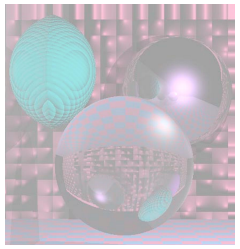
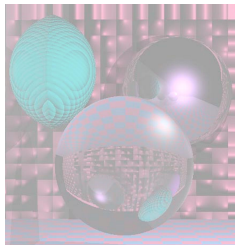


# CS 4300
# Computer Graphics

Prof. Harriet Fell

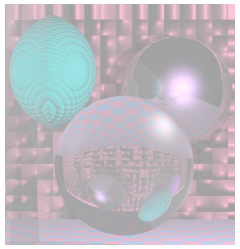
Fall 2012

Lecture 7 – September 19, 2012



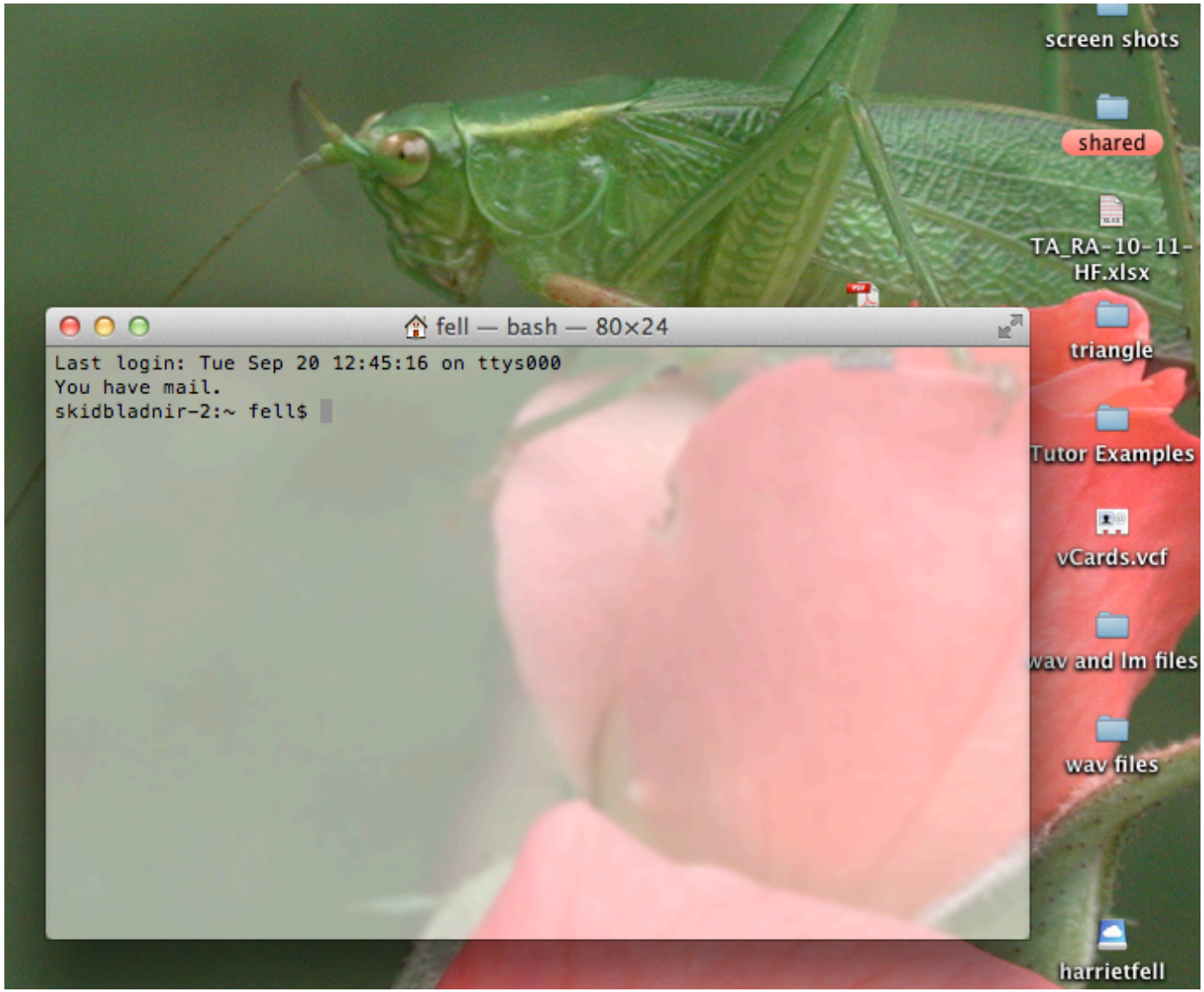
# Alpha Blending

- how to rasterize transparent objects?
- if object is totally transparent, then just do nothing
  - i.e. let the “background” show through unmodified
- for a partially transparent, or *translucent object,* one common approach is *alpha blending*
- idea: for each pixel, combine the underlying background color $c_b$ with the foreground color $c_f$, i.e. the color of the object itself at that pixel, to produce the overall pixel color $c$ according to the formula $c = \alpha c_f + (1 - \alpha) c_b$

