PENGOLAHAN SINYAL DIGITAL

Adhi Harmoko Saputro

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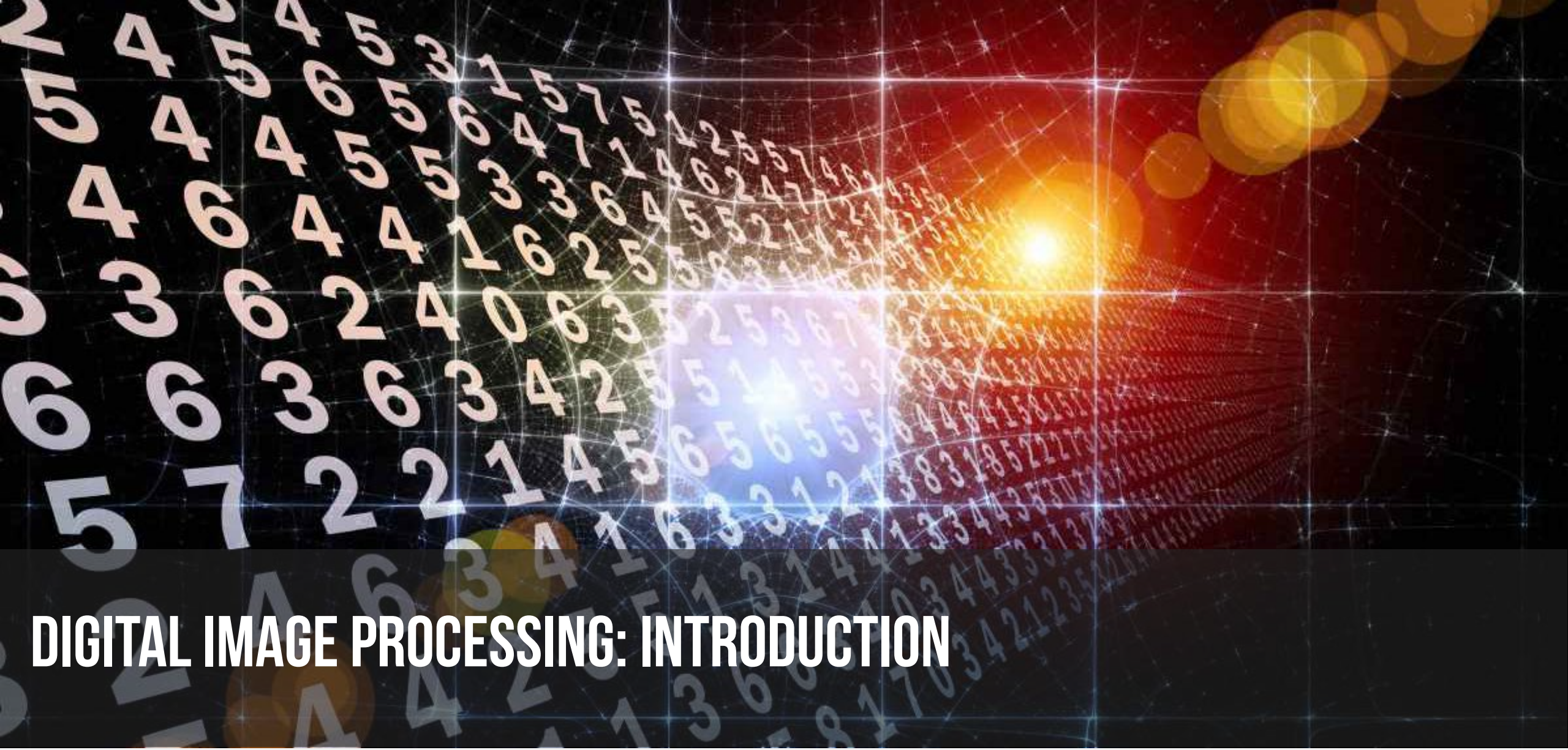
Veritas, Probitas, Iustitia



DIGITAL IMAGE PROCESSING: INTRODUCTION

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WHY DIGITAL IMAGE PROCESSING?

- Image is better than any other information form for human being to perceive.

- Humans are primarily visual creatures – above 90% of the information about the world (a picture is better than a thousand words)

- However, Vision is not intuitive for machines
  - Projection of 3D world to 2D images => loss of information
  - Interpretation of dynamic scenes, such as a moving camera and moving objects

WHAT IS DIGITAL IMAGE PROCESSING?

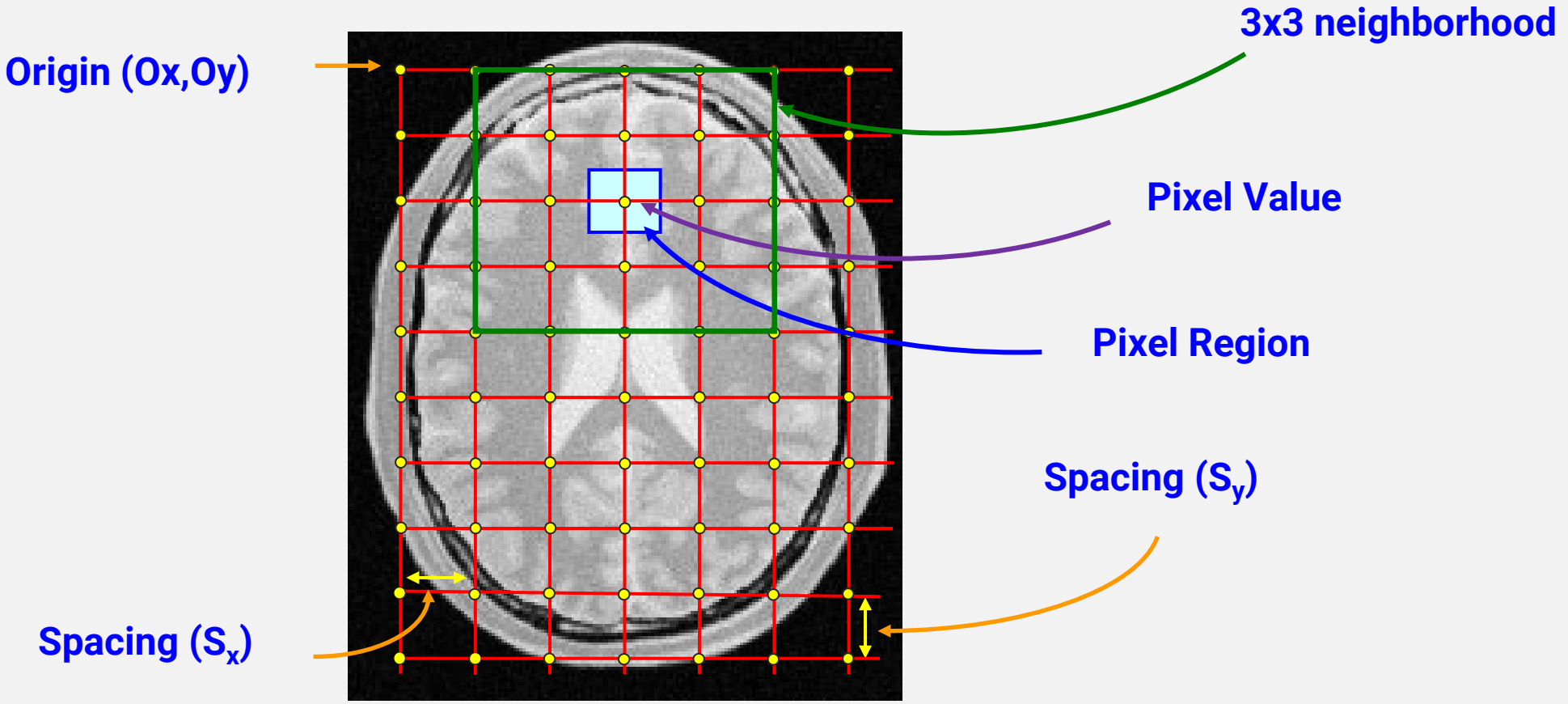
- Image understanding, image analysis, and computer vision aim to imitate the process of human vision electronically
  - Image acquisition
  - Preprocessing
  - Segmentation
  - Representation and Description
  - Recognition and Interpretation

GENERAL PROCEDURES

- Goal: to obtain similar effect provided by biological systems

- Two-level approaches
  - Low level image processing. Very little knowledge about the content or semantics of images
  - High level image understanding. Imitating human cognition and ability to infer information contained in the image.

LOW LEVEL IMAGE PROCESSING



LOW LEVEL IMAGE PROCESSING

- Image compression
- Noise reduction
- Edge extraction
- Contrast enhancement
- Segmentation
- Thresholding
- Morphology
- Image restoration

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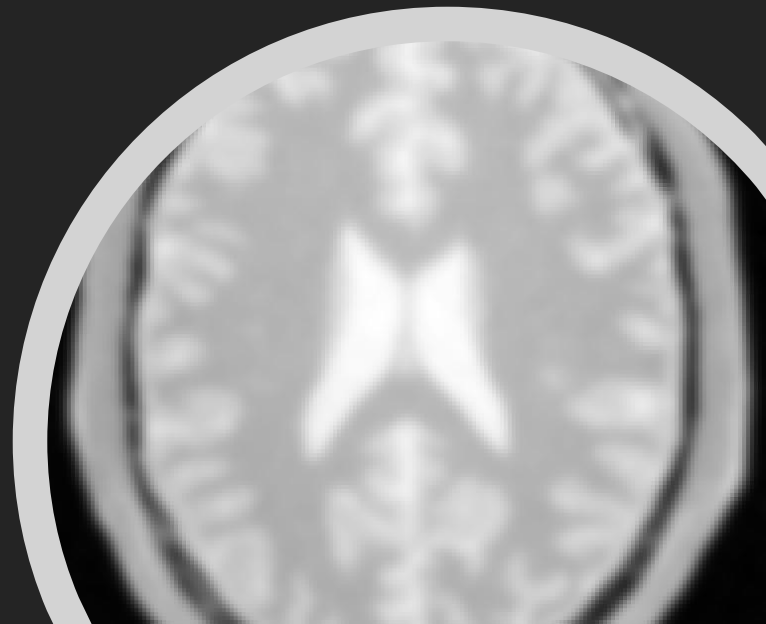

