



*EE409 – Digital Image Processing  
2021-2022 Fall*

# **1. OVERVIEW & Human Visual System**

*by: Dr. Gökhan Koray GÜLTEKİN*

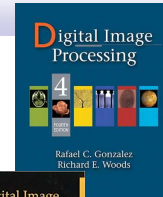
## **ABOUT ME**

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- e-mail: [gkgultekin@ybu.edu.tr](mailto:gkgultekin@ybu.edu.tr)
- Office: C-303

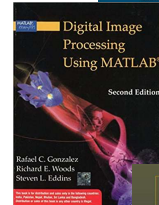


## TEXTBOOKS

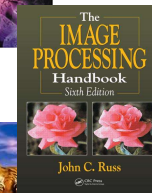
- **"Digital Image Processing"**, R. C. Gonzalez, R. E. Woods, Pearson, 4th Ed., 2017, ISBN-13: 9780133356724.



- **"Digital Image Processing using MATLAB"**, R. C. Gonzalez, R. E. Woods, B. R. Masters, and S. L. Eddins, McGraw Hill Education, 2013.



- **"The Image Processing Handbook"**, J.C. Russ, 6th Edition, IEEE Press, 2011



- **"Handbook of Image and Video Processing"**, 2nd Edition, A. Bovik, Academic Press, NY 2005



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## GRADING POLICY

- **% 30** : 3~4x Mini Projects (in Matlab)
- **% 35** : Midterm Exam (in Class)
- **% 30** : Final Project (In groups, Report+Presentation/Oral Exam)
- **% 5** : Attendance
- **Letter Grades:** Catalog
- **Cheating Policy:** Evaluations will be very strict and official rules will certainly be applied in case of cheating

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## Course Requirements

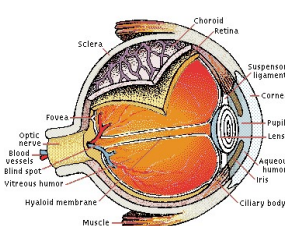
This elective course requires,

- Attending minimum 1-3 hours of online lecture per week (some of them will include online ComboQuiz)
- Scanning (or taking Picture of) your solution on paper and uploading to Aybuzem for ComboQuizes within its duration (~15min).
- Being able to reach a computer with Matlab installed for programming assignments
- Being able to work in distributed Project groups (~2 people)

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## OVERVIEW

### 1. Human Visual System



Electromagnetic spectrum:

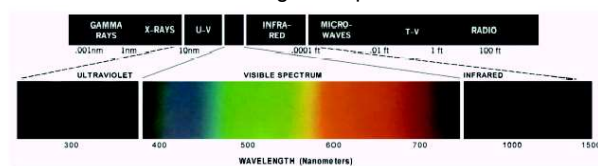
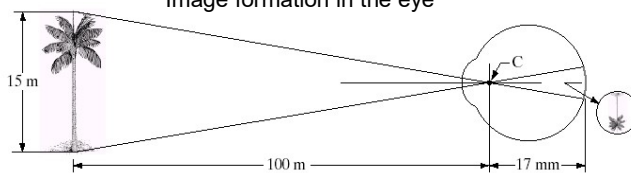
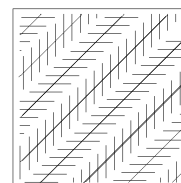


Image formation in the eye



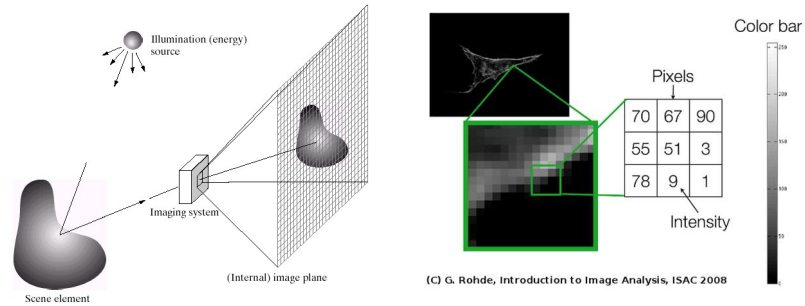
Optical illusions



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## OVERVIEW

### 2. Introduction to Images & Image Sensing Techniques



An **image** is a two-dimensional function  $f(x,y)$ , where  $x$  and  $y$  are spatial coordinates and the amplitude of  $f$  is the **intensity** of the image.