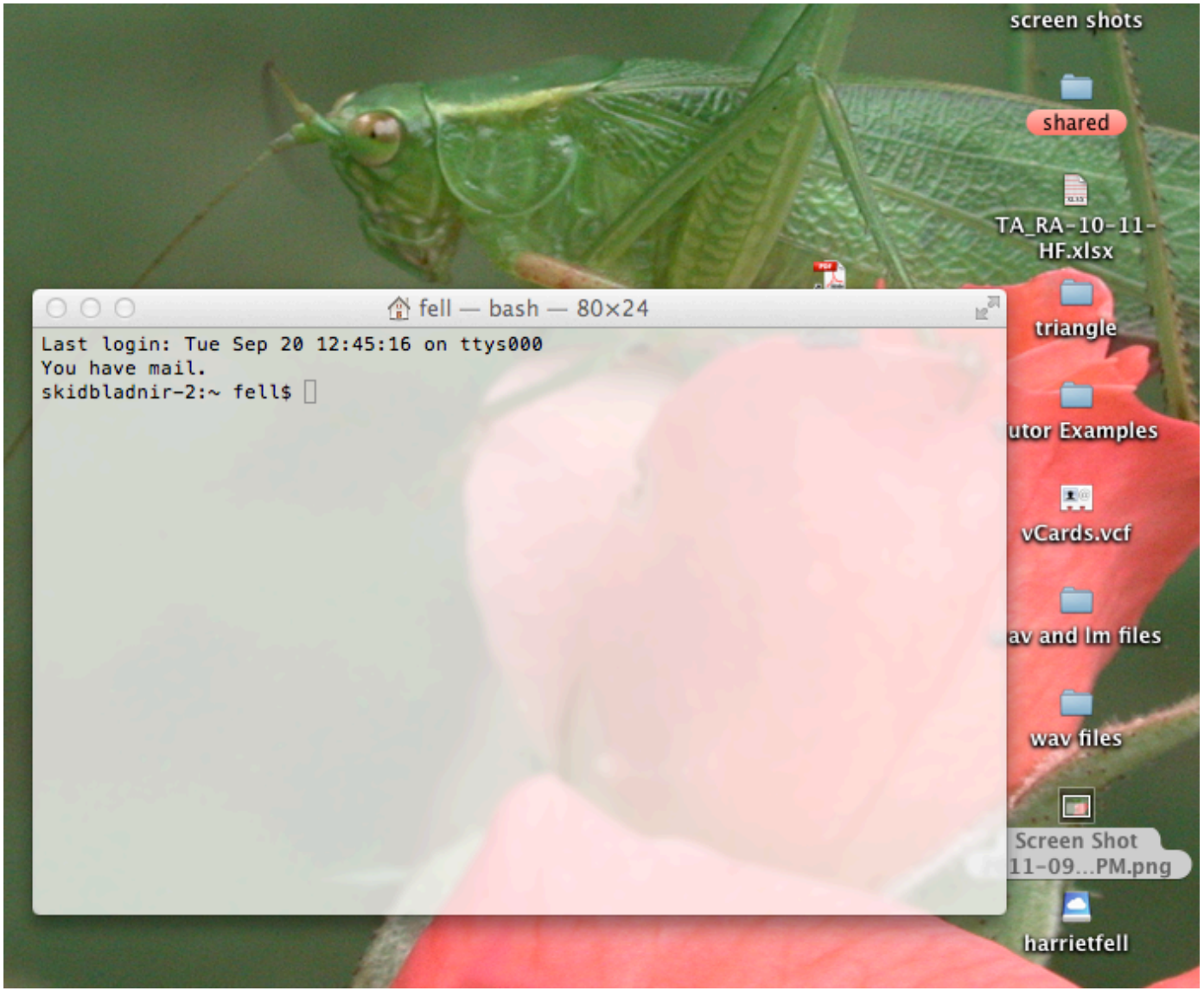


# α composting

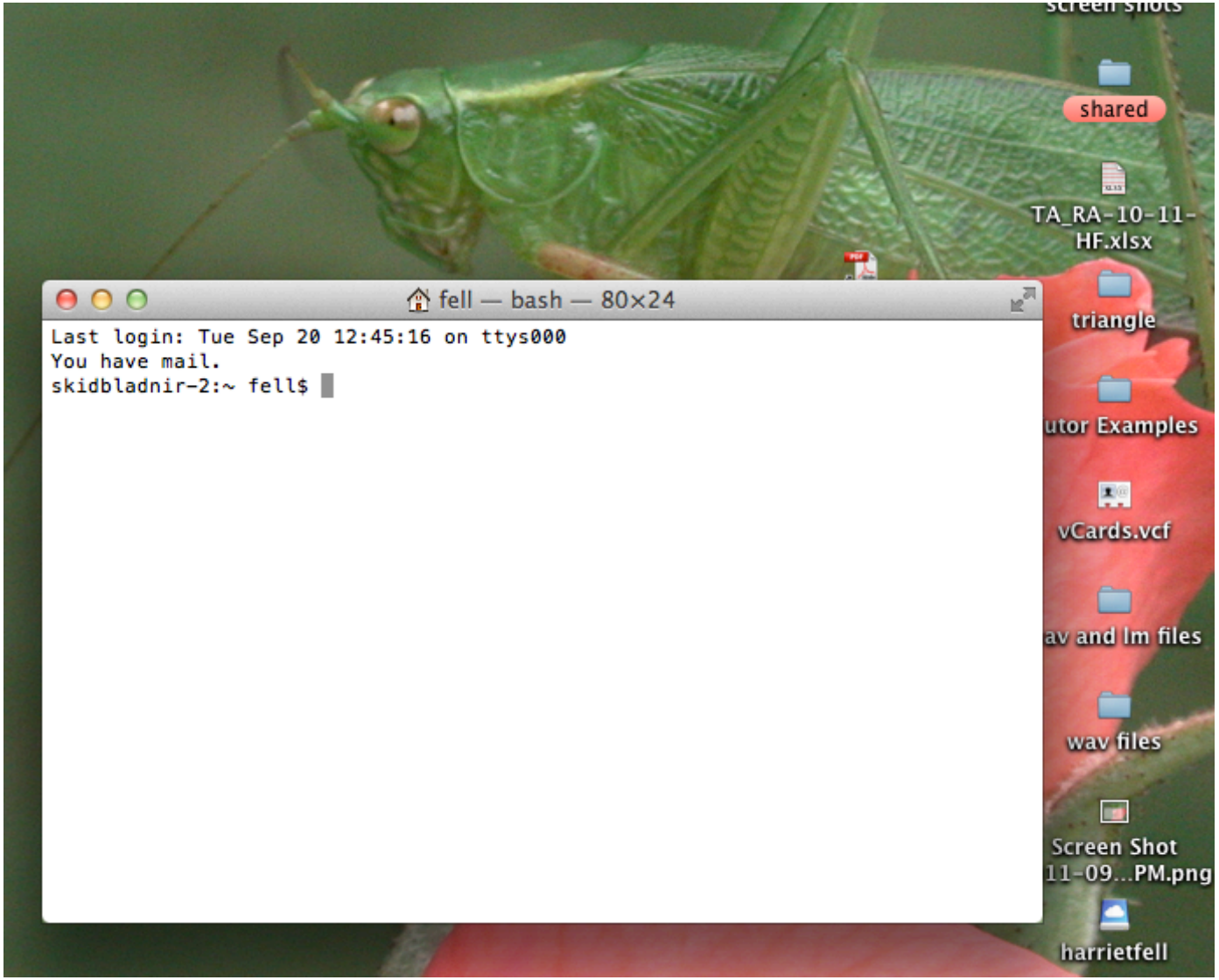
- the parameter *0 <= α <= 1* sets the amount of transparency
- *α = 1* shows only the object
- *α = 0* shows only the background
- *α = .5* shows half object and half background
- this is an example of *linear interpolation (lerping)*
- the process of combining a background image with a foreground image is called *compositing*
- can chain the process to composite many images on top of each other



