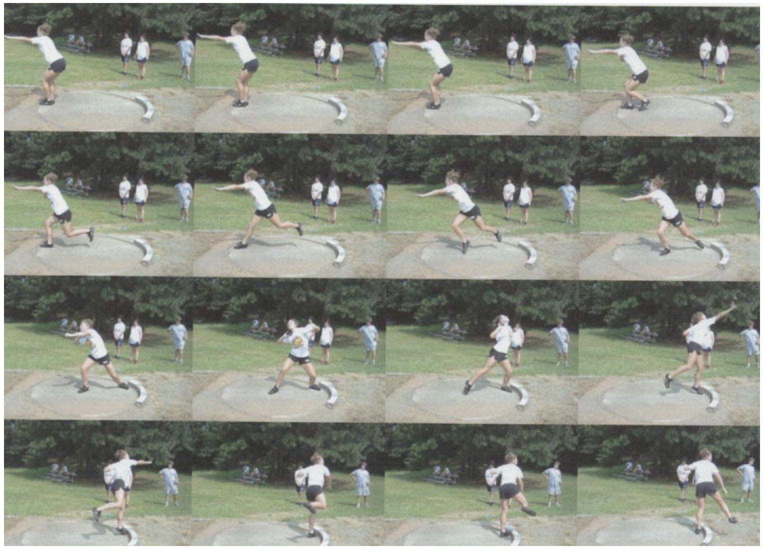
Image and Colors

More dimensions for the 2D images:

- Color
- Time (Motion)
- Stereo
- Spherical (3D)
- Fractal



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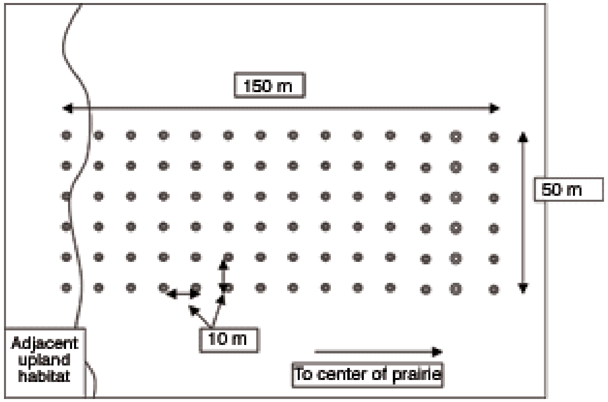
Updated: April 2009

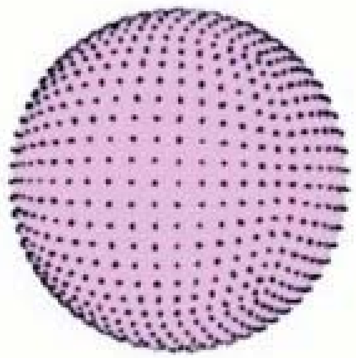
Digital Images

- A regular TV image is <u>already segmented</u> into a set of discrete lines
- To turn to a true digital image we need to:
  - <u>Take samples</u> along each scan line (regular intervals).
  - Convert the samples to into binary numbers to be stored in a "computer" system.



Sampling

- <u>Discarding</u> an enormous amount of information (spatial and amplitude)
- So, *lossless* implies only to <u>preservation</u> of the sampled data...



- Important parameters:
  - Precision (# of bits per sample)
  - Interval (# of samples per time unit)
  - Aperture (# of averaged dots per each sample)

SubSampling

- A useful tool for space (cost) saving.
- For example, subsampling by factor of 2:

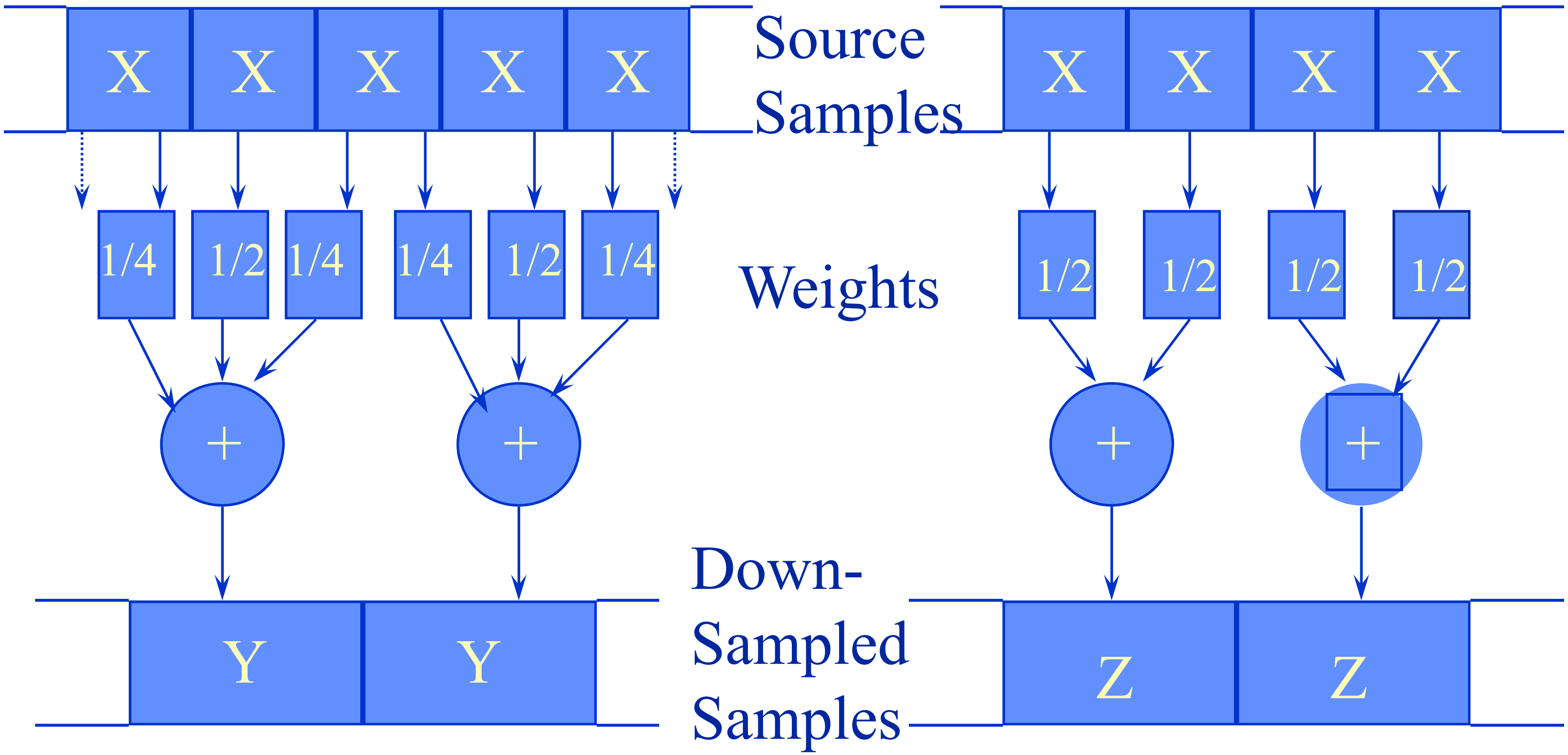
every other pixel is discarded

- net results equivalent to:
  - Sampling with too small aperture
  - Sampling with too large sampling interval

meaning: severe <u>aliasing</u> effects

Sub-Sampling (Cont'd)

- Sub-sampling with a LPF:



Pixels and Pels

- Pixel: Picture element (display industry)

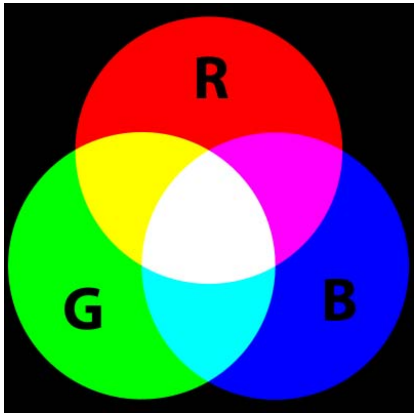
  Pel: Print element (printing industry)
- Grayscale image: Continuous-tone, usually 8/10/12 bits/pixel (displays, laser printers...)
- Binary image: bi-level representation,

  1 bit/pixel, high-resolution and halftoning process to create effect of continuous tone.

