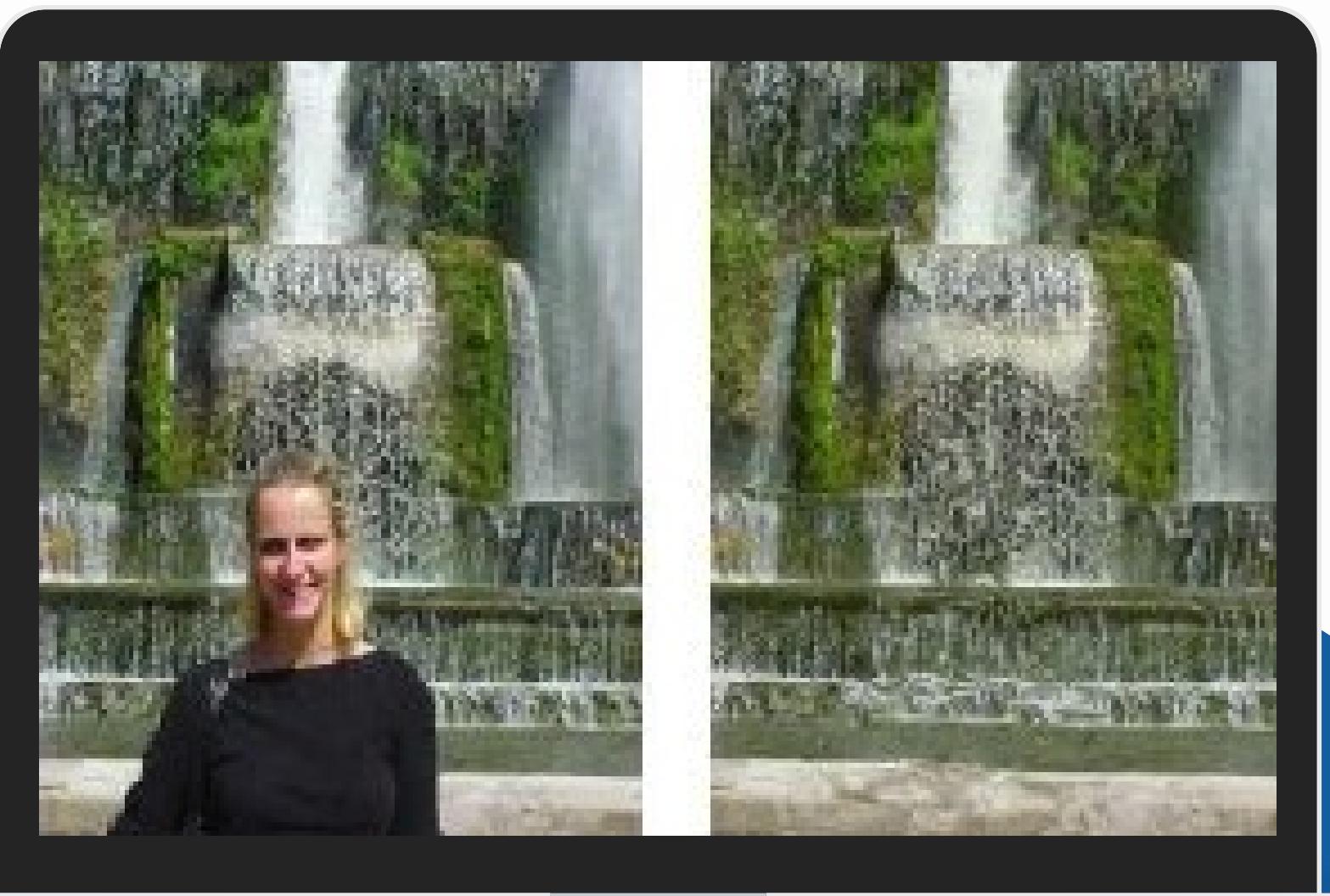


Exampler Based Inpainting

Texture Synthesis

Serkan UYSAL



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Inpainting

The modern use of inpainting can be traced back to Pietro Edwards (1744–1821), Director of the Restoration of the Public Pictures in Venice, Italy. Using a scientific approach, Edwards focused his restoration efforts on the intentions of the artist

It was during the 1930 International Conference for the Study of Scientific Methods for the Examination and Preservation of Works of Art, that the modern approach to inpainting was established. Helmut Ruhemann (1891–1973), a German restorer and conservator, led the discussions on the use of inpainting in conservation. Helmut Ruhemann was a leading figure in modernizing restoration and conservation.



