# Digital Restoration of Damaged Mural images

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# Painting Restore?

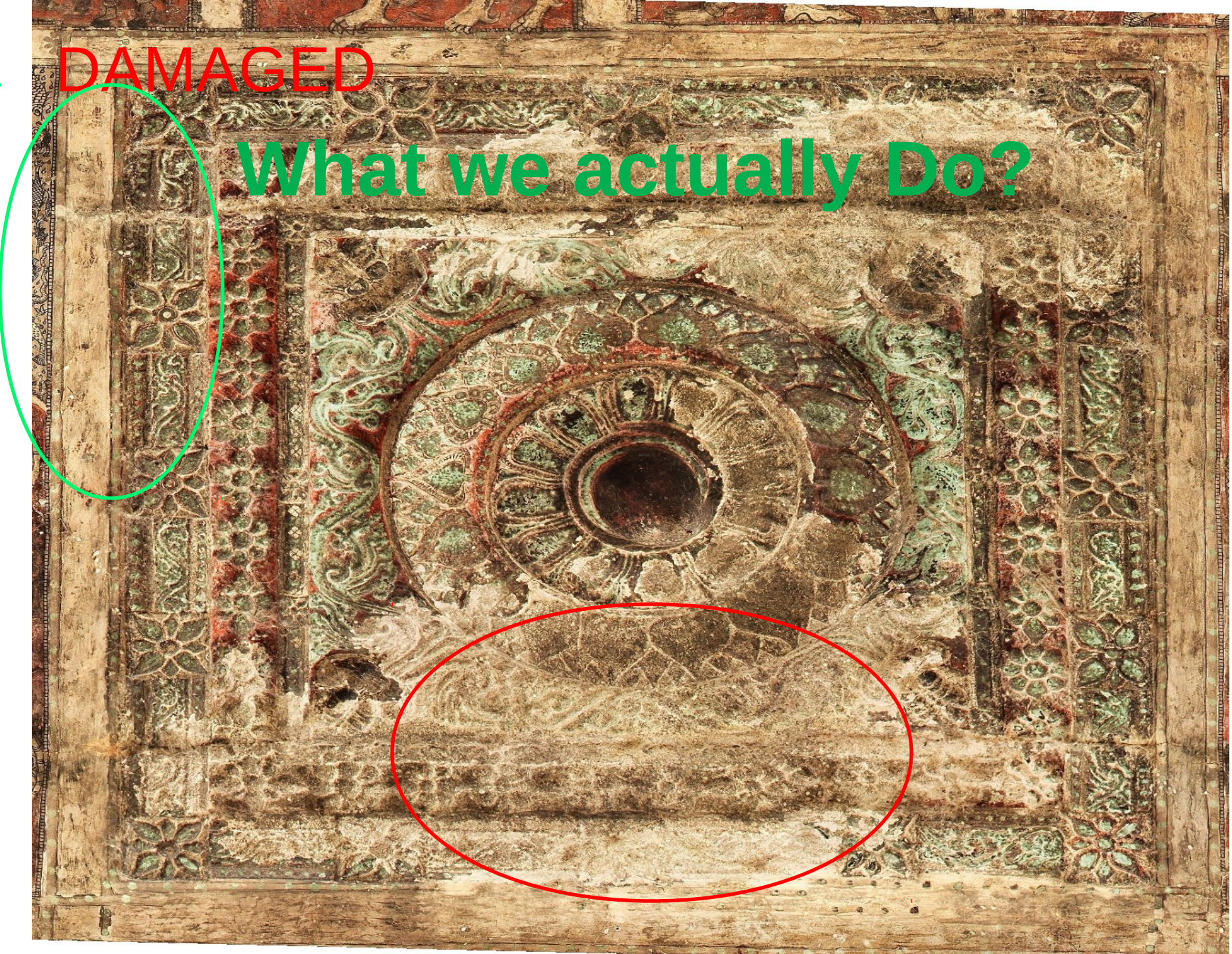
If we don’t know anything about the **Painting Arts** then how do we restore (digitally) them?

# Painting Restore?

We restore them in our own way !!

In our language (Image Restoration)
Common People : Restored Painting – Look Natural

We apologize to the Artist for using the term RESTORATION


DAMAGED
What we actually Do?


RESTORED
What we actually Do?

# A typical Damaged mural image

We observe that the Image not only degraded on individual pixels rather on blocks of pixels.

**Proposed Restoration Technique**

Based on the above observation, we proposed the following technique :

1. An inpainting technique that can generate the texture on blocks/chunk of pixels.

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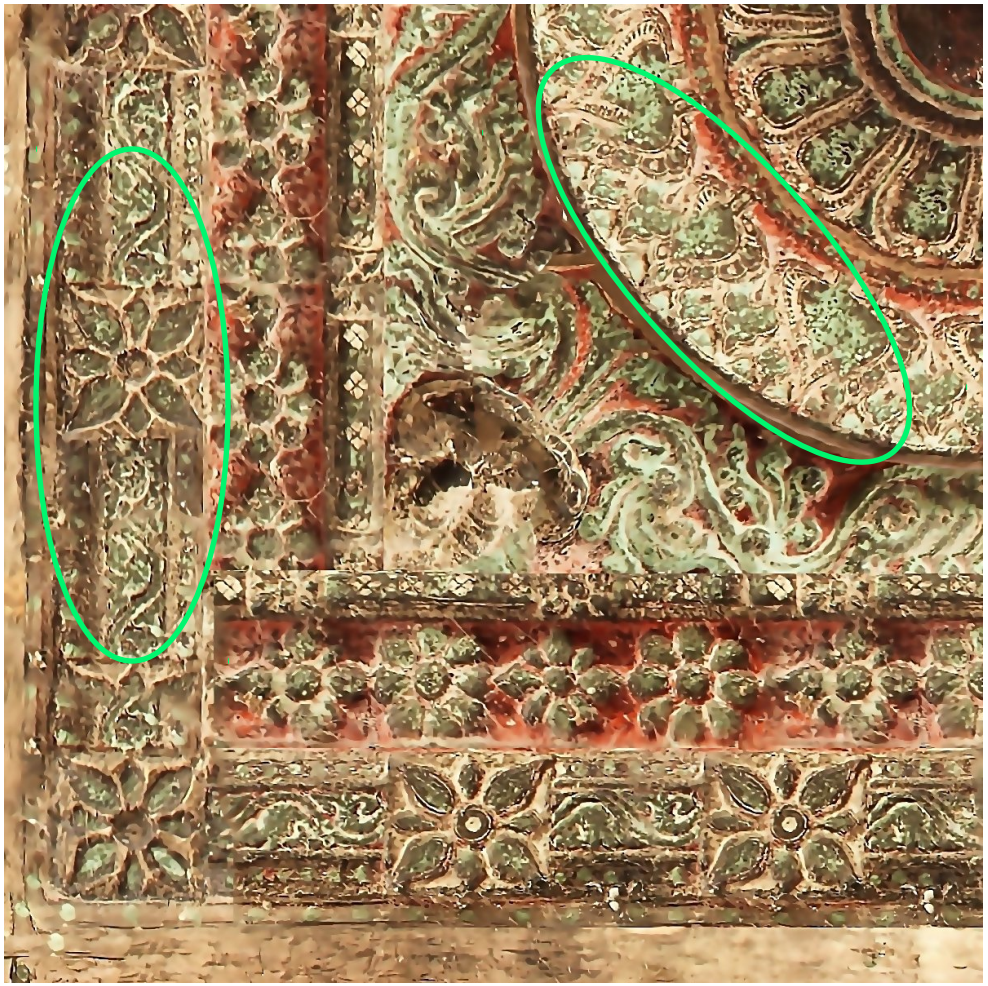
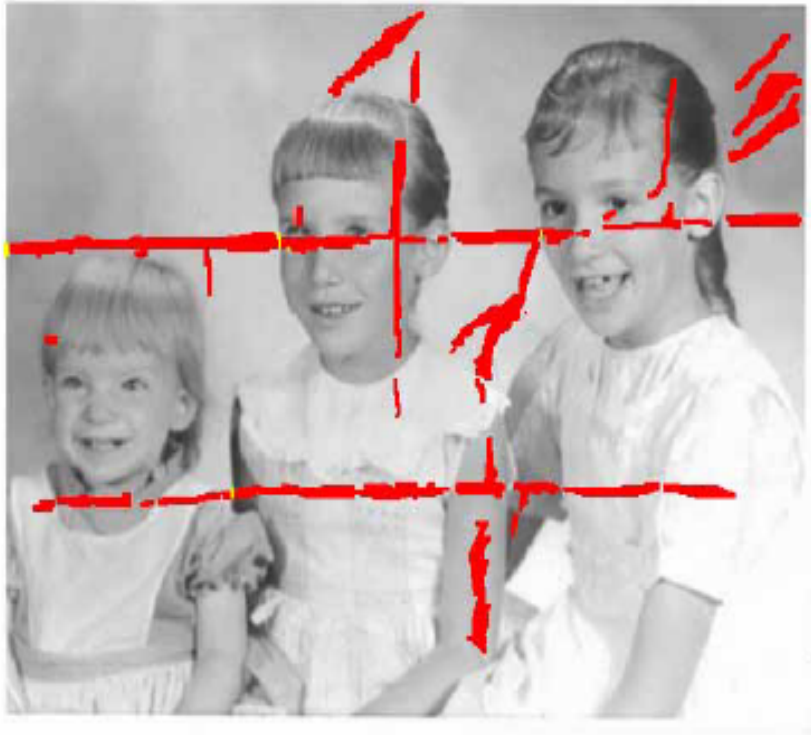


