An Investigation into the Application of Edge Detection to Detect Cells

# Aim

The aim of this experiment is to contrast and compare the suitability of various edge detection algorithms and their application in serological testing for anti-nuclear antibodies. The edge detection methods that will be investigated in this experiment are as follows: Simple gradient, Roberts, Sobel, first order Gaussian. Laplacian and Laplacian of Gaussian. The results of each will then be compared using Receiver Operator Check analysis so that a conclusion can be drawn.

# Method

In order to perform edge detection, first a single image matrix must be produced from the colour images provided as the colour images comprise of 3 separate red, green, blue (RGB) matrices. This is done by taking only the green channel of the image as the cells being detected fluoresce green. After an image matrix has been created smoothing can be applied if required and an edge detection algorithm can be applied.

## First Order Derivative Edge Detection

First order derivative edge detection approximates the gradient of an image, after the gradient of an image has been calculate the areas of change within the image are then apparent. These areas of change are normally associated with edges therefore by thresholding the gradient values with a suitable threshold the edges of the image can be found.

### Simple Gradient:

Simple gradient first calculates the vertical gradient and horizontal gradient of the image, to calculate the vertical gradient the image is convolved with and to calculate the horizontal gradient convolve the image with . After getting both the horizontal and vertical gradient an approximation for the image gradient can be made by finding the magnitude of the two gradient matrices using .

### First order derivative of Gaussian:

The first order derivative of Gaussian is similar to the simple gradient technique except that before applying the simple gradient technique the image is convolved with a Gaussian like simple gradient but convolve the filters with a Gaussian filter before application. This has the effect of removing noise from the image which should remove the number of false positives in the edge detection.

### Sobel:

Sobel utilises a three by three matrices to approximate horizontal and vertical gradients, this has the advantage of there being a centre to the matrices which retains the positioning of the gradients instead of shifting the positions which happens when using a 2x2 matrix. The image is then convolved with the matrix to find the horizontal gradient image and with to find the vertical gradient image. The image gradient can then be approximated using the same technique described in simple gradient.

### Roberts:

The Roberts edge detection method approximates the gradient of an image by first finding the differences between diagonally adjacent pixels. This is done using two 2x2 matrix and convolving them with the original image to form and . These are both gradient components of the image which are finally used to calculate a gradient magnitude with .

## Second Order Derivative Edge Detection

Second order derivative edge detection approximates the rate of change of gradient in a given image, after this has been found the point at which there is a crossing from negative to positive change can be detected, this represents an edge in the image. As each time a derivative is taken noise in the image is amplified second order derivative edge detection is considered bad for noisy images unless smoothing is applied.

### Laplacian

Laplacian edge detection utilises only a single matrix in order to approximate changes in gradient of an image. The matrix is convolved with the image matrix to create a matrix representing the change in gradient. The edges are then detected by finding the points where there is a change from negative to positive in the matrix.

### Laplacian of Gaussian

The Laplacian of Gaussian method is similar to the Laplacian method except a Gaussian matrix is first convolved with the edge detection matrix described above. After this has happened the resulting matrix is convolved with the image matrix and edges are found in the same manner as Laplacian. This has the effect of smoothing the image at the same time as applying Laplacian edge detection therefore removing noise from the image and false positives from the edge detection.

## Receiver Operator Characteristic (ROC) Analysis

Once the edge matrix has been calculated then the correctness of the detection method can be determined using ROC analysis

# Results

When doing this experiment, we have found that according to RoC analysis, the best method of edge filtering is the Difference filter.

|  |  |
| --- | --- |
| Filter | Distance Average\* |
| Difference | 0.292549 |
| Laplacian | 0.714515 |
| Laplacian of Gaussian | 0.815416 |
| Roberts | 0.33479 |
| Sobel | 0.340892 |

\*Average Distance is the average Distance to (0,1)

Roberts and Sobel all are not far behind, and the best RoC score was with Sobel filter on image 1.  
The discrepancy between the images comes from different levels of noise in the images.

The Laplacian was poor according to the RoC, and from looking at the image. The Laplacian of Gaussian is more of a special case however, as the edges it produces are very clear, but it gets a low RoC score.

These are the values we used for each image:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Image1 | Start Threshold | End Threshold | Gaussian Size | Gaussian Deviation |
| Diff | 0 | 0.09 | 3 | 0.5 |
| Laplace | 0 | 0.0175 | - | - |
| LoG | 0.7 | 1 | 9 | 3.5 |
| Roberts | 0 | 0.06 | 3 | 0.5 |
| Sobel | 0 | 0.3 | 3 | 0.5 |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Image 2 | Start Threshold | End Threshold | Gaussian Size | Gaussian Deviation |
| Diff | 0 | 0.026 | 4 | 1.5 |
| Laplace | 0 | 0.0175 | - | - |
| LoG | 0.7 | 1 | 9 | 3.5 |
| Roberts | 0 | 0.02 | 6 | 1.5 |
| Sobel | 0 | 0.14 | 3 | 1.5 |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Image 3 | Start Threshold | End Threshold | Gaussian Size | Gaussian Deviation |
| Diff | 0 | 0.05 | 7 | 2.5 |
| Laplace | 0 | 0.021 | - | - |
| LoG | 0.65 | 0.8 | 9 | 3.5 |
| Roberts | 0 | 0.045 | 6 | 1.5 |
| Sobel | 0 | 0.31 | 4 | 1.5 |

As we can see from the graphs, there is a low false positive rate for all of the filter types – but this is to be expected because edges are small, so to get any sort of useful data when detecting edges, the false positive rate should be small.

Secondly, we can see what was confirmed by the average distance score – there are two groups of scores, the Difference, Roberts and Sobel, and the Laplacian and Laplacian of Gaussian.

Laplacian is very sensitive to noise – which is why is has such a low RoC score.

The Laplacian of Gaussian is a little different, as for some reason our implementation detects the wrong part of the image

# Conclusion