CS 422/522: Digital Image Processing
Homework 6 (Fall '12)

1. Using an image of your choice do each of the following:

   (a) Use the Sobel masks:

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

   and

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

   to compute and display two images representing the x and y directional derivatives of your image.

   (b) Compute and display an image representing the gradient magnitude of your image.

   (c) Compute an image representing the normal to the gradient direction. Normalize the image with grey values $[-\pi, +\pi]$ to an image with grey values in the range $[0, 255]$ and plot its histogram. Note: The *atan* function in UNM Scheme takes two arguments, the y and x components of the slope.

   (d) Compute the zero crossings of your image convolved with Laplacian of Gaussians with standard deviations, σ equal to 1, 2, 4, and 8. See Figure 1. Note: There are many ways to do this. For example, you can do frequency domain (or space domain) filtering with a Gaussian (the σ represents the standard deviation in the space domain) followed by convolution with the 3×3 Laplacian mask:

   $$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}.$$

2. UNM Scheme contains two built-in types not found in standard Scheme called *line* and *sketch*. A line represents a line segment and a sketch represents a set of lines. Using an image of your choice (not neccessarily the one you used above) do the following:
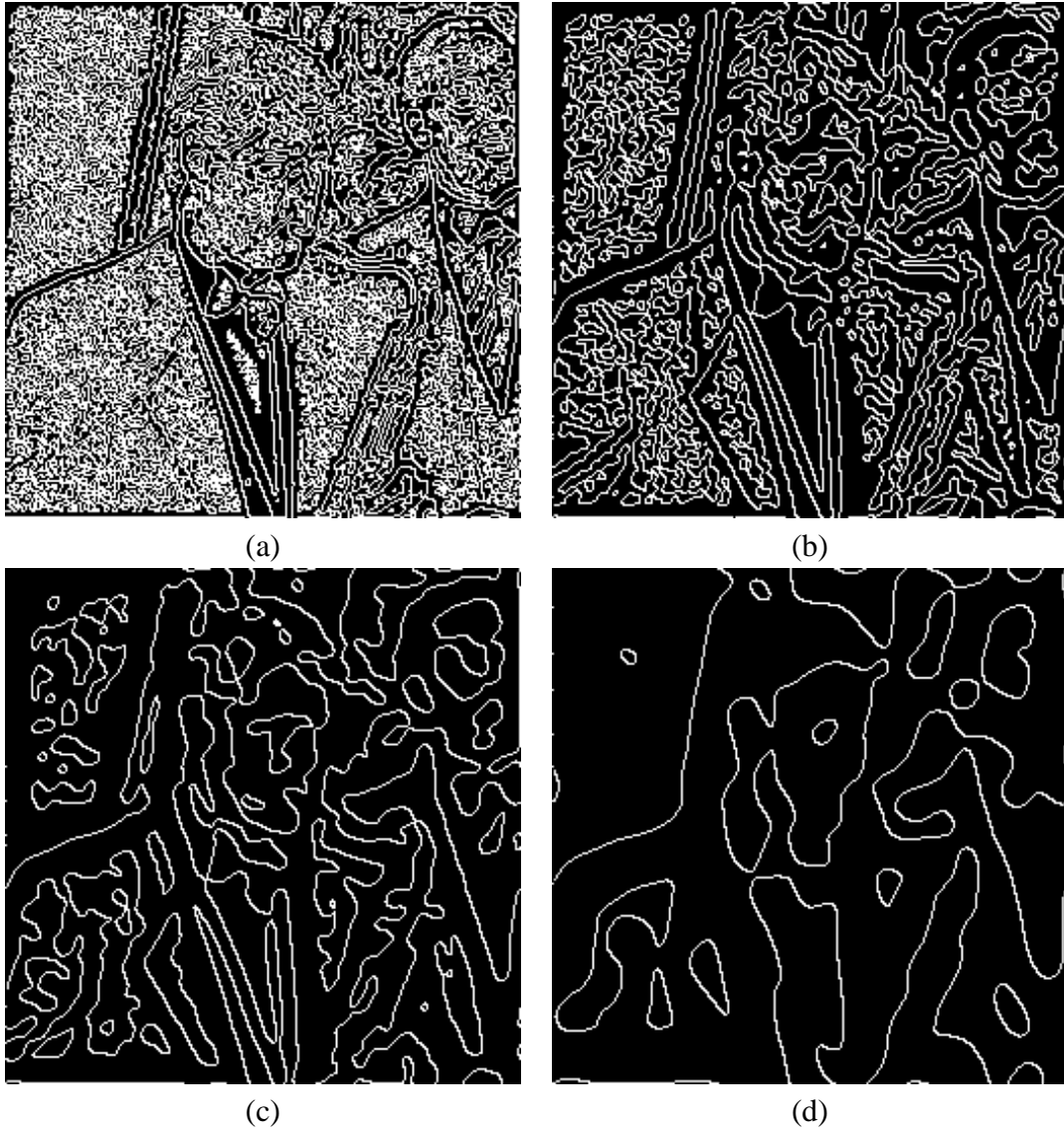
Figure 1: (a) Zero crossings of Laplacian of Gaussian ($\sigma = 1$) for Bill Clinton image. (b) $\sigma = 2$. (c) $\sigma = 4$. (d) $\sigma = 8$.

