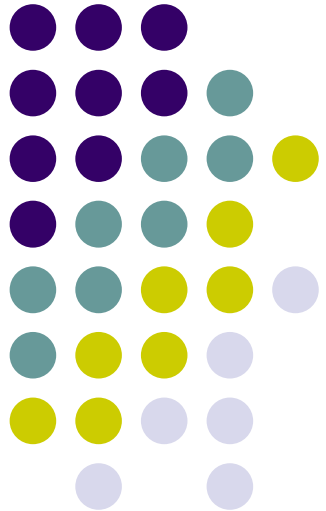
Stylized Rendering for Multiresolution Image Representation

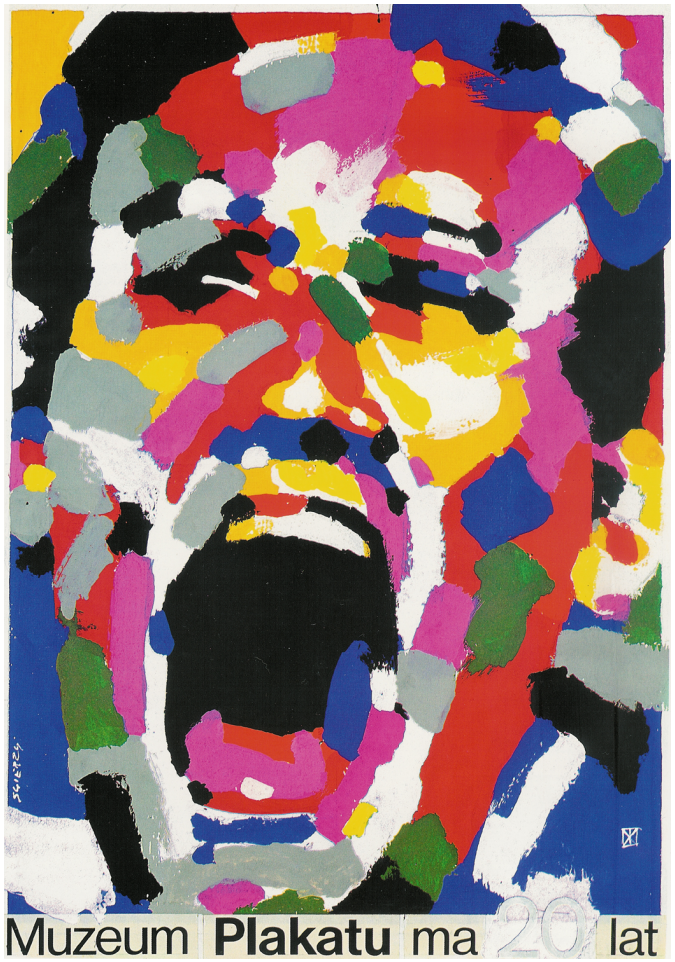
Reconciling Efficiency with Aesthetics in Image Compression

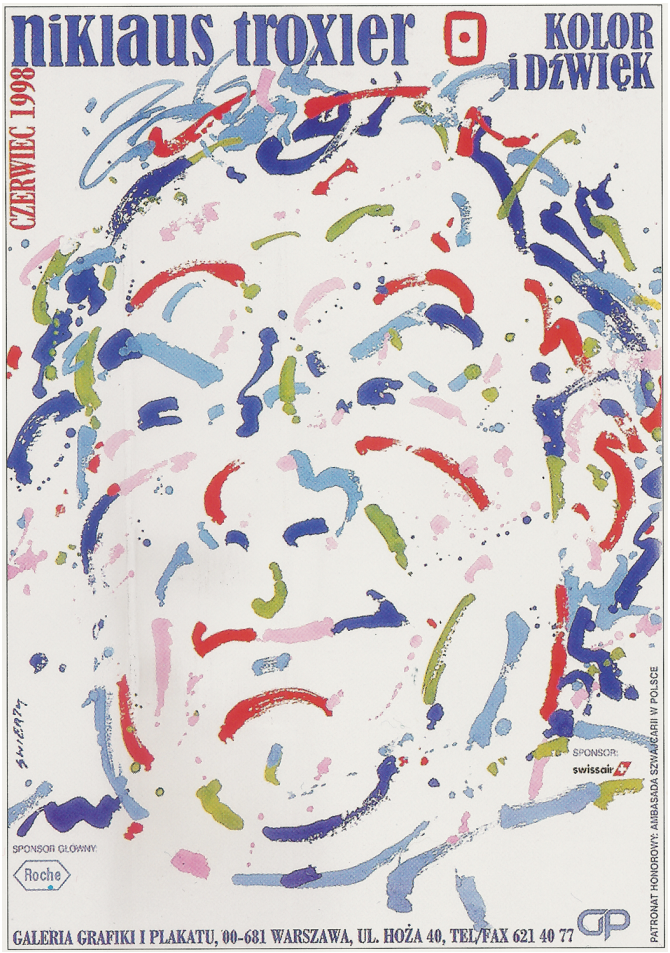


Mark Grundland • Chris Gibbs • Neil A. Dodgson
Computer Laboratory, University of Cambridge

