

# COS 791

# Image Processing and Analysis

## Chapter 1

# Lecturer

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# Recommended textbook

Feature Extraction: Image Processing for  
Computer Vision

*Third Edition*

Mark Nixon

# Assessment

- 3 assignments
- Semester mark:
  - Average of three assignments
- Final mark:
  - 50% Semester mark
  - 50% Exam mark

# Human and computer vision

- A computer vision system processes images acquired from an electronic camera
- In the human vision system the brain processes images derived from the eyes
- Computer vision systems can to some extent replicate the function of the human eye
- Sometimes a computer vision system can even improve upon the function of the eye

# Human vision system

- Sophisticated system that senses and acts on visual stimuli
- Not possible from a computer to exactly replicate the function of the human eye

# Human vision system

- Human vision system can be modeled in three parts;
  - The eye – physical model determined by pathology
  - A processing system – experimental model that cannot be determined precisely
  - Analysis by the brain – psychological model can only be inferred by experiment

# The eye

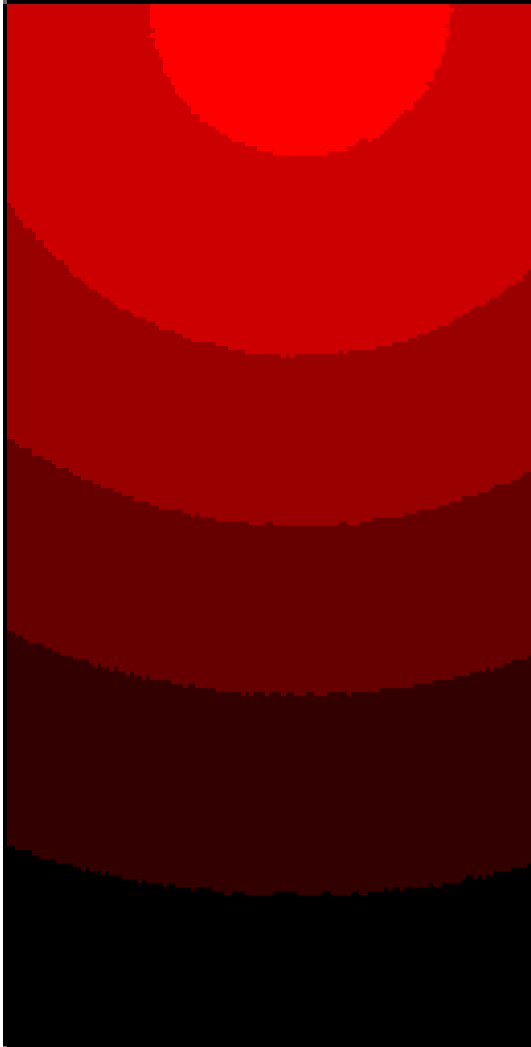
- There are nearly 100 million sensors dispersed around the retina
- Light falls on these sensors to stimulate photochemical transmissions
- Two types of sensors:
  - Rods for black and white vision
  - Cones for colour vision
- There are around 10 million cones and nearly all of them are found within 5° of the focal point



# The eye

- Three types of cones:
  - Short wavelength – sense light toward the blue end of the visual spectrum
  - Medium wavelength – sense light towards the green
  - Long wavelength – sense light toward the red
- The total response of the cones arises from summing the response of the three types of cones

