



IMGD 1001 - The Game Development Process: File Formats

by

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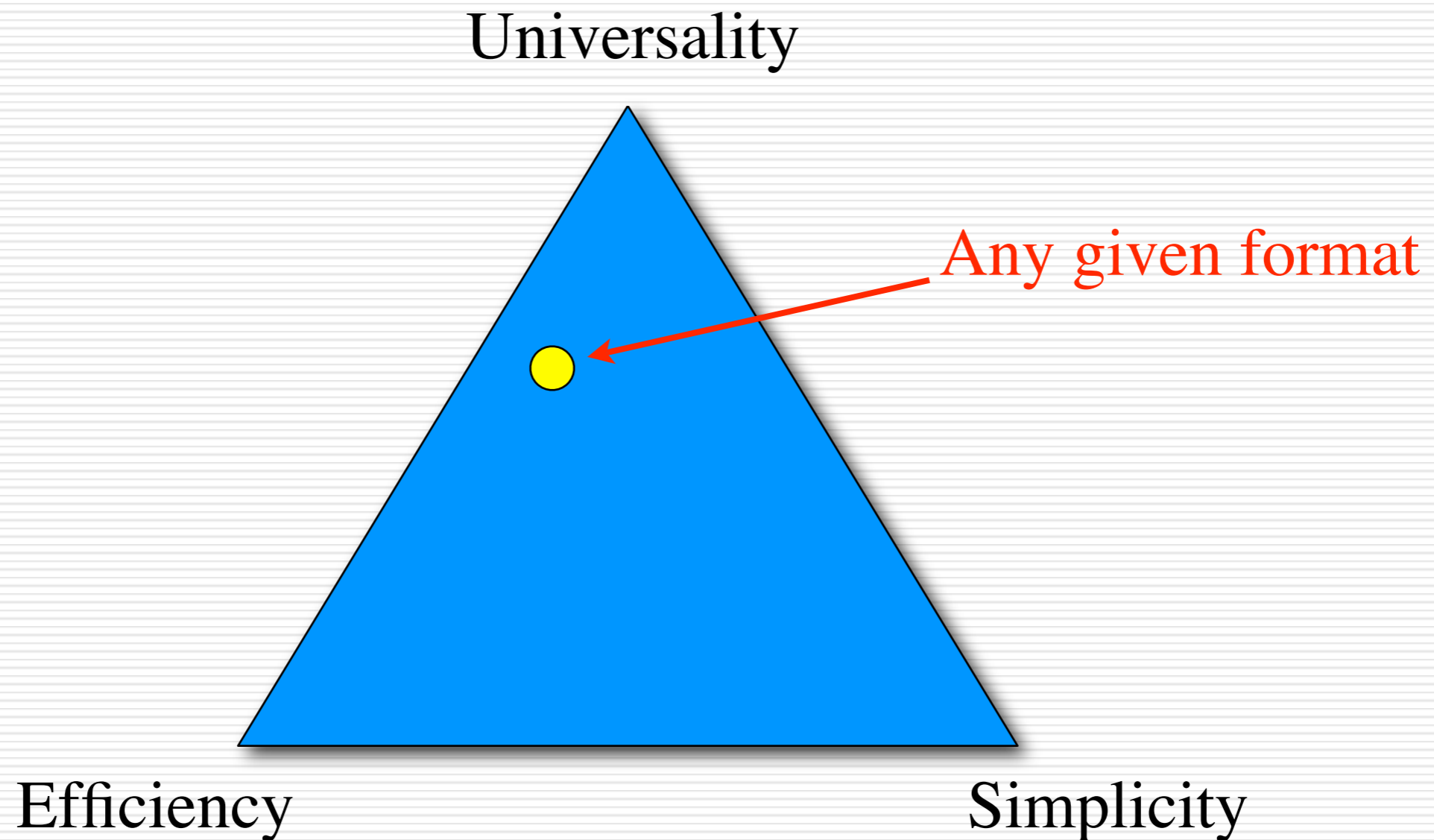
Kent Quirk (kent_quirk@cognitoy.com)

(with lots of input from Mark Claypool!)

