CS 231

Segmentation

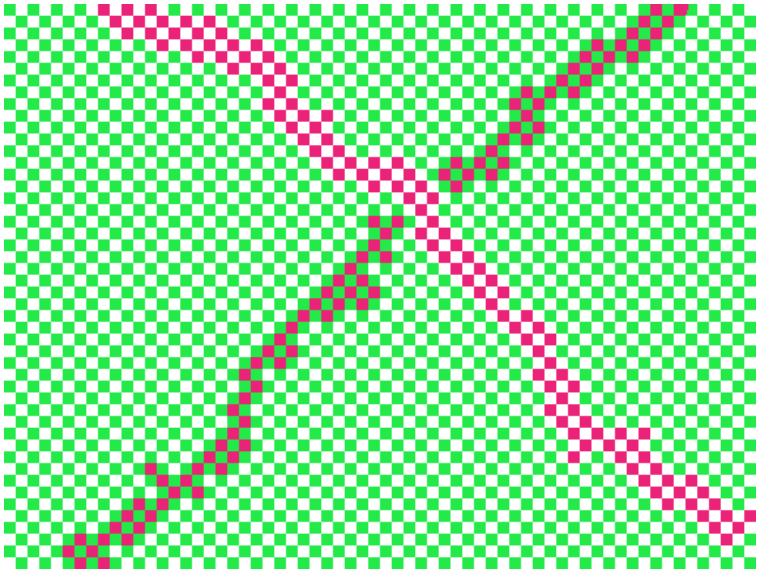
Slide credit: G.D. Hager

Grouping and Segmentation

- Grouping and Segmentation appear to be one of the early processes in human vision
- They are a way of *organizing* image content into “semantically related” groups
- In some applications, segmentation is the crucial step (e.g. some types of aerial image interpretation).

Grouping and Segmentation

- **Grouping** is the process of associating similar image features together



Grouping and Segmentation

Grouping and Segmentation

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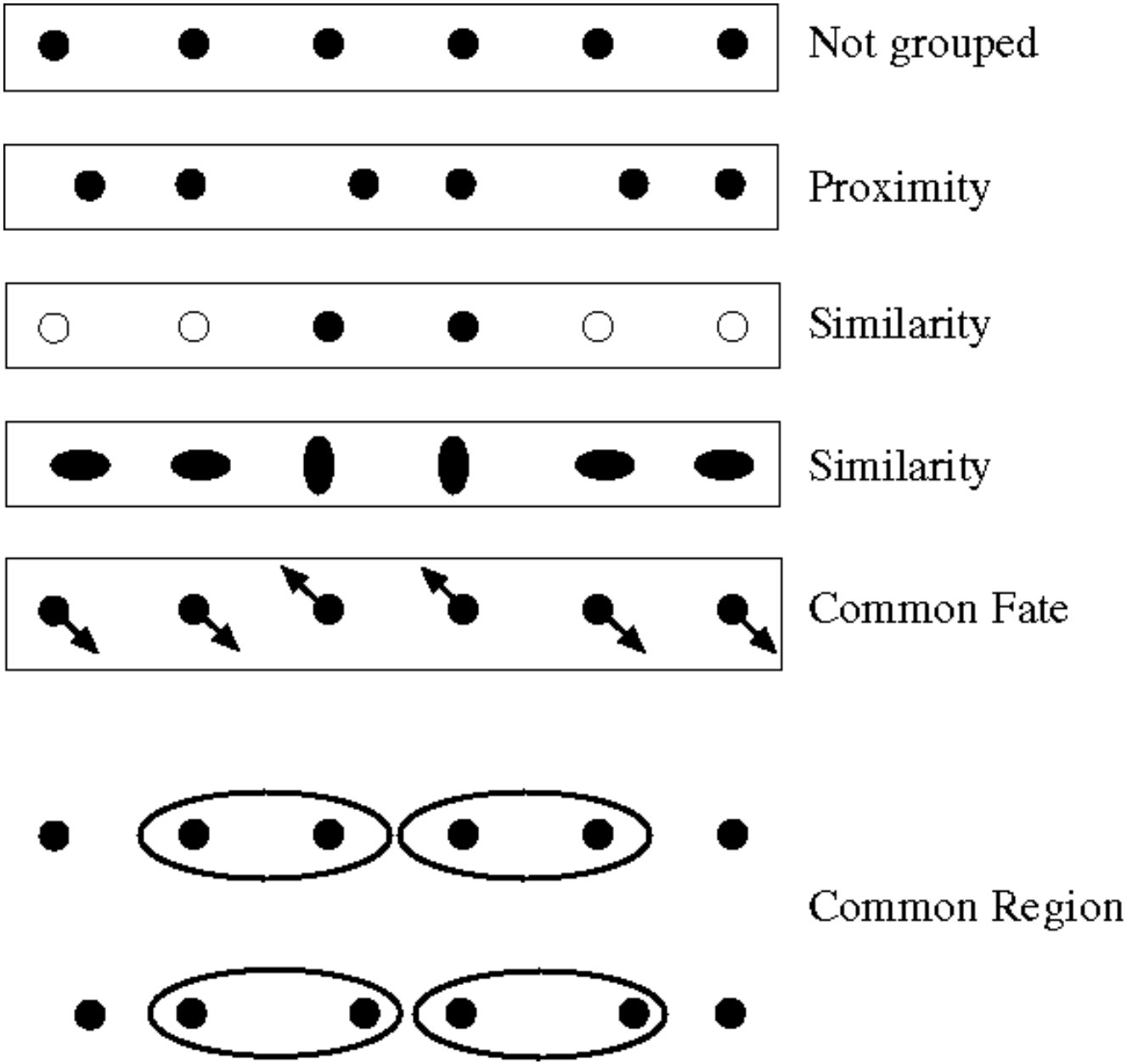
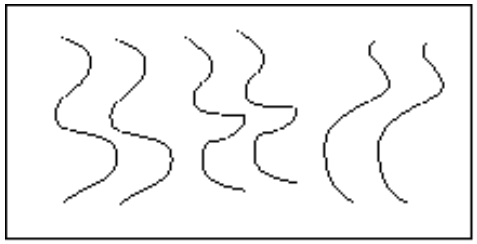
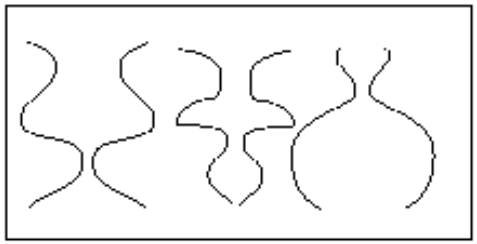
- The Gestalt School:
  - **Proximity**:tokens that are nearby tend to be grouped.
  - **Similarity:**similar tokens tend to be grouped together.
  - **Common fate**:tokens that have coherent motion tend to be grouped together.
  - **Common region:**tokens that lie inside the same closed region tend to be grouped together.
  - **Parallelism:**parallel curves or tokens tend to be grouped together.
  - **Closure:** tokens or curves that tend to lead to closed curves tend to be grouped together.
  - **Symmetry:** curves that lead to symmetric groups are grouped together.
  - **Continuity:** tokens that lead to “continuous ” (as in “joining up nicely ”, rather than in the formal sense): curves tend to be grouped.
  - **Familiar Conguration:** tokens that, when grouped, lead to a familiar object,tend to be grouped together

