Photo Enhancement with Inpainting

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SSIP 2008

Project Presentation
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The group

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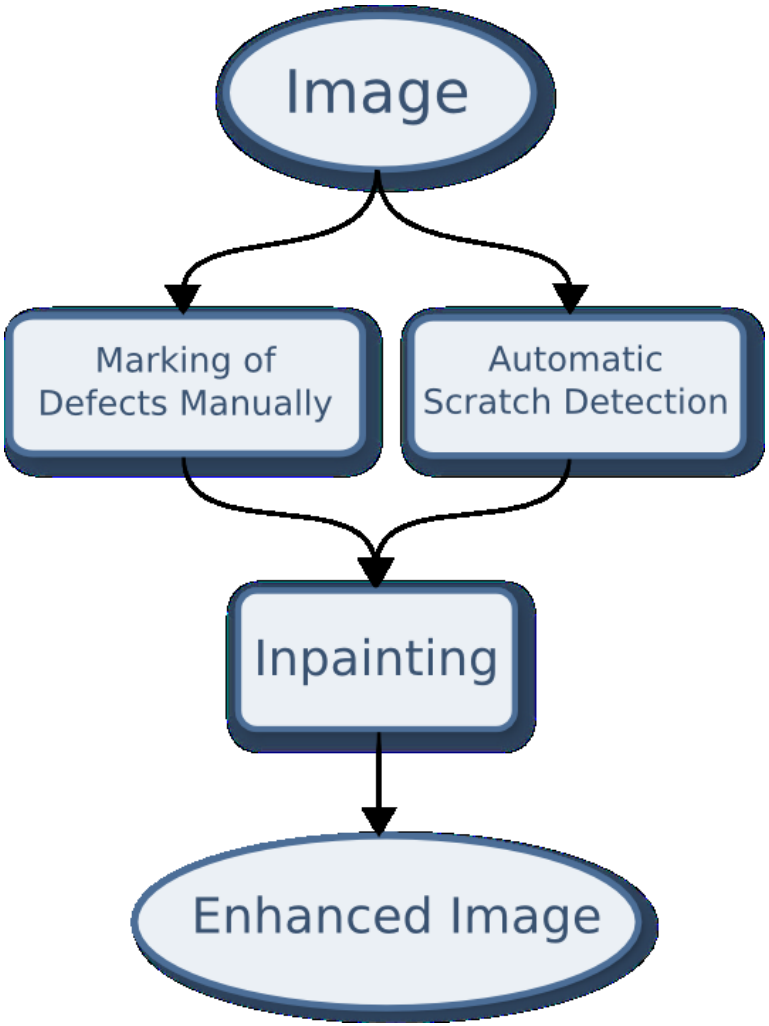
Photo manipulations

- Enhance quality
  - Remove scratches and spots
  - “Highly adaptive median filter”
  - Photo restoration
- Enhance content
  - Remove unwanted parts
    - Objects, people
    - Wires, graffiti
    - TV logo, text
  - Change the appearance of people
    - Glasses
    - Mustache, beard
    - Tattoo
  - Make people look nicer
    - Remove wrinkles, freckles
  - . . .

Nikolai Yezhov removed

Work flow of the proposed method



Defect detection

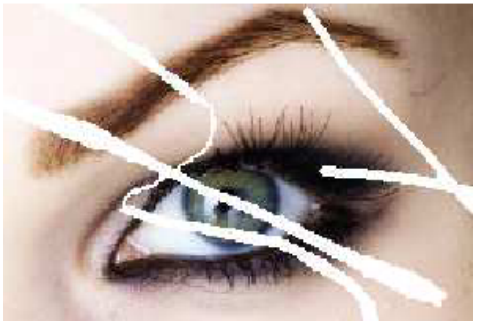
- Color based segmentation
- Hough transform
  - Detect lines
    - Long scratches
    - Wires (disturbing the view)
  - Detect circles
    - Circular blobs
    - Dirty spots
- Parallel close edges
  - Threshold on large gradients
  - Thin defected areas assumed
- Semi-automatic defect detection
  - Refine a manually selected region
  - Suitable for thin scratches and small blobs