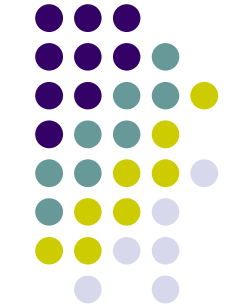
The Art of Compression

- **Image representations value economy of expression, conveying the most information with the least effort.**

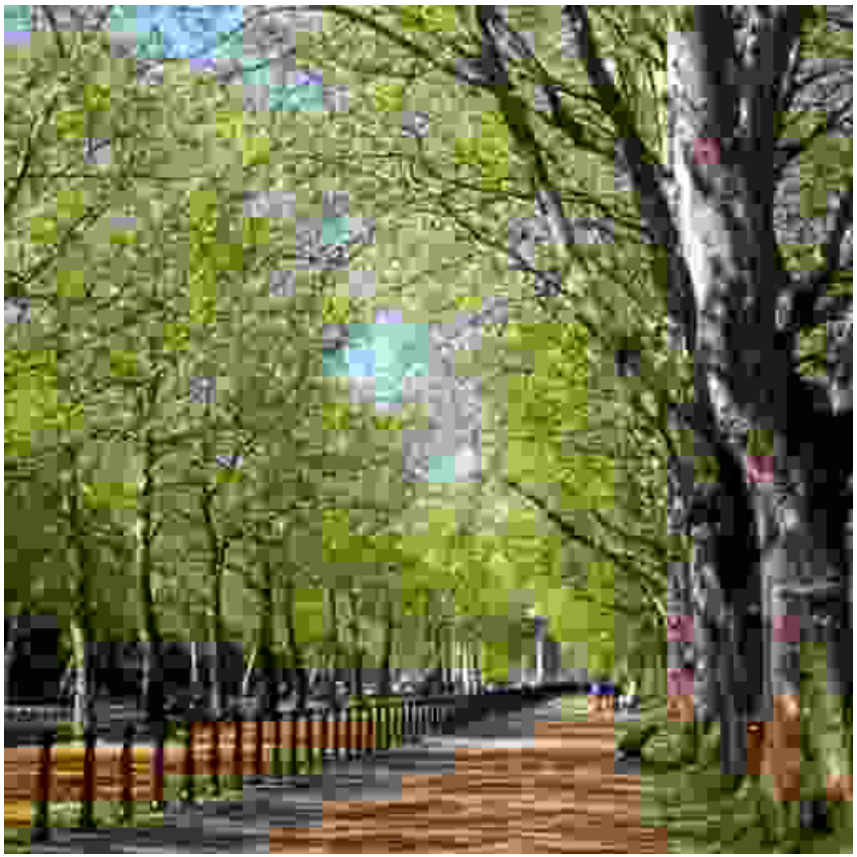


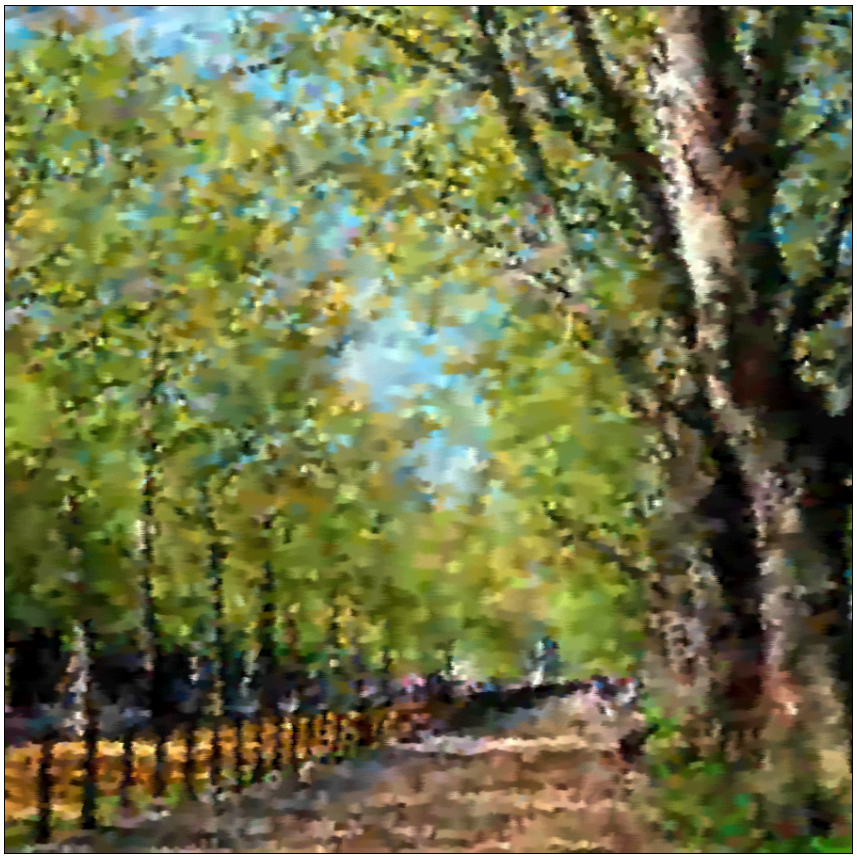


Why Stylized Rendering?



- Enables the user to control how compression affects the aesthetic appearance of an image.



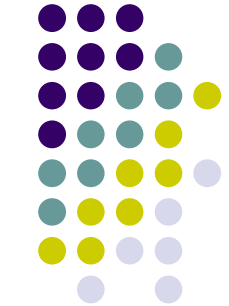


Standard JPEG
9.7KB ≈ 53:1

Lossy Image Compression

Our Technique
8.5KB ≈ 60:1

Why Multiresolution Imaging?

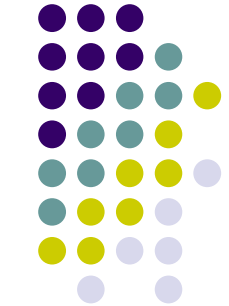