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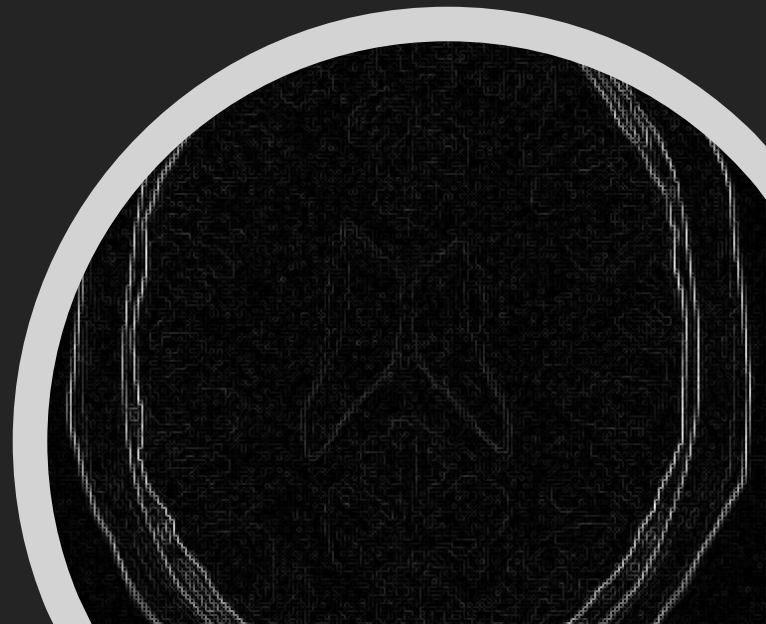

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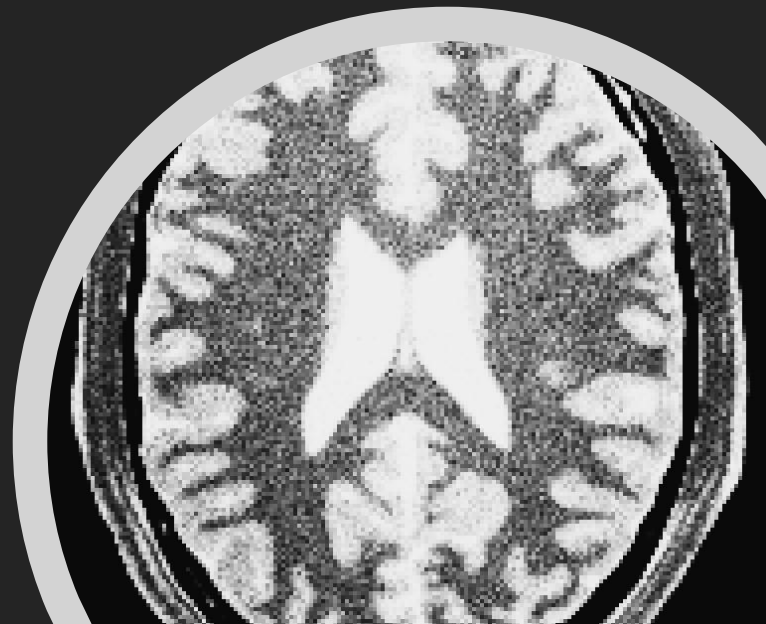

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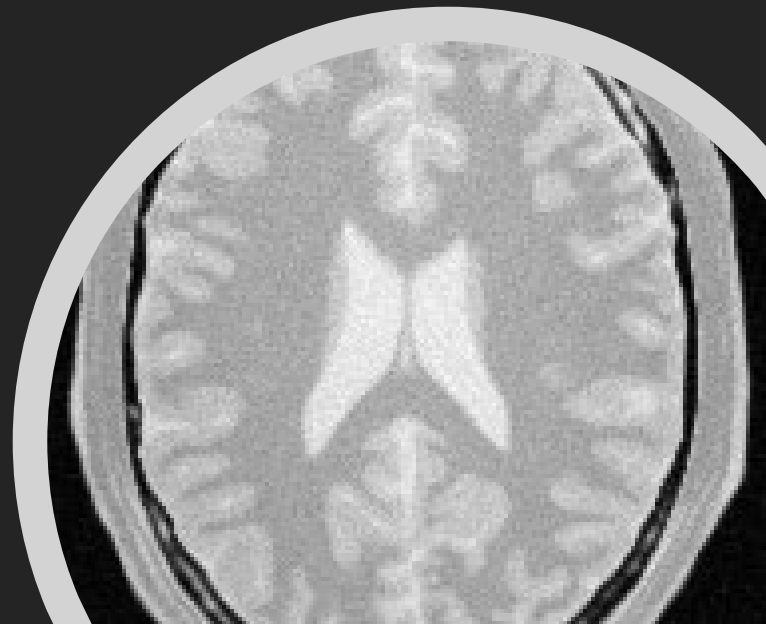

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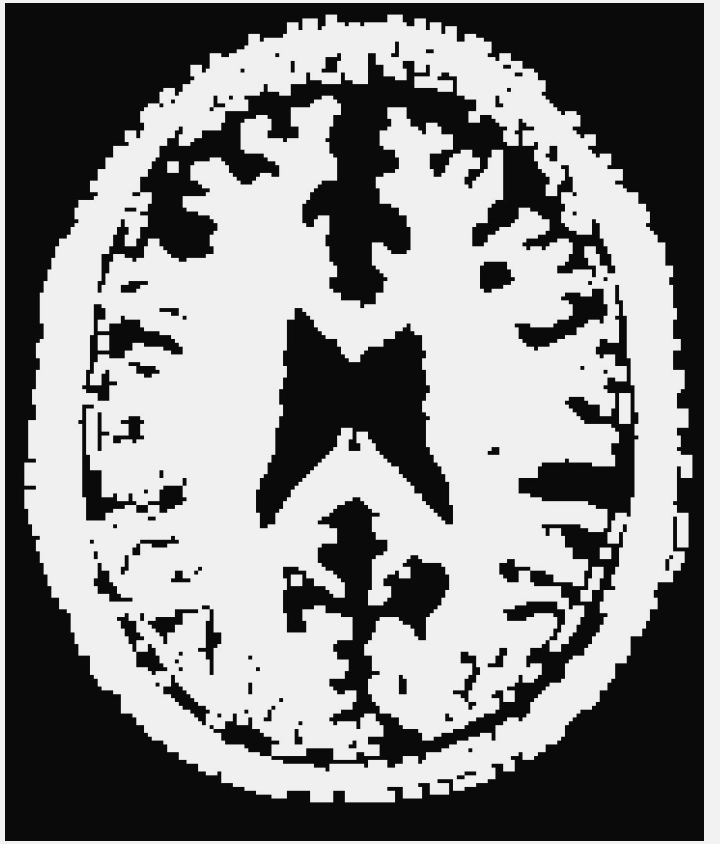

Dilation

LOW LEVEL IMAGE PROCESSING

- Image compression
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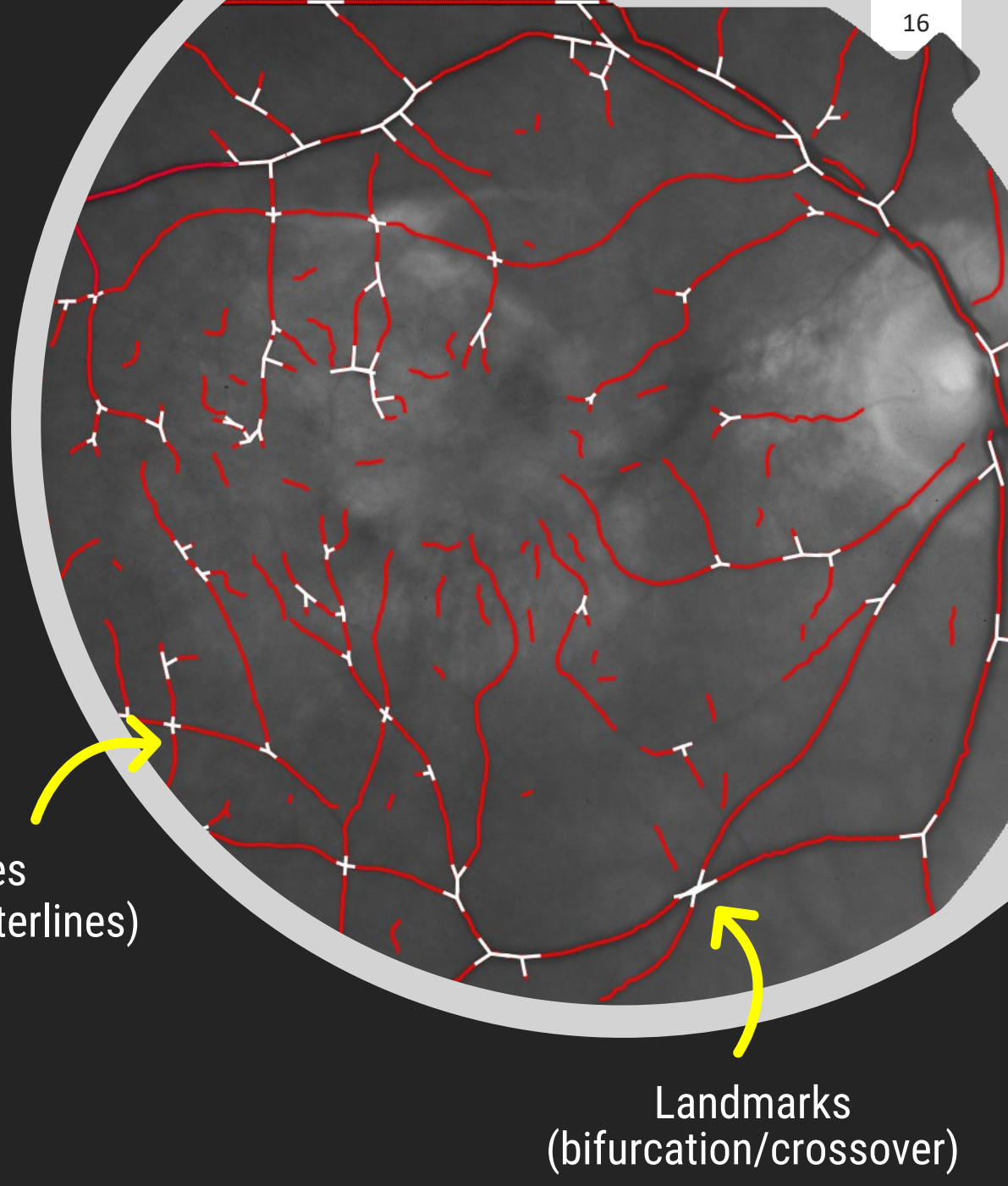
- Thresholding
- Morphology
- Image restoration

HIGH LEVEL IMAGE UNDERSTANDING

- To imitate human cognition according to the information contained in the image.
- Data represent knowledge about the image content, and are often in symbolic form.
- Data representation is specific to the high-level goal.

