Image Warping and Compositing

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C0S 426, Fall 1999

Overview

- Quantization
  - Uniform Quantization
  - Random dither
  - Ordered dither
  - Floyd-Steinberg dither
- Pixel operations
  - Add random noise
  - Add luminance
  - Add contrast
  - Add saturation
- Filtering
  - Blur
  - Detect edges
- Warping
  - Scale
  - Rotate
  - Warps
  - Morphs
- Compositing
  - Matting

Overview

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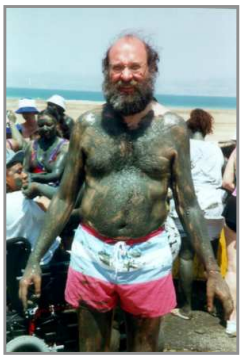
Image Warping

- Move pixels of image
  - Mapping
  - Resampling

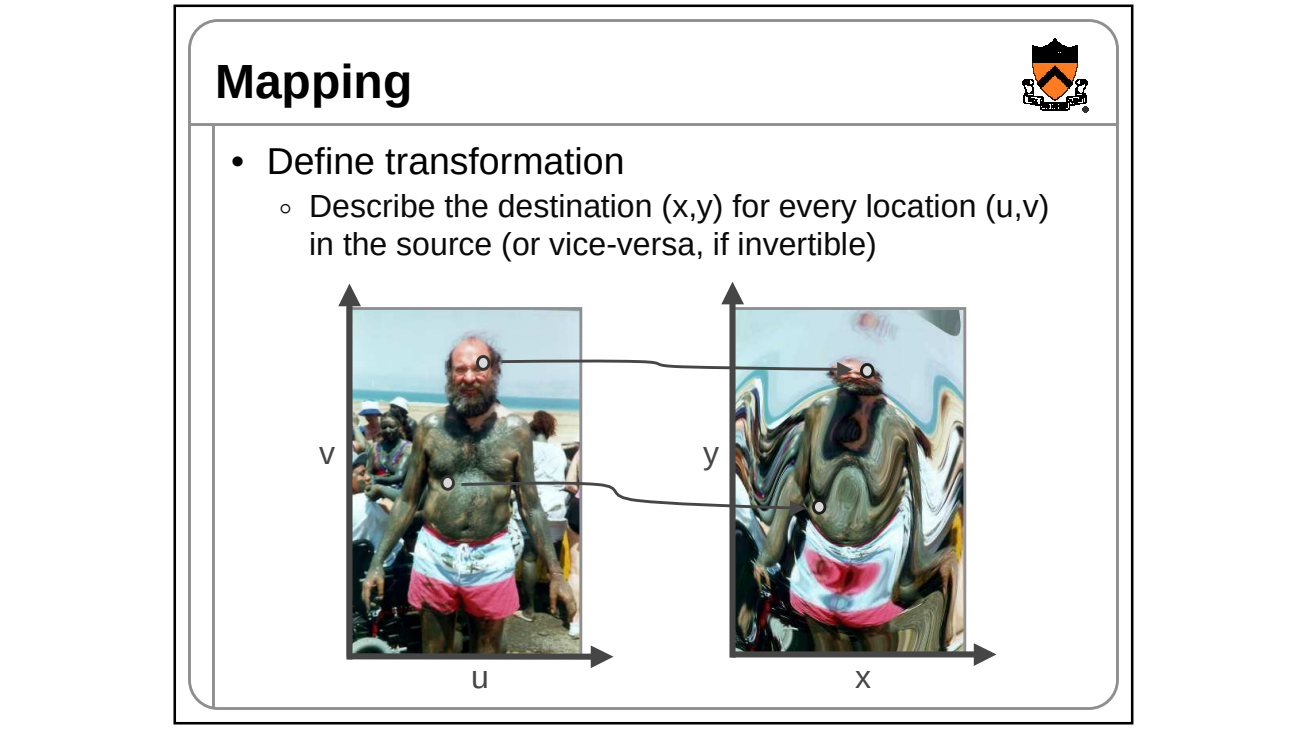


Warp

Source image

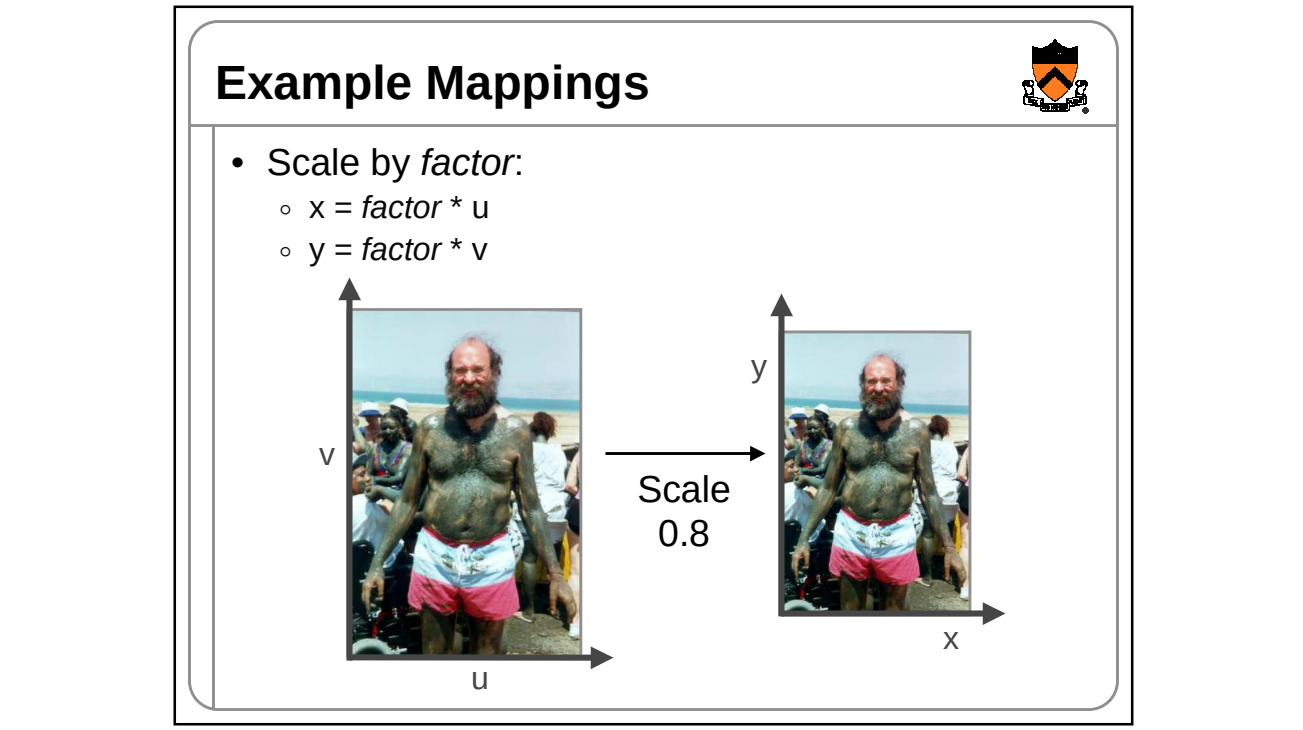
Destination image

Mapping



- Define transformation
  - Describe the destination (x,y) for every location (u,v) in the source (or vice-versa, if invertible)