# Earlier work on Image Inpainting Using PDE based technique (Diffusion Based)

Original image



Marked image

- Assign random values to the target region.
- Diffuse that region across the boundary iteratively.

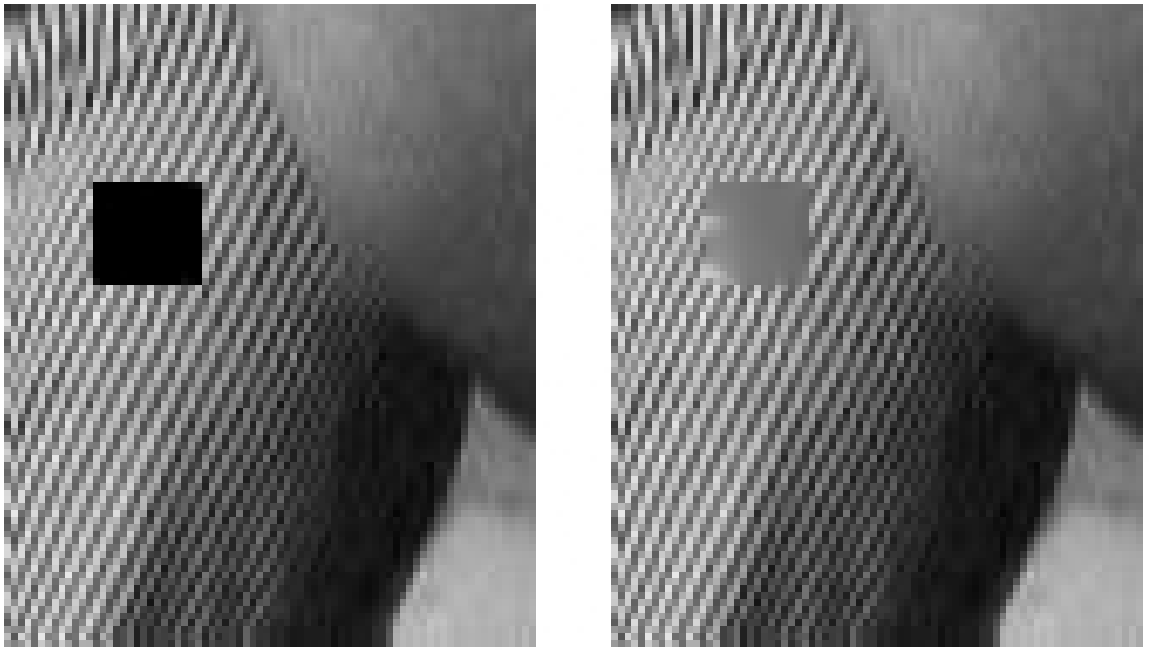
Oliveira et al. 2001

Bertalmio et al. 2000

# Image Inpainting by Diffusion

Disadvantage

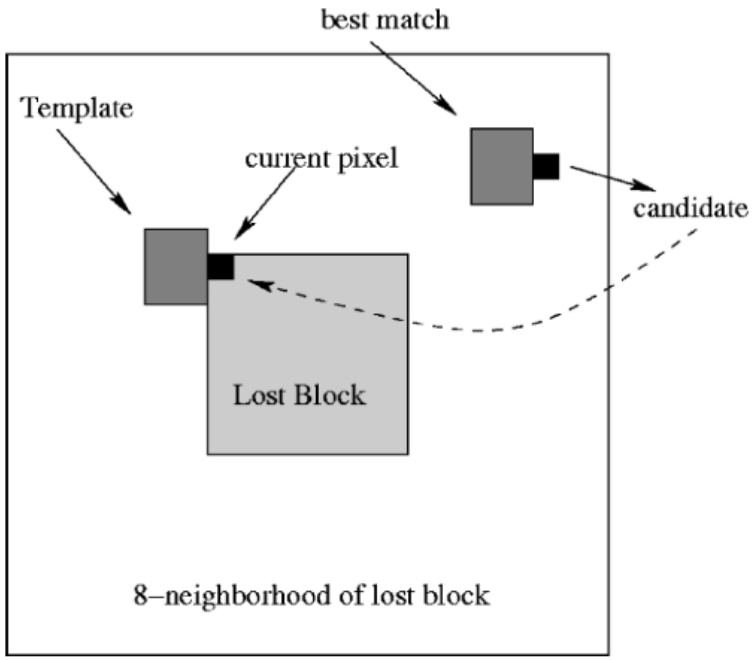
- Diffusion will cause blurs, which are usually noticeable for large region.



Definitely gives pure result for texture region.

