Concept of images

Concept of images

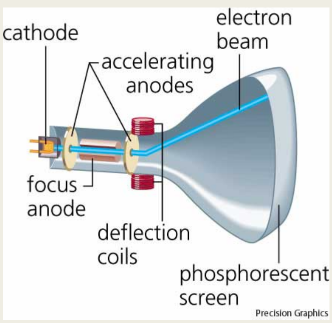
- We will consider how electronic pictures (monochrome) are made up.
- Consider some important characteristics of electronic images.
- See how image are represented in a computer.
- Appreciate compromises and limitations.
- Finally you will be able to edit individual picture elements and change the brightness, contrast and of an image, as say Photoshop may do.

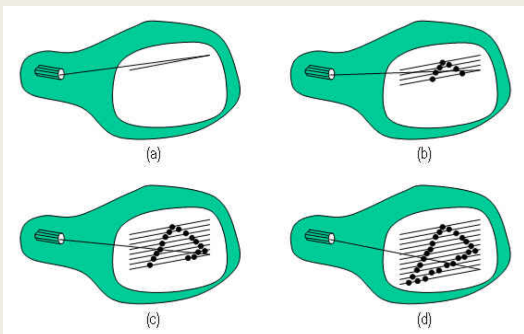
Picture presentation by a (old CRT) television set

- Consider monochrome first.
- The image that we see on our monitors is composed of a series of horizontal lines.
- So it is sampled in the vertical direction.

The television picture

Raster Scan System
the electron beam is swept across the screen, one row at a time from top to bottom. When electron beam moves across each row the beam intensity is turned ON and OFF to create a pattern of illuminated spots.

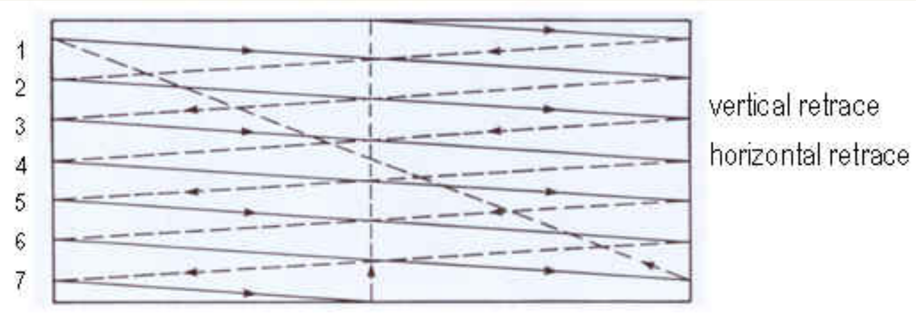




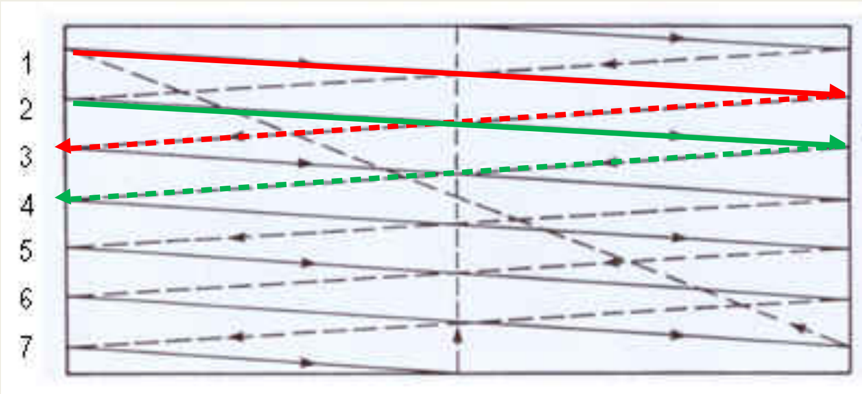
Picture definition is stored in a memory called frame buffer which holds the set of intensity values.

The television picture

At the end of each line the beam must be turned off and redirect to the left hand side of the CRT, this is called Horizontal Retrace. At the end of each frame (field), the electron beam return to top left corner of the screen to begin the next frame (field) called Vertical Retrace as shown in figure below:



Computer printers create their images basically by raster scanning.



