CSE 573
Hw2 Report
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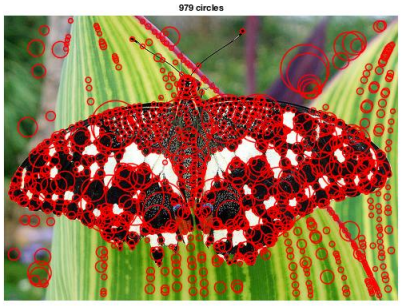
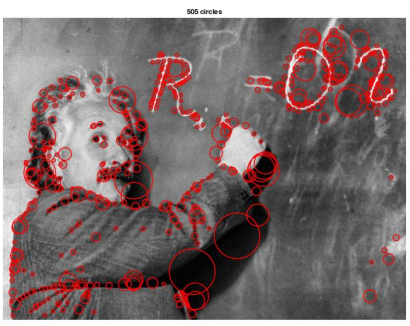
1. Output of circle detector on all images

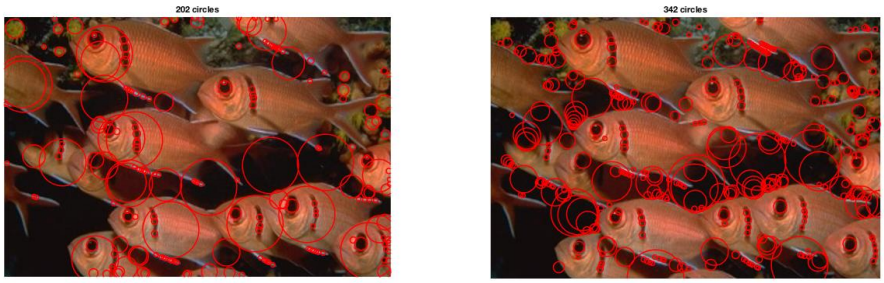
Left: With “inefficient” method, elapsed time is 1.055248 seconds.
Right: With “efficient” method, elapsed time is 0.083849 seconds.



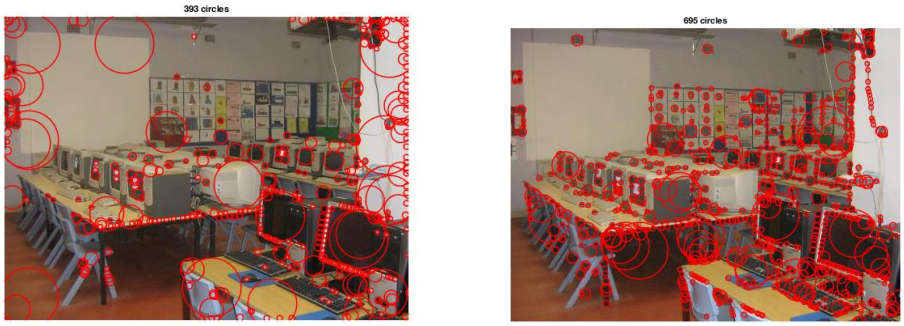
Left: With “inefficient” method, elapsed time is 1.581091 seconds.
Right: With “efficient” method, elapsed time is 0.143090 seconds.



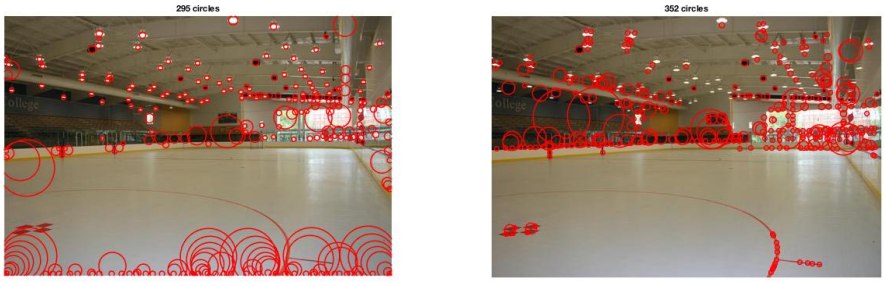
Left: With “inefficient” method, elapsed time is 2.545078 seconds.
Right: With “efficient” method, elapsed time is 0.187073 seconds.



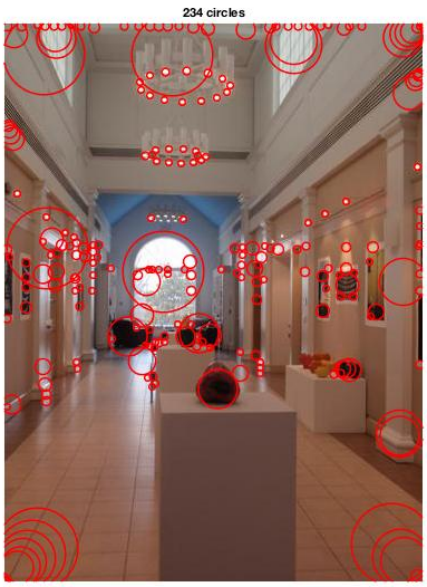
Left: With “inefficient” method, elapsed time is 1.554247 seconds.
Right: With “efficient” method, elapsed time is 0.127936 seconds.