- Enables an image's resolution to match its content, allowing for progressive image display.

Standard Rasterization | Progressive Image Compression | Our Technique

1% = 625 Samples

Why Multiresolution Imaging?



- Enables an image's resolution to match its content, allowing for progressive image display.

Standard Rasterization

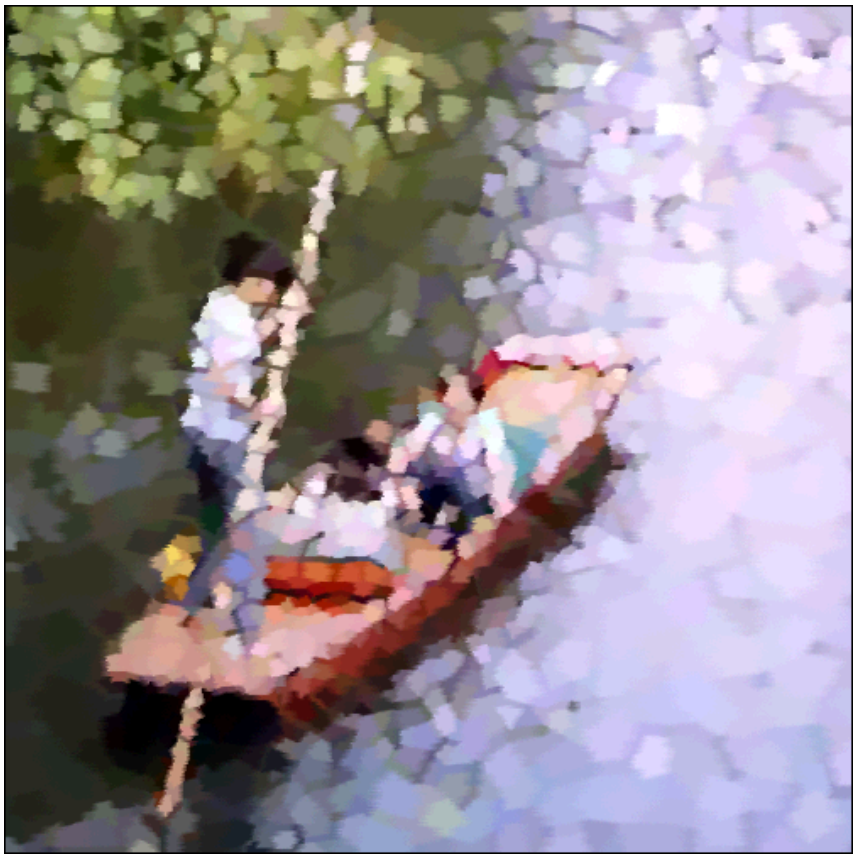
Progressive Image Compression

2% = 1,250 Samples

Our Technique

Why Multiresolution Imaging?

- Enables an image's resolution to match its content, allowing for progressive image display.