# Texture Synthesis by Non-Parametric Sampling

by Efros et al. 99



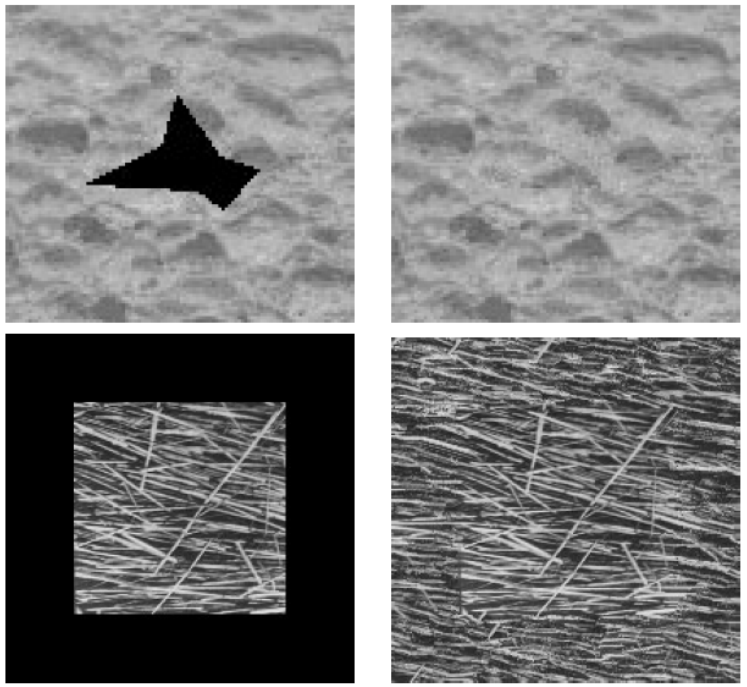
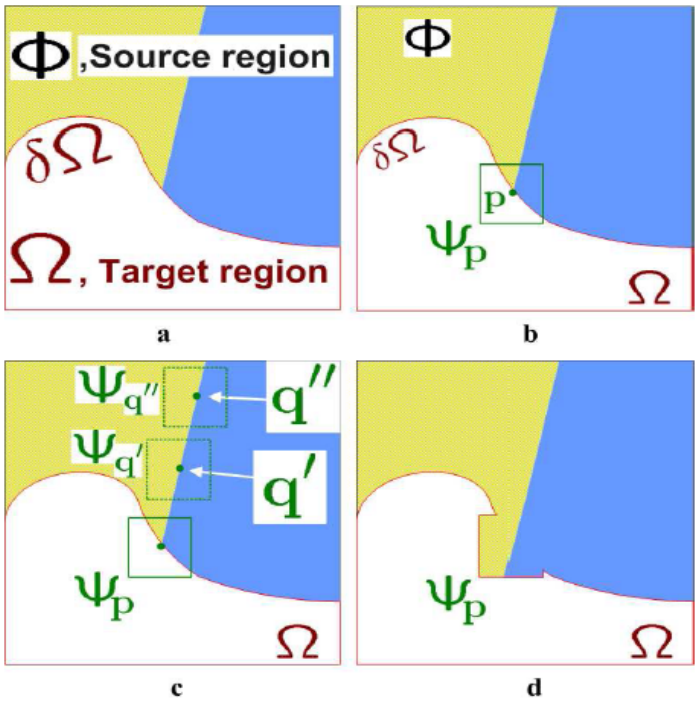