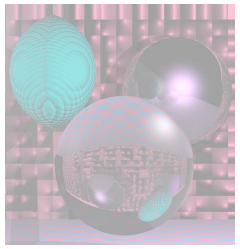

this image shows a terminal window composited with $\alpha = .5$ onto a desktop background




this image shows a terminal window composited with $\alpha = .75$ onto a desktop background

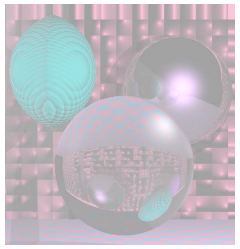



this image shows a terminal window composited with $\alpha = 1$ onto a desktop background



# RGBA

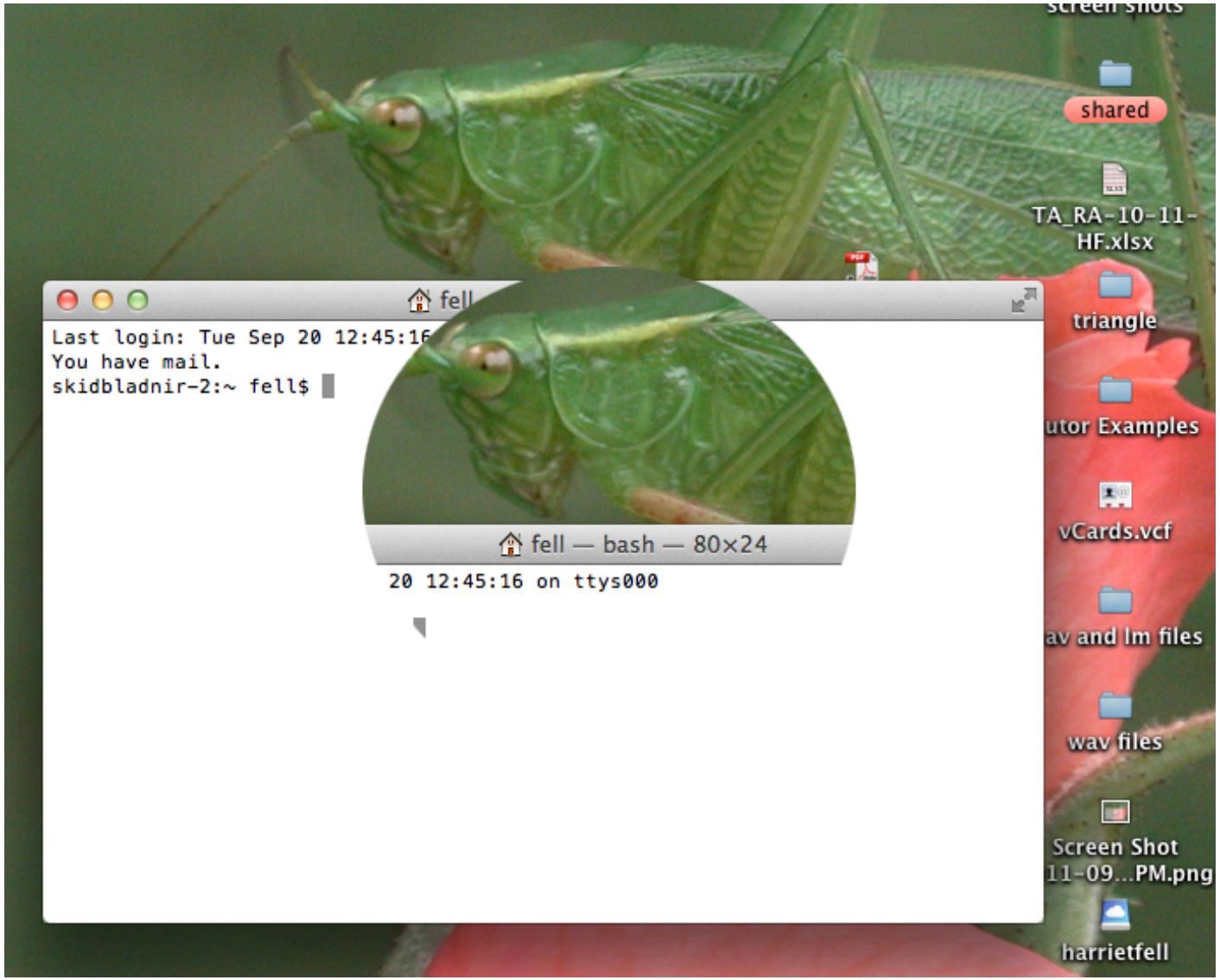
- sometimes a single $\alpha$ is specified for an entire object
- for a raster, $\alpha$ is commonly treated as a separate color channel, along with (typically) R, G, and B
- thus, an RGB image with an added alpha channel is sometimes referred to as an RGBA image
- this allows setting a different  value for each pixel in the raster
- often, a similar number of bits is allocated for the alpha channel as for the other color components
- conveniently, adding an 8 bit alpha channel to a 24 bit RGB image results in an image with 32 bits per pixel

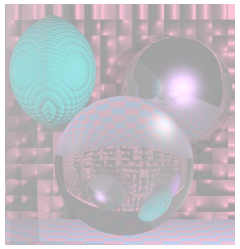