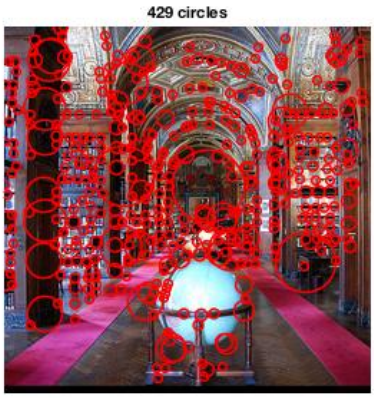
Left: With “inefficient” method, elapsed time is 1.827030 seconds.
Right: With “efficient” method, elapsed time is 0.134068 seconds.



Left: With “inefficient” method, elapsed time is 1.469022 seconds.
Right: With “efficient” method, elapsed time is 0.116854 seconds.



Left: With “inefficient” method, elapsed time is 1.628208 seconds.
Right: With “efficient” method, elapsed time is 0.139809 seconds.



Left: With “inefficient” method, elapsed time is 0.696131 seconds.
Right: With “efficient” method, elapsed time is 0.067359 seconds.

The only difference between these two implementations are the way to get scale space, so I add ‘tic toc’ into SlowGetScaleSpace.m and FastGetScaleSpace.m to get running time for each method.During my implementation, I found that outputs of inefficient and efficient method are slightly different if I keep all other parameters same(except threshold, in fact; the value of threshold doesn’t affect these two functions above); However, in order to compare the running time, I have to keep all parameters(k, level and initial_scale) staying same and give two outputs for each image.

	Sunflower	Butterfly	Einstein	Fish	Computer	Ice	Gallery	Library
Inefficient method	1.055248s	1.581091s	2.545078s	1.554247s	1.827030s	1.469022s	1.628208s	0.696131s
Efficient method	0.083849s	0.143090s	0.187073s	0.127936s	0.134068s	0.116854s	0.139809s	0.067359s

As We can see, the method that downsamples the images is a lot more efficient than the method that increases filter size.

2. An explanation of any “interesting” implementation choices that you made.

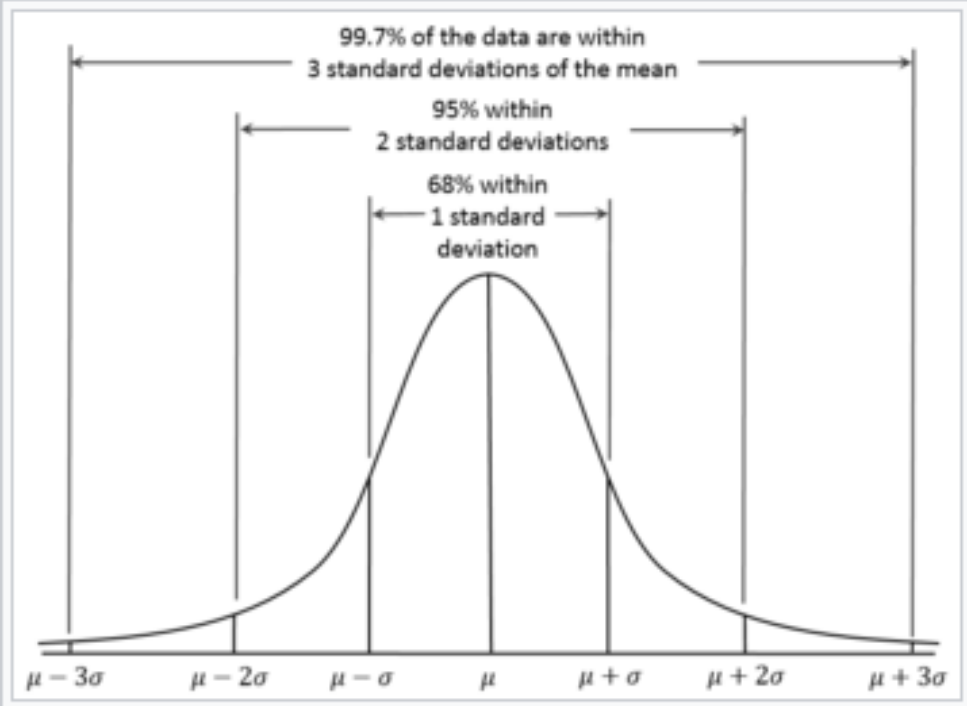
a. When I use the function: fspecial

h = fspecial('log',hsize,sigma) returns a rotationally symmetric Laplacian of Gaussian filter of size hsize with standard deviation sigma (positive).

