Objectives

- To understand pixel based image processing
- To use nested iteration
- To use and understand tuples
- To implement a number of image processing algorithms
- To understand passing functions as parameters

Digital Image Processing

- Editing and manipulating digital images
- A digital image is a collection of pixels
- A pixel is the smallest amount of information available in a digital picture
- Each pixel represents a single color
- Pixels are organized in a grid

RGB Color Model

- RGB means RED, GREEN, BLUE
- Each color is made up from amounts of red, green and blue
- Color intensities range from a minimum of 0 to a maximum of 255

clmage module

- Pixel
- ImageWin
- EmptyImage
- FileImage

Pixel objects

- getRed
- getGreen
- getBlue
- setRed
- setGreen
- setBlue

FileImage and EmptyImage

- getWidth
- getHeight
- getPixel
- setPixel
- draw

Negative Image

- Reverse the colors in each pixel

Listing 6.1

```
def negativePixel(oldPixel):
    newred = 255 - oldPixel.getRed()
    newgreen = 255 - oldPixel.getGreen()
    newblue = 255 - oldPixel.getBlue()
    newPixel = Pixel(newred, newgreen, newblue)
    return newPixel
```

Figure 6.1

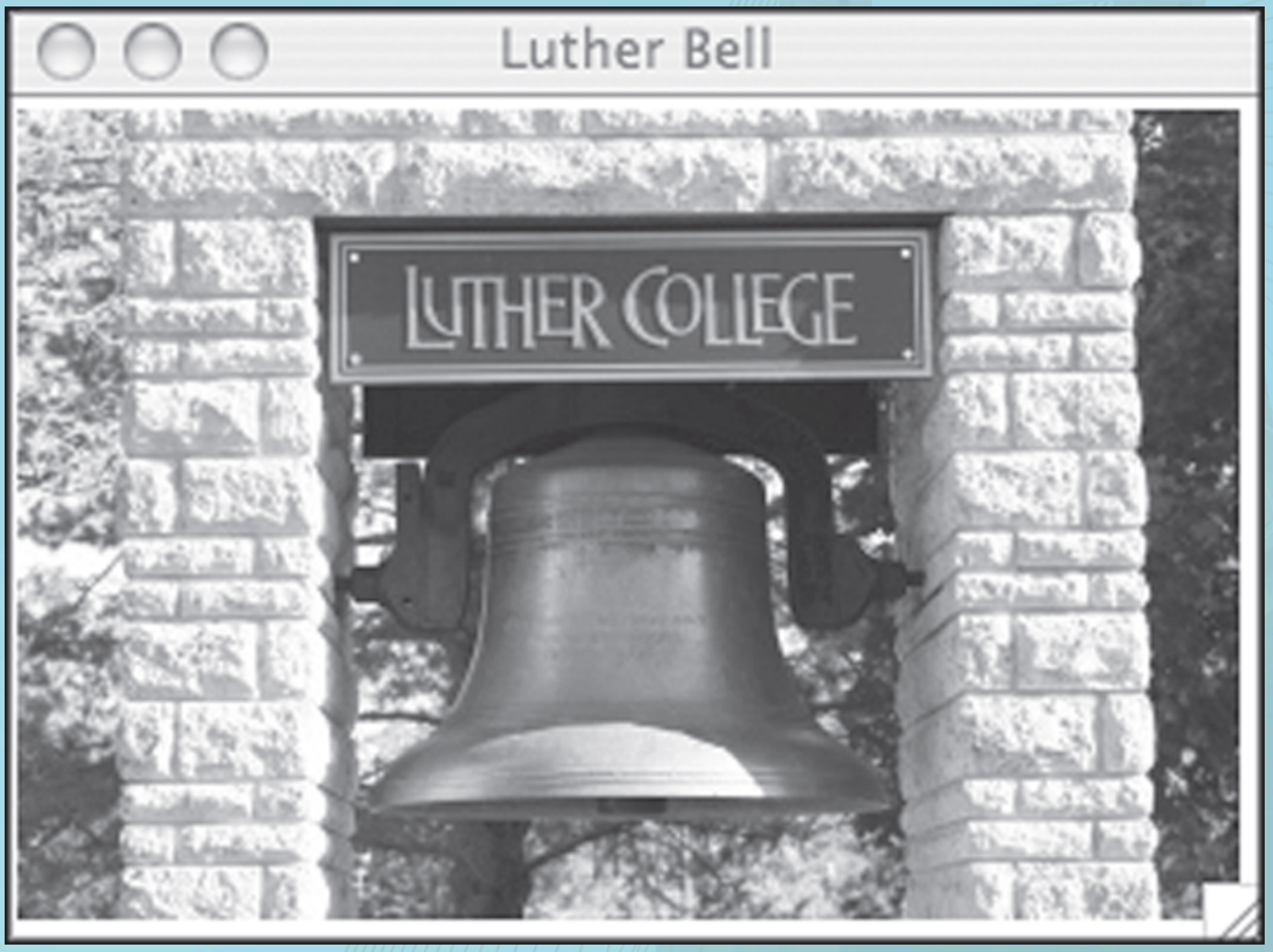
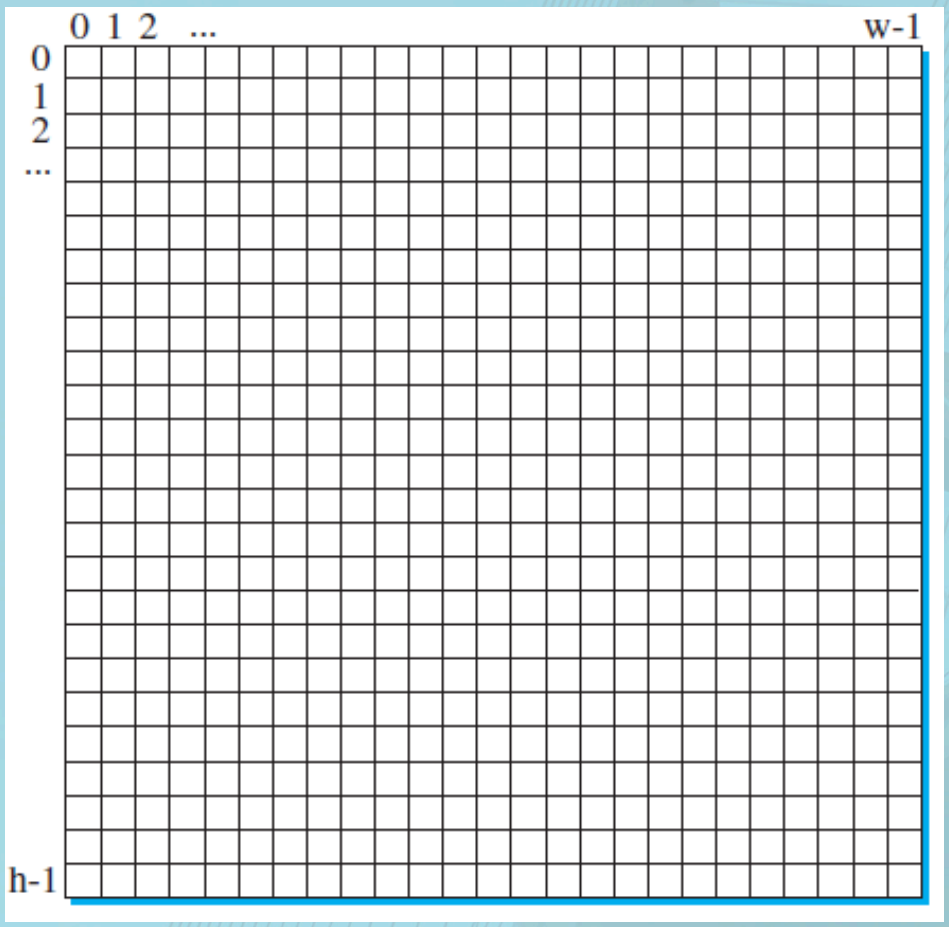


Figure 6.2



Listing 6.2

```
def makeNegative(imageFile):
    myimagewindow = ImageWin("Image Processing",600,200)
    oldimage = FileImage(imageFile)
    oldimage.draw(myimagewindow)

    width = oldimage.getWidth()
    height = oldimage.getHeight()
    newim = EmptyImage(width,height)

    for row in range(height):
        for col in range(width):
            originalPixel = oldimage.getPixel(col,row)
            newPixel = negativePixel(originalPixel)
            newim.setPixel(col,row,newPixel)

    newim.setPosition(width+1,0)
    newim.draw(myimagewindow)
    myimagewindow.exitOnClick()
```

