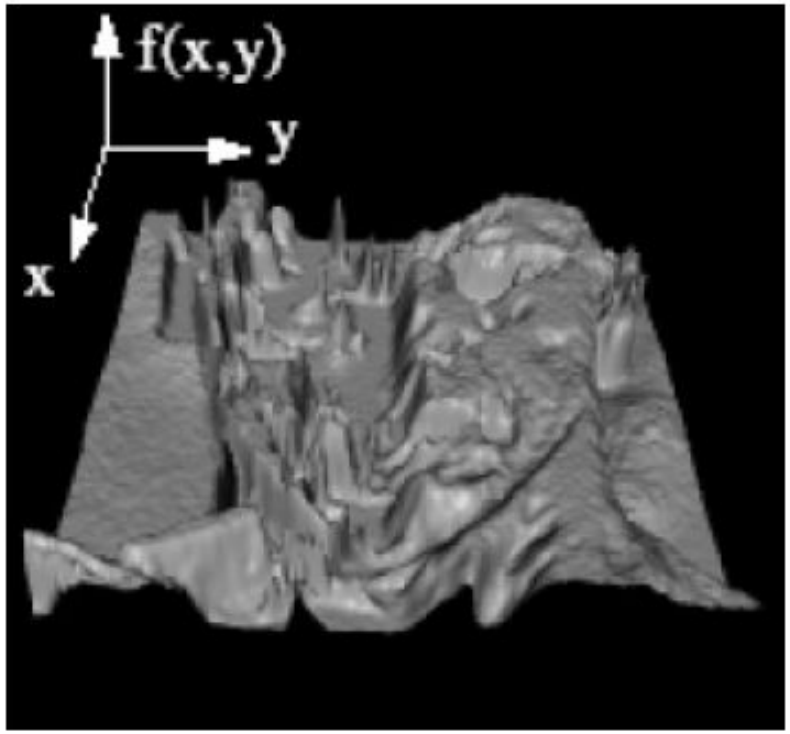
Lecture0 - Supplement

Spring 2017

What is an image?

1. Ideally, we think of an **image** as a 2-dimensional light intensity function, $f(x, y)$, where x and y are spatial coordinates, and f at (x, y) is related to the brightness or colour of the image at that point.
2. In practice, most images are defined over a rectangle.
3. Continuous in amplitude ("continuous-tone").
4. Continuous in space: no pixels!

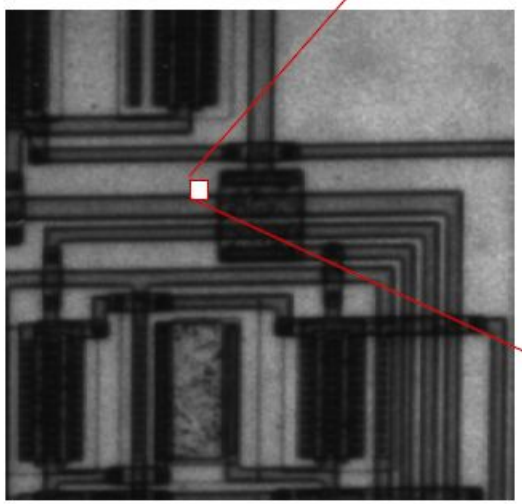

f(x,y)
y
x

Digital Images and Pixels

1. A **digital** image is the representation of a continuous image f(x,y) f(x,y) by a 2-d array of discrete samples. The amplitude of each sample is quantized to be represented by a finite number of bits.