I decided use 2*3*sigma+1 for the value of hsize.

First, add one to ensure the filter width be odd, because we can find a center in an odd width.

Second, I use 2*3*sigma as the filter size because by the property of normal distribution, the value less than three standard deviations account for 99.73%



Reference: Normal distribution, Wikipedia.

b. When I do nonmaximum suppression for each layer, I may use three functions nlfilter, colfilt orordfilt2. I run some tests on these functions as following:

```
I=imread('../data/butterfly.jpg');
I=rgb2gray(I);
I=im2double(I);
tic
ordfilt2(I(:,:,1),9,ones(3));
toc
tic
fun = @(x) max(x(:));
nlfilter(I(:,:,1),[3 3],fun);
toc
tic
colfilt(I(:,:,1),[3 3],'sliding',@max);
toc
```

```
Command Window
>> Untitled
Elapsed time is 0.021362 seconds.
Elapsed time is 1.938602 seconds.
Elapsed time is 0.068200 seconds.
fx >>
```

It turns out ordfilt2 is the fastest one. Then I choose ordfilt2 in my implementation.

When I do nonmaximum suppression for the entire scale space, for each layer, I compare it with its two neighborhoods because “Maxima and minima of the difference-of-Gaussian images are detected by comparing a pixel to its 26 neighbors in 3x3 regions at the current and adjacent scales.”

For the first and last layer, I only compared it with one other layer because it only has one neighborhood.

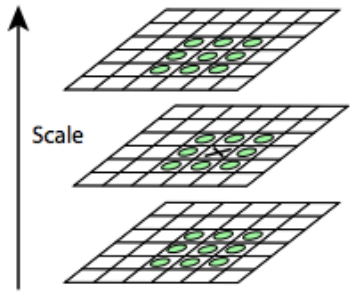
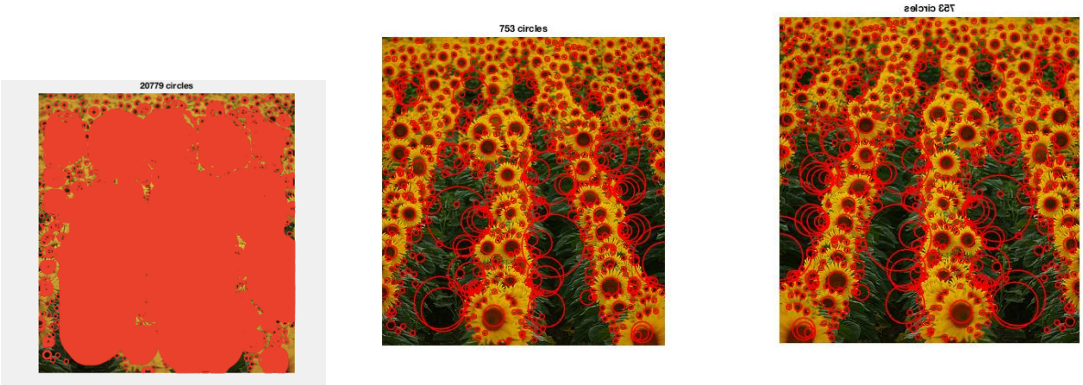


Figure 2: Maxima and minima of the difference-of-Gaussian images are detected by comparing a pixel (marked with X) to its 26 neighbors in 3x3 regions at the current and adjacent scales (marked with circles).

Reference: David G Lowe. Distinctive image features from scale-invariant keypoints.

c. There are three interpolation methods 'nearest', 'bilinear' and 'bicubic' when I use imresize to upsample the filtered images. I try all of these method and get outputs.



(Left to right: 'nearest', 'bilinear' and 'bicubic')

'bicubic' works best and I choose it in my imresize function.

3.An explanation of parameter values you have tried and which ones you found to be optimal.

Like I mentioned above, I found that outputs of inefficient and efficient method are slightly different. Hence, I found different parameters for two methods in order to get optimal output. I decide to use sunflower image to do my test because it contains most amount of circles. (Initial scale is 2.)

For inefficient method:


```
k=1.2;
level=15;
threshold=0.02;
```

For efficient method:


```
k=1.19;
level=15;
threshold=0.001;
```

4.Extensions.

The function fspecial only takes integer as size input. In order to get integer, I can either use floor or ceil function to get nearest integer. In my experience, it seems that there is no apparent difference between output images weather I use ceil or floor.