CS 376A
Digital Image Processing

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Instructor: Michael Eckmann

Today's Topics

- Questions? Comments?
- In preparation for understanding your current assignment, do a worksheet on Histogram Matching.
- Segmentation
- K means clustering

Segmentation

- The goal of segmentation is
  - to determine the different regions in an image that each represent a meaningful area
  - a region can then be further analyzed or used independent of the other regions
    - e.g. segment an image into a face and other regions, then use the face for identification

Segmentation

- Regions after segmentation should have the following characteristics
  - uniform and homogeneous with respect to some measure (e.g. greylevel, color, texture, motion)
  - interiors of regions should not have many small holes
  - adjacent regions should have significantly different values with respect to the chosen characteristic

Segmentation problem

- The segmentation problem is to find a labelling of an image such that each label represents a group of pixels that are alike in some way and each of the other labeled groups are different enough from the each other.
- There are many segmentation techniques in existence
  - What are your thoughts on ways segmentation can be done?

Segmentation

- Segmentation has been studied extensively and techniques have been developed based on
  - Edge detection / contours
  - Treating the image as a graph and doing graph partitioning
  - Histogram based techniques (like Otsu's method)
  - Clustering algorithms
  - Among many others, each with their own plusses and minuses

- I will suggest reading a survey of segmentation techniques

Segmentation

- Difference between clustering and region growing schemes.
- Each pixel is represented as an n-dimensional vector, which encodes the segmentation characteristic
- Clustering:
  - partition all the pixels into K distinct classes
  - Based on similar characteristics
- Region Growing:
  - start at some pixel in the image
  - add adjacent pixels to that pixel's region if they are similar, if not, start a new region
  - adjacency is primary here, similarity secondary

Clustering

- K-means clustering is the technique I'd like to discuss today
- It is an unsupervised learning algorithm
  - Unsupervised --- no training with answers provided

- First we decide on the n characteristics to segment on and K
- The algorithm randomly chooses K means (of those n characteristics)
- repeat
  - For each pixel, compute its n characteristics and compare the distance between those n characteristics and each of the K means. Assign that pixel to the group whose distance is smallest.
  - If no pixel changes groups (the means will have stayed the same from last iteration) then stop. Otherwise
  - Update the K means based on the pixels currently in each group and repeat

Clustering

- Distance could be any of a number of distances.
- Let me define several distance measures of vectors.

Distance

- Distance between 2 n-dimensional vectors
- L1 aka Manahattan distance aka city block distance
  - Sum of absolute differences
- L2 aka Euclidean distance
  - Square root of the Sum of the differences squared
  - Square root may not be computed in practice (why?)
    - Typical use is to find a pair of n-dimensional vectors that are closest (least distance)
- Earth mover's distance
  - Useful when dimensions are ordered by similarity (e.g. a histogram of grayvalues)

Distance

- Example distance between two four dimensional points:
- v1 = (0.5, 0.2, 0.2, 0.1)
- v2 = (0.3, 0.1, 0.2, 0.4)
- L1 distance between v1 and v2:

  |0.5-0.3| + |0.2-0.1| + |0.2-0.2| + |0.1-0.4|

  = 0.2 + 0.1 + 0 + 0.3

  = 0.6

- L2 distance between v1 and v2:

  sqrt ((0.5-0.3)^2 + (0.2-0.1)^2 + (0.2-0.2)^2 + (0.1-0.4)^2)

  = sqrt(0.2^2 + 0.1^2 + 0.3^2)

  = sqrt(0.04 + 0.01 + 0.09)

  approx. = 0.3742

K Means example on 2d data

- Let me show you how clustering might work on 2d data

Clustering

- We could have n dimensions of characteristics, each dimension could be one measure on the pixel. e.g.
  - texture
  - Red color
  - Green color
  - Blue color
  - intensity
  - etc.

Clustering

- Can think of each mean as a centroid in n-dimensions
- It's a greedy algorithm
- Results clearly depend on chosen K
- Results depend on initially chosen means
  - standard solution (according to some) is try various different initial means and then pick your favorite result

Let’s see some results

- Let's see some results of doing k means clustering on images using 3 characteristics (R, G and B)
- The resulting labels are shown as the mean RGB value of the cluster
- Let’s run my code on more images and different values of k