# α

- 8 bits is not enough to store an IEEE floating point single or double precision number, so instead alpha is represented as an integer  0 <= *α* <= 255 where the actual fractional alpha value is computed as *α/255*
- most modern microprocessors are especially fast at moving around 32 bit “words”
  - even if 8 bits are available, sometimes the alpha channel is used only as a binary image
  - i.e. the (floating point) alpha value for any given pixel is either 0.0 (show background only) or 1.0 (show foreground only)
- this produces a binary image *mask*
- one use is to allow non-rectangular windows

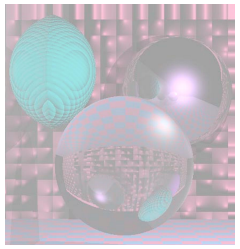
# Non-Rectangular Window





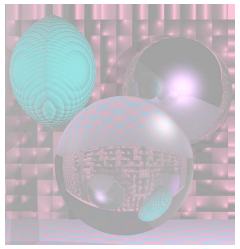
# Image Compression

- rasters take up a lot of memory!
- example: 640x480x3 BPP (Bytes Per Pixel): 921,600 bytes, or nearly 1MB
- example: 1600x1200x4 BPP: 7,680,000 bytes, or a bit over 7MB
- usually, when a raster has to actually be displayed on the screen, we do need to keep the whole thing in memory
- but for storing and transferring images, we can usually do better by compressing the data