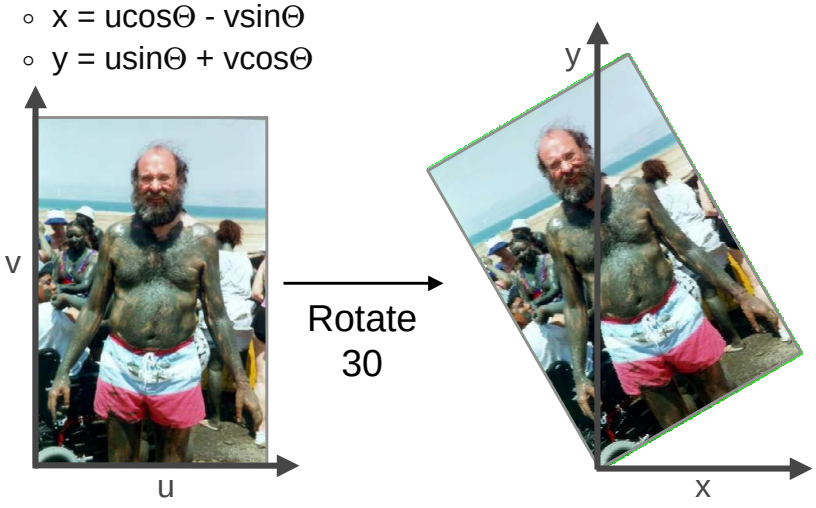
Example Mappings



- Scale by *factor*:
  - x = *factor* * u
  - y = *factor* * v

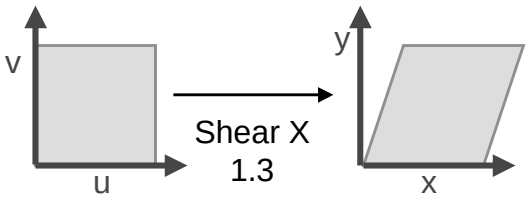
Example Mappings

- Rotate by Θ degrees:
  - x = ucosΘ - vsinΘ
  - y = usinΘ + vcosΘ

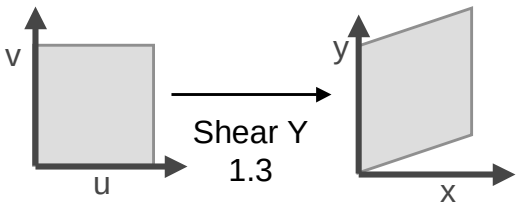


Example Mappings

- Shear in X by *factor:*
  - x = u + *factor* * v
  - y = v



- Shear in Y by *factor:*
  - x = u
  - y = v + *factor* * u

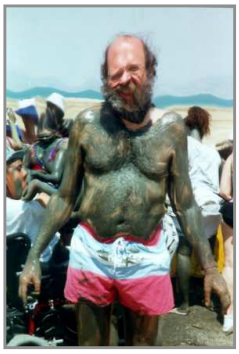


Other Mappings

- Any function of u and v:
  - $x = f_x(u,v)$
  - $y = f_y(u,v)$

Fish-eye

"Swirl"

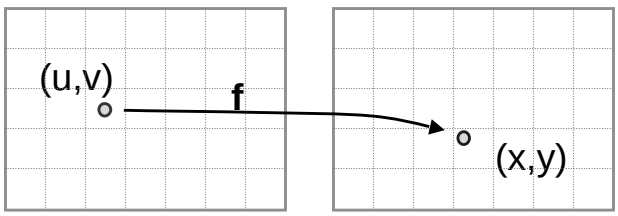


"Rain"

Image Warping Implementation I

- Forward mapping:

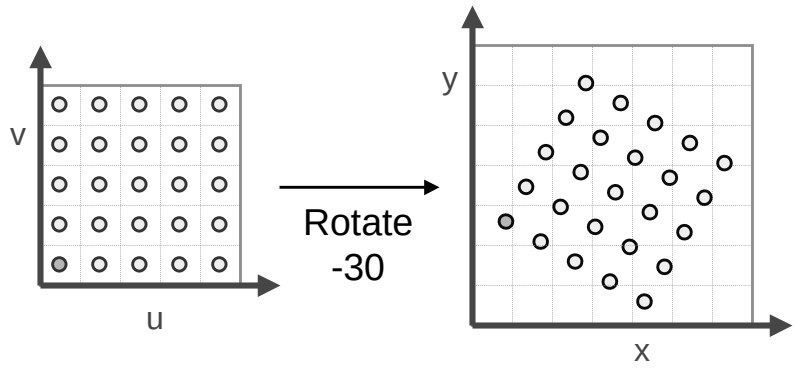
```
for (int u = 0; u < umax; u++) {
  for (int v = 0; v < vmax; v++) {
    float x = fx(u,v);
    float y = fy(u,v);
    dst(x,y) = src(u,v);
  }
}
```