Figure 6.3

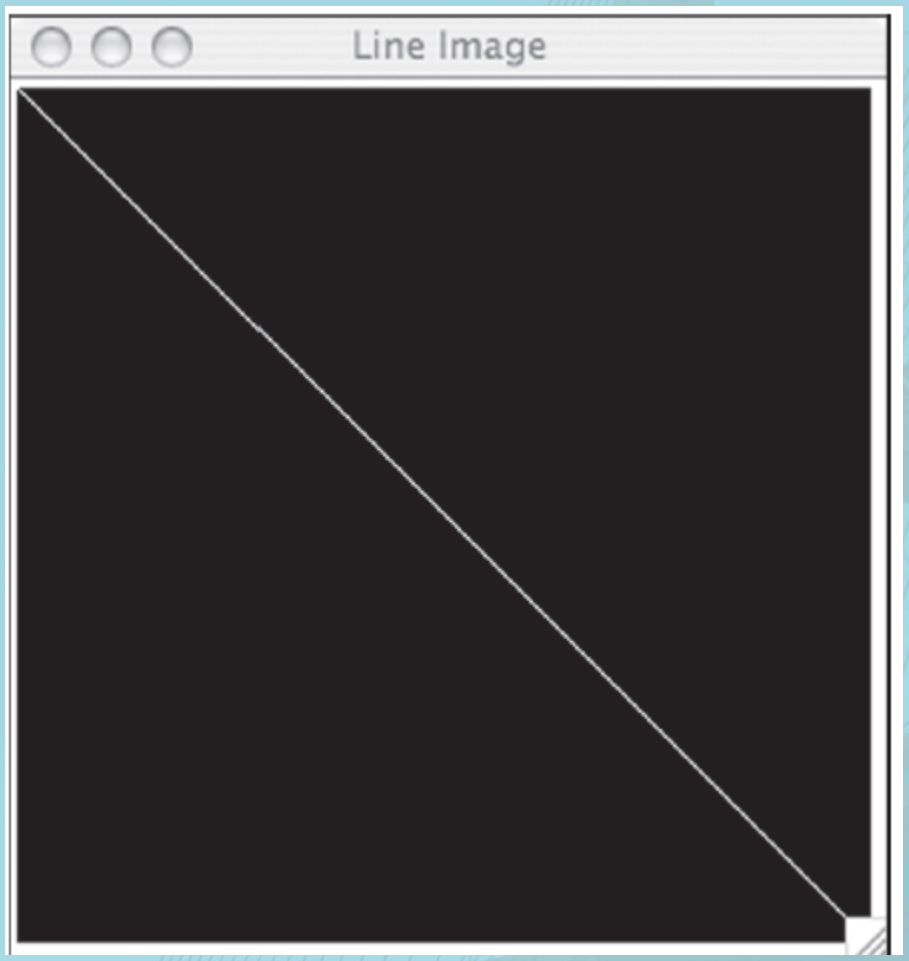
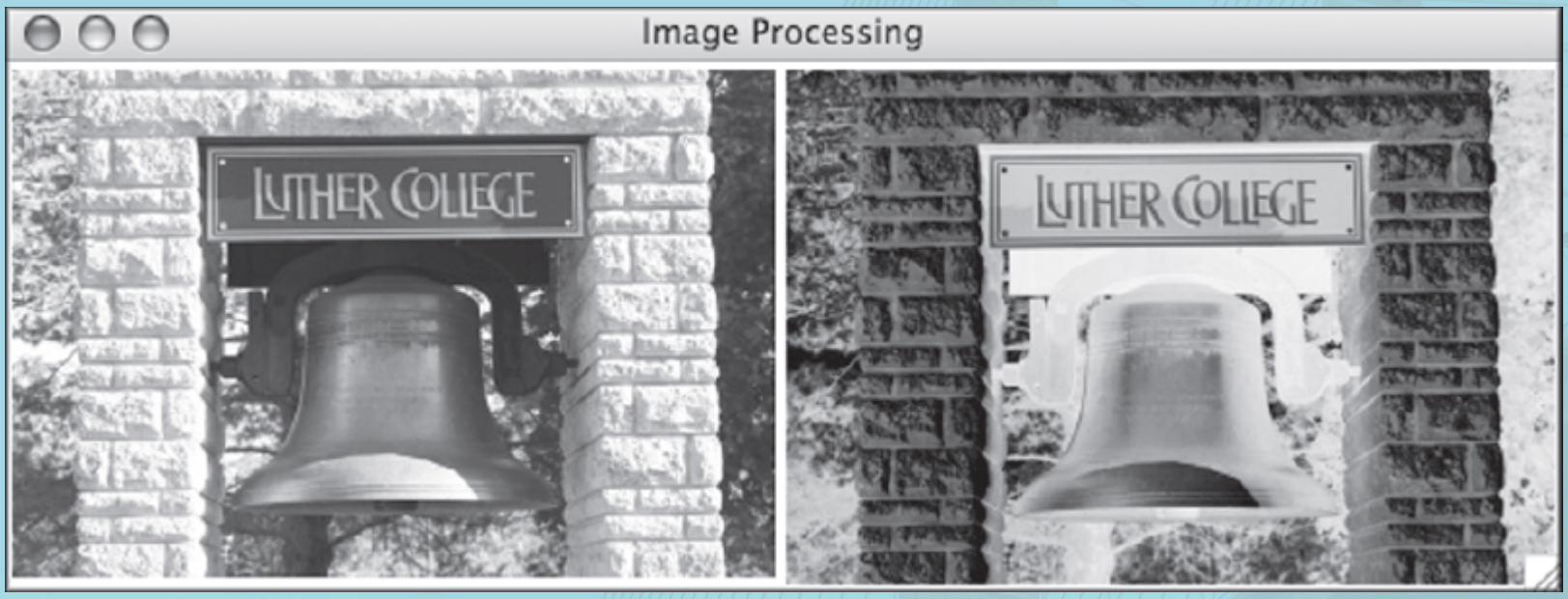


Figure 6.4



Grayscale Image

- Convert each pixel to a shade of gray
- Use average of RGB values

Listing 6.3

```
def grayPixel(oldpixel):
    intensitySum = oldpixel.getRed() + oldpixel.getGreen() + oldpixel.getBlue()
    aveRGB = intensitySum // 3

    newPixel = Pixel(aveRGB,aveRGB,aveRGB)
    return newPixel
```

Listing 6.4

```
def makeGrayScale(imageFile):
    myimagewindow = ImageWin("Image Processing",600,200)
    oldimage = FileImage(imageFile)
    oldimage.draw(myimagewindow)

    width = oldimage.getWidth()
    height = oldimage.getHeight()
    newim = EmptyImage(width,height)

    for row in range(height):
        for col in range(width):
            originalPixel = oldimage.getPixel(col,row)
            newPixel = grayPixel(originalPixel)
            newim.setPixel(col,row,newPixel)

    newim.setPosition(width+1,0)
    newim.draw(myimagewindow)
    myimagewindow.exitOnClick()
```

Figure 6.5

Generalize Pixel Mapping

- Create a function that takes a pixel manipulation function as a parameter

Figure 6.6

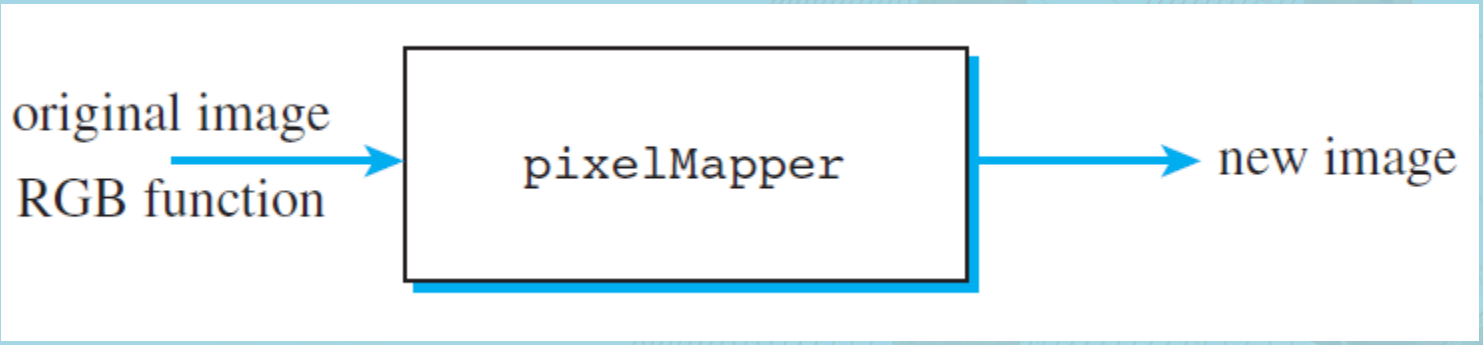


Figure 6.7

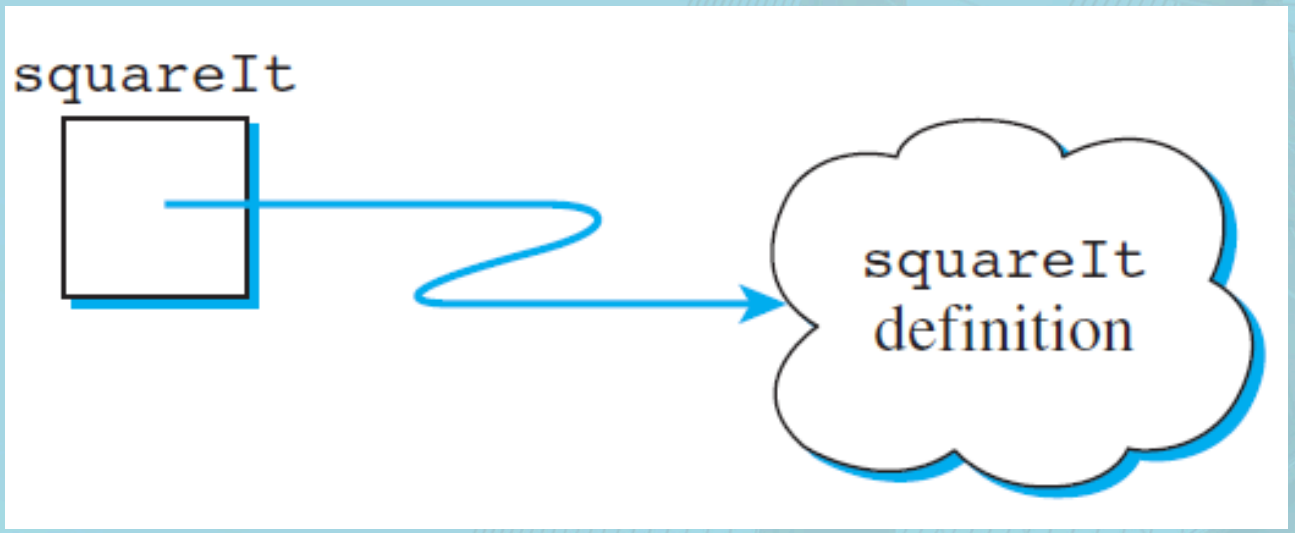
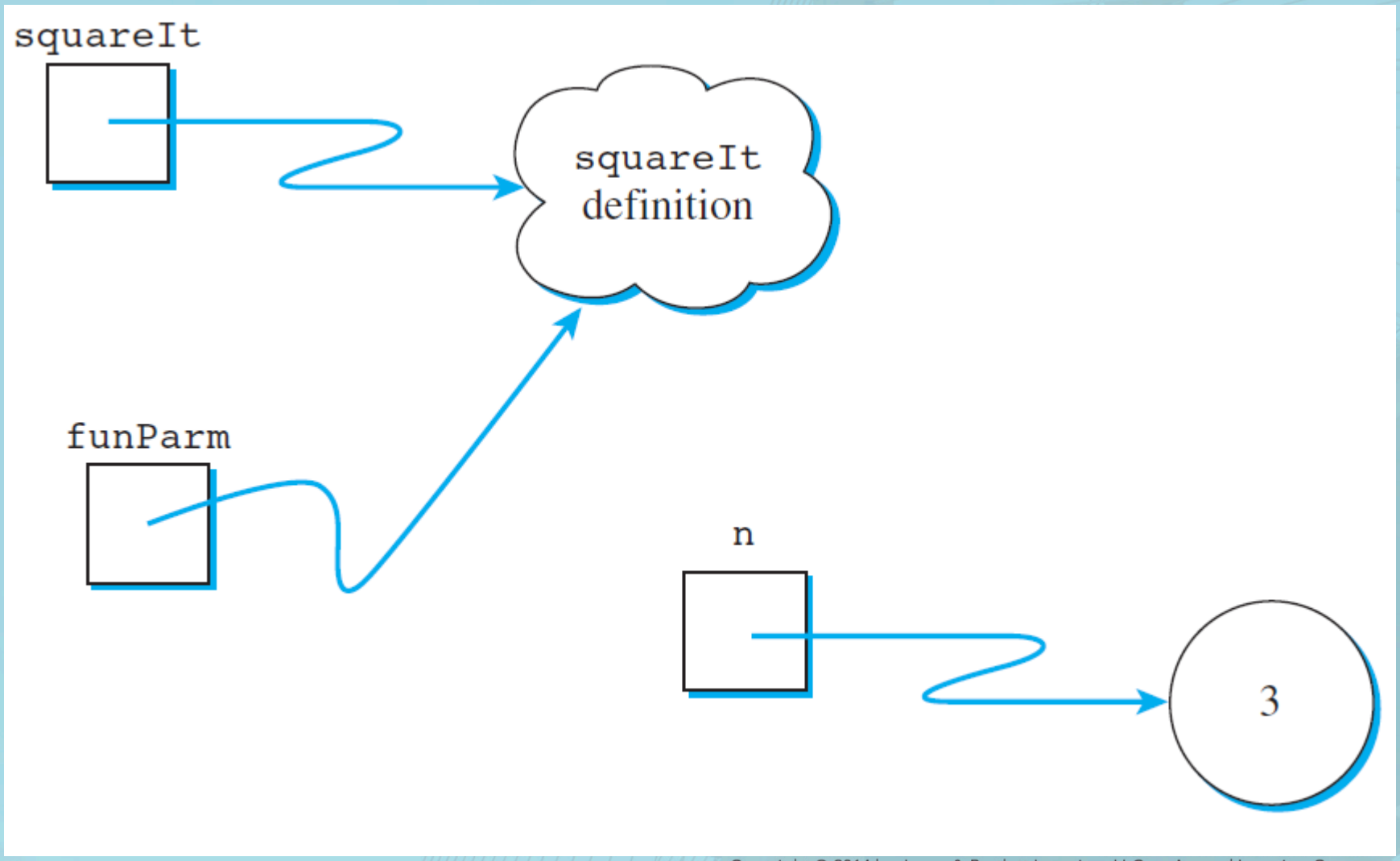


