Digital Image Processing Using MATLAB

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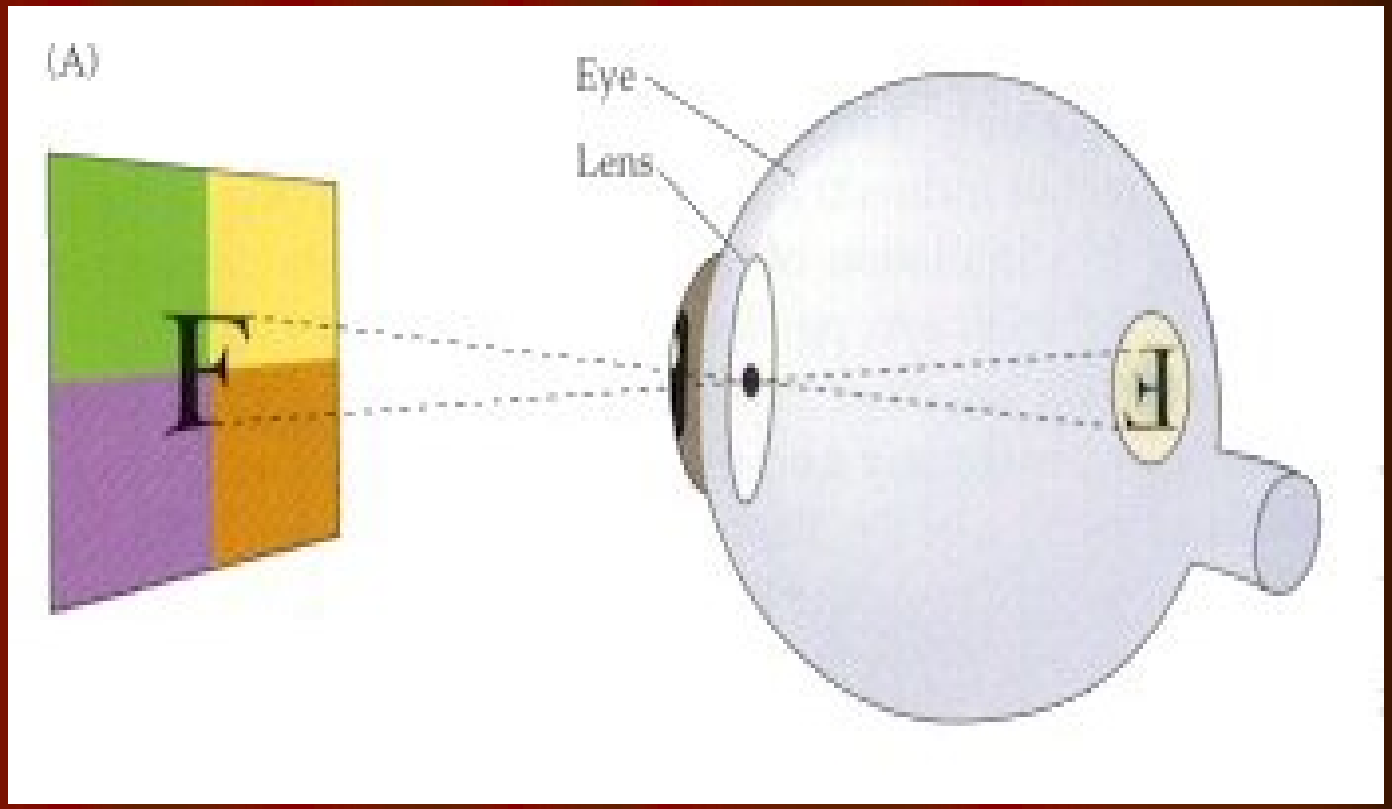
Elements of Visual Perception

- Structure of the human eye
- Image formation in the human eye
- Brightness adaptation and discrimination
- Psycho visual Effects

Image Formation



Elements of Visual Perception
Structure of the human eye

- The cornea and sclera outer cover
- The choroid
  - Ciliary body
  - Iris diaphragm
  - Lens

Elements of Visual Perception
Structure of the human eye

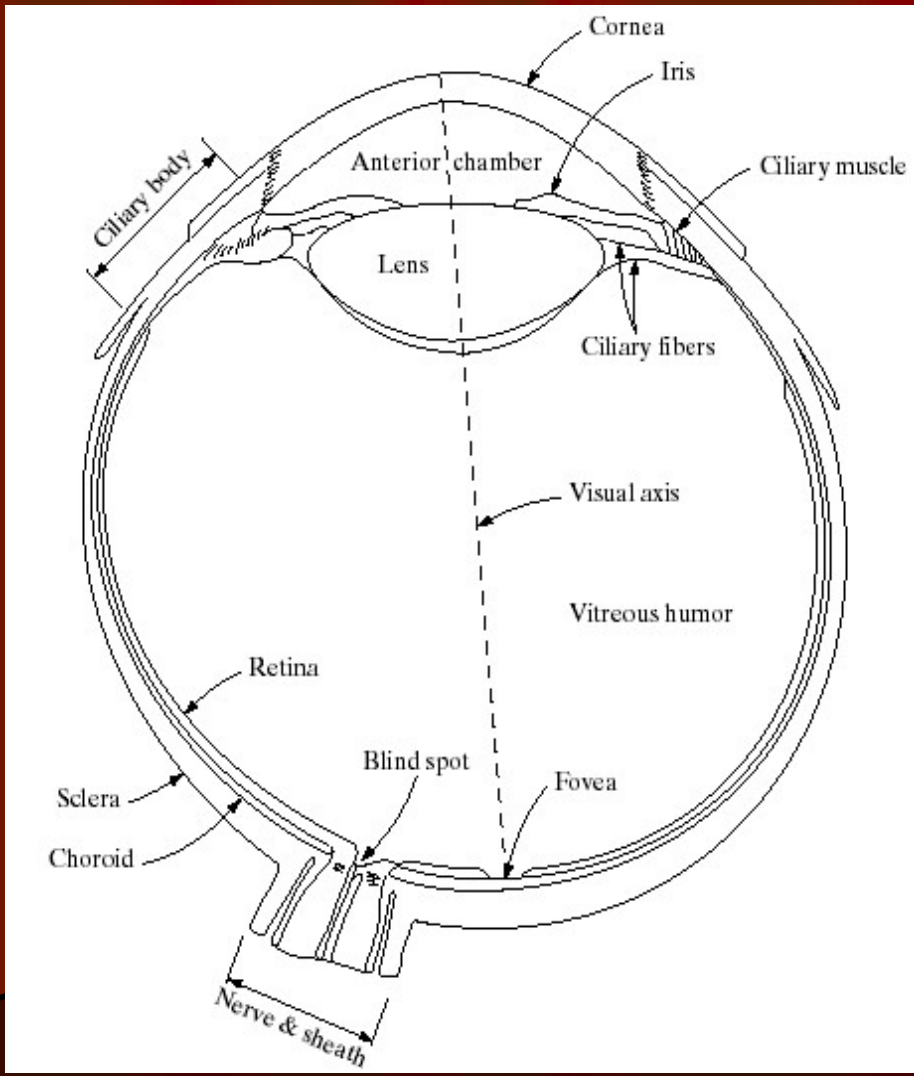


FIGURE 2.1 Simplified diagram of a cross section of the human eye.

Elements of Visual Perception
Structure of the human eye

1. The ***lens*** contains 60-70% water, 6% of fat.

2. The ***iris*** diaphragm controls amount of light that enters the eye.

3. ***Light receptors*** in the ***retina***
   - About 6-7 millions ***cones*** for bright light vision called ***photopic***
     - Density of cones is about 150,000 elements/mm^2.
     - Cones involve in color vision.
     - Cones are concentrated in ***fovea*** about 1.5x1.5 mm^2.
   - About 75-150 millions ***rods*** for dim light vision called ***scotopic***
     - Rods are sensitive to low level of light and are not involved color vision.

4. ***Blind spot*** is the region of emergence of the optic nerve from the eye.

