**Project Description**

Students are to write a computer program to perform edge detections on images. The name of the computer program is bmp\_image.cpp. The computer program reads an image (*image*.bmp) as input; *image* is the name of the .bmp image as specified by the user. *Image****.***bmp must be in the workspace directory. The word “*image*” should be replaced with the appropriate image file name. The image file must be in .bmp format. If the image is color, the image is saved in grey level as “*image\_grey*.bmp”.

In addition to the file name, the computer program takes in an odd integer as input. The odd integer represents the side-length of a M x M mask used in the adaptive-threshold technique.

The computer program performs edge detection operations on “*image*\_grey.bmp”. The computer program applies the Roberts, Sobel, Prewitt, and Robinson operators on “*image*\_grey.bmp”. *Image*\_Roberts.bmp, *image*\_Sobel.bmp, *image*\_Prewitt.bmp, and *image*\_Robinson.bmp are generated. Then, the computer program thresholds each new image in two ways; globally and locally. Edge pixels are black and non-edge pixels are white. Black-and-white edge images are generated for various thresholds for each grey-image.

The computer program performs edge detections using the Laplacian of the Gaussian. The computer program applies the Laplacian of the Gaussian with mask sizes of 11x11 and 21x21 on the images “actress.bmp”, “coins.bmp”, and “pattern2.bmp”. For each mask size, the computer program computes for various values of . The computer program uses zero crossings to detect the edges of the Laplacian of the Gaussian. The computer program generates images.

**Project Background**

**Template Matching**

The Roberts, Sobel, Prewitt, and Robinson operators are differential operators used to detect edges. The Roberts operator uses diagonally adjacent pixels to approximate a pixels gradient. This differs from the Sobel, Prewitt, and Robinson operators which use two 3x3 kernels to approximate a pixels gradient. Yet, all four operators are similar; they all compute an approximate gradient for each pixel. The Sobel, Prewitt, and Robinson operators each have two unique 3x3 kernels.

**Global Thresholding**

Global thresholds are applied to *image*\_Roberts.bmp, *image*\_Sobel.bmp, *image*\_Prewitt.bmp, and *image*\_Robinson.bmp. A global threshold is used to clip a gray-scale image into a binary image. If a pixel’s intensity exceeds the threshold, set that pixel to black. If a pixel’s intensity succeeds the threshold, set that pixel to white.

**Global Threshold Selection**

To select a global threshold a series of experiments is performed in which the thresheld image is examined as the threshold is adjusted, and the best results ascertained by eye.

**Local Thresholding**

Local thresholds are applied to *image*\_Prewitt.bmp. Local thresholding involves analyzing intensities in the neighborhood of each pixel to determine the optimal local threshold level. Local thresholding employs a local window. Both the threshold and the local window size are variables. The local window is of size NxN where N is an odd integer.

**Local Threshold Selection**

To select a local threshold a series of experiments is performed in which the thresheld images are examined as both the threshold and local window size are adjusted, and the best results ascertained by eye.

**Laplacian of Gaussian (LoG)**

The LoG is composed of two parts; first the Gaussian, second the Laplacian. Applying the Gaussian to an image will smooth the image. The Gaussian has a tendency to blur images. This means that for impulse noises with spikes, the Gaussian will smear spikes over a sizable number of pixels (Gaussian smoothing). The Laplacian highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian of an image is a measure of the sum of the second partial derivatives. Edges are highly correlated to the partial second derivatives of the Gaussian.

Zero-crossing the LoG is an edge detection method. A pixel crosses-zero if it is significantly darker than the other pixels in the neighborhood. With LoG images, the sets of zero-crossing pixels tend to be the image-edges. Therefore, computer programs detect edges using the zero-crossing of the LoG of an image.