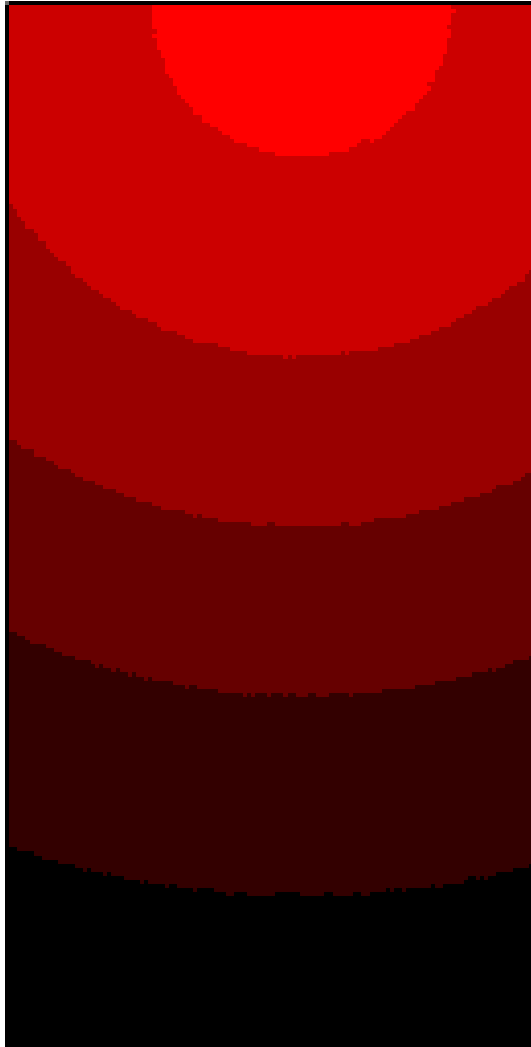
# The eye



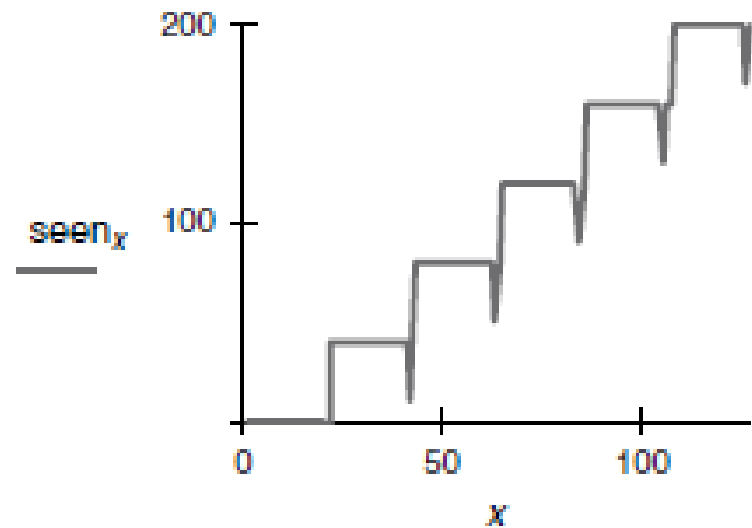
8-bit gradient

- One inherent property of how the eye perceives images is called Mach bands

# The eye

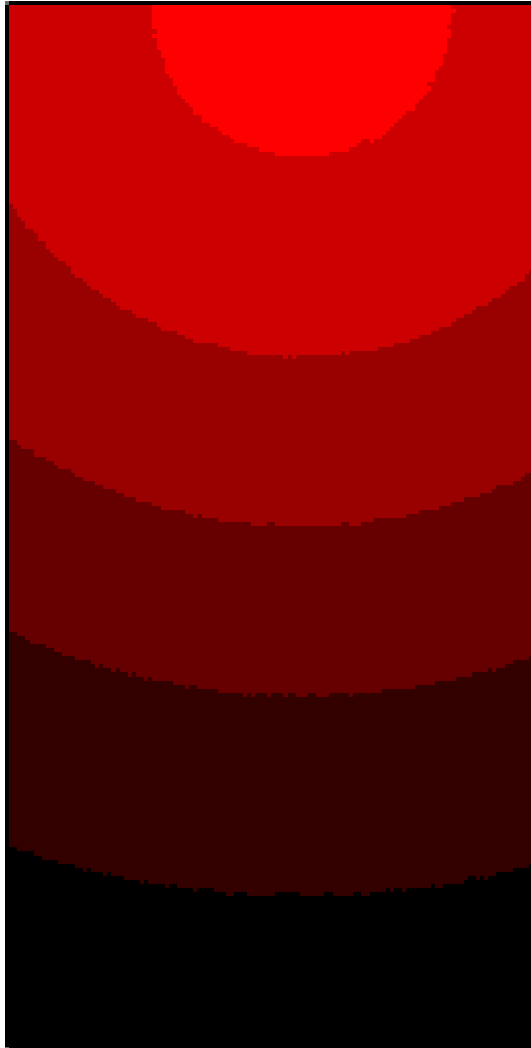


8-bit gradient

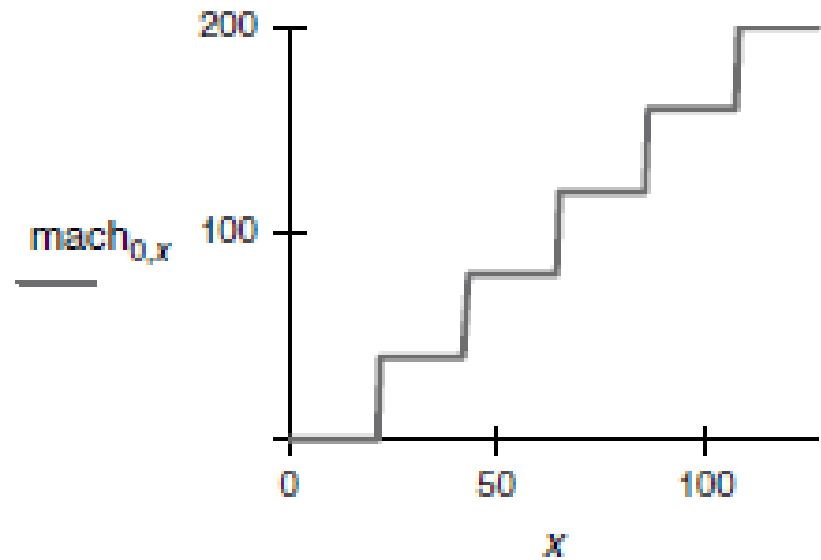


(c) Perceived cross-section through (a)

# The eye



8-bit gradient

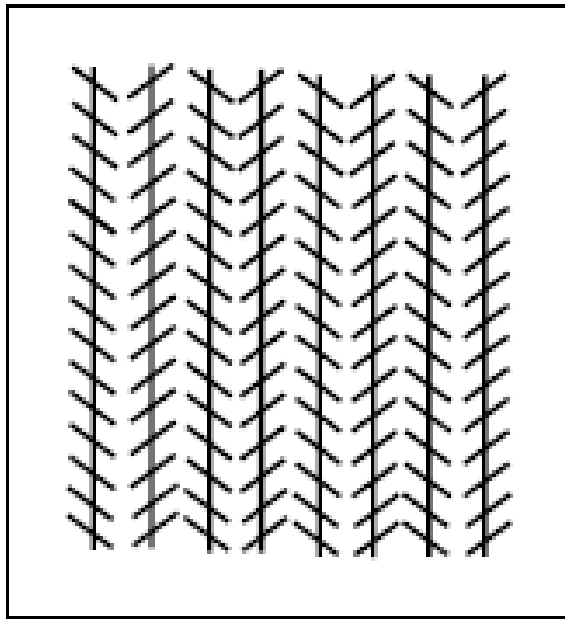


(b) Cross-section through (a)

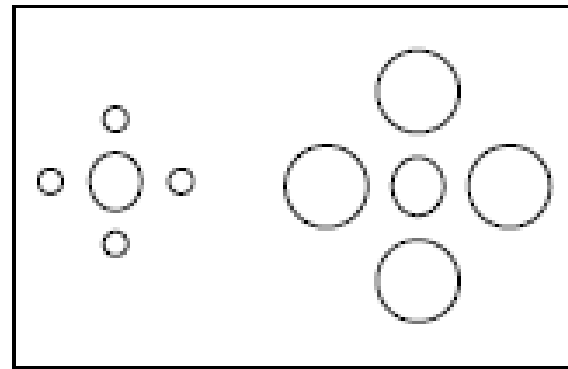
# Mach bands

- Mach bands do not really exist but are introduced by your eyes
  - In order to differentiate between objects in our field of view the eye overshoots its response at boundaries
- Mach bands and sensitivity to unsensed phenomena are typically two properties that would be unwanted in a computer vision system