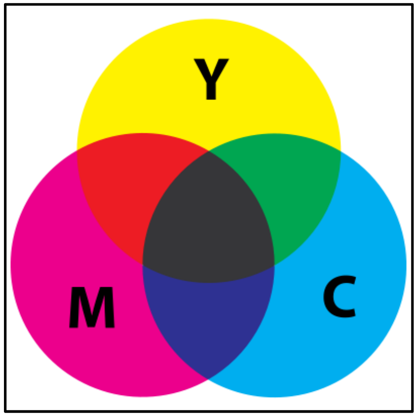
(fax, newspapers...)

Color Images

- Additive color: model involves light emitted directly from a source or illuminant of some sort: light from source of different colors added together (e.g.: CRT)



- Subtractive color: model explains the mixing of paints, dyes, inks: Passive systems, light from a given source is selectively absorbed at different wavelengths that will perceived as the desired color (e.g.. Printing industry)



Color Spaces

- Trichomatric theory tells us that, ideally, 3 components should be sufficient to present a color image
- However, output devices are limited, so not all colors can be obtained
- Red-Green-Blue (RGB) is used for displays
- Cyan-Magenta-Yellow-Black (CMYK) for printing

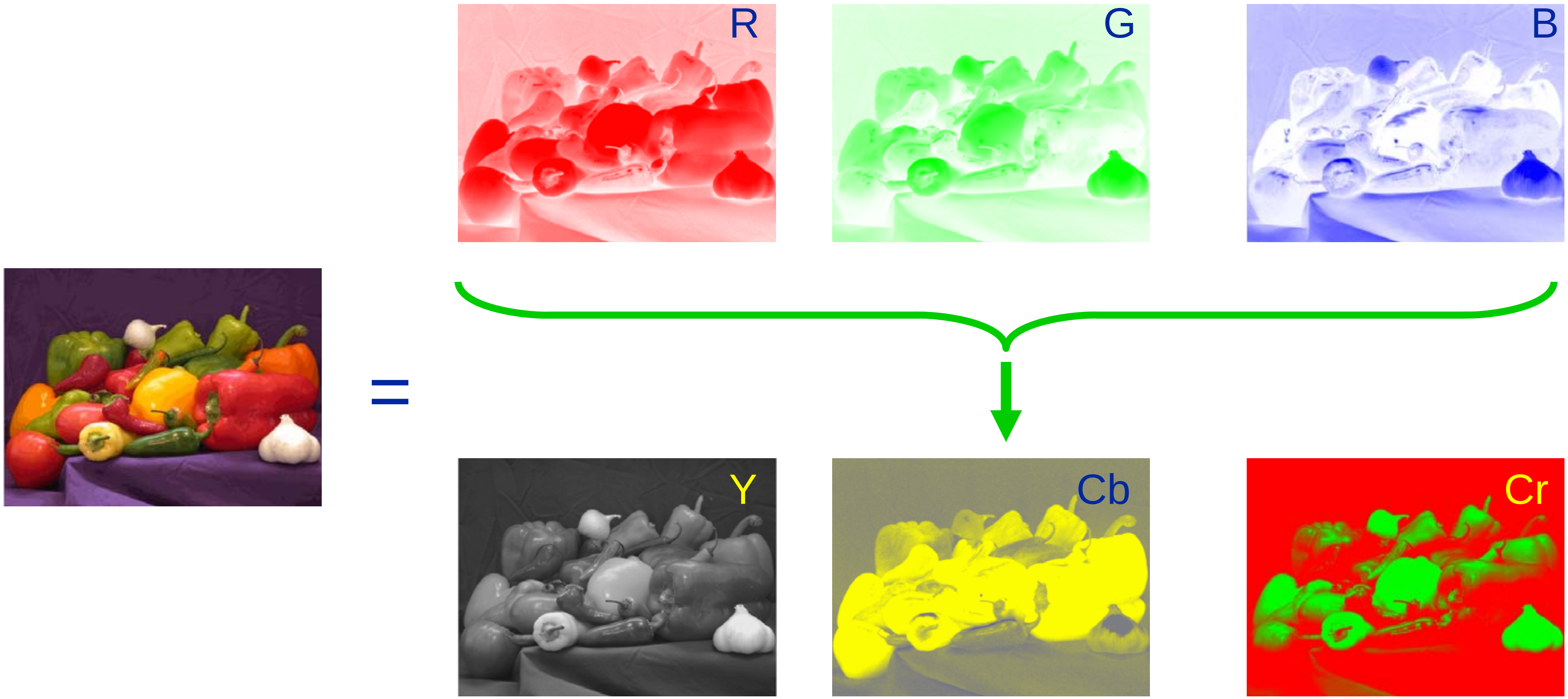
Color Spaces (Cont'd)

