Image Inpainting

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Navier Stokes, Fluid Dynamics and Image and Video Inpainting

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presented by
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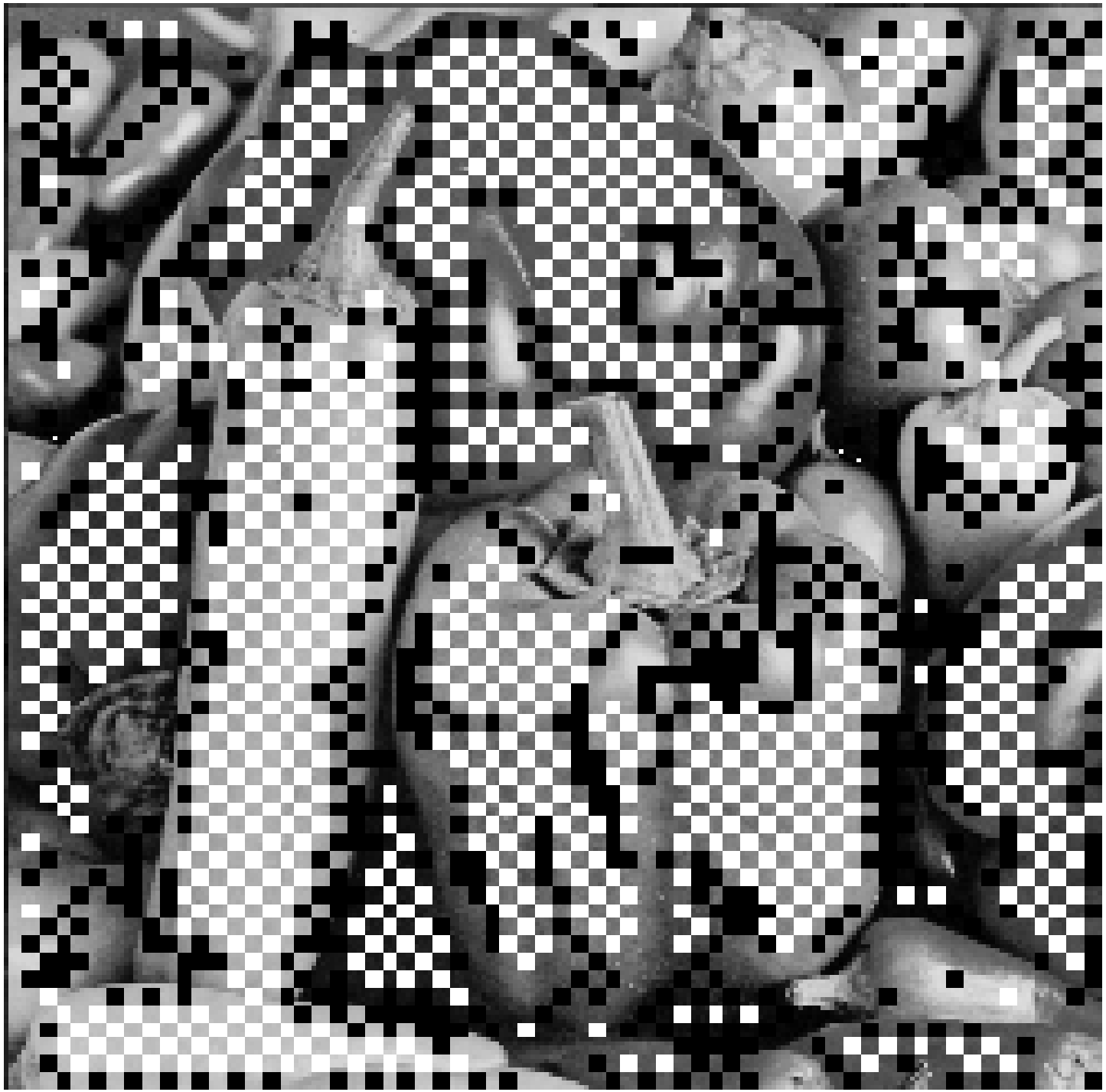
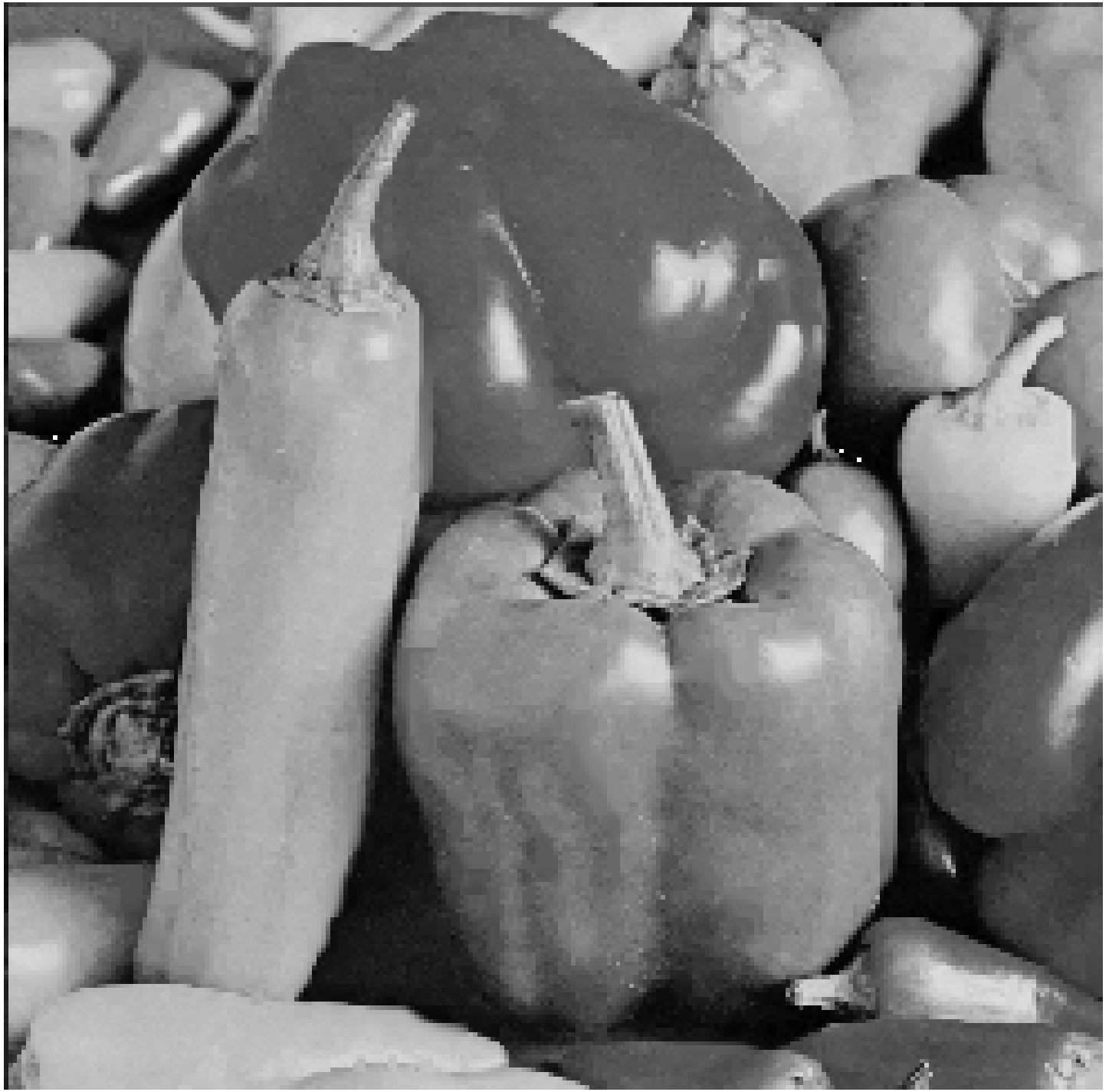
Goal