Figure 6.8



Listing 6.5

```
def pixelMapper(oldimage,rgbFunction):

    width = oldimage.getWidth()
    height = oldimage.getHeight()
    newim = EmptyImage(width,height)

    for row in range(height):
        for col in range(width):
            originalPixel = oldimage.getPixel(col,row)
            newPixel = rgbFunction(originalPixel)
            newim.setPixel(col,row,newPixel)

    return newim
```

Listing 6.6

```
def generalTransform(imageFile):
    myimagewindow = ImageWin("Image Processing",600,200)
    oldimage = FileImage(imageFile)
    oldimage.draw(myimagewindow)

    newimage = pixelMapper(oldimage,grayPixel)
    newimage.setPosition(oldimage.getWidth()+1,0)
    newimage.draw(myimagewindow)
    myimagewindow.exitOnClick()
```

Namespaces

- Parameters, Parameter Passing, and Scope

- How are the names and object organized in Python
- Builtin
- Main
- Local

Listing 6.7

```
import math

def hypotenuse(a,b):
    c = math.sqrt(a**2 + b**2)
    return c
```

Figure 6.9

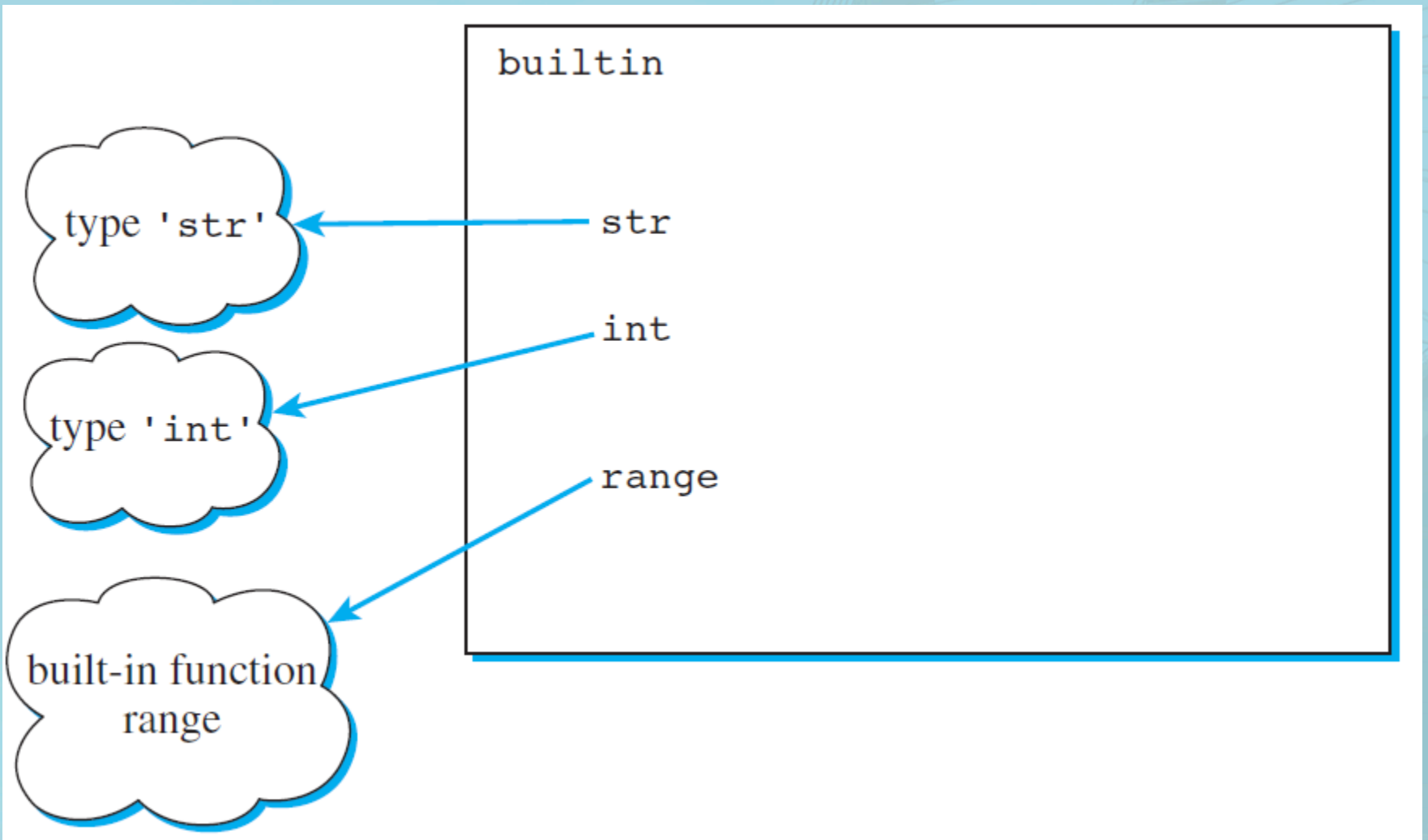


Figure 6.10

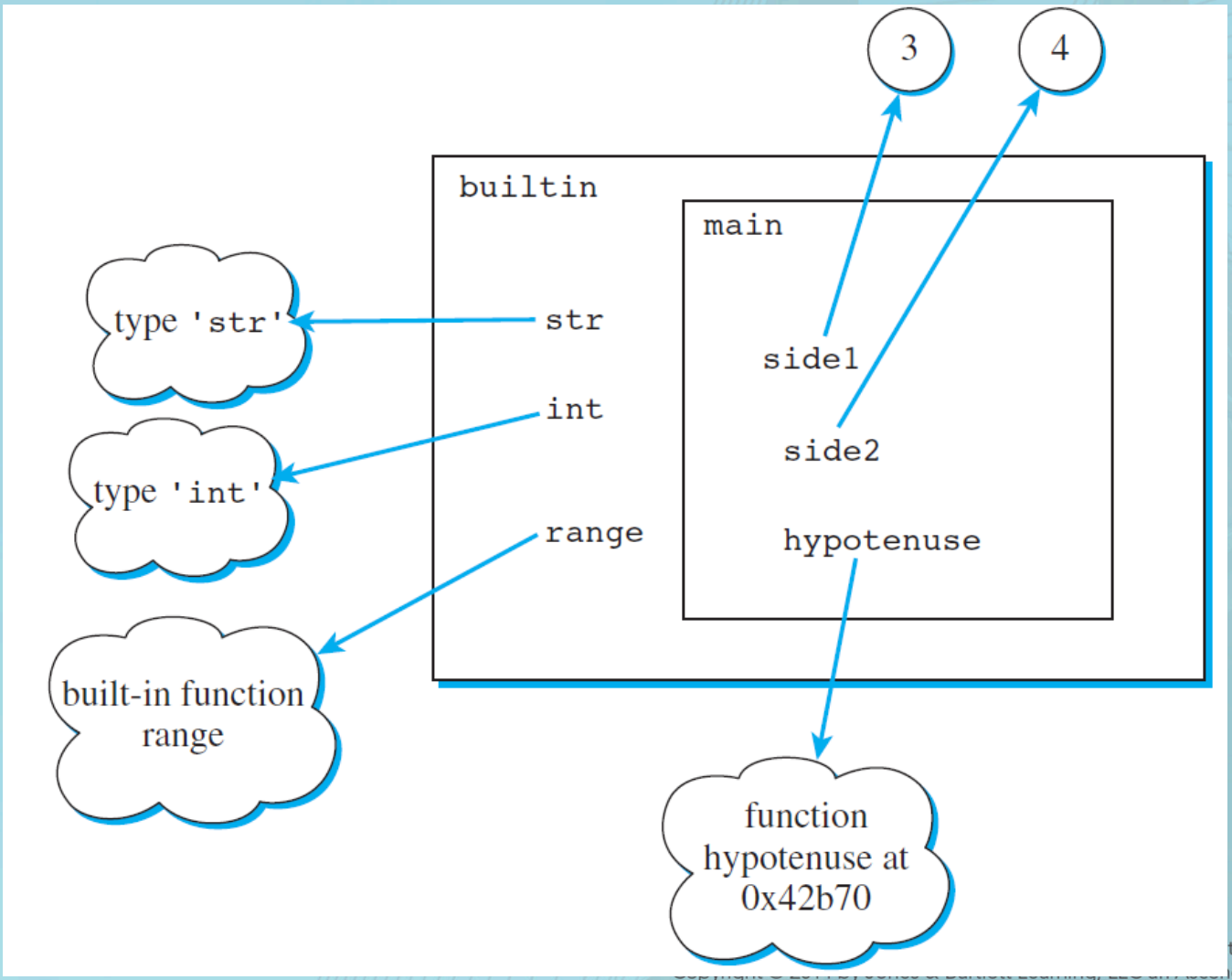


Figure 6.11

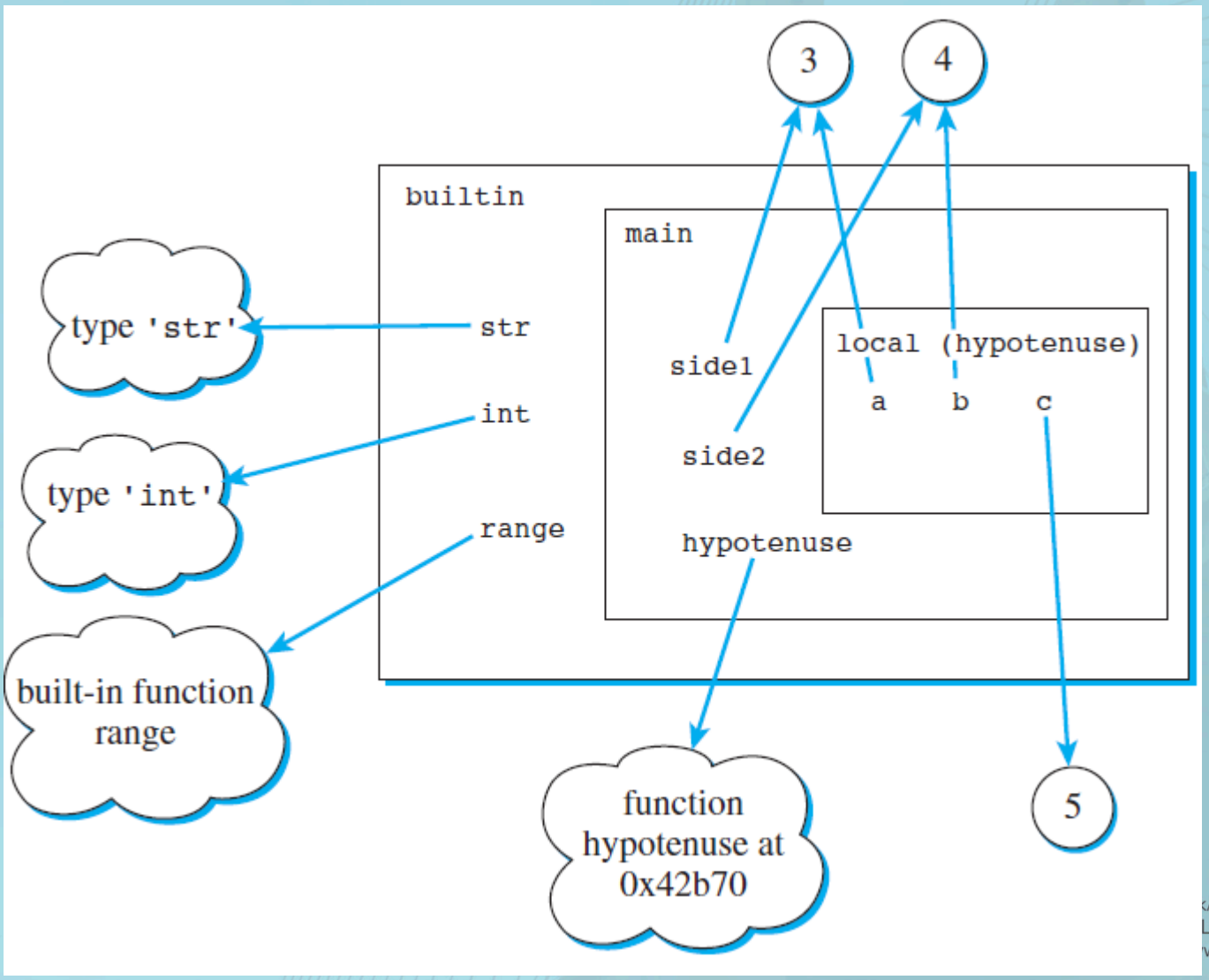


Figure 6.12

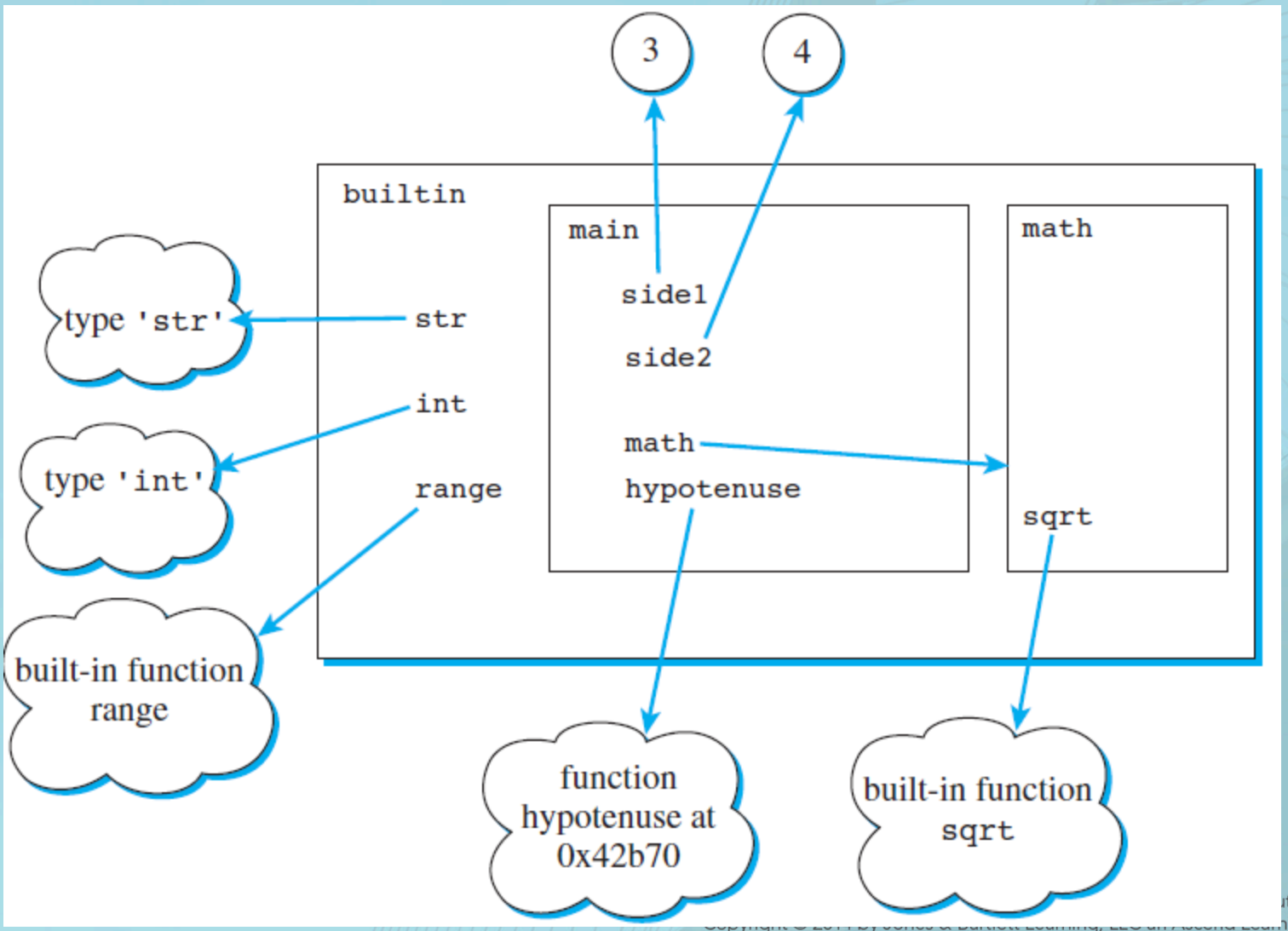
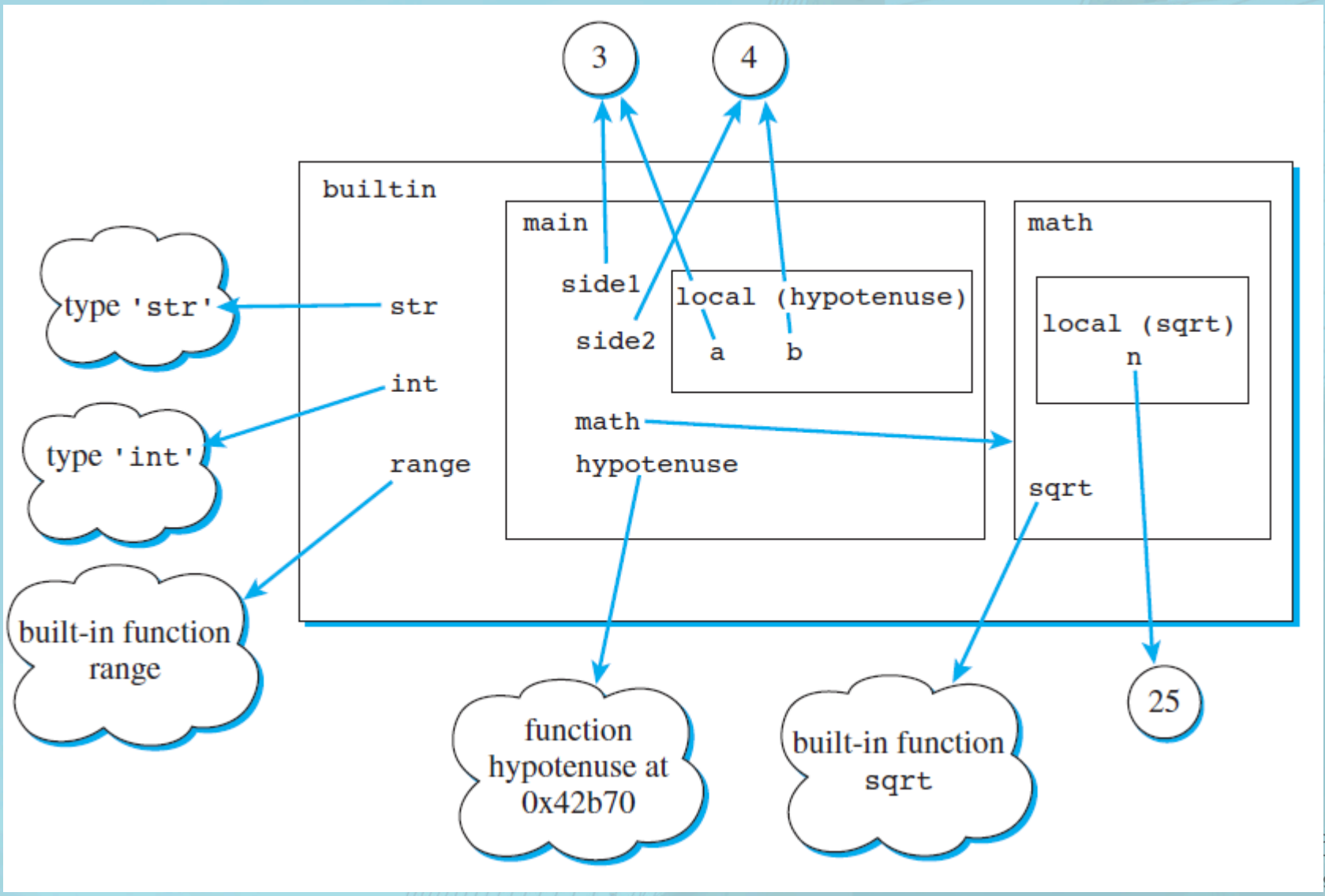


