Lecture 8 - Compositing

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Notes – not for display

Outline - Compositing

- What is compositing?
- Why? (really defer till next week)
- What is digital compositing?
- How does it work?
- (briefly) where do mattes come from?

Compositing

- How do we combine pictures seemlessly?
- Weatherman in front of weather map?
- Flying saucer/monster in 1950s movie?
- CG element in a live action movie?
- Multiple live action elements?

How would you do it by hand?

- Cut out picture and paste it
- Picture has an irregular shape
  - Not the same as the original image
- Want to keep images all the same size
  - Film: keep it all the same size
  - Digital – hard to have non-rectangles

Mattes

- Make the images the same size, but have transparent regions
- Optical Printing (old movie production)
  - Expose the film multiple times
  - Have an image that is solid where the image should not go
  - Mask or "matte"

Digital Mattes

- An image the same size as the "regular" image
- For each pixel, store whether or not you want that pixel
- When assemble the images – pick the "top" image when matte has a value

Matte as Opacity

- Value 0 = transparent
- Value 100% (255?) = solid
- Can have semi-transparent (50% opacity)

Matte as filling pixels

- Little square model
- Opacity says how full each pixel is
  - 100% - totally full, nothing gets through
  - 0% - totally empty, everything gets through
  - 50% - half full – on average, half the stuff gets through
- Can't see the details of which 50% (since its just a pixel, and has a single value)
- Get accurate edges (halfway = half full)

Alpha channel

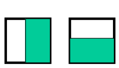
- Store opacity as a 4th "Color"
- Each pixel has RGB, A
- A=100% (255?) then solid

Compositing

- Assume 1 image "over" the other
- Image A=(r,g,b,a) and B=(r,g,b,a)
- Done per pixel (assume samples in the same place)
- What is the resulting color
  - C (r,g,b,a) = A(r,g,b,a) OVER B(r,g,b,a)
- There are other operators too

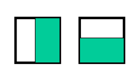
How over works

- Use the little square model for intuition
- Suppose half full for the moment
- Can't know which half – assume statistically uncorrelated.
- We'll draw pictures so that it works out.



The 4 possibilities:

- Alpha says probability a location is "covered"
  - Aa means in A
  - Ba means in B
- 4 possibilities
  - In neither (1-Aa)(1-Ba)
  - In A but not B Aa (1-Ba)
  - In B but not A Ba (1-Aa)
  - In both Aa Ba



1 = neither	2= A only
3 = B only	4 = A and B

Compositing Operator

- Decide what should happen in each region
- Weight result by the area of each region
  - Areas = probabilities, percentage of the whole
- A Over B
  - Neither = nothing
  - A only = A
  - B only = B
  - A and B = A (since over)

A over B

- Neither = (1-Aa)(1-Ba) 0
- A Only = Aa (1-Ba) Acolor
- B Only = Ba (1-Aa) Bcolor
- A and B = Aa Ba Acolor
- Add them up…

  Aa (1-Ba) + Aa Ba Acolor +
  Ba (1-Aa) B color

  = Aa Acolor + (1-Aa) Ba Bcolor

What is the new alpha?

- When is there "something"
- Aa + Ba – Aa Ba (don't count the both case twice)
- Add up the areas of the regions that are filled
  - Aa (1-Ba) + Ba (1-Aa) + Aa Ba
  - Aa – Aa Ba + Ba – Aa Ba + Aa Ba
  - Aa + Ba – Aa Ba

Other operators

- Specify what happens in each "quadrant"
  - 1 = neither (always 0)
  - 2 = A only (choices 0 or A)
  - 3 = B only (choices 0 or B)
  - 4 = A and B (choices 0, A or B)
- For each of 2-4 pick a different result to get a different operation
- 12 possible operators

A held-inside B

Warning: in the original notes I called this "atop" which is a different operator

- Give color A only when it is inside of B
- 1 = 0 (no color if neither)
- 2 = 0 (no color if A not on B)
- 3 = 0 (no color if no A)
- 4 = A (A is on top of B)

  Ccolor = Aa Ba Acolor

  Ca = Aa Ba

A atop B

Warning: in the original notes I used "atop" to describe held-in

- Give color A when it is on top of B (and give B otherwise
- 1 = 0 (no color if neither)
- 2 = 0 (no color if A not on B)
- 3 = B (places where B with no A on top)
- 4 = A (A is on top of B)

  Ccolor = Aa Ba Acolor + (1-Aa) Ba Bcolor

  Ca = Aa Ba

Pre-Multiplied Alpha

- Notice that the color always appears multiplied by alpha
- Can make all this much easier by pre-multiplying (storing Aa Acolor, not Acolor)

- Transparent pixel has no color
  - Conceptually clean
- Popular thing to do
  - Our image library does it (beware)
- Can't get colors back (alpha=0)

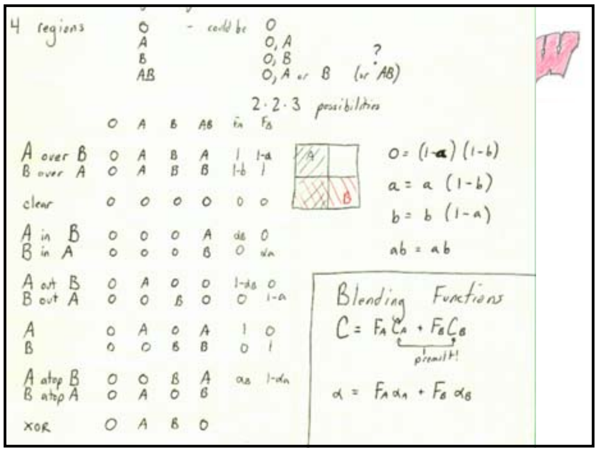
Blending functions

- Premultiplied gives easy common form

  Ccolor = F Acolor + G Bcolor

  Ca = Fa Aa+ Fb Ba

- Fa and Fb determined based on operation
  - Over   Fa = 1, Fb = (1-Aa)
  - Atop   Fa = Ba, Fb = 0



Where does alpha come from?

- Paint it as a separate channel

- Various matting algorithms
  - Chromamatte (equal to a color)
  - Lummamatte (bright/dark pixels)
  - Difference matte (pixels same in 2 image=back)
- Tricky to get partial opacities
  - Is it part red/part blue (screen) or purple?
  - Important: otherwise get fringe effects

Blue Screen / Green Screen

- Naïve version:
  - Assume objects generally have blue in proportion to other colors
  - Grey flying saucers in 1960s movies
  - Alpha = 1 – (B-uG) (where .5 < u < 1.5)
    - Clamp (gives a threshold – must be more blue than green)
  - Alpha = 1 – u1(min(Bf,Bk) + u2 G))

Really hard!

- Background is never really pure color
  - Try to get lighting constant
- Edge pixels, hair, etc. are partially background
- Shadows, spill (blue background reflects onto objects), transparent objects, …

- Modern algorithms use fancy computer vision on neighborhoods of pixels

- Expensive fancy software in effects industry!

Next week…

- I'm at a conference (show stuff later in semester)
- Monday / Wednesday – Li Zhang
  - Talk about warping and morphing (more resampling). Plus vision applications.
  - Part of project. Also, TAs to give project hints
- Fiday – Perry
  - Special Effects!
  - He has had 2 companies – won an Academy Award and an Emmy award!