2.3 Histogram Processing and Function Plotting

2.3.1 Generating and Plotting Image Histograms

The core function in the toolbox for dealing with image histogram is `imhist` , with the basic syntax:

In [ ]:

```
h = imhist(f, b)
```

where f is the input image, h is its histogram, and b is the number of bins used in forming the histogram, if b is not included in the argument, $b = 256$ is used by default.

We obtain the normalized histogram by using the expression

In [ ]:

```
p = imhist(f, b) / numel(f)
```

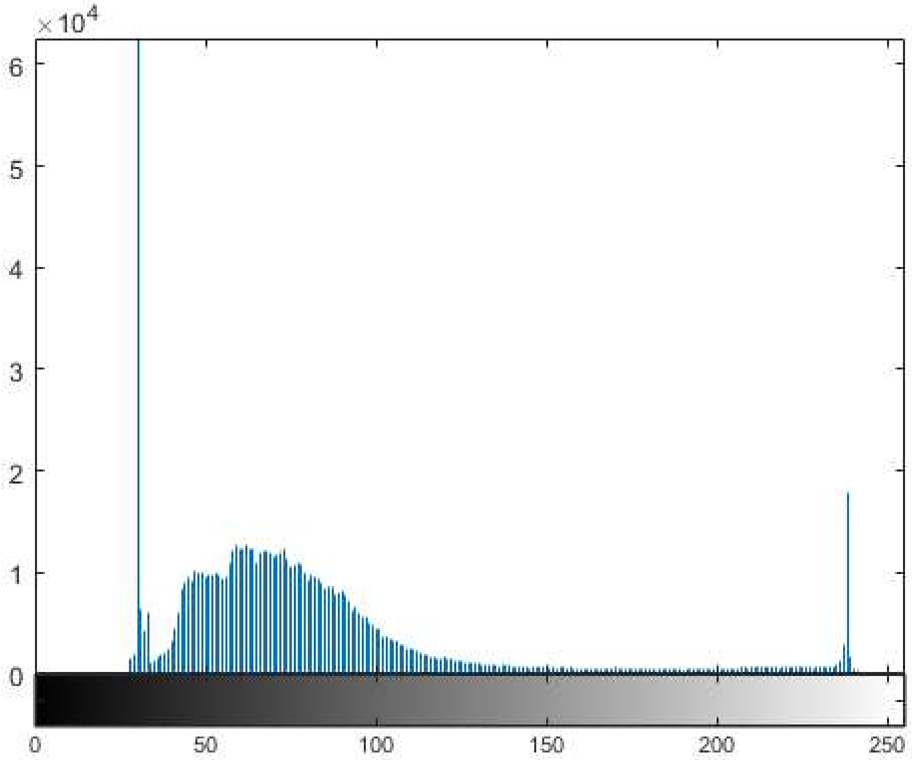
Function `numel(f)` gives the number of elements in array f (i.e., the number of pixels in the image).

Example 2.4: Computing and plotting image histograms.

The simplest way to plot its histogram on the screen is to use `imhist` with no output specified:

In [2]:

```
f = imread('Fig0203(a).tif');
imhist(f)
```



Histograms can be plotted also using *bar* graphs. For this purpose we can use the function