- **Brightness**: intensity of light , related to *Luminance* of the source
- **Hue**: color of the source, related to dominant wavelength of the light
- **Saturation**: describes how pure is the color, related to the narrowness of the spectral distribution of the source

Linear Color Transformations

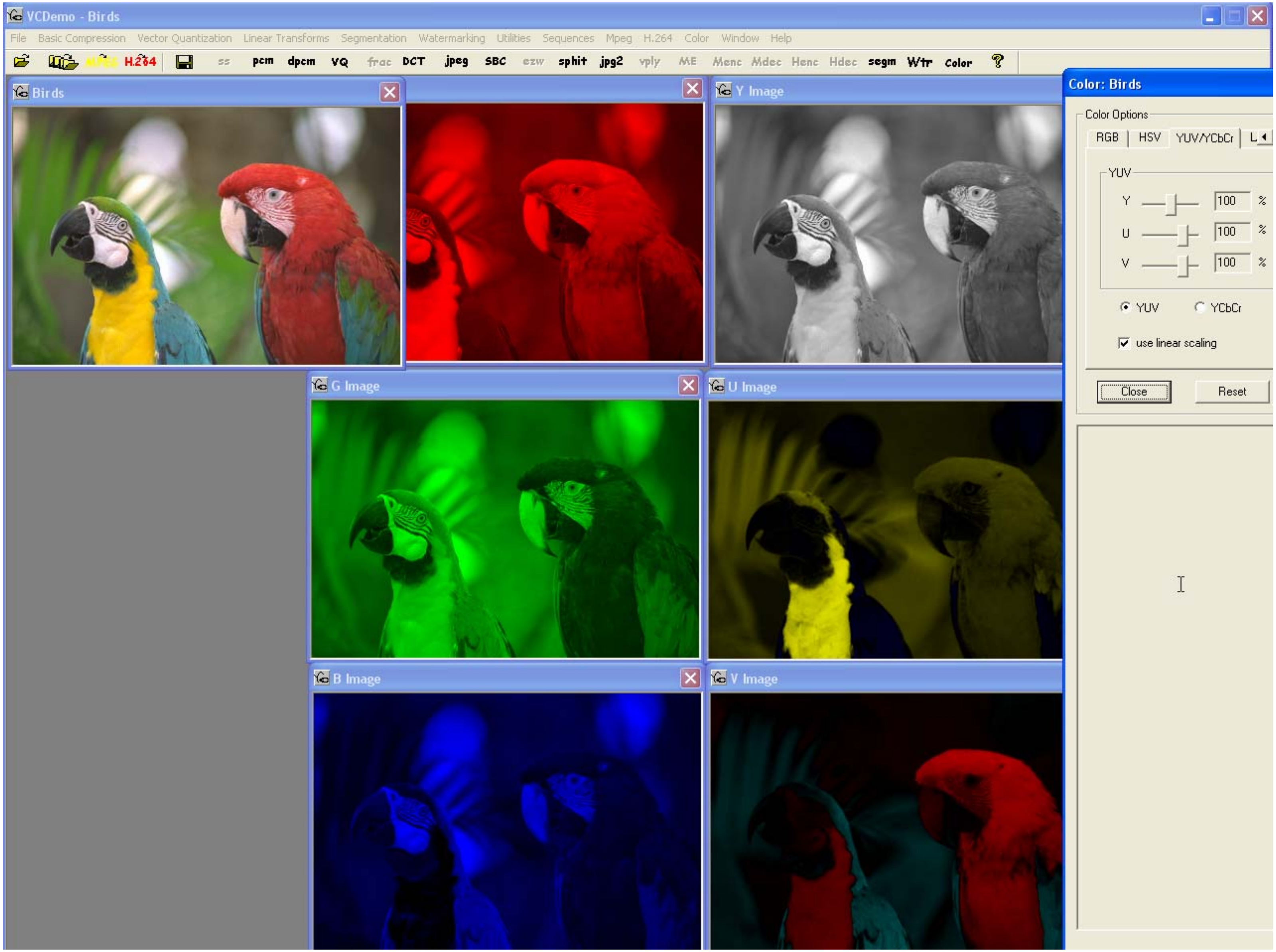
- YUV representation:
  - 1 Luminance and 2 Chrominace components
  - scale from 0 to 1 for each
  - Gray level results when R,G and B are equal
    - $Y \approx 0.3R + 0.6G + 0.1B$
    - $U = R - Y$
    - $V = B - Y$
- HSI, YIQ, YUV, YCbCr ,LAB ...

