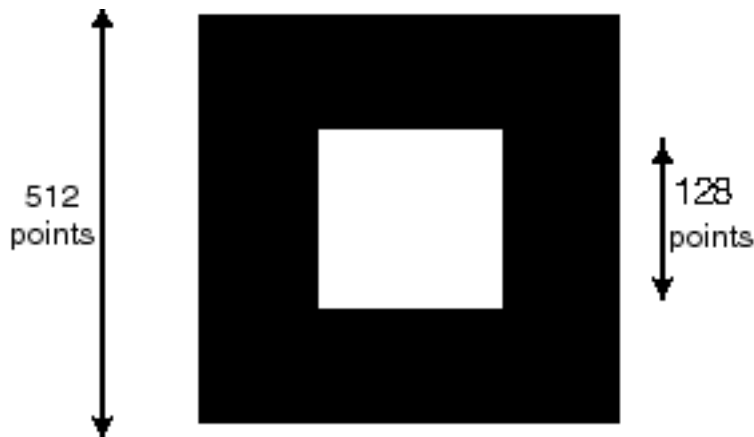


Problem 1 - Convolution of simple shapes.

Create two copies of an image that consists of a white square in a black background as:



Convolve these two images using the matlab time-domain convolution function `conv2`, with the shape parameter set to 'same'.

- i. Time the execution interval using matlab commands `tic` and `toc`. Display and submit the output image. Plot cuts through the image along one axis and also along a 45 degree angle through the origin.
- ii. Derive the convolution of two equal-size squares analytically, and compare your result to the numerical values you have determined.

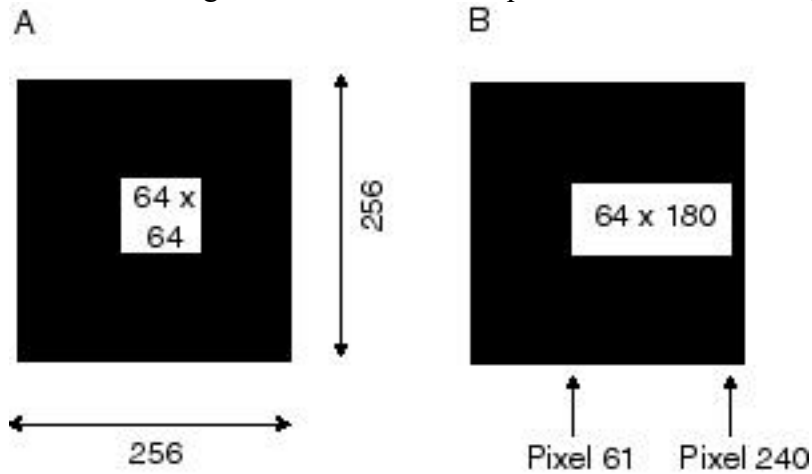
Problem 2 - Convolution with the Convolution Theorem.

Using the same image as in problem 1, convolve using fft's and the convolution theorem. Time the result again and compare with the result from problem 1.

You will have to be careful with your `fftshift` operations at the end, as `ffts` reference the origin to the upper left hand corner, while `conv2` uses an origin in the center.

### Problem 3 - Convolution end effects.

Create two images of white on black squares with the following parameters:



- Calculate the convolution of image A with image B using `conv2`. What happens to the points that fall off the end of the 256 by 256 array ?
- Repeat with fft techniques. Now what is the fate of the off the end points ?

### Problem 4 - Autocorrelation of a circular disk.

Calculate the autocorrelation (that is, the correlation of a function with itself) of a circular disk. Use a disk of radius 32 in the center of a 512 by 512 array of zeroes. Display and submit. Also submit a plot through the peak on the function.

### Problem 5 - Where, o where has my dog gone?

- Copy the files `lab6prob5data` and `lab6prob5dog` from the class website. Display the image in `lab6prob5data`, it is a byte image 512 by 512 points. There are some dogs hiding in the image, one of which is reproduced in `lab6prob5dog`, which is a 64 by 64 image. How many copies of the dog can you see using your eye directly?
- Now use correlation techniques to locate dogs in the larger picture. Note: you will need to make the reference dog a zero mean image to achieve the highest performance. Identify dogs with correlation peaks in the resulting image. Which ones are easiest to recognize ? What is it about the background that leads to the best correlation peaks ?

## Problem 6 – Computer Vision

- i. Load in the files lab6prob6data1 and lab6prob6data2 from the class website. These are .jpg and .png files, so you can use the function “imread”. Convert these images to grayscale from RGB and display them.
- ii. Act like an autonomous vehicle, and given your sign template image, find the location of the corresponding sign in the background image using only correlation techniques. Write a function that takes in a template and a background image, computes the normalized cross correlation between the two, and draws a box around the most likely spot in the target image where the template image is found. In your function, create plots of the correlation and of the final background image with the rectangle drawn. Demonstrate this function on the images from part i.  
*Hint: The MATLAB functions “normxcorr2” and “rectangle” should help you with this question.*
- iii. Though this seems like a promising technique for computer vision, it has some major limitations (and in general is not used in industry). Scale the sign image down to  $\frac{1}{4}$  the size and use that as the template image input to your function. Does the algorithm do as good of a job locating the sign? Explain why this might be the case.