Source image Destination image

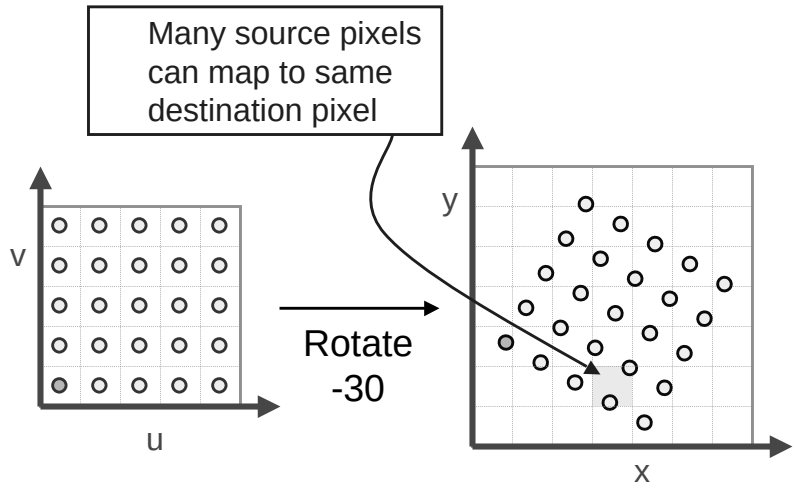
Forward Mapping

- Iterate over source image

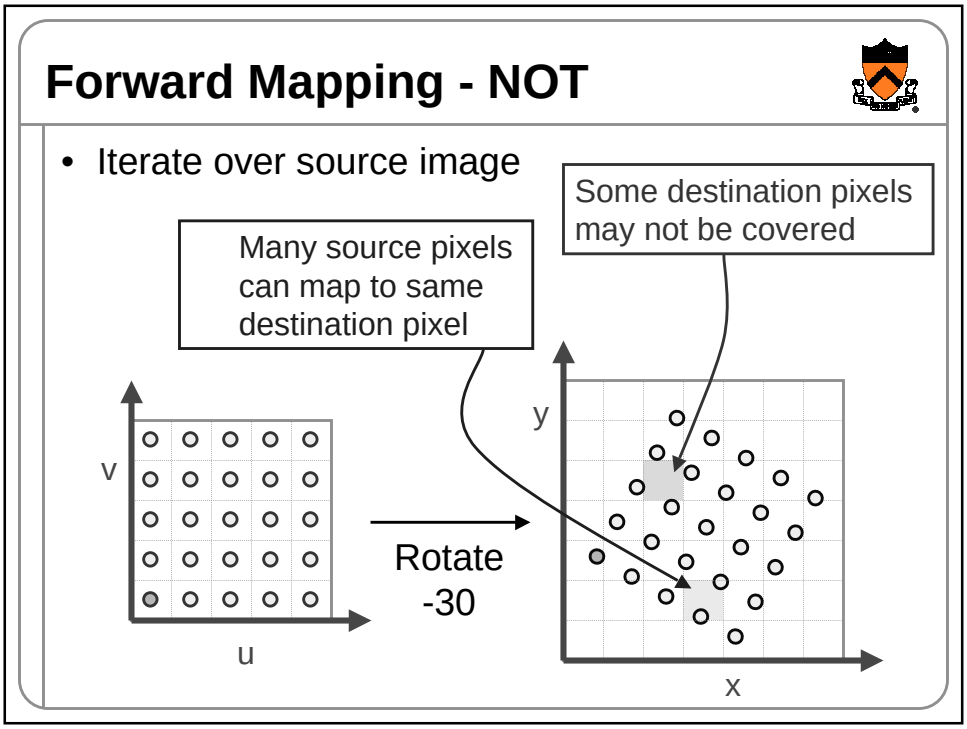


Forward Mapping - NOT

- Iterate over source image



Forward Mapping - NOT

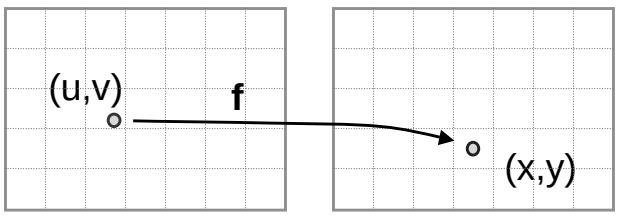


- Iterate over source image

Image Warping Implementation II

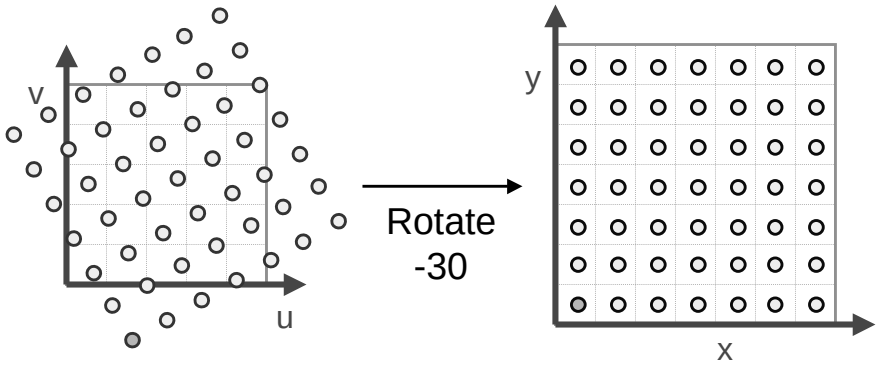
- Reverse mapping:

```
for (int x = 0; x < xmax; x++) {
  for (int y = 0; y < ymax; y++) {
    float u = f_x^-1(x,y);
    float v = f_y^-1(x,y);