- Given image with significant portions missing or damaged
- Reconstitute missing regions with data consistent with the rest of the image





Cracks in Photos

Scratches in Film

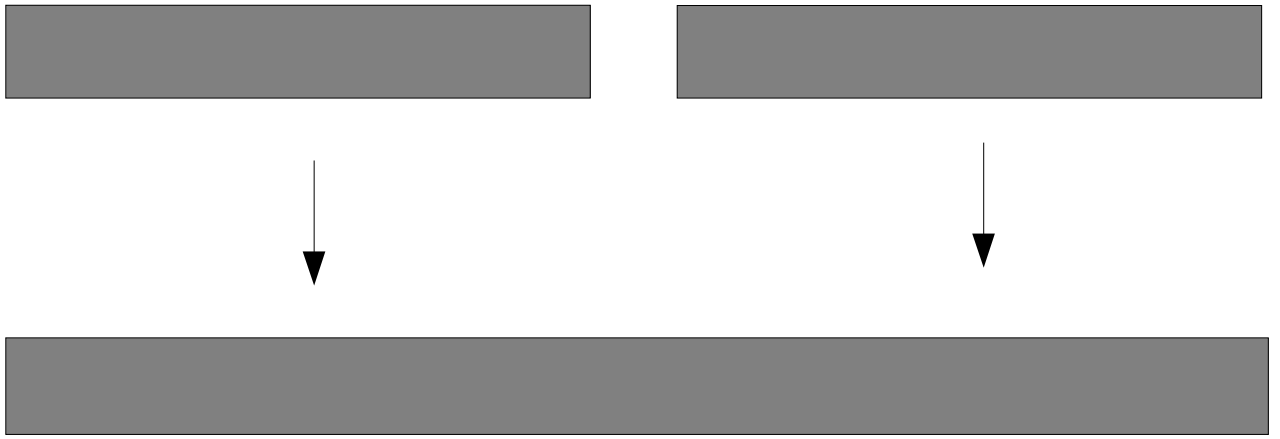
Add or remove elements

Professional Inpainters Approach

- Goal:
  - Subjectively restore unity to artwork
- General Approach:
  - Structure of surrounding area continued into gap
  - Color of surrounding area is continued into gap
  - Texture is added

Gestalt Law of Continuation

- Principle holding that there is an innate tendence to perceive a line as continuing its established direction



General Algorithm

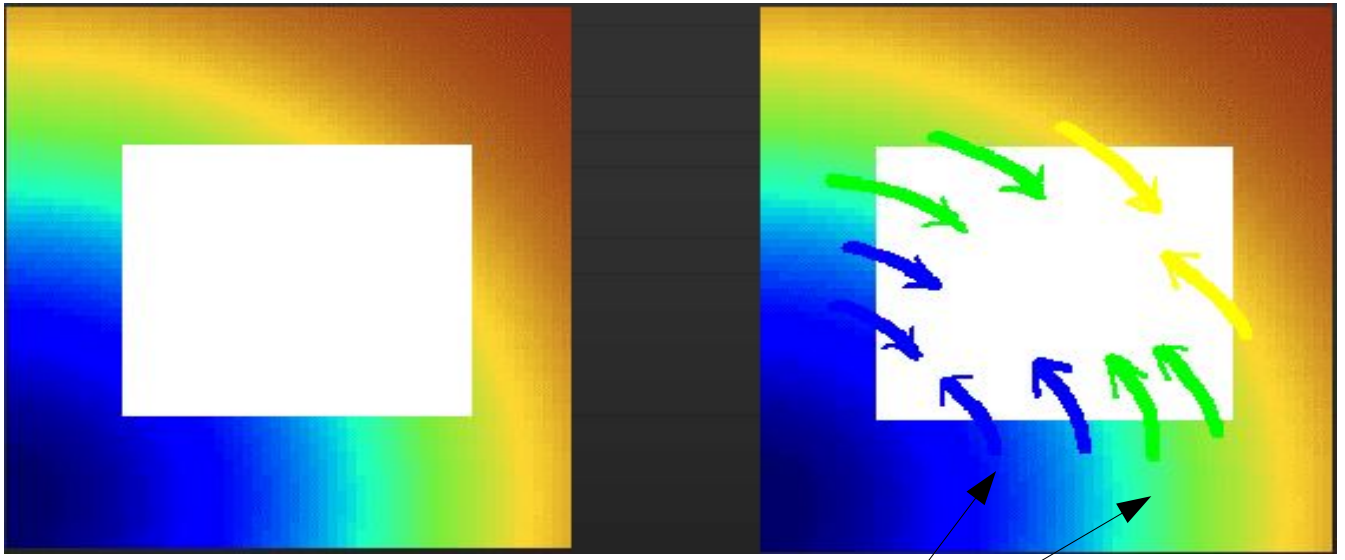
- Iteratively
  - Continue structure of surrounding area into gap
  - Continue color of surrounding area into gap