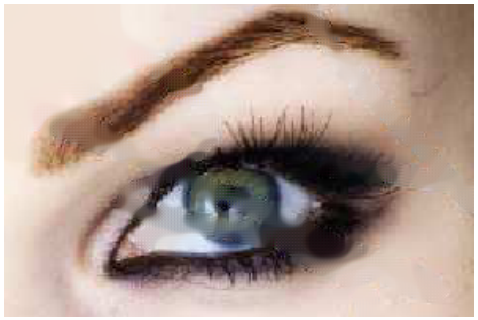
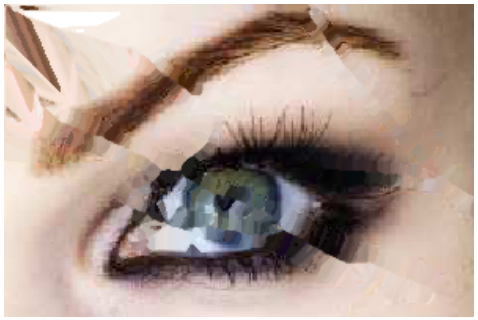


Implemented inpainting methods

- Input and mask[1]




- Output of inpainting

Isotropic diffusion | Anisotropic diffusion | Distance transform

[1] Intentionally so bad :)

Inpainting with diffusion

- Diffusion process

$$\partial_t \rho = \sum_{\alpha,\beta} \partial_\alpha \left(D_{\alpha\beta} \partial_\beta \rho \right) \tag{1}$$

- Applied to inpaint a region Ω (defined by $\mu(\Omega) = 0$)
- ρ and the derivatives of ρ are known outside the mask
- Assume some initial value inside the mask
- Solve Eq. (1) on Ω with fixed boundary conditions
- Let the system evolve until a steady state is reached

$$\sum_{\alpha,\beta} \partial_\alpha \left(D_{\alpha\beta} \partial_\beta \rho \right) = 0 \tag{2}$$

- Result = Smooth patch
- Texture synthesized in an additional step

Inpainting with diffusion

- Isotropic diffusion

$$D_{\alpha\beta} = D\delta_{\alpha\beta} \tag{3}$$

- Tends to smooth away edges
- Anisotropic diffusion
  - Eigenvectors parallel and perpendicular to image gradients
  - Diffusion only perpendicular to gradient $\Rightarrow$ Keeps edges
- Can be applied to multichannel images too
  - The diffusivity $D_{\alpha\beta}$ should be the same for all channels
  - Define a norm in the "color space"
  - Diffusion along isophote lines
- Convergence speeded up with a multiscale approach
  - Build a Gaussian pyramid and apply diffusion on all scales
  - Propagate information for lower to higher scales
  - Start diffusion form the result obtained on lower scale

Discretization

- Isotropic diffusion

$$\rho^{t+1} - \rho^t = D\left(\tilde{\rho}^t - 4\rho^{t+1}\right) \tag{4}$$

where

$$\tilde{\rho} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \star \rho \tag{5}$$

- Information taken from neighboring pixels
- Iterative solution

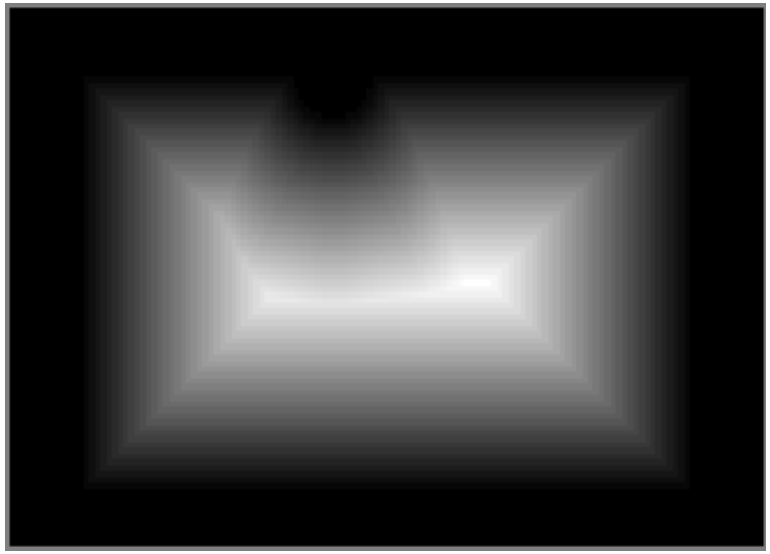
$$\rho^{t+1} = \frac{\rho^t + D\tilde{\rho}^t}{1 + 4D} \tag{6}$$

- Anisotropic diffusion discretized in a similar way
- Multiscale approach can be applied to speed up convergence