Inpainting Methods

Geometry-based

Fills missing or damaged regions in an image using geometric and mathematical principles to reconstruct the missing areas based on the shape, patterns, and structural features within the image.

Sparsity-based

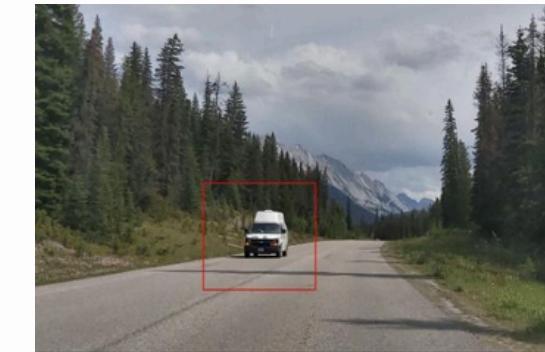
Compressed representations and the concept of sparsity to fill in missing regions of an image by finding the sparsest representation of the available data to reconstruct the missing areas.

Texture synthesis

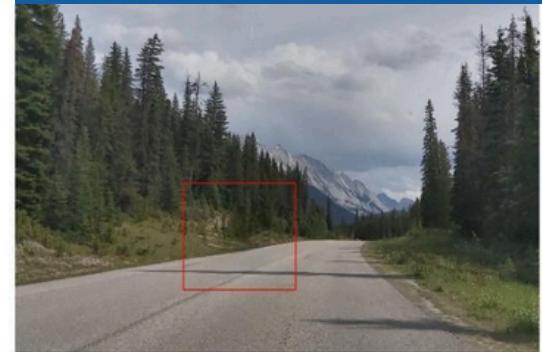
Utilizes the analysis of textures, patterns, and colors within an image to fill in missing or damaged regions, aiming to recreate these areas based on the surrounding texture characteristics.

Exampler-based

Fills missing or damaged areas in an image by borrowing information from similar regions in the image, reconstructing the missing portions based on the characteristics of surrounding exemplars.



A) Original image



B) Final inpainting result of shrinking-mask-approach
(after 4 iterations)



C) Image 3A) masked by the original mask



D) Inpainting result (iteration 1)



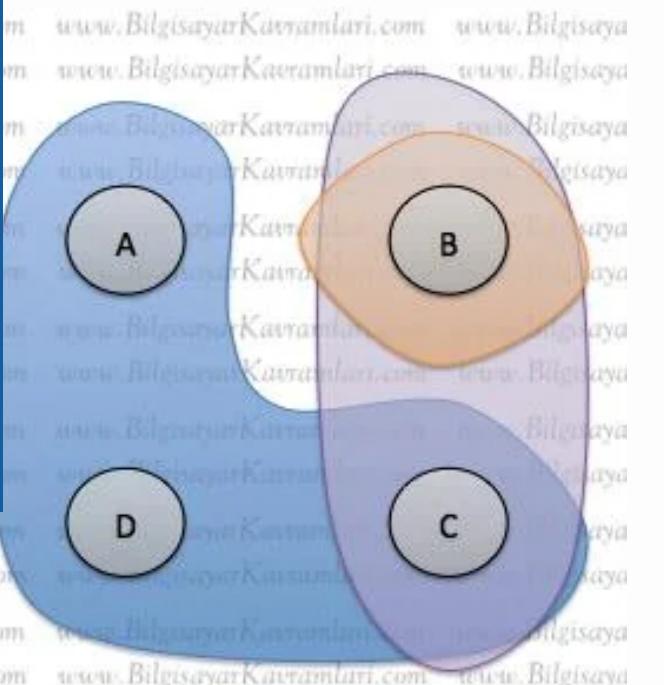
Texture Synthesis

ICCV 1999

A non-parametric method
Aims to preserve local structure

1948, Claude Shannon – English-sounding written text using n-grams
(n consecutive letters/words)