Algorithm

- Define image update as follows:
- It(i,j) = dL(i,j) . N(i,j)
  - It(i,j) is change in intensity to used to update the image
  - L(i,j) is the information to propagate
  - N(i,j) is the propagation direction
  - dL(i,j) . N(i,j) is the change in information along the propagation direction

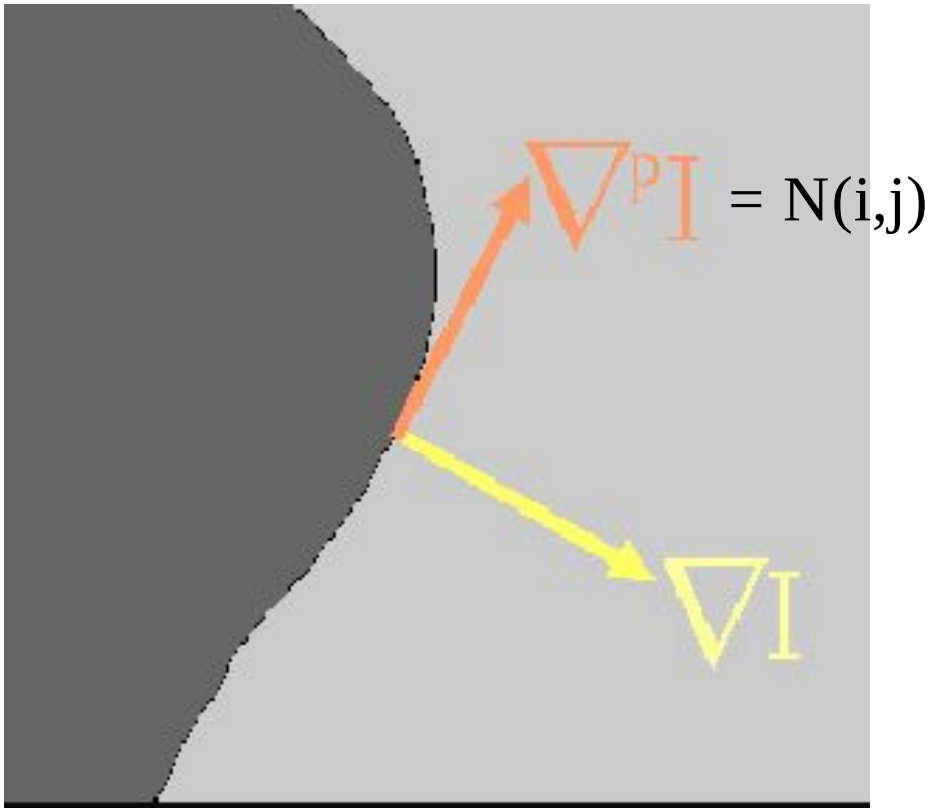
Propagation Direction

- Want to preserve angle of 'arrival'
- Propagate along isophotes
  - lines of equivalent intensity levels