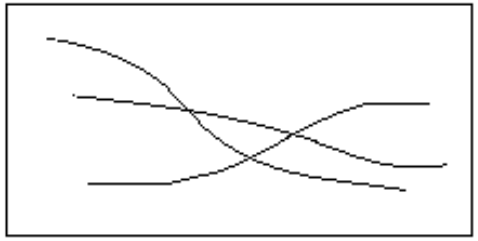

Not grouped
Proximity
Similarity
Similarity
Common Fate
Common Region



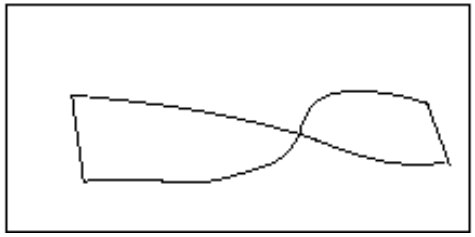
Parallelism



Symmetry



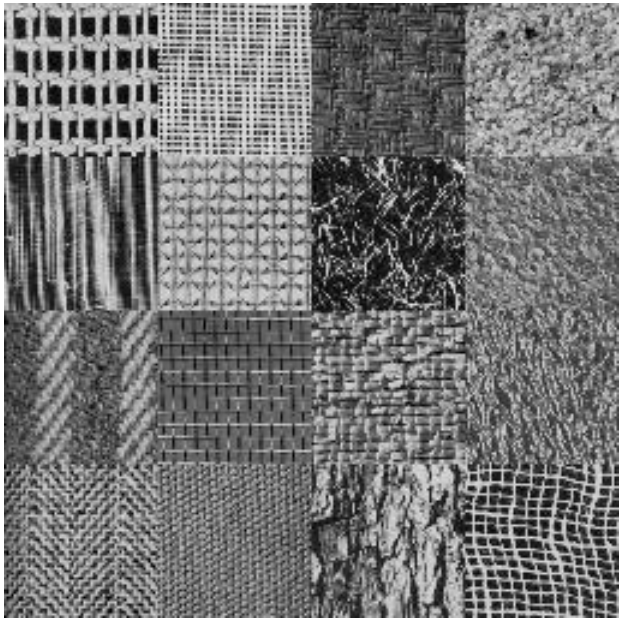
Continuity

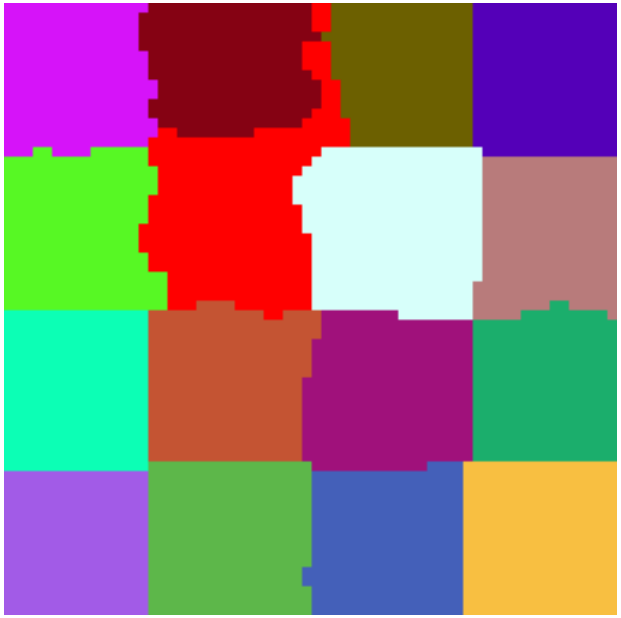


Closure

Grouping and Segmentation

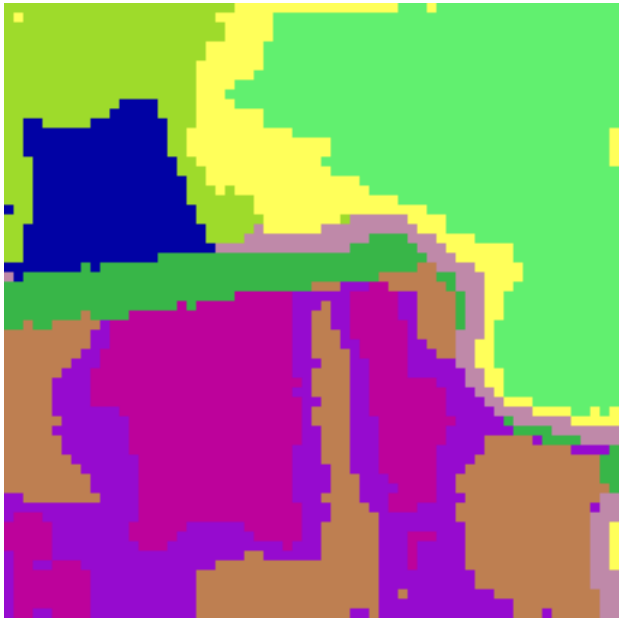
- **Segmentation** is the process of dividing an image into regions of "related content"





