# Computational Photography

Digital Visual Effects Yung-Yu Chuang

with slides by Fredo Durand, Ramesh Raskar, Sylvain Paris, Soonmin Bae, Amit Agrawal, Ramesh Raskar

#### There are a lot of cameras around us



# Photography in the mobile era









- Cameras can only provide incomplete and imperfect records of the moments at the best.
- Computational photography: photographs are results of computation, rather than simply sensing.

#### Computational photography

#### wikipedia:

**Computational photography** refers broadly to computational imaging techniques that enhance or extend the capabilities of digital photography. The output of these techniques is an ordinary photograph, but one that could not have been taken by a traditional camera.

#### What is computational photography

- Digi<mark>VFX</mark>
- Convergence of image processing, computer vision, computer graphics and photography
- Digital photography:
  - Simply mimics traditional sensors and recording by digital technology
  - Involves only simple image processing
- Computational photography
  - More elaborate image manipulation, more computation
  - New types of media (panorama, 3D, etc.)
  - Camera design that take computation into account

#### Scope

- We can't yet set its precise definition. The following are scopes of what researchers are exploring in this field.
  - Record a richer visual experience
  - Overcome long-standing limitations of conventional cameras
  - Enable new classes of visual signal
  - Enable synthesis impossible photos



DigiVFX

## Computational photography



#### Imperfect photographer



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# Deblurring



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# Deblurring



#### Digi<mark>VFX</mark>

#### Deblurring







# Motion-Based Motion Deblurring









#### Video stabilization

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#### original video

stabilized video

#### Deblurring







#### Imperfect scene







## Flash photography







Flash





#### Flash photography













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# Image Inpainting









## Image Inpainting



#### Dehazing



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# Dehazing



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# Sky replacement



# Sky replacement



## Inpainting







#### **Re-composition**















## **Re-composition**

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#### Imperfect cameras





# Noise

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real scene

image

#### Resolution





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real scene

image

#### Dynamic range



real scene



Digi<mark>VFX</mark>

image

Digi<mark>VFX</mark>

#### Color



real scene

image

#### Non-linear response



real scene



image

#### Cameras

- Image formation
- Color and color
  perception











# Exposure blending



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Our composite result

# Stitching

#### Digi<mark>VFX</mark>



# Retargeting



#### Retargeting



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scaling



## Vignette calibration













#### **De-noising**





# Super-resolution



#### original

## Super-resolution





bicubic

## Super-resolution





#### Computational camera





#### Image manipulation

• Gradient image manipulation



cloning

seamless cloning

#### sources/destinations

DigiVFX

#### Image manipulation

• Non-parametric image synthesis, inpainting, analogies





input images







Figure 1 An image analogy. Our problem is to compute a new "analogous" image B' that relates to B in "the same way" as A' relates to A. Here, A, A', and B are inputs to our algorithm, and B' is the output. The full-size images are shown in Figures 10 and 11.

B'































- Graph cuts,
  - Segmentation and mosaicing
- Gradient domain operations,
  - Tone mapping, fusion and matting
- Bilateral filters,
  - Denoising, image enhancement
- Deep learning