Fig. Example of Texture Synthesis
: Process fills the black region

# Structure Propagation by texture synthesis



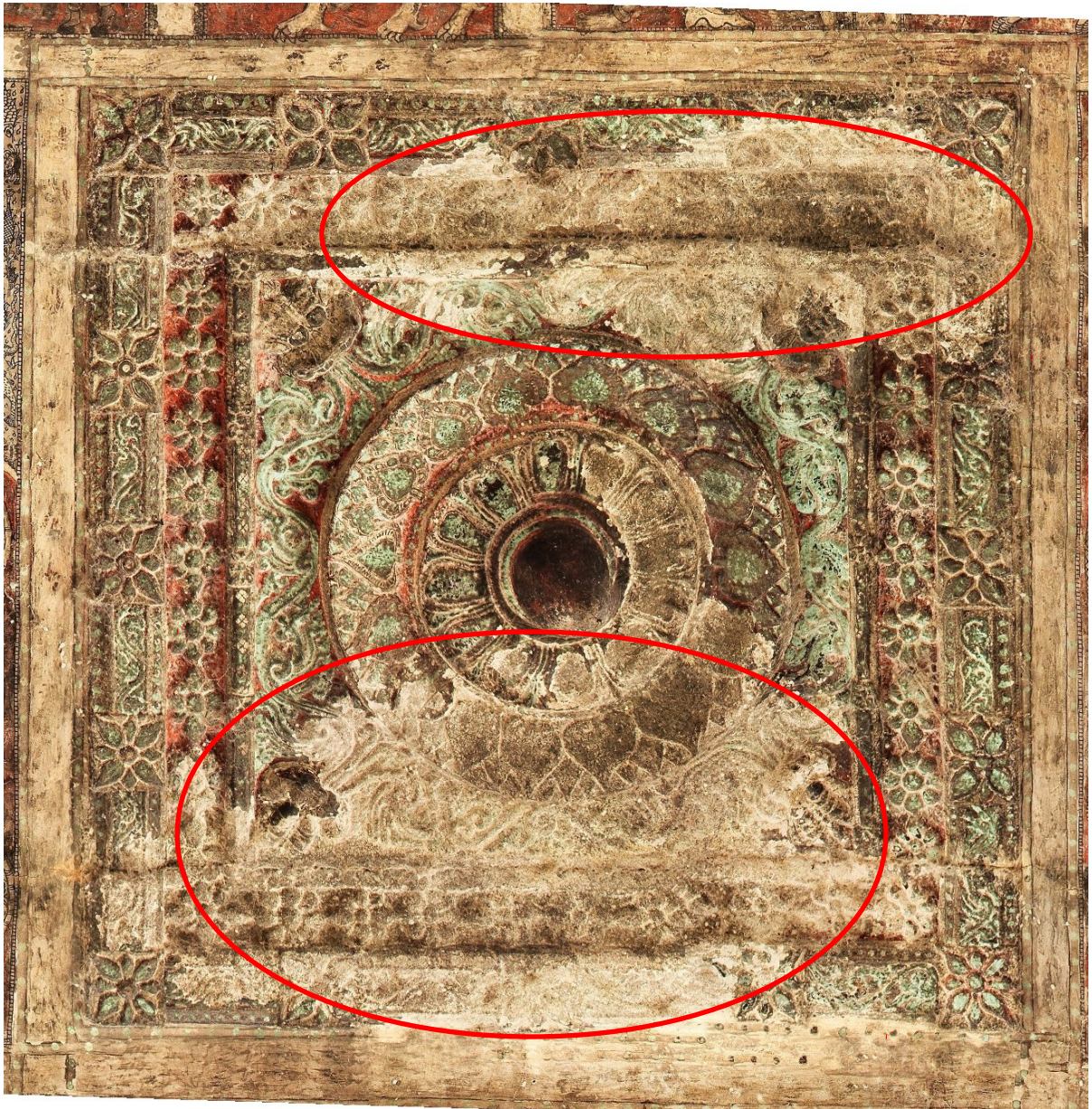

Criminisi et al 04

PDE based Texture Synthesis based

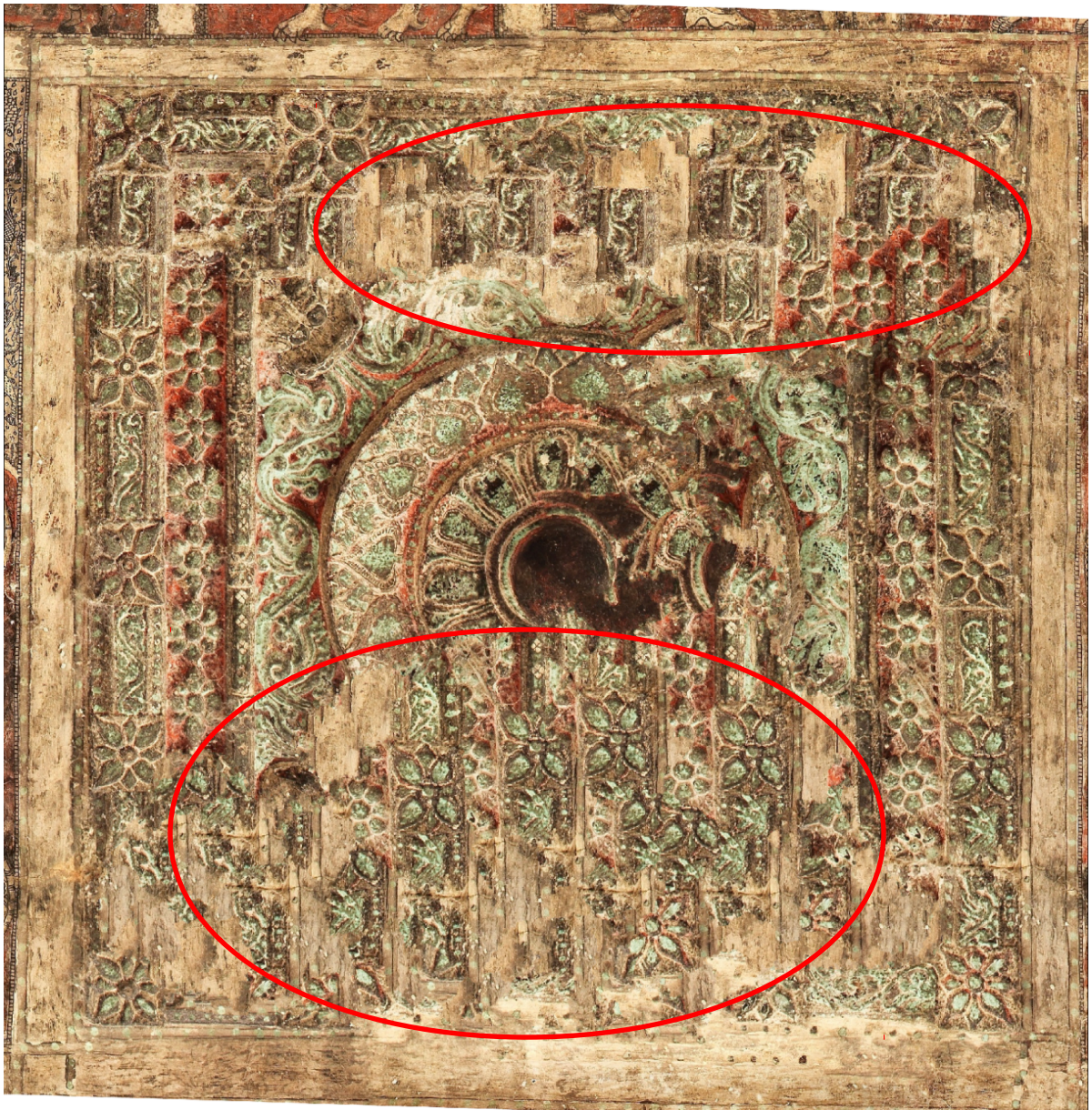
Repeat until done:

- Choose a pixel as candidate pixel from the boundary of the marked region having maximum priority.
- Find the exemplar from the source region with maximum similarity on the rest of the patch.
- Copy image data and fill the target region.
- Update the boundary and target region.

# Exemplar based Approach : Input



# Exemplar based Approach : Output(Criminisi et al.04)



# Proposed Texture Synthesis/Inpainting Technique

1. We come up with a new method that fast and work reasonably well.
2. We develop a coherence based texture synthesis scheme.

Our algorithm is based on following :

I. No new visual artifacts would be generated → every patch on the target texture must occur on source texture.

II. Structure of the image would preserve → coherent information is forced to preserve on multiple scale.

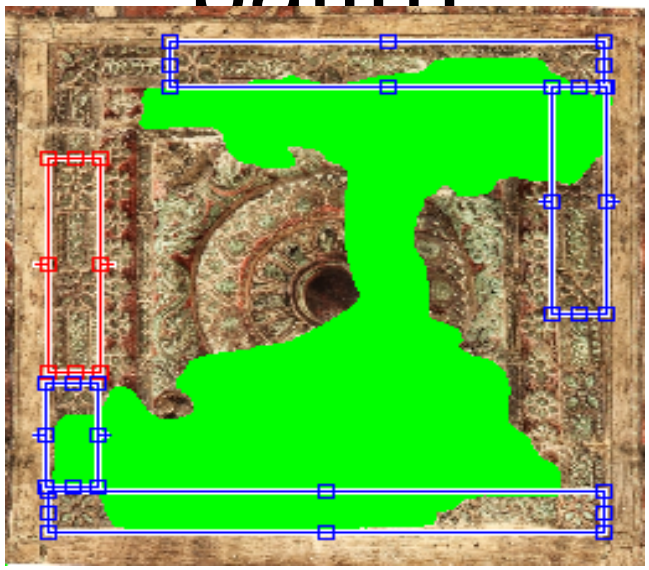
# Proposed Inpainting Algorithm

- Input : Image marked with distorted region where Texture to be filled :
  - Down-sample the image into small size and fill only the marker positions by the random texture.
  - Do the following steps for l = L, L-1,…,2,1
    - Iterate following k iterations
      - Search for nearest neighborhood (NN) for each patch (overlapping) of the marked position from the undistorted portion using fast Patch-match[1] algorithm.
      - Replace each patch of the distorted portion by the corresponding NN of actual undistorted portion.
    - Up-sample the image into higher scale by some interpolation technique and Down-sample the original source texture with resolution factor l+1.