Grouping and Segmentation

- **Segmentation** is the process of dividing an image into regions of "related content"



Grouping and Segmentation

- Both are an ill defined problem --- related or similar is often a high-level, cognitive notion

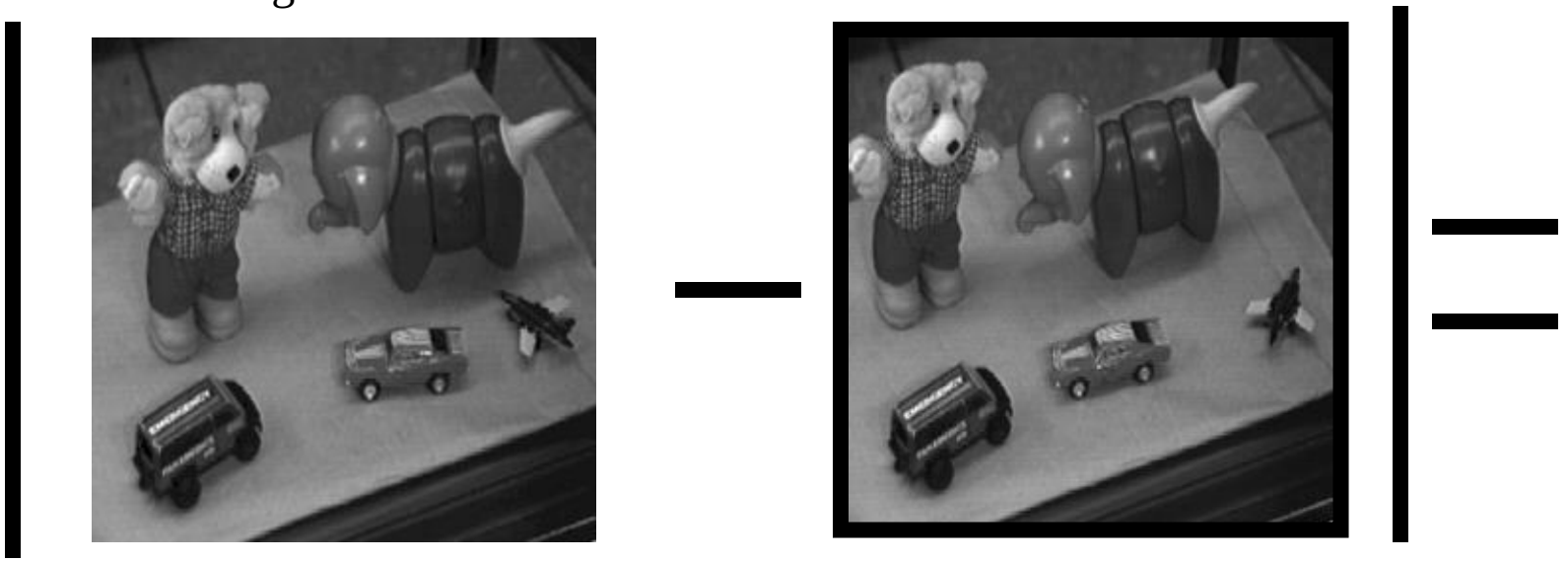
- The literature on segmentation and grouping is large and generally inconclusive --- we'll discuss a couple of algorithms and an example.

Simple Thresholding

- Choose an image criterion c
- Compute a binary image by b(i,j) = 1 if c(I(i,j)) > t; 0 otherwise
- Perform “cleanup operations” (image morphology)
- Perform grouping
  - Compute connected components and/or statistics thereof

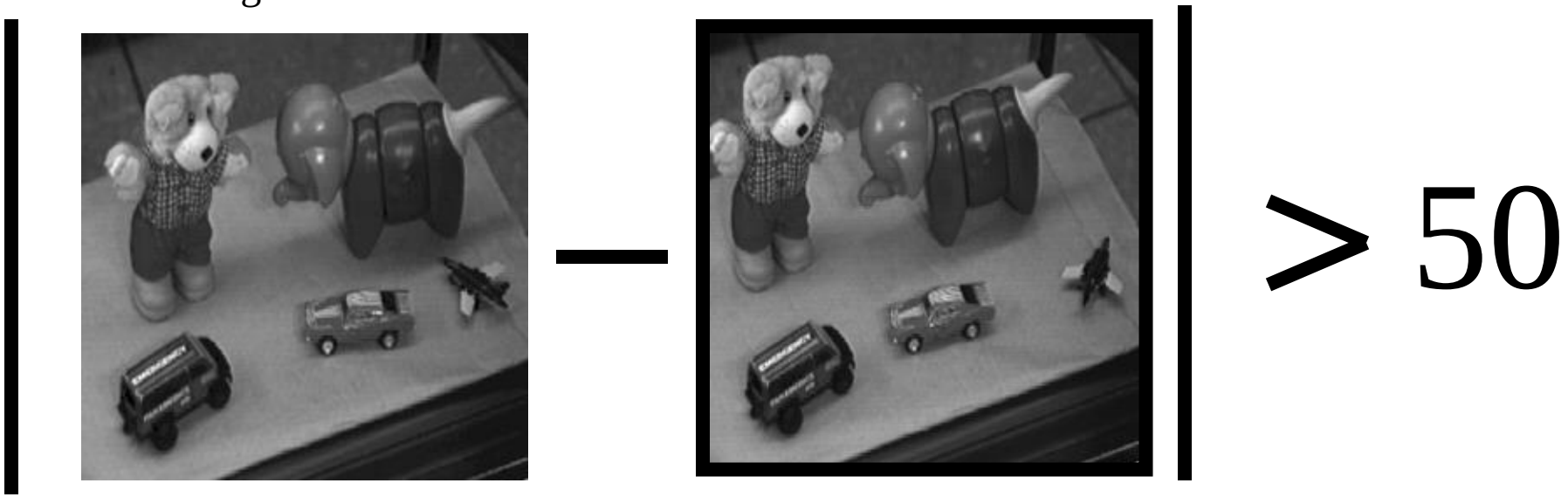
An Example: Motion

Detecting motion:



Thresholded Motion

Detecting motion:

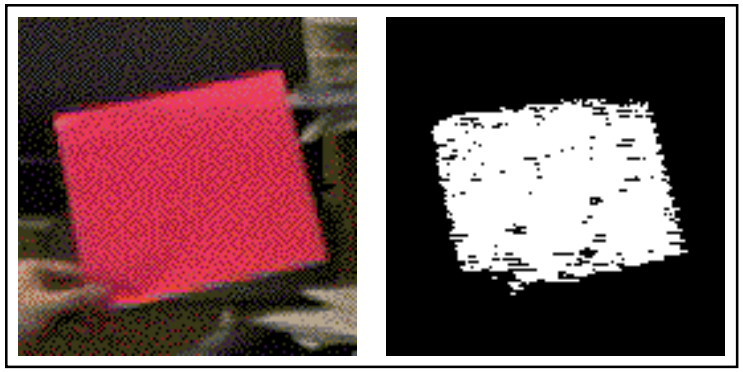


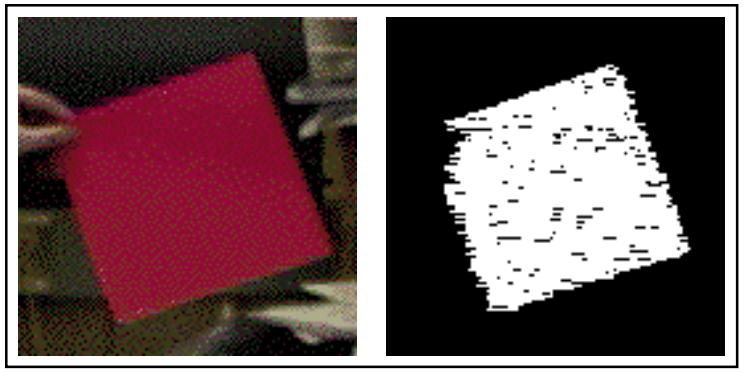
Candidate areas for motion

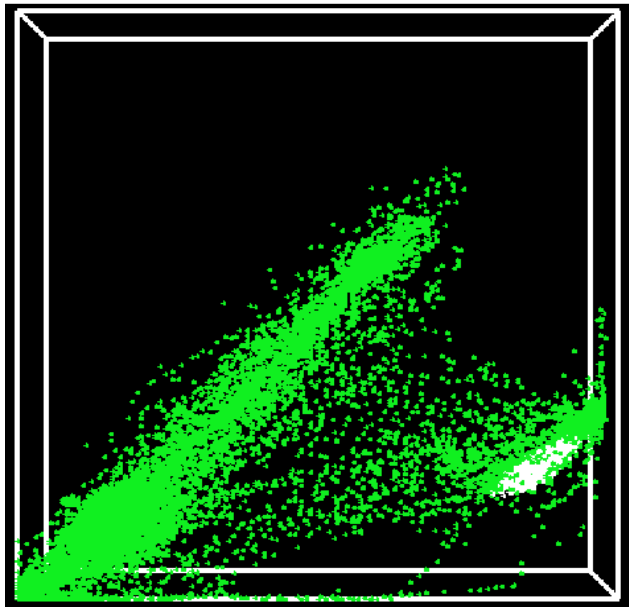
A Closer Look

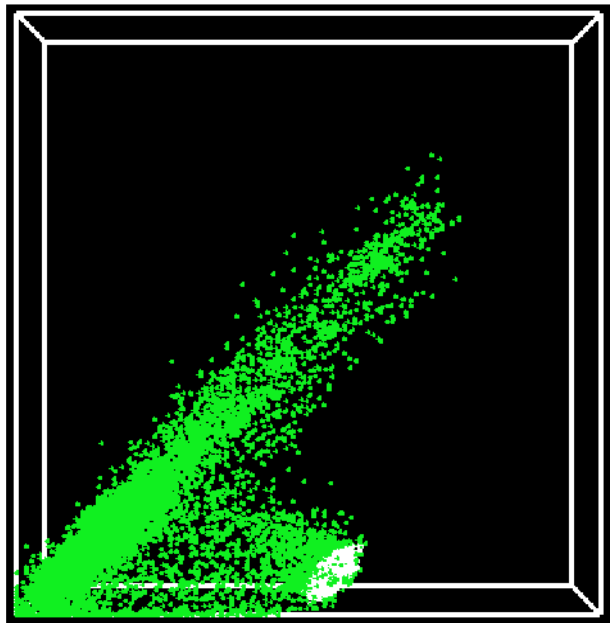
Color: A Second Example

Homogeneous Color Region: Photometry

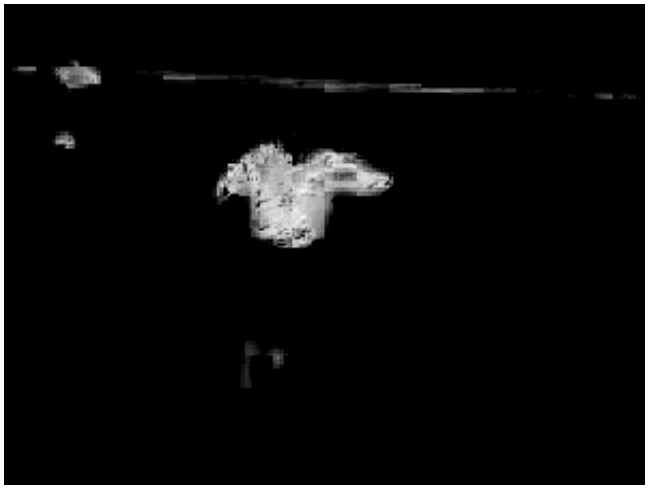




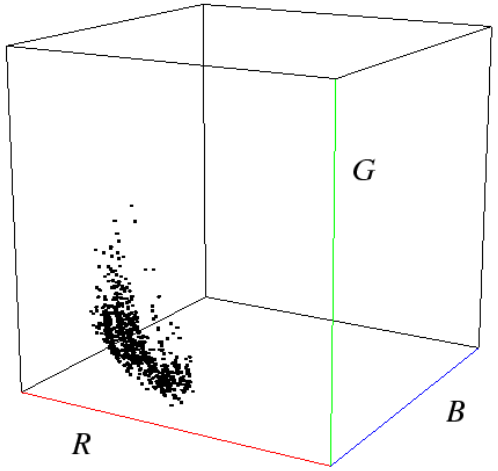


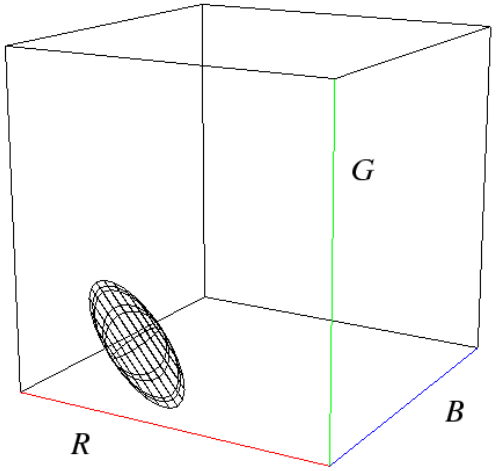


Homogeneous Region: Photometry



Sample





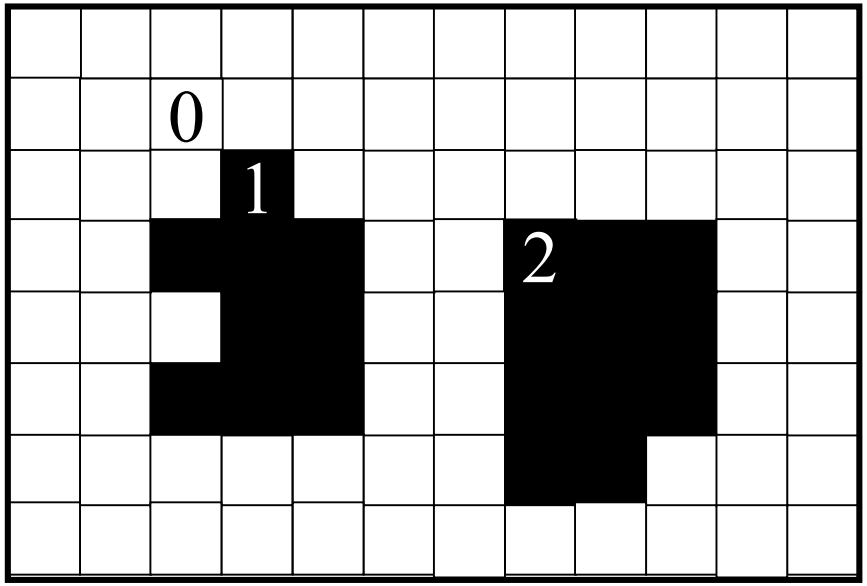
PCA-fitted ellipsoid

Binary Image Processing

After thresholding an image, we want to know usually the following about the regions found ...

- [x] How many objects are in the image?
- [ ] Where are the distinct “object” components?

Connected Component Labeling



Goal: Label contiguous areas of a segmented image with unique labels

One uses a 4-neighbor or 8-neighbor connectivity