Elements of Visual Perception
Structure of the human eye

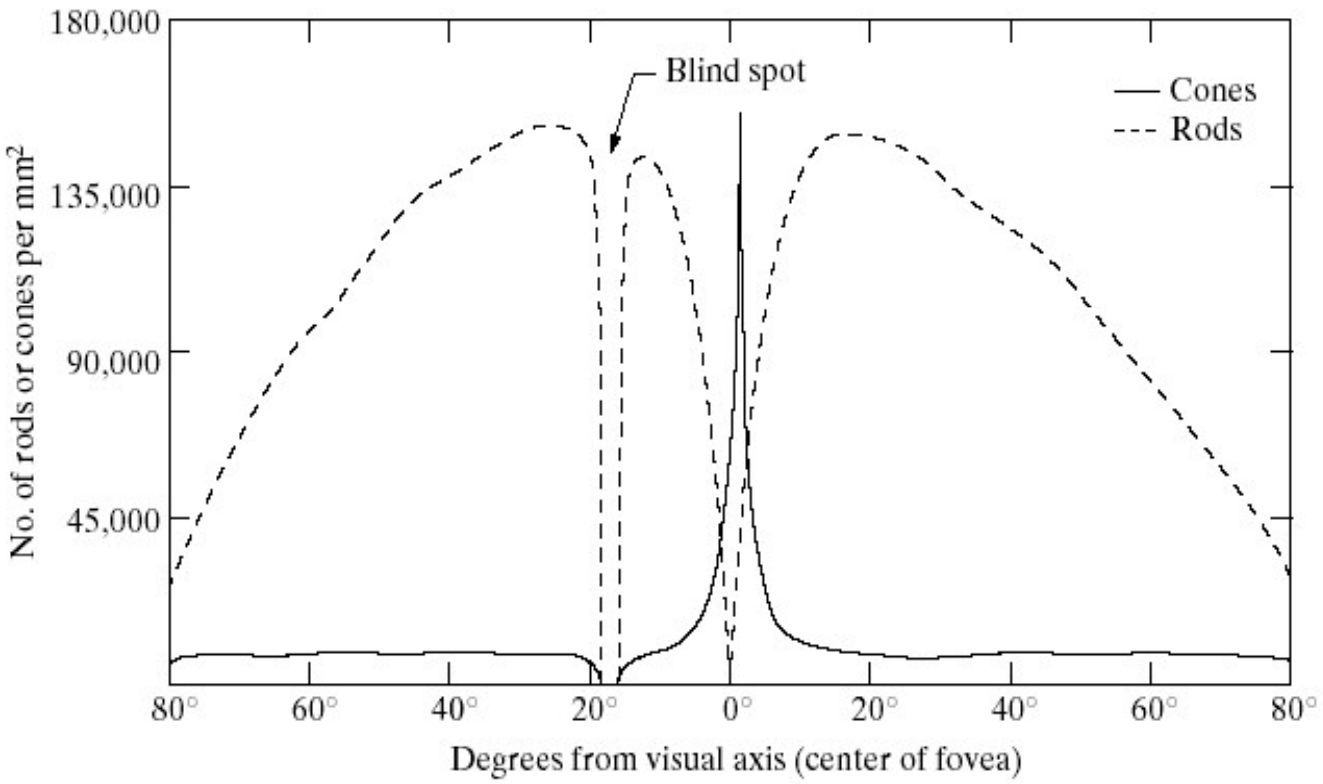


FIGURE 2.2
Distribution of rods and cones in the retina.

Elements of Visual Perception

Image formation in the human eye

- Flexible lens: the principle difference from an ordinary optical lens.
- Controlled by the tension in the fibers of the ciliary body
  - To focus on distant objects – flattened
  - To focus on objects near eye – thicker
  - Near-sighted and far-sighted

Elements of Visual Perception

Image formation in the human eye

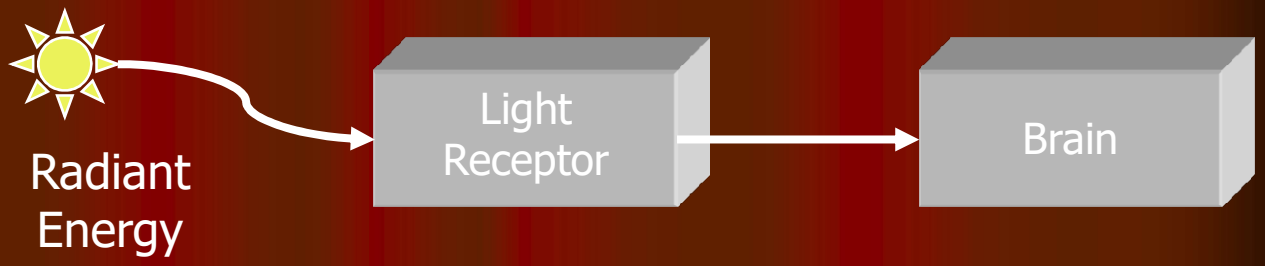
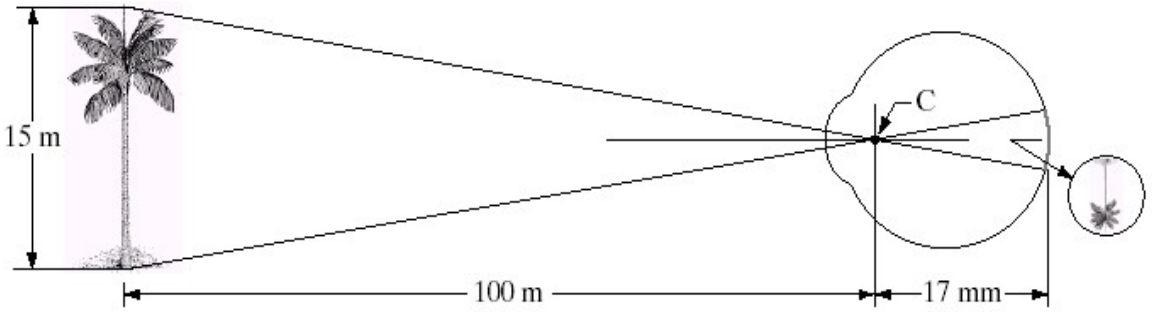


FIGURE 2.3
Graphical representation of the eye looking at a palm tree. Point *C* is the optical center of the lens.

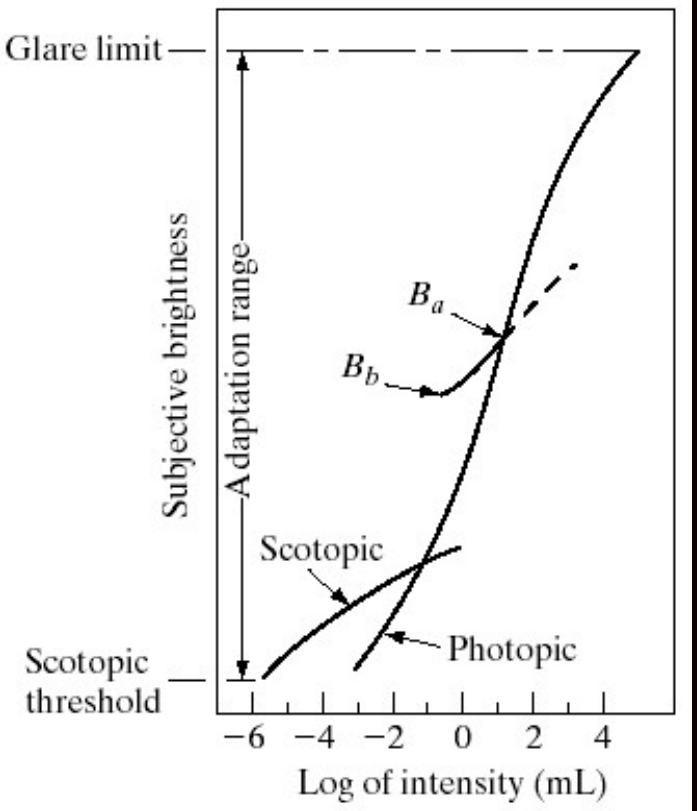


Elements of Visual Perception
Brightness adaptation

- Dynamic range of human visual system: 10^{-6}~10^{4} mL (millilambert)
- Can not accomplish this range simultaneously
- The current sensitivity level of the visual system is called **brightness adaptation level**

Elements of Visual Perception
Brightness adaptation

FIGURE 2.4
Range of subjective brightness sensations showing a particular adaptation level.