Why we care

- Because different formats have different advantages
- No one format solves everything

Format's Last Theorem



Simplicity

- Easy to write
- Easy to read
 - ♦ They're not the same
- Text-based formats (XML) are easy
- Some data formats are easy
 - ♦ TGA
 - ♦ BMP
 - ♦ WAV

Universality

- Can the file format handle all the desired variants within the file type?
- Images have:
 - ♦ Grayscale vs color
 - ♦ Paletted
 - ♦ Resolution (number of pixels)
 - ♦ Color resolution (bits per pixel)
 - ♦ Compression techniques
- Sounds:
 - ♦ Bit rate, resolution, compression

Universality in 3D

- For 3D objects, we have:
 - ◆ Polygon mesh
 - ◆ Normal data
 - ◆ NURBS control points
 - ◆ Texture coordinates
 - ◆ Textures, Normal maps, bump maps
 - ◆ Lighting information
 - ◆ Shaders
 - ◆ Physics data
 - ◆ Animation bones, joints, constraints
 - ◆ ...

Universality in 3D

- There's SO MUCH
- Either:
 - ♦ Everyone has to read it all and ignore the parts they don't want
 - ♦ Or everyone has to write it all even if they don't manipulate it
- Basically impossible to create a universal file format
- So in games, we use exporters / plugins

Efficiency

- What do we mean?
 - ♦ Stored file size
 - As small as possible
 - ♦ Performance on save
 - ♦ Performance on load
- But there are tradeoffs
 - ♦ Speed vs size
 - ♦ Accuracy vs size
 - ♦ Compression vs decompression

Compression (1 of 2)

- Information Theory: Claude Shannon
 - ♦ Entropy is a measure of the irreducible quantity of information
 - ♦ Tied to quantum mechanics and heat
 - Creating / destroying information requires energy
 - ♦ When you've eliminated all the redundancy, you have a measure of the information in a system
 - ♦ Can't compress it more than that without losing some.

Compression (2 of 2)

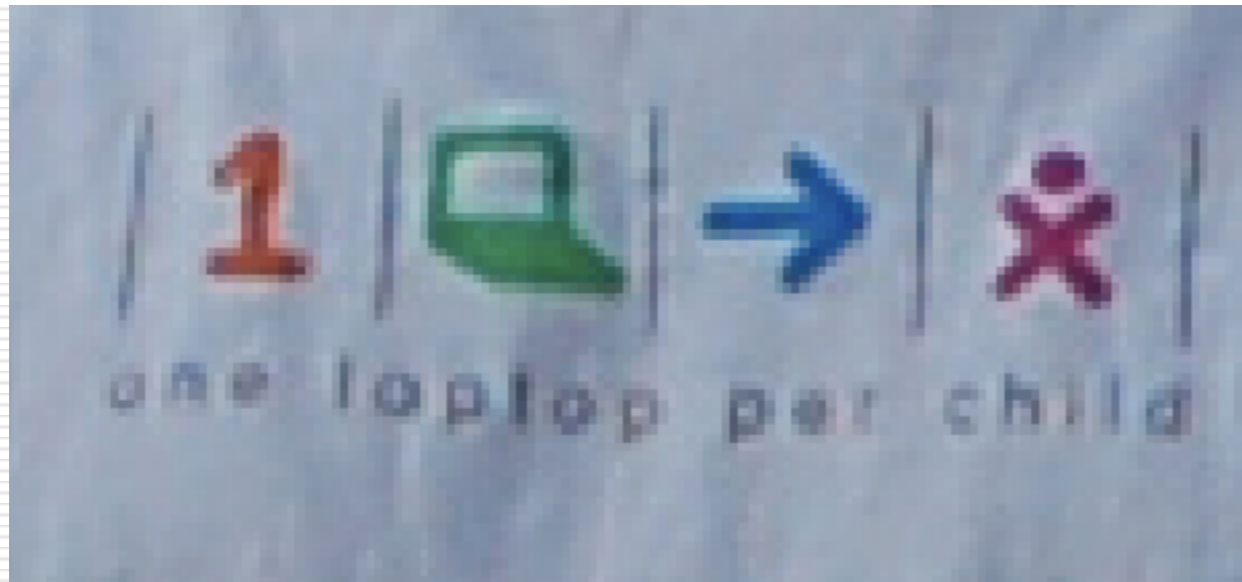
- Sometimes some information loss is OK
- The details don't always matter
- "Lossy compression":
 - ✦ Compression where information is deliberately destroyed, with the intent of losing the information that is perceptually unimportant
 - ✦ Ex: the details of every hair on someone's arm in a portrait
- This is what JPEG (images) and MPEG (sound) do