HIGH LEVEL IMAGE UNDERSTANDING

- What are the high-level components?
- What tasks can be achieved?

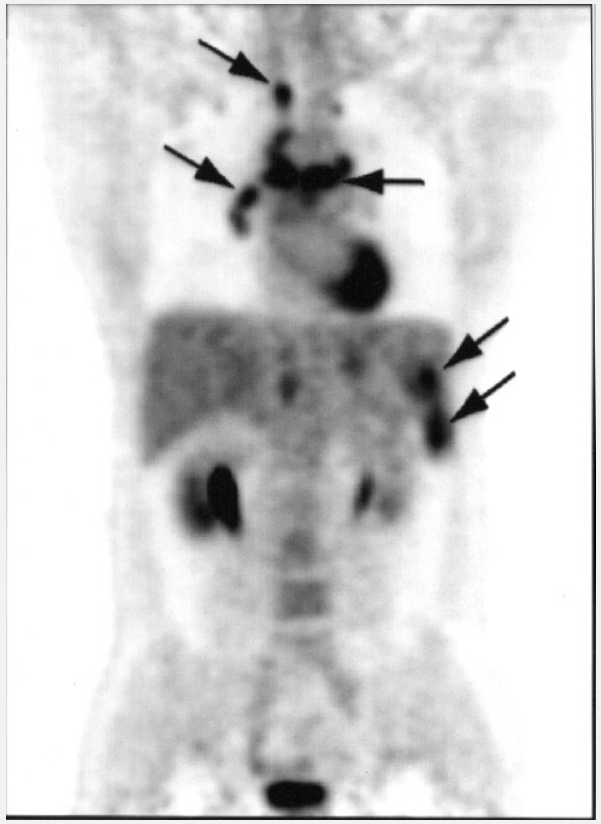


APPLICATIONS

- Medicine
- Defense
- Meteorology
- Environmental science
- Manufacture
- Surveillance
- Crime investigation

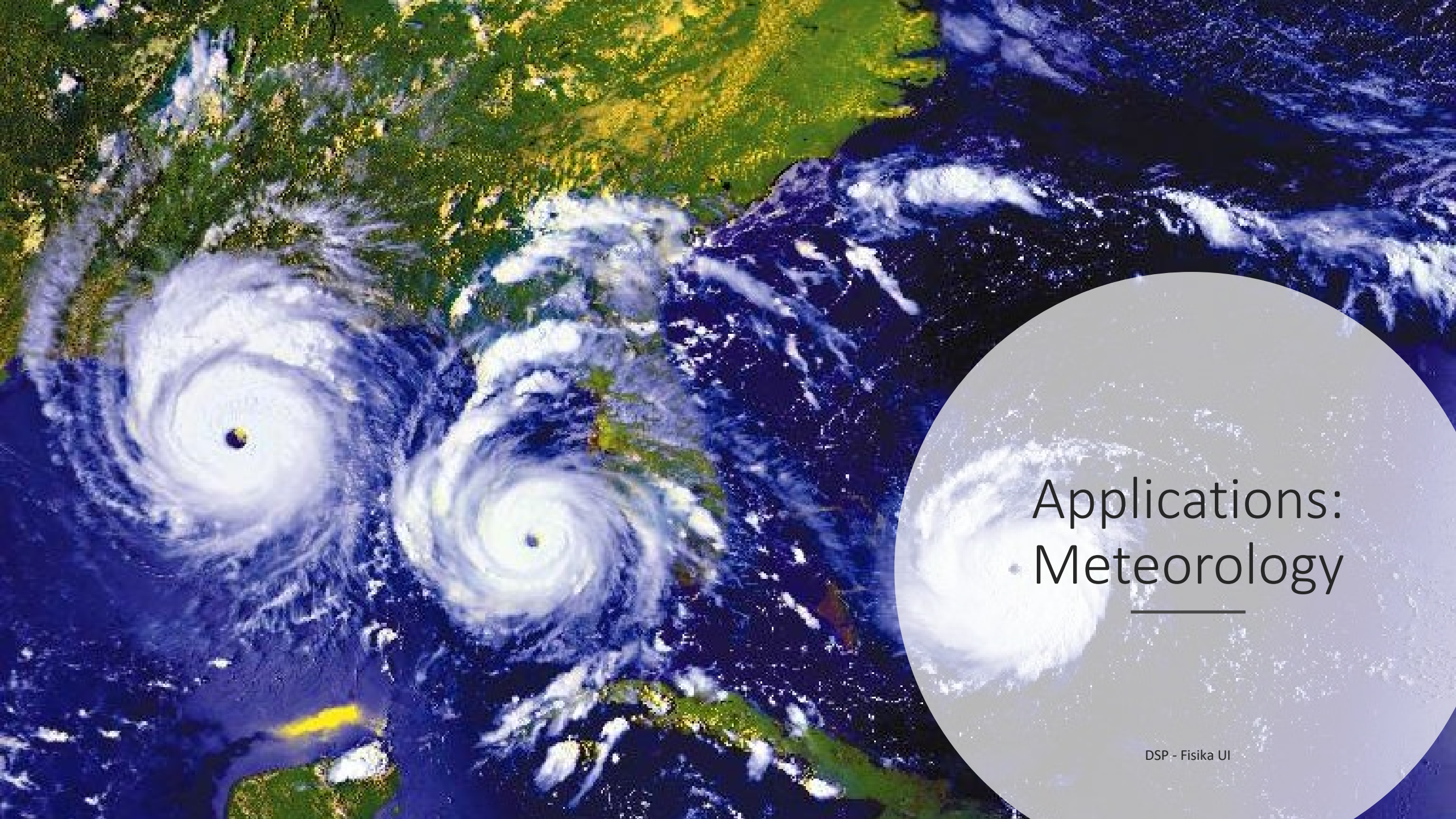
APPLICATIONS: MEDICINE

CT
(computed Tomography)



PET
(Positron Emission Tomography

PET/CT



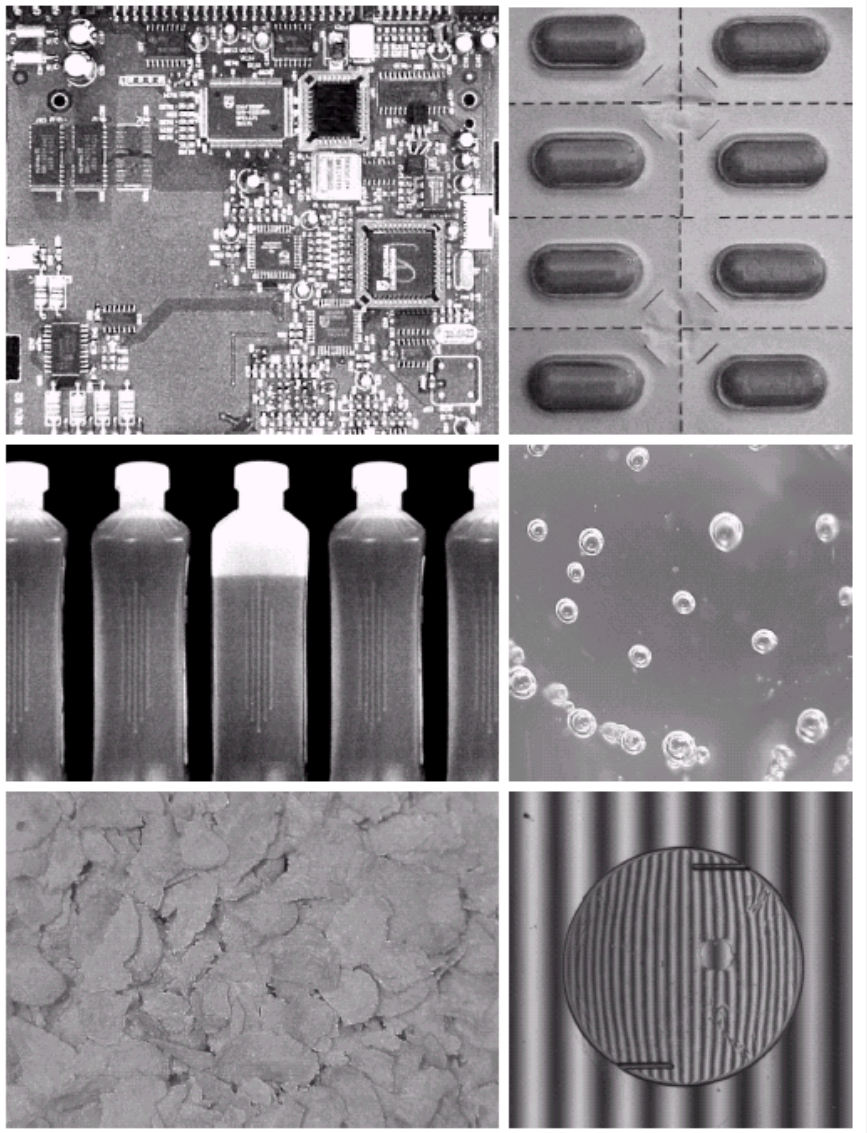
Applications: Meteorology

APPLICATIONS: ENVIRONMENTAL SCIENCE

Near Infrared imagery provided by Focal Flight LLC: Monochrome Near-Infrared, Color-Infrared and Normalized Difference Vegetation Index (NDVI).