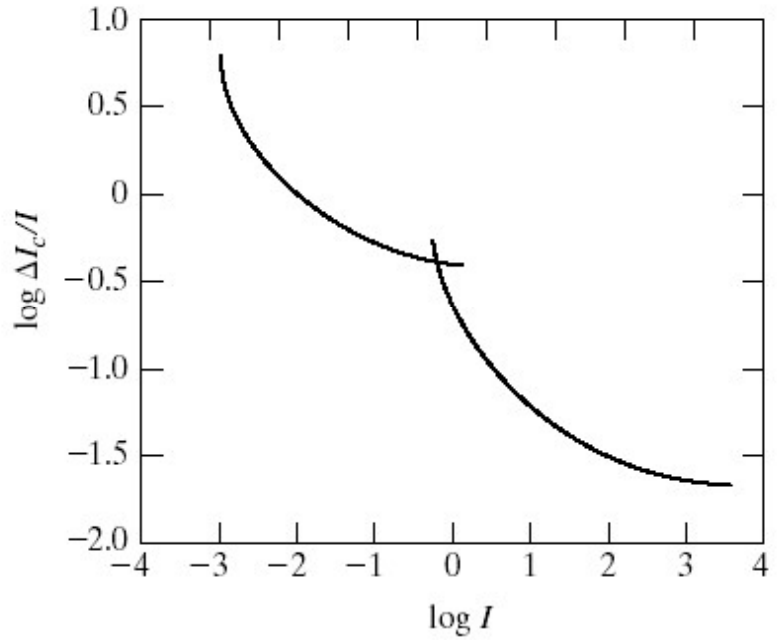


Elements of Visual Perception
Brightness discrimination

- Weber ratio (the experiment) : $\Delta I_C / I$
  - I: the background illumination
  - ΔI_C : the increment of illumination
  - Small Weber ratio indicates good discrimination
  - Larger Weber ratio indicates poor discrimination

Elements of Visual Perception
Brightness discrimination

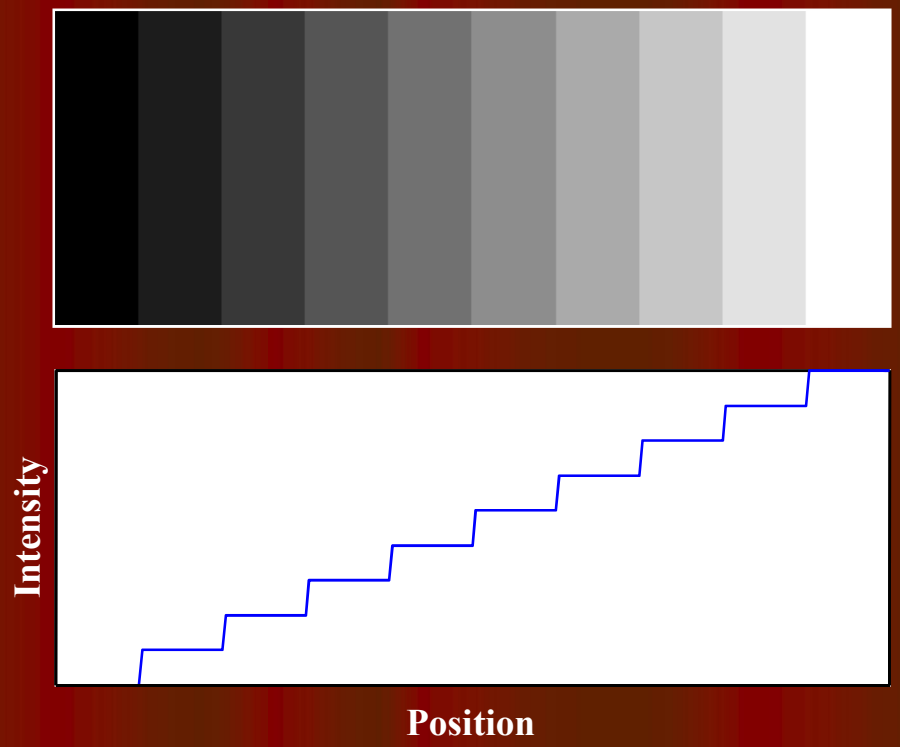
FIGURE 2.6
Typical Weber ratio as a function of intensity.



Psycho-visual effects

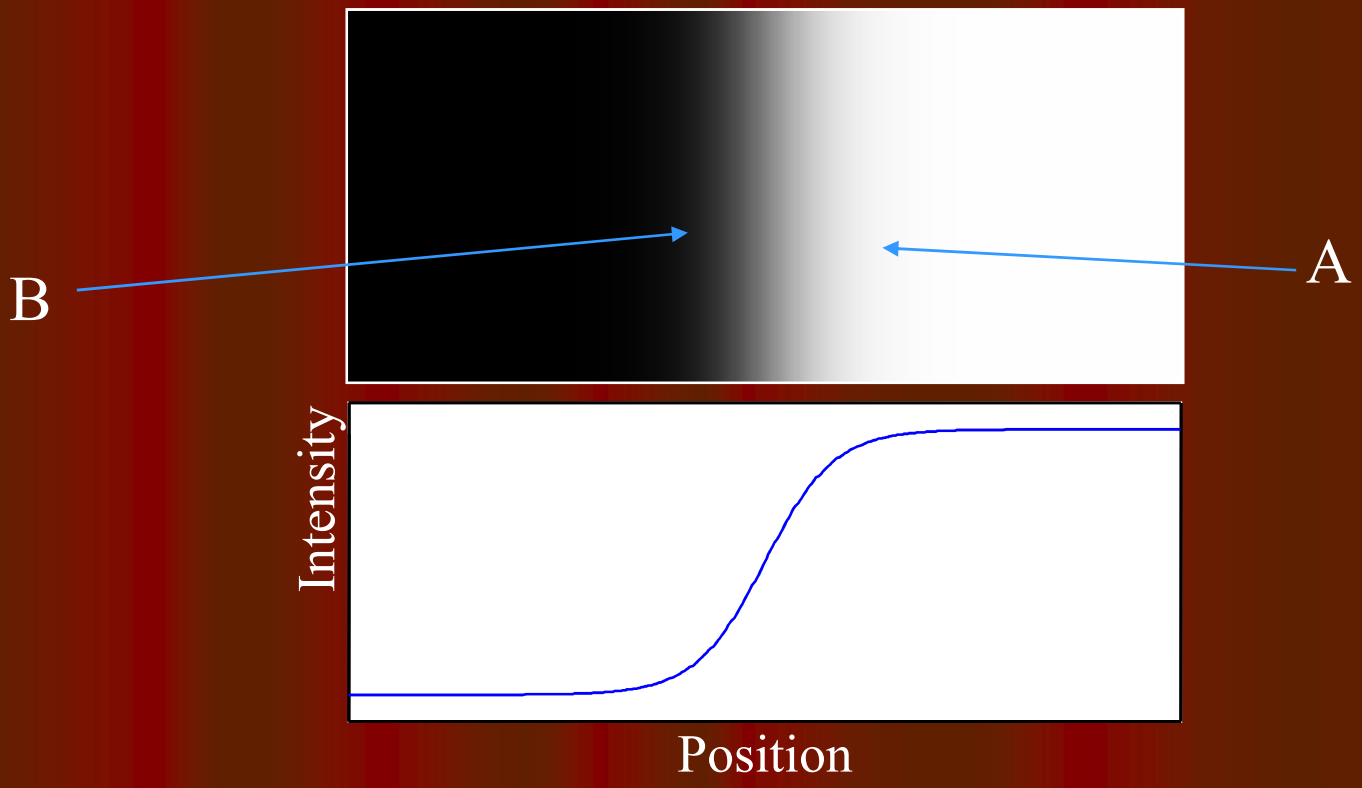
- The perceived brightness is not a simple function of intensity
  - Mach band pattern
  - Simultaneous contrast
  - Optical illusion

Mach band pattern



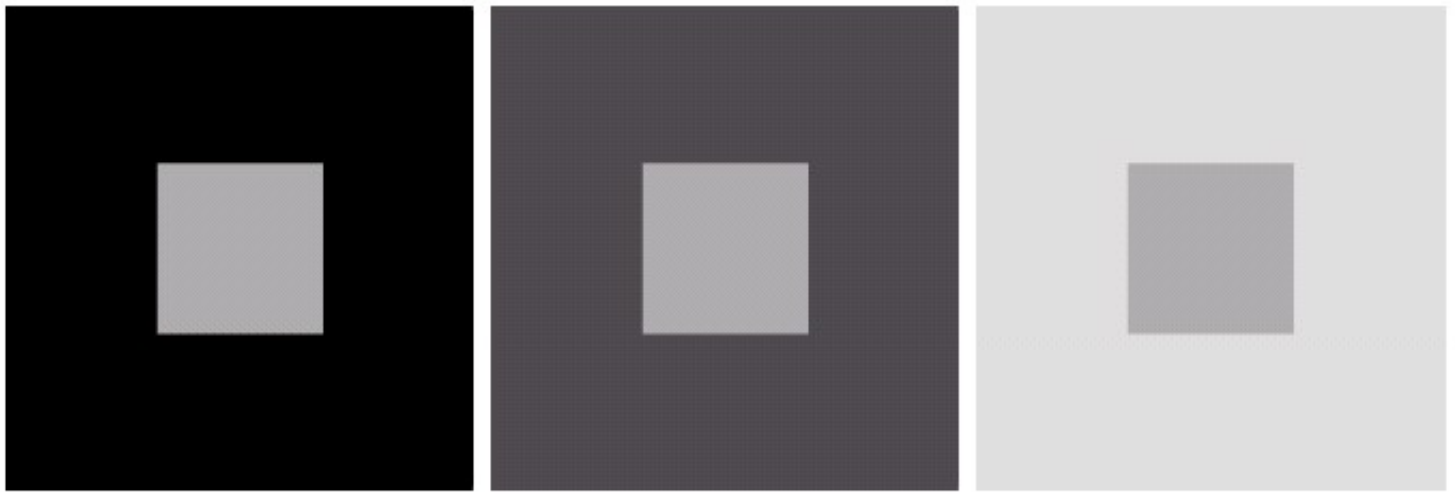
Intensities of surrounding points effect perceived brightness at each point. In this image, edges between bars appear brighter on the right side and darker On the left side.