Figure 6.13


3
4
builtin
main
math
type 'str'
str
side1
local (hypotenuse)
side2
a
b
local (sqrt)
n
int
type 'int'
math
range
hypotenuse
sqrt
built-in function
range
function
hypotenuse at
0x42b70
built-in function
sqrt
25

Enlarging an Image

- Stretching an image
- Mapping pixels from original to enlargement

Figure 6.14

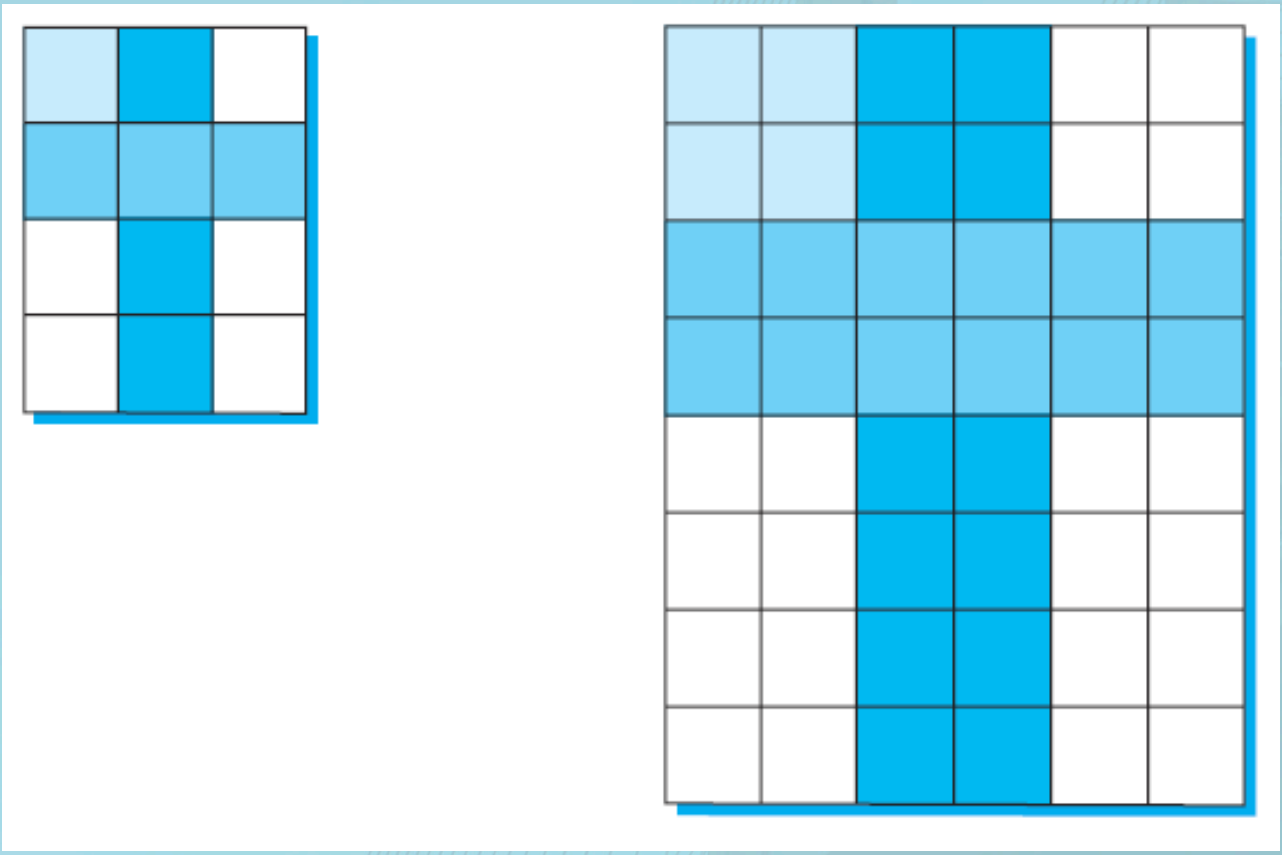


Figure 6.15

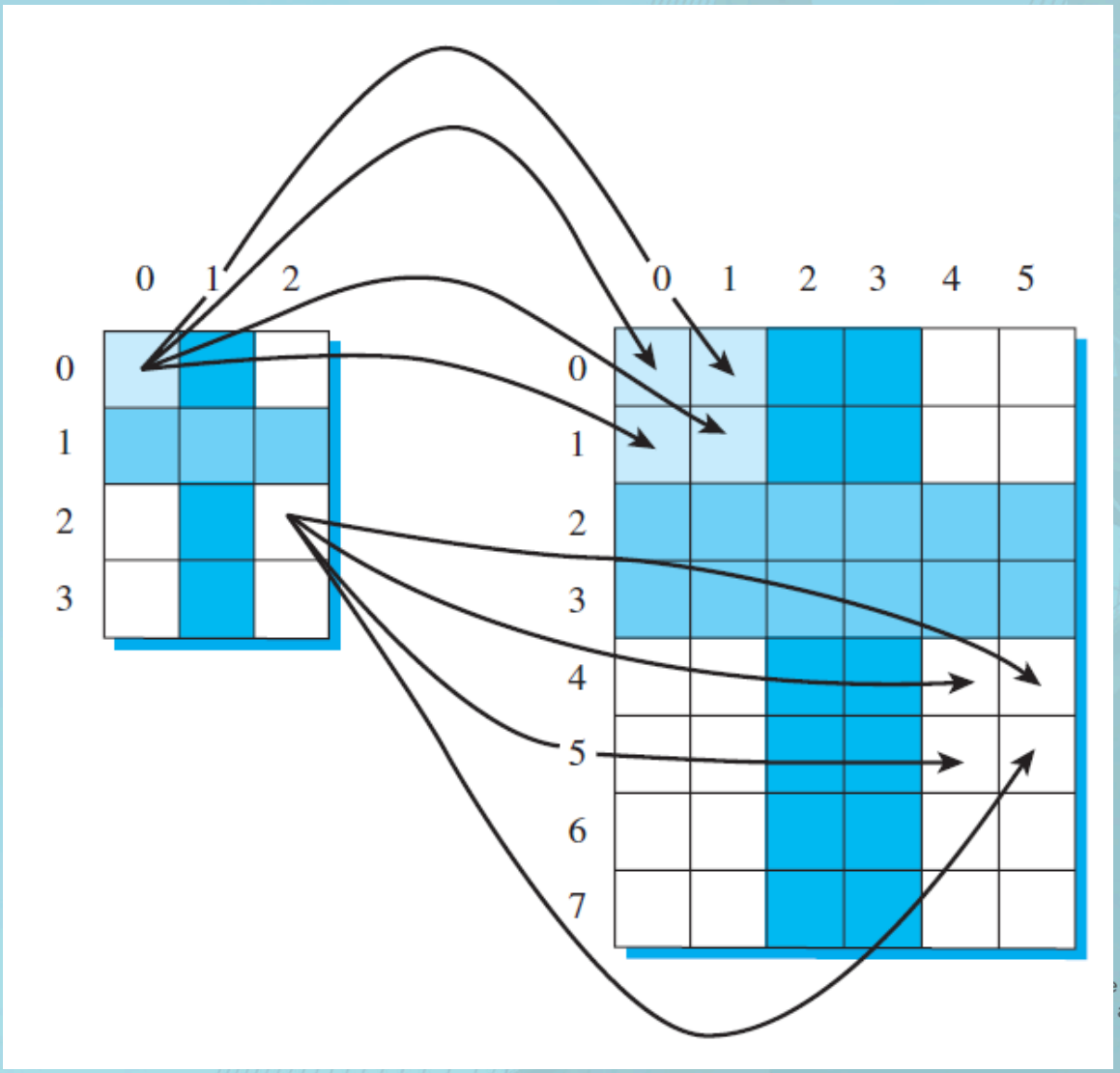
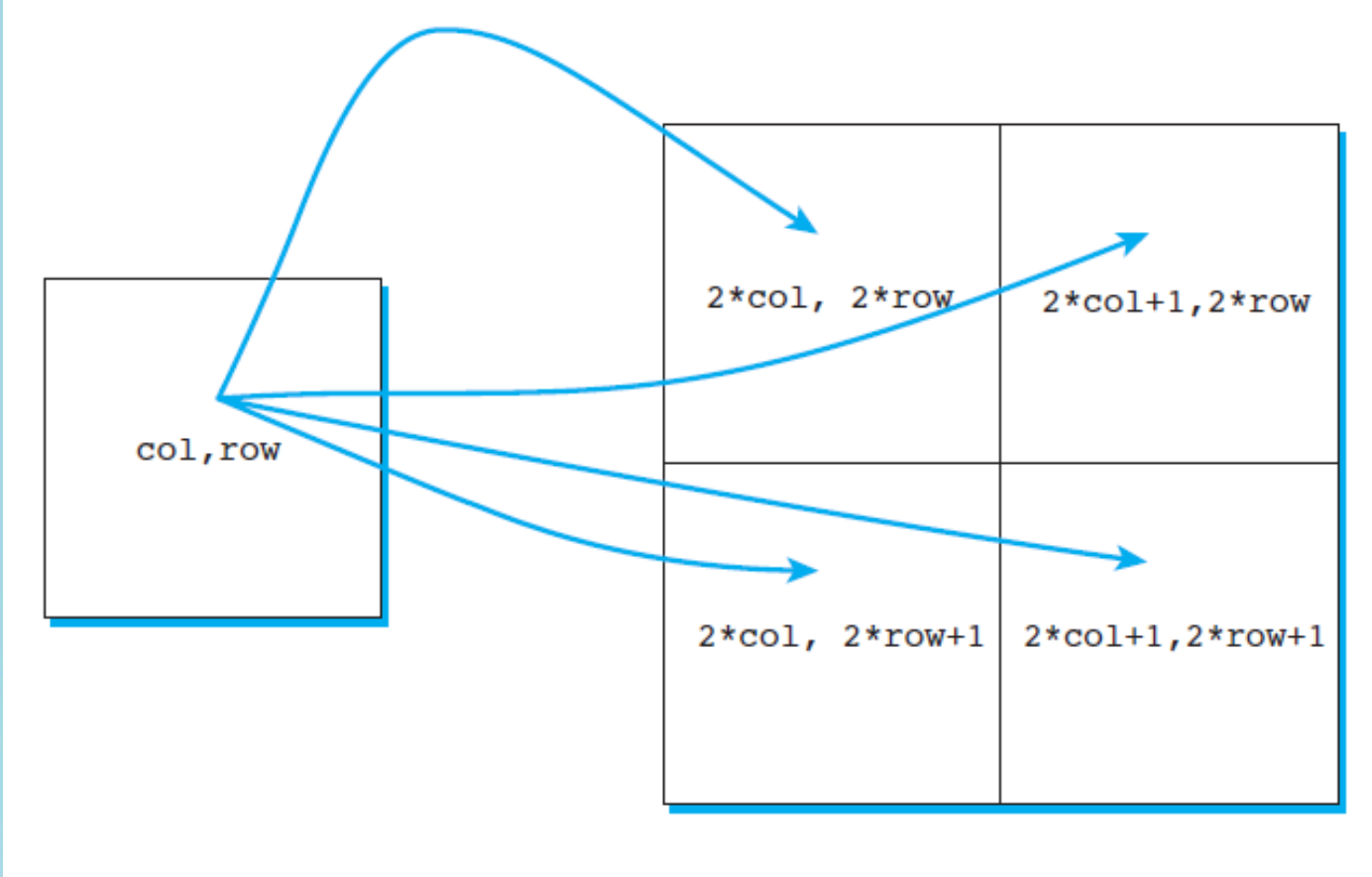