If  $f$ ,  $x$  and  $y$  are **finite, discrete** quantities then the image is a **digital image**.

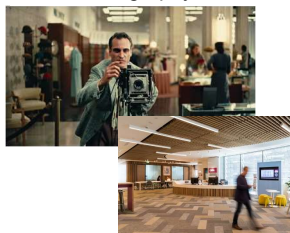
The **elements** of a digital image are usually referred to as **pixels** or **pels**(picture elements).

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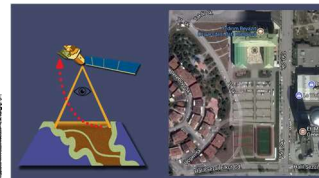
## OVERVIEW

### 2. Introduction to Images & Image Sensing Techniques

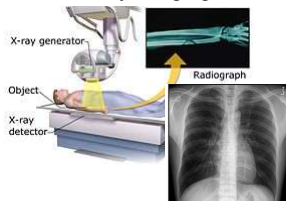
Photography



Scanning based imaging



X-Ray imaging



Ultrasound imaging



Depth image



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## OVERVIEW

### 3. Cameras & Camera Elements

Camera Shutter Mechanism



Camera Lens (or pinhole)



Photosensitive element (Film)

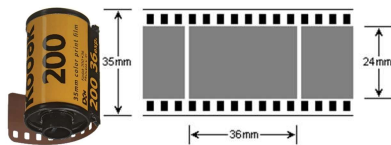
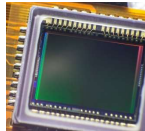


Image sensor



Iris/Diaphragm (aperture)



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## OVERVIEW

### 4. Filtering & Image Enhancement in Spatial Domain

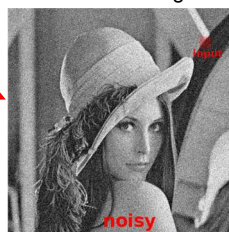
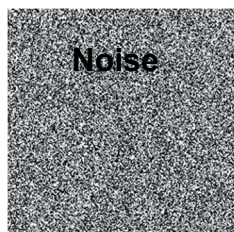
Contrast Enhancement

lack of contrast



image enhancement

Noise filtering



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## OVERVIEW

### 4. Filtering & Image Enhancement in Spatial Domain

Sharpening



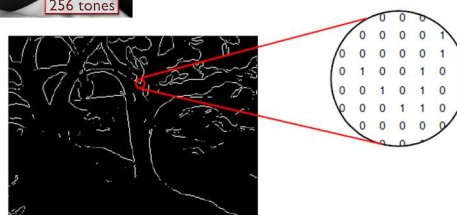
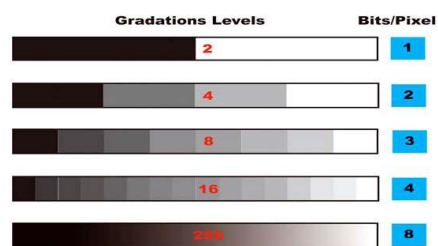
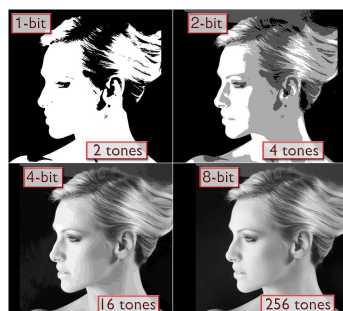
Smoothing



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## OVERVIEW

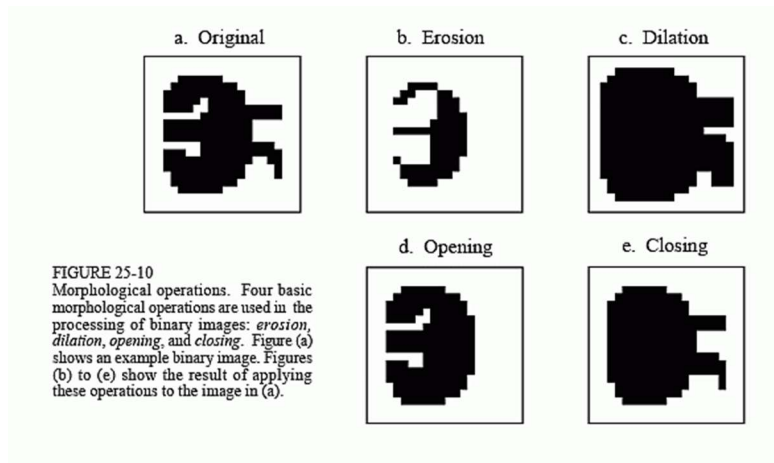
### 5. Binary & Morphological Image Processing