Mach band pattern



In area A, brightness perceived is darker while in area B is brighter. This phenomenon is called ***Mach Band Effect***.

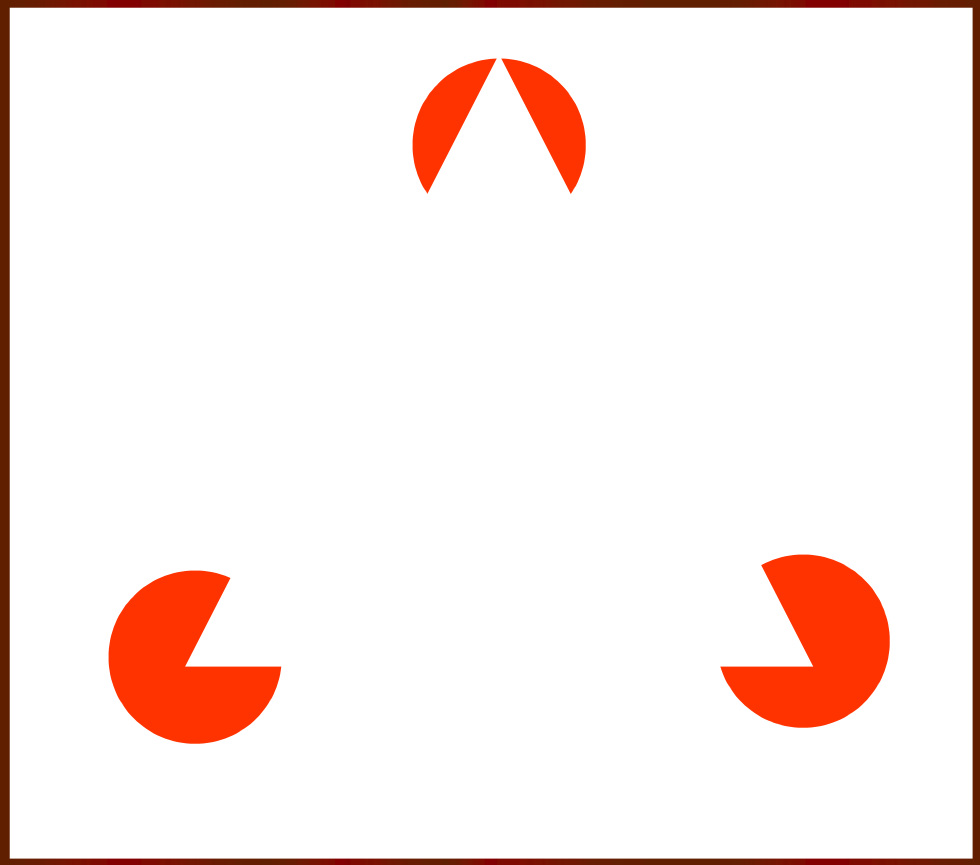
Simultaneous contrast



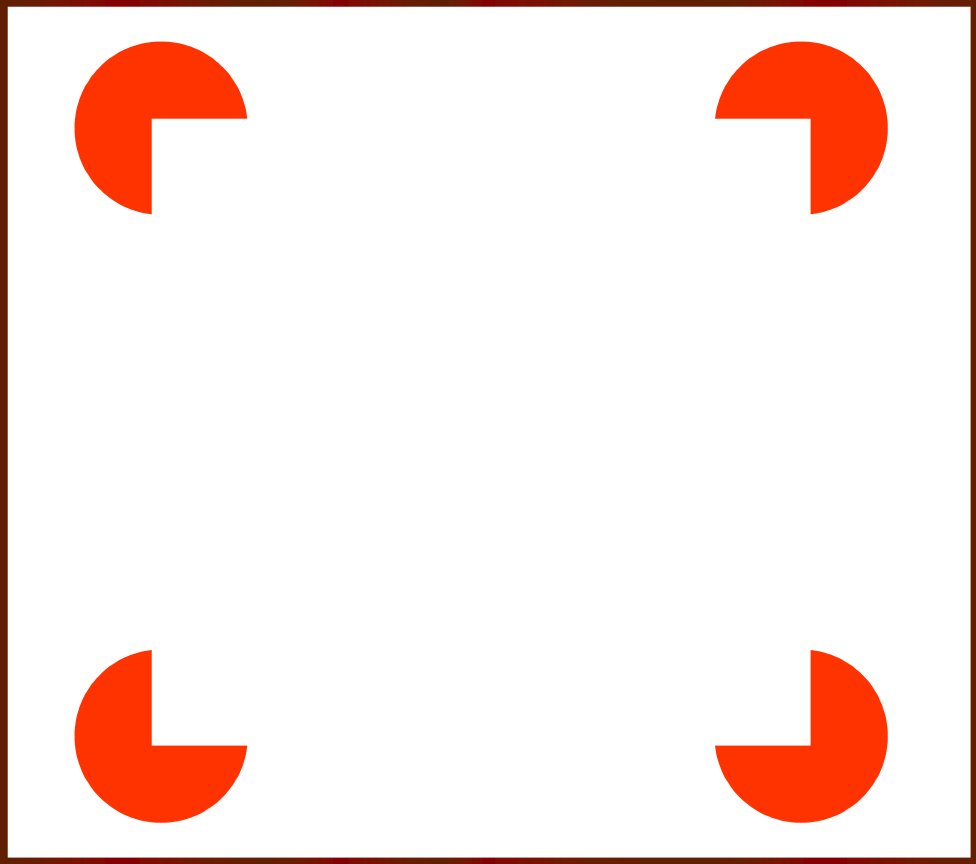
a b c

FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

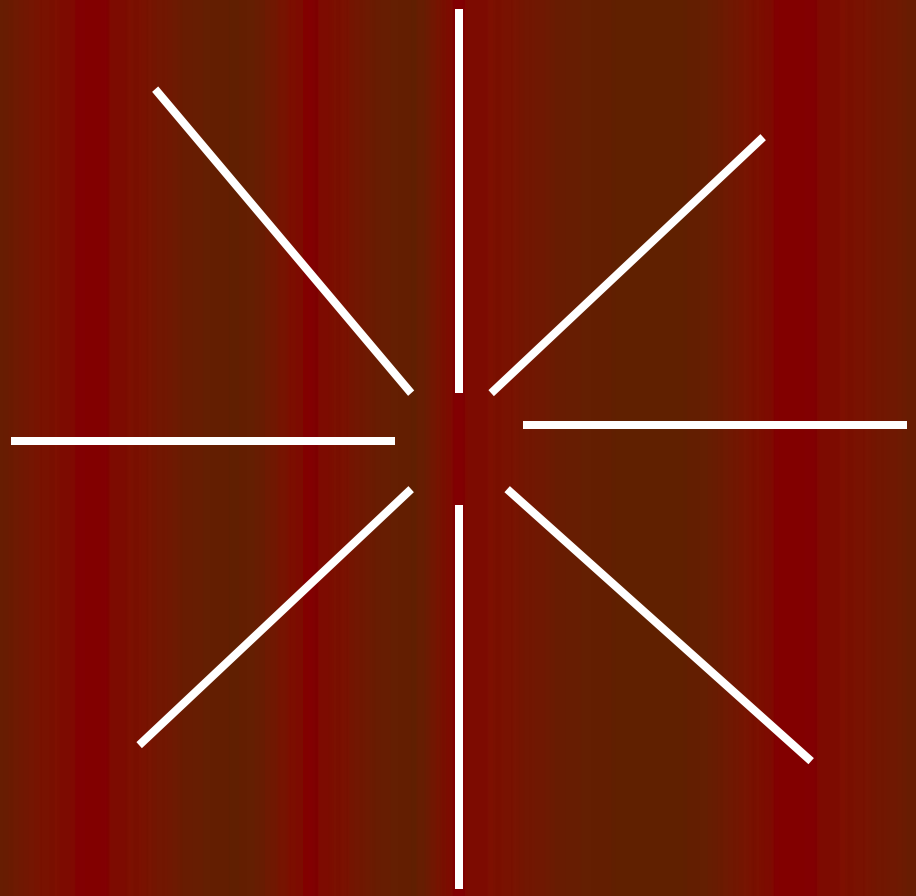
Optical illusion



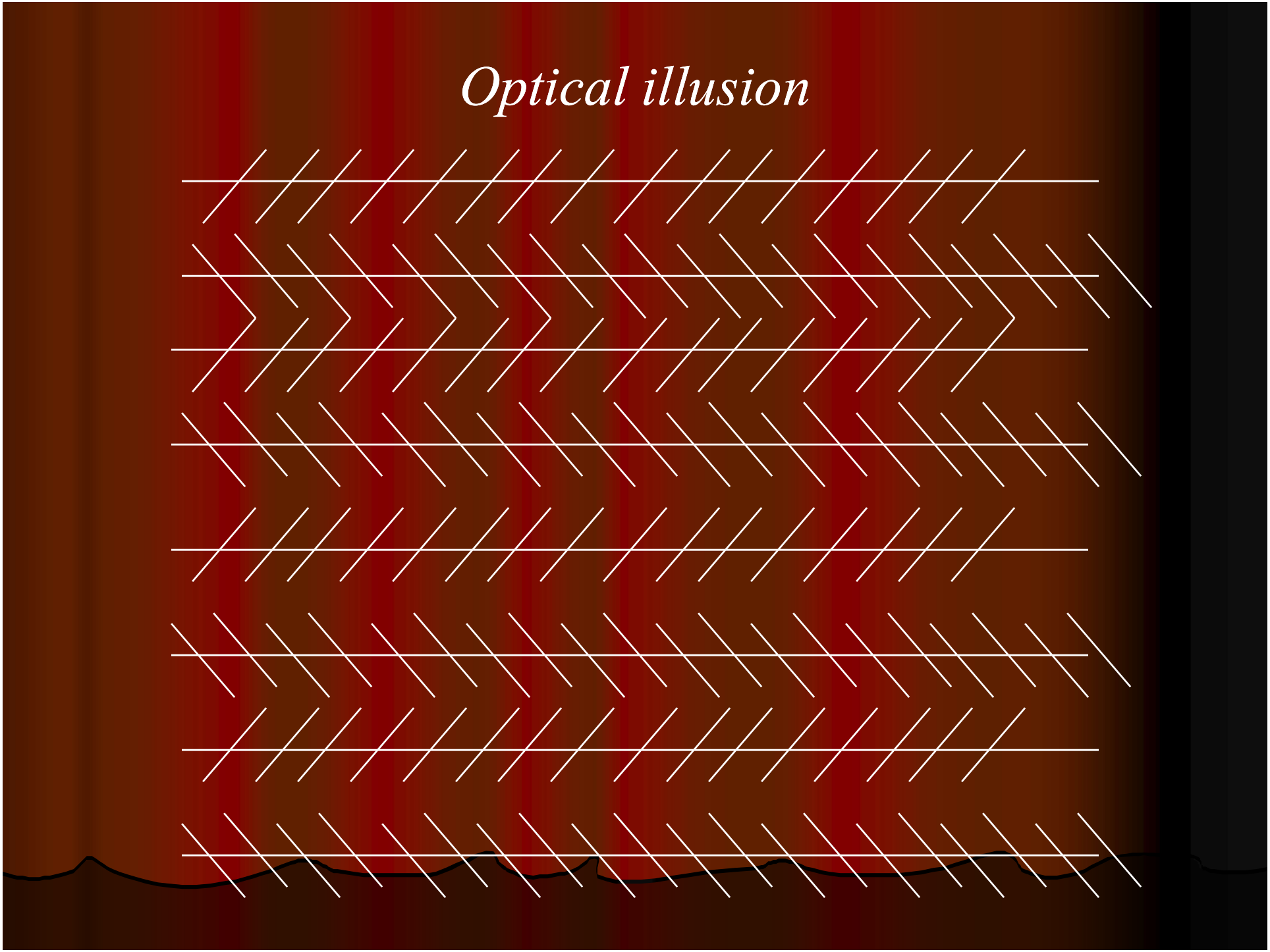
Optical illusion



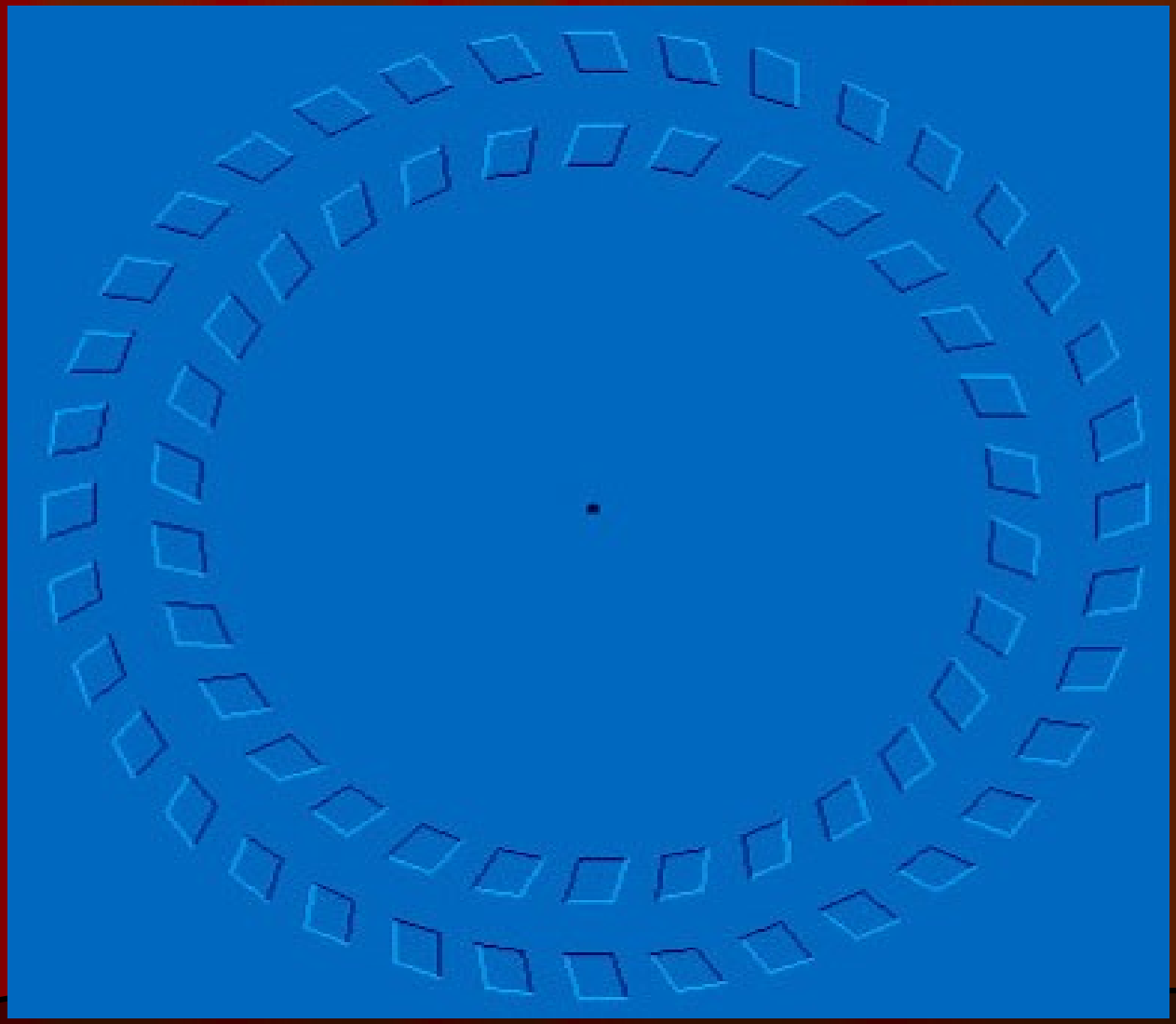
Optical illusion



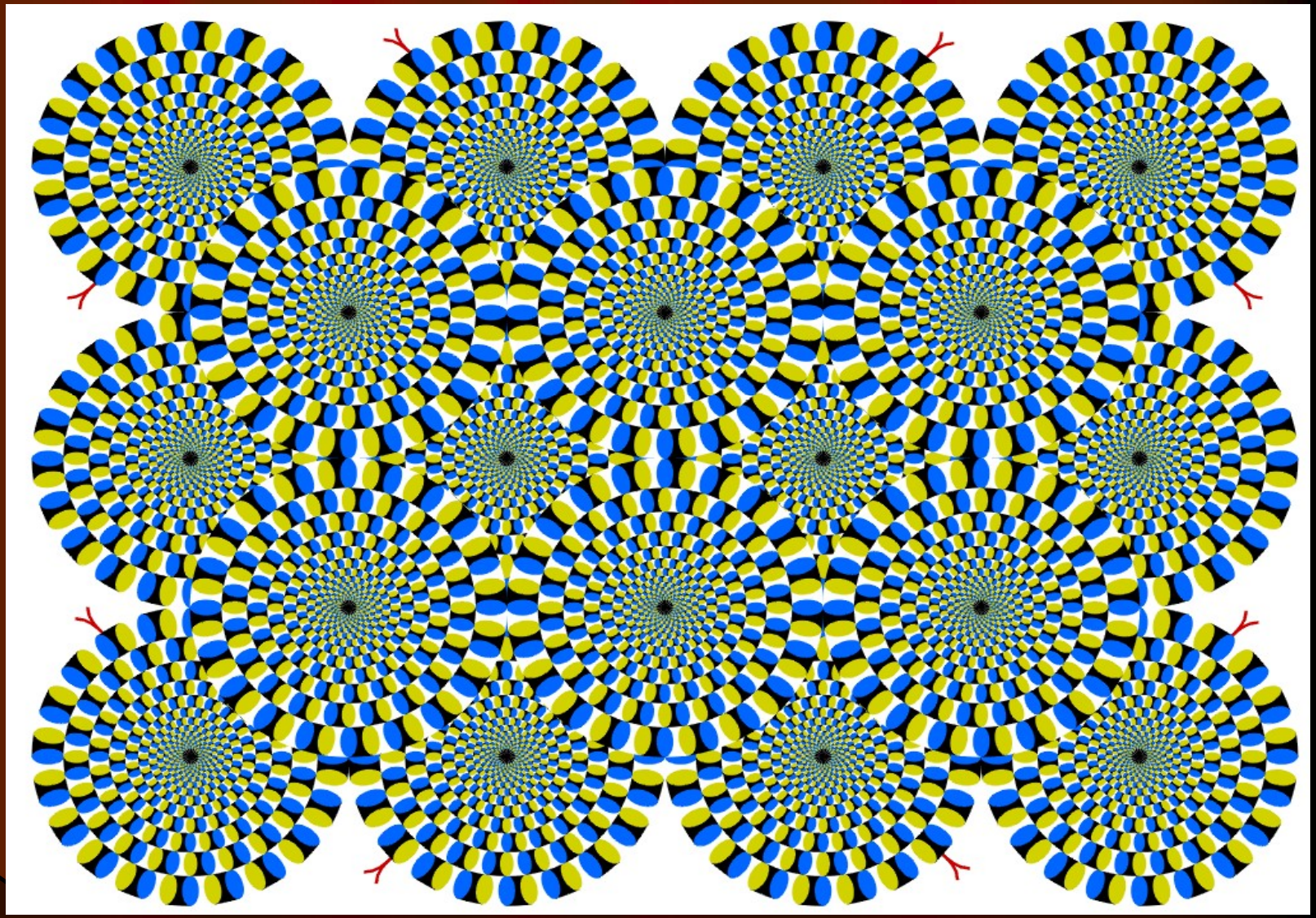
Optical illusion



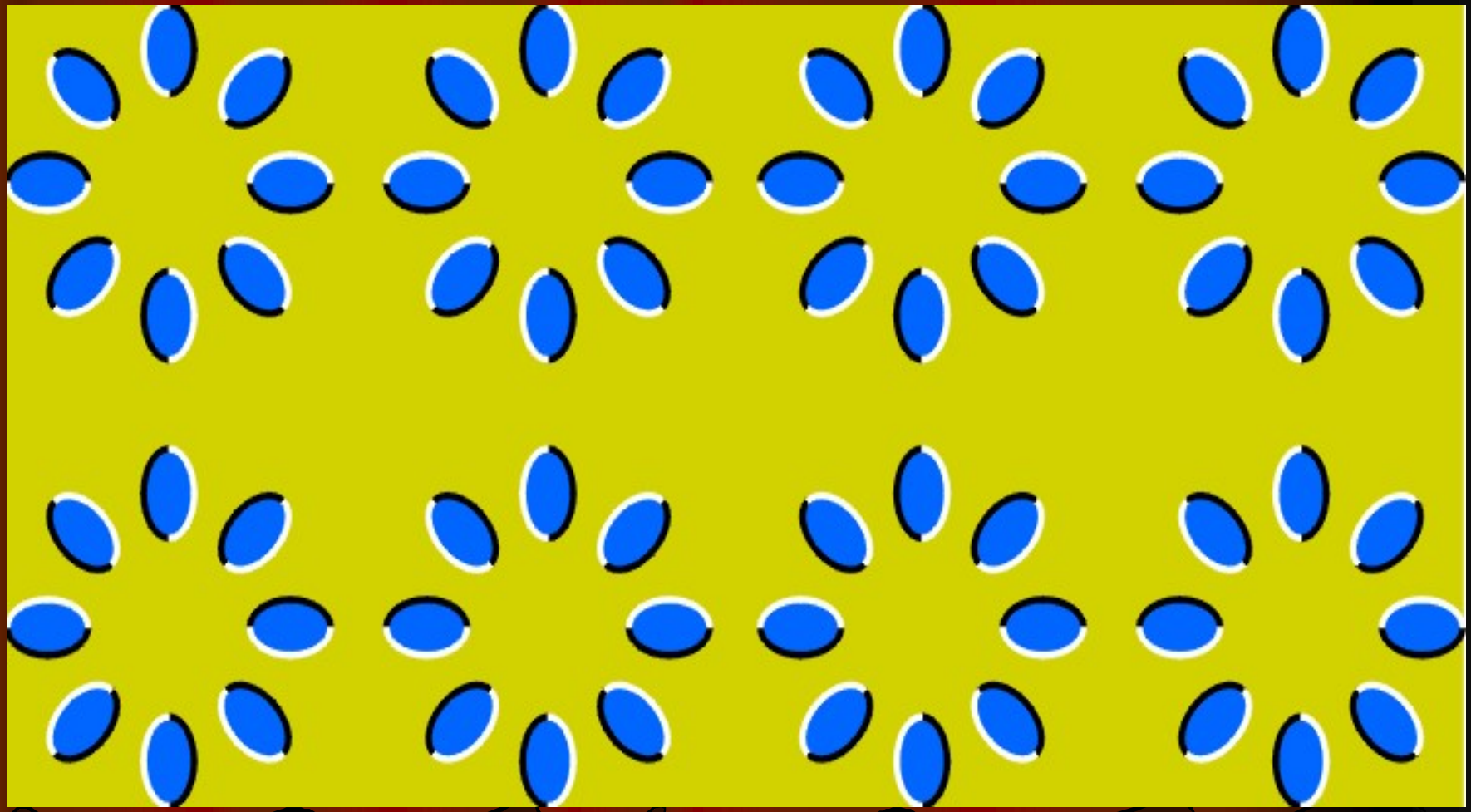
Optical illusion



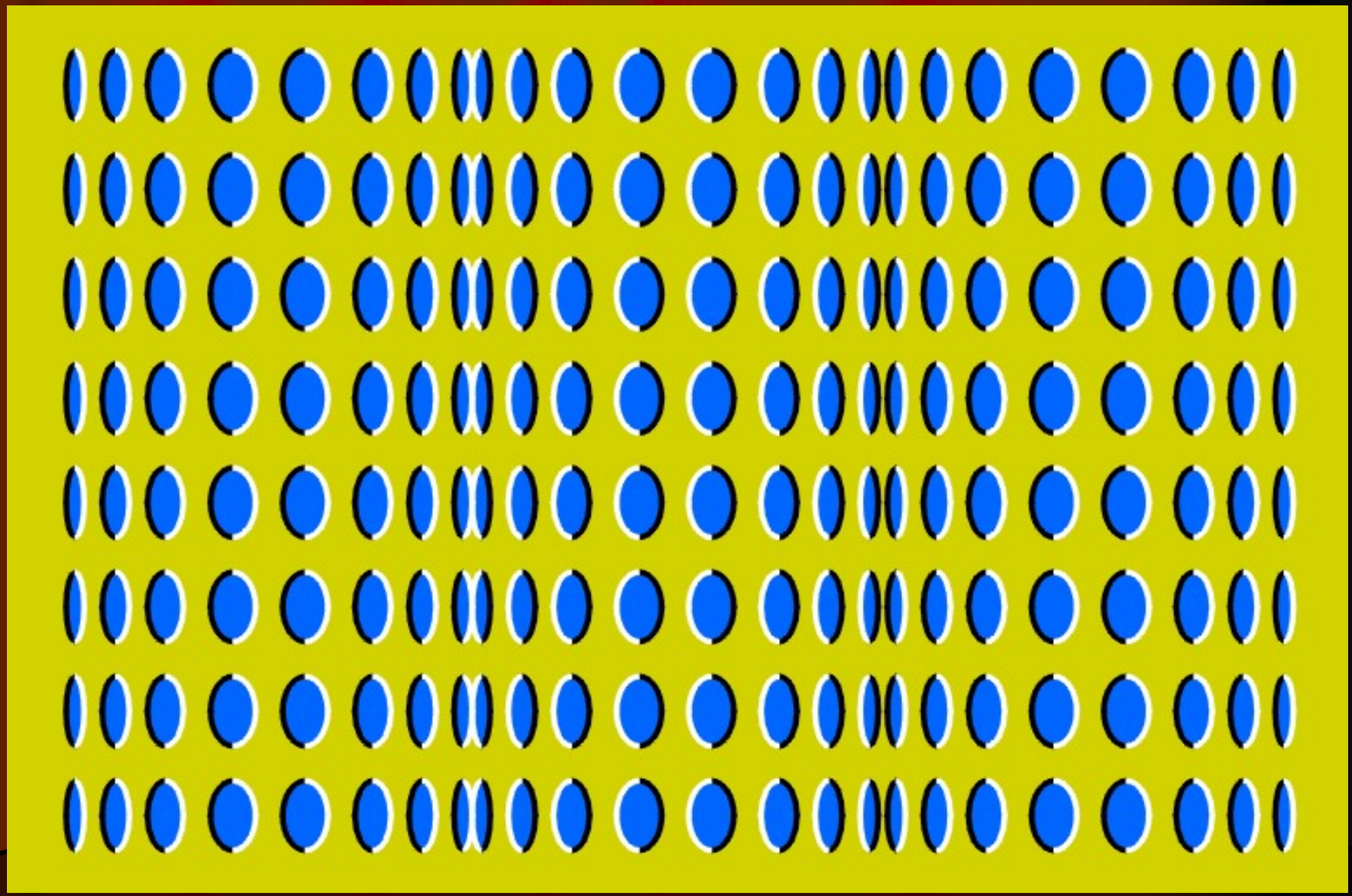
Optical illusion



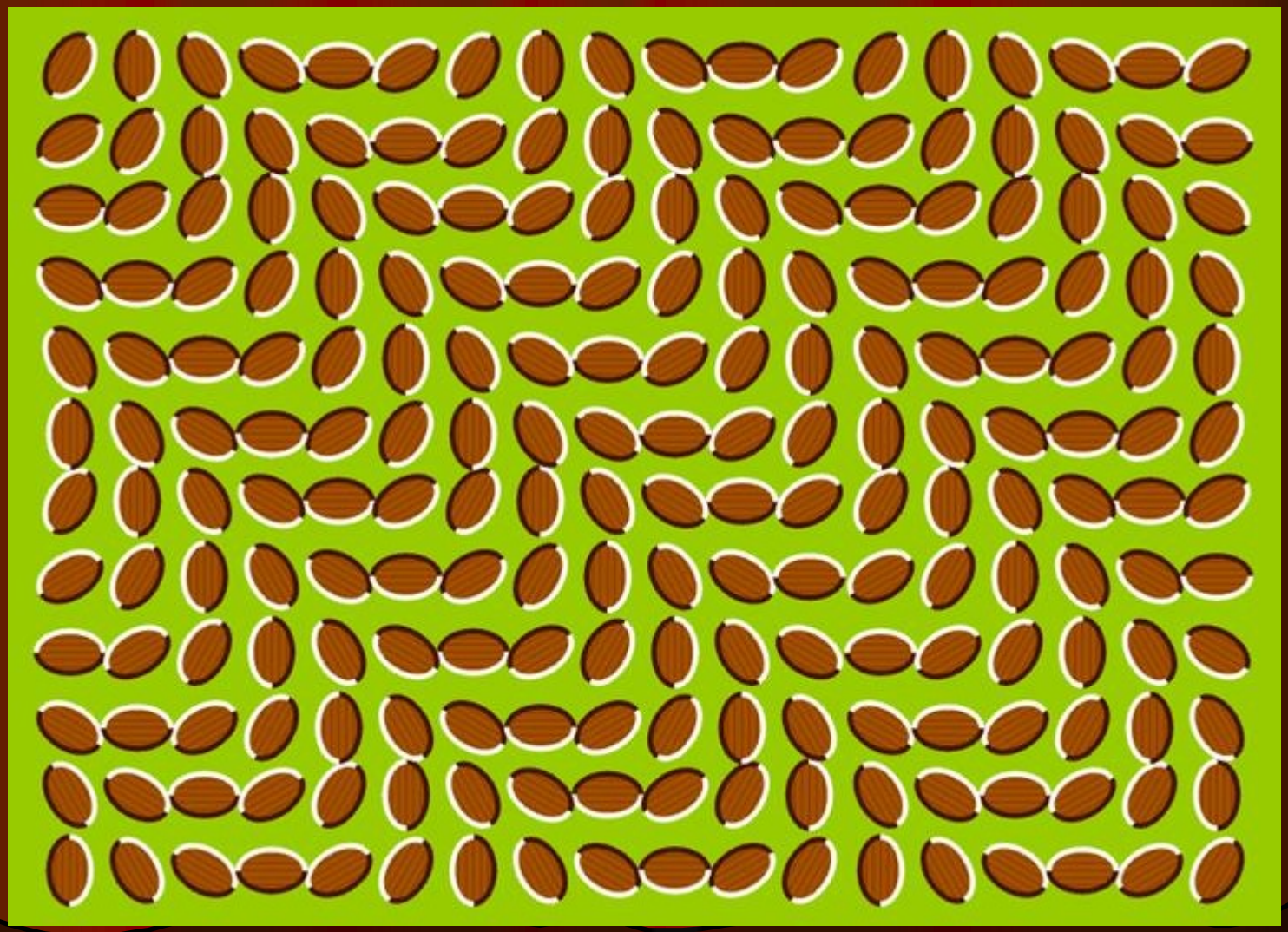
Optical illusion



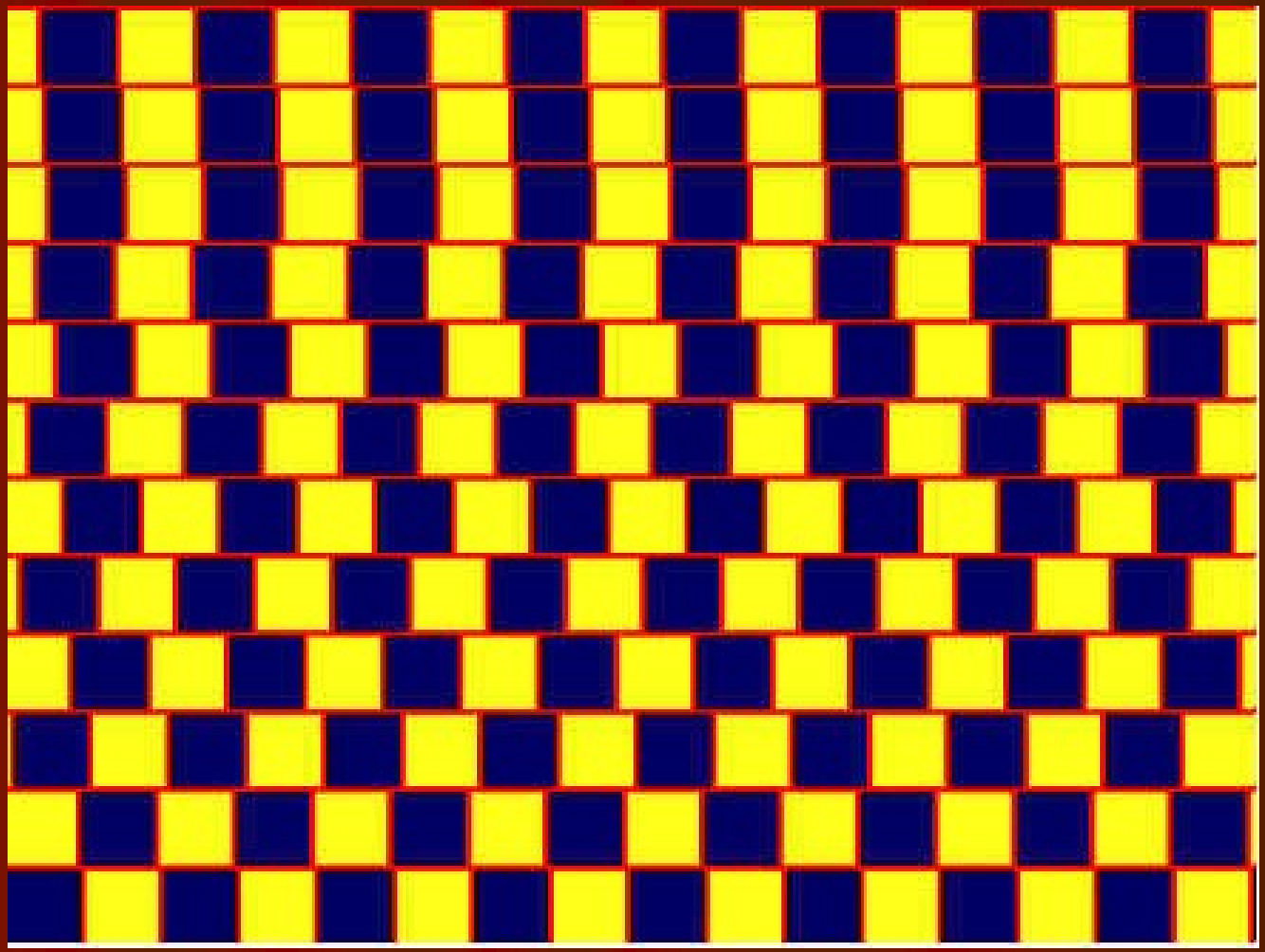
Optical illusion



Optical illusion



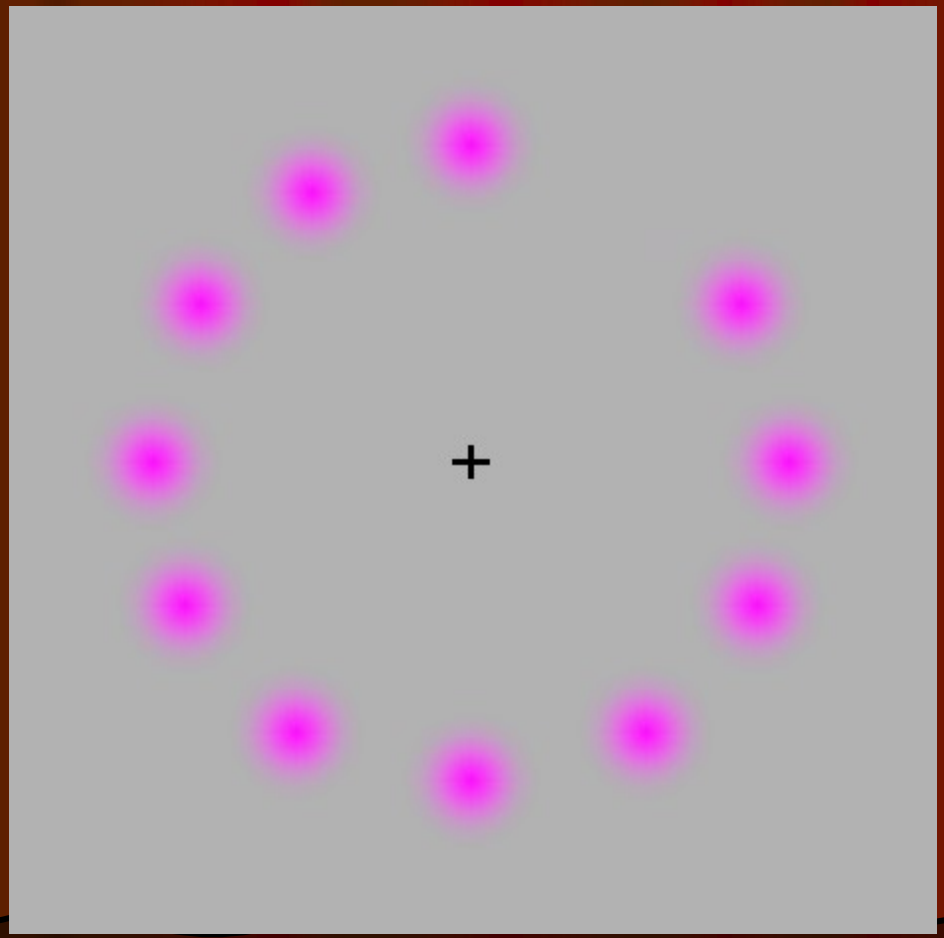
Optical illusion



Optical illusion

Optical illusion

Concentrate on the cross in the middle, after a while you will notice that this moving purple dot will turn green!