Multispectral Wetlands Health - Outline Global Imagery

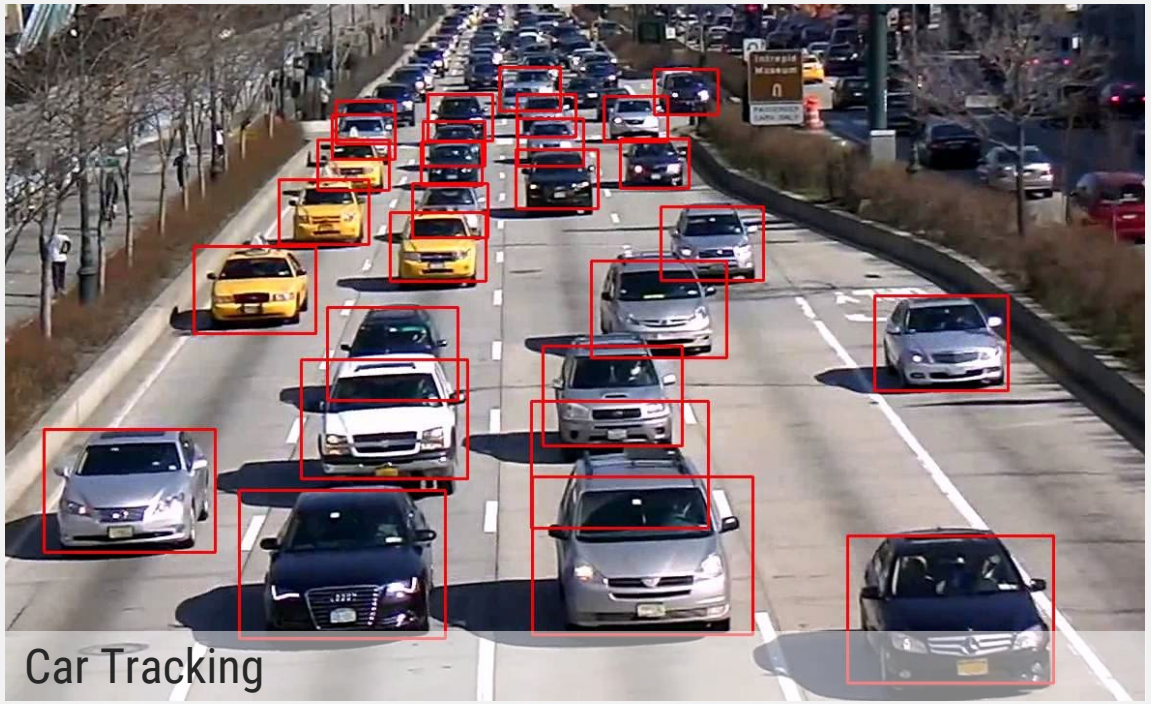
APPLICATIONS: MANUFACTURE



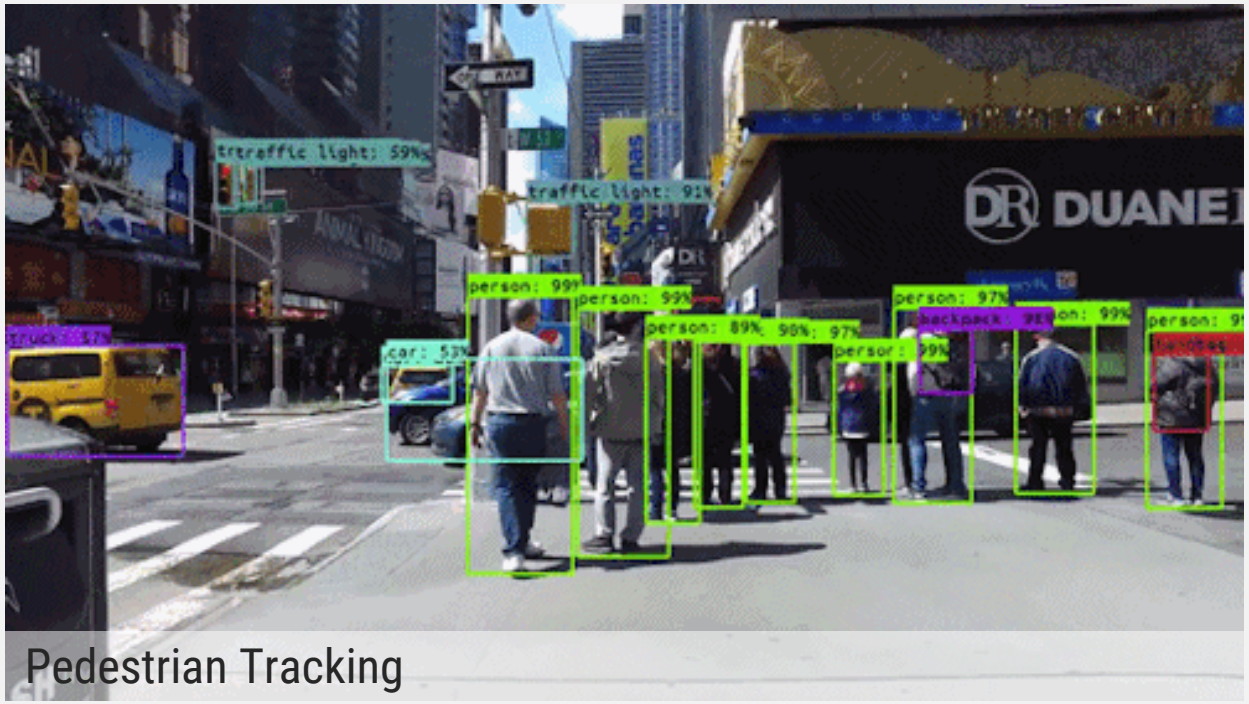
a b
c d
e f

FIGURE 1.14
Some examples of manufactured goods often checked using digital image processing. (a) A circuit board controller. (b) Packaged pills. (c) Bottles. (d) Bubbles in clear-plastic product. (e) Cereal. (f) Image of intraocular implant. (Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

APPLICATION: SURVEILLANCE



Car Tracking



Pedestrian Tracking

APPLICATIONS: CRIME INVESTIGATION

Fingerprint enhancement

WHAT ARE THE DIFFICULTIES?

- Poor understanding of the human vision system

Do you see a young or an old lady?

WHAT ARE THE DIFFICULTIES?

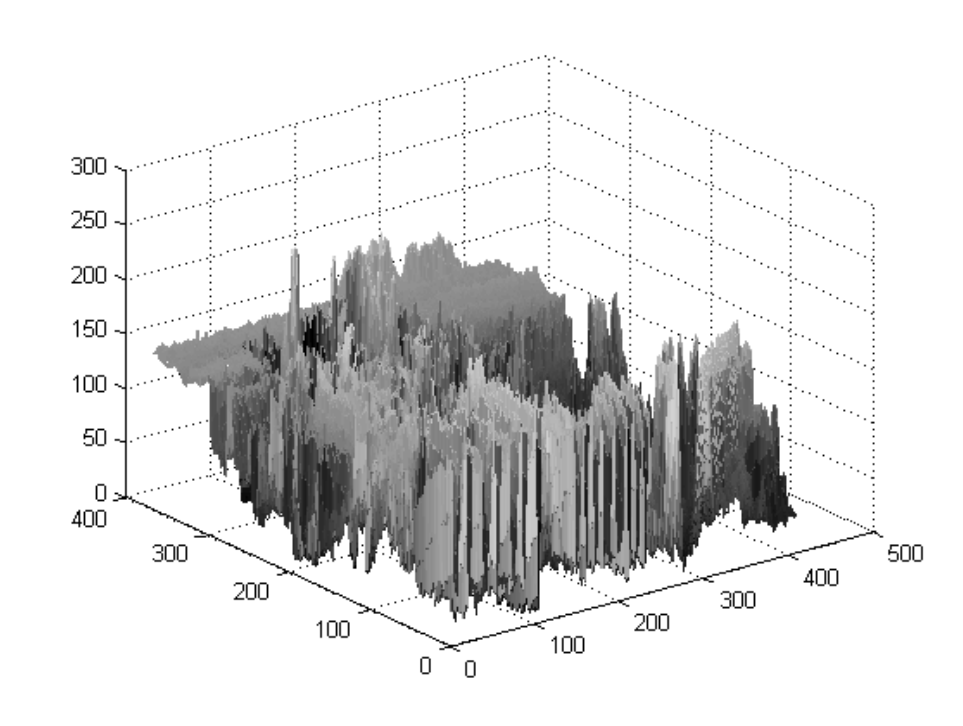
- Human vision system tends to group related regions together, not odd mixture of the two alternatives.

- Attending to different regions or contours initiate a change of perception

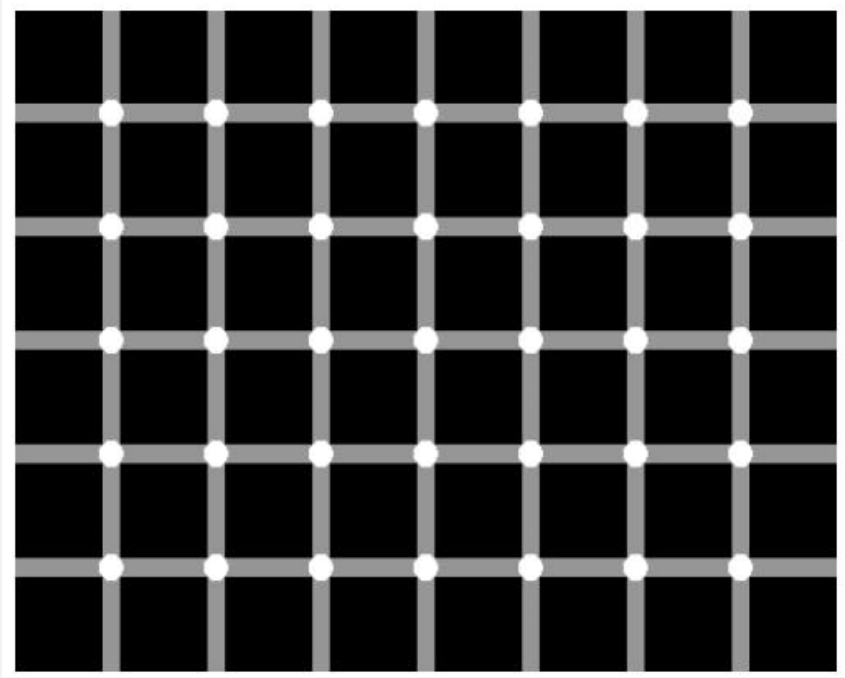
- This illustrates once more that vision is an active process that attempts to make sense of incoming information.

WHAT ARE THE DIFFICULTIES?

- The interpretation is based heavily on prior knowledge.