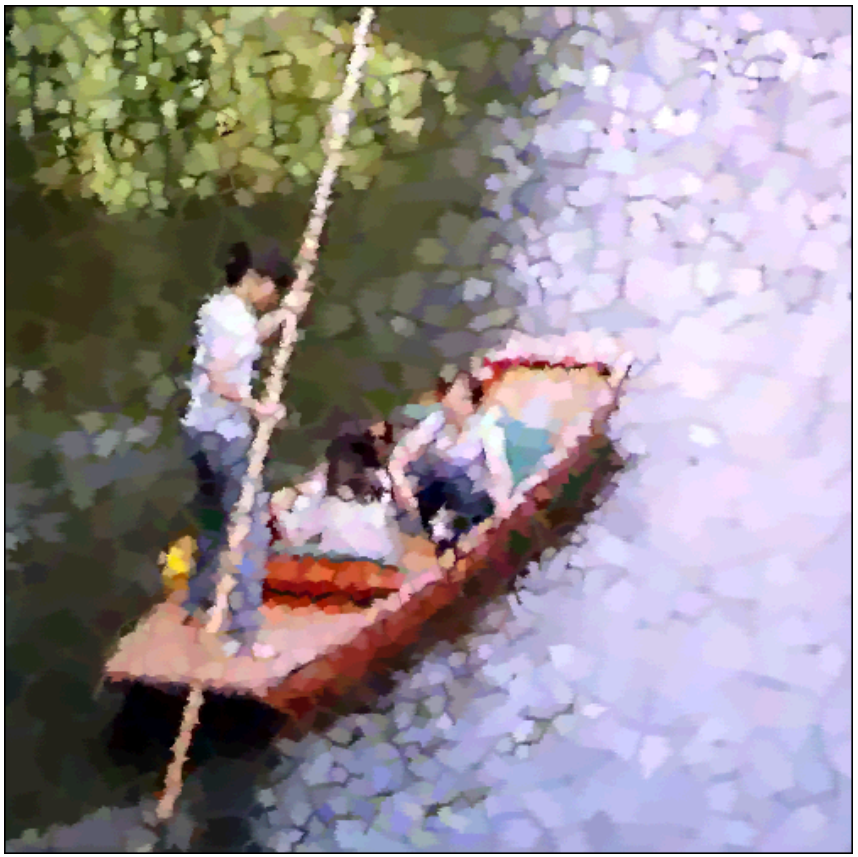


Standard Rasterization | Progressive Image Compression | Our Technique

4% = 2,500 Samples

Why Multiresolution Imaging?

- Enables an image's resolution to match its content, allowing for progressive image display.



Standard Rasterization

Progressive Image Compression

8% = 5,000 Samples

Our Technique

Why Multiresolution Imaging?

- Enables an image's resolution to match its content, allowing for progressive image display.

Standard Rasterization | Progressive Image Compression | Our Technique

16% = 10,000 Samples

Why Multiresolution Imaging?

- Enables an image's resolution to match its content, allowing for progressive image display.

Standard Rasterization

Progressive Image Compression

32% = 20,000 Samples

Our Technique

Limitations of Compression

- Conventional compression only allows the user to control the rate of data loss but not its visual consequences.