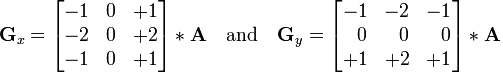
**Algorithm Description**

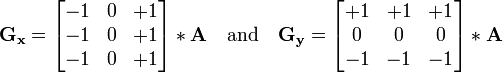
**Template Matching**

The Sobel, Prewitt, and Robinson operators uses two 3x3 kernels. The Roberts operator uses two 2x2 kernels. In either case, the two kernels are convoluted with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define **A** as the source image, **G***x* (horizontal gradient) as a point in an image formed by convolving with the first kernel, and **G***y* (vertical gradient) as a point in an image formed by convolving with the second kernel, then, for each pixel in **A,** there exists a gradient, **G**:

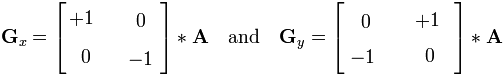
\mathbf{G} = \sqrt{ {\mathbf{G}_x}^2 + {\mathbf{G}_y}^2 }

The only difference between the Sobel, Prewitt, Robinson, and Roberts operators are in the definitions of **Gx** and **Gy**

 Sobel:

Prewitt: 

 Robinson:

 Roberts:

**Global Thresholding**

Threshold **G** to obtain the edge images. This computer program thresholds **G** globally or locally. To compute the global threshold of **G**,

// **G’** is the thresheld image of **G**

// thresh is the global threshold

// thresh is adjusted via trial and error experimentation (Bisection Method)

for all pixels in image **G** do {

[ [ if ( **G**>thresh ) **G’** = 0; else **G’** = 1; ] ]

}

**Local Thresholding**

To compute the local threshold of **G**, the computer program implements an adaptive thresholding algorithm:

// **G’** is the thresheld image of **G.**

// minrange is the minimum range.

// minrange is adjusted by the user via trial and error.

// T is the adaptive threshold.

// The size of the local-window can be adjusted by user

for all pixels in image **G** do {

find minimum and maximum of local intensity distribution;

range = maximum – minimum;

if ( range > minrange )

T = (minimum + maximum) / 2;

else

T = maximum – minrange / 2;

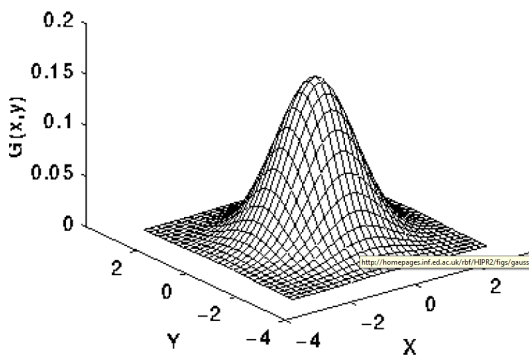
If ( **G** > T ) **G’** = 255; else **G’** = 0;

}

**The Laplacian of Gaussian**

The Gaussian (“Bell Curve”) may be used to reduce noise by blurring images.

Define the Gaussian of a xy-point to be:

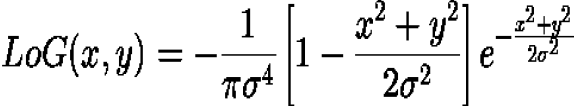
The Laplacian highlights regions of rapid intensity change;

exploiting color-spatial locality to detect edges.

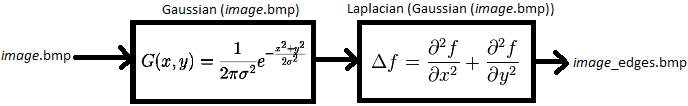
In mathematics, the Laplacian is a differential operator

given by the divergence of the gradient of a function.

The Laplacian of the Gaussian (LoG) closely defines the edges of an image. The LoG kernel can be pre calculated so only one convolution needs be performed per image.



Where the point (x,y) lies within the range of the LoG kernel. This mean that LoG is of two variables: (thestandard deviation)and the-kernel-size. The zero-crossing of the LoG binarizes the LoG into edge and non-edge pixels where edge pixels are black and non-edge pixels are white. Moreover, a zero-crossing applies a threshold of value equal to zero.



Compute the Laplacian of Gaussian kernels for various kernel sizes and . Convolve *image*.bmp with each kernel, visually-selecting the most appealing combination of kernel size and 

Pseudo code: Compute LoG.

double sigma = 3.0;

double pi = 3.14159265;

// Perform the LoG in advance to obtain mask, LoG.

double\*\* LoG = new double\* [WSIZE];

for ( i = 0 ; i < WSIZE ; i++ ) {

\*(LoG + i) = new double[WSIZE];

}

// For each element in the LoG mask.