A frame is a complete image captured during a known time interval, and a field is the set of odd-numbered or even-numbered scanning lines composing a partial image.

When video is sent in interlaced-scan format, each frame is sent as the field of odd-numbered lines followed by the field of even-numbered lines.

Interlaced video

- Some HD TV channels are broadcasted today using interlaced video format to reduce the data rate.
- The following slide gives an example of the de-interlaced TV content from one of the UK TV broadcasters.

How many lines (samples) / Spatial resolution.

- Spatial resolution is finest detail in the vertical and horizontal direction we can resolve (see).
- If the television picture is to have good spatial resolution we must have a minimum number of lines (vertical samples).
- So reducing the number of lines (samples) will limit resolution and cause aliasing.

Overscan

- For (CRT) television there are 625 lines in the European television picture, not all of these lines are used to transmit the picture.
- In the American NTSC standard there are nominally 525 lines per frame, but only approximately 480 lines make up the actual picture.
- TV sets used to be highly variable in how the video image was positioned within the borders of the screen. The solution was to have the monitor show less than the full image i.e. with the edges "outside" the viewing area of the tube.

Aspect ratios

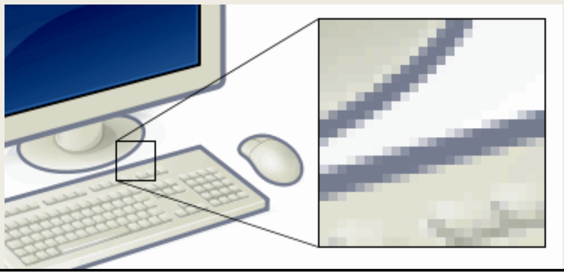
- The maximum angle that our eyes can see (without moving them) is greater in the horizontal direction (than in the vertical direction).
- TV screens are larger horizontally than vertically.
- The ratio of the width to the height is called the aspect ratio.
- Two common television aspect ratios are:
  - *4:3*
  - *16:9*

The digital picture and pixels.

- In the computer system (modern TV) we don't represent television's horizontal line.
- We need to store it as a sequence of numbers in the computer.
- So we sample the brightness values at many points along the television line and convert the brightness value to a numerical value.
- So a sample point now exists in both the horizontal and vertical directions. Called a pixel (Picture element).

Total number of samples, physical significance

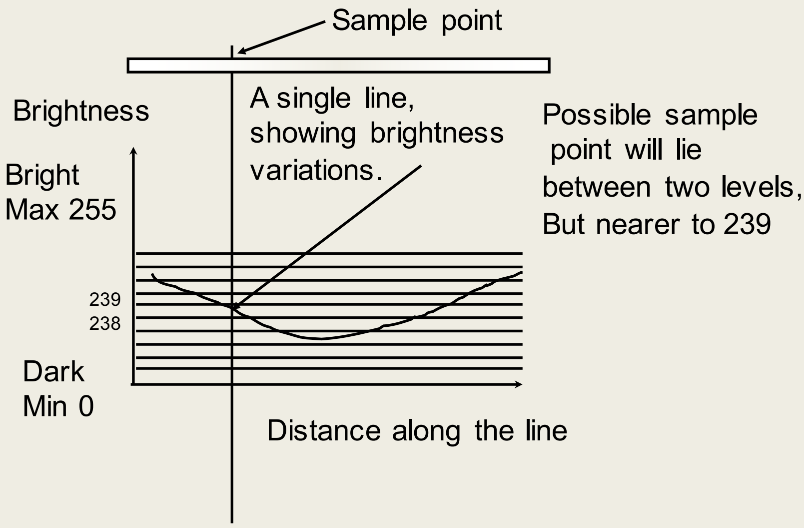
- We can consider a block of 640 horizontal samples (in a 640 x 480 image) as a television line or a row of a 2 dimensional matrix.
- The full picture is made up of 480 such lines stacked on top of each other.
- We can consider our digital picture as a matrix, therefore called a bitmap.