    dst(x,y) = src(u,v);
  }
}
```



Reverse Mapping

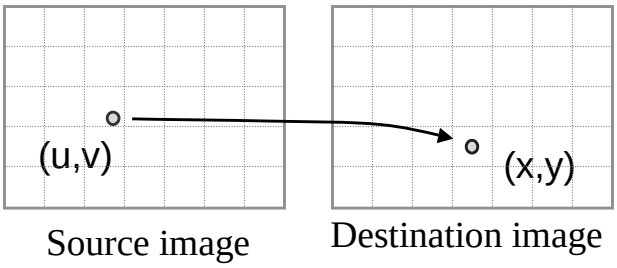
- Iterate over destination image
  - Must resample source
  - May oversample, but much simpler!



Resampling

- Evaluate source image at arbitrary (u,v)

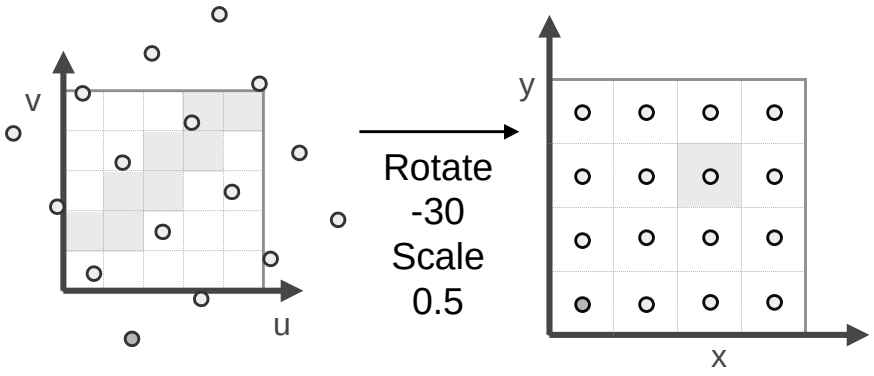
(u,v) does not usually have integer coordinates



Point Sampling

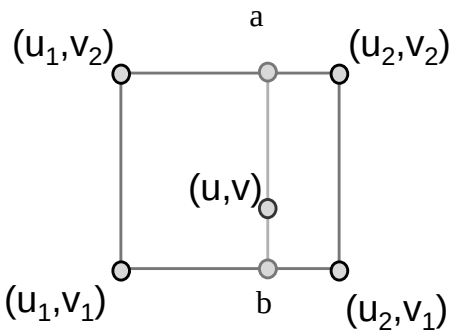
- Take value at closest pixel:
  - int iu = trunc(u+0.5);
  - int iv = trunc(v+0.5);
  - dst(x,y) = src(iu,iv);

