Homework #2: Towards Contour-Detection

Due Wednesday, February 14th, 2007.

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Consider the images (work with 8 neighbors, not 16, to make it simple)

![Test Images](image1.png) ![Test+Noise Images](image2.png) ![Butterfly](image3.png)

Fig 1 (a) Test Images (b) Test+Noise Images (c) Butterfly

The goal is to understand better the local probability to detect intensity edges as described in class (using only 8 neighbors, but you are welcome to study 16 neighbors) and show the results as images.

Consider the cost function.

\[
 f_s(p, \theta) = \beta \left| \frac{D\hat{I}(p, \theta + s)}{T} \right| - \ln \log(1 + \alpha \left| \frac{D\hat{I}(p, \theta + \pi / 2, s)}{T} \right| + \varepsilon)
\]

where \( \alpha = 2^{n-1} - 1 \) and \( \beta' = \ln 2 \log_2 \left( \frac{n-1}{n} K \right) \) and in order to cope with precision values near \( |D\hat{I}(p, \theta + \pi / 2, s)| / T \approx 0 \) we must set \( \varepsilon \) small so that \(-\ln \varepsilon\) is a large number.

Before proceeding, let us “scale up” the cost function so that all values are positive. In this way, we will be able to run dynamic programming as well as Dijkstra’s algorithm on the same cost function and compare results. Given the global minimum value \( f_{\text{min}} = \min_{p, \theta} f(p, \theta) \), and global maximum value \( f_{\text{max}} = \max_{p, \theta} f(p, \theta) \), we can assure a linear scale and a positive quantity \( f_{s=5}^+(p, \theta) \), with a range from 0 to 255, with the formula

\[
 f_{s=5}^+(p, \theta) = \left( f_{s=5}^+(p, \theta) - f_{\text{min}} \right) \frac{255}{(f_{\text{max}} - f_{\text{min}})}
\]

For each image in the homework, display the function \( f_{s=5}^+(p, \theta) \), i.e., the minimum value of the function \( f_{s=5}^+(p, \theta) \) among the eight (8) different angles \( \theta = 0, \pi / 4, \pi / 2, 3\pi / 4, \pi, 5\pi / 4, 3\pi / 2, 7\pi / 4 \).
Note that the scale is 5, i.e., s=5. Try the following parameters with n=4,5 and K=2,4 and choose T appropriately and according to the image (vary with image to image). Say what T values you used Hint: T is the threshold for when a derivative is high enough to be detected as an “intensity edge”. So one can try by inspection what locations in the image have derivatives above a given T. You can adapt your program to show the edge locations that pass a threshold T. If these locations include too many pixels that are not edge in your opinion, than T is too low. If these locations include too few pixels that are edges in your opinion, and many edges in your opinion are not detected this way, than T was chosen to high. Note that T will be different for different images, i.e., don’t expect to have the same value of T for all the images in this homework or thereafter.

Also you can get an extra point by trying K=3.