Inpainting Based on Distance Transform

- Distance to closest non-zero pixel

Input



Output

- Apply distance transform on the mask $\mu \rightarrow d(\mu)$
- Update image within the mask

$$\rho(\mathbf{r}) \leftarrow \rho\left(\mathbf{r} + d(\mu)\frac{\nabla d(\mu)}{\|\nabla d(\mu)\|}\right) \tag{7}$$

Applications




Image restoration



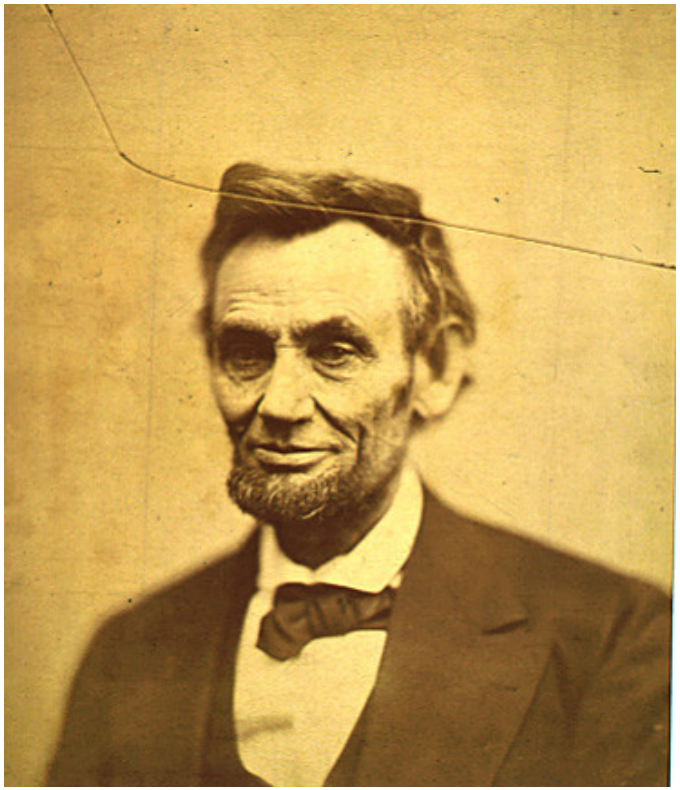


Image restoration

Original

Enhanced

Image restoration



Original

Enhanced

Image restoration

Original

Enhanced

Image restoration

Original

Enhanced

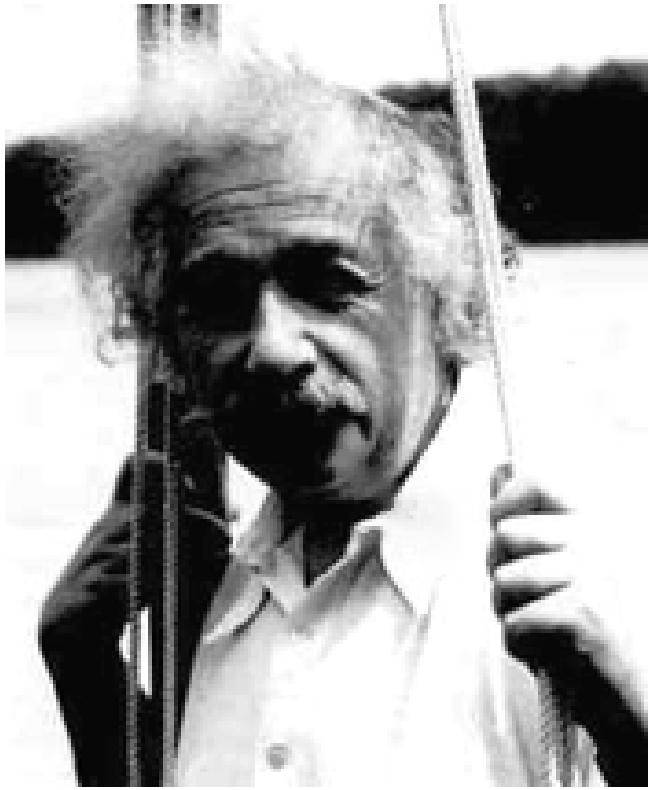
Removing unwanted image regions





Removing objects

Original



Enhanced

Removing text

Original

Enhanced

Fully automatic!

