CS148: Introduction to Computer Graphics and Imaging

Image Compositing

Colbert Challenge

Key Concepts

Optical compositing and mattes

The alpha channel

Compositing operators

Premultipled alpha

Matte extraction

Optical Compositing

Image Composition

Defn: Combine foreground element with background

Examples:

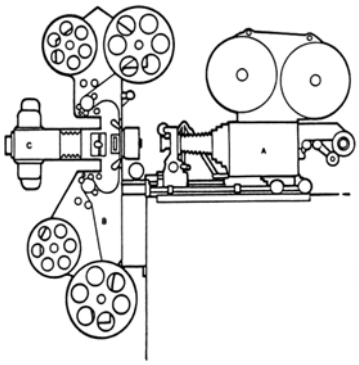
- **Graphics arts: masking tape, friskets, stencils**
- **Animation: cels, multiplane camera**
- **Film: optical printing, blue screen matting**
- **Video: chroma-keying**
- **Computer graphics: alpha channel**

Multiplane Camera – Walt Disney

http://disneyandmore.blogspot.com/2007/09/walt-disney-multiplane-camera-and.html

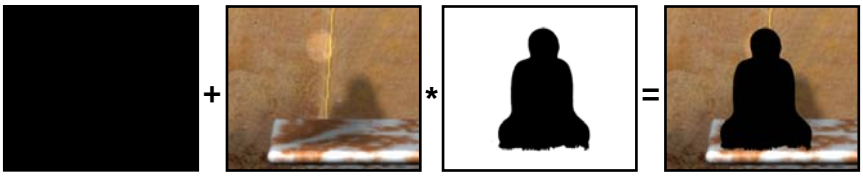
Optical Printing

From: "Industrial Light and Magic," Thomas Smith (p. 181)



From: "Special Optical Effects," Zoran Perisic

Composing Two Elements



Background Holdout Matte

Foreground Traveling Matte

The Alpha Channel

The Alpha Channel

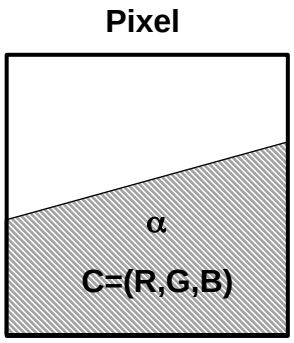
A alpha channel is an additional image that defines:

- **The transparency or opacity of an image**
- **The presence or absence of imagery**
  - **Geometric coverage: soft-edge**
- **Or both coverage and transparency**

Alpha channels may be

- **Masks: all or none, binary**
- **Mattes: 0 to 1, n-ary**

Fragment: Color + Coverage



α = A
= Coverage
= Area
= Opacity
= 1 - Transparency

Color c of pixel is an area-weighted average of C

$$c = \alpha C$$

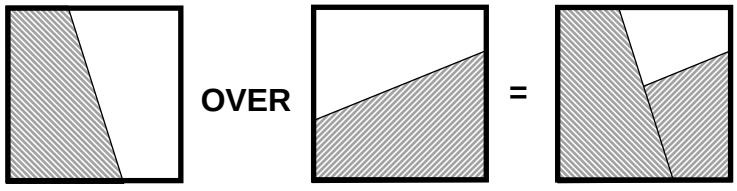
Image Composition

OVER Operator

$\alpha_F C_F$ $\alpha_B C_B$

$A_F = \alpha_F$

$A_B = (1-\alpha_F)\,\alpha_B$

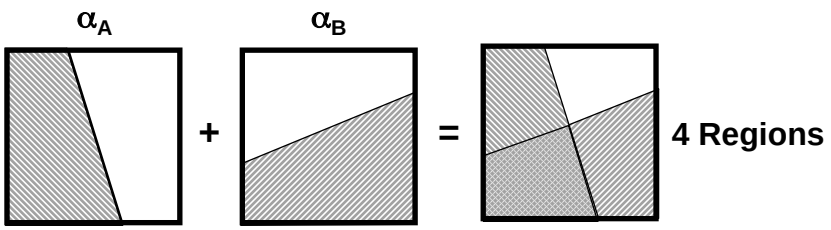


Foreground Background Composite

Composite color: $c = A_F C_F + A_B C_B = (\alpha_F C_F) + (1-\alpha_F)(\alpha_B C_B)$

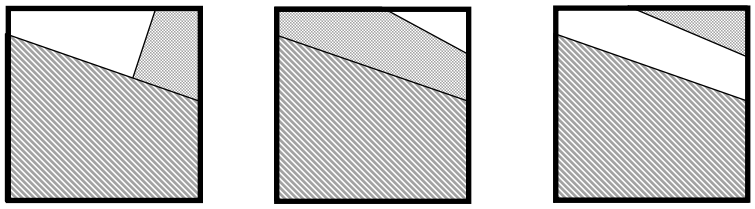
Composite alpha: $\alpha = A_F + A_B = \alpha_F + (1-\alpha_F)\,\alpha_B$

Region Coverage



Region	Fraction
$A \cap B$	$\alpha_A \alpha_B$
$\sim A \cap B$	$(1- \alpha_A)\alpha_B$
$A \cap \sim B$	$\alpha_A (1- \alpha_A)$
$\sim A \cap \sim B$	$(1- \alpha_A) (1- \alpha_B)$

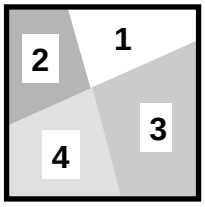
Assumptions



Uncorrelated **Correlated** **Anticorrelated**

Porter-Duff Compositing Algebra

How many ways can two pixels be combined?



