Display-aware Image Editing

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Very large images are easy to create

- We are interested in 100+ Mpixels.
- large choice of panorama software
- taking plenty of pictures is easy
  - hand-held with a telephoto lens
  - dedicated devices, e.g. GigaPan
  - medical scanners

Demo

A tour of Hong Kong in 300 megapixels

Challenges

- A lot of pixels to process
  - 100 Mpixels and above
  - everything is slow
- Scene changes completely with location and zoom level
  - no single adjustment works everywhere

Our approach
Display-aware Image Editing

- Only 1 to 4 Mpixels visible at a given time

- Our silver bullet: **Take into account and process only the visible pixels.**

Related work: Fast image filters

- Bilateral grid [Chen 07, Paris 09], edge-aware wavelets [Fattal 09], guided filtering [He 10], geodesic image editing [Criminisi 11]…
  - designed for a few tens of megapixels
  - slow down on 100 Mpixels and above
    - process every pixel

Related work: Bounding boxes

- Process only the affected regions [Shantzis 94]
  - global algorithms need touch every pixel
  - ignore zoom level
    - large regions can appear small when fully zoomed out

Related work: Adaptive tone mapping

- Viewer for HDR panoramas [Kopf 07]
  - adapt viewing parameters to visible image portion
  - does not allow user control

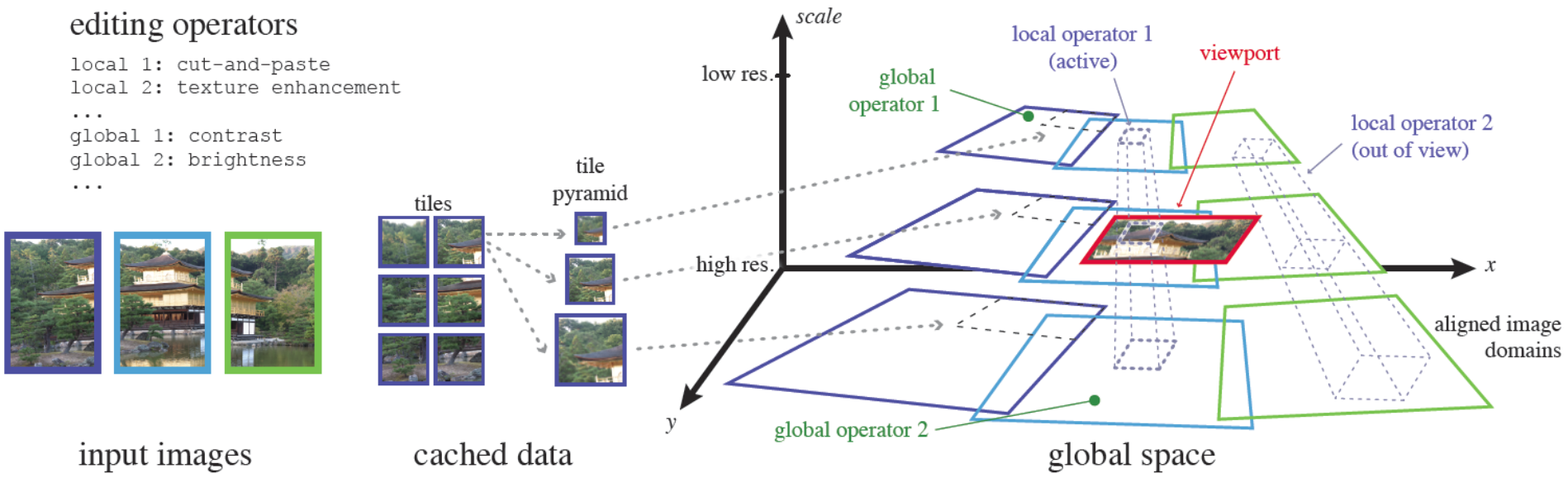
Talk outline

1. Efficient viewer
2. Display-aware algorithms
3. Display-aware viewing parameters

Our viewer

- Design choice: displayed image computed on-the-fly each time
  - dependencies straightforward to handle
- Efficient implementation
  - tile-based cache hierarchy
  - GPU-accelerated filters
  - bounding boxes

Viewer design



We load only the visible data.

We execute only the operators that affect the current view.

Extended in [Jeong et al. Vis'10].

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1. Efficient viewer
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Formal discussion

- A filter f is display-aware if the visible portion of its output can be computed only from the visible portion of the input I.

- Sufficient to process Laplacian pyramids locally
  - output coefficients depend only on nearby coefficients
  - proof in the paper
  - also a limitation, i.e. constrains algorithm design

Formal discussion

- A filter f is display-aware if the visible portion of its output can be computed only from the visible portion of the input I.
  - s is the operator that display an image on the screen
  - f is display-aware if $s(f(I)) = f(s(I))$

Formal discussion

- Displaying an image I on the screen, $s(I)$:
  1. low-pass filter followed by downsampling
     - equivalent to crop in Fourier domain
  2. crop in image space
- To commute with s, a filter f should not use data than may be cropped by s
  - use only local data in space and frequency
  - **Local processing on Laplacian pyramids**

Example application: Seamless image compositing

- Standard approach: gradient-domain + Poisson eq.
  - global optimization: does not scale up

Our approach

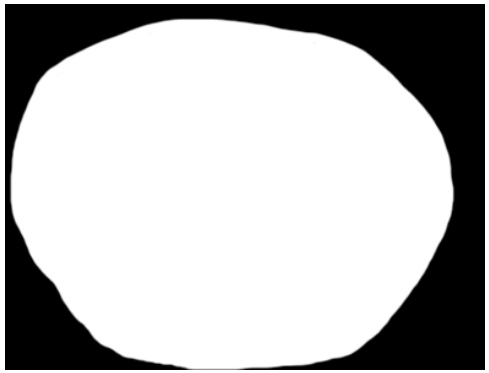
- Inspired from [Farbman 09]
  - core operation is computing a smooth interpolant of offset values defined at boundaries