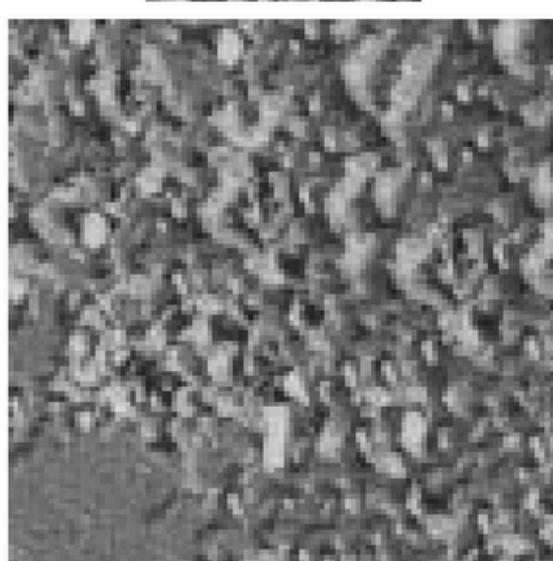
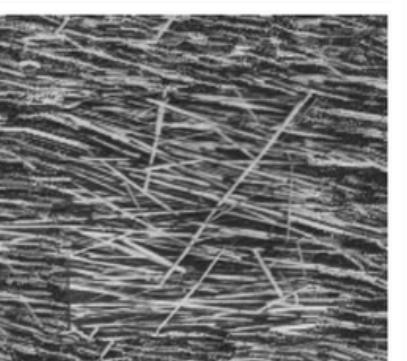
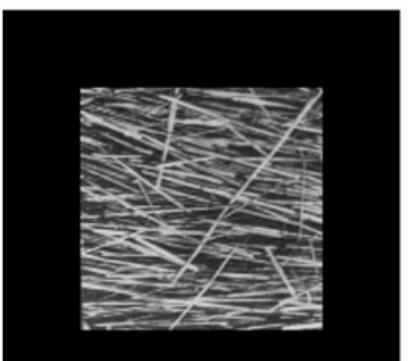
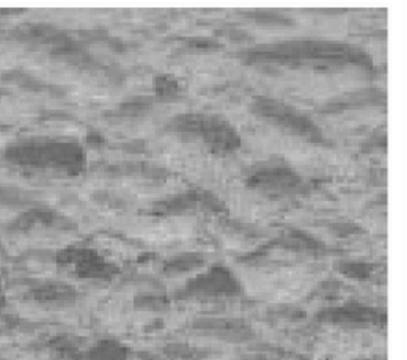
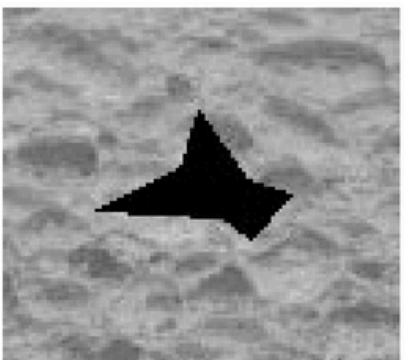
Choose non-parametric technique not clustering, etc.