Region 1: 1 possibility - 0

Region 2: 2 possibilities - A or 0

Region 3: 2 possibilities - B or 0

Region 4: 3 possibilities - A, B or 0

4 Regions

Operators: 12 total possibilities

Porter-Duff Compositing Algebra

Operation	F_A	F_B
Clear	0	0
A	1	0
B	0	1
A over B	1	$1-\alpha_A$
B over A	$1-\alpha_B$	1
A in B	α_B	0
B in A	0	α_A
A out B	$1-\alpha_B$	0
B out A	0	$1-\alpha_A$
A atop B	α_B	$1-\alpha_A$
B atop A	$1-\alpha_B$	α_A
A xor B	$1-\alpha_B$	$1-\alpha_A$

$$c = F_A C_A + F_B C_B$$

OpenGL `blendfunction`

Specify src and dst F's

0, 1,
As, Ad, 1-As, 1-Ad,
min(As,1-Ad),
Cs, Cd, 1-Cs, 1-Cd,

Premultiplied Alpha

Represent as c = αC = (αr,αg,αb,α)

- **One formula for compositing color and alpha**

  $c = c_F + (1-\alpha_F)\, c_B$

- **Less arithmetic**

  Associated: OVER (1 sub, 4 muls, 4adds)

  Unassociated: OVER (1 sub, 7 muls, 4 adds)

- **Closure**
  - **Recovering C from c would require divide by α**
- **Display c ; c over K = c + (1-α_C) K = c**

Interpolation

Interpolate c = (αr,αg,αb,α)

Two ways of interpolating an image:

Compositing over the background and then interpolating

Interpolating and then compositing over the background

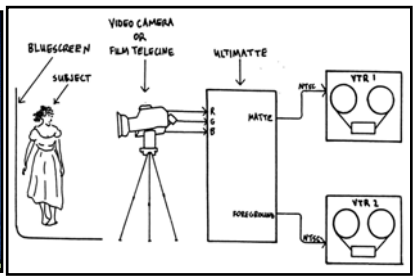
These should be the same!

Work it out (only works if interpolate c)

Similar reasoning applies to filtering, antialiasing, …

Matte Extraction

Blue Screen



“Pulling a Matte” - Matte Creation

From digitized images

- **Image processing**
  - **Set of colors marked transparent, region growing …**
  - **Demonstration: Photoshop Magic Wand**
- **Video or chroma-keying**
  - **Range of luminances marked transparent**
- **Blue-screen matting (Petro Vlahos)**
  - **Separate blue background from foreground image**

Blue/Green-Screen Matte Extraction

Given:

C - Observed color

C_B - Backing color

Compute:

$C_F = (\alpha_F R_F, \alpha_F G_F, \alpha_F B_F, \alpha_F)$

Matte equation: $C = C_F + (1-\alpha_F) C_B$

Three equations (R, G, B) in four unknowns

$$R = R_F + (1-\alpha_F) R_B$$

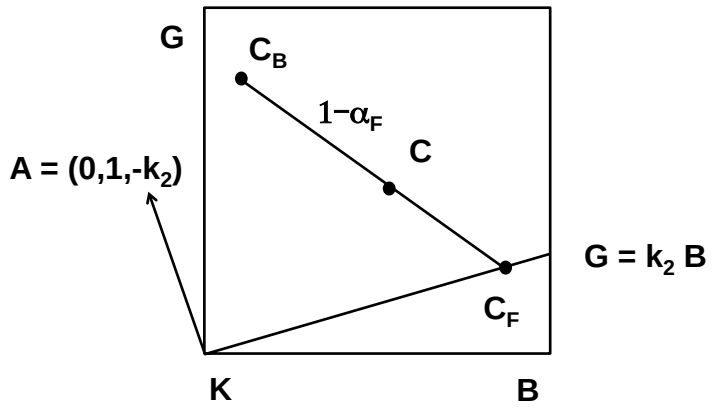
$$G = G_F + (1-\alpha_F) G_B$$

$$B = B_F + (1-\alpha_F) B_B$$

Petros Vlahos Algorithm

$C = C_F + (1-\alpha_F)\, C_B \rightarrow C_F = C - (1-\alpha_F)\, C_B$

$A \bullet C_F = A \bullet C - (1-\alpha_F)\, A \bullet C_B = 0$



Things to Remember

Classic techniques: masks, mattes, optical printing

Definition of the alpha channel as opacity/coverage

Premultiplied alpha

Porter-Duff image compositing algebra

Vlahos matte extraction algorithm