[1] Source Code : http://gfx.cs.princeton.edu/pubs/Barnes_2009_PAR/index.php

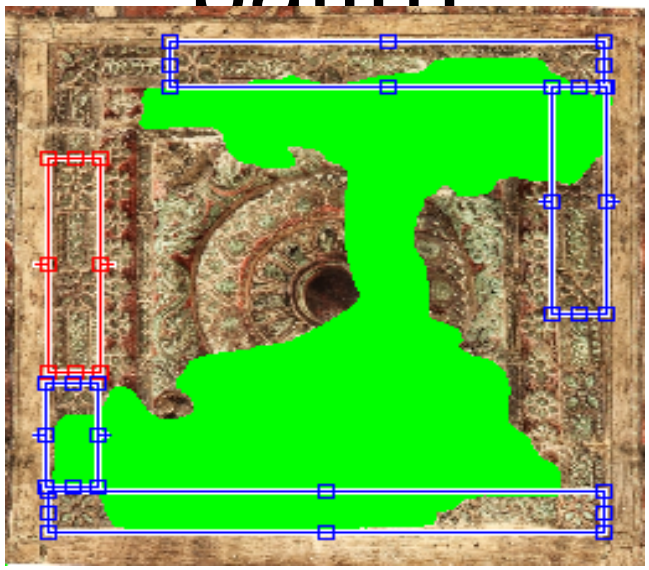
# Result of proposed Inpainting technique

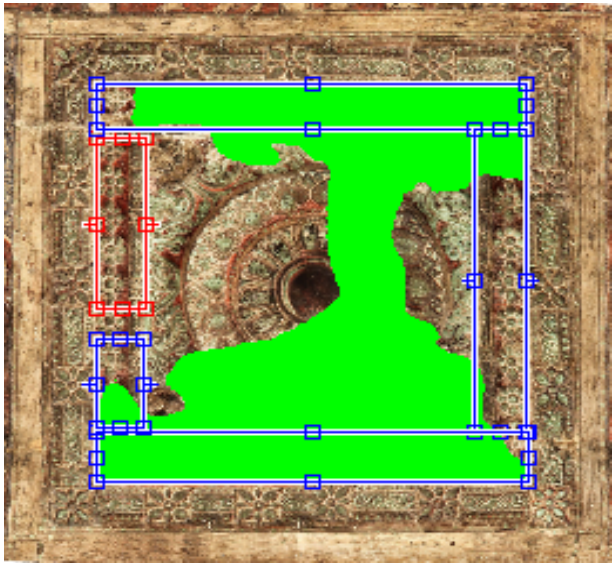
# Image with repeatitative texture pattrn



1. **We Mark the corrupted Region to be filled.**
2. **Select the area where texture to be generated (blue lines) and the source unaffected and similar texture.**

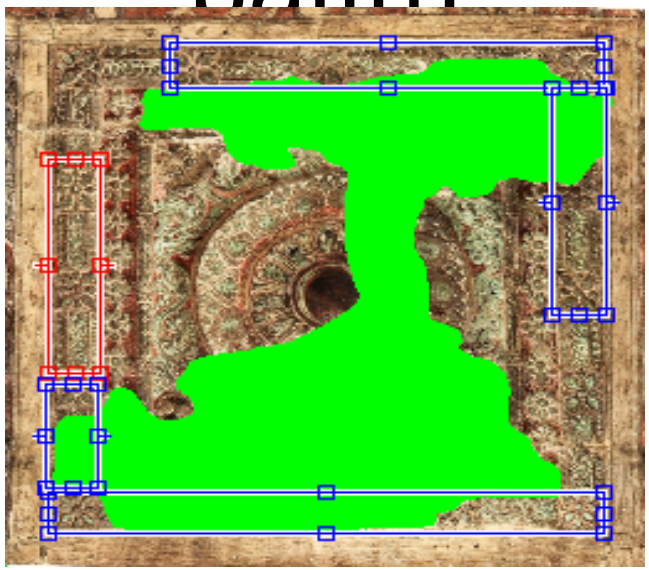
# Image with repeatitative texture pattrn

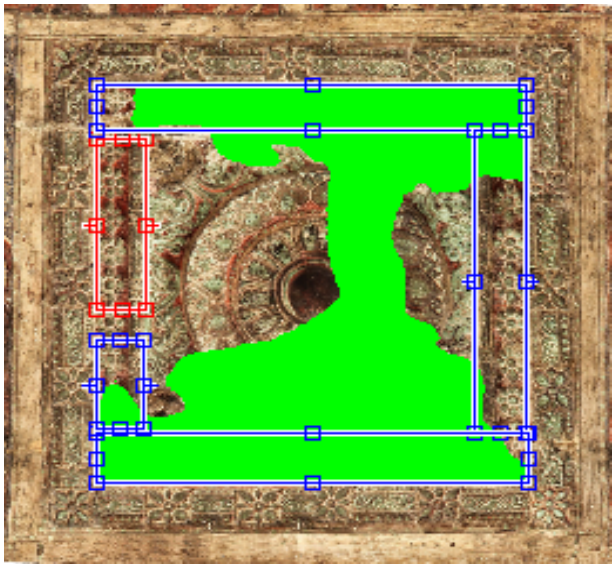


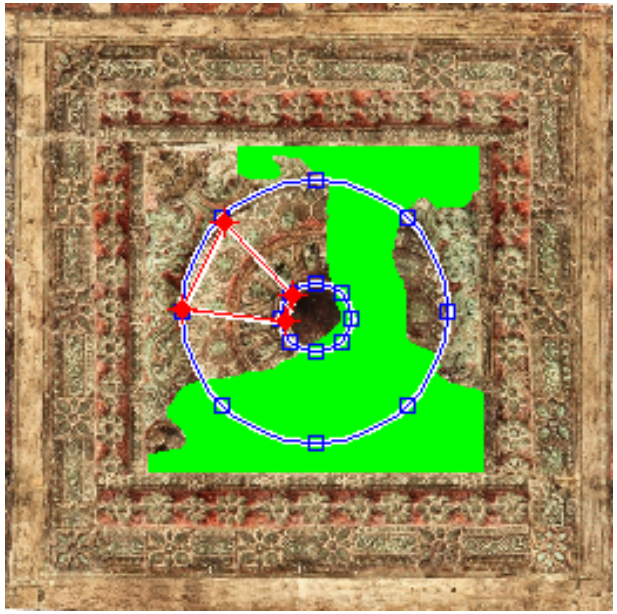


1. We Mark the corrupted Region to be filled.
2. Select the area where texture to be generated (blue lines) and the source unaffected and similar texture.
3. **Repeat the process of selection.**