Limitations of Thresholding

- A uniform threshold may not apply across the image
- It measures the uniformity of regions (in some sense), but doesn't examine the inter-relationship between regions.
- Local "disturbances" can break up nominally consistent regions

More General Segmentation

- Region Growing:
  - Tile the image
  - Start a region with a seed tile
  - Merge similar neighboring tiles in the region body
  - When threshold exceeded, start a new region

Bottom-up approach

- Region Splitting
  - Start with one large region
  - Recursively
    - Choose the region with highest dissimilarity
    - If sufficiently similar, stop, otherwise split
    - repeat until no more splitting occurs

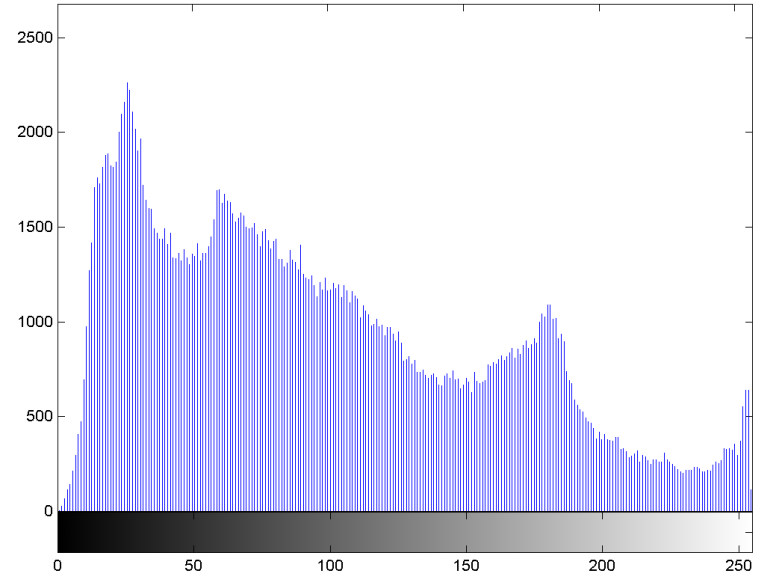
Top-down approach

Another Example: Image Segmentation

- The goal: to choose regions of the image that have similar “statistics.”