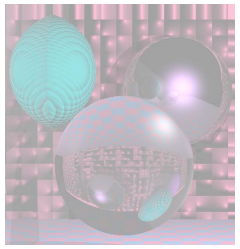
# PNG and JPG

- an image compression algorithm starts with the original raster, and produces a stream of bytes which describes the image, ideally so that the length of that stream of bytes is significantly smaller than the original raster
- an image decompression algorithm does the opposite
- today, two compression algorithms are very common in practice:
  - Portable Network Graphics (PNG) and the
  - Joint Photographic Experts Group method (JPEG)actually,
- these are not only compression and decompression algorithms, but also standards for the specific layout of the associated byte streams

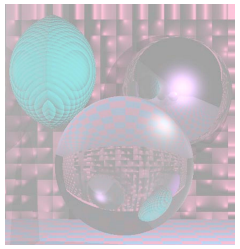


# which is better, PNG or JPEG?

- PNG supports both color, greyscale, and indexed images, and allows inclusion of an alpha channel
- JPEG supports color and greyscale images, but not indexed, and does not allow inclusion of an alpha channel
- but most importantly, PNG is lossless, while JPEG is lossy:



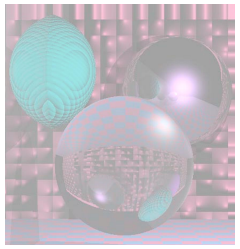
# JPG vs. PNG



# PNG

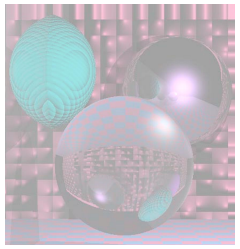
http://en.wikipedia.org/wiki/Portable_Network_Graphics

- PNG is a lossless compression technique: the raster that results from decompression is guaranteed to be exactly the same as the original
  - often a compression ratio of 5:1 to 10:1 is still achieved, because image data is typically redundant
  - e.g. there are often areas filled with a single color
  - this is particularly true for computer generated images, like line drawings, cartoon graphics, and user-interface graphics that do not depict real-world scenes
  - these are also the kinds of scenes for which JPEG compression is poorly suited, as we will see later



# PNG compression

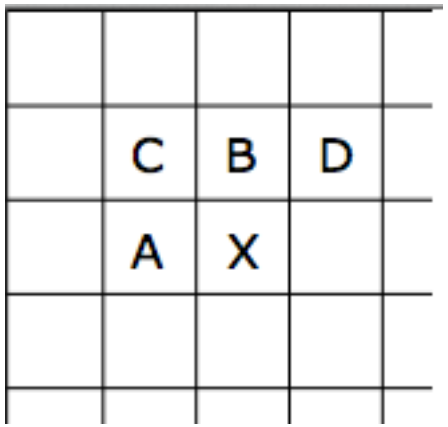
- the basic process of PNG compression takes two stages
  1. first, a pre-compression prediction filter is applied to the image
  2. then, a standard general purpose lossless compression algorithm called DEFLATE is applied to the raster, treated as a linear array of bytes

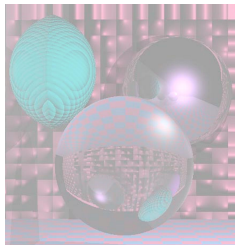


# DEFLATE

- DEFLATE is the same algorithm used in the common zlib compression library, which is what implements gzip, a variant of ZIP
- we will not cover DEFLATE, but we will look at the first step, the prediction filter
- one problem with DEFLATE is that by treating a raster as a linear sequence of bytes, correlations from one row to the next may be lost

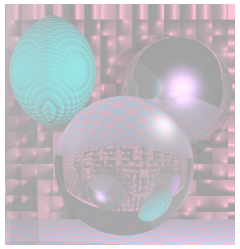
The PNG prediction filter essentially replaces the value of each color component of a pixel at X with a difference between the actual value in the original image and a value that would be predicted for that pixel based on the three pixels at A, B, and C.