# Image with repeatitative texture pattrn

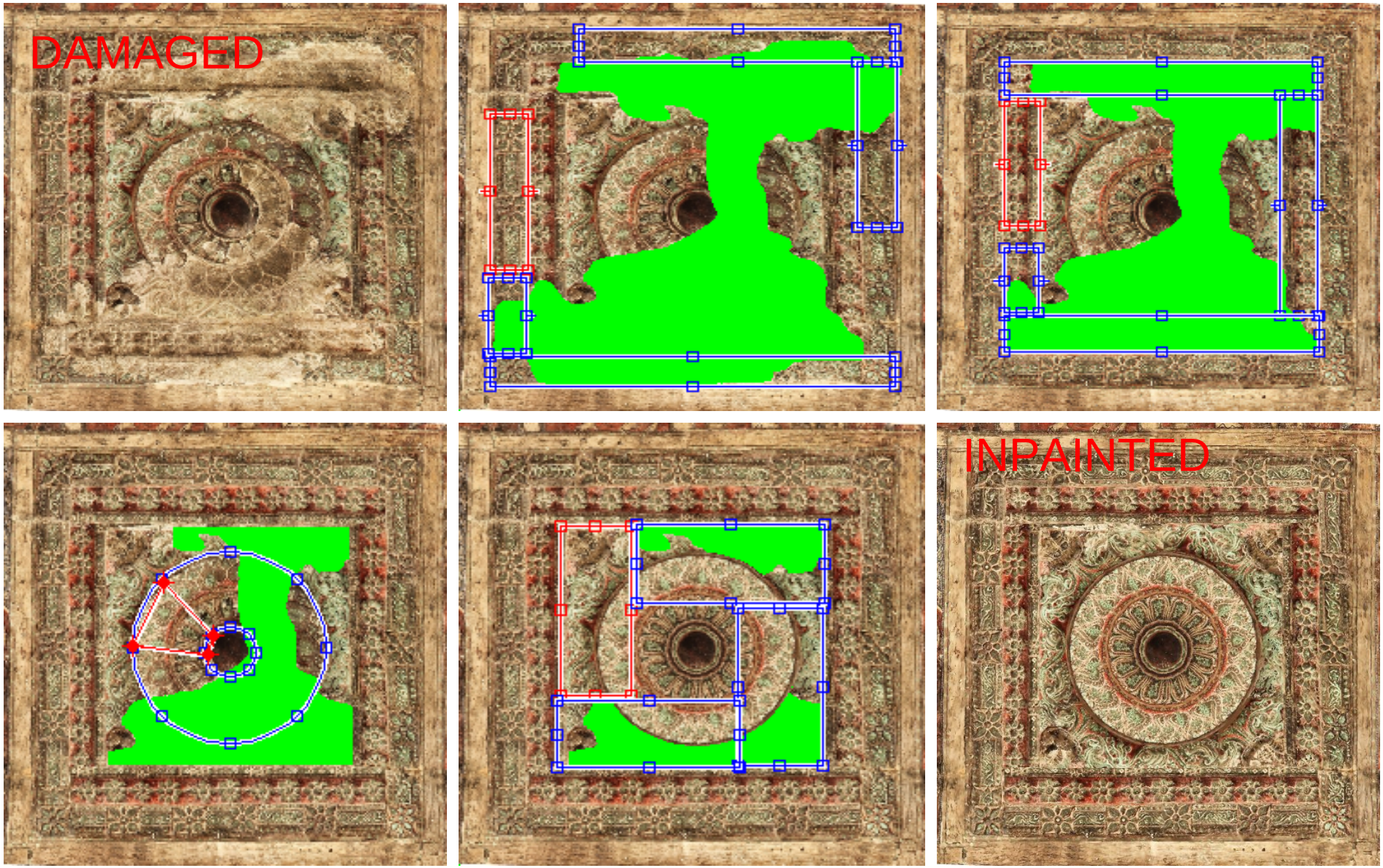






1. We Mark the corrupted Region to be filled.
2. Select the area where texture to be generated (blue lines) and the source unaffected and similar texture.
3. Repeat the process of selection.
4. **Only Circular and rectangular selection has been implemented.**

# Image with repeatitative texture pattern



# Noise in pixel level?

Input

1. To restore this kind of image we need some denoising technique.
2. We observe that anisotropic diffusion technique gives painting realizations.
3. However diffusion technique smoothen some important image details.
4. A patch based high-frequency enhancement scheme is proposed.
5. We run an alternating iterations of high-frequency enhancement scheme with anisotropic diffusion to get a realistic painting realization.

