SYDE 575: Introduction to Image Processing

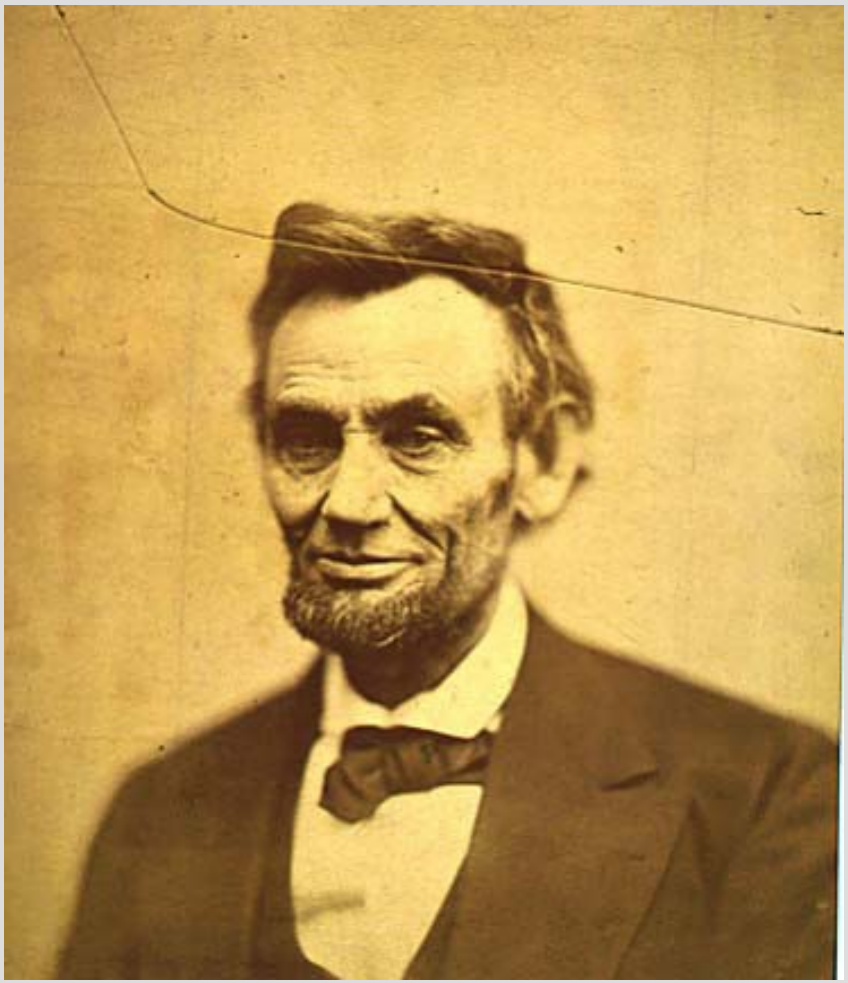
Image Restoration:
Digital Inpainting

What is Inpainting?

- Term “inpainting” originated from art restorers, who manually fills in parts of a painting that has cracked off over time
- In digital image processing, inpainting refers to the process of automatically restoring missing information in images and videos

Why inpainting?

- Remove physical deterioration
  - Cracks
  - Scratches
  - Dust



Source: Oliveira et al. 2001

Why inpainting?