Markov Random Field

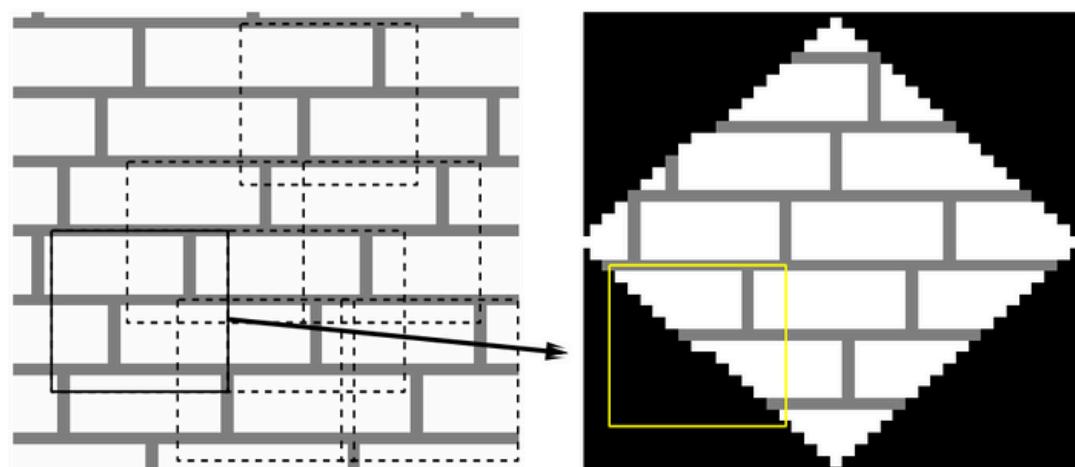
It was during the 1930 International Conference for the Study of Scientific Methods for the Examination and Preservation of Works of Art that the term 'inpainting' was first used. In his *Discourse on the Restoration of Pictures* (1801), Pietro Edwards (1744–1821), a German restorer and conservator, focused his investigation efforts on the intentions of in conservation. Helmut Ruhemann was a leading figure in modernizing restoration and conservation.

Texture Synthesis



(a)

(b)



Pros & Cons



Pros

Preservation of image structure

Non-parametric



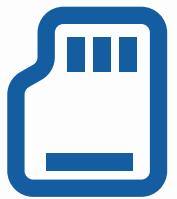
Cons

Texture slip into wrong part

Get locked onto one place

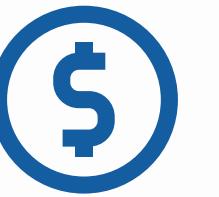
Exemplar-Based Inpainting

Exemplar-based inpainting is a technique used in image processing and computer vision to fill in missing or damaged parts of an image. It works by analyzing the surrounding pixels of the damaged area and finding similar patches in the image that can be used as references or exemplar to reconstruct the missing information



Identification of damaged areas

Identify the image that needs to be inpainted.



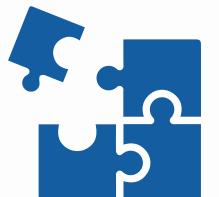
Selection of exemplars

For each damaged region, a suitable exemplar is chosen from the surrounding undamaged areas of the image.
Closely match the texture, color, and structure.



Exemplar patch placement

The exemplar patches are aligned with the damaged areas. Techniques such as texture blending, image interpolation, or diffusion-based methods may be employed to seamlessly integrate the exemplar patches into the image