Using color based segmentation

Removing wires

Original

Enhanced

Fully automatic!
Using Hough transform

Removing wires

Original

Enhanced

Fully automatic!
Using Hough transform

Removing wires

Original

Enhanced

Making people look nicer on photographs





Removing freckles

Original

Enhanced

Removing freckles

Original

Enhanced

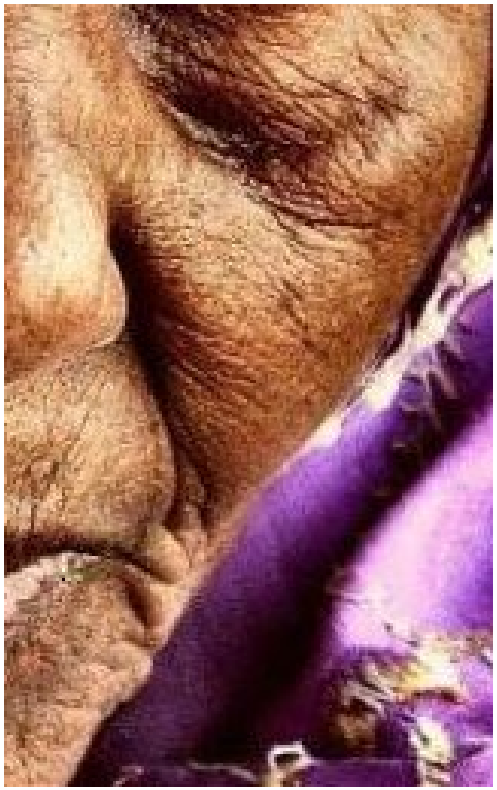
Removing wrinkles

Original

Enhanced

High frequency components of the texture kept

Removing wrinkles

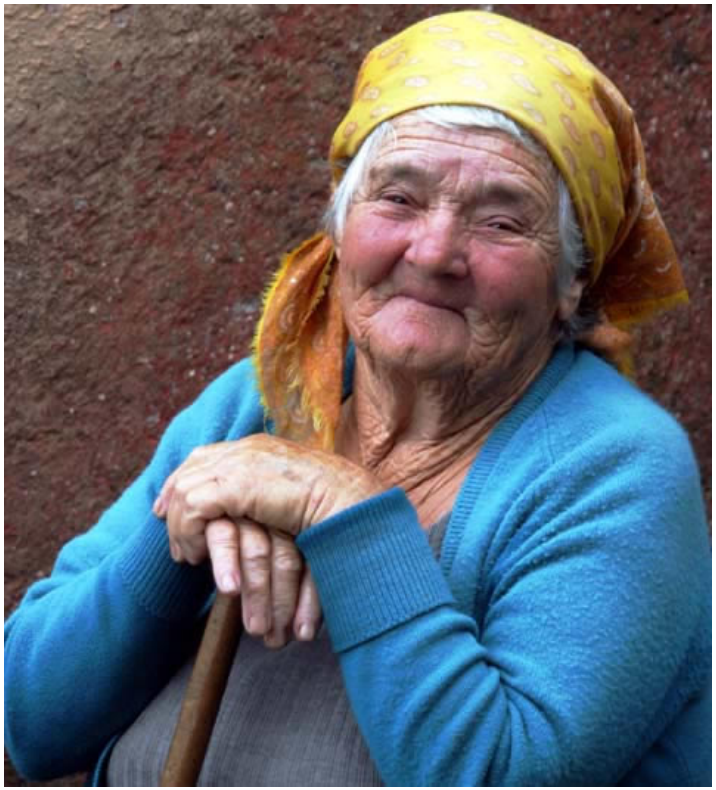


Original

