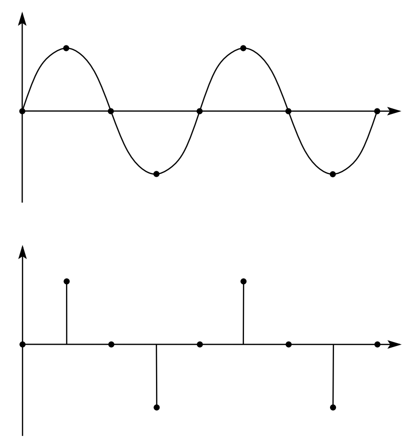
Compositing

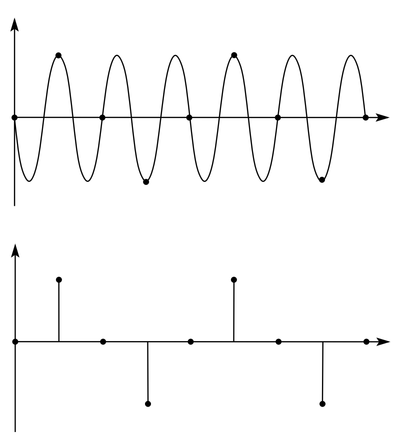
Aliasing

- Real-world signals are continuous. When we sample them digitally, we pick off values at some set of times.
- How well do these samples approximate the signal?



Aliasing

- When the signal's frequency is sufficiently high, the samples are inadequate and aliasing results:



- The high-frequency signal has been "aliased": it has taken on the identity of a lower-frequency signal.

Examples of Aliasing

- Rendering objects to the framebuffer
- Rapidly-varying continuous signal
- Temporal aliasing

Antialiasing

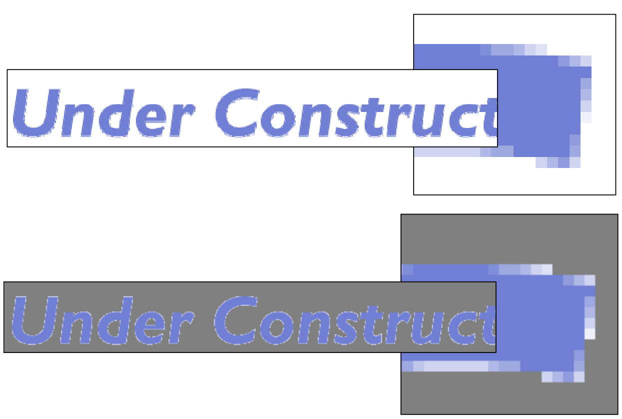
- How can we eliminate aliasing?

Compositing Motivation

- Sometimes, a single image needs to be constructed out of parts.
  - Mixing 3D graphics with film
  - adding a backdrop to a scene
  - Painting objects into a scene
- Sometimes, it's just better to do things in parts
  - Can save time in ray tracing
  - A small problem in one part can easily be fixed in the final image
- Need a method for building up an image from a set of components
  - Ideally, invent a general "algebra" of compositing

Image Matting

- To assemble images from parts, we associate a matte with each part
  - Record which pixels belong to the foreground, which to the background
  - Discard background pixels when assembling
- Problem: The matte must record more than a single bit of information per pixel



The Alpha Channel

- To make compositing work, we store an alpha value along with colour information for every pixel.
- α records how much a pixel is covered by the given colour
  - The set of alpha values for an image is called the alpha channel
  - Transparent when $\alpha = 0$
  - Opaque when $\alpha = 1$
- Relationship between α and RGB:
  - computed at same time
  - Need comparable resolution
  - Can manipulate in almost exactly the same way

The Meaning of Alpha

- How might we store the information for a pixel that's 50% covered by red?
- It turns out that we'll always want to multiply the colour components by α, so store (R,G,B,α) in premultiplied form:
- What do the premultiplied R, G and B values look like?
- What does (0,0,0,1) represent?
- What about (0,0,0,0)?

Compositing Assumptions

- The goal of compositing is to approximate the behaviour of overlaid images inside partially-covered pixels
  - We don't know how the pixel is covered, just how much
  - We need to make assumptions about the nature of this coverage
- We'll consider two cases:
  - Two semi-transparent objects; alpha channel records transparency
  - Two hard-edged opaque objects; alpha channel records coverage

Compositing Semi-Transparent Objects

- If we wish to composite two semi-transparent pixels over a background, things are a little easier.
- Suppose we wish to composite colours A and B with opacities α_A and α_B over a background G
- How much of G shows through A and B?
- How much of G is blocked by A and passed by B?
- How much of G is blocked by B and passed by A?
- How much of G is blocked by A and B?

