ECE/CSE 576

HW 1 Notes

Overview

- Assignment 1 is a big set of exercises to code functions that are basic and many of which are needed for future assignments.
- Sample functions are provided at the beginning of the code, so you get an idea how to work with the images in Qt.
- The required functions come from the lectures on filtering, edge finding, and segmentation.

QImage Class in the QT package

- The Qimage class provides a hardware-independent image representation
- Some of the useful methods
  - QImage() (and other forms with parameters)
  - copy(int x, int y, int width, int height) const
  - setPixel(int x, int y, uint index_or_rgb) can use function qRgb(int r, int g, int b)
  - width() const, height() const
- The QRgb class holds a color pixel.
- from http://doc.qt.io/qt-4.8/qimage.html

Double Arrays

- We've modified the original assignment, which had truncation problems when passing images around.
- Instead, you will pass around arrays of doubles.
- The function ConvertQImage2Double() that we provide will convert a Qimage to a 2D matrix.
- The first dimension handles both columns (c) and rows (r), while the second one specifies the color channel (0, 1, 2).
- Position (c,r) maps to r*imageWidth + c.
- This will lead nicely in HW 2, which also uses doubles.
- You don't have to convert back to Qimage!
- You do have to copy any images that you are going to modify.

1. Convolution

- The first task is to code a general convolution function to be used in most of the others.
- void Convolution(double **image, double *kernel, int kernelWidth, int kernelHeight, bool add)
- image is a 2D matrix of class double
- kernel is a 1D mask array with rows stacked horizontally
- kernelWidth is the width of the mask
- kernelHeight is the height of the mask
- if add is true, then 128 is added to each pixel for the result to get rid of negatives.

Reminder: 2D Gaussian function with standard deviation σ

In 2-D, an isotropic (*i.e.* circularly symmetric) Gaussian has the form:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

This distribution is shown in Figure 2.

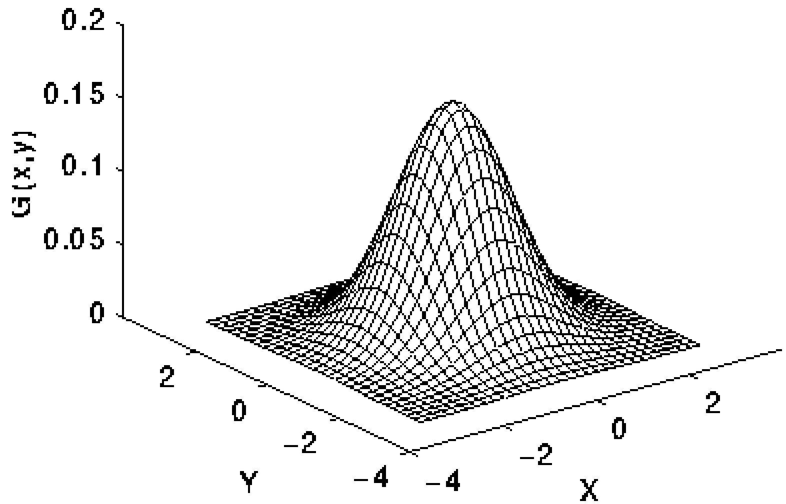


Figure 2 2-D Gaussian distribution with mean (0,0) and σ=1

2. Gaussian Blur

- The second task is to code a Gaussian blur which can be done by calling the Convolution method with the appropriate kernel.
- void GaussianBlurImage(double **image, double sigma)
- Let the radius of the kernel be 3 times σ
- The kernel size is then (2 * radius) + 1

3. Separable Gaussian Blur

- Now implement a separable Gaussian blur using separate filters for the horizontal blur and then the vertical blur. Call your Convolution function twice.
- void SeparableGaussianBlurImage(double **image, double sigma)
- The results should be identical to the 2D Gaussian Blur.

