Image processing

- Quantization
  - Quantization
  - Dithering

- Pixel operation
  - Add noise
  - Add luminance
  - Add contrast
  - Add saturation

- Filtering
  - Blur
  - Detect edges

- Warping
  - Scale
  - Rotate
  - Warp

- Combining
  - Composite
  - Morph
Image warping

Beyond Photography
The digital darkroom
Holzmann
Altered images
Altered images
Altered images
Altered images
Altered images
Altered images
Compositing

Compositing is the process of combining several pictures called elements to form a final picture called the composite.
Motivation

- Sometimes we cannot render the entire scene by a single program
- Portions of the image are optically scanned
- Transparency
Tricky pixel
From an abstract image to the frame buffer

Abstract Image

Sample (scan conversion)

Graphics state

Imaging model

Frame buffer
Uses for imaging models

- Clear
- Copy
- Invert
- Mask
- Combine
Mattes

A matte is a single channel image which defines an opaque region against a transparent background

- Digital matte: 0=transparent  1=opaque
- Transparency = 1 - opacity
- Opacity = $\alpha$
Matte extraction

In computer graphics - coverage

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>Translucent</th>
<th>No Coverage</th>
<th>Opaque</th>
<th>Full Coverage</th>
<th>Partial Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>transparent</td>
<td>no coverage</td>
<td>opaque</td>
<td>full coverage</td>
<td>partial coverage</td>
</tr>
<tr>
<td>1</td>
<td>translucent</td>
<td>no coverage</td>
<td>opaque</td>
<td>full coverage</td>
<td>partial coverage</td>
</tr>
</tbody>
</table>

![Diagram of matte extraction](image)
Matte representation

- Separate objects
- Combine with the image
  - RGB$\alpha$
  - RGB$\beta$
Compositing operators

c = A_A C_A + A_B C_B =
    = F_A \alpha_A C_A + F_B \alpha_B C_B
    = F_A C_A + F_B C_B
### Table of operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Quadruple</th>
<th>Diagram</th>
<th>$F_A$</th>
<th>$F_B$</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>(0,0,0,0)</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>(0,A,0,A)</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>(0,0,B,B)</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A over B</td>
<td>(0,A,B,A)</td>
<td></td>
<td>1</td>
<td>1 - $\alpha_A$</td>
</tr>
<tr>
<td>B over A</td>
<td>(0,A,B,B)</td>
<td></td>
<td>1 - $\alpha_B$</td>
<td>1</td>
</tr>
<tr>
<td>A in B</td>
<td>(0,0,0,A)</td>
<td></td>
<td>$\alpha_B$</td>
<td>0</td>
</tr>
<tr>
<td>B in A</td>
<td>(0,0,0,B)</td>
<td></td>
<td>0</td>
<td>$\alpha_A$</td>
</tr>
<tr>
<td>A cut B</td>
<td>(0,A,0,0)</td>
<td></td>
<td>1 - $\alpha_B$</td>
<td>0</td>
</tr>
<tr>
<td>B cut A</td>
<td>(0,0,B,0)</td>
<td></td>
<td>0</td>
<td>1 - $\alpha_A$</td>
</tr>
<tr>
<td>A atop B</td>
<td>(0,0,B,A)</td>
<td></td>
<td>$\alpha_B$</td>
<td>1 - $\alpha_A$</td>
</tr>
<tr>
<td>B atop A</td>
<td>(0,A,0,B)</td>
<td></td>
<td>1 - $\alpha_B$</td>
<td>$\alpha_A$</td>
</tr>
<tr>
<td>A xor B</td>
<td>(0,A,B,0)</td>
<td></td>
<td>1 - $\alpha_B$</td>
<td>1 - $\alpha_A$</td>
</tr>
</tbody>
</table>
Compositing arithmetic

$$\alpha = F_A \alpha_A + F_B \alpha_B$$

Same arithmetic for all channels!
Advantages / Disadvantages

- The same arithmetic for the four channels
- Avoid arithmetic (pre-multiplied)
- First 3 components are equivalent to the color obtained by matting the color to opaque black.

- Limited precision - undesirable quantization results
- Some colors cannot be distinguished.
Unary operators

- Darken(A,ρ) = (ρR_A, ρG_A, ρB_A, α_A)
- Fade(A,δ) = (δR_A, δG_A, δB_A, δα_A)
- Opaque (A, ω) = (R_A, G_A, B_A, ωα_A)

Example

- Fade(A,t) plus Fade(B,1-t)
Painting

- Canvas = image being created
- Brush = matte giving shape of brush
- Paint = color and texture paint

```latex
\text{canvas} = \\
(\text{canvas out brush}) + (\text{canvas op paint}) \text{ in brush}
```

Examples: PAINT-COPY, PAINT-OVER, PAINT-AROUND, PAINT-IN
Morphing
Metamorphosis

Metamorphosis is the gradual evolution of a source object, through intermediate objects to a target object.

Object = image, polygon, curve, volume, polyhedron, surface
Cross Dissolves

Problem - misaligned regions
Issues in Morphing

- Correspondence:
  - Feature specification
  - Warp generation
- Transition control
Morphing