JPEG compression example

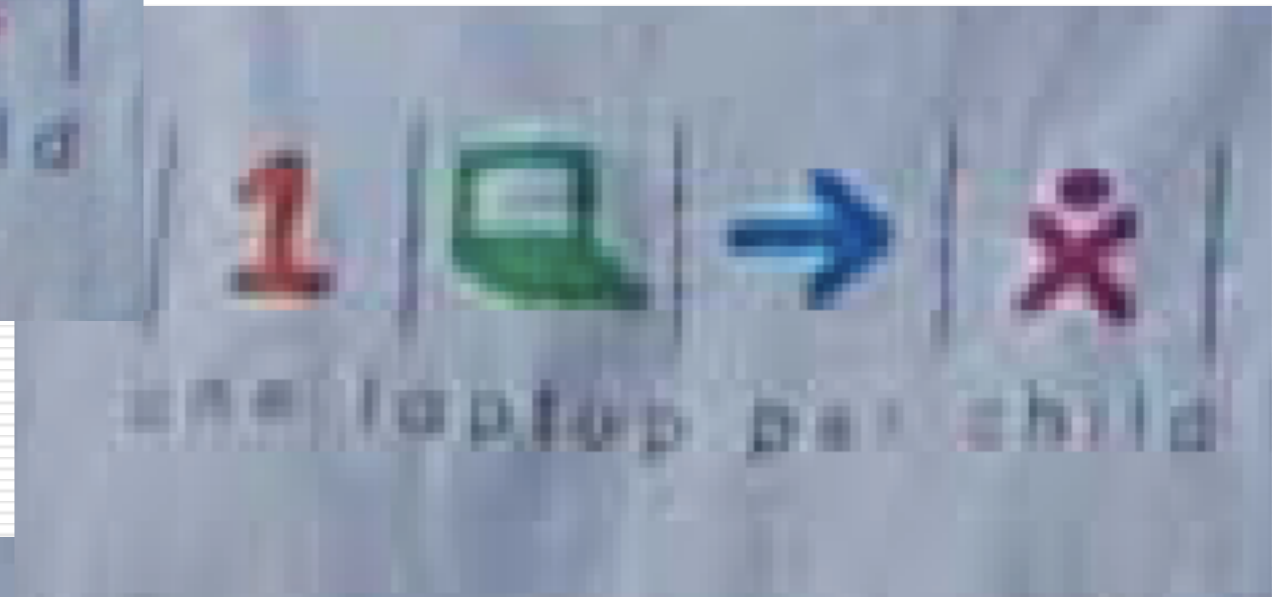
- Original image