4. First and Second Derivatives of the Gaussian

- void FirstDerivative_x(double **image, double sigma) takes the image derivative in the x direction using a 1*3 kernel of { -1.0, 0.0, 1.0 } and then does a standard Gaussian blur.
- void FirstDerivative_y(double **image, double sigma) takes the derivative in the y direction and then does a standard Gaussian blur
- void SecondDerivImage(double **image, double sigma) computes the Laplacian function and then does a standard Gaussian. For the Laplacian, rather than taking the derivative twice, you may use the 2D kernel:

  0.0, 1.0, 0.0
  1.0, -4.0, 1.0
  0.0, 1.0, 0.0

- All of these add 128 to the final pixel values in order to see negatives. This is done in the call to Convolution().

5. Sharpen Image

- Sharpen an image by subtracting the Gaussian-smoothed second derivative image from the original. Will need to subtract back off the 128 that second derivative added on.
- void SharpenImage(double **image, double sigma, double alpha)
- Sigma as usual and alpha is the constant to multiply the smoothed 2^{nd} derivative image by.

6. Sobel Edge Detector

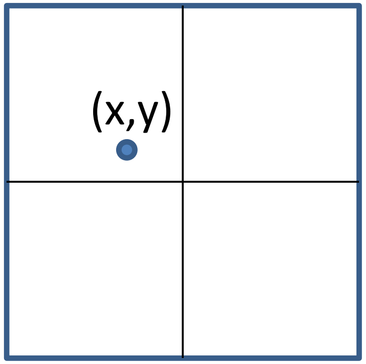
- Implement the Sobel operator, produce both the magnitude and orientation of the edges, and display them.
- void SobelImage(double **image)
- Use the standard Sobel masks:

```
-1,  0,  1,
-2,  0,  2,
-1,  0,  1

 1,  2,  1,
 0,  0,  0
-1, -2, -1
```

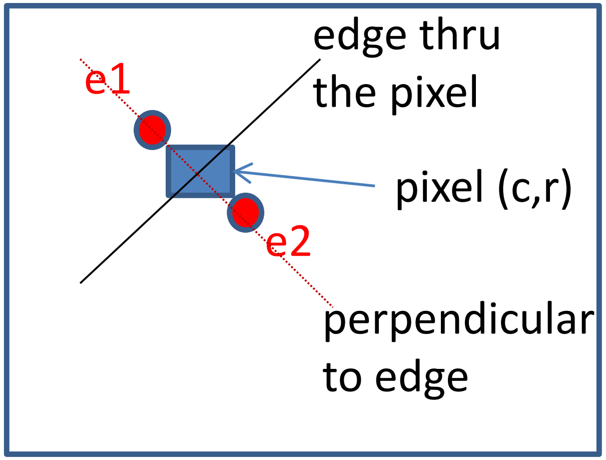
7. Bilinear Interpolation

- Given an image and a real-valued point (x,y), compute the RGB values for that point through bilinear interpolation, which uses the 4 closest pixel value.
- void BilinearInterpolationdouble **image, double x, double y, double rgb[3])
- Put the red, green, and blue interpolated results in the vector rgb.



8. Find Peaks of Edge Responses

- This function finds the peaks of the edge responses perpendicular to the edges.
- void FindPeaksImage(double **image, double thres)
- It first uses Sobel to find the magnitude and orientation at each pixel.
- Then for each pixel, it compares its edge magnitude to two samples perpendicular to the edge at a distance of one pixel, which requires BilinearInterpolation().
- If the pixel edge magnitude is e and these two are e1 and e2, a peak e must be larger than “thres” and larger than or equal to e1 and e2.
- See next slide.



e1x = c + 1 * cos(θ);
e1y = r + 1 * sin(θ);
e2x = c – 1 * cos(θ);
e2y = r – 1 * sin(θ);

Example: r=5, c=3, θ=135 degrees
sin θ = .7071, cos θ =-.7071
e1 =(2.2929,5.7071)
e2 = (3.7071, 4.2929)

9. Color Clustering

- Perform K-means clustering on a color image first with random seeds and then by selecting seeds from the image itself.
- void RandomSeedImage(double **image, int num_clusters)
- void PixelSeedImage(double **image, int num_clusters)
- Use the RGB color space, and the distance between two pixels with colors (R1,G1,B1) and (R2,G2,B2) is $|R1-R2|+|G1-G2|+|B1-B2|$.
- Use epsilon = 30 or max iteration# = 100