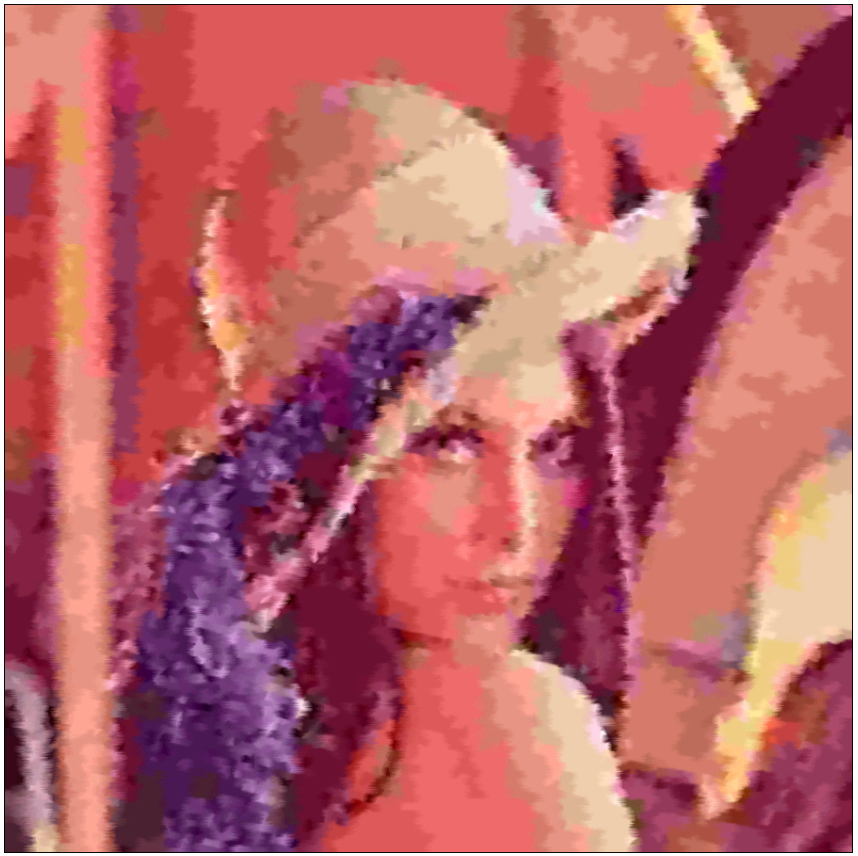
Original Image
512KB = 1:1

Standard JPEG
7.0KB ≈ 73:1

Limitations of Stylization

- In image representation, stylization should not be treated as an afterthought: at some resolution, it is inevitable.

Original Image
512KB = 1:1



Stylized Rendering of the JPEG Image
7.0KB ≈ 73:1

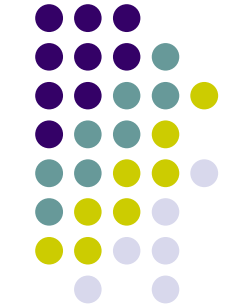
Compression and Stylization

- Use an image representation suited to stylized rendering and rendering elements designed for compact encoding.

Original Image
512KB = 1:1

Our Stylized and Compressed Representation
7.2KB ≈ 71:1

Image Representation Requirements

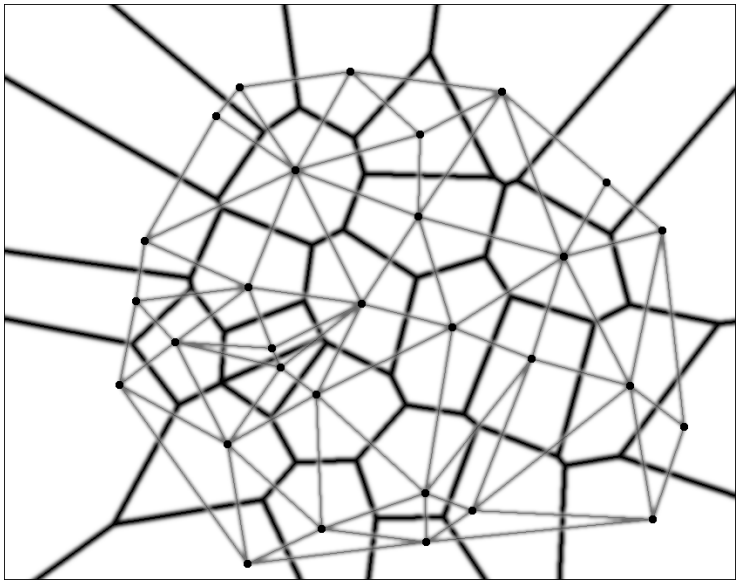


Representing an image by a suitable sequence of colors, we propose a point-based framework for image sampling, image compression, and image reconstruction:

- **Compact:** Enables efficient lossless and lossy compression.
- **Secure:** Deters unauthorized access by scrambling the data.
- **Progressive:** Exhibits a smooth transition between multiple levels of detail, culminating in an exact reconstruction.
- **Flexible:** Supports diverse photorealistic reconstruction techniques and non-photorealistic rendering styles.
- **Intentional:** Allows the artist to creatively formulate novel rendering styles.