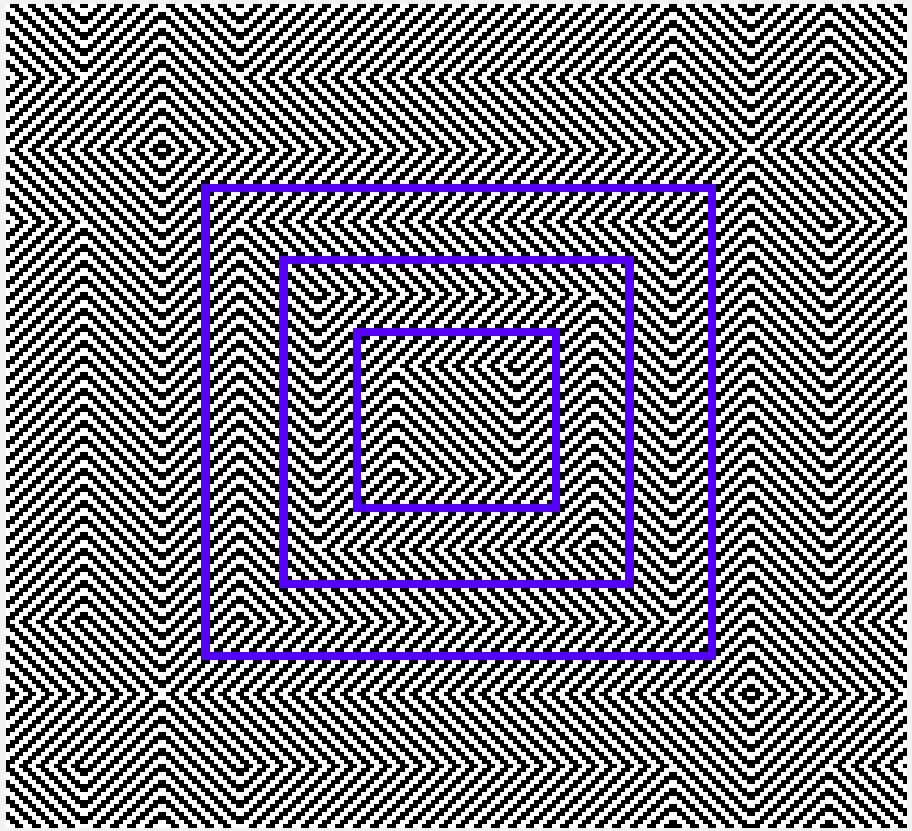


JUST SOME FUN VISUAL PERCEPTION GAMES



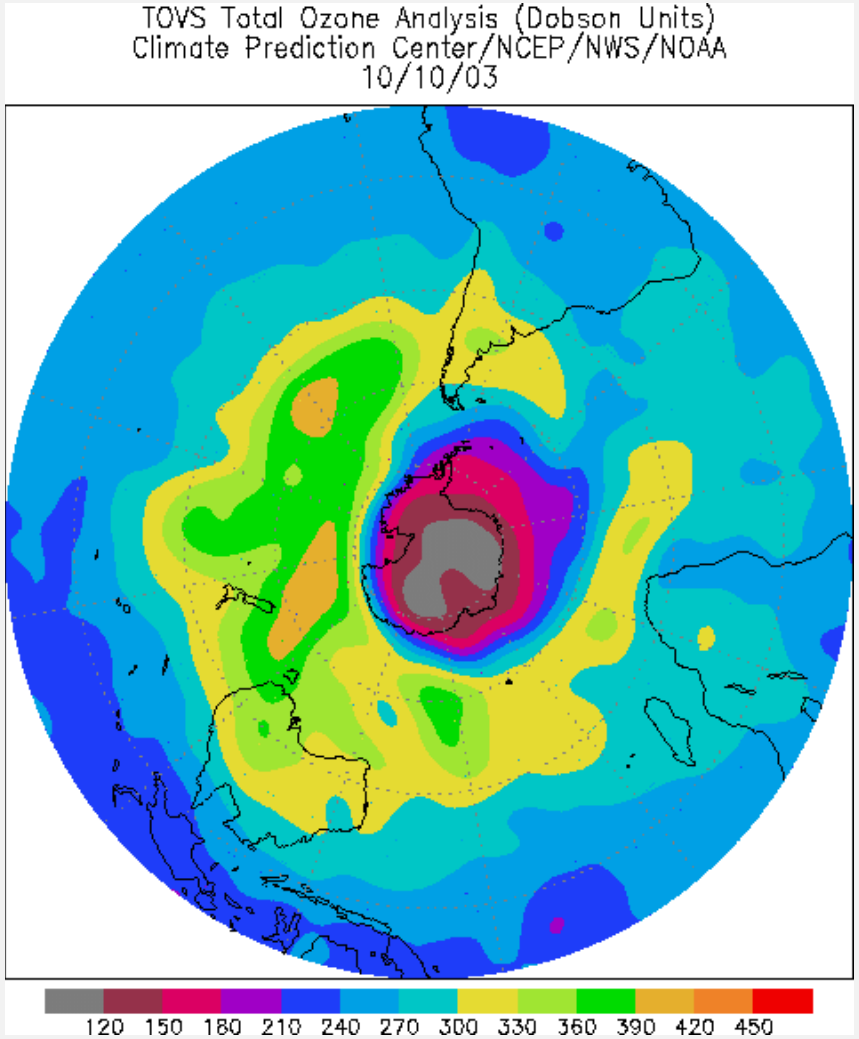
Can you count the dots?

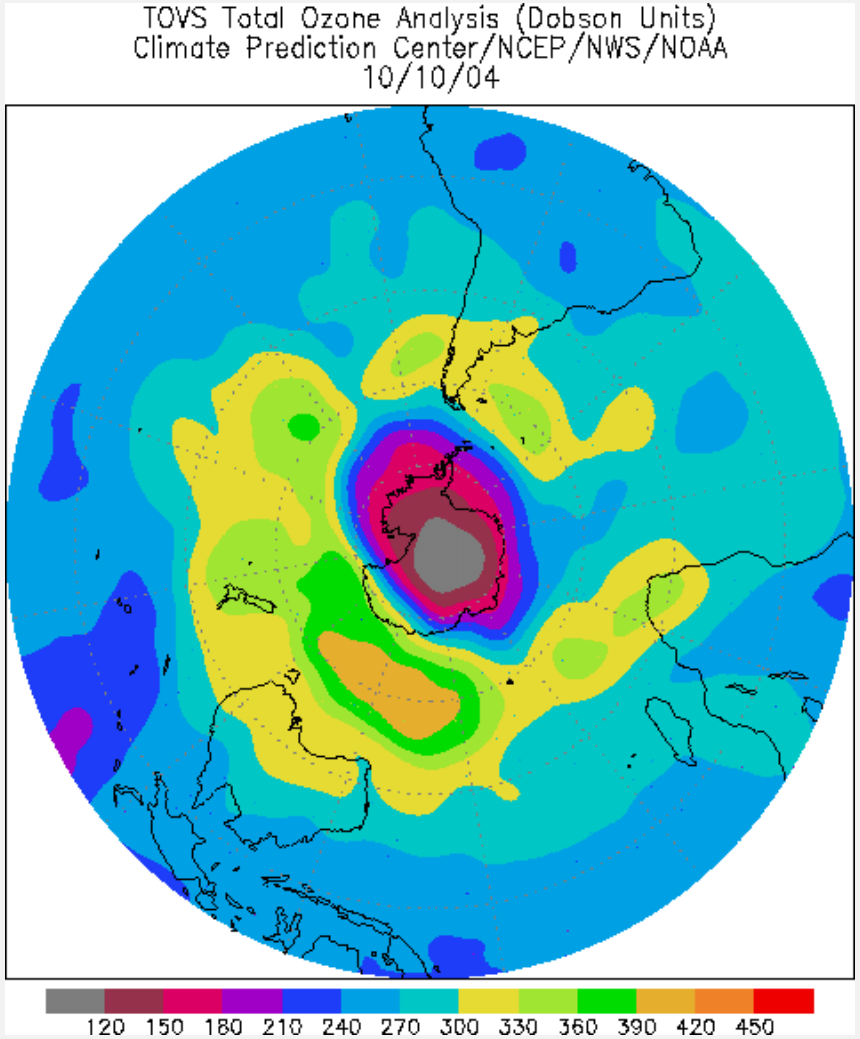
MORE . . .



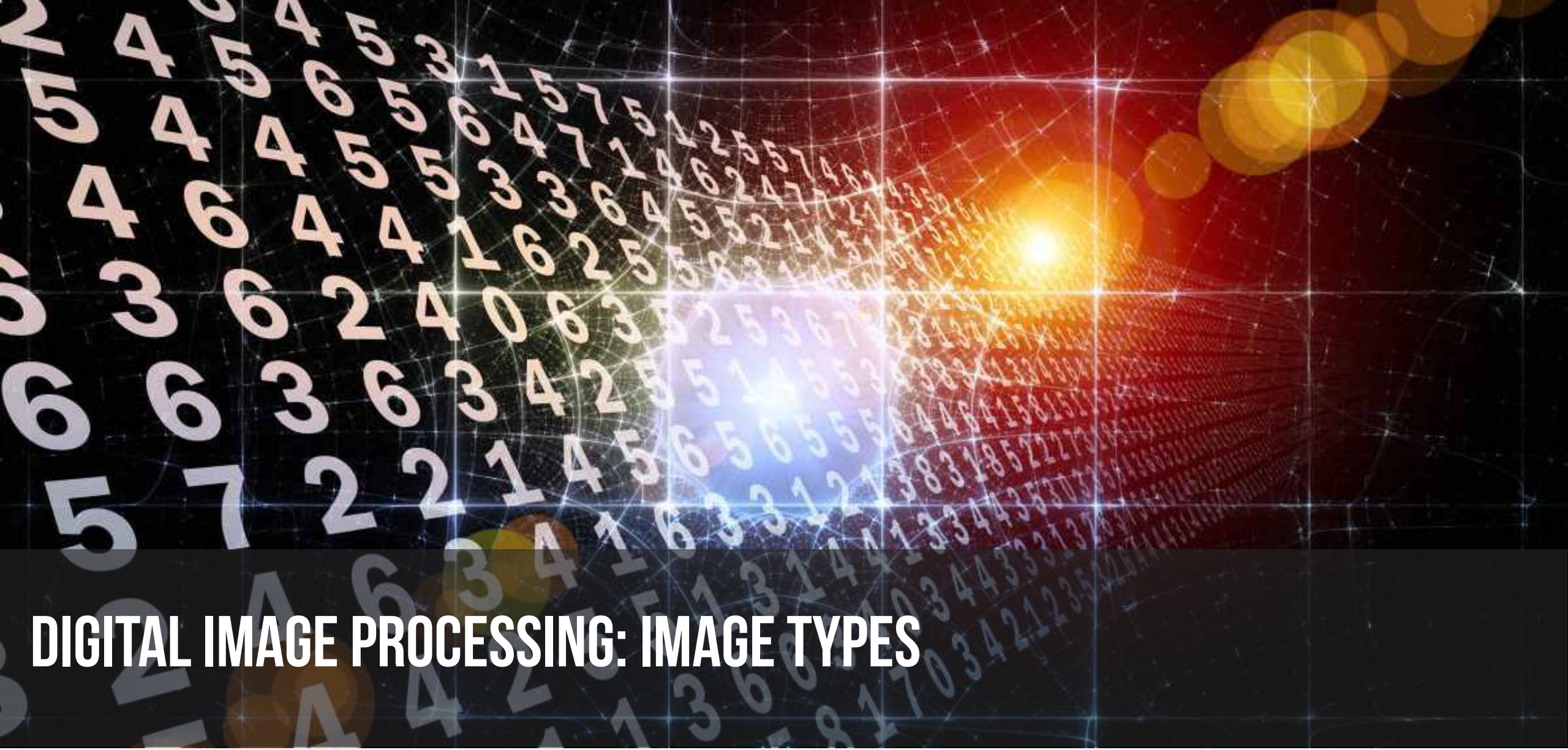
Do you see squares?