- Possible statistics:
  - mean
  - Variance
  - Histograms

An Image Histogram



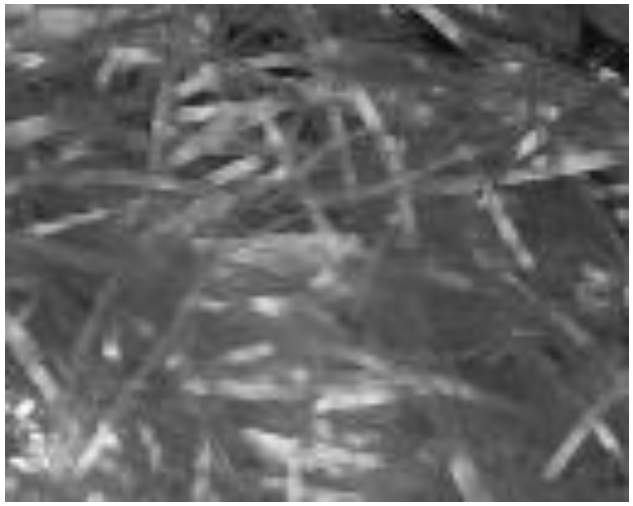
How does one form a histogram?

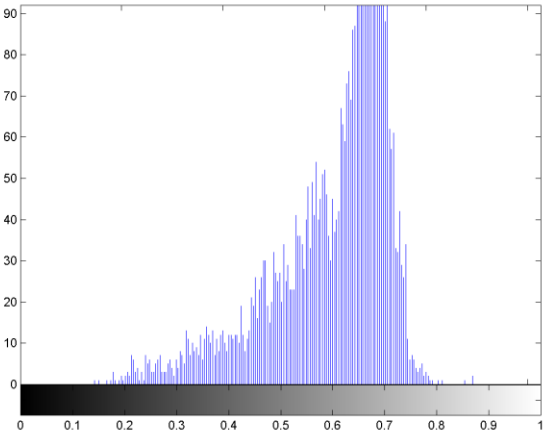
- Let us consider a gray scale image for simplicity (image values ranging from 0-255)
- Select the number of bins n (max 256 bins)
- Width of each bin is 256/n. If n = 8, width = 32

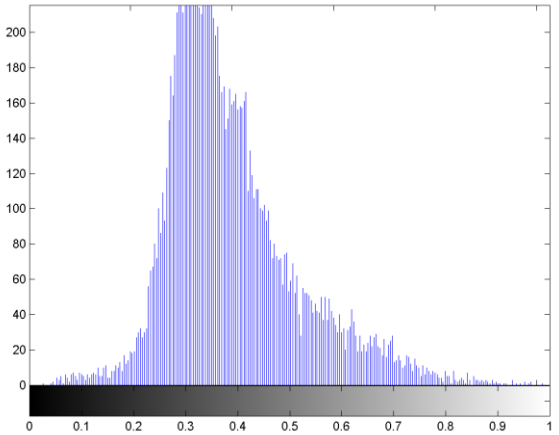
0-32	33-64	65-96					

- Set counter for each bin to zero.
- Now for each pixel, depending on its gray scale value, increment the counter of the bin where the gray scale value of the pixel falls.
- The final counter values of the bins is the histogram of the image for the specified number of bins.

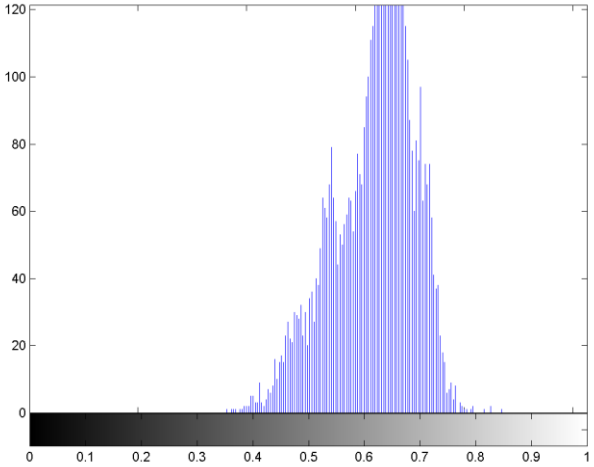
Comparing Histograms







Which is More Similar?



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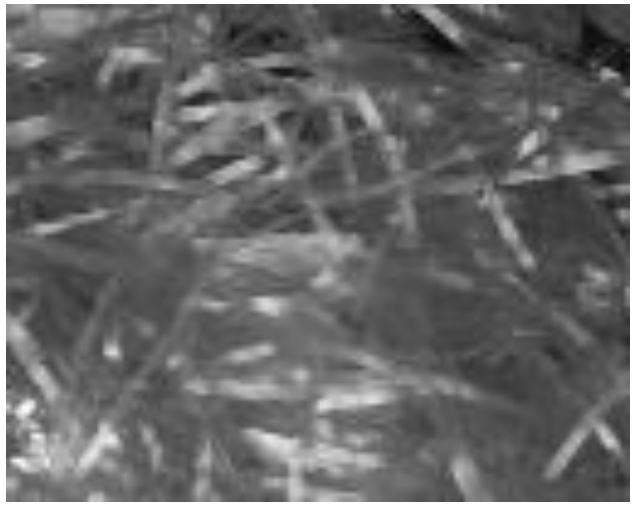
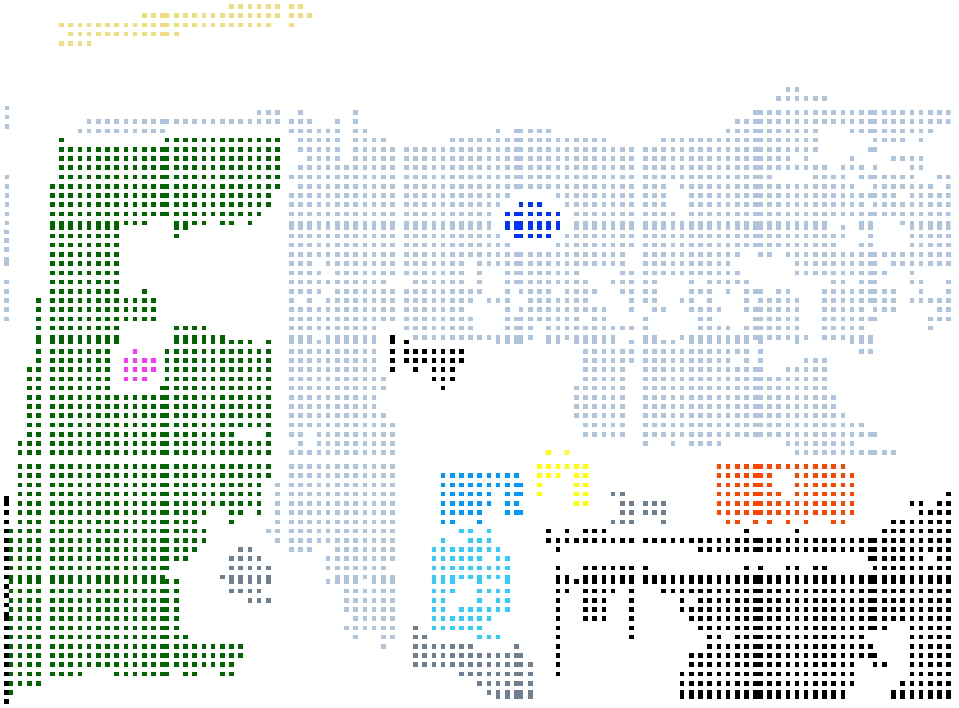