Compositing Opaque Objects

- Assume that a pixel is partially covered by two objects, A and B.
  - We can use α_A and α_B to encode what fractions of the pixel are covered by A and B respectively
- How does A divide the pixel?
- How does B divide the pixel?
- How does A divide B?
- Compositing assumption: A and B are uncorrelated
  - This lets us make educated guesses about the colour of the composed pixel
  - Works well in practice

Pixel Pieces

- Given the compositing assumption, we can state the areas of different parts of the pixel:

$\overline{A}\cap\overline{B}$

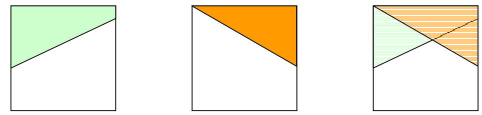
$\overline{A}\cap B$

$A\cap\overline{B}$

$A\cap B$

- Why do these areas depend on lack of correlation?

Compositing Possibilities



- The contributions of A and B to the pixel divide the pixel area into four regions. When compositing, we have to choose what will be visible in each region.

Name	Description	Possibilities
0	$\overline{A}\cap\overline{B}$	*0*
A	$A\cap\overline{B}$	*0, A*
B	$\overline{A}\cap B$	*0, B*
AB	$A\cap B$	*0, A, B*

- According to this enumeration, how many binary compositing operators are there?

12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12

The 12 Compositing Operators

- We can define a compositing operator by giving a 4-tuple listing what to keep in the regions 0, A, B and AB.

(0,0,0,0)

(0,A,0,A)

(0,0,B,B)

(0,A,B,A)

(0,A,B,B)

(0,0,0,A)

(0,0,0,B)

(0,A,0,0)

(0,0,B,0)

(0,0,B,A)

(0,A,0,B)

(0,A,B,0)

12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12 12

Computing the Colour

- Let's say we want to show a fraction F_A of A and a fraction F_B of B in the composite.
- What should the alpha value of the composite be?

- What should the colour component be in each channel?

The "plus" operator

- All the operators are all-or-nothing in region AB. Sometimes we want to show a blend of A and B in AB, for example when dissolving from one image to another.
- We define A plus B using the tuple (0,A,B,AB) where AB represents a blend of A and B.

Computing F_A and F_B

- All that remains is to compute F_A and F_B.
  - Depends on and determines the compositing operator
  - Can be derived by inspection of the compositing diagrams
- Examples

Operation	F_A	F_B
clear		
A		
B		
A over B		
A in B		
A plus B		

- Note correspondence with `glBlendFunc`

Unary Operators

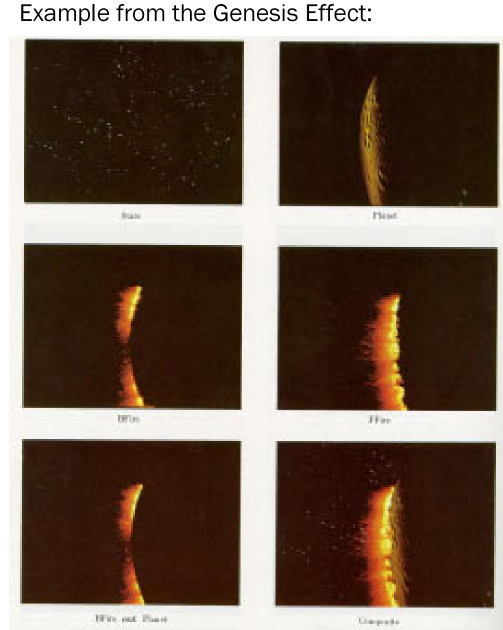
- There are also some useful unary operators

darken(R,G,B,α,ϕ) =

dissolve(R,G,B,α,δ) =

Example

- Example from the Genesis Effect:



(*FFire* **plus** (*BFire* **out** *Planet*) **over** **darken**(*Planet, 0.8*) **over** *Stars*

Summary

- Sources of aliasing and techniques for antialiasing
- Reasons for doing compositing
- The meaning of alpha and the alpha channel
- Definition of compositing operators
- Definition and implications of the compositing assumption
- Computation of composited images
- Practical use of compositing