In [ ]:

```
bar(horz, z, width)
```

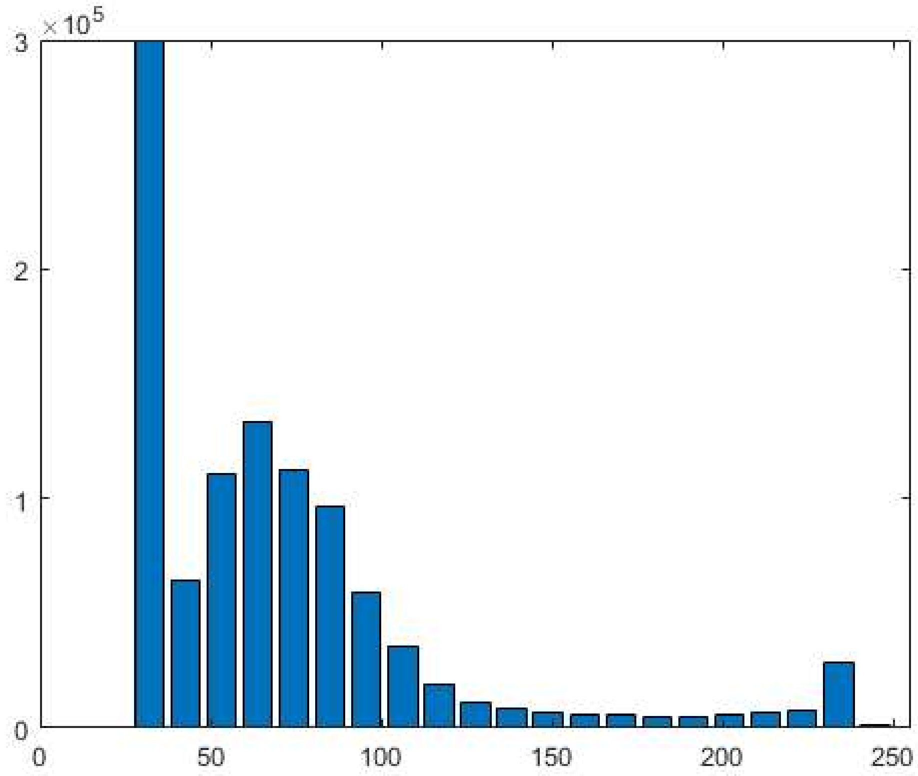
where z is a row vector containing the points to be plotted, `horz` is a vector of the same dimension as z that contains the increments of the horizontal scale, and `width` is a number between 0 and 1.

In other words, the values of `horz` give the horizontal increments and the values of z are the corresponding vertical values. If `horz` is omitted, the horizontal axis is divided in units from 0 to `length(z)`. When `width` is 1, the bars touch; when it is 0, the bars are vertical reduce the resolution of the horizontal axis by dividing it into bands.

The following commands produce a bar graph, with the horizontal axis divided into group of approximately 10 levels:

In [15]:

```
f = imread('Fig0203(a).tif');
h = imhist(f, 25);
horz = linspace(0, 255, 25);
bar(horz, h)
axis([0 255 0 300000])
set(gca, 'xtick', 0:50:255)
set(gca, 'ytick', 0:100000:300000)
```



One of the `axis` function syntax forms is

In [ ]:

```
axis([horzmin horzmax vertmin vertmax])
```

which sets the mininum and maximum values in the horizontal and vertical axes.

`gca` means "get current axis" (i.e., the axes of the figure last displayed), and `xtick` and `ytick` set the horizontal and vertical axes ticks in the intervals shown.

Another syntax used frequently is

In [ ]:

```
axis tight
```

which sets the axis limits to the range of the data.

Axis labels can be added to the horizontal and vertical axes of a graph using the functions

In [ ]:

```
xlabel('text string', 'fontsize', size)
ylabel('text string', 'fontsize', size)
```

where $size$ is the font size in points.

Text can be added to the body of the figure by using function `text`, as follows:

In [ ]:

```
text(xloc, yloc, 'text string', 'fontsize', size)
```

where $xloc$ and $yloc$ define the location where starts.

It is important to note that functions that set axis values and labels are used after the function has been plotted.

A title can be added to a plot using function `title`, whose basic syntax is

In [ ]:

```
title('title string')
```

where `title string` is the string of characters that will appear on the centered above the plot.

A stem graph is similar to a bar graph. The syntax is

In [ ]:

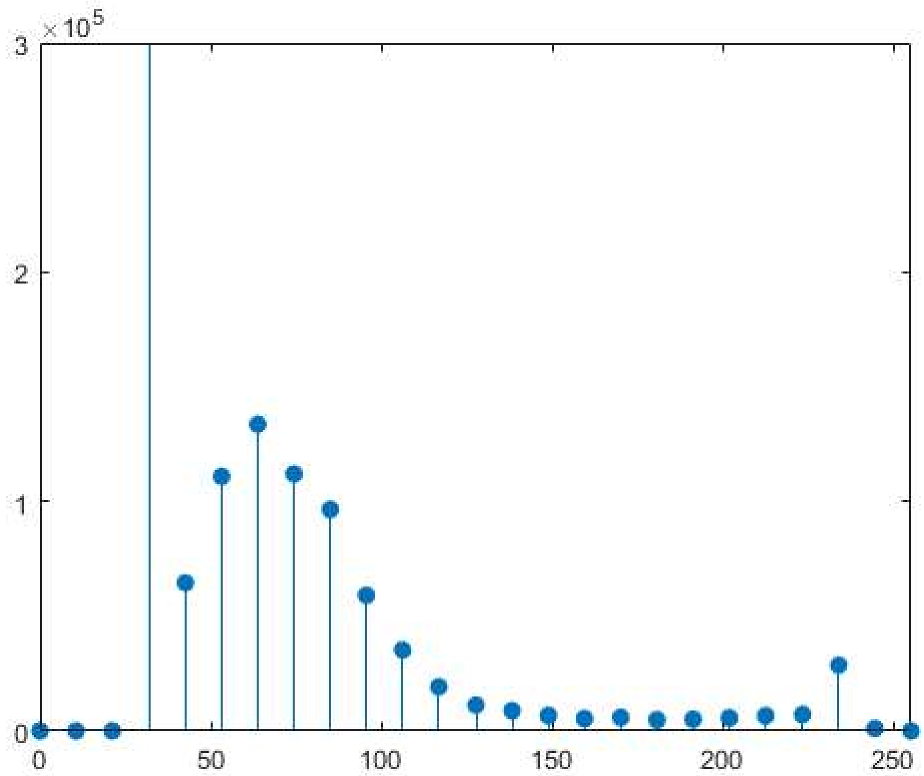
```
stem(horz, z, 'LineSpec', 'fill')
```

where z is row vector containing the points to be plotted, and $horz$ is as described for function bar. If $horz$ is omitted, the horizontal axis is divided in units from 0 to $length(z)$, as before.

The argument, `LineSpec` **is a triplet of values from Table 2.1.**

In [16]:

```
f = imread('Fig0203(a).tif');
h = imhist(f, 25);
horz = linspace(0, 255, 25);
stem(horz, h, 'fill')
axis([0 255 0 300000])
set(gca, 'xtick', 0:50:255)
set(gca, 'ytick', 0:100000:300000)
```



Next, we consider function `plot` **, which plots a set of points by linking them with straight lines. The syntax is**

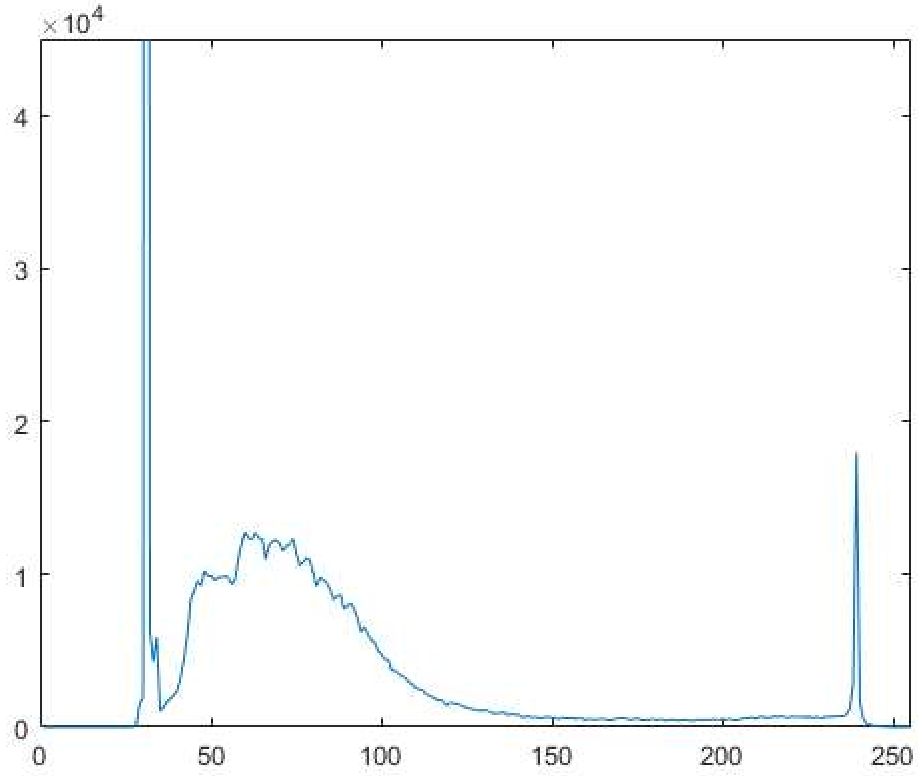
In [ ]:

```
plot(horz, z, 'LineSpec')
```

where the arguments are as defined previously for stem plots.