Figure 6.16



Listing 6.8

```
def double(oldimage):
    oldw = oldimage.getWidth()
    oldh = oldimage.getHeight()

    newim = EmptyImage(oldw*2,oldh*2)

    for row in range(oldh):
        for col in range(oldw):
            oldpixel = oldimage.getPixel(col,row)

            newim.setPixel(2*col,2*row,oldpixel)
            newim.setPixel(2*col+1,2*row,oldpixel)
            newim.setPixel(2*col,2*row+1,oldpixel)
            newim.setPixel(2*col+1,2*row+1,oldpixel)

    return newim
```

Figure 6.17

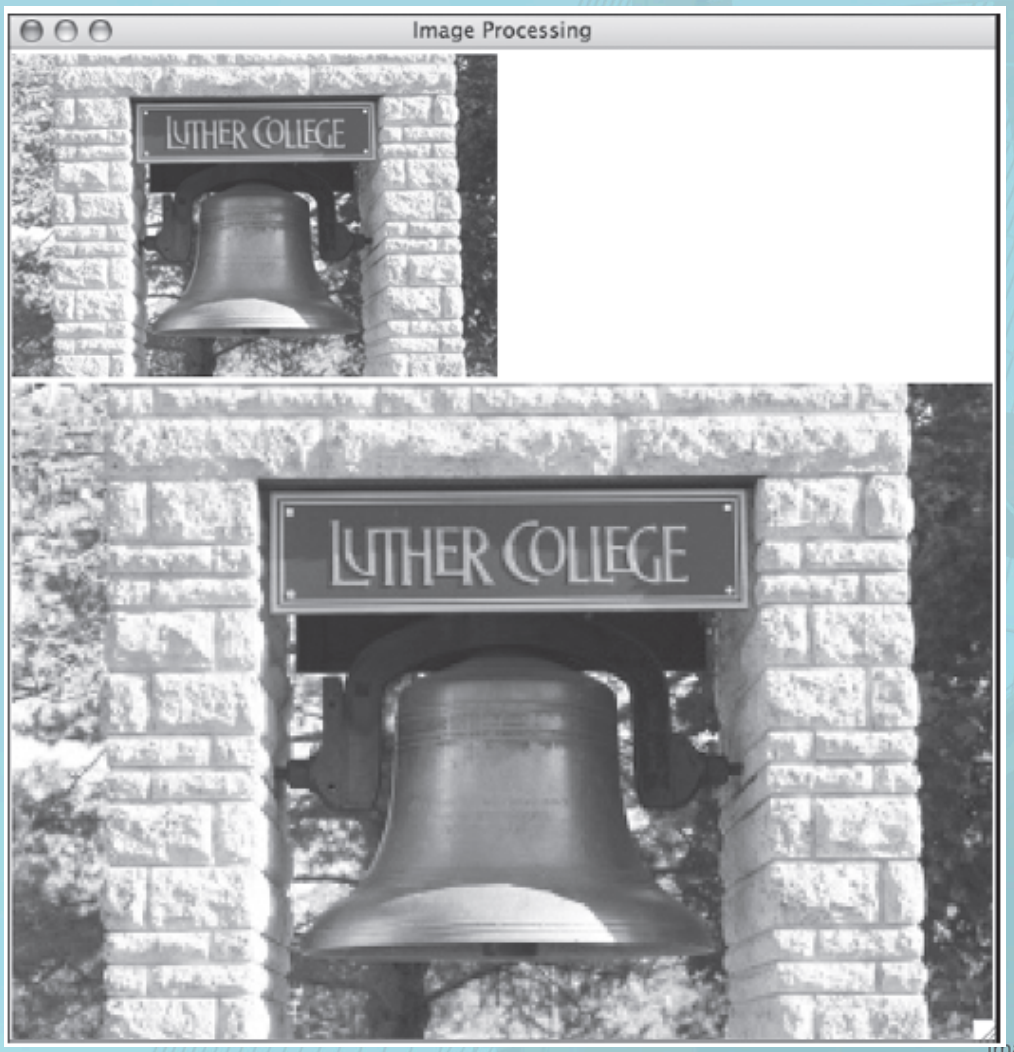
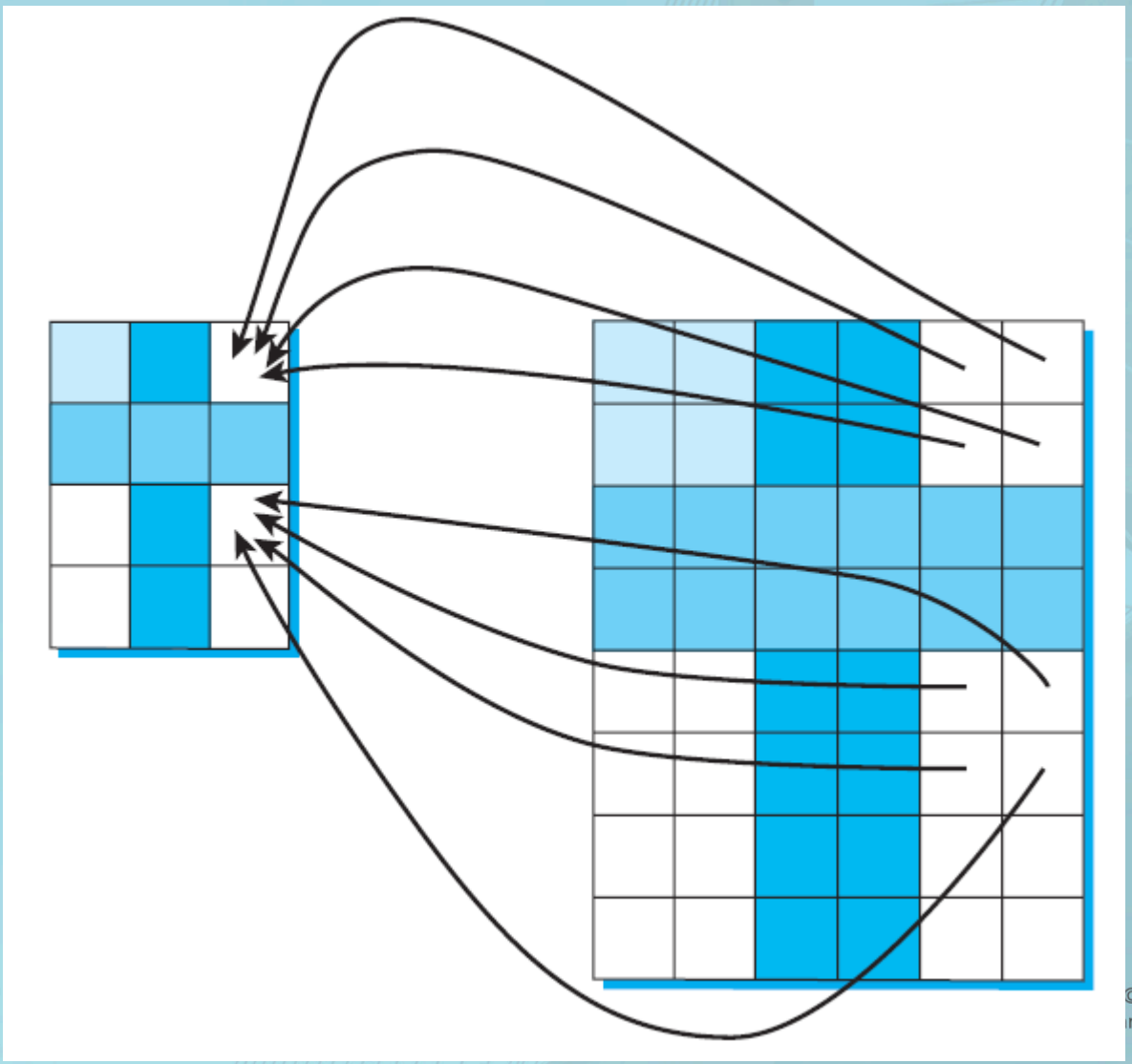