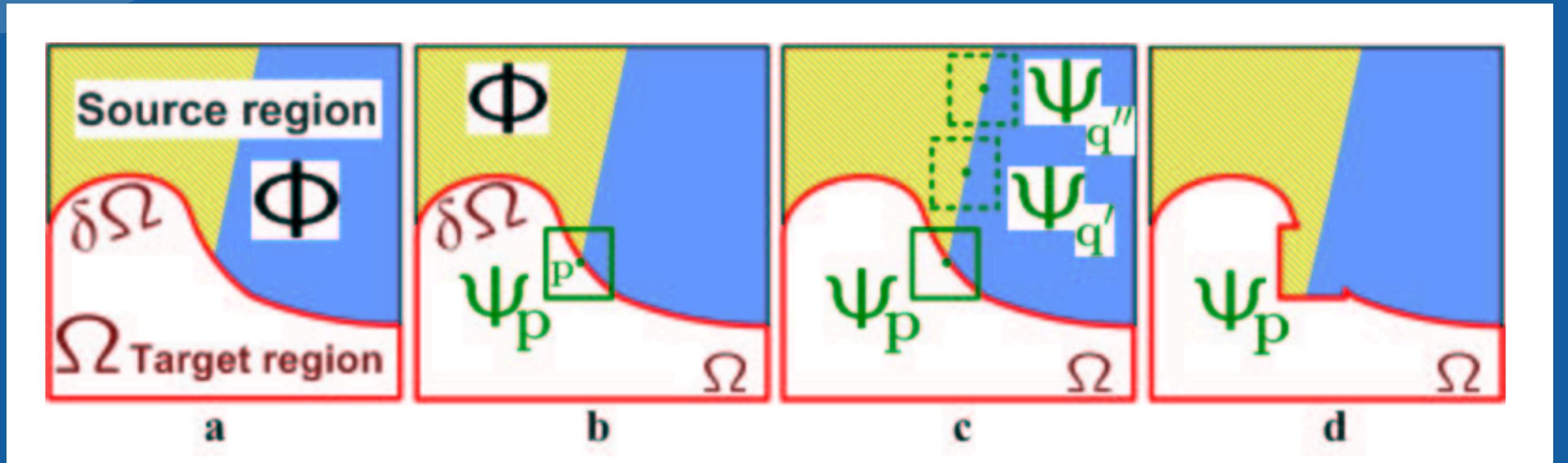


Refinement and post-processing

Additional refinement steps to improve the quality of the inpainted image.



Exemplar-Based Inpainting



- Extract the manually selected initial front $\delta\Omega^0$.
- Repeat until done:
 - 1a. Identify the fill front $\delta\Omega^t$. If $\Omega^t = \emptyset$, exit.
 - 1b. Compute priorities $P(\mathbf{p}) \quad \forall \mathbf{p} \in \delta\Omega^t$.
 - 2a. Find the patch $\Psi_{\hat{\mathbf{p}}}$ with the maximum priority,
i.e., $\Psi_{\hat{\mathbf{p}}} \mid \hat{\mathbf{p}} = \arg \max_{\mathbf{p} \in \delta\Omega^t} P(\mathbf{p})$
 - 2b. Find the exemplar $\Psi_{\hat{\mathbf{q}}} \in \Phi$ that minimizes $d(\Psi_{\hat{\mathbf{p}}}, \Psi_{\hat{\mathbf{q}}})$.
 - 2c. Copy image data from $\Psi_{\hat{\mathbf{q}}}$ to $\Psi_{\hat{\mathbf{p}}}$.
 3. Update $C(\mathbf{p}) \quad \forall \mathbf{p} \mid \mathbf{p} \in \Psi_{\hat{\mathbf{p}}} \cap \Omega$

Table 1: Region filling algorithm.