- Recover lost blocks in transmission of images and videos

Source: Liu et al. 2007

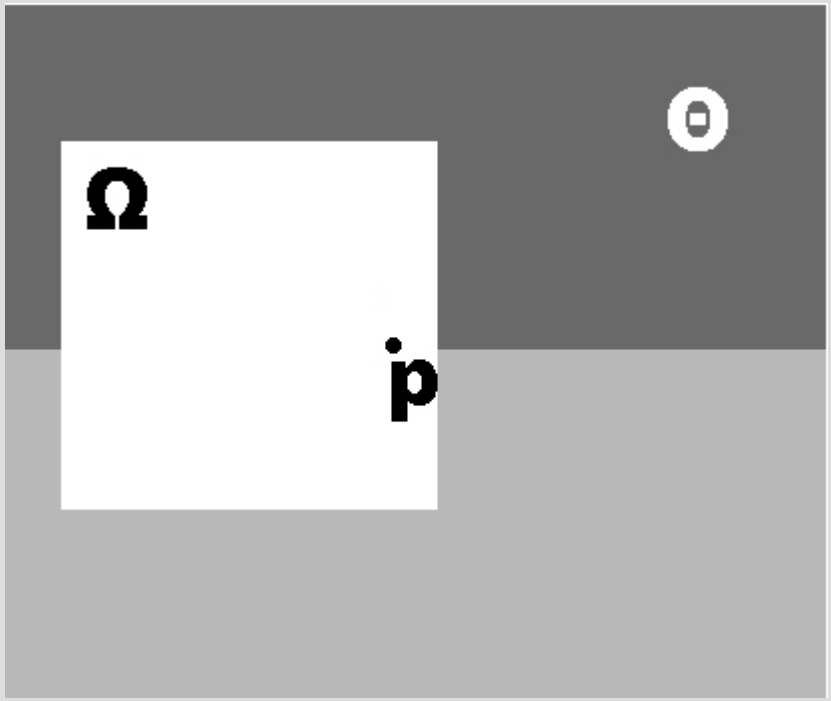
Why inpainting?

- Remove unwanted image content
  - Power-lines
  - Birds
  - People
  - Text

Source: Oliveira et al. 2001

Problem Formulation

- Fill in target region Ω using information from source region Θ



Inpainting Algorithms

- Digital inpainting algorithms generally categorized into two main groups:
  - Diffusion-based methods
  - Exemplar-based methods

Diffusion-based Methods

- Inspired by the physical diffusion process, where molecules spread from areas of high concentration to areas of low concentration to fill a volume
- For digital inpainting, information from source region is “diffused” into the target region to fill in missing information

