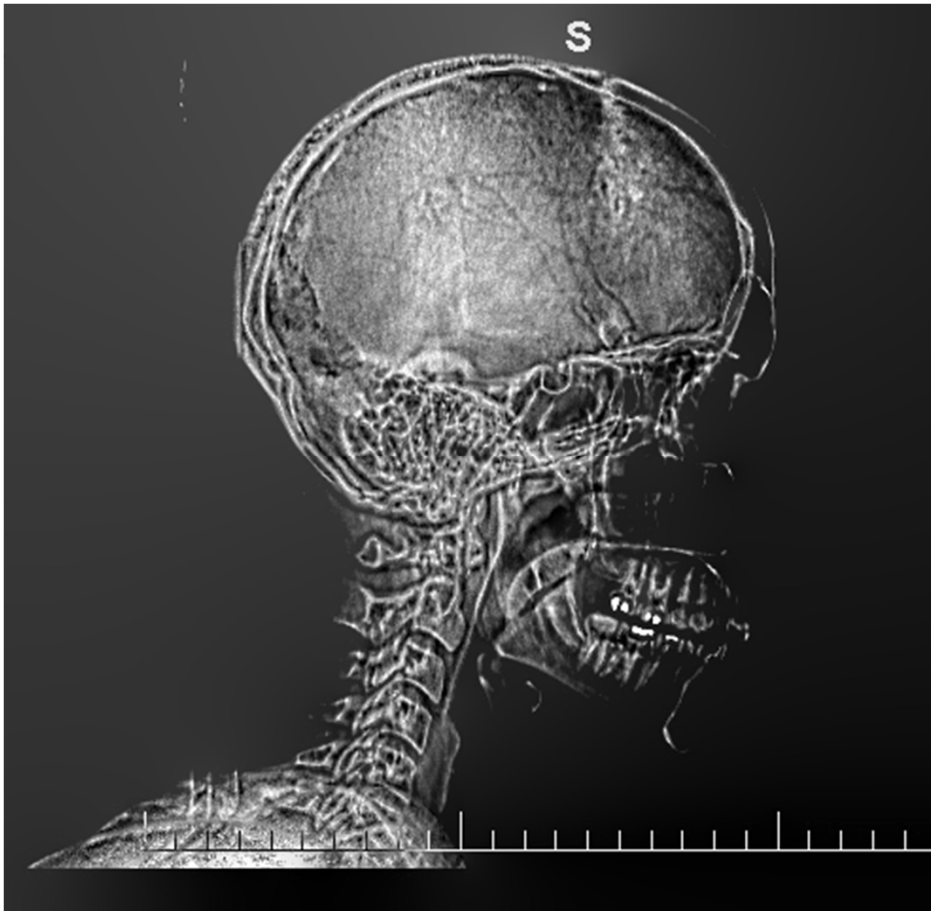
- Medical image enhancement





Results

- Medical image enhancement



Results

- Comparison

Input

Detail enhanced [Xu11]

Detail enhanced + tone mapping [Farbman08]

Detail enhanced + tone mapping [Paris11]

Our result

Results

- Comparison with art photography

Input LDR image

HDR imaging by Trey Ratcliff

Detail enhanced + tone mapping [Paris11]

Our result

Conclusion

- Extreme detail enhancement inspired by art photography
  - Tone transform model with base shift as well as detail scaling
  - Region-specific detail exaggeration using piecewise smooth transform
  - Optimization framework aiming to bring out extreme details in each region
- Interpolation-based level-of-detail control

Conclusion

- Limitations
  - Highly relying on soft region segmentation
  - Possibility of brightness reversal
  - Noise amplification
  - 4 minutes for 512x512 size image

- Future work
  - Multi-level approach
  - Semantic segmentation
  - Specialized optimization
  - Extension to color channels

http://cg.postech.ac.kr/research/art_photograph