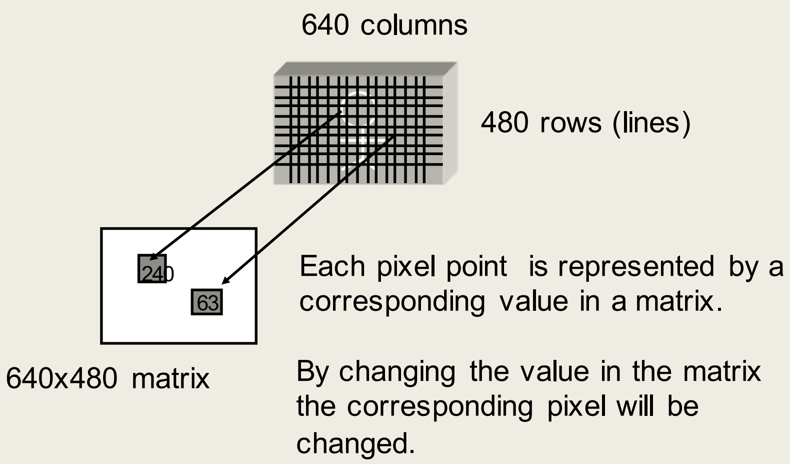
The digital picture/ Pixel values.

- We allow 256 values (typically) for each pixel value (8 bit).
- Each sample from our television line must be quantised.
- That is we must find the nearest value in the range 0-255 to represent it.

Brightness variation and sampling/quantization.



Total number of samples, physical significance



Matrices and pictures

- But the matrix doesn't have to be so large.
- We can make up an image by putting values into a 3 x 3 matrix.
- The values at each point in the matrix represent the brightness of a pixel.
- The position (in terms of rows and columns) in the matrix will correspond directly to the position on the screen.

Matrices and pictures

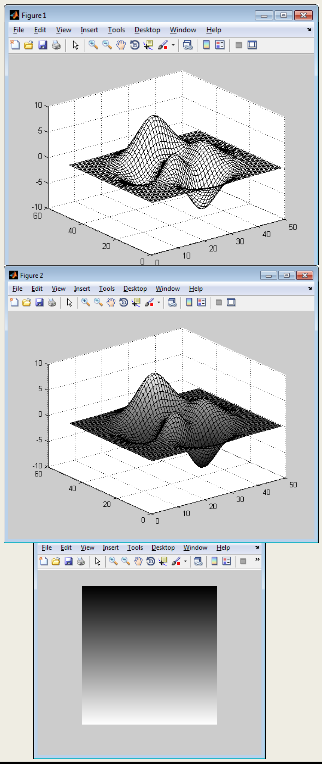
```
clc
clear all
% make 3x3 matrix with ones. When Matlab sees double type value, it recognises the data range as 0 (darkest) to 1(brightest). When Matlab sees uint8 type value as input, it recognises the data range as 0(darkest) to 255(brightest).
grey1 =ones(3,3);

% Set up Matlab to respond to normal range of intensity (0-255).
for i=1:256
    grey2(i,1:3)=(i-1)/255;
    grey3(i,1:250)=(i-1)/255;
end

figure(1), surf(peaks)
colormap(grey1) %three-column matrix of RGB triplets

figure(2), surf(peaks)
colormap(grey2) %three-column matrix of RGB triplets

figure(3), imshow(grey3)
```



Brightness and contrast

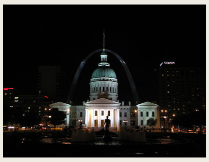
- The value of each point in this two dimensional matrix represents the brightness of a pixel.
- In other words brightness is the absolute value of a pixel.
- Contrast is the difference between the brightest pixel and the darkest pixel in an image.