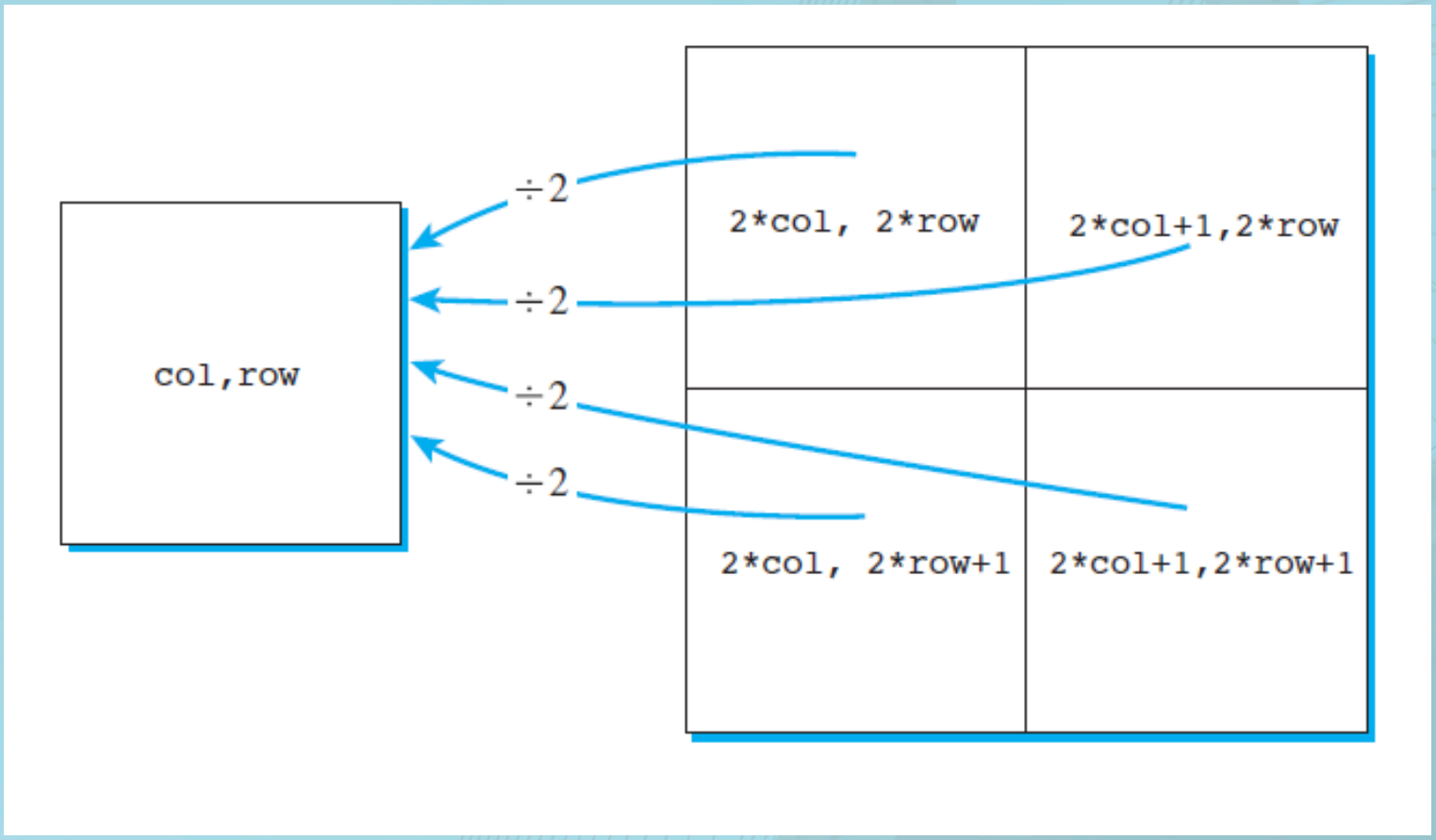
Figure 6.18



Listing 6.9

```
def double(oldimage):
    oldw = oldimage.getWidth()
    oldh = oldimage.getHeight()

    newim = EmptyImage(oldw*2,oldh*2)

    for row in range(newim.getHeight()):
        for col in range(newim.getWidth()):

            originalCol = col//2
            originalRow = row//2
            oldpixel = oldimage.getPixel(originalCol,originalRow)

            newim.setPixel(col,row,oldpixel)

    return newim
```

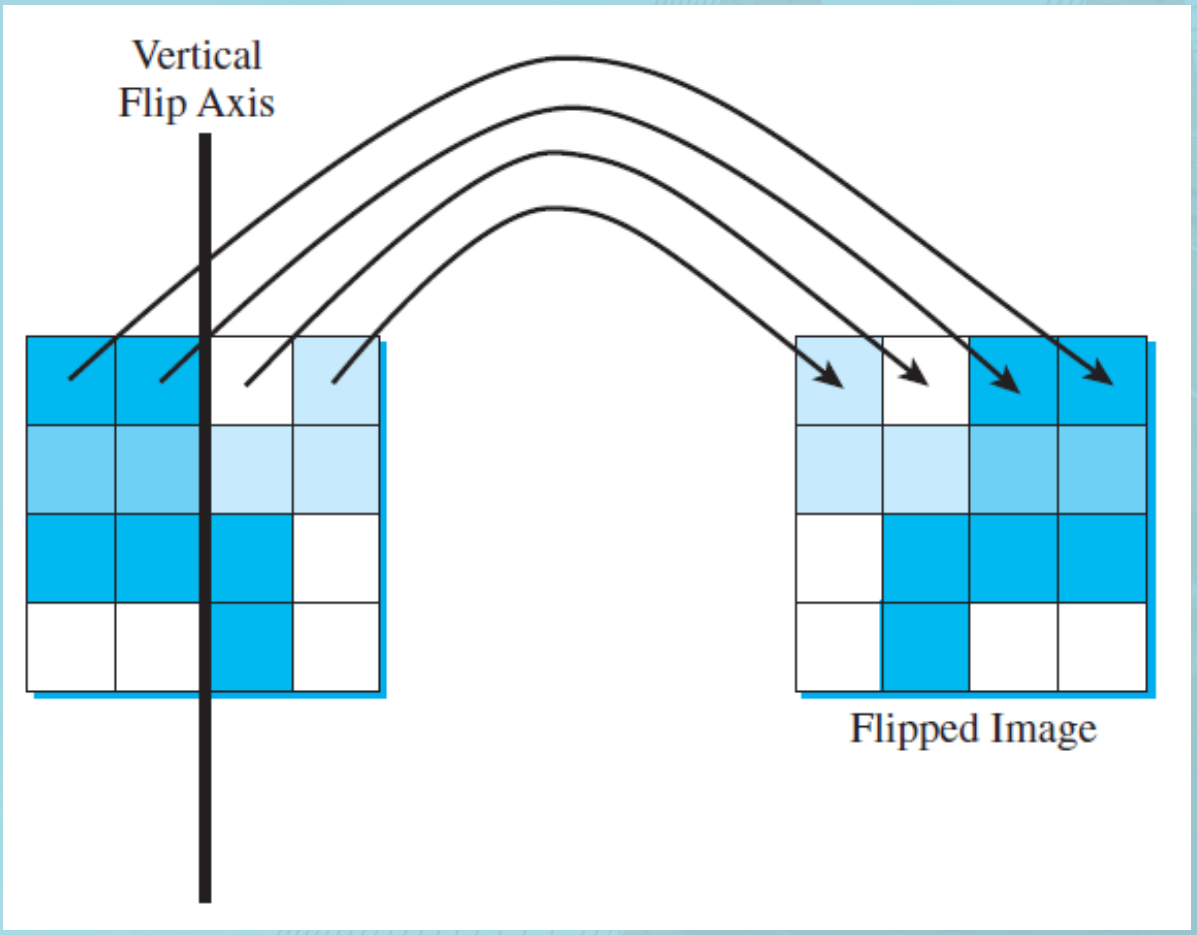
Figure 6.19



Flipping an Image

- Moving pixels to a new location
- Flip axis

Figure 6.20



Listing 6.10

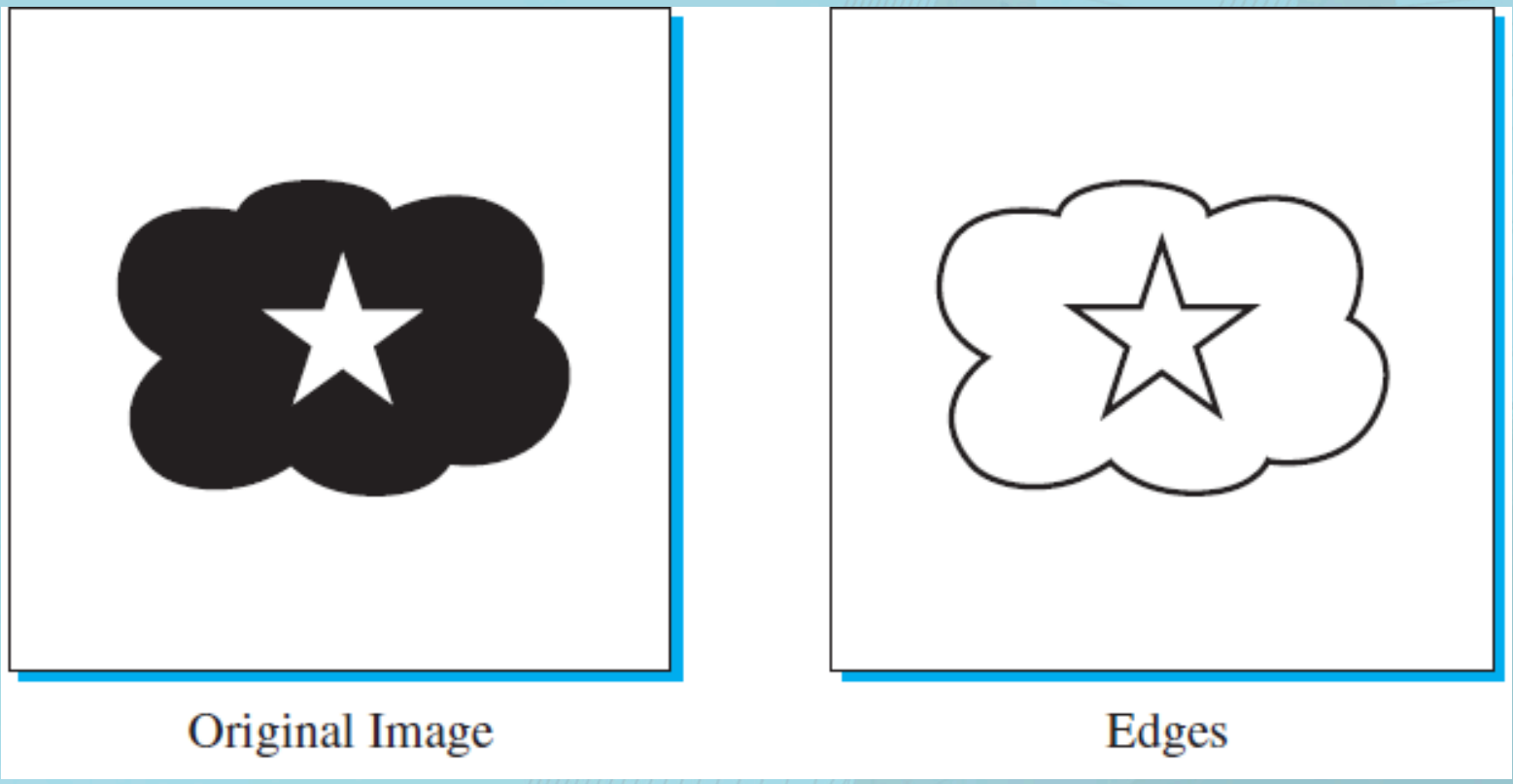
```
def verticalFlip(oldimage):
    oldw = oldimage.getWidth()
    oldh = oldimage.getHeight()

    newim = EmptyImage(oldw,oldh)

    maxp = oldw -1
    for row in range(oldh):
        for col in range(oldw):

            oldpixel = oldimage.getPixel(maxp-col,row)

            newim.setPixel(col,row,oldpixel)

    return newim
```

