Smoothing Spatial Filters

1. Function `imfilter`

The toolbox implements linear spatial filtering using function `imfilter`, which has the following syntax:

g = imfilter(f, w, filtering_mode, boundary_options, size_options)

where f is the input image, w is the filter mask, g is the filtered result, and the other parameters are summarized in table.

Parameter	Content	
filtering_mode	'corr'	default
filtering_mode	'conv'	
boundary_options	P	default
boundary_options	'replicate'	
boundary_options	'symmertric'	
boundary_options	'circular'	
size_option	'full'	
size_option	'same'	default

The `filtering_mode` specified as `'corr'` for correlation (this is the default) or as `'conv'` for convolution.

The `boundary_options` deal with the border-padding issue, with the size of the border being determined by the size of the filter.

The `size_options` are either `'same'` or `'full'`.

The most common syntax for `imfilter` is

g = imfilter(f, w, 'replicate')

The syntax is used when implementing standard linear spatial filters in the toolbox.

When working with filters that are neither pre-rotated nor symmetric, and we wish to perform convolution, we have two options. One is to use the syntax

```
g = imfilter(f, w, 'conv', 'replicate')
```

The other approach is to use function `rot90(w, 2)` to rotate w by 180°, and then use `imfilter(f, w, 'replicate')`. The two steps can be combined into one:

```
g = imfilter(f, rot90(w, 2), 'replicate')
```

2. Function `fspecial`

The toolbox supports a number of predefined 2_D linear spatial filters, obtained by using function `fspecial`, which generates a filter mask, w, using the syntax

```
w = fspecial('type', parameters)
```

where `'type'` specifies the filter type, and `parameters` further define the specified filter. The spatial filters that `fspecial` can generate are summarized in table below, including applicable parameters for each filter.

type	parameters	
'average'	[r c]	A rectangular averaging filter of size $r \times c$
'disk'	r	A circular averaging filter
'gaussian'	[r c], sig	A Gaussian lowpass filter
'laplacian'	alpha	A 3×3 Laplacian filter
'log'	[r c], sig	Laplacian of a Gaussian filter
'sobel'		Outputs a 3×3 Sobel filter
'unsharp'	alpha	Outputs a 3×3 unsharp filter

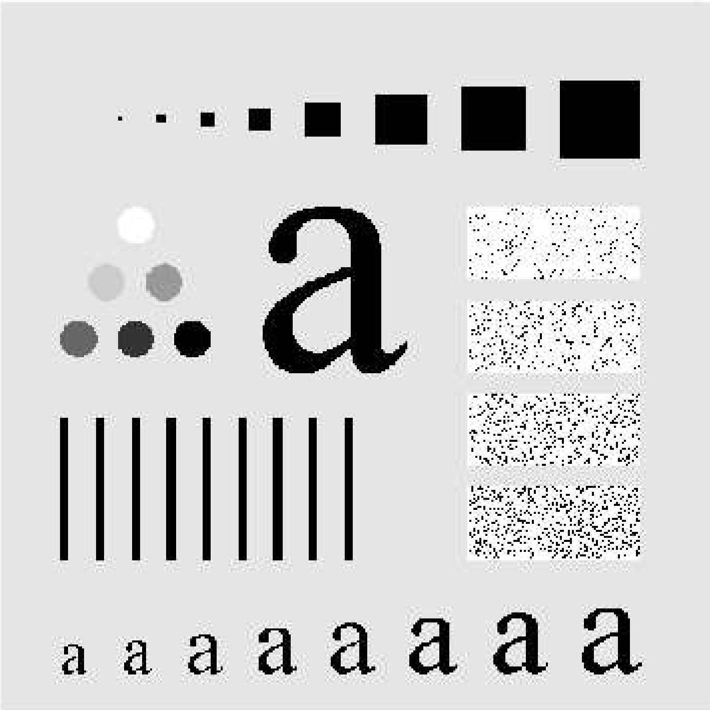
Example 1: Image smoothing with masks of various sizes.

The effects of smoothing as a function of filter size are illustrated in the following figures, which shows an original image and the corresponding smoothed results obtained using square averaging filters of size $m = 3, 5, 9, 15, 35$ pixels, respectively.