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## OVERVIEW

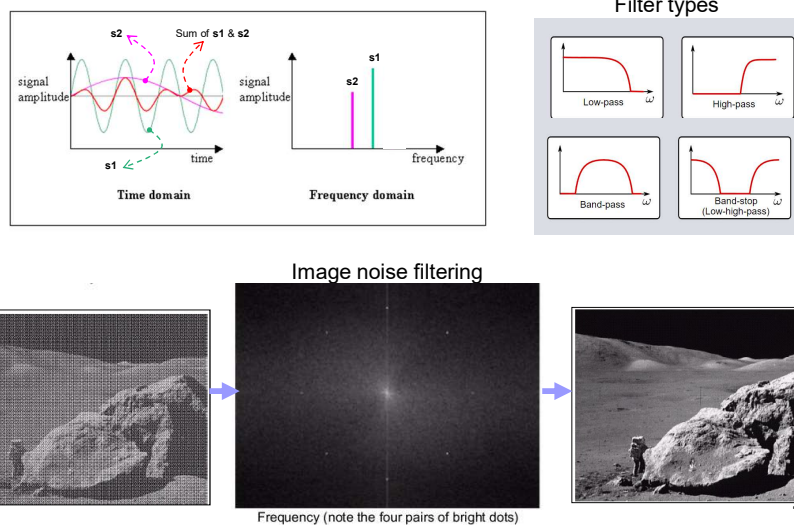
### 5. Binary & Morphological Image Processing



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## OVERVIEW

### 6. Image Processing in Frequency Domain



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## OVERVIEW

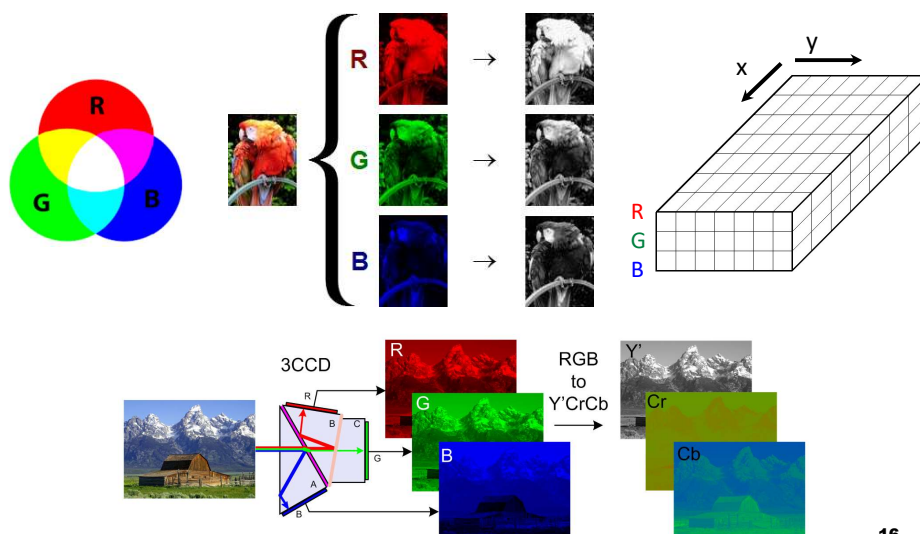
### 7. Image Restoration



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## OVERVIEW

### 8. Color Spaces & Color Image Processing



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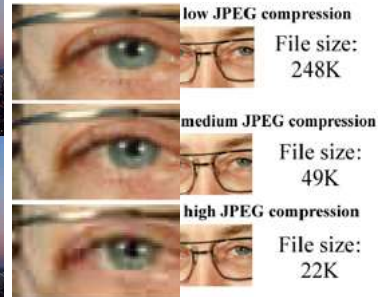