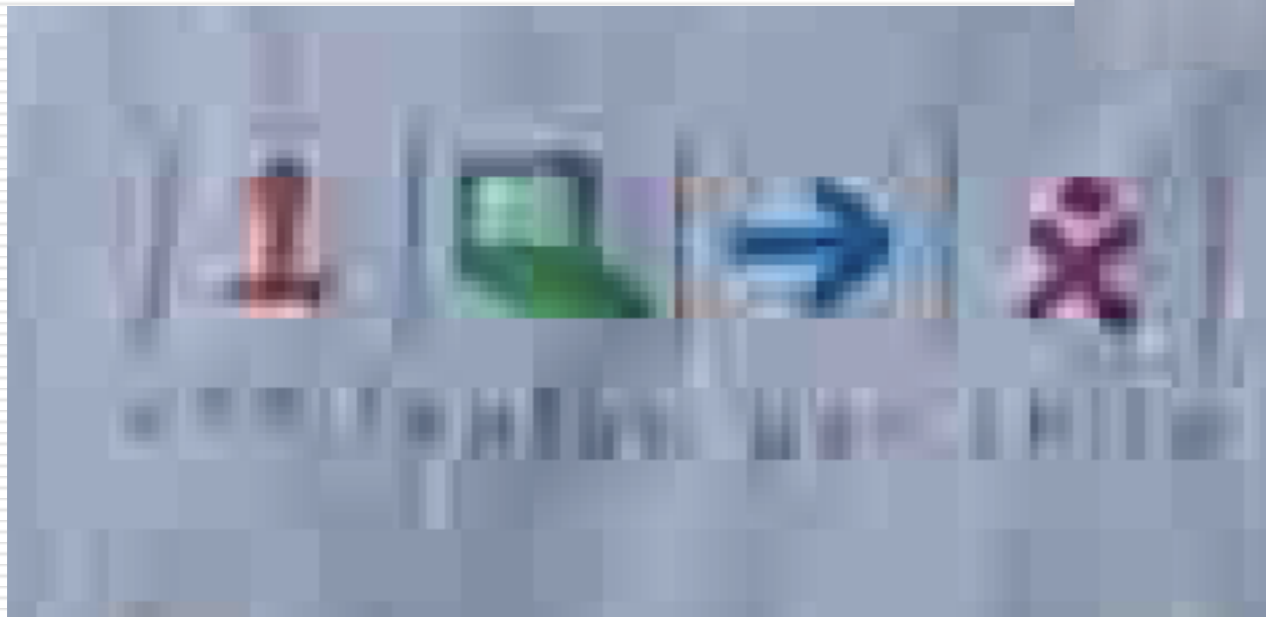
JPG compression (Photoshop, zoomed in)