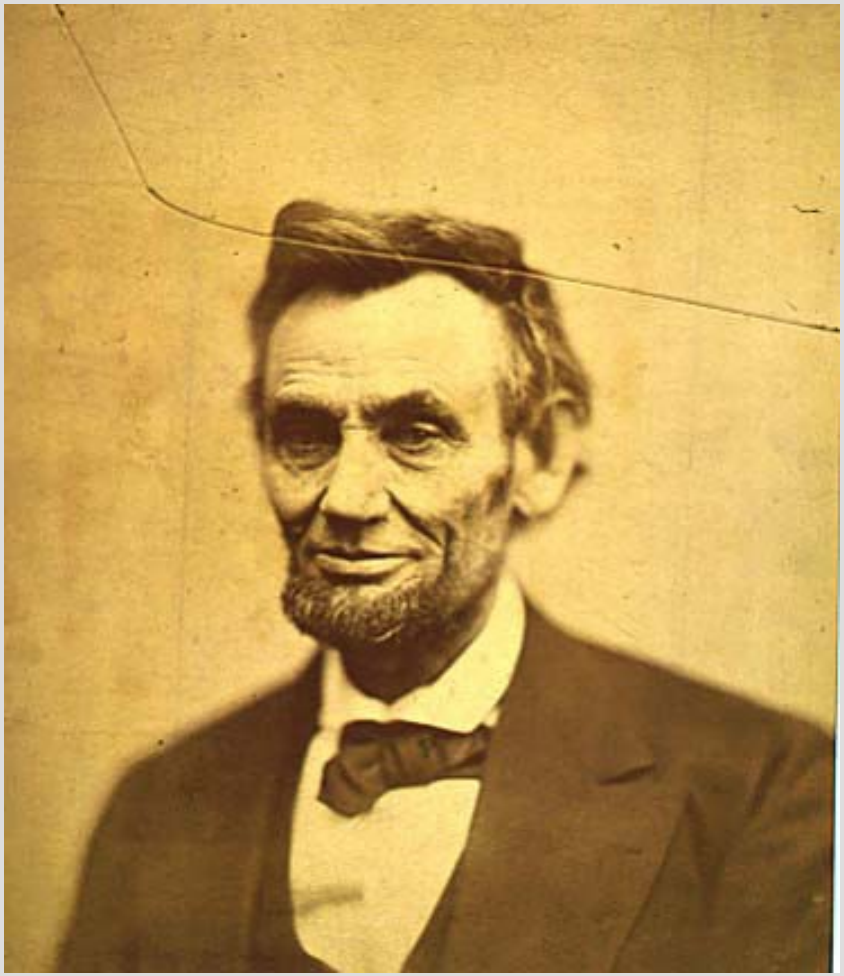
Diffusion-based Methods

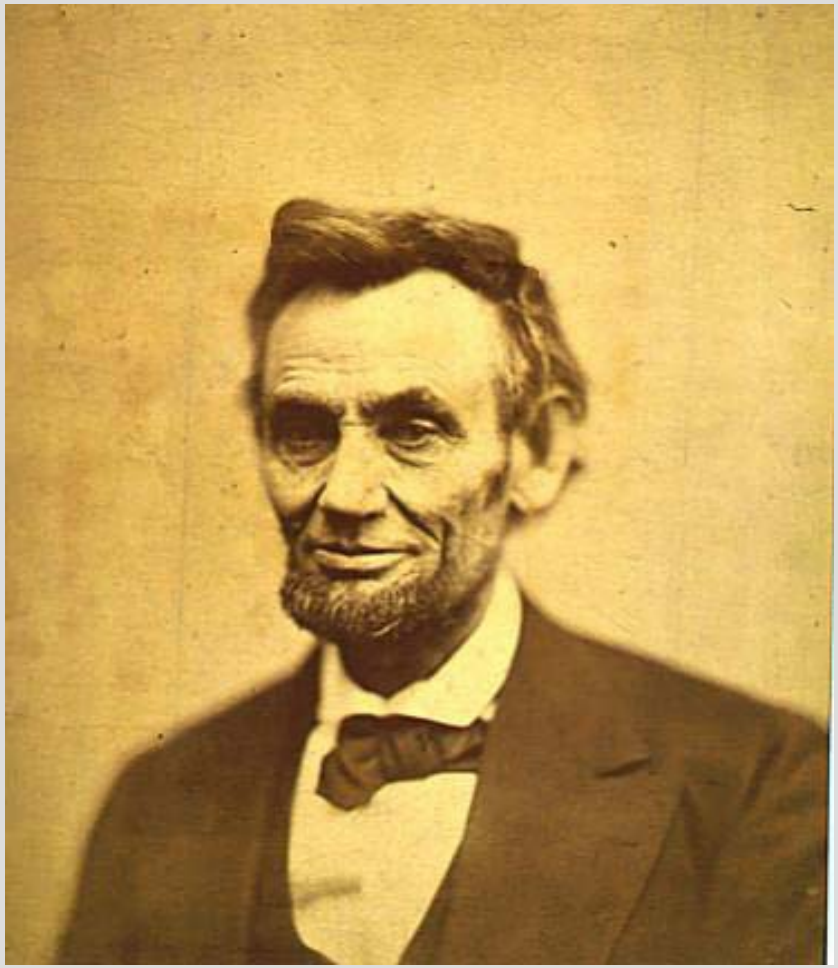
- Diffusion in digital images is analogous to repeatedly smoothing (convolution)
- Intuitively, diffusion-based methods repeatedly smooth image content from the source region to the target region until the target region is filled

Simple Diffusion-based Algorithm

- Let Ω be the target region, Θ be the source region
  - Define boundary $\partial\Theta_1$ in target region Θ
  - Convolve $\partial\Theta_1$ with isotropic smoothing kernel (e.g., Gaussian) for a number of iterations
  - Define new boundary $\partial\Theta_2$ in new smaller target region
  - Repeat process until the entire target region is filled in