- We use pyramid-based interpolant [Burt 88]
  - classical push-pull operation

Input data

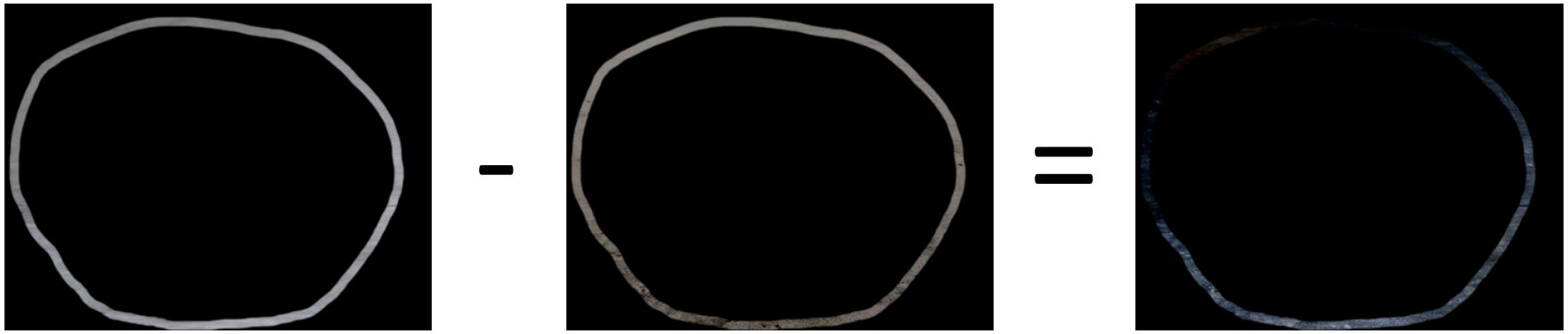
foreground

background



mask

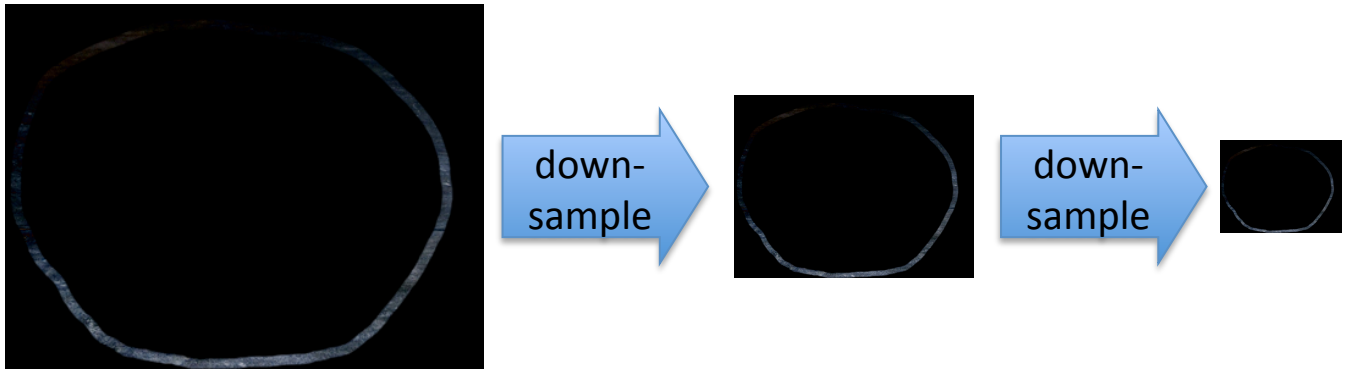
1- Compute offsets at boundary



foreground background offsets

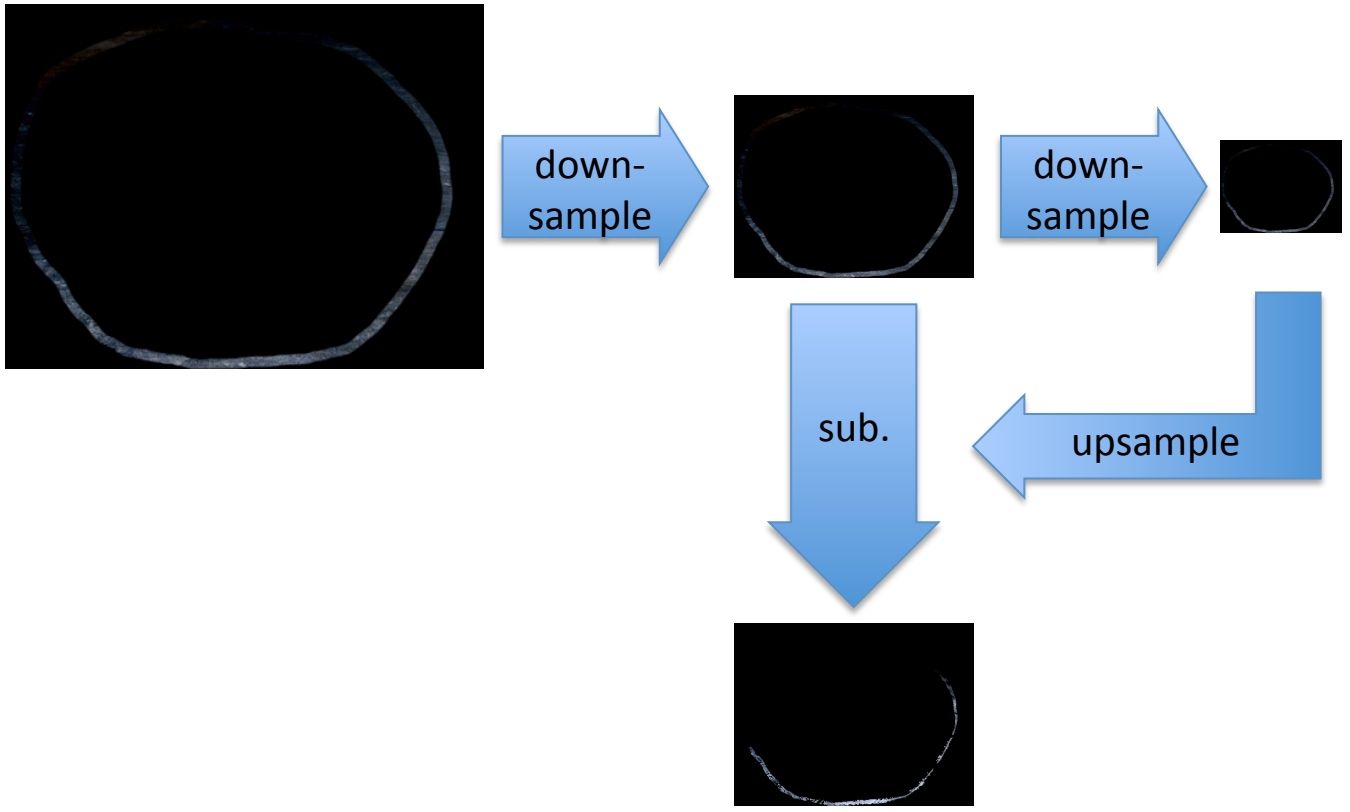
2- Build a Laplacian pyramid with the offsets