## OVERVIEW

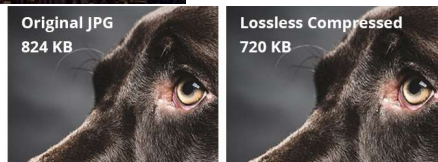
### 9. Image Encoding & Compression



#### Lossy compression



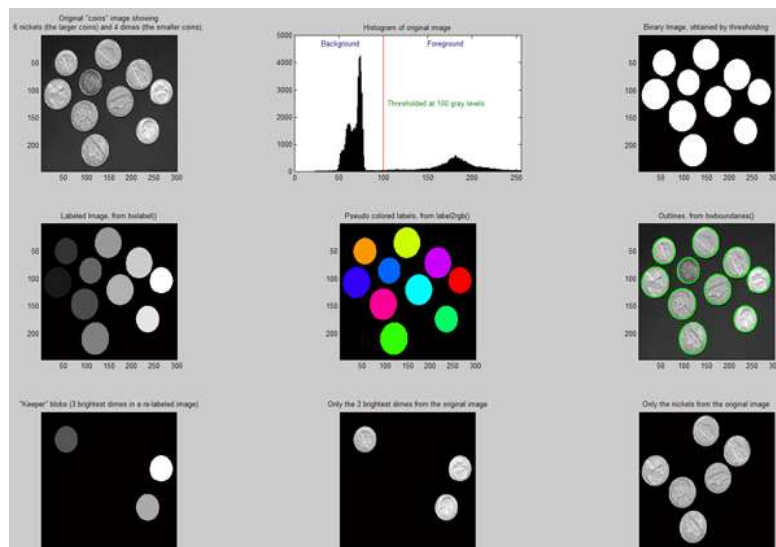
#### Lossless compression



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## OVERVIEW

### 10. Basic Image Segmentation



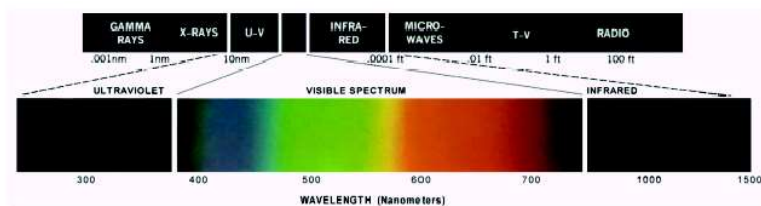
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# Questions ?

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## *Human Visual System*

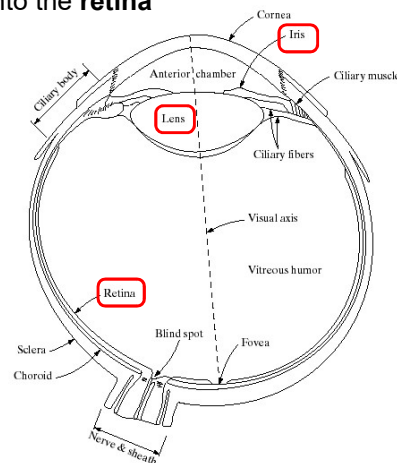
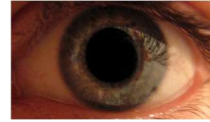
- The best vision model we have!
- The eye can be viewed as a **biological camera**
- It has a **lens**, a **shutter**, an equivalent of **film** and equivalent of **cable** to transfer images
- It can sense wavelengths from **400nm** to **700nm**



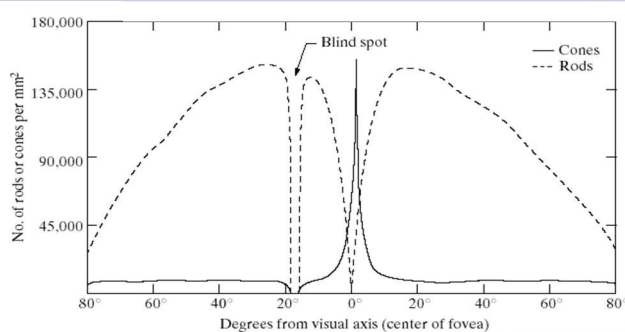
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## Structure Of The Human Eye