# The brain can be misled...

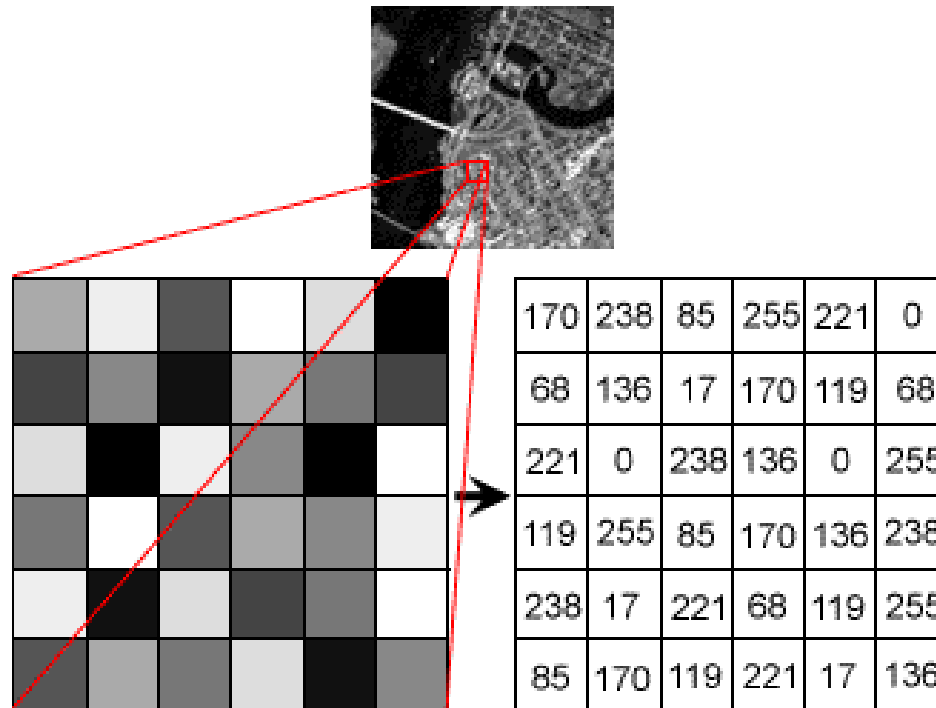


(a) Zollner



(b) Ebbinghaus

# Digital image representation



# Image processing

- Image processing is a group of techniques performed on images to enhance them or to extract information from them
- Includes, but not limited to:
  - Operations to enhance image quality
  - Edge detection
  - Feature extraction
  - Object description
  - Object detection, etc.



# Operations to enhance image quality



- Image is very noisy and this obscures the shape of the artery
- Need to be able to 'clean up' the image without removing important details
- Ultrasound image of the cross section of the carotid artery