Level 10



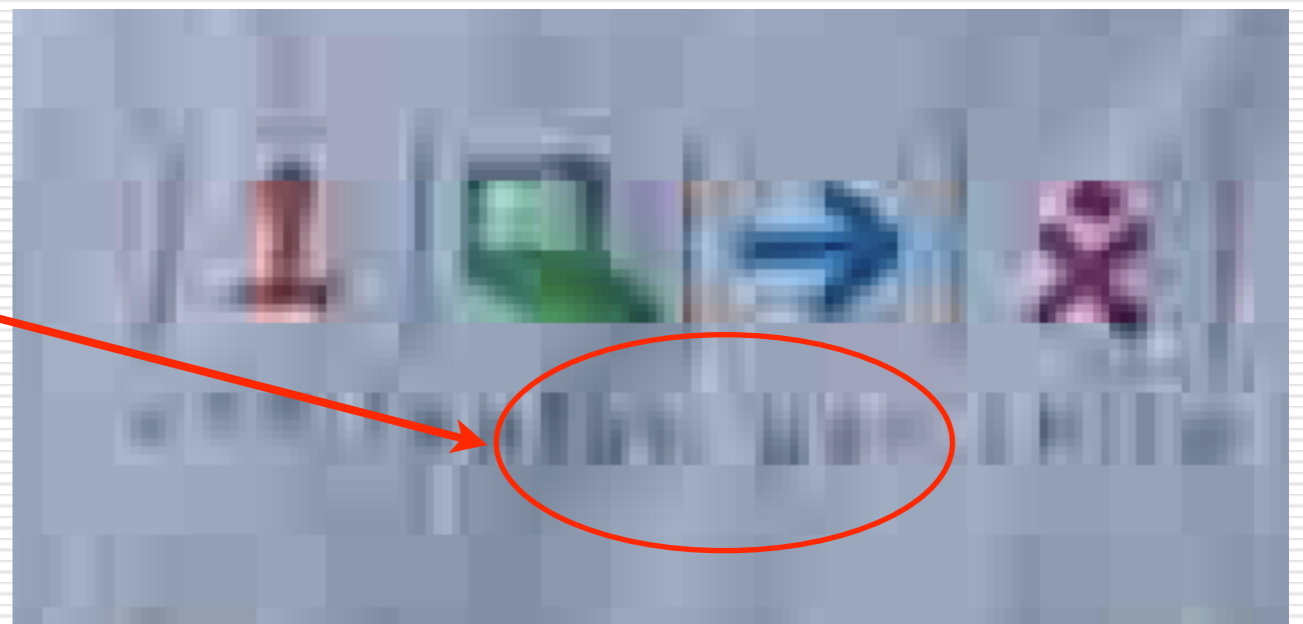
Level 5



Level 0

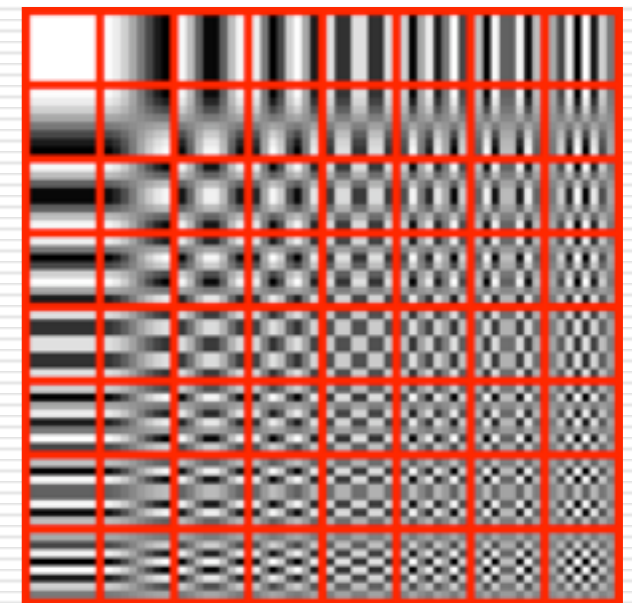
How JPEG works (1 of 3)

- Convert the image to YCbCr (like HDTV)
 - ♦ Y = brightness
 - ♦ Cb, Cr are “chrominance” (color)
 - ♦ Humans more sensitive to Y, so emphasize it (use more bits) and use fewer bits for Cb, Cr
- Chop the image up into squares of 8x8 pixels
 - ♦ You can see them in the level 0 image:



How JPEG works (2 of 3)

- For each block of pixels in each channel
 - ◆ Convert to frequency domain
 - Remember Fourier analysis from calculus?
 - JPEG uses Discrete Cosine Transform, but it's similar
 - Convert to a linear combination of the following images
- Now discard some portion
 - ◆ Starting with the lower right



How JPEG works (3 of 3)

- Went from this:

$$\begin{bmatrix} 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\ 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\ 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\ 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\ 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\ 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\ 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \end{bmatrix}$$