EXAMPLE: DETECTION OF OZONE LAYER HOLE





Over the Antarctic, normal value around 300 DU



DIGITAL IMAGE PROCESSING: IMAGE TYPES

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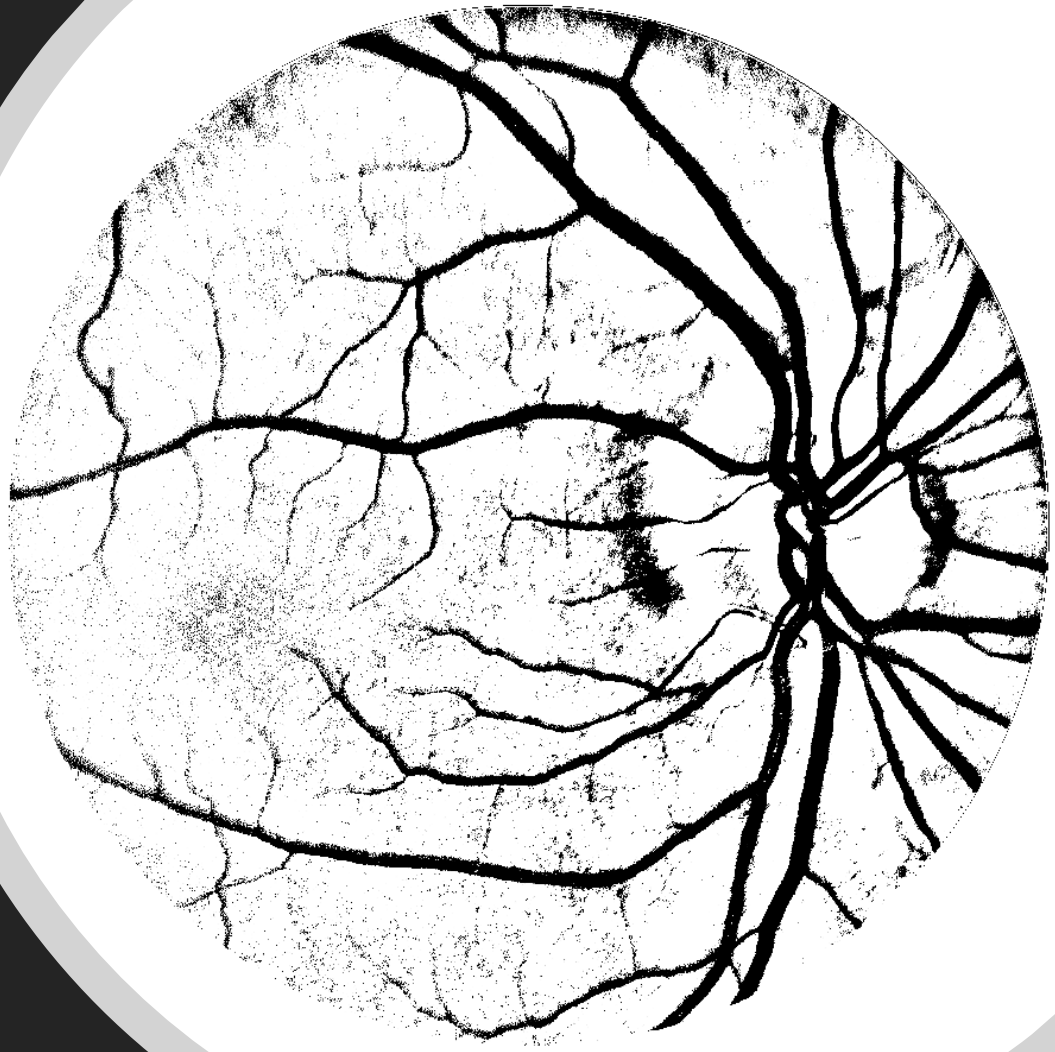
TYPES

- Four basic types of images:
  - Binary
  - Grayscale
  - True color (red-green-blue)
  - Indexed

TYPES - BINARY

- Each pixel is black or white
- What is the maximum storage for each pixel?
- Applications?

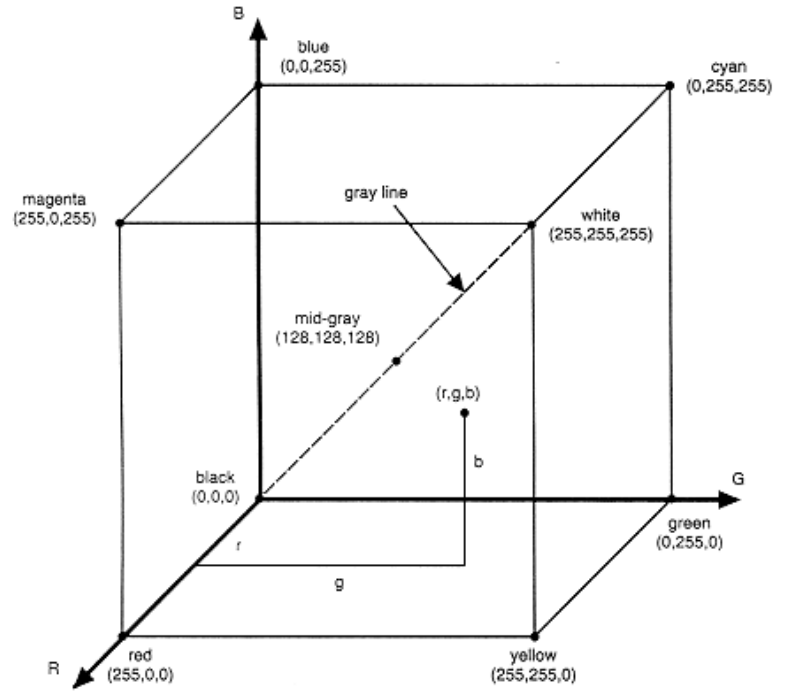


TYPES: GRAYSCALE

- Normally from 0 (black) to 255 (white)
- Represented by 8 bits (1 byte)
- 256 gray levels are enough for recognition of most natural objects.

TYPES: COLOR

- Hardware generally delivers or displays color via RGB model (red, green, and blue).
- Each pixel associated with a 3d vector (r,g,b)

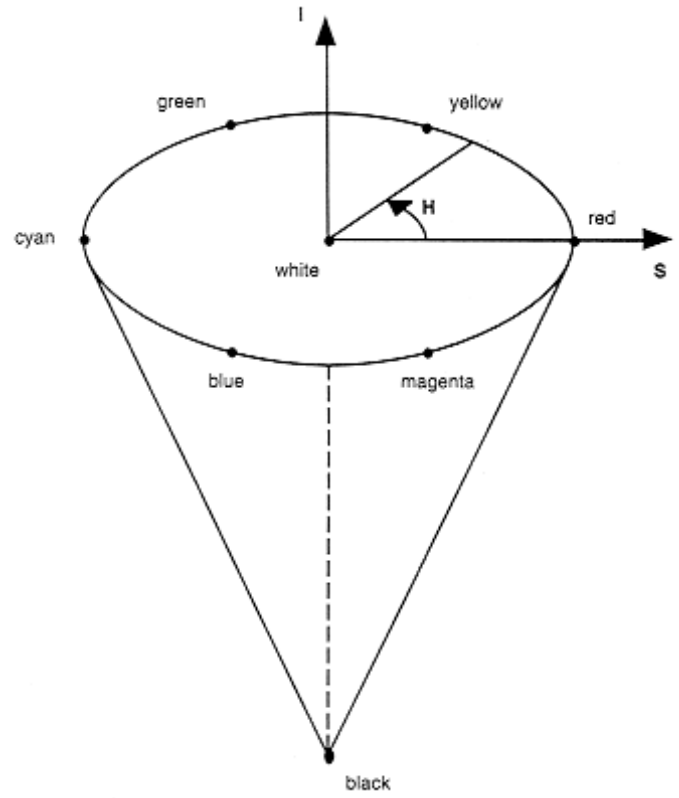


TYPE: COLOR (CON'D)

- Another model most relevant to image processing is HIS – hue, saturation and intensity.
- Hue: perceived color (the dominant wavelength)
- Saturation: dilution by white color , e.g. light purple, dark purple, etc.
- Intensity: brightness
- This model is closer to human perception.

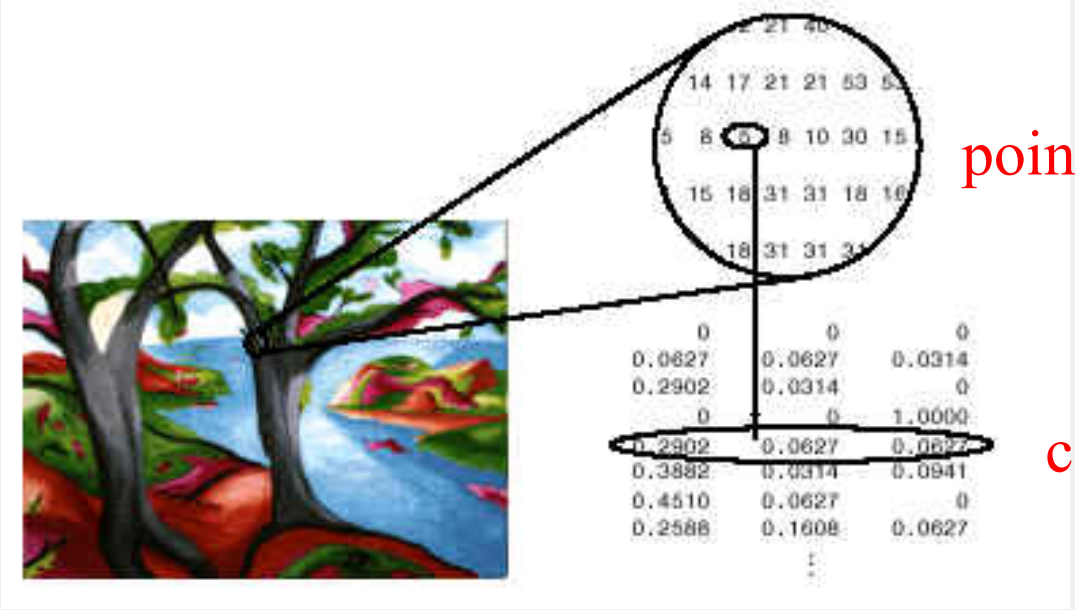
TYPE: COLOR (CON'D)

- Central axis for intensity
- The circle for hue, determined by the angular location
- Saturation is the distance perpendicular to the intensity axis.
- Can easily perform RGB<->HIS.