The original image

In [1]:

```
f = imread('Fig0313(a).tif');
imshow(f);
```

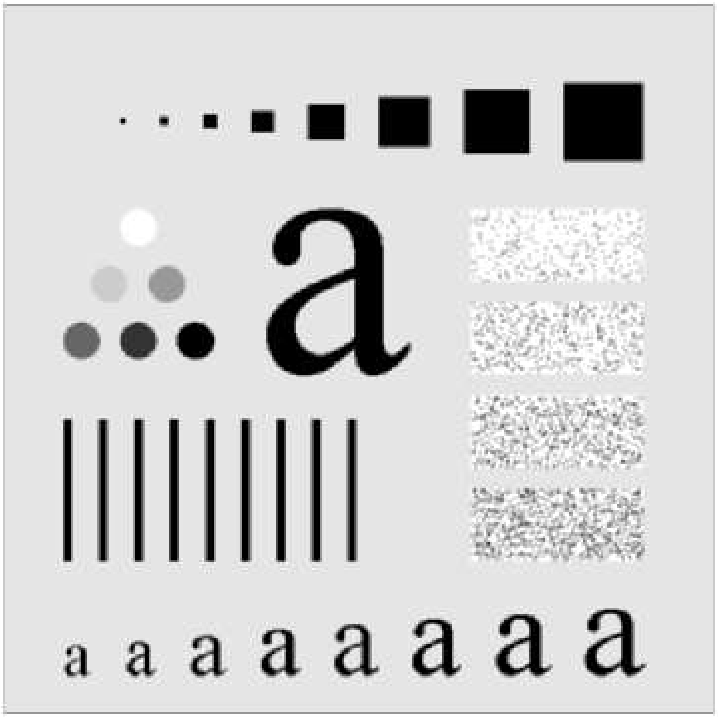


Then, we generate rectangular averaging filters w, and apply the w to image f:

$m = 3$

In [2]:

```
w3 = fspecial('average', [3 3]);
g3 = imfilter(f, w3);
figure, imshow(g3)
```



$m = 5$

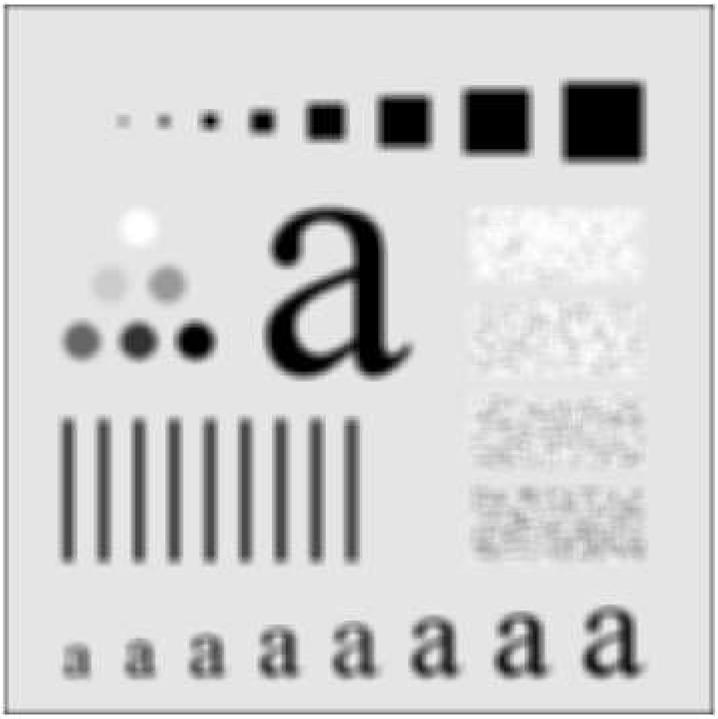
In [3]:

```
w5 = fspecial('average', [5 5]);
g5 = imfilter(f, w5);
figure, imshow(g5)
```

$m = 9$

In [4]:

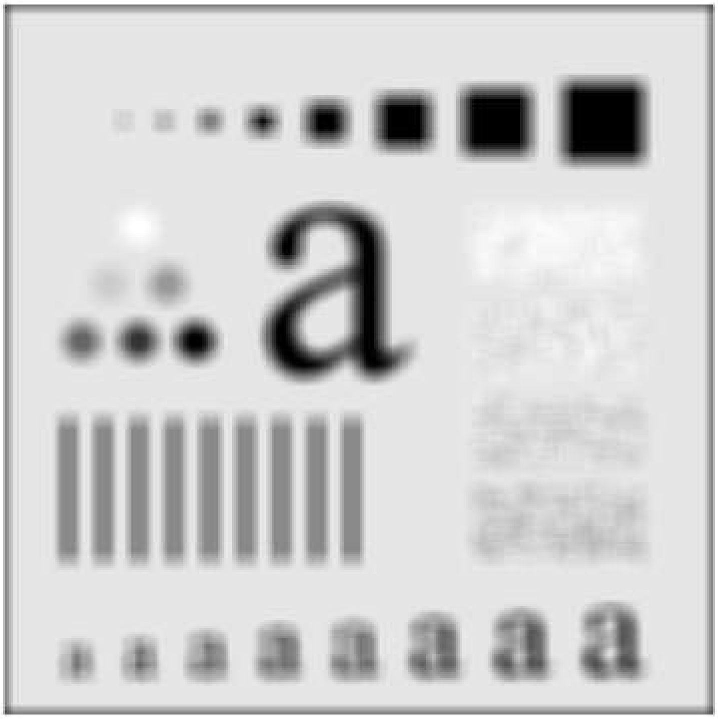
```
w9 = fspecial('average', [9 9]);
g9 = imfilter(f, w9);
figure, imshow(g9)
```



$m = 15$

In [5]:

```
w15 = fspecial('average', [15 15]);
g15 = imfilter(f, w15);
figure, imshow(g15)
```



$m = 35$

In [6]:

```
w35 = fspecial('average', [35 35]);
g35 = imfilter(f, w35);
figure, imshow(g35)
```

Example 2: Image filtering with averaging mask.

The original image

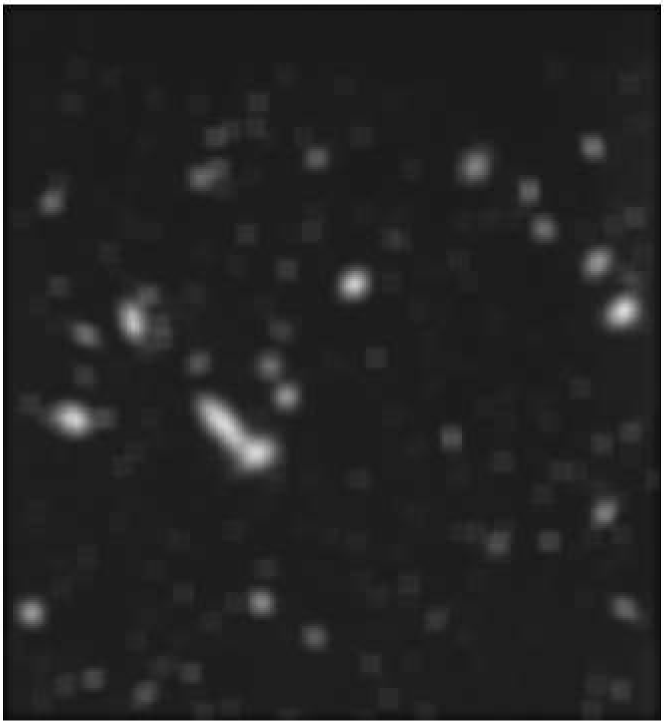
In [13]:

```
f = imread('Fig0334(a).tif');
imshow(f);
```

Then we apply 15×15 averaging mask to image f

In [16]:

```
w = fspecial('average', [15 15]);
g = imfilter(f, w);
figure, imshow(g);
```

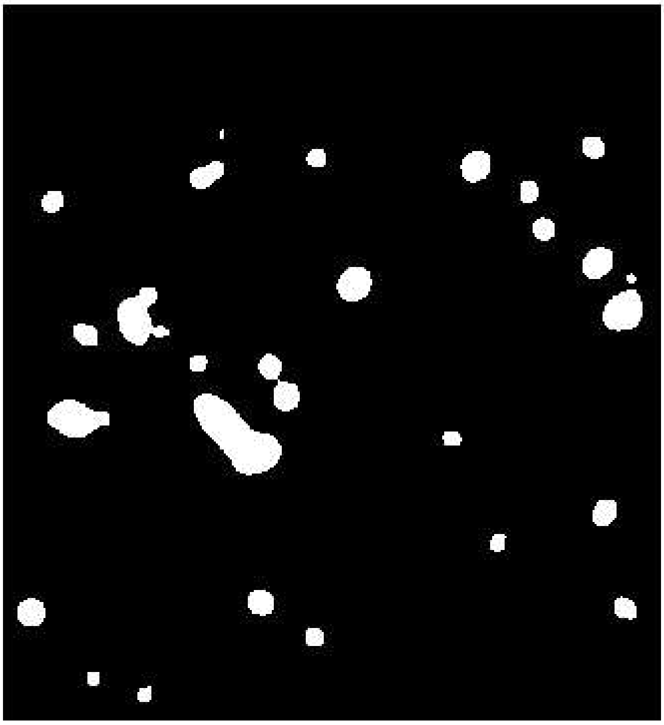


We see that a number of objects have either blended with the background or their intensity has diminished considerably.