In [11]:

```
f = imread('Fig0203(a).tif');
hc = imhist(f);
plot(hc)
axis([0 255 0 45000])
set(gca, 'xtick', 0:50:255)
set(gca, 'ytick', 0:10000:45000)
```



Function `plot` **is used frequently to display transformation functions.**

To set the limits and ticks automatically, use functions `ylim` **and** `xlim` **, which for our purpose here, have the syntax forms**

In [ ]:

```
ylim('auto')
xlim('auto')
```

Among other possible variations of the syntax for these two functions, there is a manual option, given by

In [ ]:

```
ylim([ymin ymax])
xlim([xmin xmax])
```

If the limits are specified for only one axis, the limits on the other axis are set to `'auto'` **by default.**

Typing `hold on` at the prompt retains the current plot and certain axes properties so that subsequent graphing commands add to the existing graph.

2.3.2 Histogram Equalization

Histogram equalization is implemented in the toolbox by function `histeq`, which has the syntax

In [ ]:

```
g = histeq(f, nlev)
```

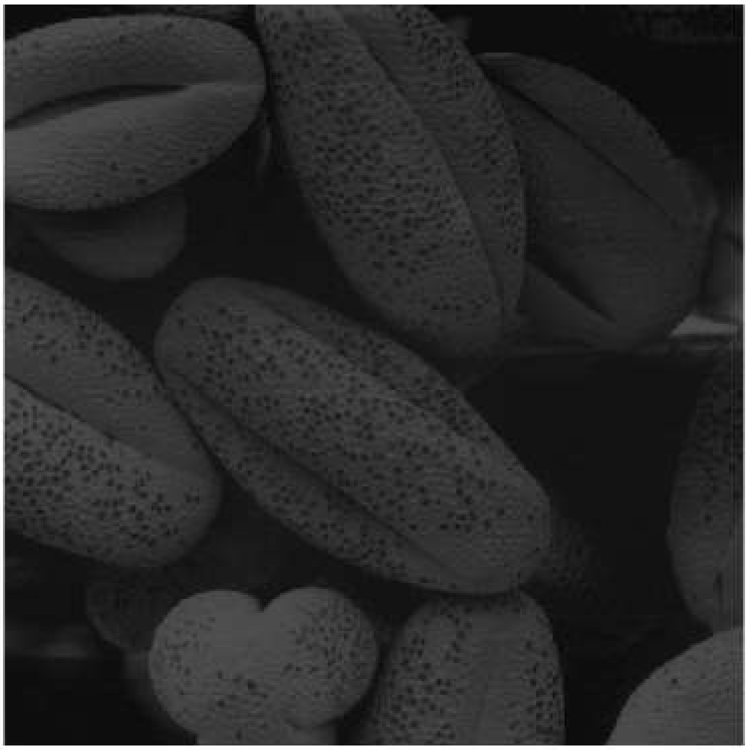
where f is the input image and $nlev$ is the number of intensity levels specified for the output image.

Example 2.5: Histogram equalization

In [3]:

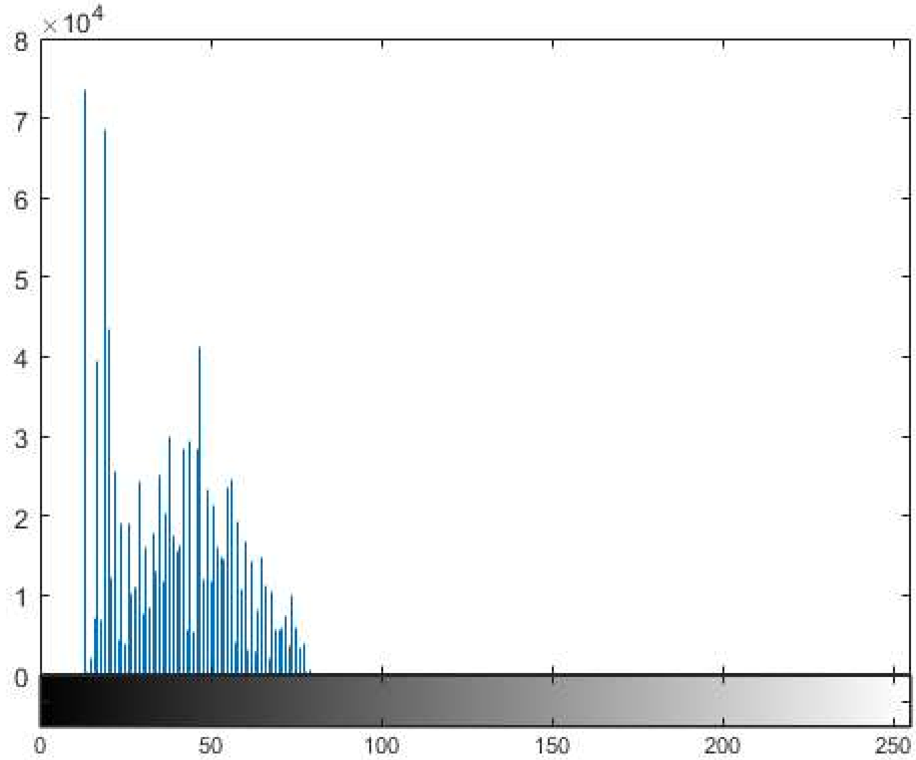
```
f = imread('Fig0208(a).tif');
imshow(f)
```

```
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)
```



In [4]:

```
imhist(f)
ylim('auto')
```



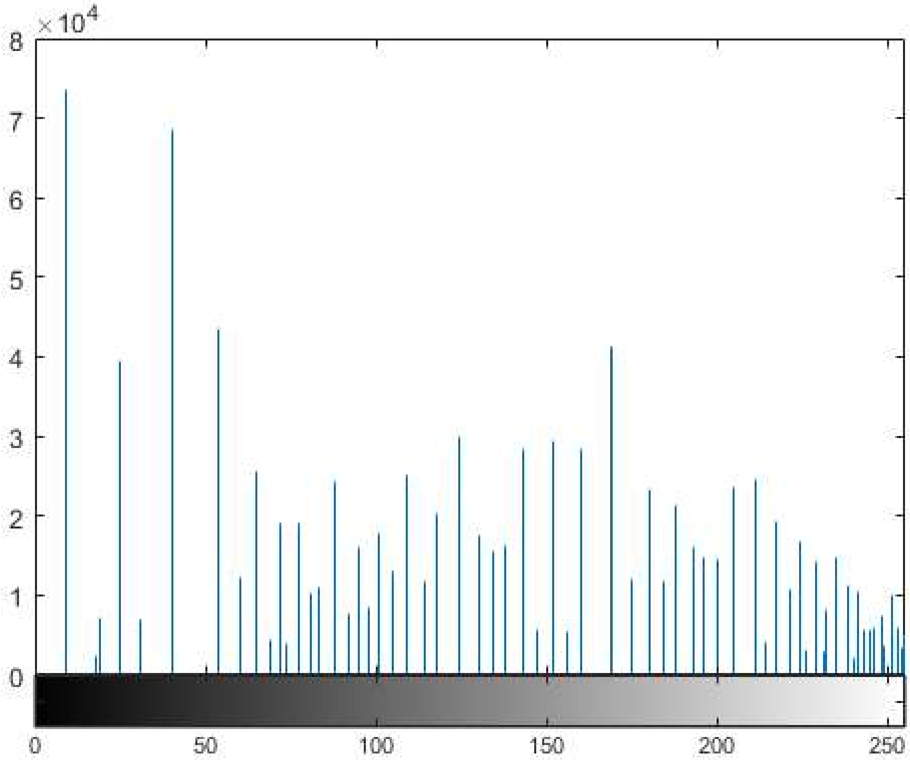
In [7]:

```
g = histeq(f, 256);
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)

In [8]:

```
imhist(g)
ylim('auto')
```

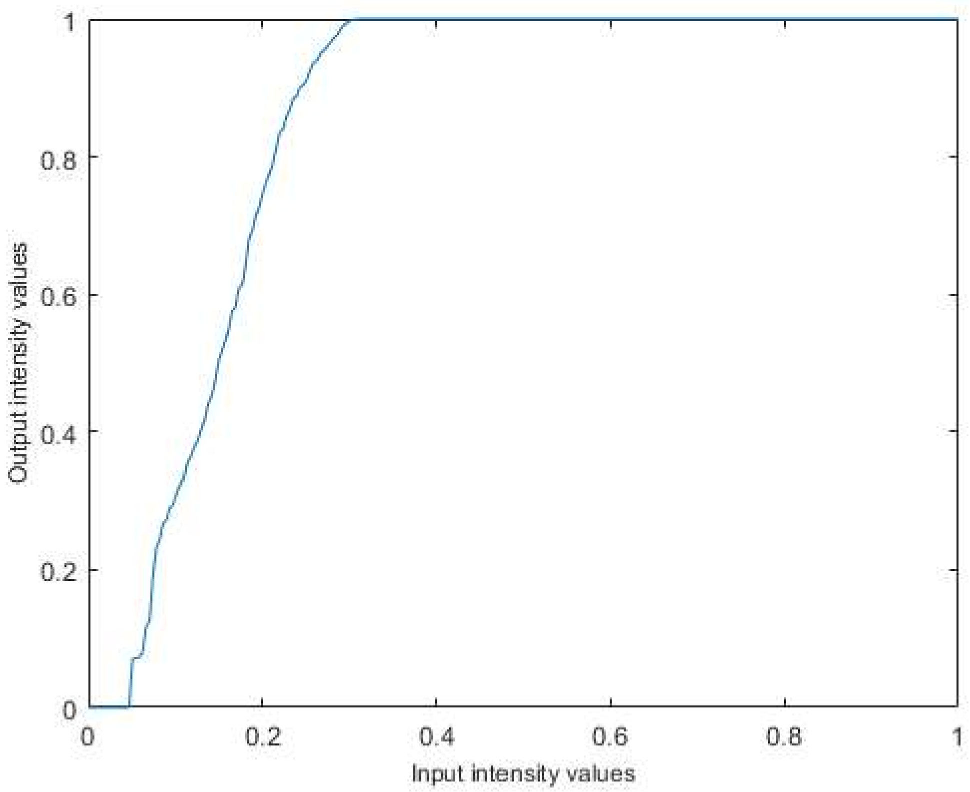


As noted earlier, the transformation function used in histogram equalization is the cumulative sum of normalized histogram values. We can use function `cumsum` to obtain the transformation function, as follows:

In [24]:

```
hnorm = imhist(f)./numel(f);
cdf = cumsum(hnorm);

x = linspace(0, 1, 256);
plot(x, cdf)
axis([0 1 0 1]);
set(gca, 'xtick', 0:.2:1)
set(gca, 'ytick', 0:.2:1)
xlabel('Input intensity values', 'fontsize', 9)
ylabel('Output intensity values', 'fontsize', 9)
```



2.3.3 Histogram Matching (Specification)

The toolbox implements histogram matching using the following syntax in `histeq` **:**

In [ ]:

```
g = histeq(f, hspec)
```

where f is the input image, $hspec$ is the specified histogram (a row vector of specified values), and g is the output image, whose histogram approximates the specified histogram, $hspec$. This vector should contain integer counts corresponding to equally spaced bins. A property of `histeq` is that the histogram of g generally better matches $hspec$ when $length(hspec)$ is much smaller than the number of intensity levels in f.

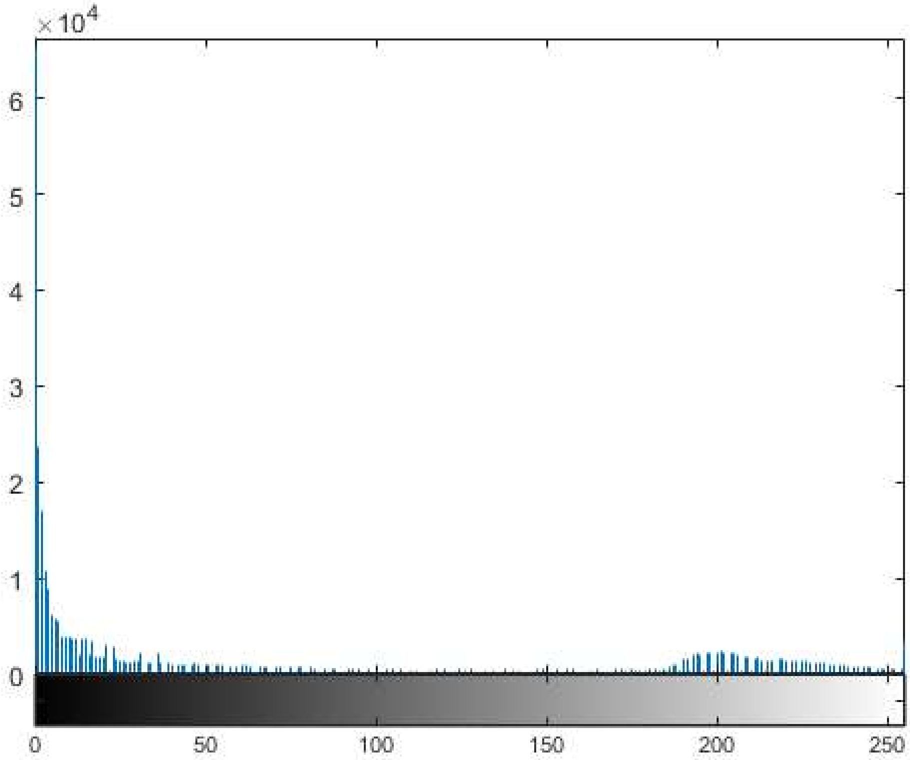
In [1]:

```
f = imread('Fig0210(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)
```

In [2]:

```
imhist(f)
```



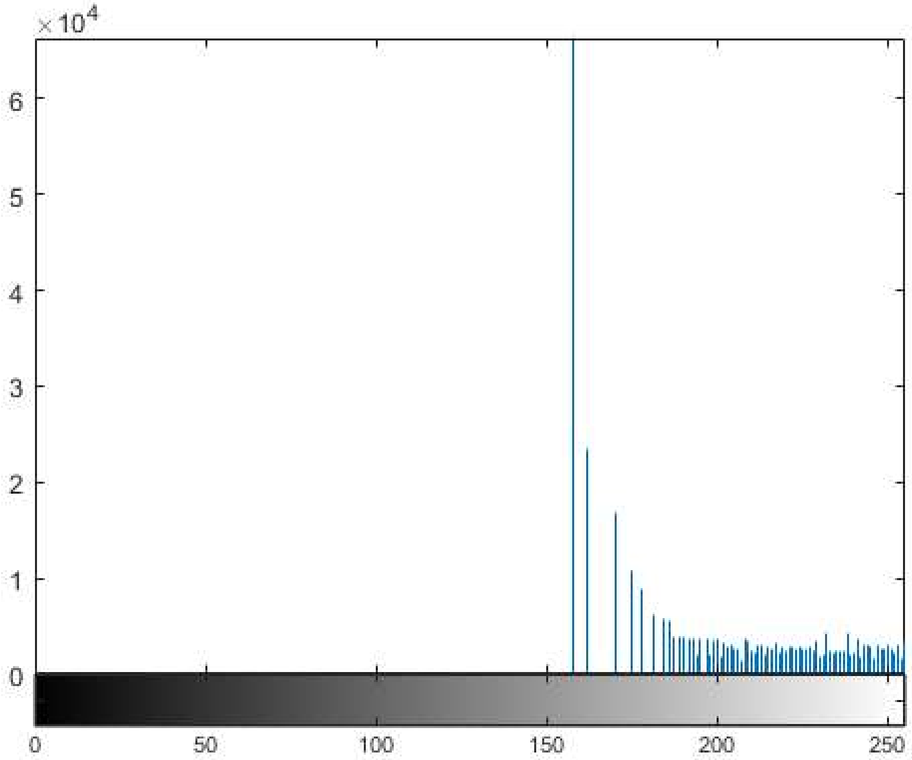
In [3]:

```
f1 = histeq(f, 256);
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)

In [4]:

```
imhist(f1)
```



2.3.4 Function adapthisteq

The syntax for `adapthisteq` is

g = adapthisteq(f, param1, val1, param2, val2, ...)

where f is the input image, g is the output image, and the `param/val` pairs are as listed in Table 2.2.

In [5]:

```
f = imread('Fig0210(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)

In [6]:

```
g1 = adapthisteq(f);
imshow(g1)
```

```
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)
```

In [7]:

```
g2 = adapthisteq(f, 'NumTiles', [25 25]);
imshow(g2)
```

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)

In [8]:

```
g3 = adapthisteq(f, 'NumTiles', [25 25], 'ClipLimit', 0.05);
imshow(g3)
```

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)