Results



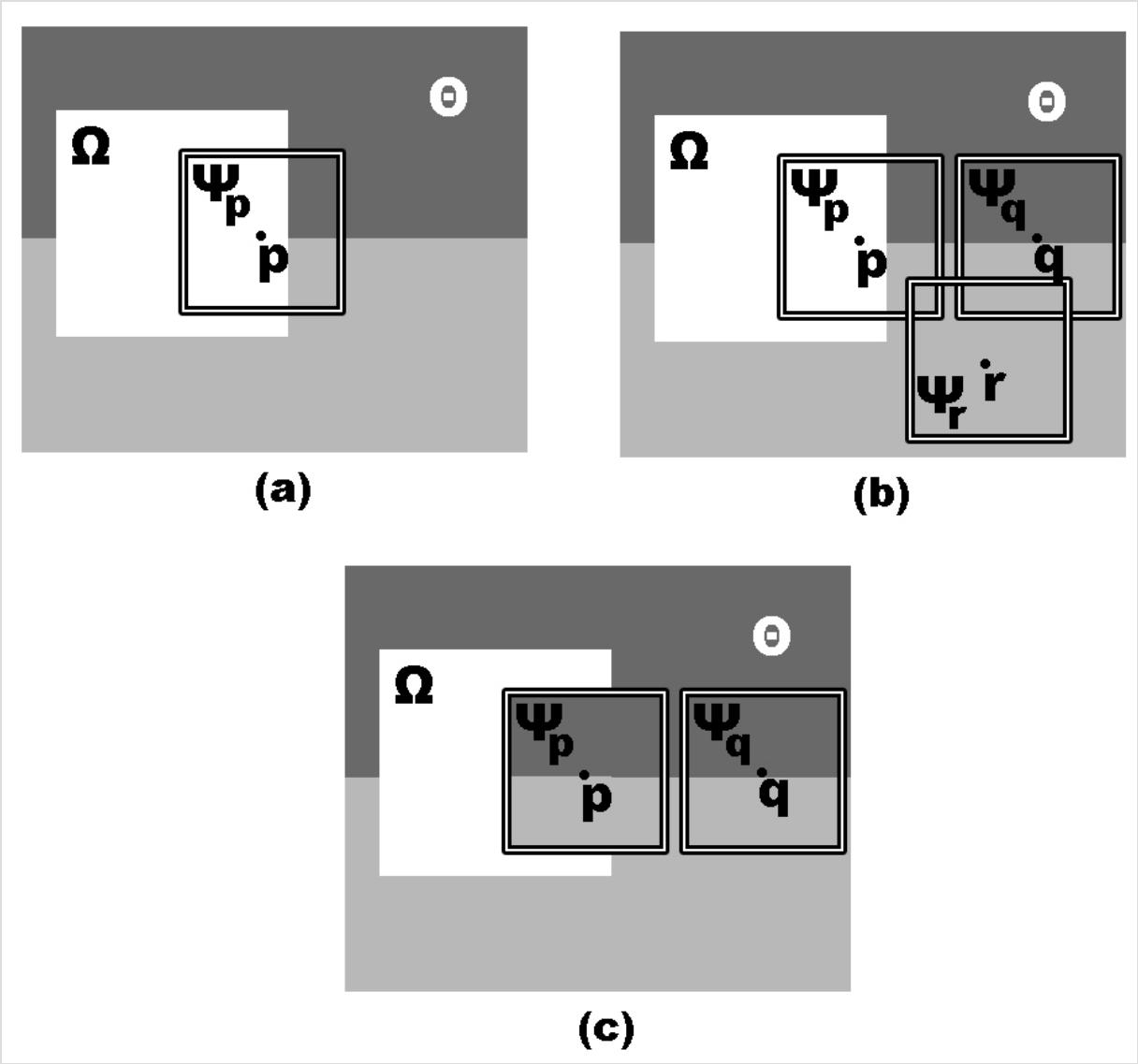


Source: Oliveira et al. 2001

Disadvantages

- Appearance of blurring
  - Very noticeable for large regions and structures
- Difficult to fill in large regions properly
  - Why?
    - Restricted to using local information
    - Many situations where local information does not characterize the missing information

Illustration of Exemplar-based Inpainting



Simple Exemplar-based Algorithm

- Let Ω be the target region, Θ be the source region
  - Define boundary $\partial\Theta_1$ in target region Θ
  - Find patches with the best match for patches around $\partial\Theta_1$ as exemplars
    - Similarity between patches can be determined using measures such as mean square error (MSE)

Simple Exemplar-based Algorithm (Cont'd)

- Fill patches around $\partial\Theta_1$ with the exemplars
- Define new boundary $\partial\Theta_2$ in new smaller target region
- Repeat process until the entire target region is filled in

Results

Source: Criminisi et al. 2004