Gaussian pyramid:



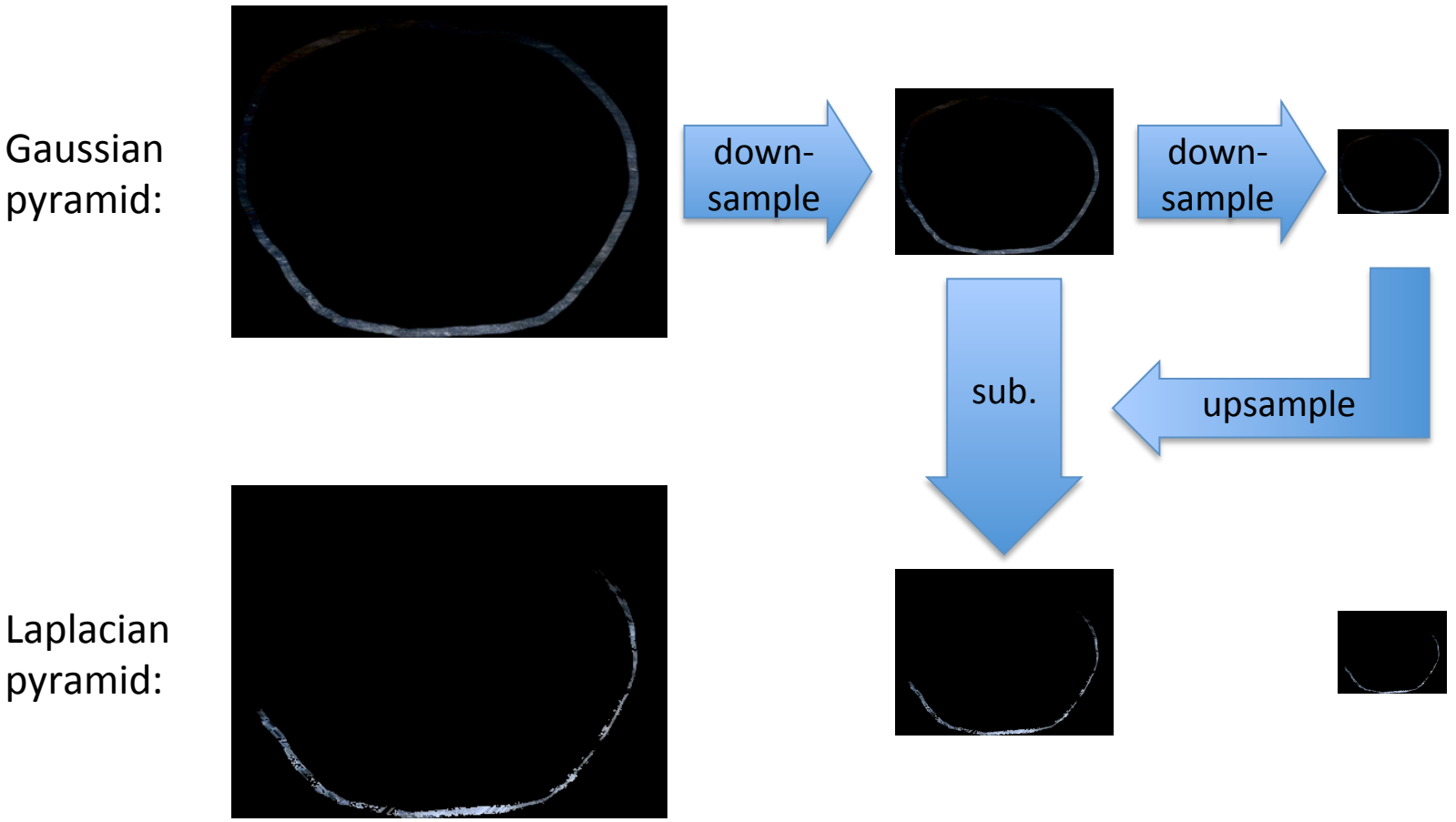
2- Build a Laplacian pyramid with the offsets

Gaussian pyramid:



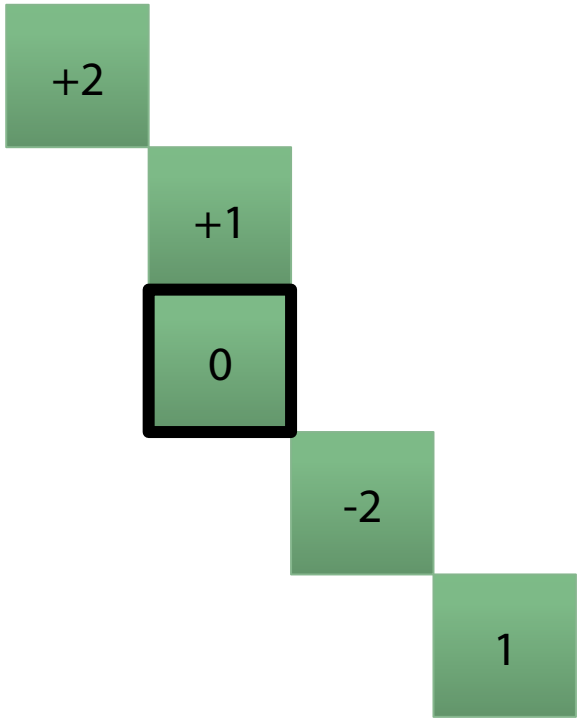
Laplacian pyramid:

2- Build a Laplacian pyramid with the offsets

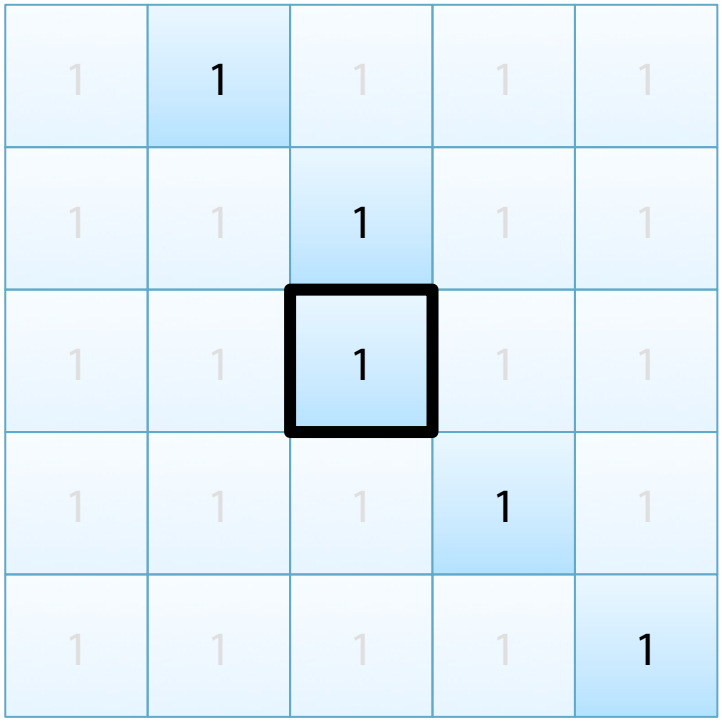


2- Build a Laplacian pyramid with the offsets

To downsample, keep only the values where there are data.



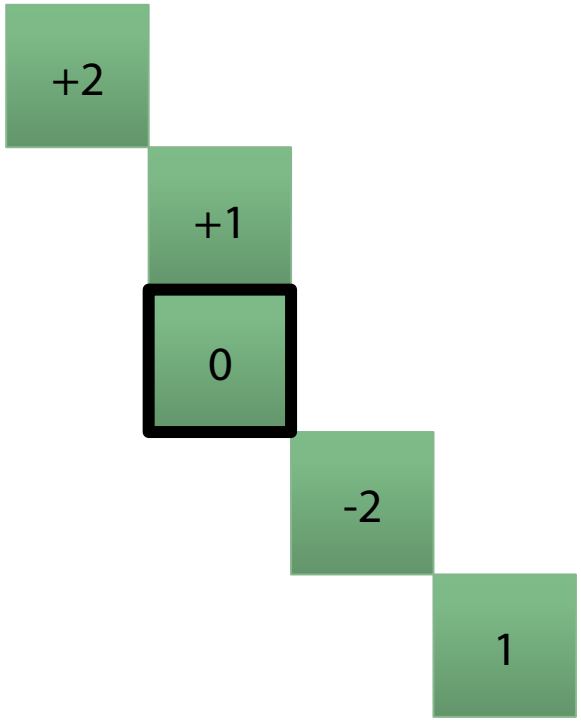
boundary offset values



blurring kernel
(box for illustration)

2- Build a Laplacian pyramid with the offsets

To upsample, keep all the values.