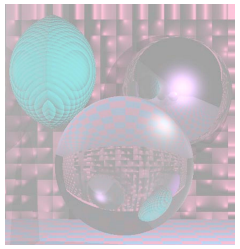
# Filters

| Type byte | Filter name | Predicted value |
|---|---|---|
| 0 | None | Zero (so that the raw byte value passes through unaltered) |
| 1 | Sub | Byte *A (to the left)* |
| 2 | Up | Byte *B (above)* |
| 3 | Average | Mean of bytes *A and B, rounded down* |
| 4 | Paeth | *A, B, or C, whichever is closest to* $p = A + B - C$ |



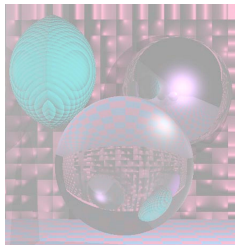
# Which Method?

- the compressor selects one of these to use for each line of the raster
- the whole line then uses the same method, but different lines may use different methods
- a notation is put in the compressed bytestream so that the decompressor can “undo” the filter

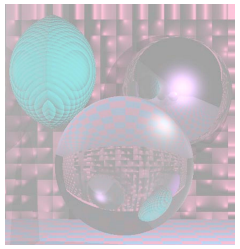


# JPEG

- JPEG is a lossy compression algorithm:
- the raster that results from decompression is not guaranteed to be exactly the same as the original
- this often allows significantly more compression than PNG
- some of the data is actually discarded
- the idea is to try to prioritize so that the least perceptually significant data is discarded first
- JPEG can achieve a compression ratio ranging from typically around 10:1 for high quality to 100:1 for low quality

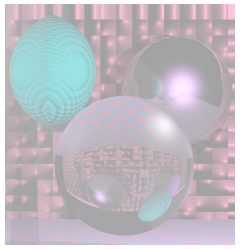


# Image constructed with increasing JPEG compression from left to right



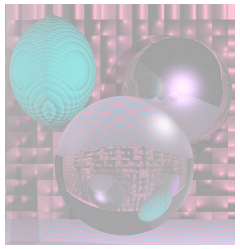
# When is JPEG good?

- JPEG compression is well-suited for scenes where colors change continuously, without sharp edges
- in particular, real-world scenes captured with cameras often compress well with JPEG
- computer-generated line drawings and other art will become blurred at sharp edges



