Image Processing

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Outline

- Introduction to Digital Images
- Introduction to Digital Image Processing
- Picture and Luminance Data Types

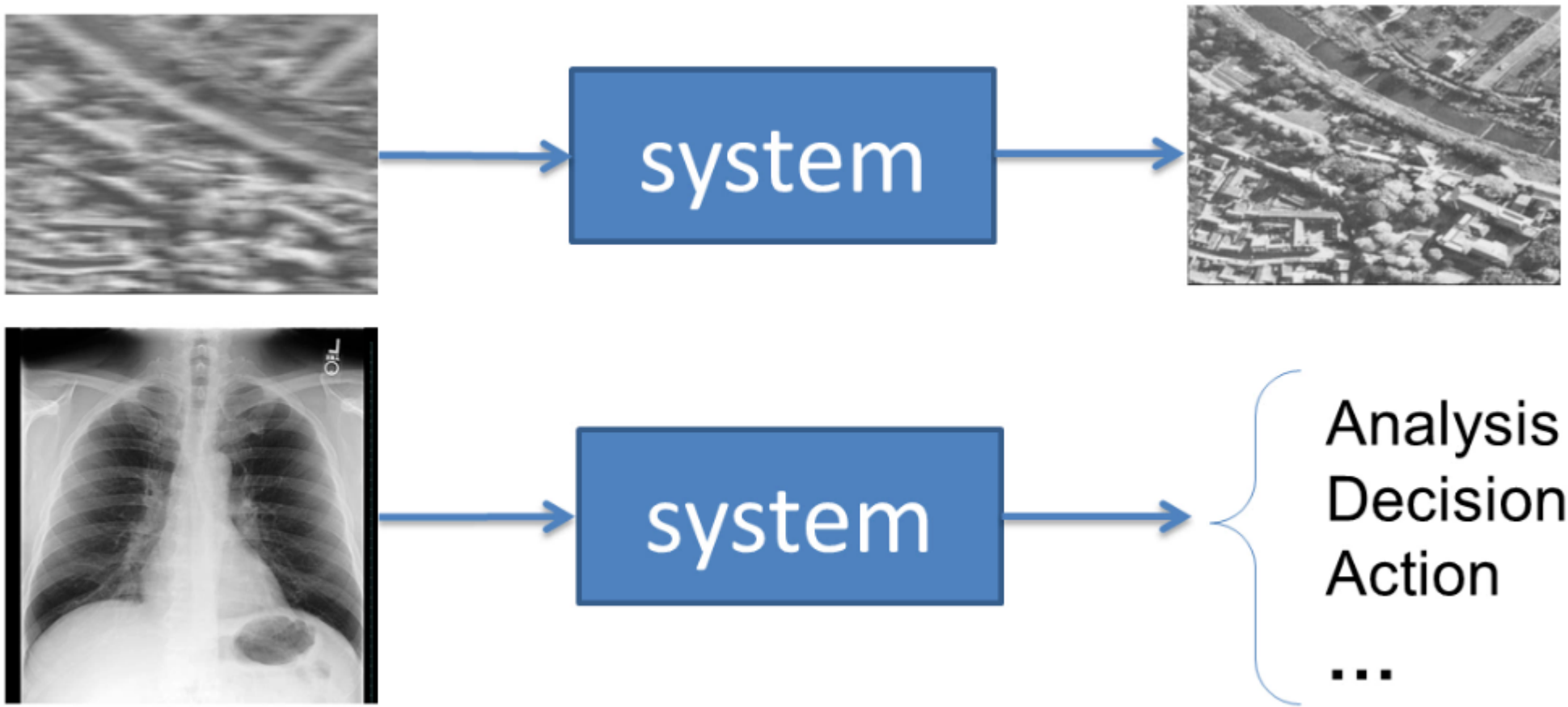
A Digital Image

https://www.cs.cmu.edu/~dellaert/aligned/

Digital Image Definitions

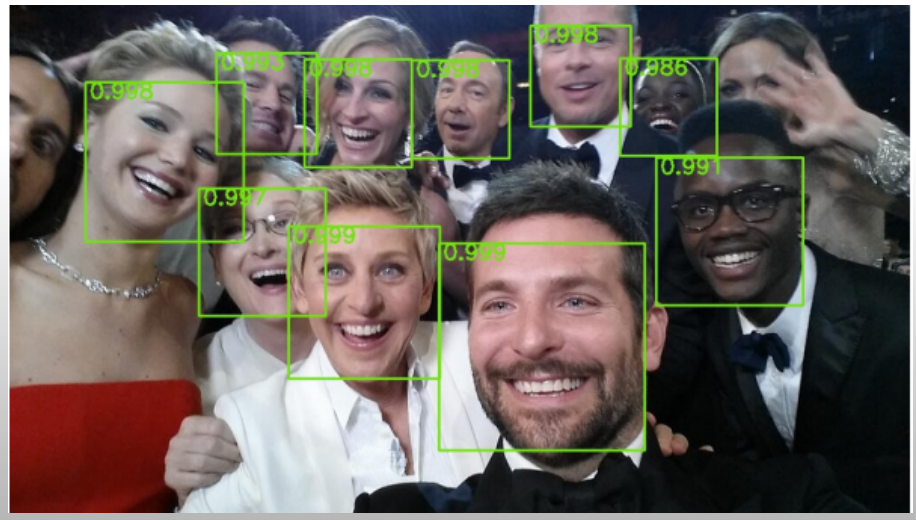
- **Image is a function of two real variables, *a*(*x*,*y*):**
  - *a* as the amplitude (e.g. brightness) of the image at the *real* coordinate position (*x*,*y*).
- **Image Processing**
  - *image in -> image out*
  - *Sometimes necessary before analysis*
- **Image Analysis**
  - *image in -> measurements out*
  - *e.g. number of objects in an image*

Image Processing



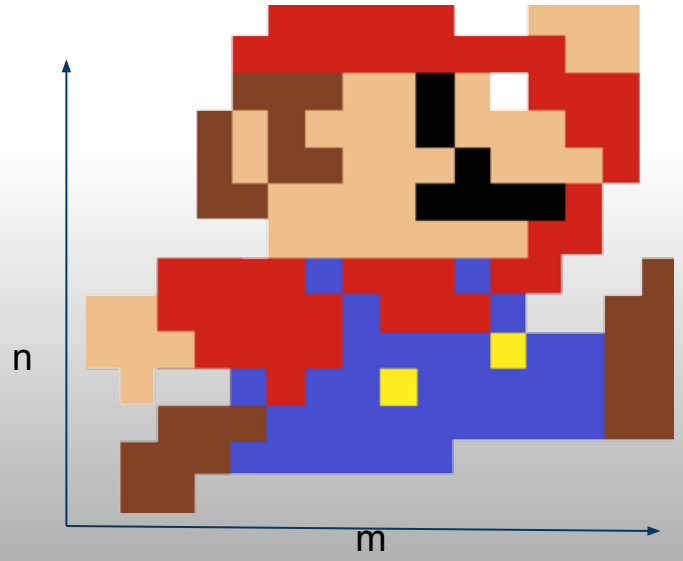
Digital Image

- Digitizing an image converts it to a form that can be stored in digital or electronic media(e.g. hard disk, flash memory...)