Propagation Direction

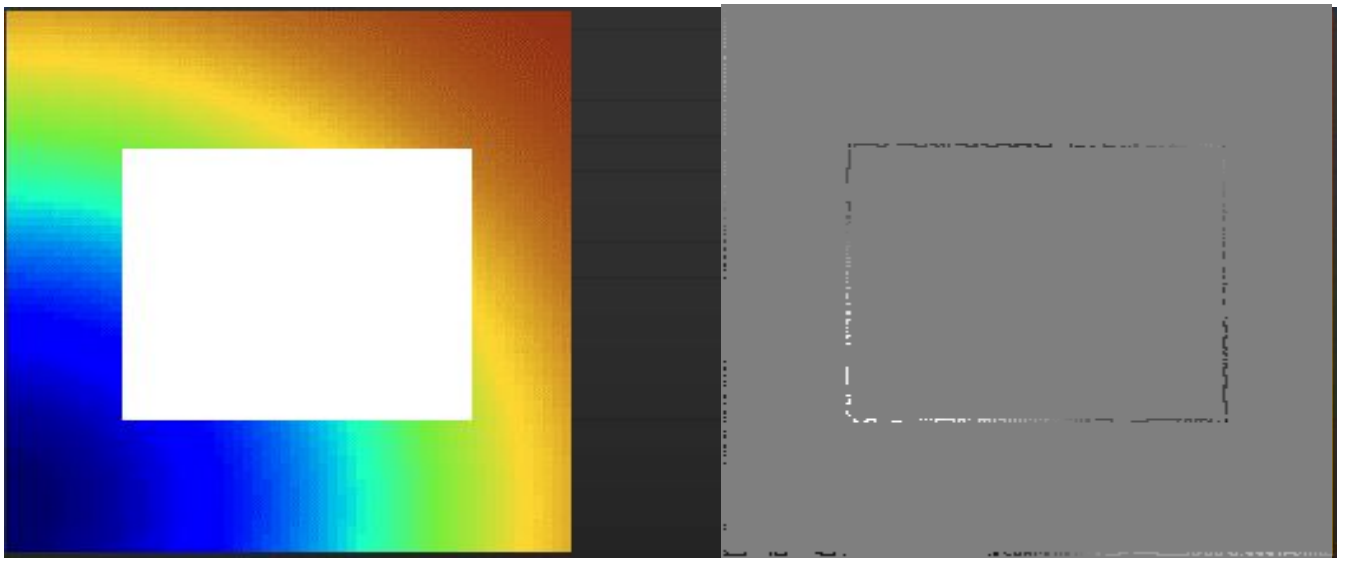
- More formally:
  - Image gradient
    - largest change
  - Perpindicular
    - smallest change
    - this is the isophote



Isophote is this boundary

Algorithm

- What information to propagate?
  - 'smoothness'
    - Laplacian == Ixx(i,j) +Iyy(i,j) = L(i,j)