# Operations to enhance image quality

noisy lena



Gaussian filter



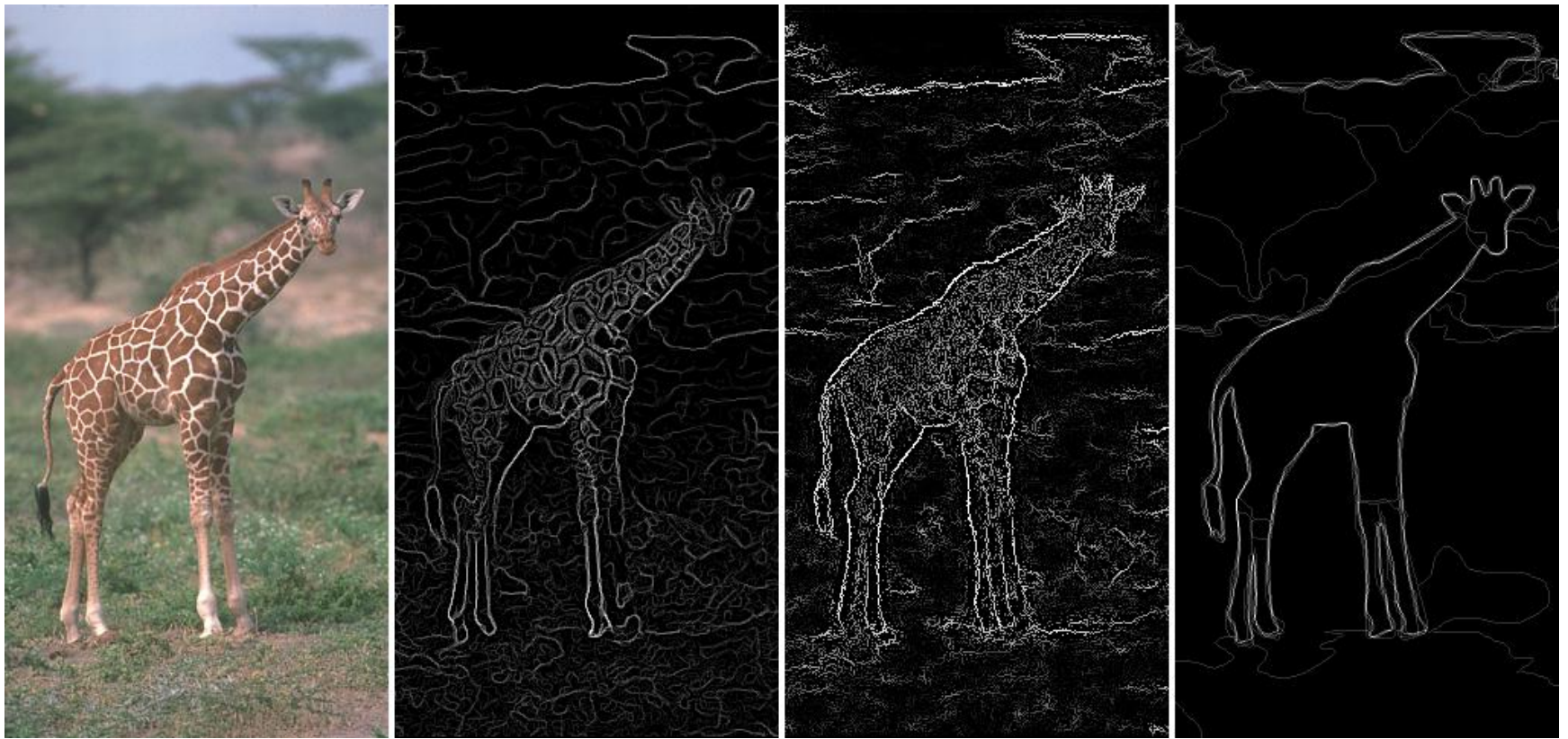
median filter



Wiener filter



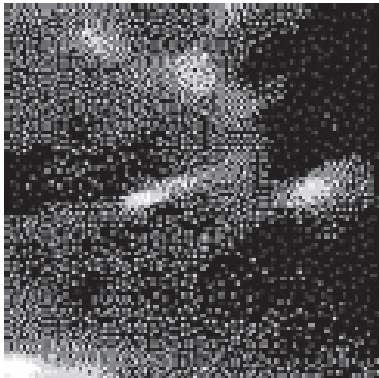
# Edge detection



# Edge detection

- Edge detection is helpful in identifying prominent features of an image
- Edge detection is often the first step for more complex image processing techniques

