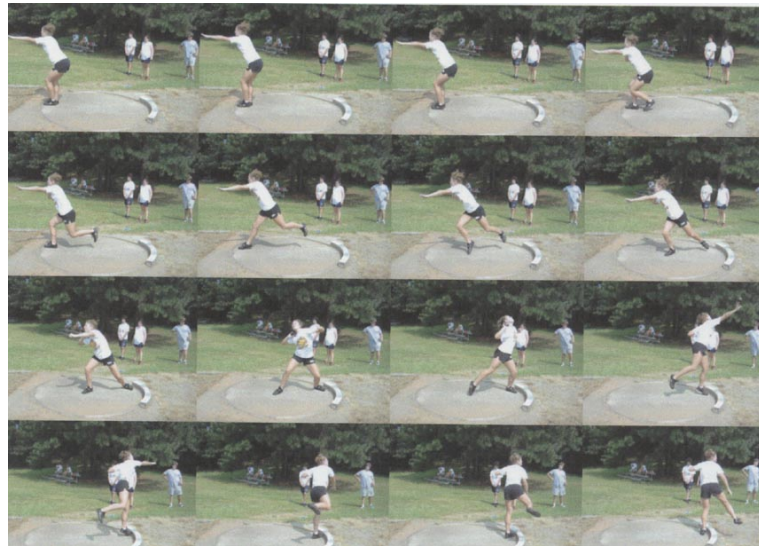


# Image and Colors

More dimensions for the 2D images:

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

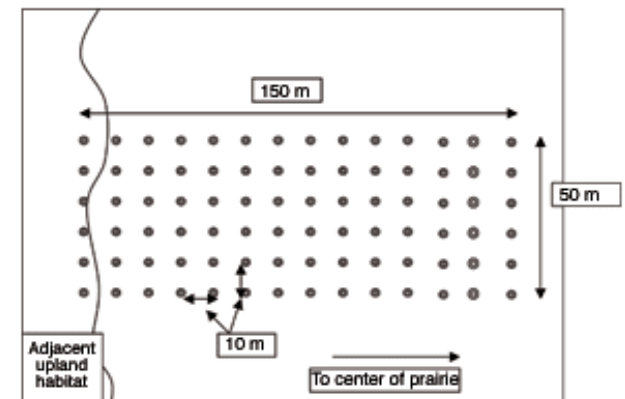


Nimrod Peleg

Updated: April 2009

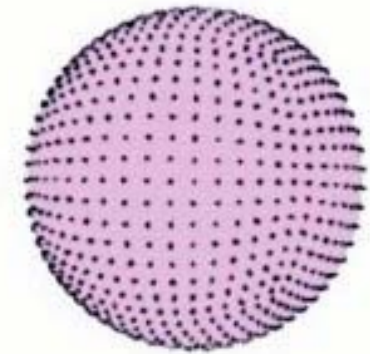
# Digital Images

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



# Sampling

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



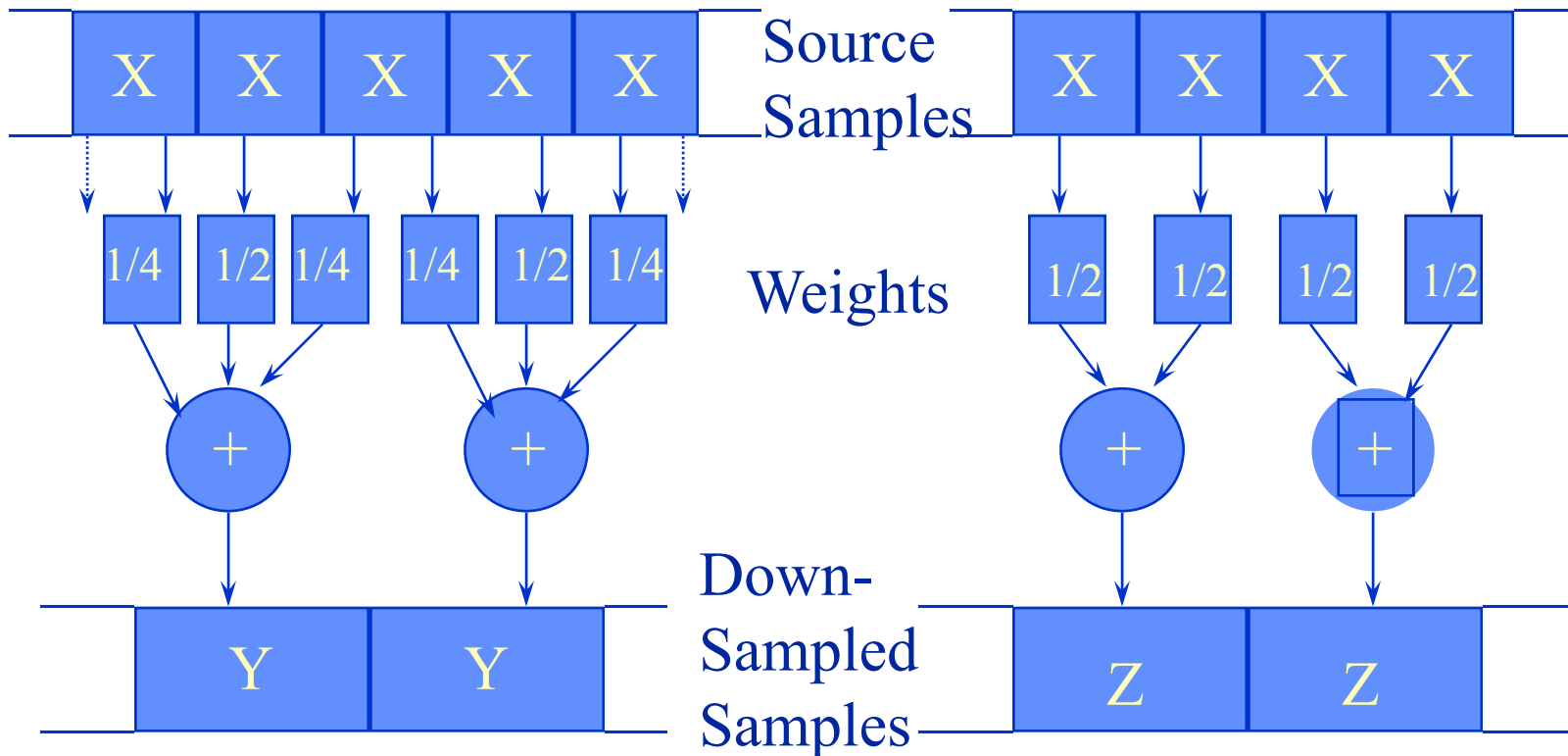
- Important parameters:
  - **Precision** (# of bits per sample)
  - **Interval** (# of samples per time unit)
  - **Aperture** (# of averaged dots per each sample)

# 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 aliasing effects

# Sub-Sampling (Cont'd)

- Sub-sampling with a LPF:







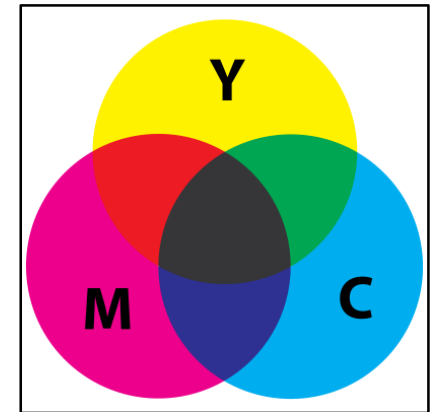
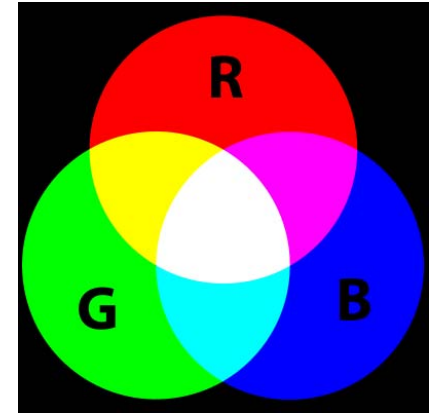
# Pixels and Pels

- 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 be perceived as the desired color (e.g.. Printing industry)