Spatial Proximity Graphs

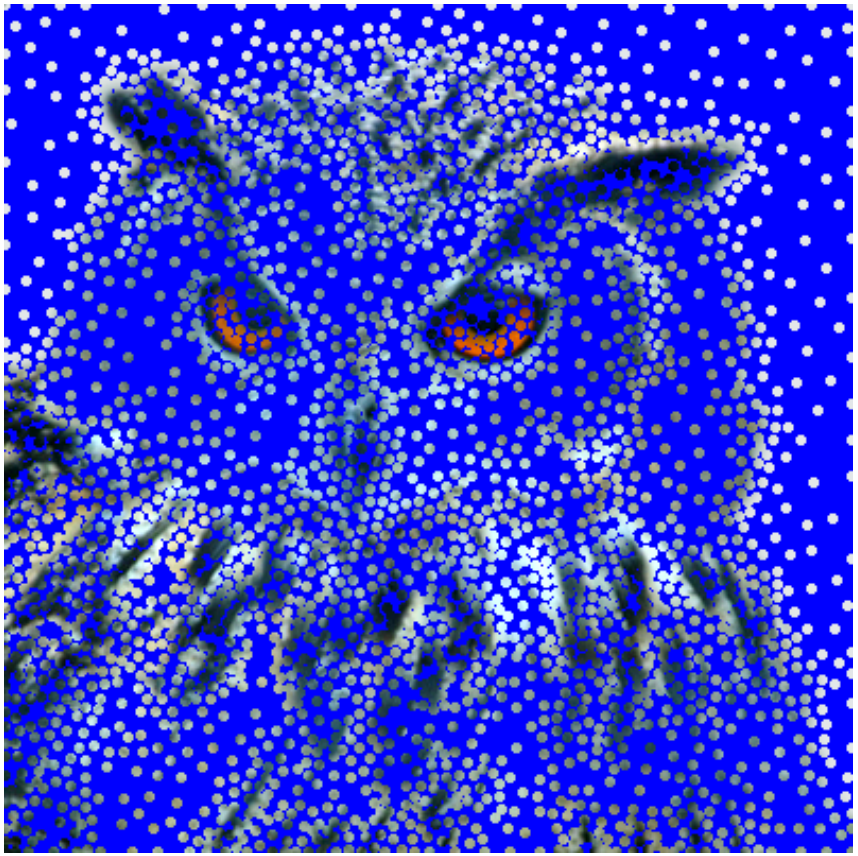
- The Voronoi diagram and its dual Delaunay triangulation are the basis for our sampling and rendering framework:
  - For each sample site, only its color needs to be stored explicitly.
  - The appearance, shape, and position of its region of influence on the rendition are all inferred from its color sample as well as the colors and positions of the preceding sample sites.



Adaptive Sampling

- Balancing global coverage with local precision, our method selectively samples the vertices of the Voronoi diagram.

Original Image



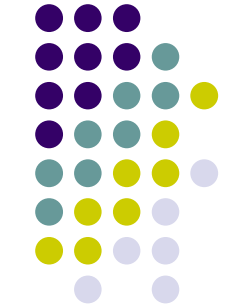
Our Adaptive Farthest Point Sampling

2% = 3,200 Samples

Adaptive Sampling Technique

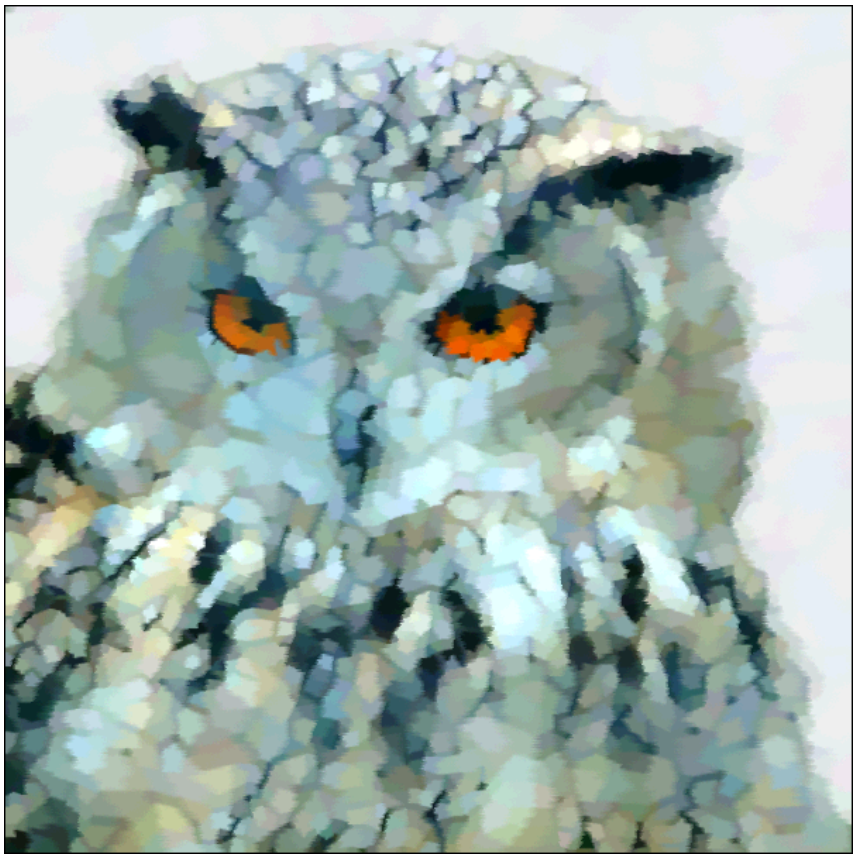
- **How to balance global coverage C with local precision P?**
  - **For each sample site candidate, consider its neighboring samples.**
  - **Measure coverage C_i as squared nearest neighbor distance. Measure precision P_i as local mean absolute luminance deviation.**
  - **Z-scores make the measures comparable: $C_i' = \frac{C_i - \mu(C)}{\sigma(C)}$, $P_i' = \frac{P_i - \mu(P)}{\sigma(P)}$ for mean μ and mean absolute deviation σ.**
  - **Select the sample site with the highest combined score: $S_i = \min(C_i', P_i') + \lambda \max(C_i', P_i')$ with tradeoff parameter $0 < \lambda < 1$.**
  - **To balance two potentially conflicting criteria, the final score gives greater weight to the lower z-score over the higher z-score, with the tradeoff λ parameter dictating how high the higher z-score must be to dominate the influence of the lower z-score.**