This method is simple, but it causes aliasing



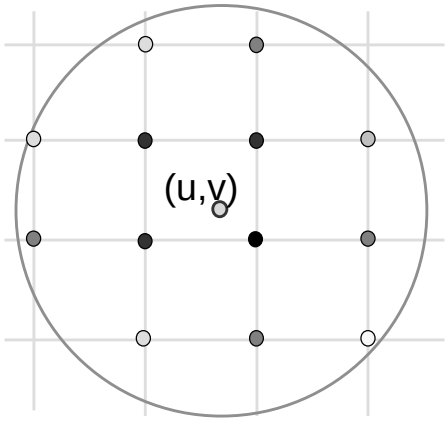
Triangle Filtering

- Bilinear interpolation of four closest pixels
  - a = linear interpolation of src(u_1,v_2) and src(u_2,v_2)
  - b = linear interpolation of src(u_1,v_1) and src(u_2,v_1)
  - dst(x,y) = linear interpolation of “a” and “b”



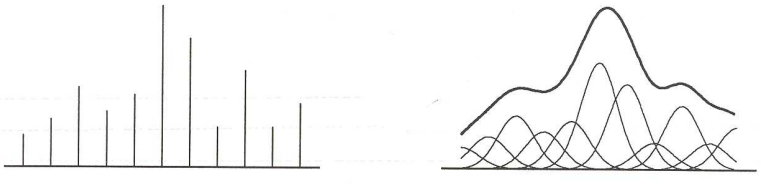
Gaussian Filtering

- Weighted combination of pixel neighborhood:
  - Weights are normalized values of gaussian function



Gaussian Filtering

- Width of gaussian kernel affects bluriness



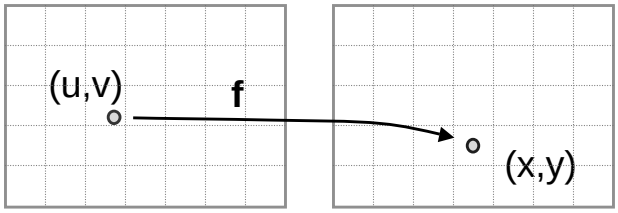
Input Output

Figure 2.4 Wolberg

Image Warping Implementation

- Reverse mapping:

```
for (int x = 0; x < xmax; x++) {
  for (int y = 0; y < ymax; y++) {
    float u = f_x^-1(x,y);
    float v = f_y^-1(x,y);
    dst(x,y) = resample_src(u,v);
  }
}
```



Source image Destination image

Overview

- Image warping
  - Mapping
  - Resampling
- Image compositing
  - Blue-screen mattes
  - Alpha channel
  - Porter-Duff compositing algebra

Image Compositing

- Separate an image into “elements”
  - Render independently
  - Composite together
- Applications
  - Cel animation
  - Chroma-keying
  - Blue-screen matting

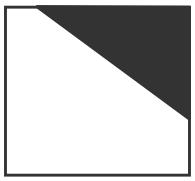
Dobkin meets Elvis

Blue-Screen Matting

- Composite foreground and background images
  - Create background image
  - Create foreground image with blue background
  - Insert non-blue foreground pixels into background

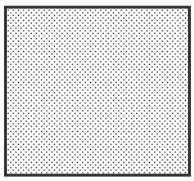
Alpha Channel

- Encodes pixel coverage information
  - $\alpha = 0$: no coverage (or transparent)
  - $\alpha = 1$: full coverage (or opaque)
  - $0 < \alpha < 1$: partial coverage (or semi-transparent)
- Example: $\alpha = 0.3$



