UCLA
Dept. of Electrical Engineering
EE 114, Spring 2016
Computer Assignment 5: 2-D Convolution
Due: May 12, 2016

Introduction: This assignment focuses on two-dimensional convolution. In addition, it considers peak signal to noise ratio (PSNR), a metric for comparing images.

This is a brief overview of the image functions that may be helpful for this assignment. You can download the file `ca5_image.tif` from the course website.

Loading an image (`imread`): Images can be loaded into workspace with the `imread` function:

```
image = imread(ca5_image.tif);
```

Displaying an image (`imagesc`): Throughout all the computer assignments of the rest of this quarter, we will only deal with grayscale images. Grayscale images are matrices in the Matlab workspace. They can be displayed by the `imagesc` function with a grayscale colormap:

```
imagesc(ca5_image); colormap(gray);
```

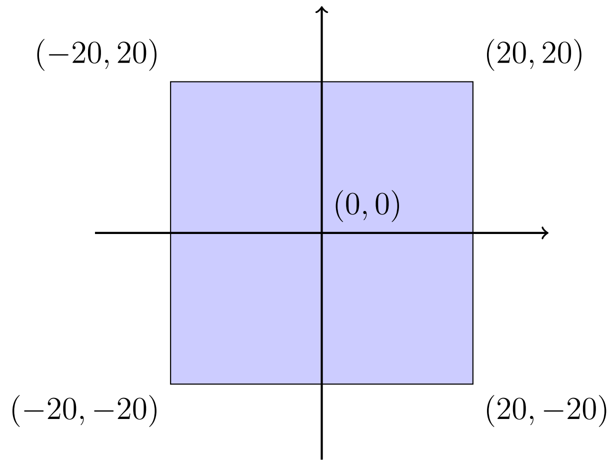
Cropping an image (`imcrop`): An image can be cropped by using the function `imcrop`, which crops image to a specified rectangular area:

```
rect = [30, 20, 99, 199]; imcrop (ca5_image, rect);
```

This will crop an image to size 100×200 with upper left corner at $(30, 20)$.

Tasks: The **boldface** text indicates what you need to turn in for completion of your computer assignment. You also need to turn in all the Matlab code that you write.

1. **Load and display an image**. Load and display the `ca5_image.tif` file. Try to display it with the correct aspect ratio, and print out the image.
2. **Generate a 2-dimensional Gaussian distribution matrix**. Generate a matrix of size 41×41, and fill it with the Gaussian distribution with $\lambda = 5$.



The Gaussian distribution is:

$$H(x, y) = C \exp\left(-\frac{m^2 + n^2}{\lambda}\right).$$

The constant C is computed such that the elements of $H(m, n)$ add up to 1:

$$\sum_{m,n} H(m, n) = 1.$$

Note that indices of the matrix you generated range from 1 to 41, not from -20 to 20 because Matlab supports only positive indexes. In other words, the "origin" in your matrix is at $(21, 21)$, not $(0, 0)$.

3. **Convolve the image with the Gaussian matrix**. Convolve the image loaded in task 1 with the Gaussian matrix generated in task 2. You may use the Matlab function `conv2` to perform the two dimensional convolution:

```
g = conv2(ca5_image,H);
```

Please note that `conv2` outputs a matrix in which each dimension is the sum of the corresponding dimensions of the two input matrices. After the convolution is complete, crop the image back to the original size. Display and print out the cropped image. Turn in the print out of that image.

When you crop the image, you need to consider the fact that the origin of the Gaussian matrix is at $(21, 21)$. You want to ensure that convolving with the Gaussian matrix does not introduce an unintentional shift to the image. To avoid the shift of the resulting image (this is important to obtain the correct PSNR result below), you need to crop the image properly so that the upper left corners of the original image (before convolution) and the cropped image (after convolution) are consistent. To explore this, you can create an image consisting of only a delta function and convolve the image with the Gaussian matrix. Then, you can see if the result is equal to the Gaussian convolution mask centered at the place where the delta function was located (you dont need to turn in the results of this delta function experiment; its simply to assist you in ensuring your program is working as desired).

What happened to the image `ca5_image.tif` when it is convolved with the Gaussian matrix? (Write your observations on the report you are turning in).

4. **Measurement of the difference between images**. There are many was to measure the difference between two (typically) similar images. The PSNR between two images is a commonly used metric, and is defined by:

$$\mathrm{PSNR} = 10 \log_{10} \left(\frac{255^2}{\frac{1}{M,N} \sum_{k=1}^{M} \sum_{\ell=1}^{N} \left(\mathrm{image1}(k,\ell) - \mathrm{image2}(k,\ell)\right)^2} \right),$$

   where M and N are the horizontal and vertical sizes of your images.

5. **More blur**. Repeat tasks 2 to 4 with $\lambda = 10$. Turn in the convolved image and the corresponding PSNR result.