Look at the cross a bit longer and you‘ll notice that all dots except the green one will disappear.

Optical illusion

Follow the instruction below.

1) Stare at the 4 little dots on the middle of the picture for 30 seconds
2) then look at a wall near you
3) a bright spot will appear
4) twinkle a few times and you‘ll see a figure
5) What do you see? Or even WHO do you see?

Optical illusion

Image Processing Functions-I

- A = imread (filename, fmt)

  This function reads a grayscale or true color image named filename into matrix A.

  If the file contains a grayscale image, A is a 2-Dimensional array i.e. m x n.

  If the file contains a true color image (RGB) image, A is a 3-Dimensional Array i.e. m x n x 3.

  fmt indicate various possible file formats (image types) that can be opened directly in MATLAB.

Image Processing Functions-I

Format	Description
Bmp	Windows Bitmap
Ico	Windows icon resources
Jpeg	Joint Photographic Experts Group
Pcx	Windows Paint Brush
Tiff	Tagged Image file format
Png	Portable Network Graphic

Image Processing Functions-I

- imwrite (A, filename, fmt)

  This function writes the image matrix A to filename in the format specified by fmt.

  A can be grayscale image or a true color image.

  If A is of class uint8 or uint16, the function writes the actual values in the array to the file.

  If A is of class double, imwrite rescales the values in the array before writing using uint8(round(255 *A)).

  This operation converts the floating point numbers in the range [0,1] to 8-bit integers in the range [0 255].

Image Processing Functions-I

- imshow (A)

  This function displays the image matrix A.

  The function imshow (A, n) displays the image with n discrete levels of gray.

  If you omit n, imshow uses 256 gray levels on 24-bit displays or 64 gray levels on other systems.

Image Processing Functions-I

- rgb2gray (A)