boundary offset values

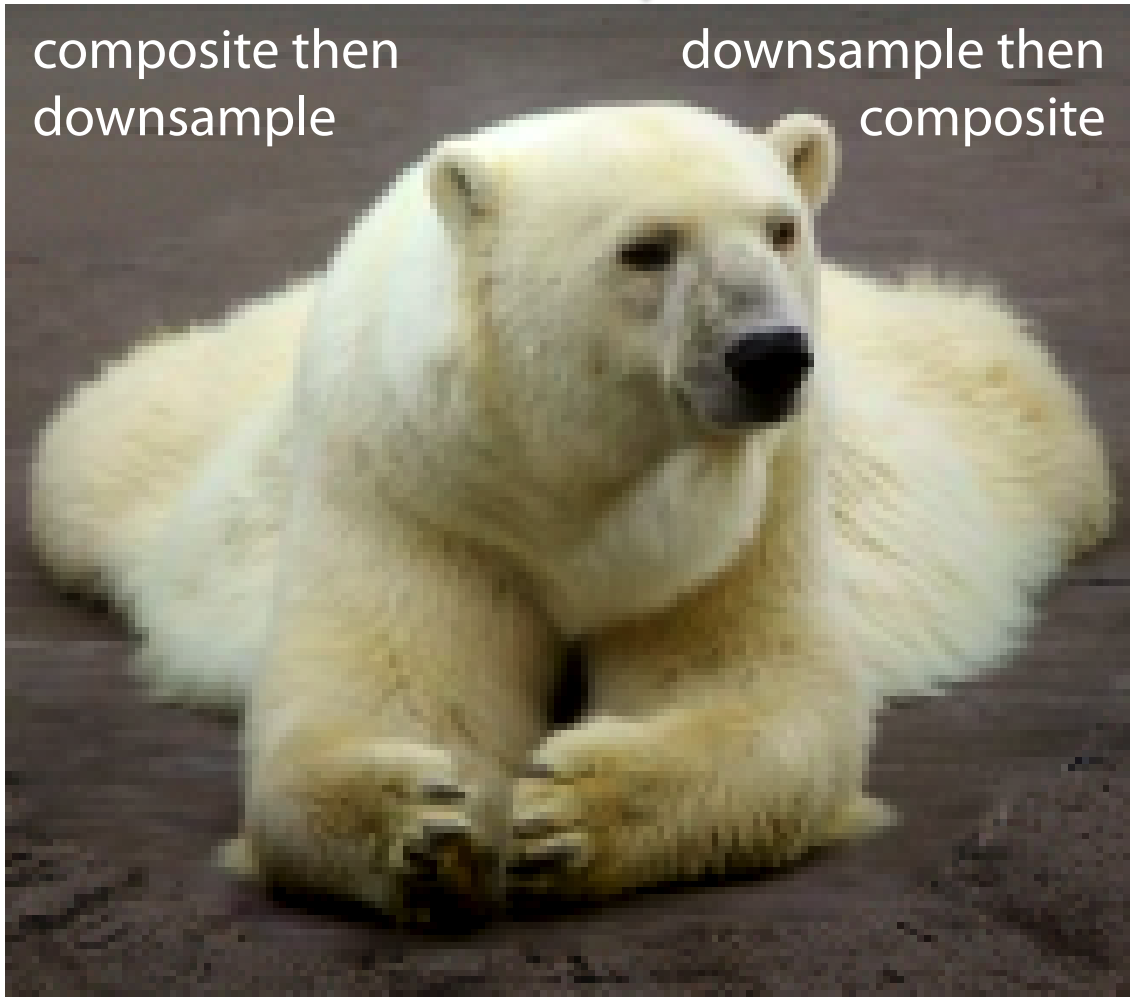
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

blurring kernel
(box for illustration)

3- Collapse the pyramid

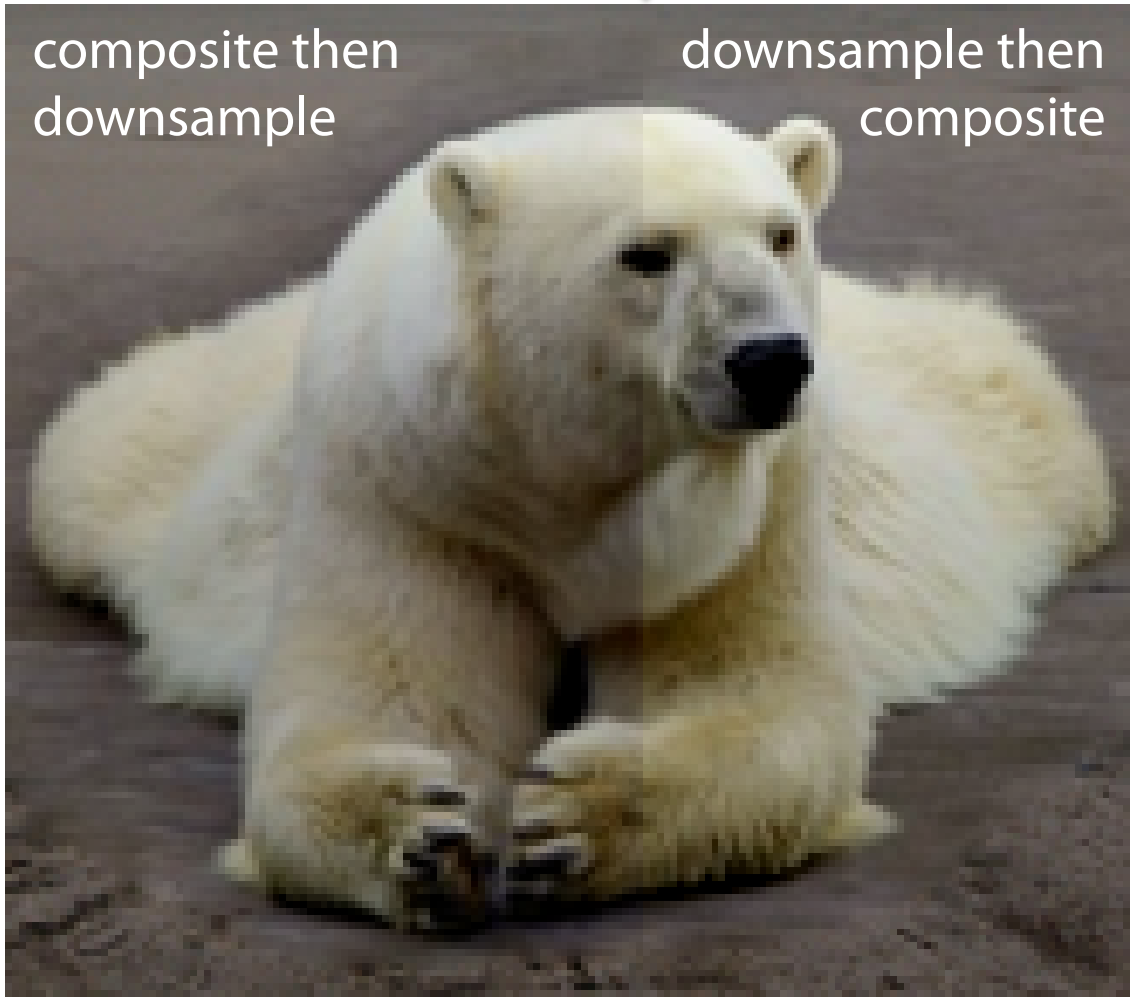
our result

Is it really display-aware?