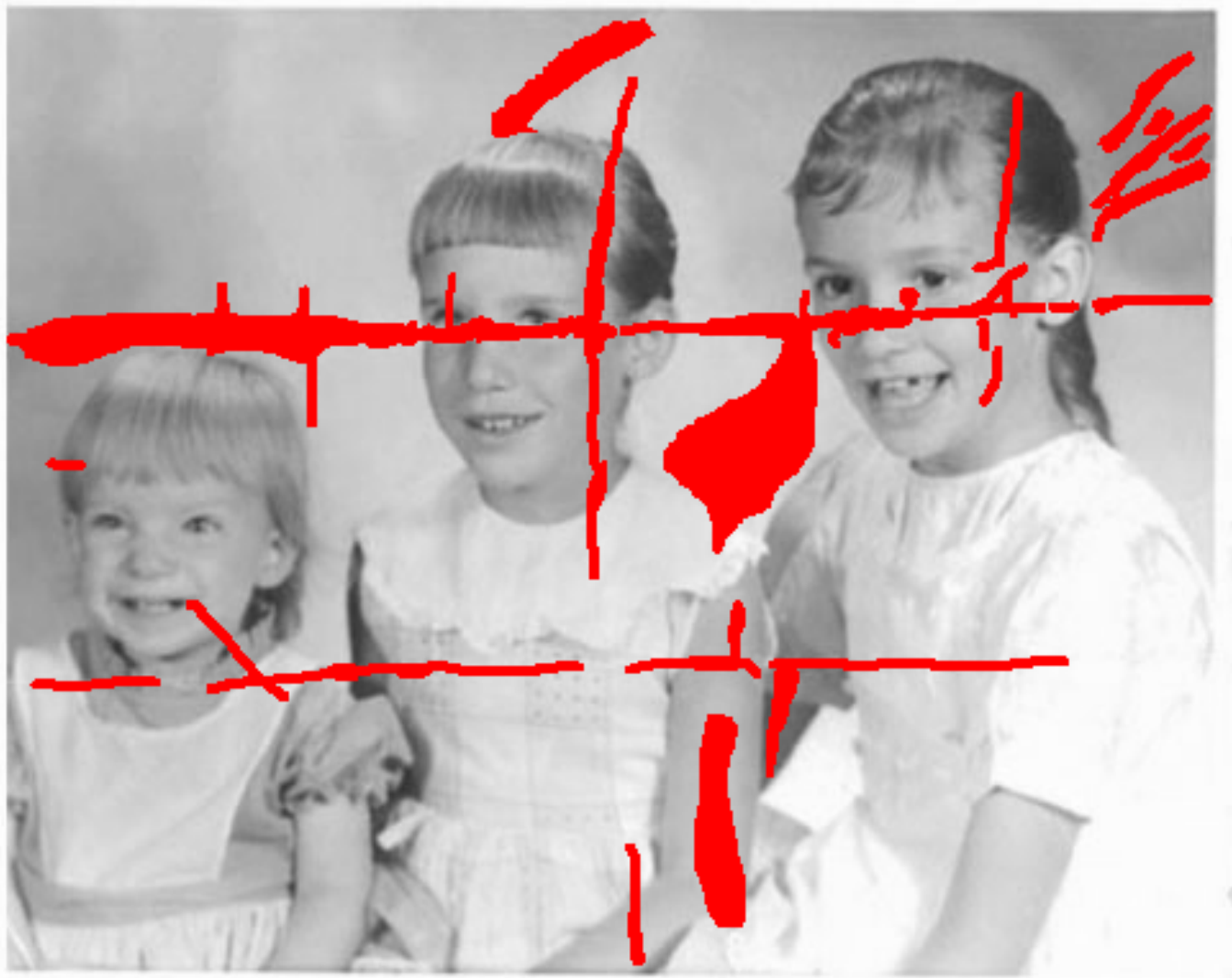


Algorithm

- Repeat this image update step to restore image
- When to stop?
  - Stop when update value is negligible
    - i.e. It(i,j) < epsilon for all i,j
  - Stop after n iterations