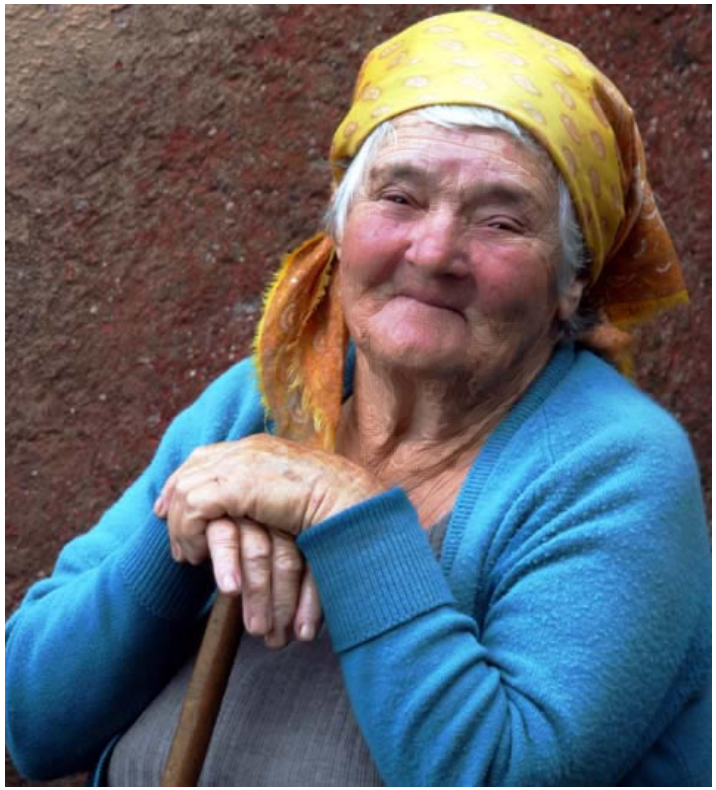
Enhanced

High frequency components of the texture kept

Removing wrinkles



Original

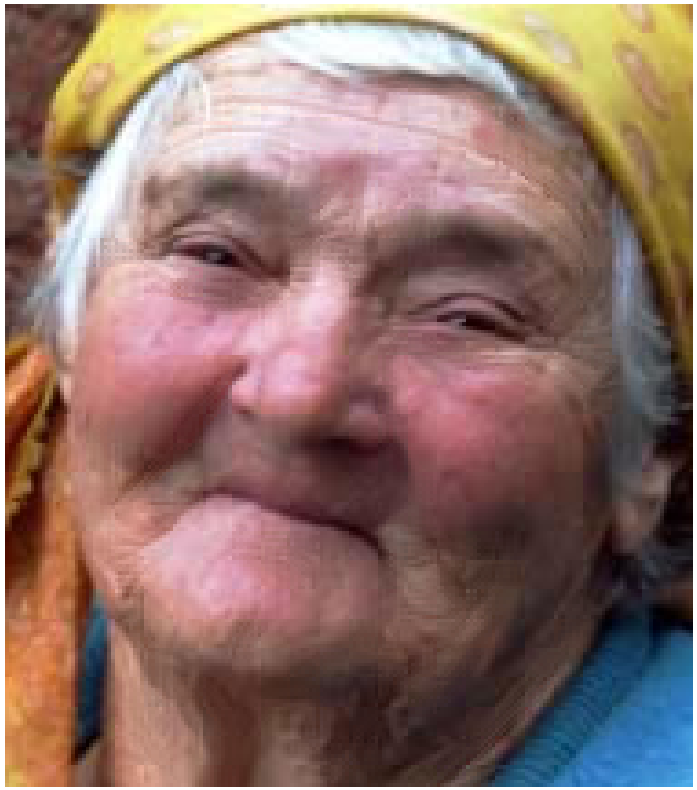


Enhanced

High frequency components of the texture kept

Removing wrinkles

Original

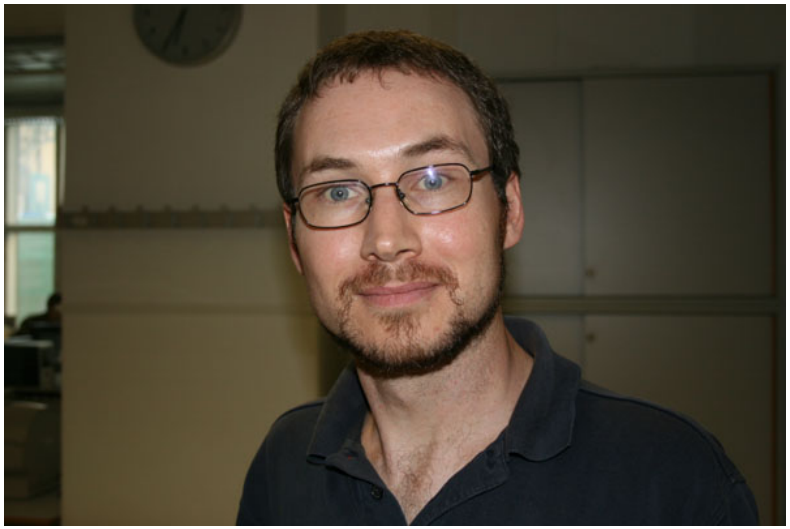


Enhanced

High frequency components of the texture kept

Changing the appearance of people

Removing glasses and mustache



Original

Enhanced

Removing glasses and mustache

Original

Enhanced

Limitations!




Limitations

Original

Enhanced

Thank you for your attention!