.266

Results of a Merge Segmentation



More Examples

K-Means

Algorithm

- Choose a fixed number of clusters and initial cluster centers
- Allocate points to clusters that they are closest too
- Recompute the cluster centers
- Go back to step 2, and repeat until convergence

Image

Clusters on intensity

Clusters on color

K-means clustering using intensity alone and color alone

An Example: BlobWorld

(Carson, Belongie, Greenspan, Malik)

The problem: query images (e.g. from the WEB) using image information

The solution: segment images into roughly uniform regions and search based on feature vectors

The features:

color
texture
location (i.e. spatial compactness)

Example Segmentations

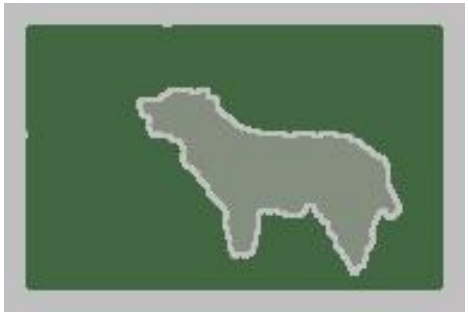
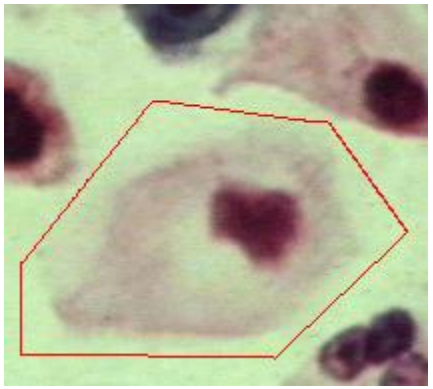


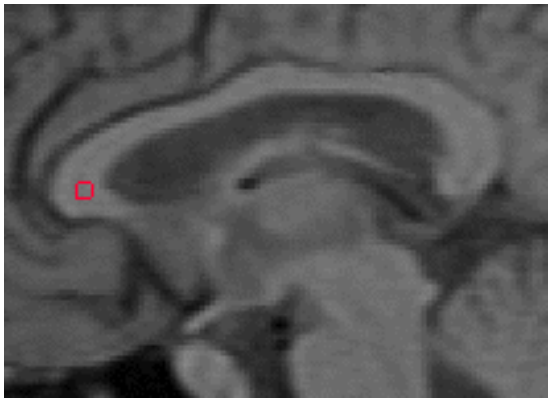
Figure 5. Segmentation of randomly selected images of tigers, cheetahs/leopards/jaguars, zebras, airplanes, and bald eagles. Boundaries and regions smaller than 1% of the image (which do not become blobs) are shown in gray.

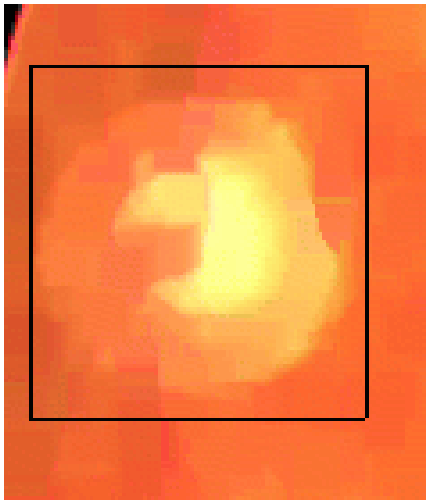
More Complex Segmentation Methods

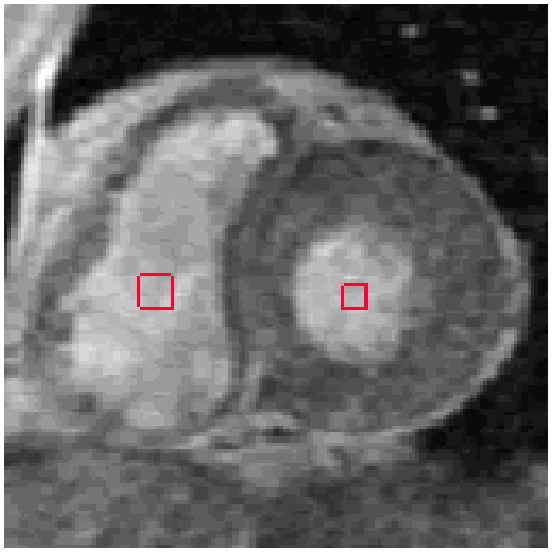
- Snakes
- Level Sets
- Graph Cuts
- Generalized PCA