Figure 6.21

Edge Detection

- Convert to grayscale
- Look for changes from light to dark or dark to light

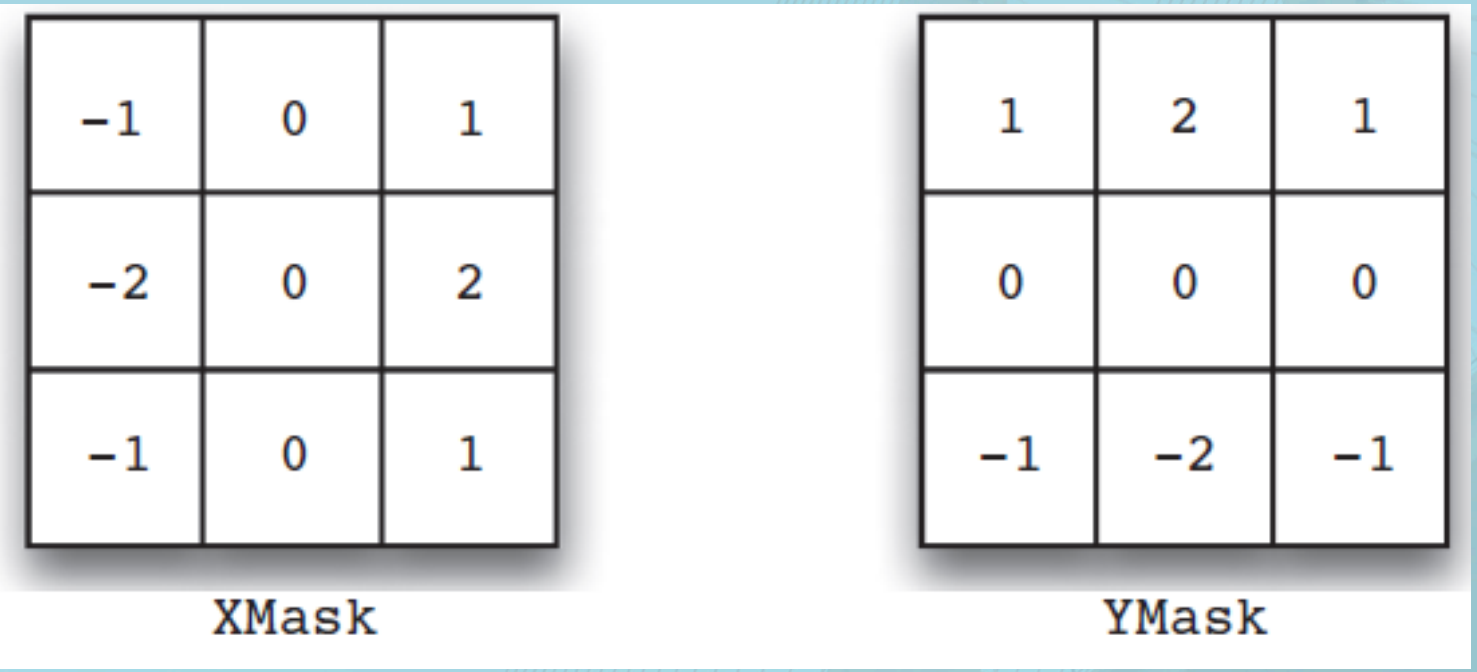
Figure 6.22



Original Image

Edges

Figure 6.23



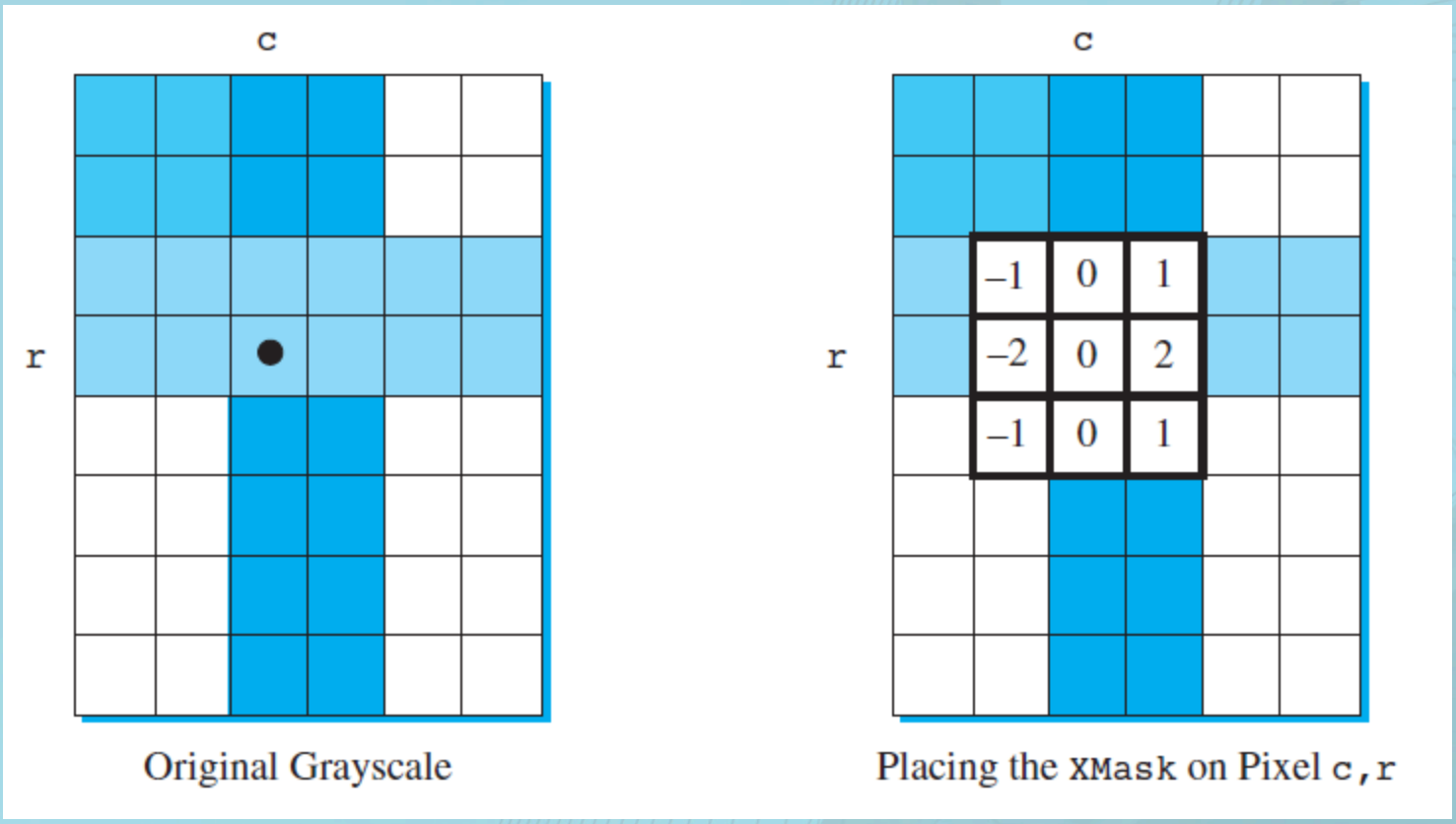
−1	0	1
−2	0	2
−1	0	1

XMask

1	2	1
0	0	0
−1	−2	−1

YMask

Figure 6.24



Original Grayscale

Placing the `XMask` on Pixel `c,r`

Listing 6.11

```
def convolve(anImage,pixelRow,pixelCol,kernel):
    kernelColumnBase = pixelCol - 1
    kernelRowBase = pixelRow - 1

    sum = 0
    for row in range(kernelRowBase,kernelRowBase+3):
        for col in range(kernelColumnBase,kernelColumnBase+3):
            kColIndex = col-kernelColumnBase
            kRowIndex = row-kernelRowBase

            apixel = anImage.getPixel(col,row)
            intensity = apixel.getRed()

            sum = sum + intensity * kernel[kRowIndex][kColIndex]

    return sum
```

Listing 6.12

```
import math

def edgeDetect(theImage):
   grayImage = pixelMapper(theImage,grayPixel)
   newim = EmptyImage(grayImage.getWidth(), grayImage.getHeight())
   black = Pixel(0,0,0)
   white = Pixel(255,255,255)
   xMask = [ [-1,-2,-1],[0,0,0],[1,2,1] ]
   yMask = [ [1,0,-1],[2,0,-2],[1,0,-1] ]

   for row in range(1,grayImage.getHeight()-1):
      for col in range(1,grayImage.getWidth()-1):
         gx = convolve(grayImage,row,col,xMask)
         gy = convolve(grayImage,row,col,yMask)
         g = math.sqrt(gx**2 + gy**2)

         if g > 175:
            newim.setPixel(col,row,black)
         else:
            newim.setPixel(col,row,white)

   return newim
```

Figure 6.25