// half is the kernel-size (WSIZE) divided by 2.

for (k=-half; k<=half; k++) {

for (m=-half; m<=half; m++) {

// Perform the LoG(x,y)

LoG[k+half][m+half] = ((-1)/(pi\*sigma\*sigma\*sigma\*sigma))\*

(1-(k\*k+m\*m)/(2\*sigma\*sigma))\*

(exp((-1)\*(k\*k+m\*m)/(2\*sigma\*sigma)));

}

}

Pseudo code: Zero-Crossing

double sum = 0;

// For each pixel

for (int j=0; j<yd; j++) {

for (int i=0; i<xd; i++) {

sum = 0;

for (k=-half; k<=half; k++) {

for (m=-half; m<=half; m++) {

if (i+k>=0 && i+k<xd && j+m>=0 && j+m<yd) {

/\* if pixel k,m of the window centered at i,j is

within [0,xd-1],[0,yd-1] \*/

sum += (LoG[k+half][m+half] \* array1[RED][i+k][j+m]);

}

}

}

if (sum < 0) \*indexr = 255;

else \*indexr = 0;

indexr++;

}

}

Show the values of the LoG masks:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 11 x 11 **** = 1 | | | | | | | | | | |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0005 | 0.0007 | 0.0005 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.0000 | 0.0003 | 0.0026 | 0.0085 | 0.0124 | 0.0085 | 0.0026 | 0.0003 | 0.0000 | 0.0000 |
| 0.0000 | 0.0001 | 0.0026 | 0.0175 | 0.0392 | 0.0431 | 0.0392 | 0.0175 | 0.0026 | 0.0001 | 0.0000 |
| 0.0000 | 0.0004 | 0.0086 | 0.0392 | 0.0000 | -0.0965 | 0.0000 | 0.0392 | 0.0086 | 0.0004 | 0.0000 |
| 0.0000 | 0.0007 | 0.0123 | 0.0431 | -0.0965 | -0.3183 | -0.0965 | 0.0431 | 0.0123 | 0.0007 | 0.0000 |
| 0.0000 | 0.0004 | 0.0086 | 0.0392 | 0.0000 | -0.0965 | 0.0000 | 0.0392 | 0.0086 | 0.0004 | 0.0000 |
| 0.0000 | 0.0001 | 0.0026 | 0.0175 | 0.0391 | 0.0431 | 0.0391 | 0.0175 | 0.0026 | 0.0001 | 0.0000 |
| 0.0000 | 0.0000 | 0.0003 | 0.0026 | 0.0086 | 0.0124 | 0.0086 | 0.0026 | 0.0003 | 0.0000 | 0.0000 |
| 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0005 | 0.0007 | 0.0005 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

|  |
| --- |
| 21 x 21 **** = 1 |
|  |

**Results and Analysis**

**Template Matching**

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|  | **Actress Edge Detection** | | | | |
| Roberts | Sobel | Prewitt | Robinson-3 | Robinson-5 |
| Global Thresh | **✓** | **✓** | **✓** | **✓** | **✓** |
| Local Thresh | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | **✓** | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg |

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| **Actress.bmp Roberts Global Threshold** | | | | | | | | | |
| **Actress** | **Roberts** | **5** | **15** | **25** | **50** | **75** | **100** | **125** | **150** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_75.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_125.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Roberts_globalThresh_150.bmp |

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| **Actress.bmp Sobel Global Threshold** | | | | | | | | | |
| **Actress** | **Sobel** | **5** | **15** | **25** | **50** | **75** | **100** | **125** | **150** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_75.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_125.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Sobel_GlobalThresh_150.bmp |

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| **Actress.bmp Prewitt Global Threshold** | | | | | | | | | |
| **Actress** | **Prewitt** | **5** | **15** | **25** | **50** | **75** | **100** | **125** | **150** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_75.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_125.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_GlobalThresh_150.bmp |

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| **Actress.bmp Robinson3 Global Threshold** | | | | | | | | | |
| **Actress** | **Robinson3** | **5** | **15** | **25** | **50** | **75** | **100** | **125** | **150** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_75.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_125.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson3_GlobalThresh_150.bmp |