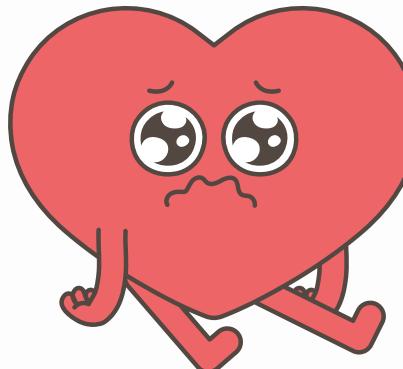
Pros & Cons



Pros

Preservation of image structure

Flexibility and scalability



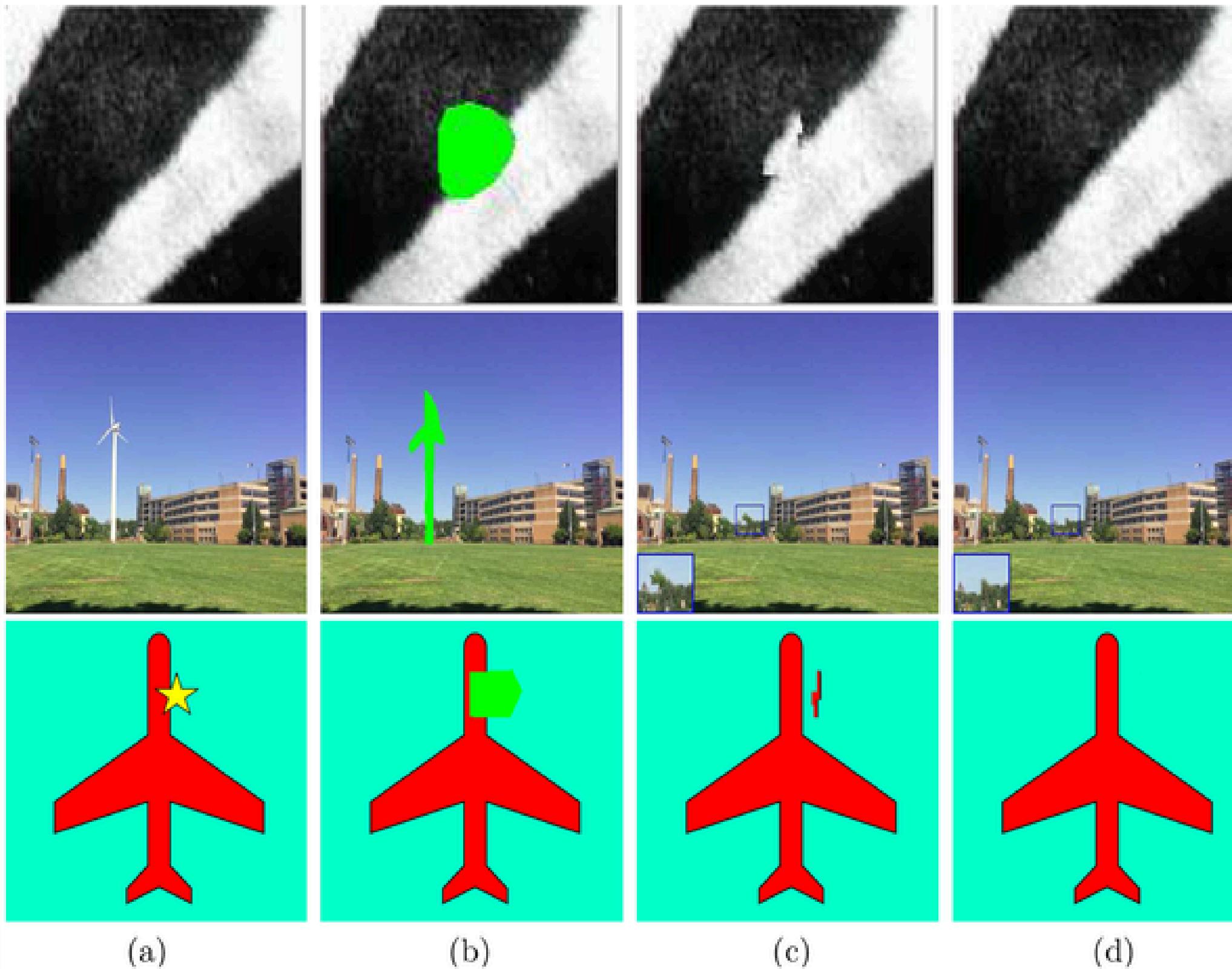
Cons

Computational complexity

Dependency on surrounding information

Potential for artifacts

Examples



Examples

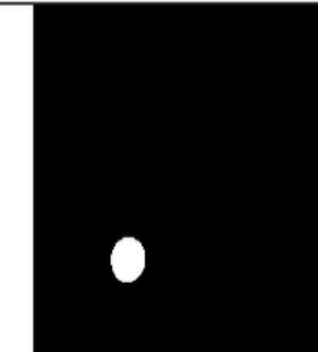
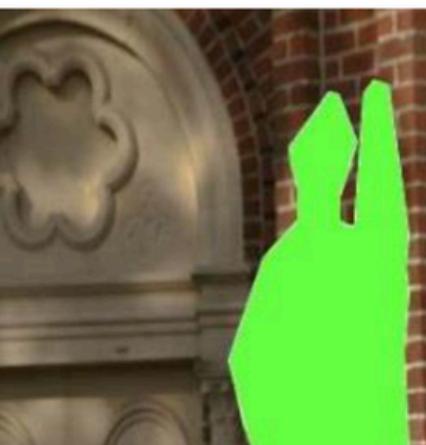
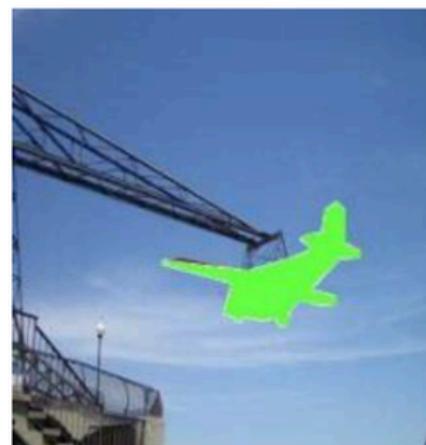
Original Image	Image Mask	Criminisi's Algorithm Result	Proposed Algorithm Result
			