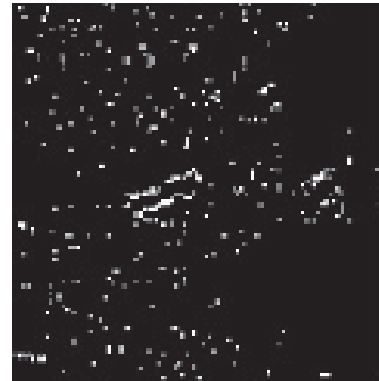
# Edge detection algorithms



(a) Original image



(b) First order



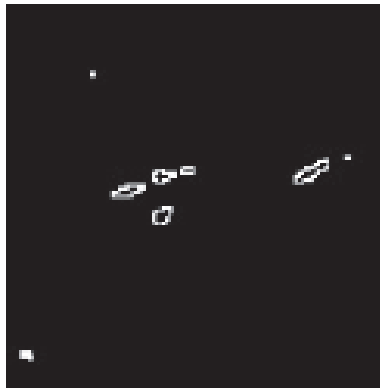
(c) Prewitt



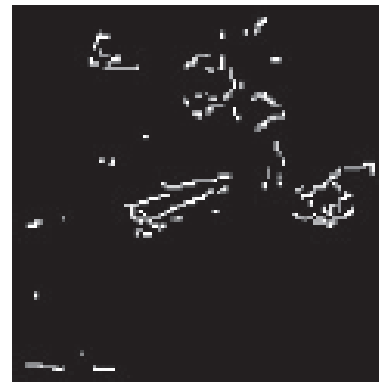
(d) Sobel



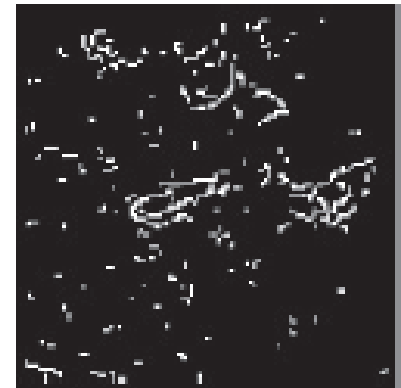
(e) Laplacian



(f) Marr-Hildreth



(g) Canny



(h) Spacek

# Feature extraction

- Feature extraction in image processing is the process of deriving values from an image that is intended to be informative
  - Reducing the collection of pixels to a subset that is more indicative of the object(s) in the image
- Low level: edge detection, corner detection, etc.
- High level: fixed shapes or deformable methods
  - Fixed shapes: lines, circles, ellipses etc.
  - Deformable shapes: unknown or compound shapes

# Feature extraction – straight line



Image from <https://www.wolfram.com/mathematica/new-in-8/comprehensive-image-processing-environment/detect-straight-lines.html>

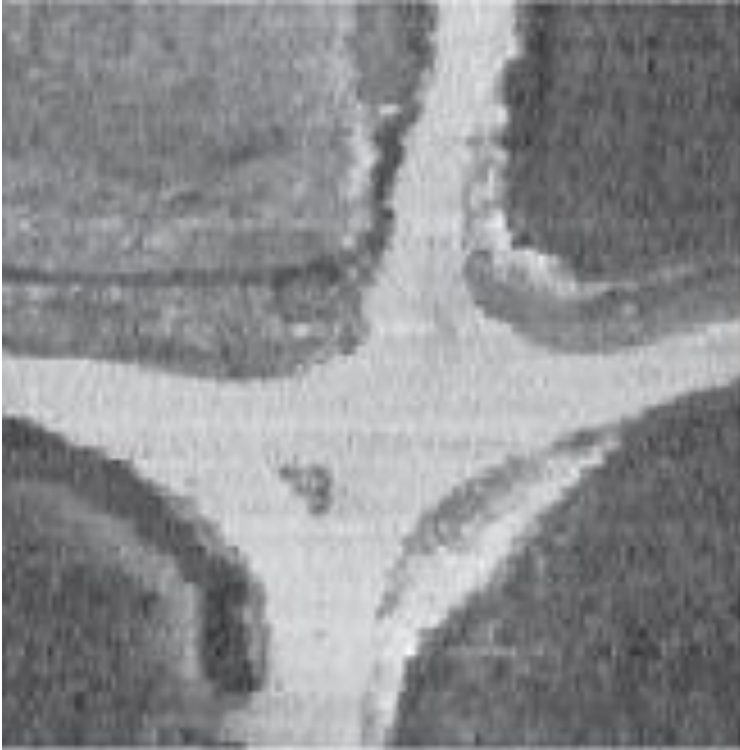
# Feature extraction – deformable shapes



- Facial recognition:
  - To recognize a face we need to be able to analyze shapes – shape of the nose, the eyes etc
  - For this we need to be able to recognise and extract deformable shapes