TYPES: INDEXED

- If using 0-255 for each color channel, there are 2553=16,777,216 (about 16 million)
- Normally, only a small subset of the colors is needed => wasting of space
- Solution: color map or color pallette (color values stored in the colormap)



SWITCHING IMAGE REPRESENTATION

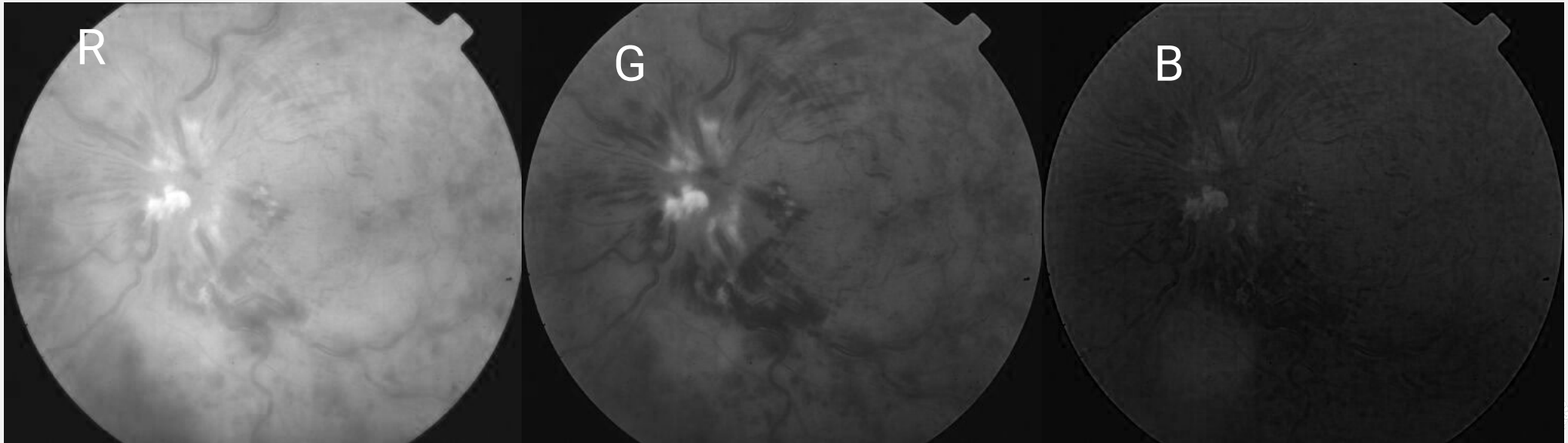
- RGB to grayscale
  - Taking the average

$$I_{grey}(p) = \frac{I_R(p) + I_G(p) + I_B(p)}{3}$$

where I_R, I_G and I_B are red, green and blue channels, respectively.

  - Using channel mixer (different % for the 3 channels)
  - Taking only one channel

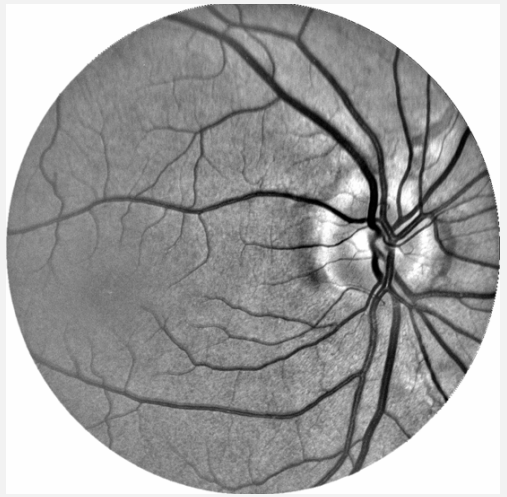
EXAMPLE

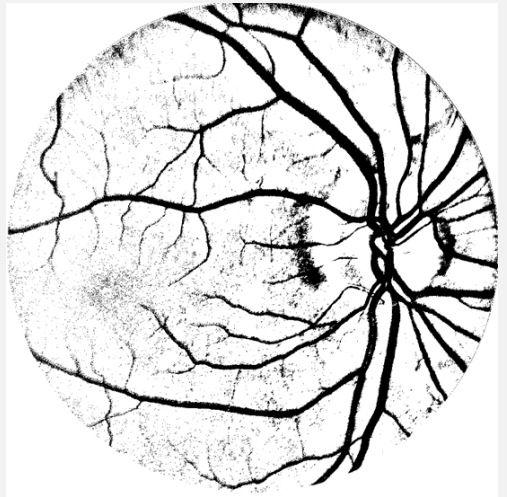


SWITCHING IMAGE REPRESENTATION

- Going from greyscale to binary
  - Simplest way is to apply a threshold d

$$I_{bin}(p) = \begin{cases} 1 & \text{if } I_{grey}(p) \geq d \\ 0 & \text{otherwise} \end{cases}$$





  - Problem:
    - Throws away information
    - Threshold must generally be chosen by hand
    - Not robust: different thresholds usually required for different images.
  - (Will discuss more possibilities later in the course)

MATLAB

- To read an image

```
w=imread('hello.tif');
% The image is now stored in a matrix w of
% size height x width of image hello.tif
```

- To display an image

```
figure;       % creates a figure on the screen
imshow(w);    % display matrix as an image
pixelval on;  % turns on the pixel values
```

MATLAB (CON'D)

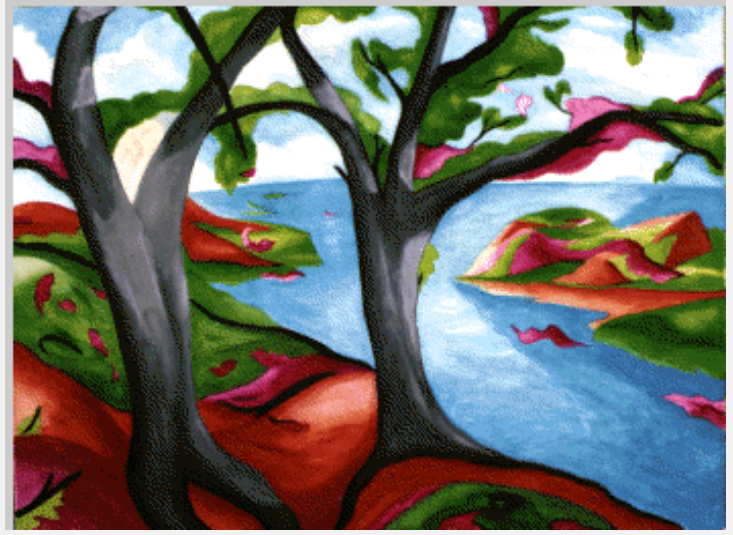
- Grayscale image: r x c matrix
- Color image: r x c x 3 matrix (3 for 3 channels)
  - e.g. w(:,:,1) is the image of the red channel
- Indexed color image: two matrices
  - color map and
  - Index to the color map

```
[em,emap]=imread('emu.tif');
figure, imshow(em,emap), pixval on;
```

- Functions for converting images

MATLAB: EXAMPLE

```
[i,map] = imread('trees.tif');
imshow(i);
i1 = ind2rgb(i,map);
figure;  imshow(i1)
i2= ind2gray(i,map);
figure;  imshow(i2)
i3 = im2bw(i,map,0.5);
figure;  imshow(i3)
```



MATLAB: EXAMPLE (CON'D)

```
>> whos
  Name        Size                Bytes  Class

  i         258x350                90300  uint8 array
  il        258x350x3            2167200  double array
  i2        258x350               722400  double array
  i3        258x350                90300  uint8 array (logical)
  map       256x3                   6144  double array

Grand total is 542568 elements using 3076344 bytes
```

Please note, class double has range [0,1], and class uint8 has range [0,255].

DIGITAL IMAGE FORMATS

- From *compression* point of view, there are effectively two kinds of image formats, uncompressed and compressed
  - **Uncompressed images** take the most disk space (like TIFF, BMP)
  - **Compressed images** have another two kinds of format, known as lossy and loss-less (meaning image data is lost during the compression process)

FORMAT: JPEG

- JPEG: Joint Photographic Experts Group.
  - You can often have the dramatic reductions in file size offered by JPEG: with little or no loss of image quality (depending on the characteristics of the image).
- The target of the JPEG format was quite specific:
  - The subject matter best suited for JPEG compression are the types of images found in nature, with lots of colour gradients and few sharp edges.
  - Image elements with sharp edges, such as typefaces and line art are poor subjects for JPEG compression.
  - Water, sky and skin can be generously compressed with the minimum of loss and retain their rich, true colours.

FORMAT: JPEG (CON'D)

- One of the important characteristics of human visual perception discovered is :

  We perceive small changes in brightness more readily than we do small changes in colour.

- It is this aspect of our perception that the JPEG committee exploited when they designed the compression standard.

FORMAT: JPEG (CON'D)

- JPEG format converts RGB (red, green, blue) value to luminance (brightness) and chrominance (hue+saturation).
  - This allows for separate compression of these two factors. JPEG attempts to maintain brightness and contrast information (which the human eye is sensitive to) at the expense of colour information.

JPEG: EXAMPLE

FORMAT: BMP

- Microsoft Windows bitmap
- It is platform-dependent, but the near ubiquity of the Windows platform makes it widely understood by programs on other systems.
- Unlike most other bitmapped formats, BMP only supports a simple form of lossless compression, and BMP files are usually stored uncompressed, thus are large files.
- It is a common default file format for images on Windows applications, but is less commonly used in the professional print industry because of the early dominance of Macintosh in this industry.

FORMAT: GIF

- GIF: Graphics Interchange Format
  - was originally developed by CompuServe
  - Designed to facilitate the exchange of raster image information
  - GIF is nominally a lossless compression scheme; for greyscale images, it truly is lossless

- GIF works only on indexed colour images, and a huge amount of information is lost.
  - When you convert a 24-bit colour image to 8-bit indexed colour you go from a possible 16.7 million colours to a mere 256.