(a) Use the function *boldt* to compute a sketch from your image.

(b) Use the function *filter-on-length* to create a sketch which contains only lines of length greater than two.

(c) Use the function *filter-on-contrast* to create a sketch which contains only lines of contrast greater than ten.

(d) Use *sketch–>postscript* to render the last two sketches as postscript files.

3. Homogeneous coordinates are a device by which a non-linear *affine* transformation, $\mathbf{y} = \mathbf{Ax} + \mathbf{b}$, between two vectors in $\mathbb{R}^2$ is implemented as a linear transformation between two vectors in a plane in $\mathbb{R}^3$:

$$
\begin{bmatrix} y_0 \\ y_1 \\ \hline 1 \end{bmatrix} = \left[\begin{array}{cc|c} a_{00} & a_{01} & b_0 \\ a_{10} & a_{11} & b_1 \\ \hline 0 & 0 & 1 \end{array} \right] \begin{bmatrix} x_0 \\ x_1 \\ \hline 1 \end{bmatrix}.
$$

For example, using homogeneous coordinates, the operator which rotates $\mathbf{x}$ by θ about a point (u_0, u_1) while scaling it by a factor of s can be represented as a product of 3×3 matrices:

$$
\begin{bmatrix} y_0 \\ y_1 \\ \hline 1 \end{bmatrix} = \left[\begin{array}{cc|c} s & 0 & u_0 \\ 0 & s & u_1 \\ \hline 0 & 0 & 1 \end{array} \right] \left[\begin{array}{cc|c} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ \hline 0 & 0 & 1 \end{array} \right] \left[\begin{array}{cc|c} 1 & 0 & -u_0 \\ 0 & 1 & -u_1 \\ \hline 0 & 0 & 1 \end{array} \right] \begin{bmatrix} x_0 \\ x_1 \\ \hline 1 \end{bmatrix}.
$$

(a) Write a function *transform-sketch* which takes a sketch and one or more 3×3 arrays representing transformation matrices in homogeneous coordinates and returns a sketch where the transformations have been applied. Note: An array is simply a vector of vectors.

(b) Use *transform-sketch* to rotate one of the sketches you computed in the last problem about its center by $45°$ and scale it by a factor of 75%. See Figure 2.

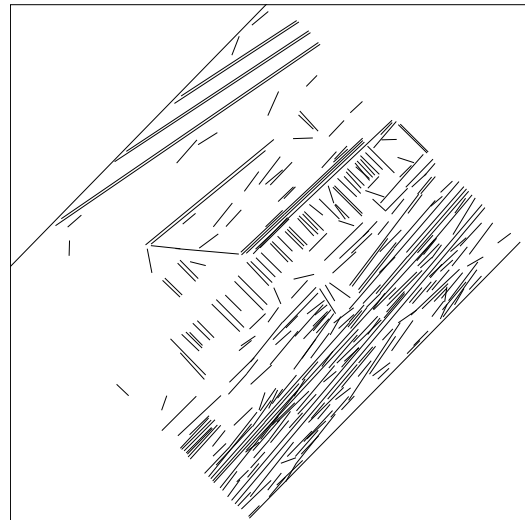(c) Use *sketch–>postscript* to render your sketch as a postscript file.
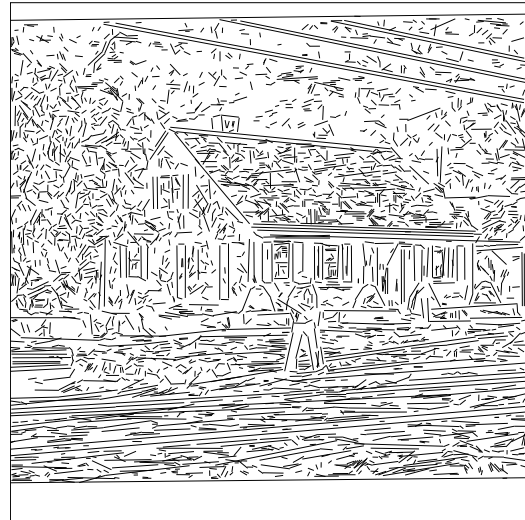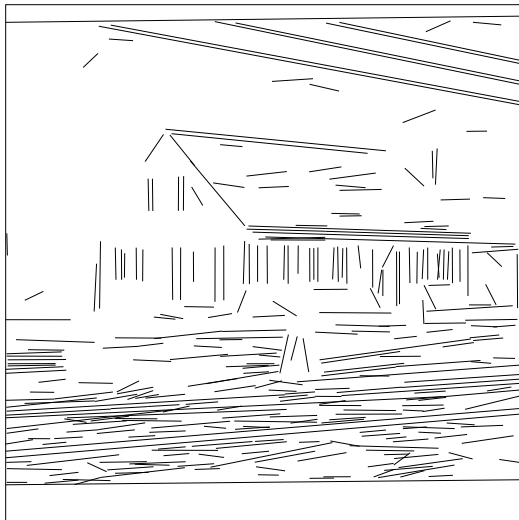
Figure 2: (a) House image. (b) Boldt lines of length greater than two. (c) Boldt lines of length greater than ten. (d) Boldt lines of length greater than ten after rotation about image center by 45° and scaling by 75%.