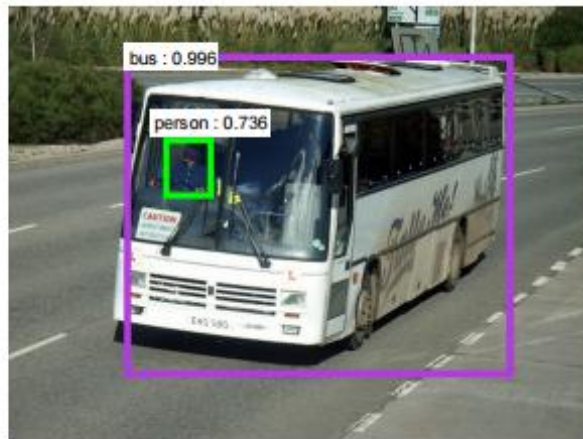
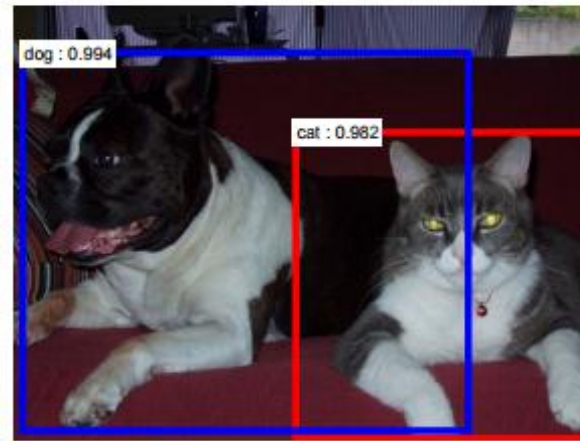
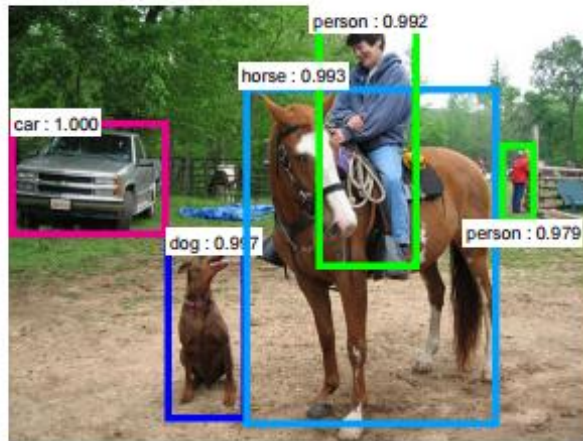


# Image processing



- Remotely sensed images (geospatial) are often analyzed by texture
- The perceived texture of the road is different from the different types of foliage

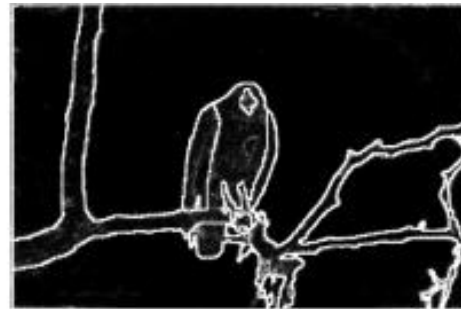
# Object recognition



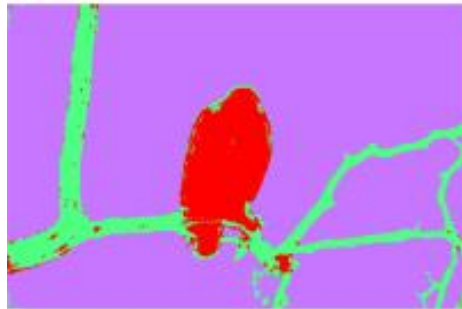
# Image segmentation



Original image



Boundary detection



Semantic segmentation

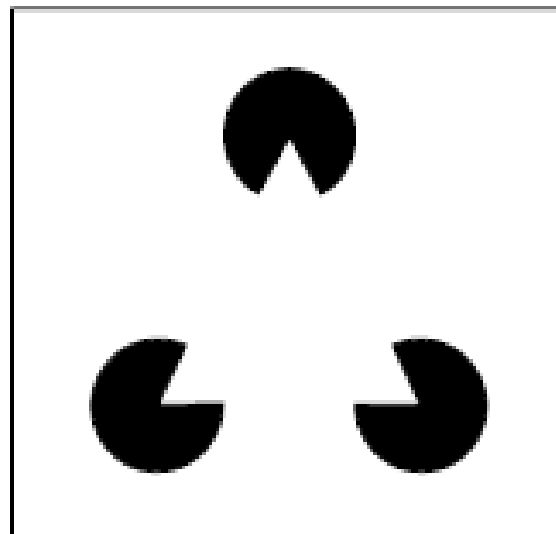


Object detection

# Challenges in image processing



(a) Word?



(b) Pacmen?