Snakes



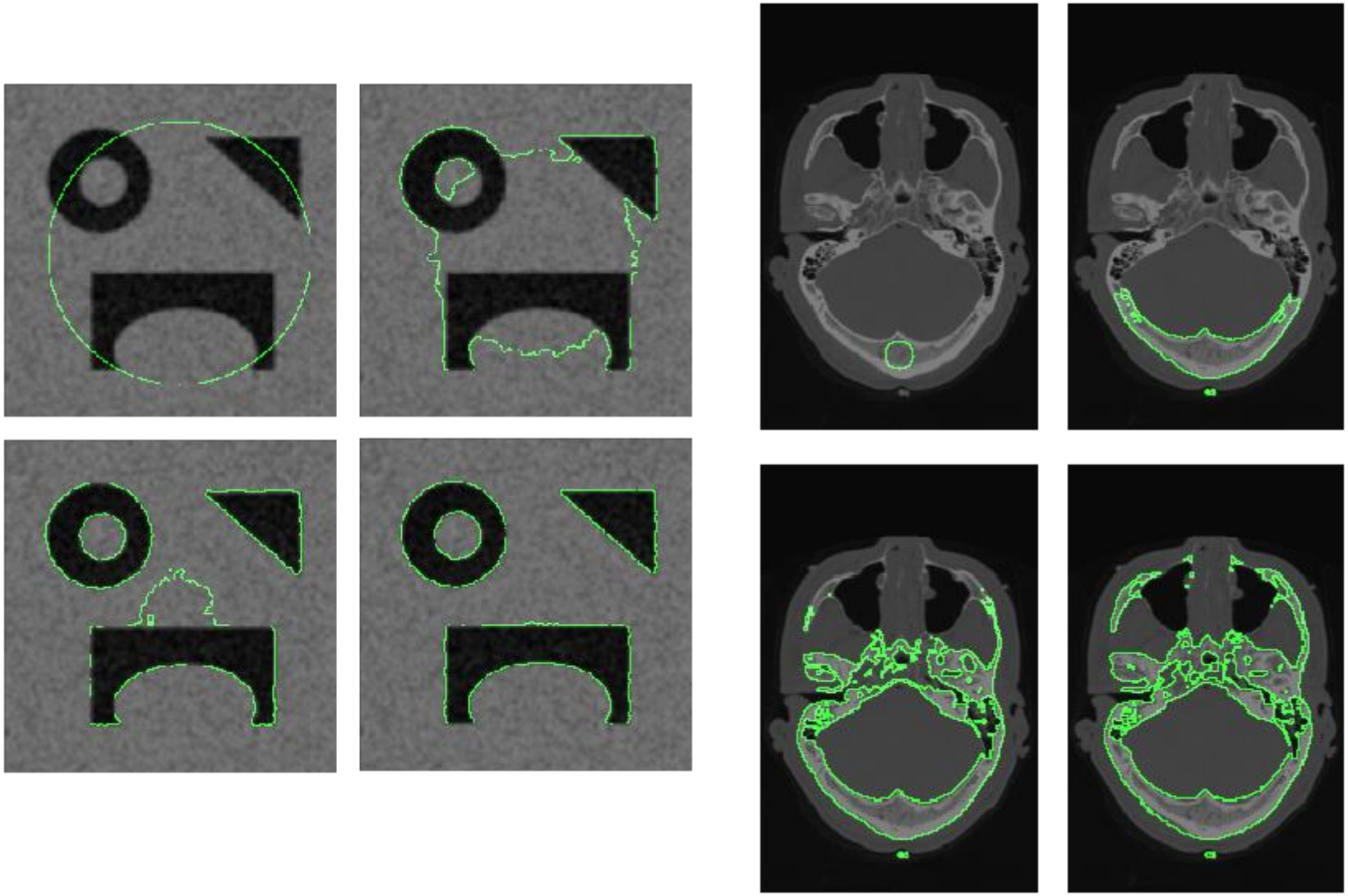






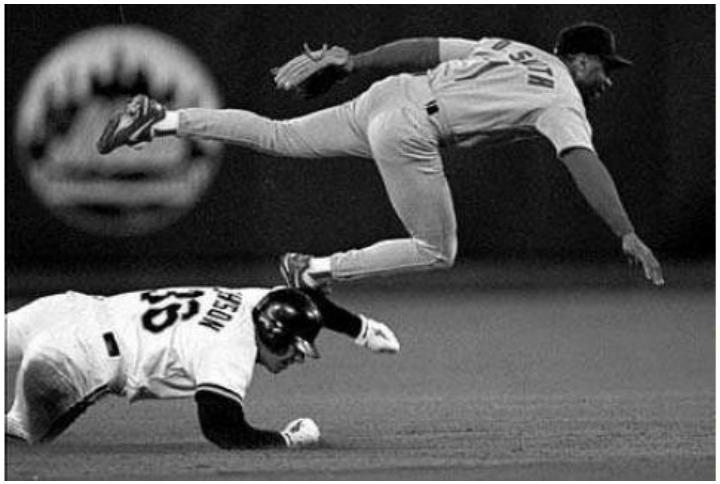
Images taken from
http://www.cs.bris.ac.uk/home/xie/content.htm

Level Sets

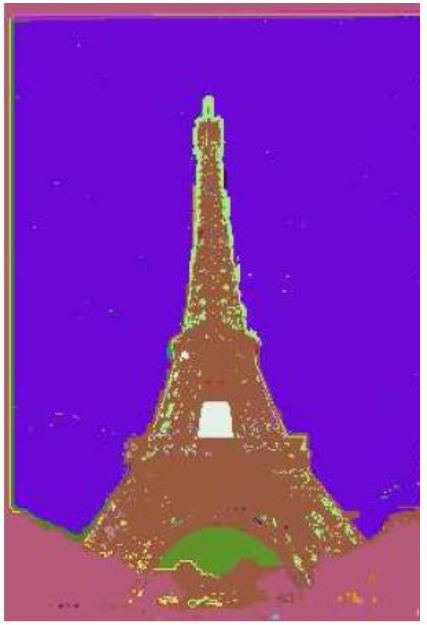


Images taken from
http://www.cgl.uwaterloo.ca/~mmwasile/cs870/

Graph Cuts





Images taken from efficient graph-based segmentation paper

GPCA (Rene Vidal)

Human

GPCA