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| **Actress.bmp Robinson5 Global Threshold** | | | | | | | | | |
| **Actress** | **Robinson5** | **5** | **15** | **25** | **50** | **75** | **100** | **125** | **150** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_75.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_125.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5_GlobalThresh_150.bmp |

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| **Actress.bmp Prewitt Local Threshold (minrange)** | | | | | | | |
|  | **Actress** | **Prewitt** | **5** | **25** | **50** | **100** | **200** |
| 5 x 5 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_5x5_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_5x5_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_5x5_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_5x5_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_5x5_LocalMinRange_200.bmp |
| 9 x 9 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_9x9_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_9x9_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_9x9_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_9x9_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_9x9_LocalMinRange_200.bmp |
| 13 x 13 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Robinson5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_13x13_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_13x13_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_13x13_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_13x13_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\actress_Prewitt_Window_13x13_LocalMinRange_200.bmp |

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|  | **Coins Edge Detection** | | | | |
| Roberts | Sobel | Prewitt | Robinson-3 | Robinson-5 |
| Global Thresh | **✓** | **✓** | **✓** | **✓** | **✓** |
| Local Thresh | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | **✓** | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg |

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| **Coins.bmp Roberts Global Threshold** | | | | | | | | | |
| **Coins** | **Roberts** | **5** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
| C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |  |  |  |

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| **Coins.bmp Sobel Global Threshold** | | | | | | | | | |
| **Coins** | **Sobel** | **5** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
| C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Coins.bmp Prewitt Global Threshold** | | | | | | | | | |
| **Coins** | **Prewitt** | **5** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
| C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |  |  |  |

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| **Coins.bmp Robinson3 Global Threshold** | | | | | | | | | |
| **Coins** | **Robinson3** | **5** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
| C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |  |  |  |

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| **Coins.bmp Robinson5 Global Threshold** | | | | | | | | | |
| **Coins** | **Robinson5** | **5** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
| C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |  |  |  |

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| **Coins.bmp Prewitt Local Threshold (minrange)** | | | | | | | |
|  | **Coins** | **Prewitt** | **5** | **25** | **50** | **100** | **200** |
| 5 x 5 | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |
| 9 x 9 | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |
| 13 x 13 | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\Coins.bmp |  |  |  |  |  |  |

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|  | **Pattern2 Edge Detection** | | | | |
| Roberts | Sobel | Prewitt | Robinson-3 | Robinson-5 |
| Global Thresh | **✓** | **✓** | **✓** | **✓** | **✓** |
| Local Thresh | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | **✓** | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg | http://www.easyvectors.com/assets/images/vectors/afbig/x-icon-clip-art.jpg |

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| **Pattern2.bmp Roberts Global Threshold** | | | | | | | |
| **Pattern2** | **Roberts** | **5** | **10** | **15** | **20** | **25** | **50** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_10.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_20.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Roberts_GlobalThresh_50.bmp |

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| **Pattern2.bmp Sobel Global Threshold** | | | | | | | |
| **Pattern2** | **Sobel** | **5** | **10** | **15** | **20** | **25** | **50** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_10.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_20.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Sobel_GlobalThresh_50.bmp |

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| **Pattern2.bmp Prewitt Global Threshold** | | | | | | | |
| **Pattern2** | **Prewitt** | **5** | **10** | **15** | **20** | **25** | **50** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_10.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_20.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_GlobalThresh_50.bmp |

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| **Pattern2.bmp Robinson3 Global Threshold** | | | | | | | |
| **Pattern2** | **Robinson3** | **5** | **10** | **15** | **20** | **25** | **50** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_10.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_20.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson3_GlobalThresh_50.bmp |

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| **Pattern2.bmp Robinson5 Global Threshold** | | | | | | | |
| **Pattern2** | **Robinson5** | **5** | **10** | **15** | **20** | **25** | **50** |
|  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_10.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_15.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_20.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Robinson5_GlobalThresh_50.bmp |