  Convert rgb image to grayscale image.

  rgb2gray converts RGB image to grayscale image by eliminating the hue and saturation information while retaining the luminance (Value).

- imfinfo filename

  This gives us the information of image file like name, size, format, width, height, colortype
  etc.

- mat2gray (A)

  Converting an arbitrary array of class double to an array of class double scaled to the range [0,1].

Image Processing Functions-I

- im2double (A)

im2double takes an image as input and returns an image of class double.

If the imput image is of class double, the output image is identical to it.

If the imput image is of class uint8 or uint16, im2double returns the equivalent image of class double, rescaling the data in the range [0.1] .

If an array of class double results from the computations yield values outside the range [0,1], inputing this array into im2double will have no effect.

```
h= uint8( [ 25 50 ; 128 200]);
g = im2double(h)
g =
        0.0980        0.1961
        0.4706        0.7843
```

Image Processing Functions-I

- im2uint8(A)

Function detects the class of input data and performs necessary scaling for the toolbox to recognize the data as valid image data.

consider f of class double

f =

```
    - 0.5        0.5
     0.75        1.5
```

g = im2uint8(f)

gives

g =

```
      0        128
    191        255
```

Image Processing Functions-I

Data Class Name	Description
double	Double precision floating point numbers
uint8	Unsigned 8-bit integers in range [0,255]
uint16	Unsigned 16-bit integers in range [0,65535]
uint32	Unsigned 32-bit integers
char	Character (2 bytes per element)
logical	Values are 0 or 1 (1 bye per element)

Image Processing Functions-I

Name	Output	Input
im2uint8	uint8	logical, uint8, uint16 and double
im2uint16	uint16	logical, uint8, uint16 and double
mat2gray	double (in range [0, 1])	double
Im2double	double	logical, uint8, uint16 and double
im2bw	Logical	uint8, uint16 and double