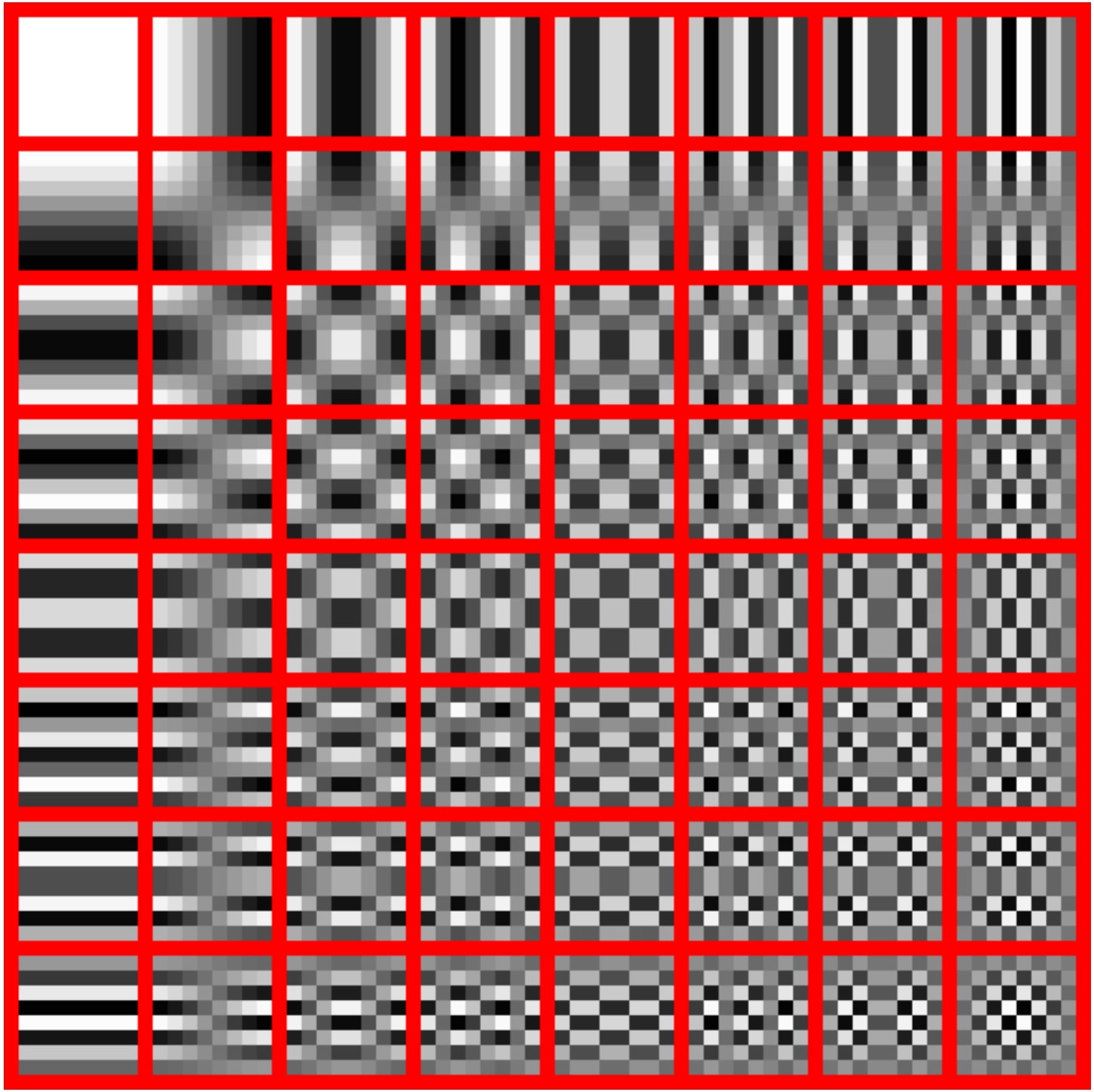
# JPEG compression

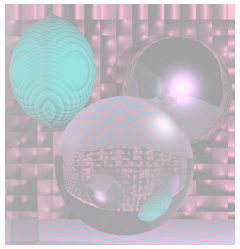
1. original RGB data is converted to a color space called YCbCr. We did not study this; but it is another space where the brightness or *luminance* (Y) is separated from the color information, in this case Cb and Cr.
2. because the eye is less sensitive to color details than it is to intensity, Cb and Cr are typically thrown out for half of the pixels
3. for each block of 8x8 pixels, a *discrete cosine transform* is applied
4. the DCT is lossless, but puts the data into a frequency domain form where we can more easily discard perceptually less significant information. In particular, rapid high frequency variations are less noticeable than slower changes. So some of the bits are discarded for the high frequency components. This is an instance of quantization.
5. the resulting bitstream is losslessly compressed, in this case with the version of Huffman encoding



# Discrete Cosine Transform

- so what is DCT? we will not cover the math
- the DCT algorithm decomposes a block of 8x8 pixel color component values (separate DCT are done for Y, Cb, and Cr) into a weighted sum of the following basis functions





- observe that the original 8x8 block of pixel color components was stored in e.g. 8x8x8 = 512 Bits
- if 8 bits are used to represent the relative weight of each of the 64 basis functions, then the DCT result will again be 512 bits
- this gives an intuition, the actual proof (and the way to compute the DCT) depends on math involving the *Fourier Transform*
- so DCT conversion is itself lossless, but it is the quantization step where some of the bits for the weights for higher-frequency basis functions are discarded