Now, we use a threshold value equal to 25% of the highest intensity in the blurred image is shown below. Comparing this result with the original image, we see that it is a reasonable representation of what we would consider to be the largest, brighest objects in that image.

In [17]:

```
bw = im2bw(g, 0.25);
figure, imshow(bw);
```



3. Function `imnoise`

The Image Processing Toolbox uses function `imnoise` to corrupt an image with noise. This function has the basic syntax

g = imnoise(f, type, parameters)

where f is the input image, and `type` and `parameters` are as explained below. Function `imnoise` converts the input image to class `double` in the range $[0, 1]$ before adding noise to it. The syntax forms for this function are:

g = imnoise(f, 'gaussian', m, var)

adds Gaussian noise of mean m and variance var to image f. The default is zero mean noise with 0.01 variance.

4. Function `medfilt2`

The toolbox provides a specialized implementation of 2D median filter.

g = medfilt2(f, [m n], padopt)

where the tuple `[m n]` **defines a neighborhood of size** $m \times n$ **over which the median is computed, and** `padopt` **specifies one of three possible border padding options:** `'zeros'` **(the default),** `'symmetric'` **in which** f **is extended symmetrically by mirror-reflecting it across its border, and** `'indexed'` **, in which** f **is padded with 1s if it is of class** `double` **and with 0s otherwise.**

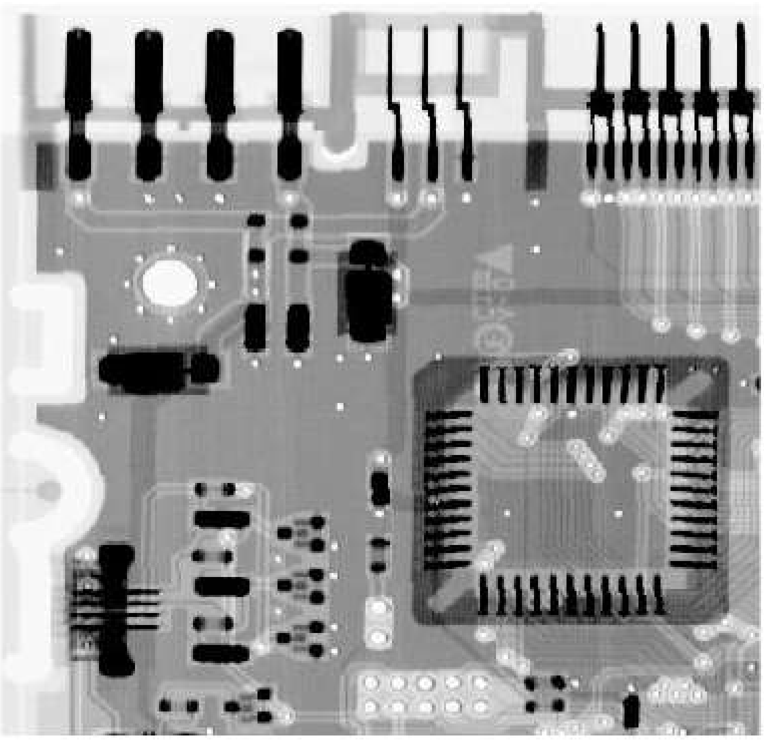
Example 3: Adaptive median filtering.

The original image is a circuit board image, f**.**

In [7]:

```
f = imread('Fig0406(a).tif');
imshow(f);
```

```
警告: 图像太大，无法在屏幕上显示；将以 67% 显示
> In images.internal.initSize (line 71)
  In imshow (line 336)
```