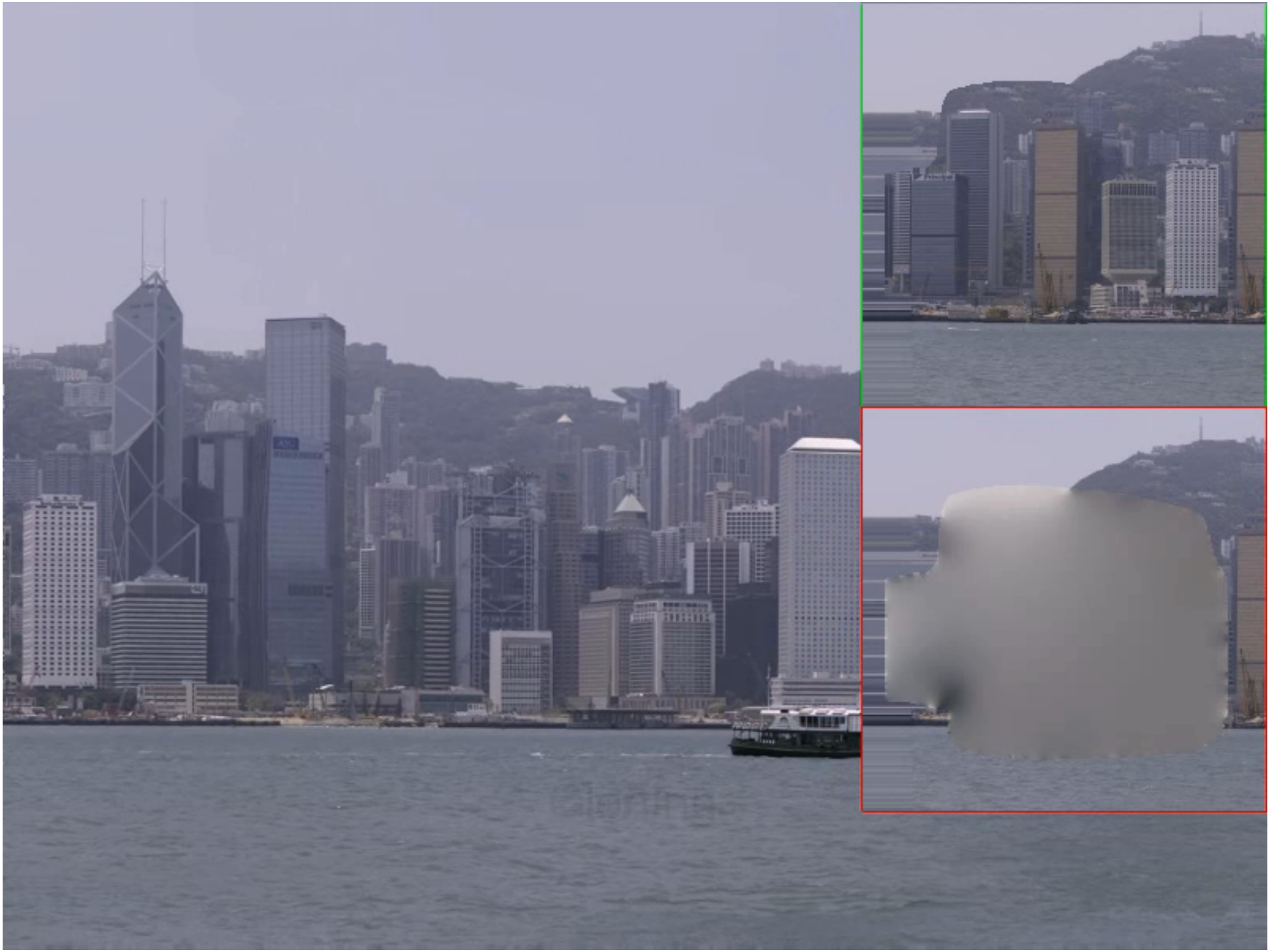


our result

Is it really display-aware?

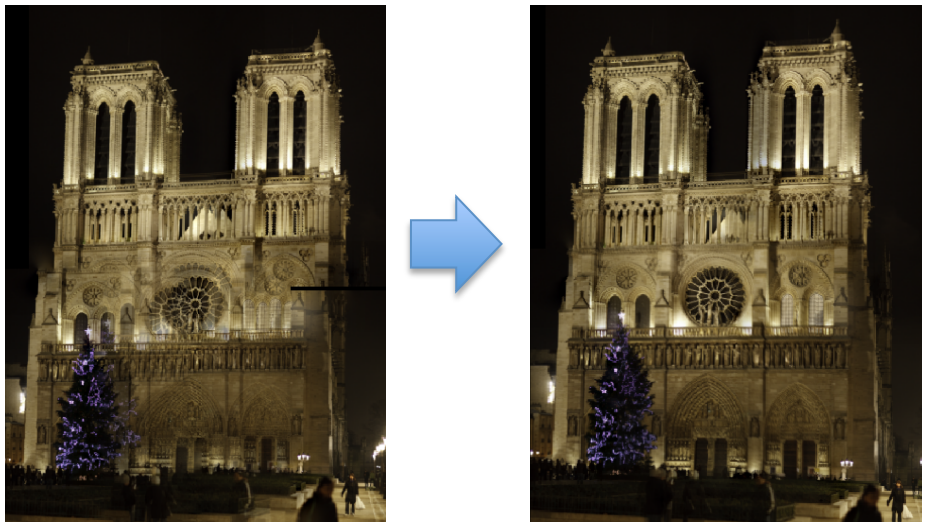


Photoshop result (gradient domain)



Other Applications

- Image alignment
  (see the paper)



- Edge-aware image editing
  (to appear at Siggraph)