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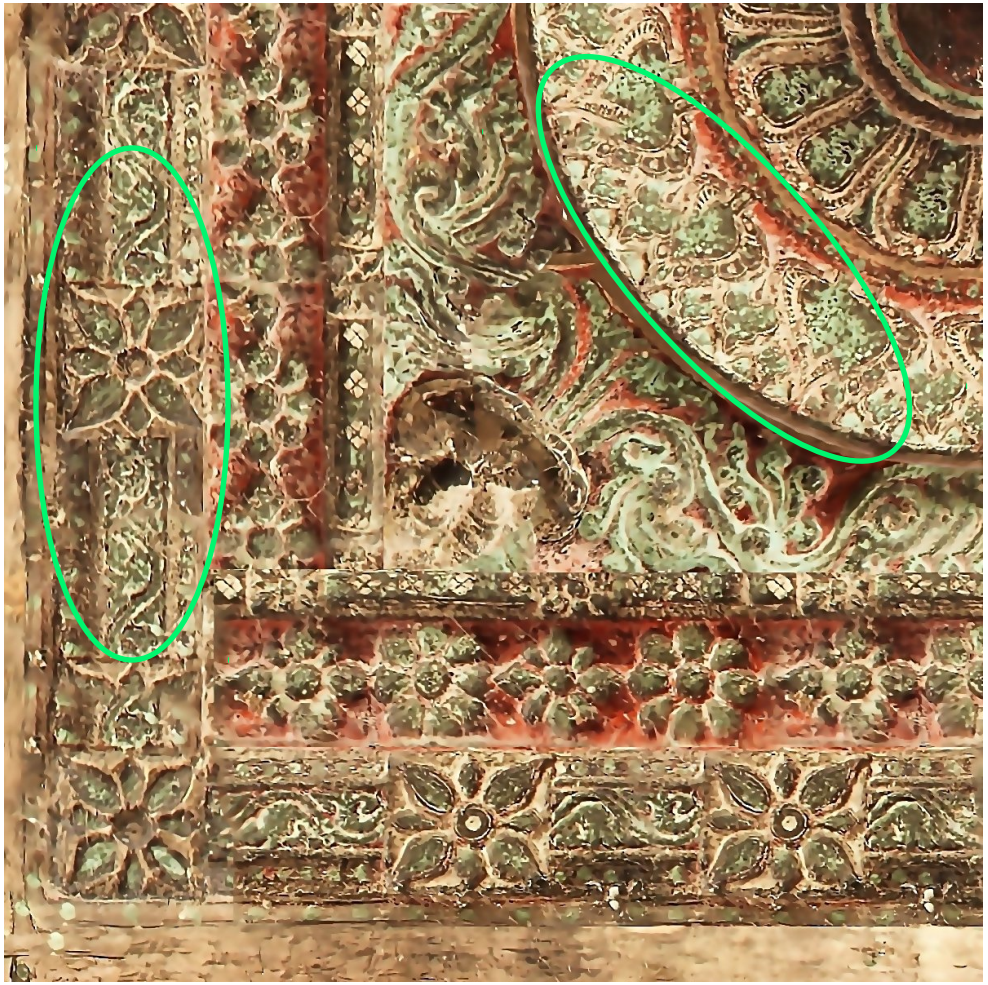
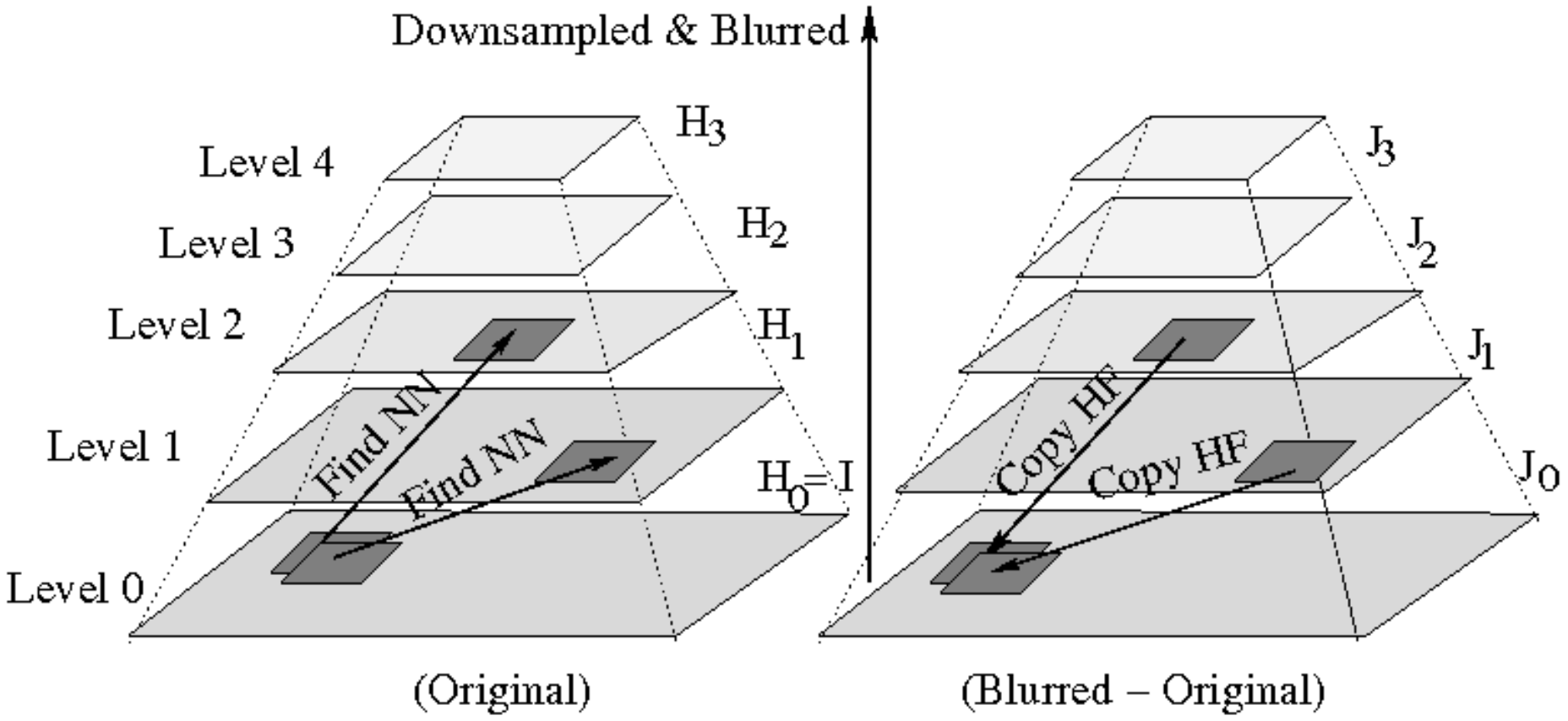
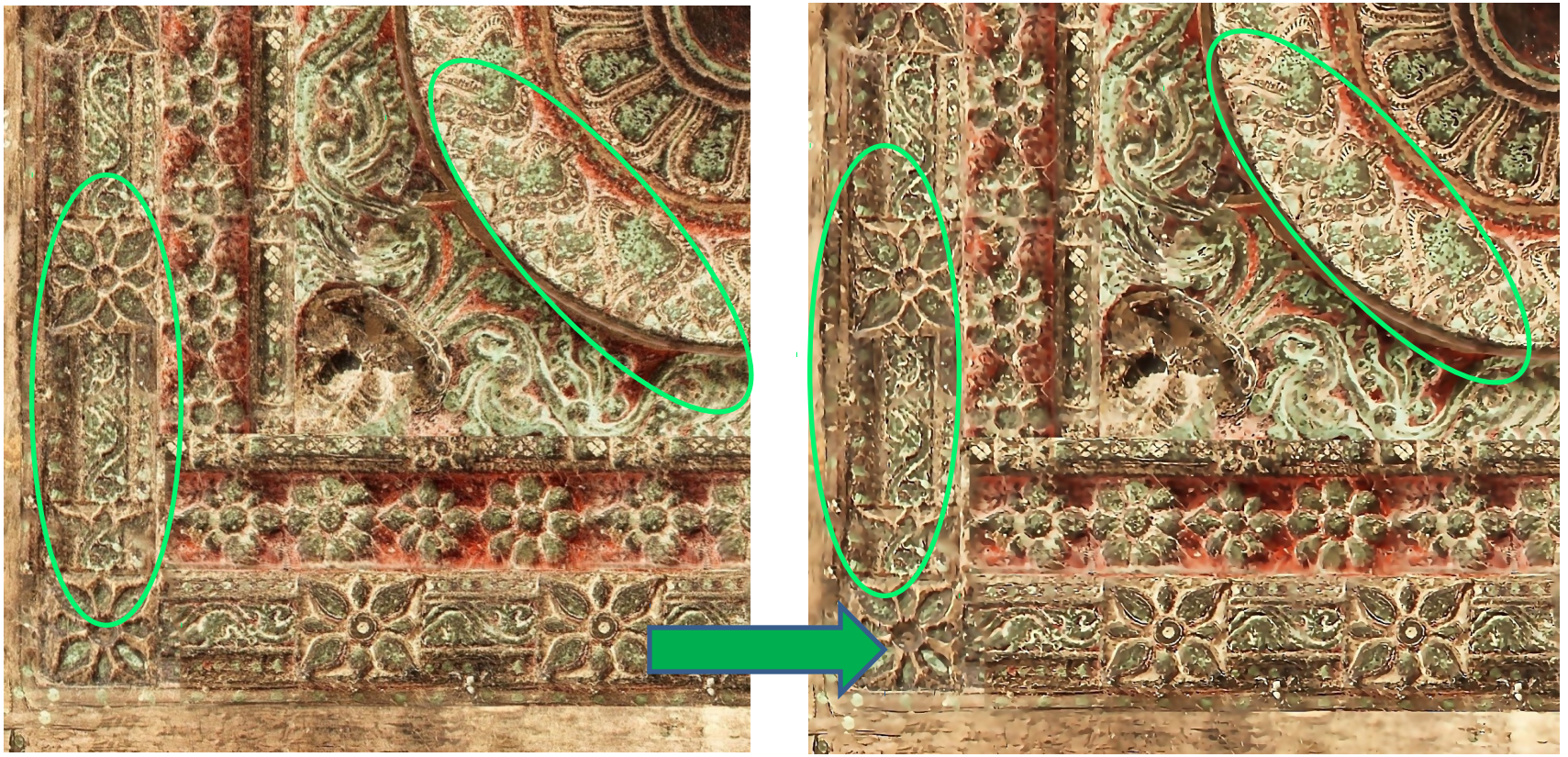