- Digitization procedure performed by capture device(e.g. scanner, digital camera)
- Once digitized, image can be processed using various filters and techniques:
  - compression
  - restoration
  - measurement extraction
  - Object identification/location



Digital Image Definitions

- A digital image $a[m,n]$ described in a 2D discrete space
  - derived from an analog image $a(x,y)$ in 2D continuous space
  - 2D continuous image $a(x,y)$ is divided into *N rows* and *M columns*. The intersection of a row and a column is termed a *pixel*.
- The value assigned to the integer coordinates $[m,n]$ with $\{m=0,1,2,...,M-1\}$ and $\{n=0,1,2,...,N-1\}$ is $a[m,n]$.

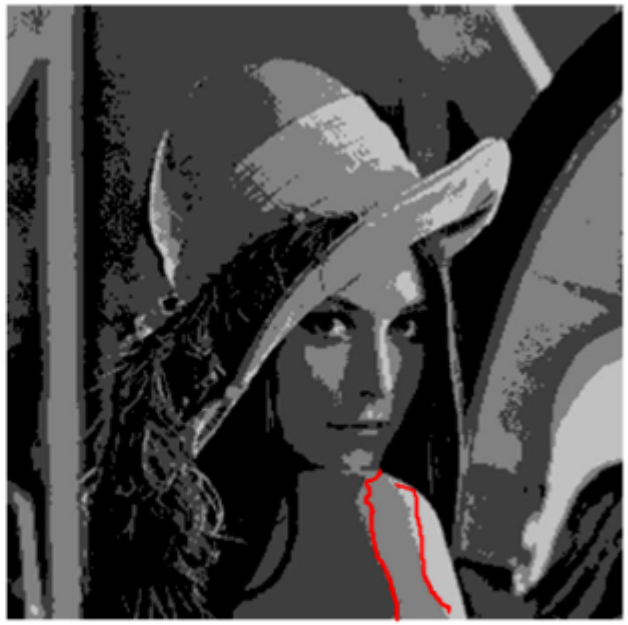


Quantisation

Quantisation process reduces the number of colours used.
Depends on number of bits used per pixel.
Results for different quantisation:

8 bits per pixel

4 bits per pixel



2 bits per pixel

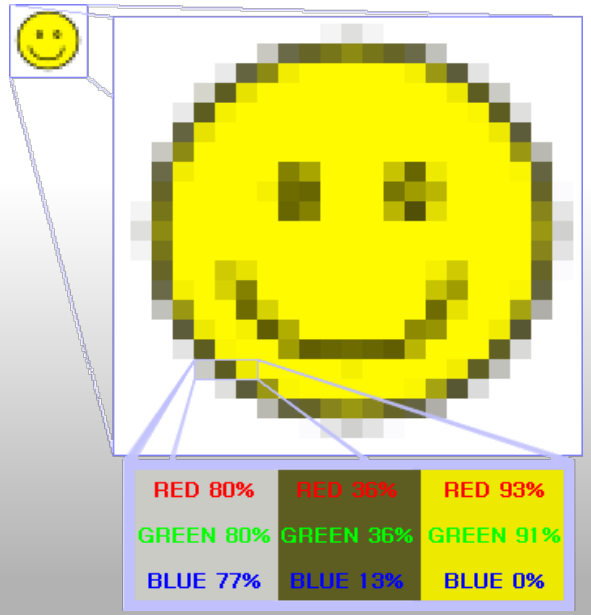
Digital Image Example

- 8 bit grey scale bitmap(.bmp)
  - *does not use compression, making pixel data retrieval much easier than .gif/.jpg*
- Possible 256 colors (2^8) stored in a 8-bit image(0-255)
- In an 8 bit BMP image, black is 0 and white is 255
- Often referred to as Raster Graphic or Raster Data (grid of pixels).
- Following image is a 512x512 bmp:

  - 512x512 =262144 bytes of data
  - row 0 and column 0 in a BMP would correspond to the bottom left corner
  -

Digital Image Example

- 24-bit true color BMP has a possible 16 million colors (2^24)
- Pixel represents a RGB (Red Green Blue) data value
  - one byte each for red, green and blue(3x8=24 bit)
  - (255, 0, 0) is equivalent to (Red=255, Green=0, and Blue=0), or Red!
- How large will the image file be?



Digital Image Resolution

- total number of pixels (*resolution*), and the amount of information in each pixel (often called *color depth*) determine the quality of a raster image:
  - 24 bits of color-information per pixel (a standard for displays since around 1995) can represent smoother degrees of shading than one that only stores 8 bits per pixel
  - image sampled at 640 x 480 pixels (307,200 pixels) will look rough and blocky compared to one sampled at 1280 x 1024 (1,310,720 pixels).

Spatial Domain Processing Methods

- As already stated, image processing involves a transformation
  - *image in -> image out*
  - $F_{original} -> F_{enhanced}$
  - $F_{enhanced}$ pixel(x,y) calulated by by performing some operation on the corresponding pixels in the neighbourhood of (x,y) in $F_{original}$
- Neighbourhoods can be any shape, but usually they are rectangular
- We will look at Grey Scale images initially
- Simplest operation is on each pixel(ignores neighbouring pixels)
- Referred to as *mapping* or *transformation*

Grey Scale Manipulation:Thresholding

- Operator *T* only acts on a 1x1 pixel neighbourhood in the input image(Simplest form of operation)
- Intensity profile is replaced by a step function
  - threshhold value chosen
  - pixel with a grey level below the threshold in the input image gets mapped to 0
  - Others mapped to 255
  - Also known as binarization(black and white)

Grey Scale Manipulation: Threshold

- Transformation of 512x512, 8 bit image. Threshold set at 128.
- if pixel value < 128 then new pixel value = 0, otherwise pixel value = 255
- 0 corresponds to black, 255 corresponds to white

Images in Java

- Several Abstract Data Types (or classes) are available to process images in Java - Example: Picture and Luminance class:

```
//Converts color image to greyscale.
Picture pic = new Picture("My/pic/location.jpg");
int width  = pic.width();
int height = pic.height();
// convert to grayscale
for (int x = 0; x < width; x++) {
    for (int y = 0; y < height; y++) {
        Color color = pic.get(x, y);
        Color gray = Luminance.toGray(color);
        pic.set(x, y, gray);
    }
}
pic.show();
```

Image Binarisation in Java

```
//Binarise colour picture
        Picture pic = new Picture("My/pic/location.jpg");
        int width  = pic.width();
        int height = pic.height();
        double thresholdPixelValue = 128.0;
        // convert to grayscale
        for (int x = 0; x < width; x++) {
            for (int y = 0; y < height; y++) {
                Color c = p.get(x, y);
                if (Luminance.lum(c) < thresholdPixelValue) {
                                p.set(x, y, Color.BLACK);
                        } else {
                                p.set(x, y, Color.WHITE);
                        }
              }
        }
        pic.show();
```