Some results

Some results



Some results

More results

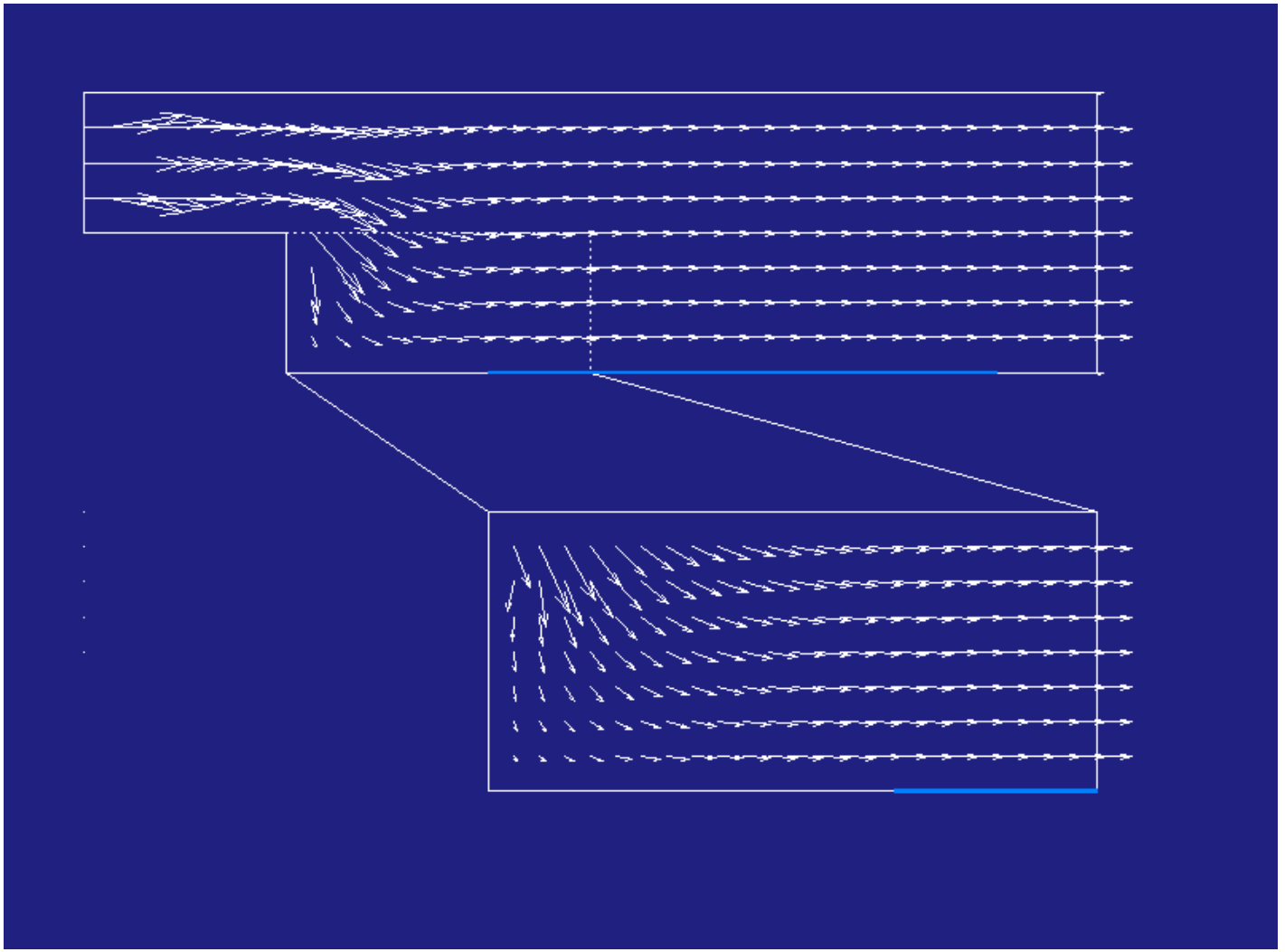
More results

More results

Navier-Stokes equations

- Nonlinear partial differential equations
- Describe the flow of fluids such as liquids and gases
  - Air currents
  - Ocean currents
  - Water flow in a pipe

Navier-Stokes equations



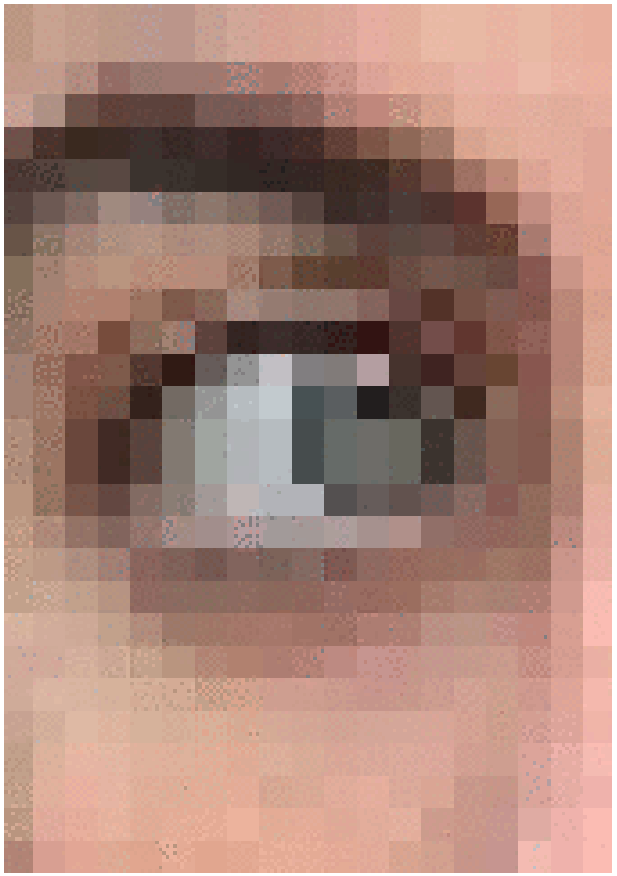
Relation to Inpainting

- Inpainting
  - Propagation of intensity along isophote according to smoothness
- Fluid mechanics
  - Convection of fluid along velocity field according to vorticity