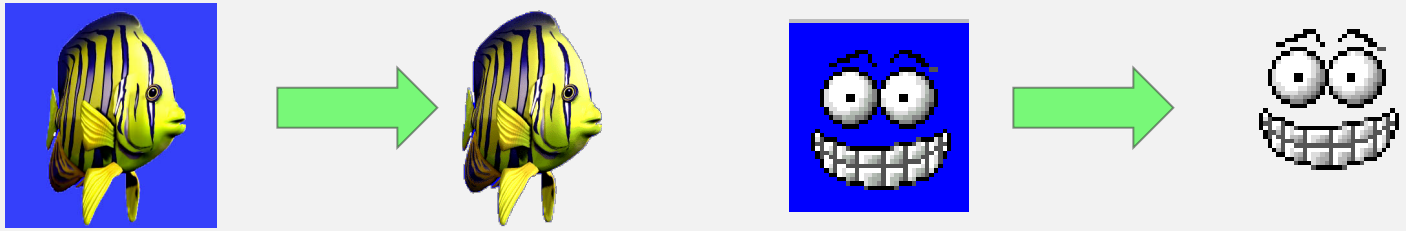
FORMAT: GIF (CONT)

- GIF has some advantages
  - It's a de facto standard, supported by every graphical Web browser.
  - If you use GIF, you can expect that everyone will be able to download your image everywhere.

FORMAT: GIF (TRANSPARENCY)

- GIF is also a widely adopted format that lets you use transparent pixels in you images, which allows for the specification of one of the colours in the palette to be ignored while processing the image for your display device.

- Transparent GIFs are commonplace on the web.
  - Using transparency, you can create images that seem to merge with or overlay the existing background, giving the illusion that the graphic is not rectangular (even though it really is).



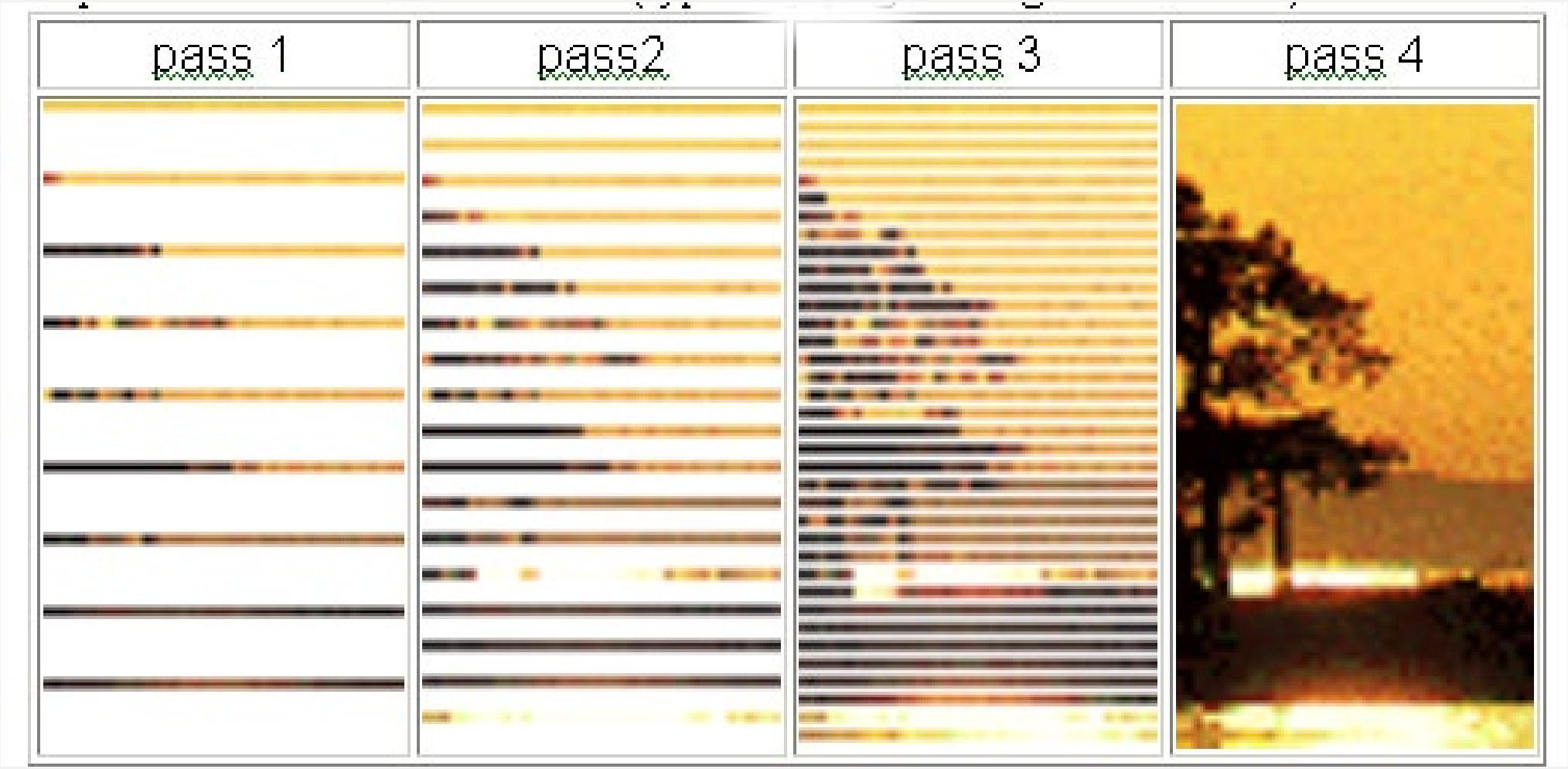
http://www.htmlgoodies.com/tutors/transpar.html

FORMAT: GIF (INTERLACING)

- GIF supports interlacing
  - The images on your page to appear more quickly, albeit at an initially low quality, in order to keep your viewer interested.
  - Physically, an interlaced GIF just has the scan lines stored in an unusual order:
    - the first pass has pixel rows 1, 9, 17, ...1+8n (every eighth row)
    - the second pass has rows 5, 13, 21, ... 1+4n (every remaining fourth row);
    - the third pass has rows 3, 7, 11, 15, ... 3 + 4n (every remaining odd-numbered row);
    - the last pass has rows 2, 4, 6, ...2n (every remaining even-numbered rows).

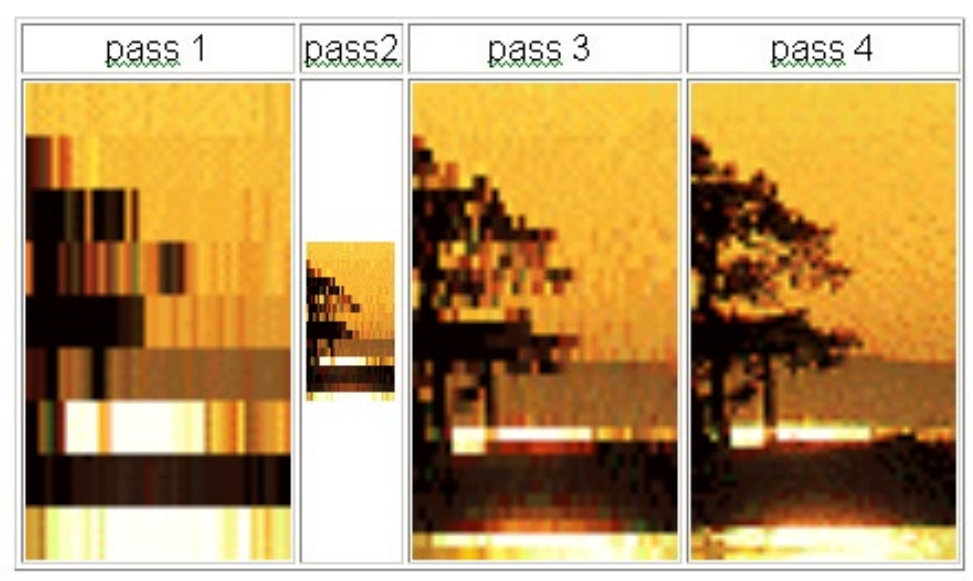
- How the browser chooses to display this is up to the browser

FORMAT: GIF (CON'D)



FORMAT: GIF (CON'D)

- Netscape and Explorer draw each incoming row several times, to fill not only its assigned place but also the immediately following not-yet-received rows. So the first few rows are big blocks which get overwritten progressively:
  - scan 1 fills 1 to 8 with scan line 1 data and then 9 to 16 with 2.
  - scan 2 fills 5 to 8 with scan line 2 data and then 13-16 with 2
  - scan 3 fills 3 and 4 with scan line data and then 7-8 with 2
  - scan 4 overwrites 2, 4, 6 ....



FORMAT: GIF (CON'D)

- The GIF89a specification add a few enhancements to the file header which allows browsers to display multiple GIF images in a timed and/or looped sequence.
- Netscape and I.E. both support GIF animation. There are many freeware tools for creating GIF animation.

FORMAT: GIF (CON'D)

- The process is actually very simple:
  - First create a series of frames
  - which contain the same image
  - Each frame is modified
  - according to a plotted timeline
  - Construct a multi image GIF file
  - with the desired delay between image
- http://www.htmlgoodies.com/tutors/animate.html

FORMAT: TIFF

- TIFF: Tagged Image File Format
- More general than GIF
- Allows 24 bits/pixel
- Supports 5 types of image compression including
  - RLE (Run length encoding)
  - LZW (Lempel-Ziv-Welch)
  - JPEG (Joint Photographic Experts Group)

FORMAT: PNG

- PNG: Portable Network Graphics
- A replacement for GIF: supporting grayscale, true color and indexed images.
- Support alpha channels, which are ways of associating variable transparencies with an image.
- Support gamma correction, ensuring same image appearance, independent of computer display system.

FORMAT: PGM

- P2 means ASCII gray; P5 means binary gray image Comments
- W=16; H=8
- 192 is max intensity
- Can be made with editor

An example of a PGM file of type "P2" is given below

```
P2
# sample small picture 8 rows of 16 columns, max gray value of 192
# making an image of the word "Hi".
  16 8   192

 64 64  64  64  64  64  64  64  64 64 64  64  64 64 64 64
 64 64 128 128  64  64  64 128 128 64 64 192 192 64 64 64
 64 64 128 128  64  64  64 128 128 64 64 192 192 64 64 64
 64 64 128 128 128 128 128 128 128 64 64  64  64 64 64 64
 64 64 128 128 128 128 128 128 128 64 64 128 128 64 64 64
 64 64 128 128  64  64  64 128 128 64 64 128 128 64 64 64
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```

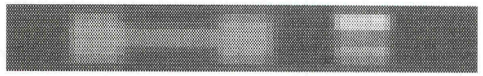

FORMAT: DICOM

- DICOM: Digital Imaging and Communications in Medine.
- An image can be a slice or a frame of a 3D object.
- A header contains size, number of slices, modality used, patient information, and compression used.

SUMMARY

- Types of images
- Simple Matlab commands related to reading and displaying of images
- File formats of images.

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