			
			
			

Figure 4. Experimental results of the proposed algorithm in comparison to the Criminisi's inpainting algorithm

Examples



(a)

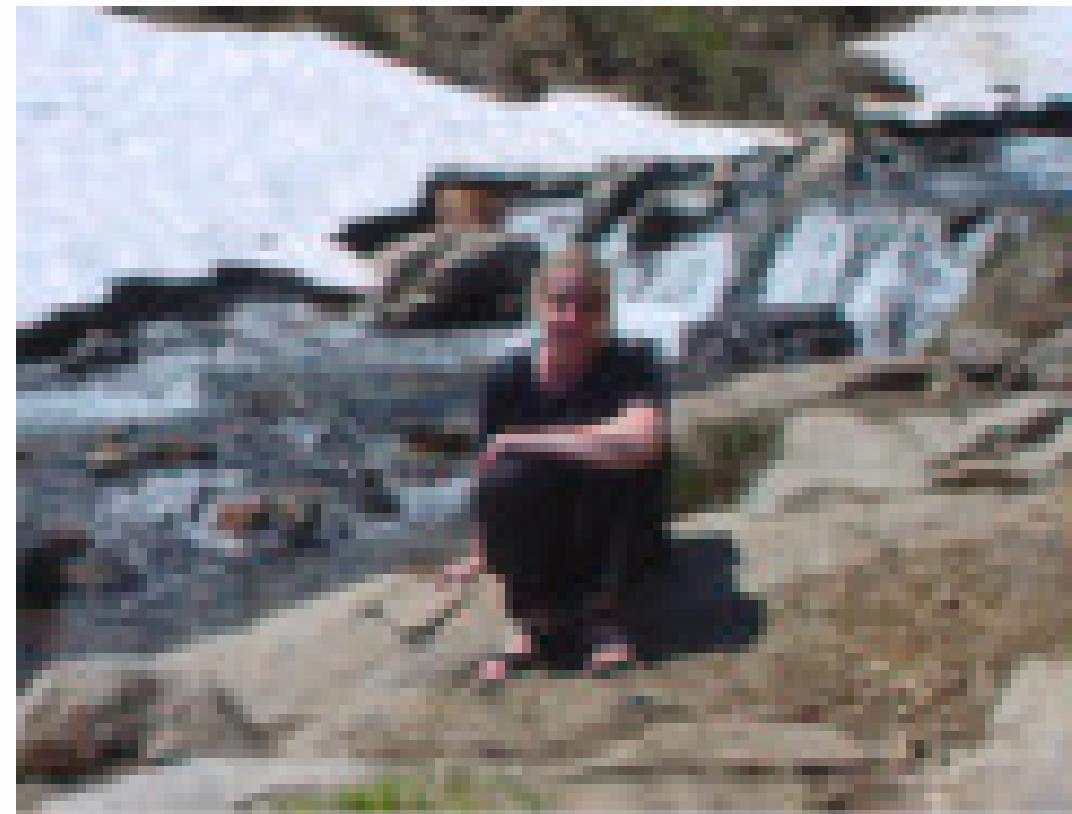


(b)



(c)

Examples



(a) Reference



(b) Mask



(c) Proposed

References

Alexei A. Efros, Thomas K. Leung "*Texture Synthesis by Non-parametric Sampling*"

<https://en.wikipedia.org/wiki/Inpainting>

A. Criminisi, P. Perez and K. Toyama, "*Object removal by exemplar-based inpainting,*"

<https://bilgisayarkavramlari.com/2012/05/04/markof-rastgele-alani-markov-random-field/>

THANK YOU!