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| **Pattern2.bmp Prewitt Local Threshold (minrange)** | | | | | | | |
|  | **Pattern2** | **Prewitt** | **5** | **25** | **50** | **100** | **200** |
| 5 x 5 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_5x5_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_5x5_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_5x5_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_5x5_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_5x5_LocalMinRange_200.bmp |
| 9 x 9 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_9x9_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_9x9_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_9x9_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_9x9_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_9x9_LocalMinRange_200.bmp |
| 13 x 13 |  | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_13x13_LocalMinRange_5.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_13x13_LocalMinRange_25.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_13x13_LocalMinRange_50.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_13x13_LocalMinRange_100.bmp | C:\Users\UserName\Documents\Visual Studio 2010\Projects\bmp_image\bmp_image\pattern2_Prewitt_Window_13x13_LocalMinRange_200.bmp |

Observations (Global Thresholding):

* The Roberts, Sobel, Prewitt, Robinson3 and Robinson5 operations are real edge detectors.
* The Roberts, Sobel, Prewitt, Robinson3 and Robinson5 operations are unique edge detectors.
* The Robinson5 operator is a better edge detector than Robinson3.
* The Robinson3 operator is a better edge detector than Sobel.
* The Sobel operator is the least effective at eliminating noise.
* The Roberts operator is the most effective at eliminating noise.
* The Roberts operator is the least effective at detecting edges.
* The Robinson5 operator is the most effective at detecting edges.
* Robinson3 is less noisy than Robinson5, however Robinson5’s edges are more defined than Robinson3’s.
* The threshold that produces the optimal edge detection is a variable of the image.

Observations (Local Thresholding):

* Compared to global thresholding, adaptive (local) thresholding is an effective edge detection technique.
* The optimal window-size is a variable of the image.
* The optimal minrange is a variable of the image.
* Increasing the window-size thickens the edges.

**Laplacian of Gaussian**

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| **Actress.bmp** | | | | | |
|  | **= 1.0** | **= 1.5** | **= 2.0** | **= 2.5** | **= 3.0** |
| 11 x 11 | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_11x11_sigma_1.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_11x11_sigma_1.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_11x11_sigma_2.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_11x11_sigma_2.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_11x11_sigma_3.0_zero_X.bmp |
| 21 x 21 | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_21x21_sigma_1.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_21x21_sigma_1.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_21x21_sigma_2.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_21x21_sigma_2.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\actress_LoG_21x21_sigma_3.0_zero_X.bmp |

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| **Coins.bmp** | | | | | |
|  | **= 1.0** | **= 1.5** | **= 2.0** | **= 2.5** | **= 3.0** |
| 11 x 11 |  |  |  |  |  |
| 21 x 21 |  |  |  |  |  |

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| **Pattern2.bmp** | | | | | |
|  | **= 1.0** | **= 1.5** | **= 2.0** | **= 2.5** | **= 3.0** |
| 11 x 11 | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_11x11_sigma_1.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_11x11_sigma_1.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_11x11_sigma_2.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_11x11_sigma_2.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_11x11_sigma_3.0_zero_X.bmp |
| 21 x 21 | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_21x21_sigma_1.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_21x21_sigma_1.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_21x21_sigma_2.0_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_21x21_sigma_2.5_zero_X.bmp | C:\Users\UserName\Desktop\CSULB\CECS 553\machinevision\Assignments\Assignment 1\pattern2_LoG_21x21_sigma_3.0_zero_X.bmp |

Observations:

* The zero-crossing of the Laplacian of the Gaussian is an edge detection mechanism.
* Increasing the mask size results in thicker edges and thicker noise.
* Increasing **** eliminates noise; however, increasing **** too much will eliminate edges.
* There exists an optimal pair (****mask-size) for each and every image.

**Conclusion**

Because local thresholding is a more effective edge detecting method than global thresholding, we may conclude that exploiting spacial locality can only improve edge detection; in the worst case, local (adaptive) thresholding will be at least as effective as global thresholding.

Template Matching and the Laplacian of the Gaussian are two edge detecting methods. With local thresholding, increasing the window size increases the width of the edges. With the Laplacian of the Gaussian, increasing the window size increases the width of the edges.

With the Laplacian of the Gaussian edge detection method; increasing the mask size results in thicker edges and thicker noise, and increasing **** eliminates noise, however, increasing **** too much will eliminate edges.