# Proposed High-frequency Generation Scheme



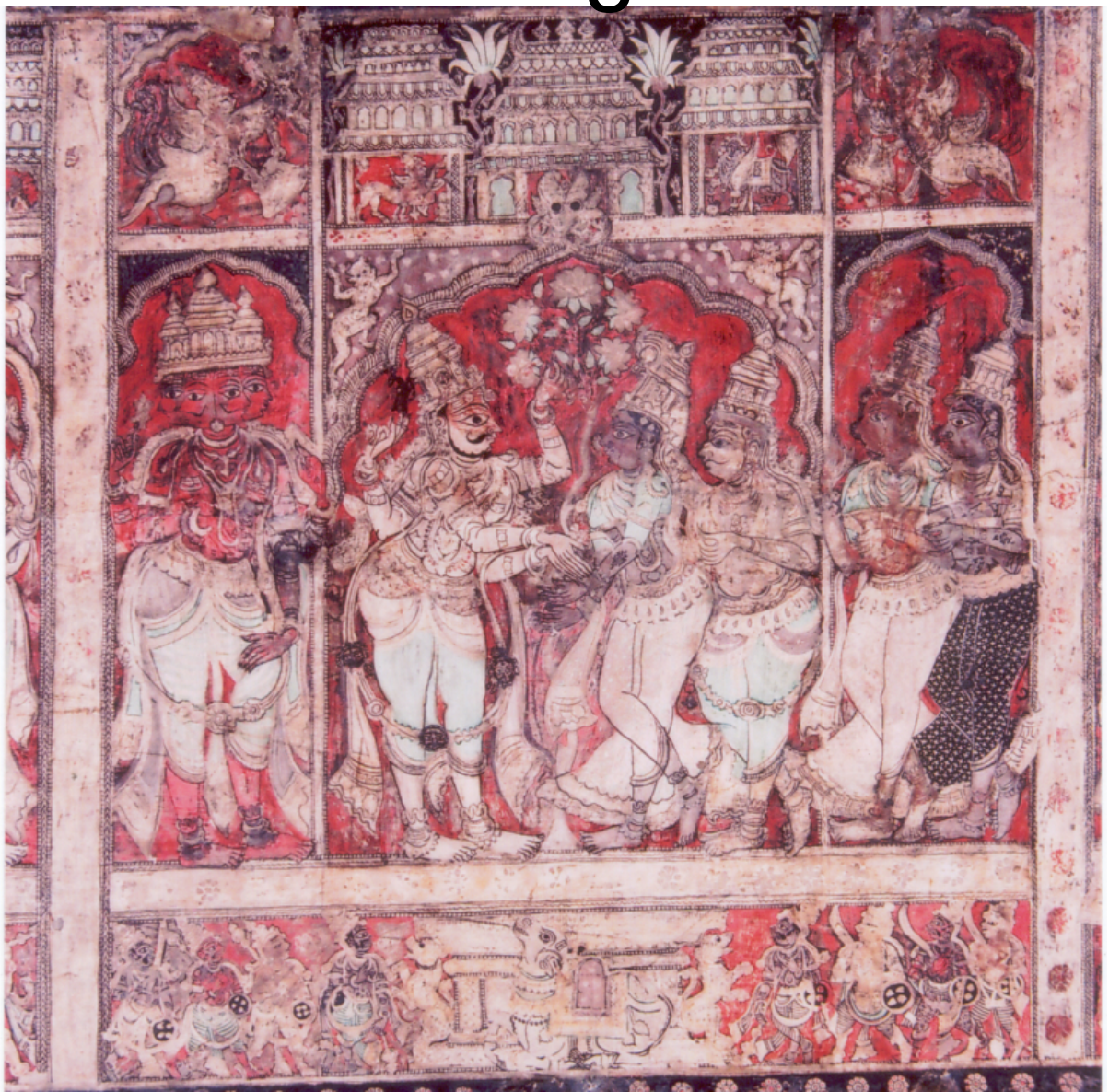
# Proposed High-frequency enhancing diffusion scheme

- Do the following two technique alternatively :
  - ✓ Use prerona-malik anisotropic diffusion scheme for few iterations.
  - ✓ Apply high-frequency enhancing scheme.



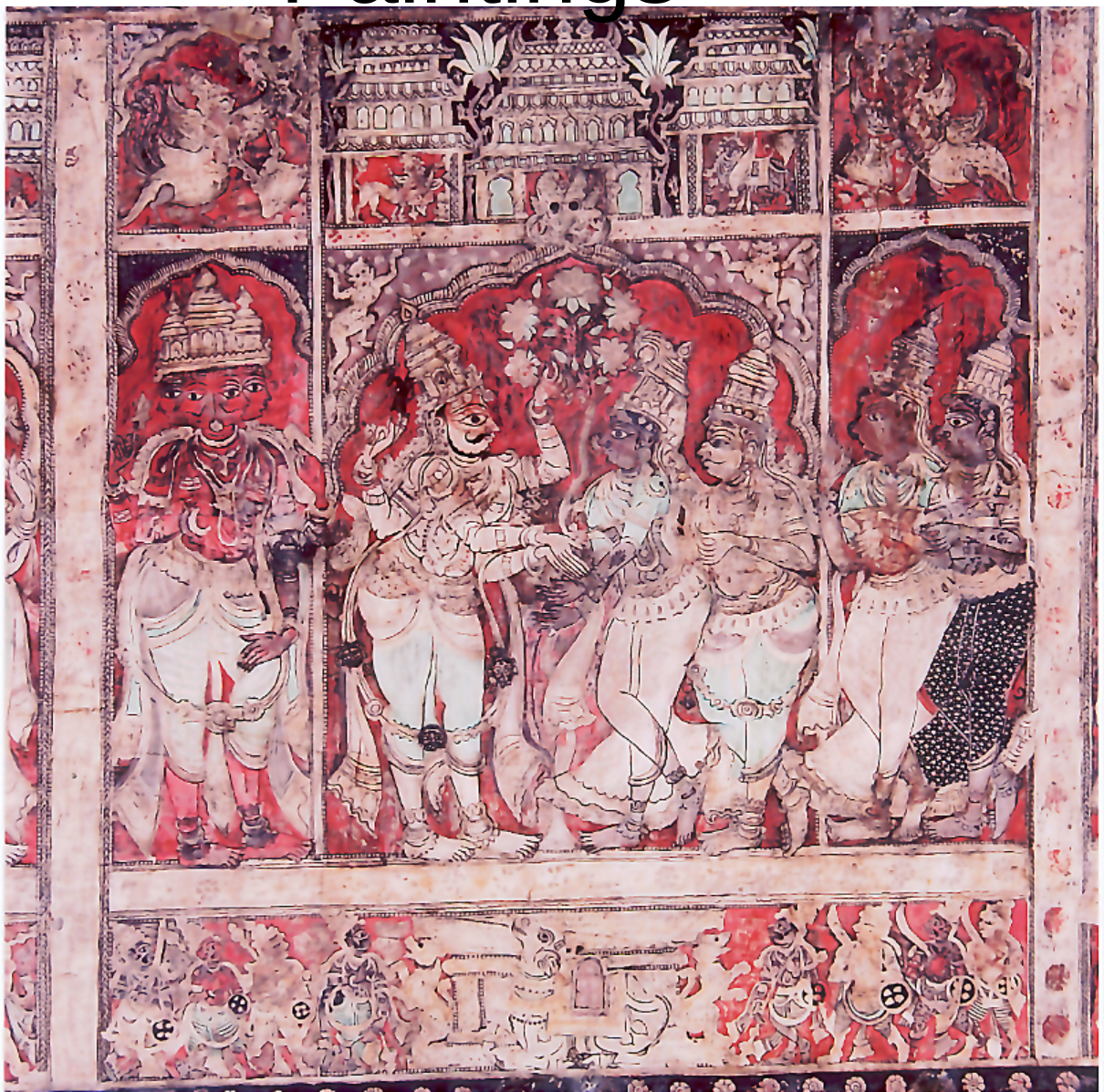
# Proposed Diffusion on Mural Paintings

Input



# Proposed Diffusion on Mural Paintings

Diffused



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# Results on Mural Images

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# THANKS
# ?

Demo code is available on
*http://www.isical.ac.in/~pulak_r*