Geometric Rendering Styles



- Geometric subdivision refines the image mesh, defines the colors of the new vertices, and uses various shading styles.

Delaunay Triangulation

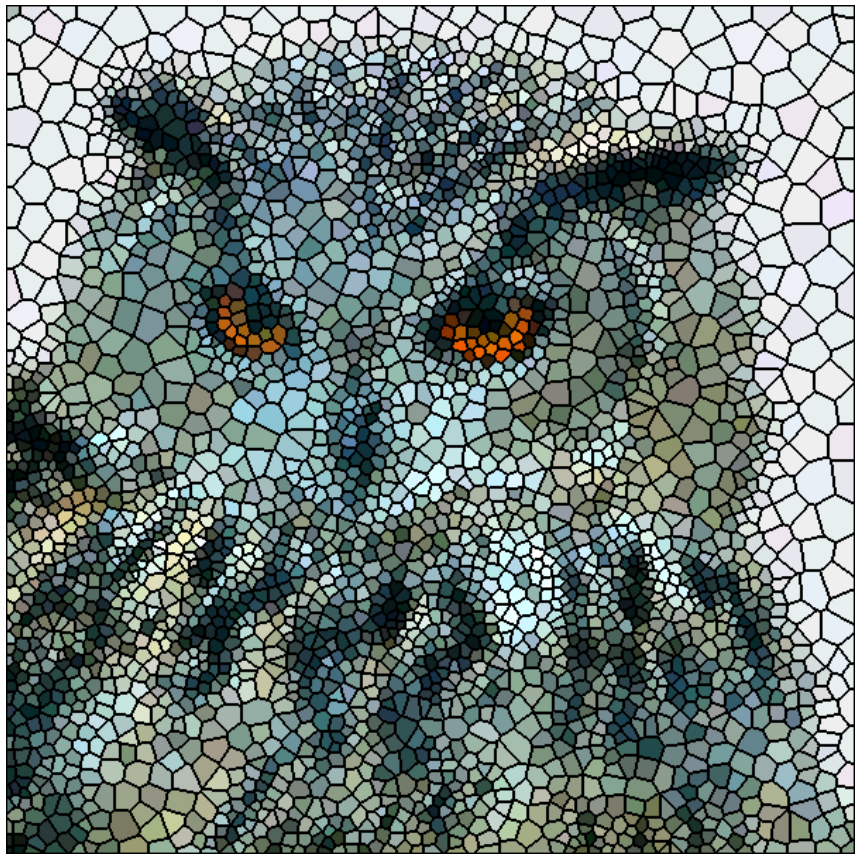


Geometric Rendering Style

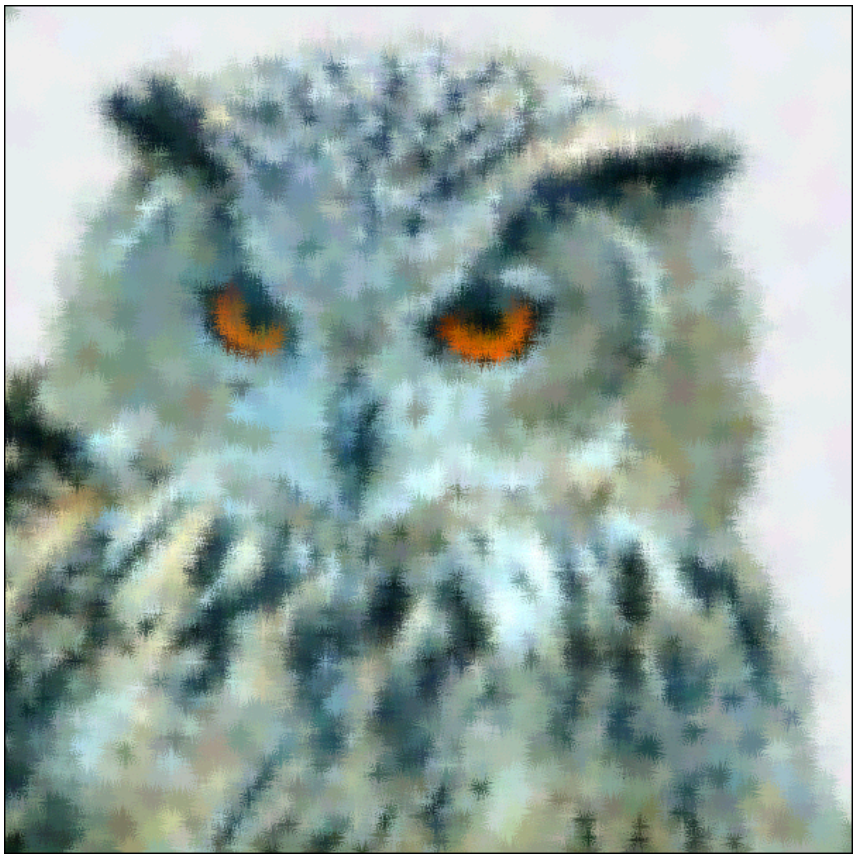
2% = 3,200 Samples

Procedural Rendering Styles

- Parametric procedural textures reconstruct the image from filter functions centered on the sample sites.



Voronoi Diagram

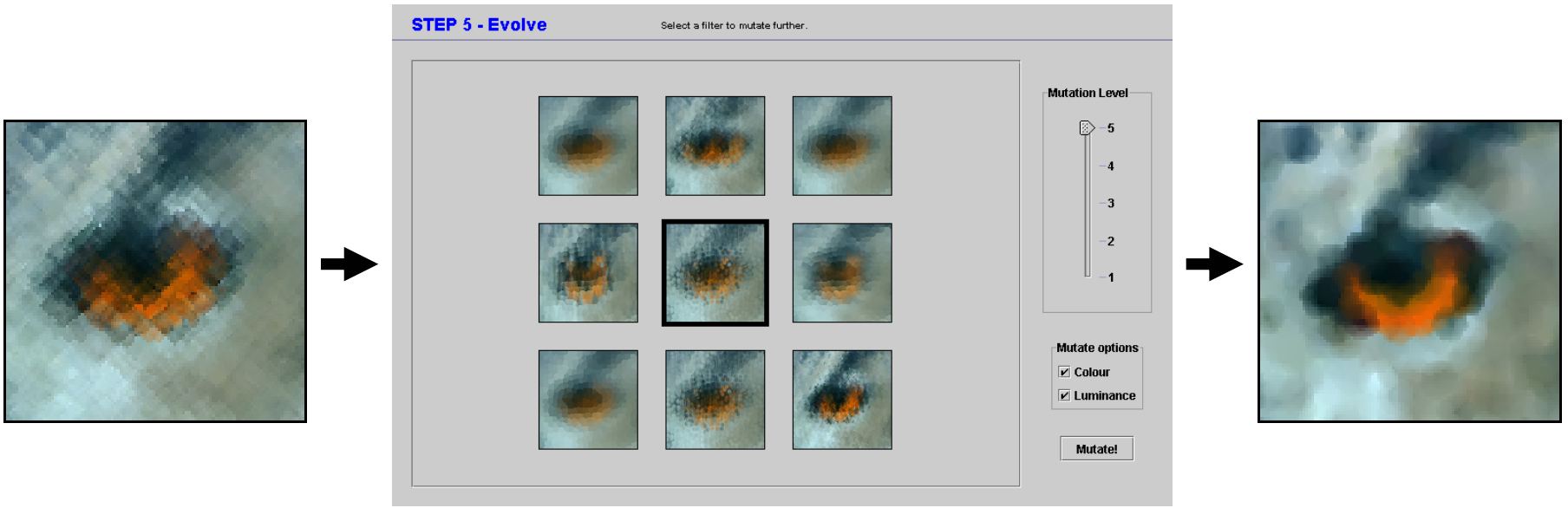


Procedural Rendering Style

2% = 3,200 Samples

Evolving Rendering Styles

- Using genetic programming, novel rendering styles are evolved in response to the user's aesthetic judgment.
  - The parameters and functions that define the symbolic expression of a procedural style are randomly mutated and recombined.
  - The resulting variations are presented to the user who selects which one should survive for further refinement.



Perspectives for Research

- When images communicate ideas or illustrate narratives, stylized expression could be both more appropriate and more efficient than photorealistic reproduction.
- By shaping the viewer's impression of an image, deliberate stylized rendering could allow for visual artifacts to play a constructive role in visual communication.
- The perceived visual quality of a highly compressed image could be improved by shifting the viewer's expectation from a photographic reproduction to an artistic rendition.
- Stylized rendering could help make abstraction and simplification appear legitimate, encouraging the viewer's imagination to complete the picture.


Any Questions?