Talk outline

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Objective

- Adapting the viewing parameters (brightness, contrast…) to the current view

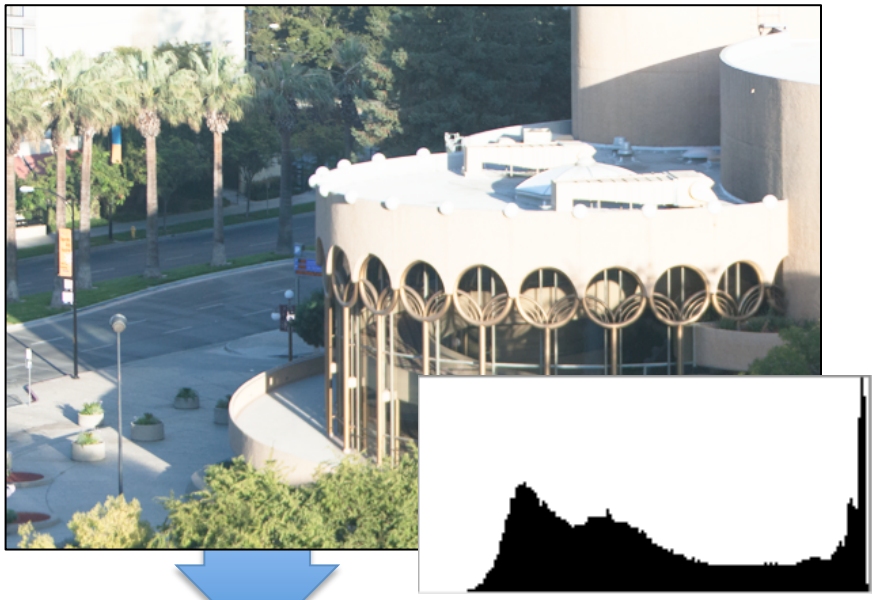
- Automatic by default, user can override

User study (Mechanical Turks)

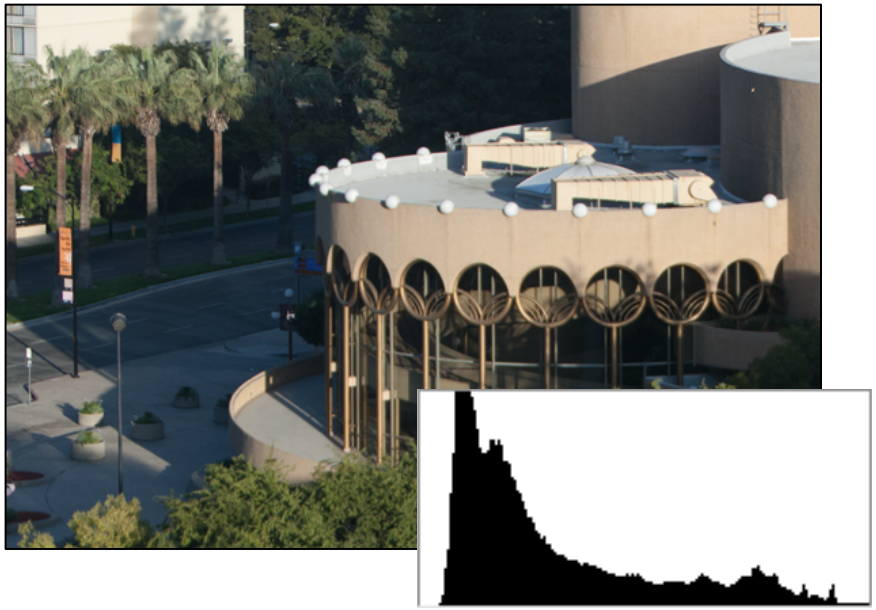
- Users adjust photos.
  - instruction: neutral pleasing rendition (postcard)

- We compare before and after.
  - **Image histograms are more similar after adjustment than before**.
  - Confirms the results of [Bae 06]