Partial Coverage

or



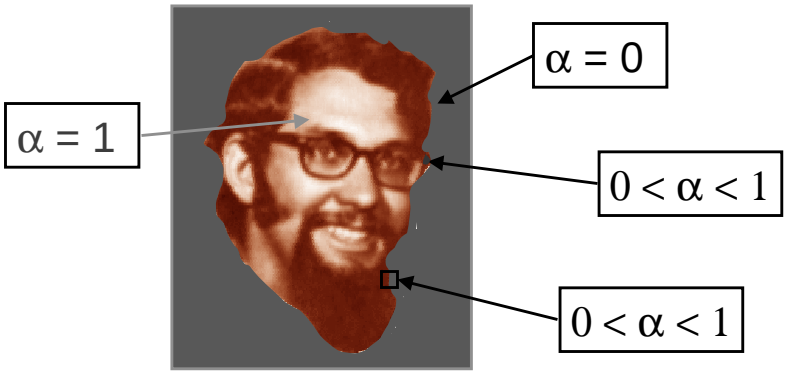
Semi-Transparent

Pixels with Alpha

- Alpha channel convention:
  - (r, g, b, α) represents a pixel that is α covered by the color C = (r/α, g/α, b/α)
    - »Color comonents are premultiplied by α
    - »Can display (r,g,b) values directly
    - »Closure in composition algebra
- What is the meaning of the following?
  - (0, 1, 0, 1) = Full green, full coverage
  - (0, 1/2, 0, 1) = Half green, full coverage
  - (0, 1/2, 0, 1/2) = Full green, half coverage
  - (0, 1/2, 0, 0) = No coverage

Compositing with Alpha

- Controls the linear interpolation of foreground and background pixels when elements are composited



Semi-Transparent Objects

- Suppose we put A over B over background G
  - How much of B is blocked by A?

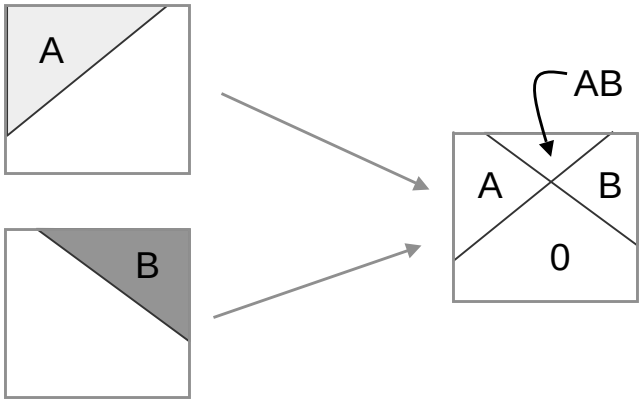
    α_A
  - How much of B shows through A?

    $(1-\alpha_A)$
  - How much of G shows through both A and B?

    $(1-\alpha_A)*(1-\alpha_B)$

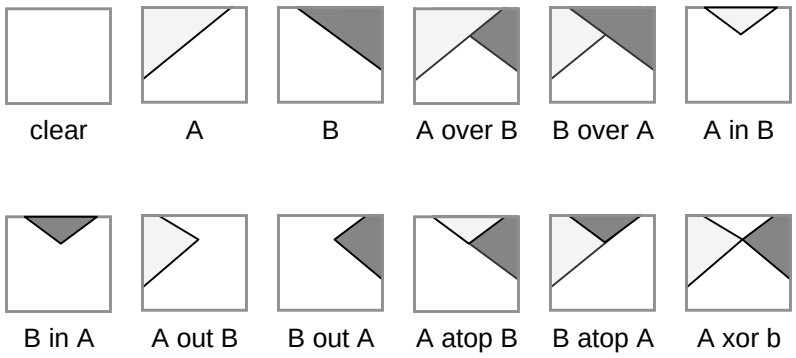
Opaque Objects

- How do we combine two partially covered pixels?
  - 3 possible colors (0, A, B)
  - 4 regions (0, A, B, AB)



Composition Algebra

- 12 reasonable combinations



Porter & Duff ‘84

Over Operator

- For C_B and C_F, which are not premultiplied:
  - $C' = \alpha_B(1-\alpha_F)*C_B + \alpha_F*C_F$
  - $\alpha = \alpha_B(1-\alpha_F) + \alpha_F$
- For C'_B and C'_F, which are premultiplied:
  - $C' = (1-\alpha_B)*C'_F + C'_B$
  - $\alpha = \alpha_B(1-\alpha_F) + \alpha_F$

Assumption: coverages of B and F are uncorrelated for each pixel

Image Composition Example

Summary

- Image Warping
  - Mapping
  - Resampling
  - Reconstruction
- Image Composition
  - Alpha channel
  - Composition algebra
  - Blue-screen matting