High dynamic range (HDR)

- High-dynamic-range imaging (HDRI or HDR) reproduces a greater dynamic range of luminosity than is possible with standard digital imaging or photographic techniques.
- The human eye, through adaptation of the iris (and other methods) adjusts constantly to the broad dynamic changes ubiquitous in our environment. The brain continuously interprets this information so that most of us can see in a wide range of light conditions. Most cameras, on the other hand, cannot.
- The two primary types of HDR images are computer renderings and images resulting from merging multiple low-dynamic-range (LDR) or standard-dynamic-range (SDR) photographs. HDR images can also be acquired using special image sensors.
- Due to the limitations of printing and display contrast, acquiring an HDR image is only half the story. The method of rendering an HDR image to a standard monitor or printing device is called tone mapping.

HDR example


-4 stops


-2 stops


+2 stops


+4 stops


Local tone mapping

Changing Brightness and contrast

- The above implies that we must add or subtract to change the brightness of a pixel, and multiply or divide the change the contrast of an image.
- We can try it on our simple image, but it will work with larger images.

Changing Brightness

- Our image is full brightness in most parts so lets decrease the brightness and view it.

Im=Im-127

image(Im)

- We can increase it again

Im=Im+127

image(Im)

- If we increase/decrease values below 0 or above 255 we lose information in the image, try it.

Changing Contrast

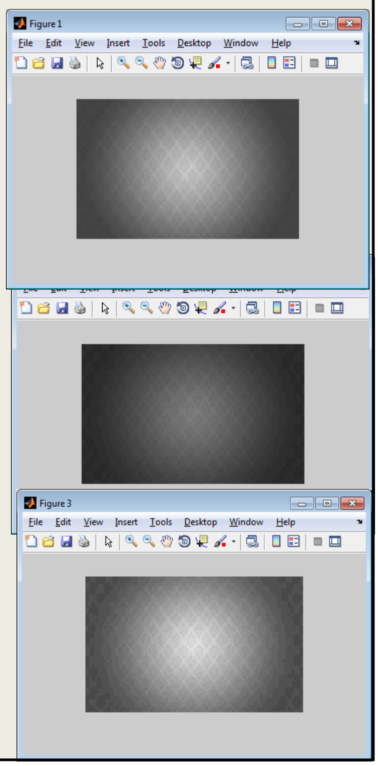
```
clc
clear all

I = rgb2gray(imread('image1.jpg'));
figure(1),imshow(I);
J = (I*0.6);

figure(2),imshow(J);

J = round(I*1.2);
figure(3),imshow(J);
```

x	1	3	5	5-1=4
x*0.6	0.6	1.8	3	3-0.6=2.4
x*1.2	1.2	3.6	6	6-1.2=4.8



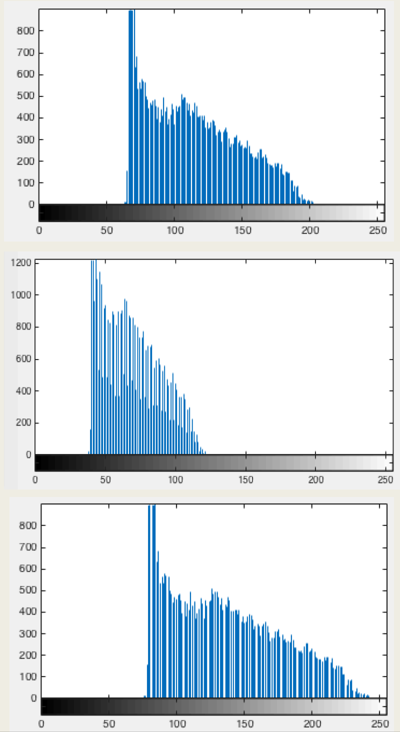
Changing Contrast

```
clc
clear all

I = rgb2gray(imread('image1.jpg'));
%figure(1),imshow(I);
figure(1), imhist(I)

J = (I*0.6);
%figure(2),imshow(J);
figure(2), imhist(J)

J = round(I*1.2);
%figure(3),imshow(J);
figure(3),imhist(J)
```



Changing Contrast

```
I = rgb2gray(imread('image1.jpg'));
figure(1), imshow(I);

J = imadjust(I);  % maps the intensity values in grayscale image I to new values in J such
that 1% of data is saturated at low and high intensities of I. This increases the contrast of the
output image J
figure(2), imshow(J)
figure(3), imhist(J,64)
```