- The iris/diaphragm controls amount of light that enters eye
- The **lens** focuses light from objects onto the **retina**
- The **retina** is covered with light receptors called cones (6-7 million) and rods (75-150 million)
- **Cones** are **concentrated** around the **fovea** and are very **sensitive to colour**
- **Rods** are **more spread out** and are **sensitive to low levels of illumination**



## Structure Of The Human Eye



**FIGURE 2.2**  
Distribution of rods and cones in the retina.

- Cone receptors are **concentrated** around the center of the visual axis, therefore we see the **colors** of the objects **in front of us** more accurately than the sides



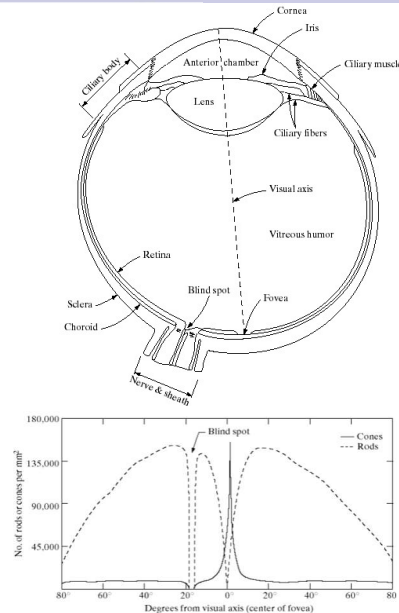
## Structure Of The Human Eye

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

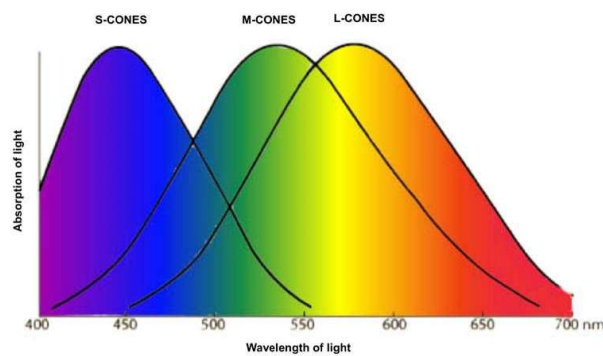
2. **Light receptors** in the **retina**

- About 6-7 millions **cones**
  - Density of cones is about 150,000 elements/mm<sup>2</sup>.
  - Cones involve in color vision.
  - Cones are concentrated in **fovea** about 1.5x1.5 mm<sup>2</sup>.
- About 120 millions **rods**
  - Sensitive to low level of light and are not involved in color vision.

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



## Structure Of The Human Eye

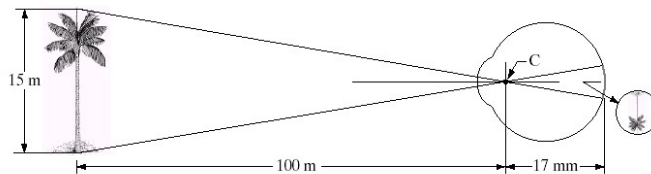
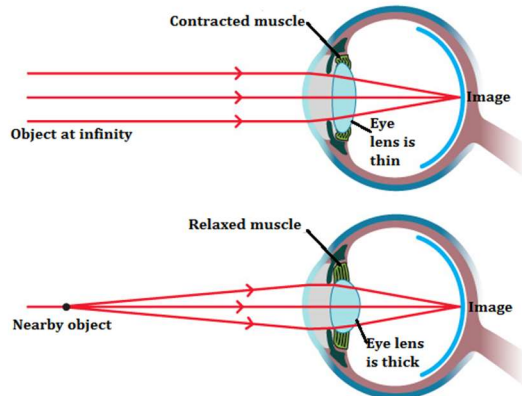


- There are **3 types** of **cones** each with different photo pigment
- **Short(S)** wavelength cones: Max. sensitivity at **440 nm**
- **Medium(M)** wavelength cones: Max. sensitivity at **540 nm**
- **Long(L)** wavelength cones: Max. sensitivity at **565 nm**

## Image Formation In The Eye

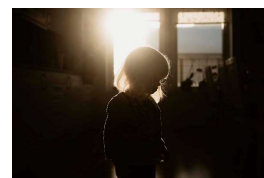
- Muscles within the eye can be used to **change** the **shape of the lens** allowing us **focus** on objects that are **near or far away**

