Due: 11^{th} **Feb 2015 11:55 PM**

Canny Edge detection

10 points

1. Read the attached paper on Canny Edge Detection and briefly explain in one or two paragraphs, or as a list, the algorithm and the important points.

2. Implementation:

   Read image 'lena_std.tiff' and convert to gray scale and do the following operations

   (a) **Noise Reduction**
   Filter using

$$\frac{1}{159}\begin{bmatrix}2 & 4 & 5 & 4 & 2\\ 4 & 9 & 12 & 9 & 4\\ 5 & 12 & 15 & 12 & 5\\ 4 & 9 & 12 & 9 & 4\\ 2 & 4 & 5 & 4 & 2\end{bmatrix}$$

   (b) **Gradient Magnitude and Angle**

   - Compute the derivatives ($D_x(x,y)$ and $D_y(x,y)$) using following filters respectively

$$\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix} \quad , \begin{bmatrix}1 & 2 & 1\\ 0 & 0 & 0\\ -1 & -2 & -1\end{bmatrix}$$

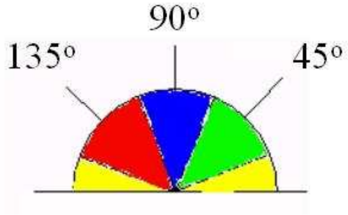
   - Compute the gradient magnitude

$$D = \sqrt{D_x^2(x,y) + D_y^2(x,y)}$$

   and the angle of the gradient

$$\theta = \arctan(\frac{D_y(x,y)}{D_x(x,y)})$$

   Compute θ' by rounding the angle θ to one of four directions 0° , 45° , 90° , or 135° . For edges, 180° = 0°, 225 = 45 , etc. This means θ in the ranges [22.5°...22.5°] and [157.5° ...202.5°] would "round" to $\theta' = 0°$. For a pictorial representation, each edge take on one of for colors:



Here, the colors would repeat on the lower half of the circle (green around 225° , blue around 270° , and red around 315°)

(c) **Non-Maximum Suppression**
Three pixels in a 3 × 3 around pixel (x, y) are examined:

- If $\theta'(x, y) = 0°$, then the pixels $(x+1, y), (x, y)$, and $(x-1, y)$ are examined.
- If $\theta'(x, y) = 90°$, then the pixels $(x, y+1), (x, y)$, and $(x, y-1)$ are examined.
- If $\theta'(x, y) = 45°$, then the pixels $(x+1, y+1), (x, y)$, and $(x-1, y-1)$ are examined.
- If $\theta'(x, y) = 135°$, then the pixels $(x+1, y-1), (x, y)$, and $(x-1, y+1)$ are examined.

If pixel (x, y) has the highest gradient magnitude of the three pixels examined, it is kept as an edge. If one of the other two pixels has a higher gradient magnitude, then pixel (x, y) is not on the "center" of the edge and should not be classified as an edge pixel.
At the end of this process, you should achieve an one pixel wide edge.

(d) **Hysteresis Thresholding** Some of the edges detected by above steps will not actually be valid, but will just be noise. We would like to filter this noise out. Eliminating pixels whose gradient magnitude D falls below some threshold removes the worst of this problem, but it introduces a new problem.
A simple threshold may actually remove valid parts of a connected edge, leaving a disconnected final edge image. This happens in regions where the edge's gradient magnitude fluctuates between just above and just below the threshold. *Hysteresis* is one way of solving this problem. Instead of choosing a single threshold, two thresholds t_{high} and t_low are used. Pixels with a gradient magnitude $D < t_{low}$ are discarded immediately. However, pixels with $t_{low} \leq D < t_{high}$ are only kept if they form a continuous edge line with pixels with high gradient magnitude (i.e., above t_{high}).

- If pixel (x, y) has gradient magnitude less than t_{low} discard the edge (write out black).
- If pixel (x, y) has gradient magnitude greater than t_{high} keep the edge (write out white).
- If pixel (x, y) has gradient magnitude between t_{low} and t_{high} and any of its neighbors in a 3 × 3 region around it have gradient magnitudes greater than t_{high} , keep the edge (write out white).

- If non of pixel (x, y)'s neighbors have high gradient magnitude but at least one falls between t_{low} and t_{high}, search the 5×5 region to see if any of these pixels have a magnitude greater than t_{high}. If so, keep the edge (write out white).
- Else, discard the edge (write out black).

Submission Instructions

Every student must submit following 2 files:

- An organized report submitted as a PDF document. The report should describe the implementation, issues (problems encountered, surprises), and an analysis of the test results (interpretation of effects of varying parameters, different image results). Intermediate and final results must be provided.
- A ZIP file containing the necessary codes.

The heading of the PDF file should contain the assignment number and topic. Also, attach a photo of yourself at top-left of the PDF along with your name and department.

Late Submission Policy

Assignments are expected to be submitted on the due date. Each student gets a total of 3 late days that can be used however you wish. For examples, all 3 days can be used towards 1 assignment or 1 day late for 3 assignments or other combinations. Late submissions beyond that will be penalized as below:

- One day late will be penalized 25% of the credit.
- Two Days late will be penalized 50%.
- Submissions more than 2 days late will not be considered for credit.

I will be ruthless in enforcing this policy. There will be no exceptions

Collaboration Policy

I encourage collaboration both inside and outside class. You may talk to other students for general ideas and concepts but the programming must be done independently. For mid-term and final examination there will be no collaboration permitted.

Plagiarism

Plagiarism of any form will not be tolerated. You are expected to credit all sources explicitly. If you have any doubts regarding what is and is not plagiarism, talk to me.