Review Homework 5
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1. What are the two primary uses of K-means clustering? Given an example of each.

K-means clustering can be used for exploration and for encoding. When used for exploration, the goal is to find both how many natural groupings of data exist and to identify their mean positions in the data space. For example, if you asked the question, "how many unique colors exist in this image?", k-means might be one way to answer the question.

K-means can also be used as an encoding mechanism. Vector quantization (VQ) is the process of converting a vector of real values into a discrete set of categories. K-means is often used to generate the code book, or mapping from real-valued vectors into the category space. For example, in the case of texture analysis, imagine you had a training set of pictures of grass, asphalt, concrete, gravel, and dirt. After running a Gabor filter bank on the training data, you have lots of examples that are N-element real vectors, which are the filter responses at each pixel. Using K-means, find the 256 groups that best represent the set of vectors. Then you can convert the Gabor filter responses at a pixel into one of 256 categories, or a number between [0, 255]. This is the dictionary or textons. A good representation of texture is to look at the histogram of textons in a local area.

The GIF encoding, finding the 256 most important colors to use to represent an image, is another use of K-means as an encoding mechanism.

2. How does aliasing affect building histograms? What is a solution to avoid aliasing when building a histogram?

Aliasing can affect histograms when the distribution of values in the data has high frequencies, such as a bin with a high count next to a bin with a low count, when combined with distance metrics like SSD or histogram intersection. Similar histograms can have high distances because a value is placed into a single bin.

A solution to avoid aliasing is to consider each value as having a width, or variance and distributing the weight of a single value between bins if the variance crosses a bin boundary.

3. Why is connectedness important in binary image processing? Given an example as to how it might affect something like segmentation/

connected components analysis.

Overall, both segmentation and morphological filtering will give different results depending on how connectedness is defined. In particular, regions that are considered connected in an 8-connected process may not be connected in a 4-connected process. A 4-connected segmentation will almost always contain more, and smaller, regions than the same image segmented using 8-connectedness.

4. What is the purpose of the morphological operators (A) growing/dilation, and (B) shrinking/erosion?

Growing/dilation is intended to close holes in spaces that might be cause by noise or specular reflections.

Shrinking/erosion is intended to remove small regions or noise that aren't relevant to the primary shape.

5. How could you extend region growing to general RGB images so that the algorithm groups areas of similar color?

In the innermost loop of region growing, the algorithm adds neighbors of the current focus pixel to the stack if they are unlabeled foreground pixels.

You can change the test to be: "if the pixel is unlabeled and is similar enough in color to the focus pixel" then label it and add it to the stack.

A slightly more stable test is: "if the pixel is unlabeled and is similar enough in color to the seed pixel" then label it and add it to the stack. Comparing to the seed pixel is more stable, because the seed pixel is constant for the region. Comparing only to the adjacent pixel can lead to leaking where a string of small changes ends up connecting two regions with very different colors.

The result will be pixel groups of similar color. These groupings can be useful for further analysis. They can be treated as "superpixels" to reduce the complexity of the image analysis.