JPEG Color Space Conversion



Color Spaces: in VCDemo

Color Spaces: VCDemo



Luminance Sensitivity

- Sensitivity of the eye to luminance changes is greatest for objects at dimensions of about 0.2cm, if viewed at a distance of 1m.
- At the same distance the eye has trouble resolving objects smaller than ~0.01cm
- Meaning: for 1m distance, a 40cm object should have 4,000 pixels for an ideal digital image.

Twice the performance of high-end commercial displays !

More Features (luminance)

- Vertical and horizontal patterns have similar response, but much higher than diagonals.
- Under ideal conditions (including linear color space), the eye can distinguish between 1,000 gray levels. For a regular display this goes down to a 100 gray levels, so 8 bit is usually enough.

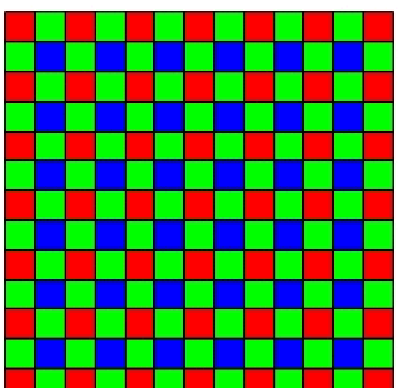
Chrominance Sampling

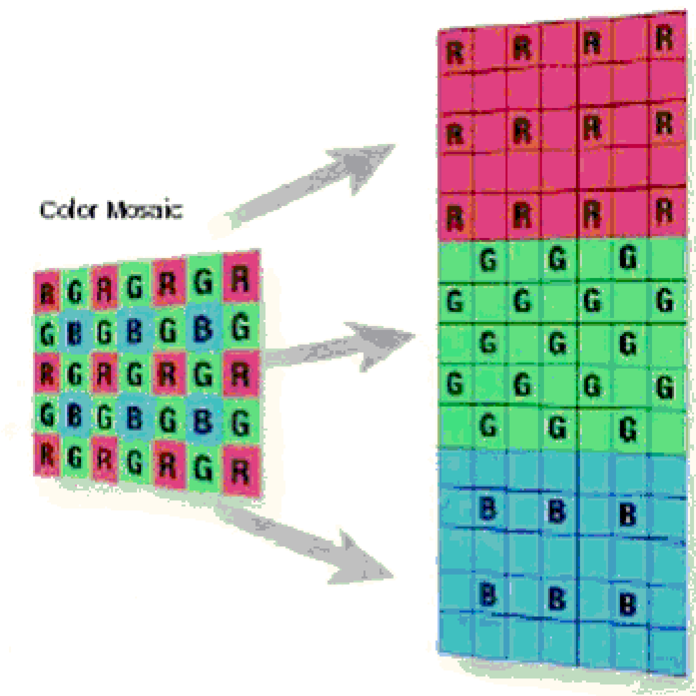
- Much reduced sensitivity, should and is used in compression algorithms,

  by taking a lower resolution

  data for the chrominance

  components.





Color and False Colors (Lighthouse)

Lighthouse (detail)

Color and False Colors (Window)

Window (detail)

Mother of All Aliasing ☺