# Color Spaces

- Trichromatic 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

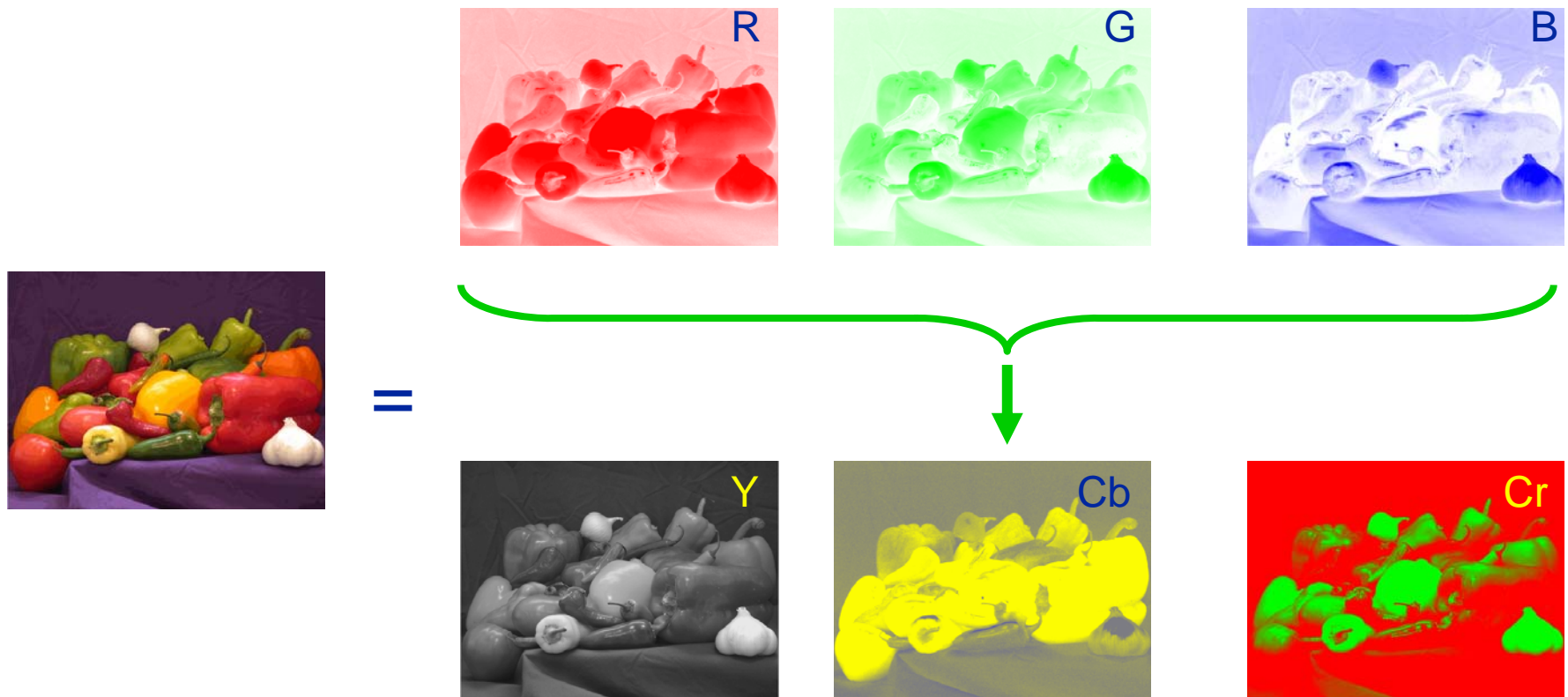
# Color Spaces (Cont'd)

- **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 Chrominance 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

The screenshot displays the VCDemo software interface, which is used for demonstrating color space conversions. The main window, titled "VCDemo - Birds", features a menu bar with options like "File", "Basic Compression", "Vector Quantization", "Linear Transforms", "Segmentation", "Watermarking", "Utilities", "Sequences", "Mpeg", "H.264", "Color", "Window", and "Help". Below the menu bar is a toolbar with various icons and labels for different color spaces and formats, including "ss", "pcm", "dpcm", "VQ", "frac", "DCT", "jpeg", "SBC", "eZW", "sphit", "jpg2", "vply", "ME", "Menc", "Mdec", "Henc", "Hdec", "segm", "Wtr", and "Color".

The interface is divided into several panes:

- Birds:** The original color image of two parrots.
- Y Image:** The luminance (Y) component of the image, shown in grayscale.
- G Image:** The green (G) component of the image, shown in green.
- U Image:** The blue (U) component of the image, shown in blue.
- B Image:** The blue (B) component of the image, shown in blue.
- V Image:** The red (V) component of the image, shown in red.

On the right side, there is a "Color: Birds" dialog box with "Color Options". It includes tabs for "RGB", "HSV", and "YUV/YCbCr". The "YUV" tab is selected, showing sliders for Y, U, and V, each set to 100%. There are also radio buttons for "YUV" (selected) and "YCbCr", and a checked option for "use linear scaling". "Close" and "Reset" buttons are at the bottom of the dialog.

# 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  $\sim 0.01\text{cm}$
- 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.





# Color and False Colors (Lighthouse)



# Lighthouse (detail)



# Color and False Colors (Window)



# Window (detail)



# Mother of All Aliasing ☺