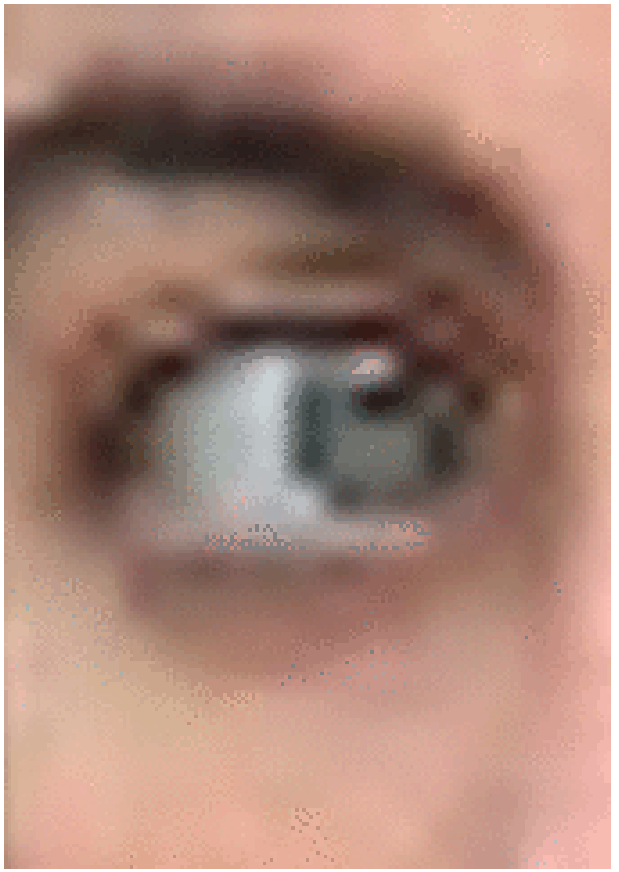
Relation to Inpainting

- Mapping
  - Image intensity == Stream function
  - Isophote direction == fluid velocity
  - Smoothness == vorticity
- Propels inpainting into an established field with a wealth of theoretical and numerical literature!

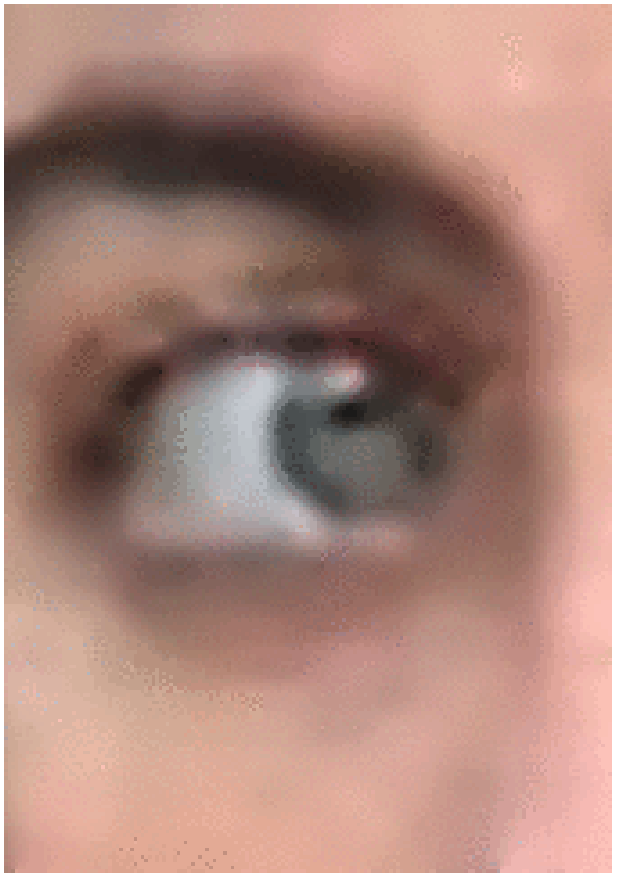
Super Resolution Result



Up scaled image



Bicubic sampled



Navier-Stokes