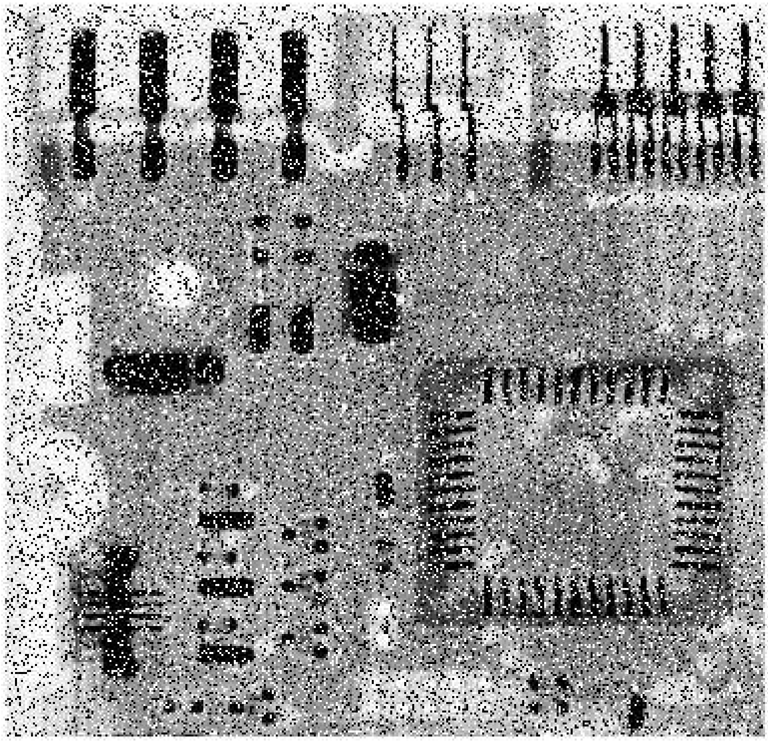


g **is an image corrupted by salt-and-pepper noise generated using the command**

In [9]:

```
g = imnoise(f, 'salt & pepper', 0.25);
figure, imshow(g);
```

警告: 图像太大，无法在屏幕上显示；将以 67% 显示
> In images.internal.initSize (line 71)
  In imshow (line 336)

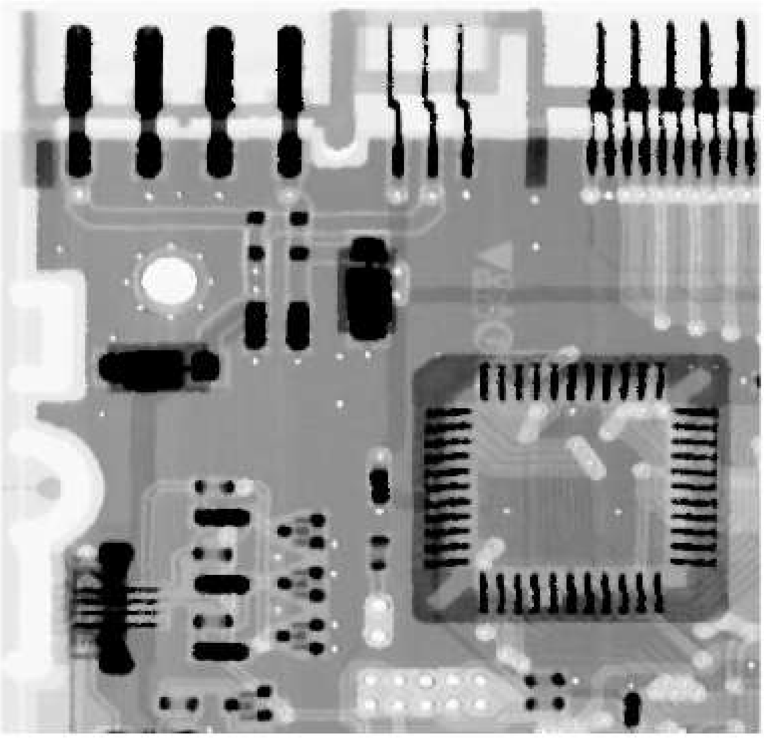


Next figure shows the result obtained using the command

In [10]:

```
f1 = medfilt2(g, [7 7], 'symmetric');
figure, imshow(f1);
```

```
警告: 图像太大，无法在屏幕上显示；将以 67% 显示
> In images.internal.initSize (line 71)
  In imshow (line 336)
```



This image is reasonably free of noise, but it is quite blurred and distorted.

On the other hand, the next command yielded the next image, which is also reasonably free of noise, but is considerably less blurred and distorted.

In [11]:

```
f2 = adpmedian(g, 7);
figure, imshow(f2);
```

警告: 图像太大，无法在屏幕上显示；将以 67% 显示
> In images.internal.initSize (line 71)
  In imshow (line 336)