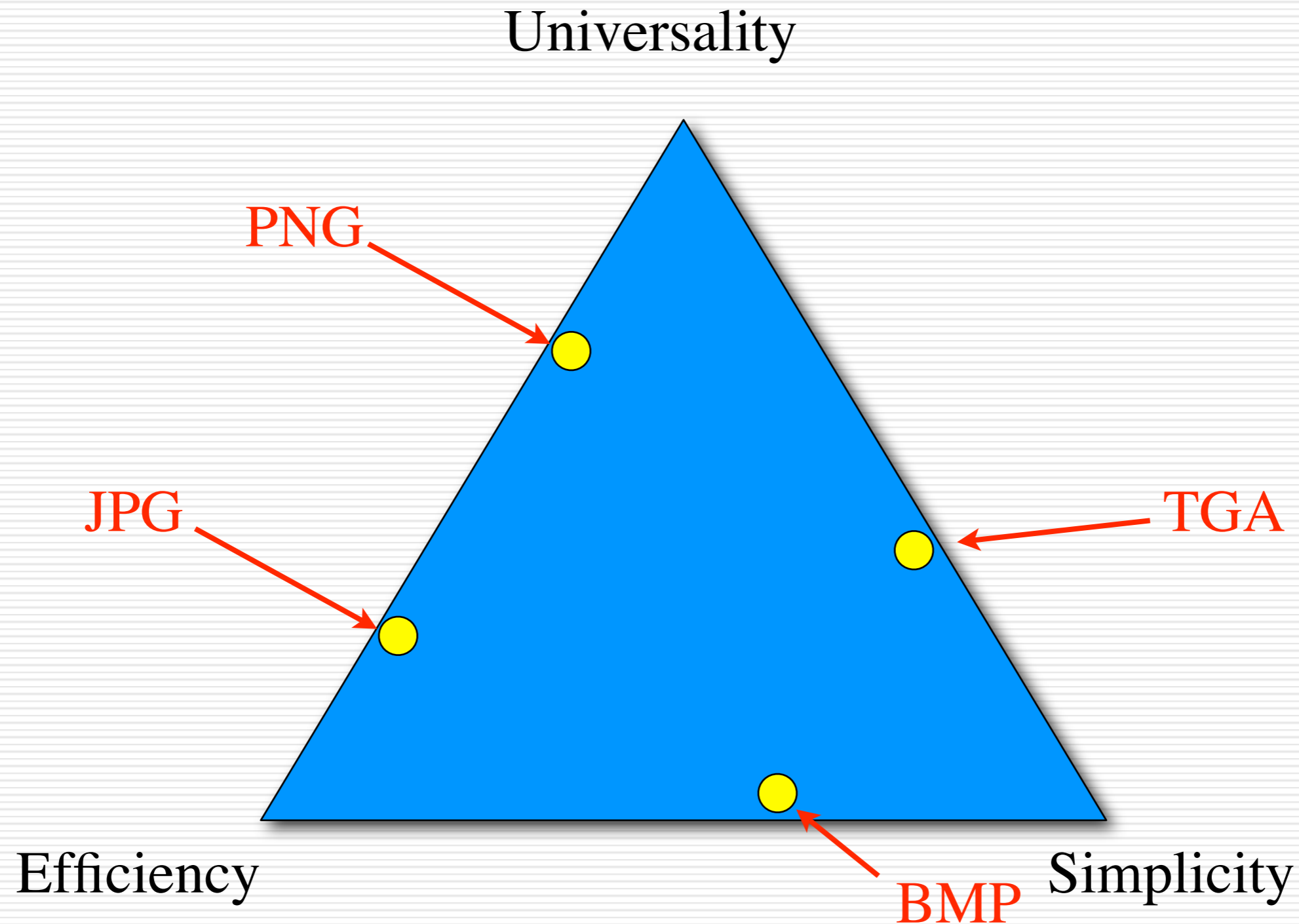
- To this:

$$\begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Easy to get rid of
all those zeros!



A few image formats



Choosing formats

- Decide what you really need
- Look for libraries that solve your problem
 - ◆ But sometimes the libraries themselves can be the problem!
 - Fonts are often encumbered with licensing issues
 - ◆ Check the licensing!
 - Some libraries are so big that you lose the space you would have saved
- If you have to write it yourself, favor simplicity