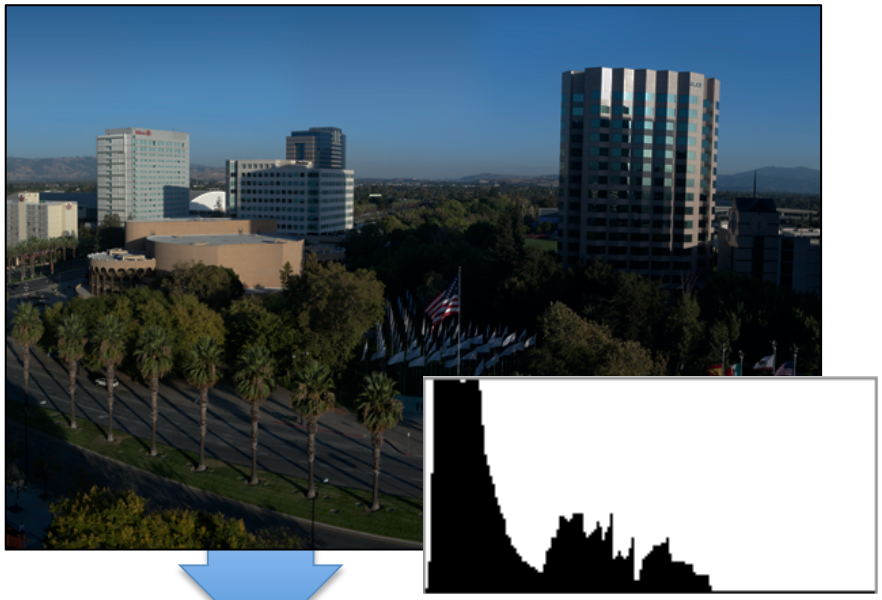
before adjustment



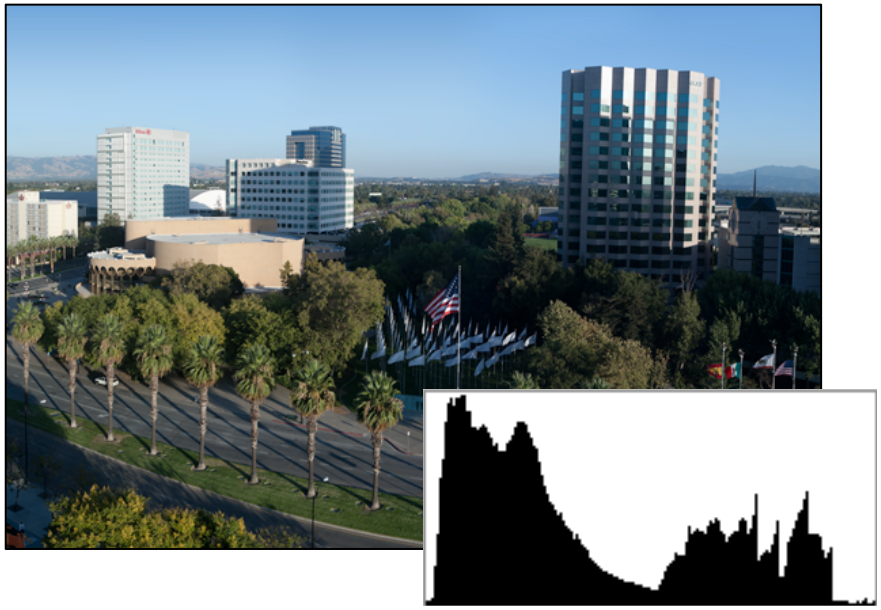
after



before adjustment



after



Our strategy

Keep histogram as constant as possible.

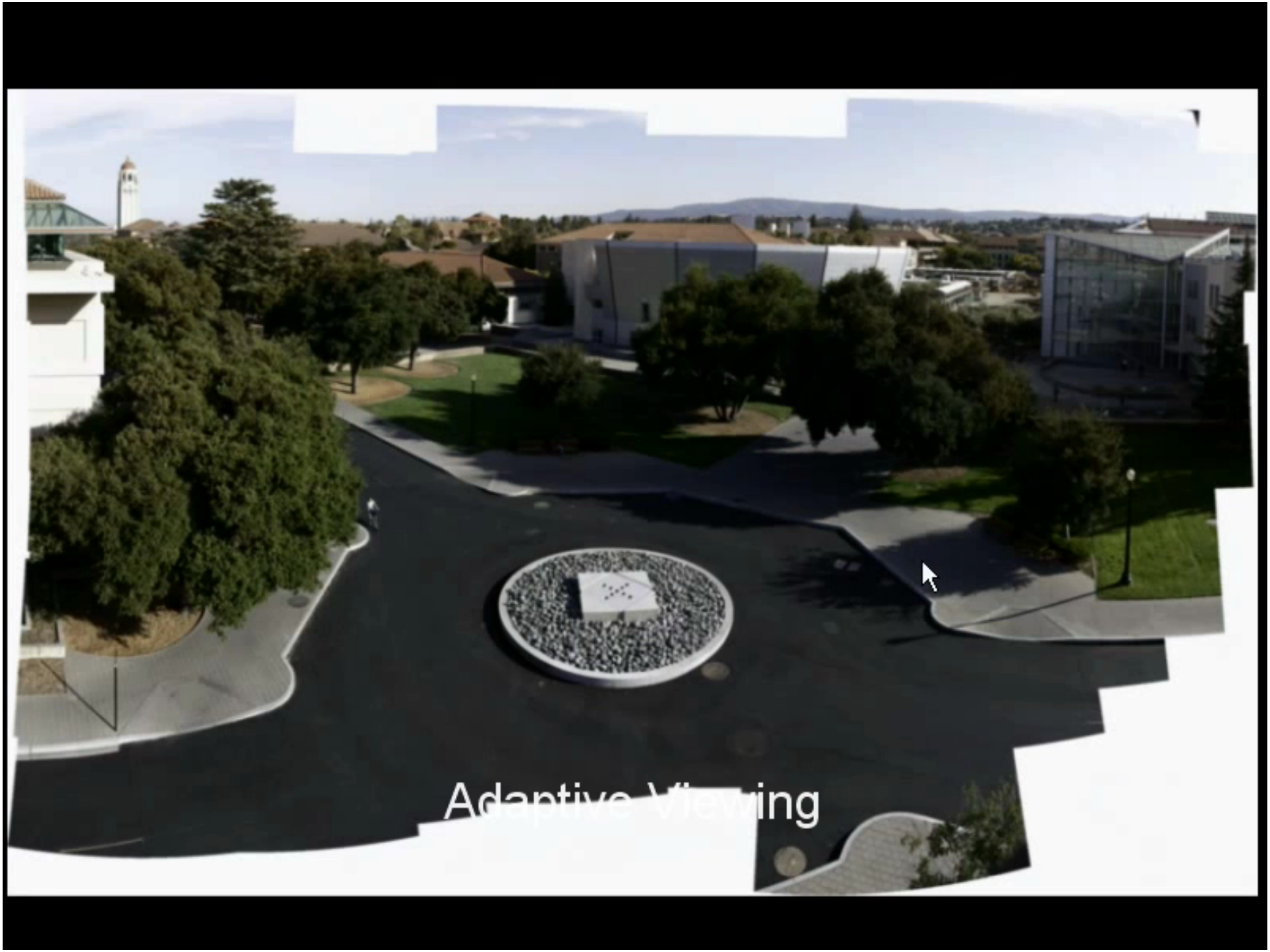
Algorithm overview

1. User specifies parameters at a few locations and scales.

2. For unspecified views, find k nearest neighbors with edits.
   - distance = EMD on unedited image histogram

3. Compute average edited histogram of the k neighbors

4. Estimate viewing parameters to best match that histogram


Adaptive Viewing

Conclusion

- We enable the editing of
  very large images (1+ Gpixel).
- Laplacian pyramids are key.
- Histogram distance
  characterizes adjustments.
- Well-suited for mobile devices with small screens and limited computational power.

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HAPPY BIRTHDAY!
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