- An image is **focused onto** the **retina** causing rods and cones to become excited which ultimately send signals to the brain



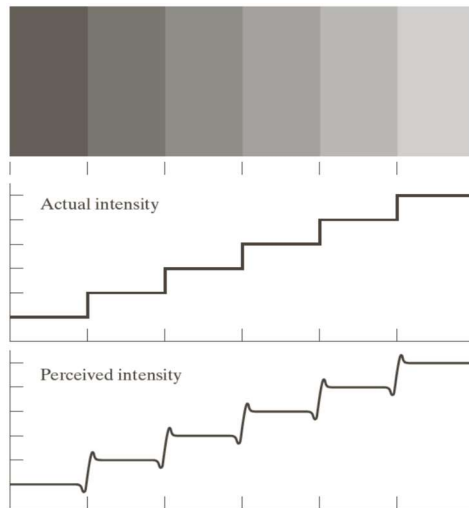
## Brightness Adaptation & Discrimination

- The human visual system can perceive approximately **10<sup>10</sup>** different light **intensity levels**
- However, at any one time we can only discriminate between a much smaller number (**brightness adaptation**)
- Similarly, the **perceived intensity** of a region is **related to** the light intensities of the regions **surrounding it**



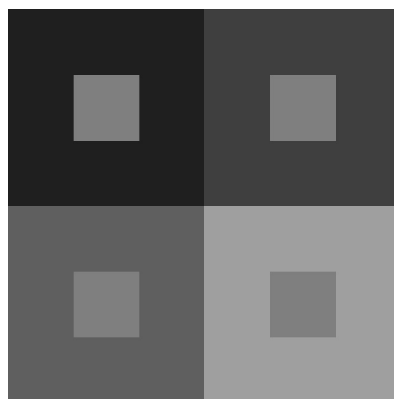
## Brightness Adaptation & Discrimination

### Mach Band Effect



- Intensities of surrounding points effect perceived brightness at each point
- Human visual system undershoots and overshoots around the boundary of step transitions in intensity
- In this image, edges between bars appear **brighter on the right side** and **darker on the left side**

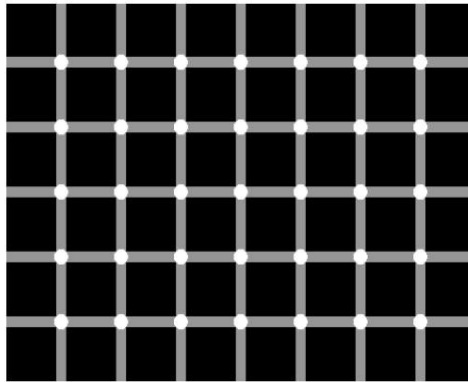
## Brightness Adaptation & Discrimination



*Simultaneous contrast.* All small squares have exactly the same intensity but they appear progressively darker as background becomes lighter.

## **Brightness Adaptation & Discrimination**

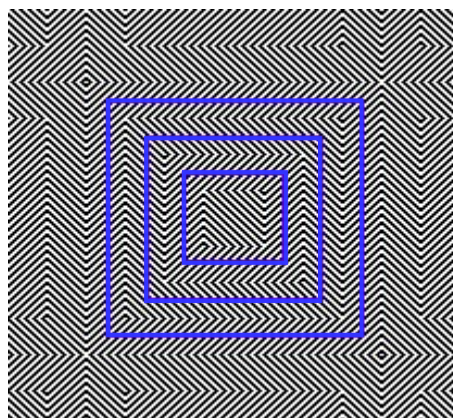
Optical illusions



Count the black dots! :o)

## **Brightness Adaptation & Discrimination**

Optical illusions

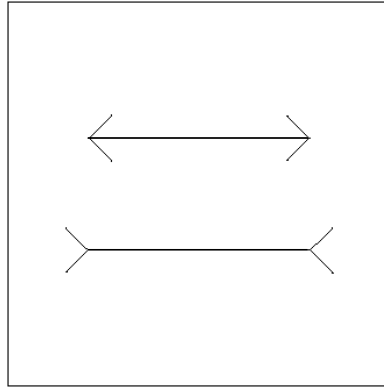


Do you see squares?



## ***Brightness Adaptation & Discrimination***

Optical illusions



# **Questions ?**