2. Each element of the 2-d array of samples is called a pixel or pel (from "picture element").

A Digital Image is Represented by Numbers



272 pixels

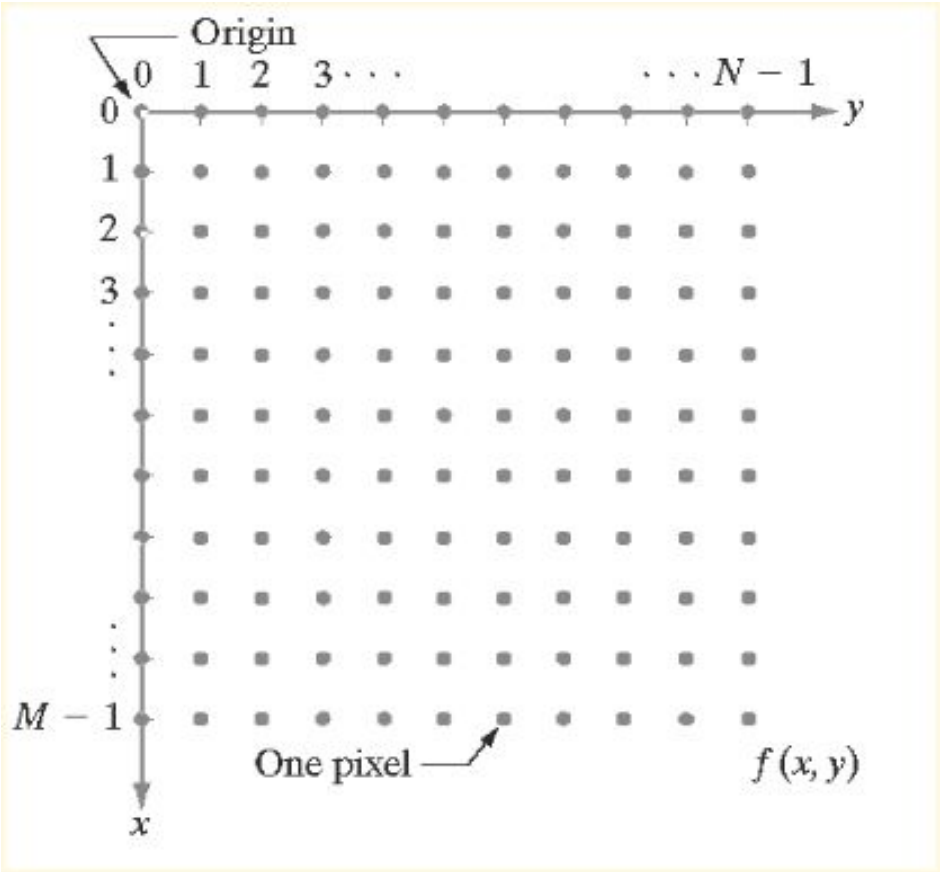
280 pixels

128	125	107	105	110	118	116	114	110
121	122	115	108	106	107	116	116	107
110	114	112	107	105	103	106	106	100
100	96	100	99	94	94	101	101	89
85	82	81	80	76	75	80	82	72
58	58	56	54	53	52	51	49	45
41	41	41	39	39	38	36	35	33
43	43	42	43	41	41	41	43	40
60	60	59	59	60	59	59	58	56

- Pixel = “picture element”
- Represents brightness at one point

A digital image can be represented as a matrix

Coordinate convention used in this course to represent digital images (Matlab uses another convention).



The notation introduced in the preceding slide allows us to write the complete $M \times N$ digital image in the following compact matrix form:

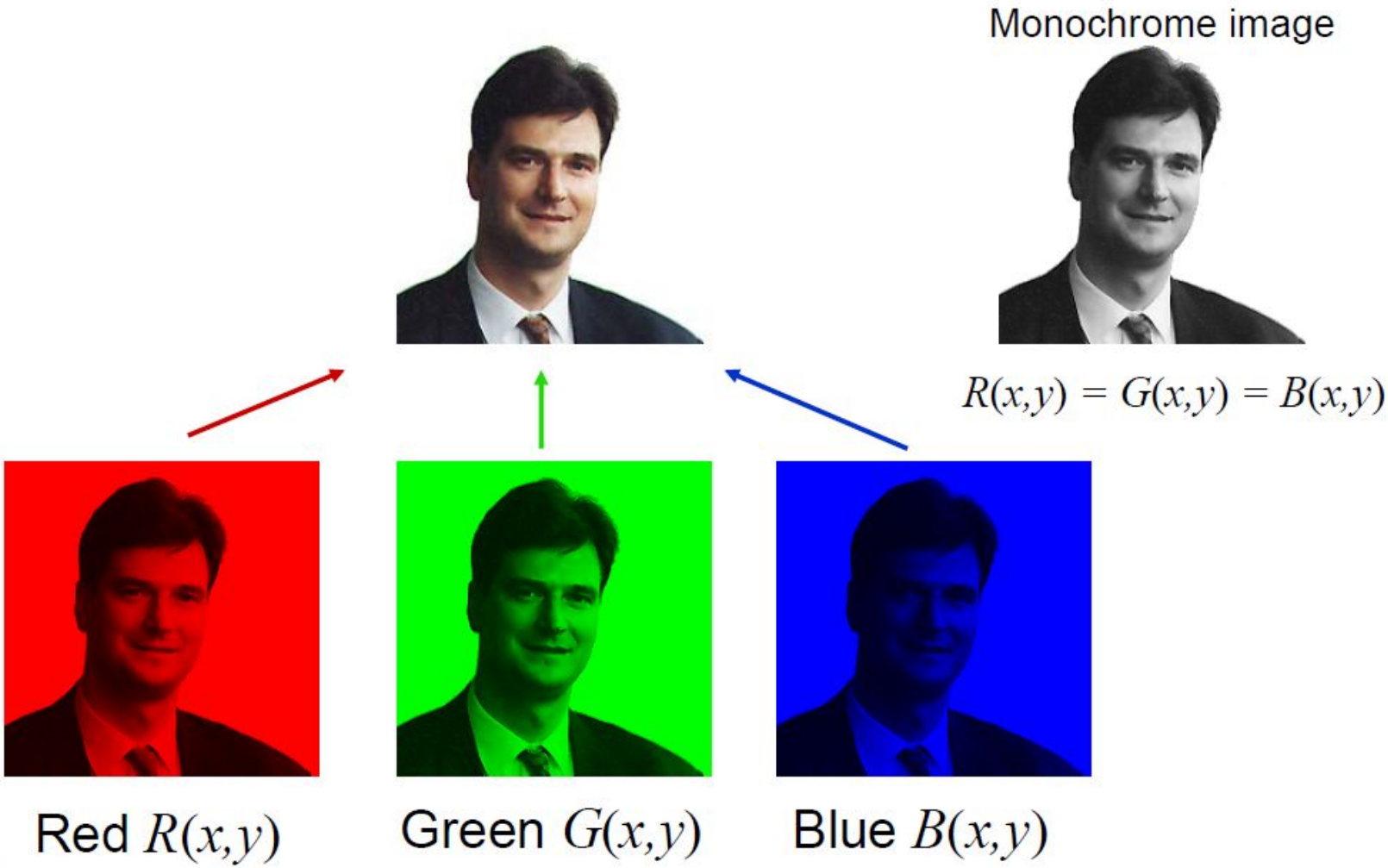
$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}.$$

In some discussions, it is advantageous to use a more traditional matrix no- notation to denote a digital image and its elements:

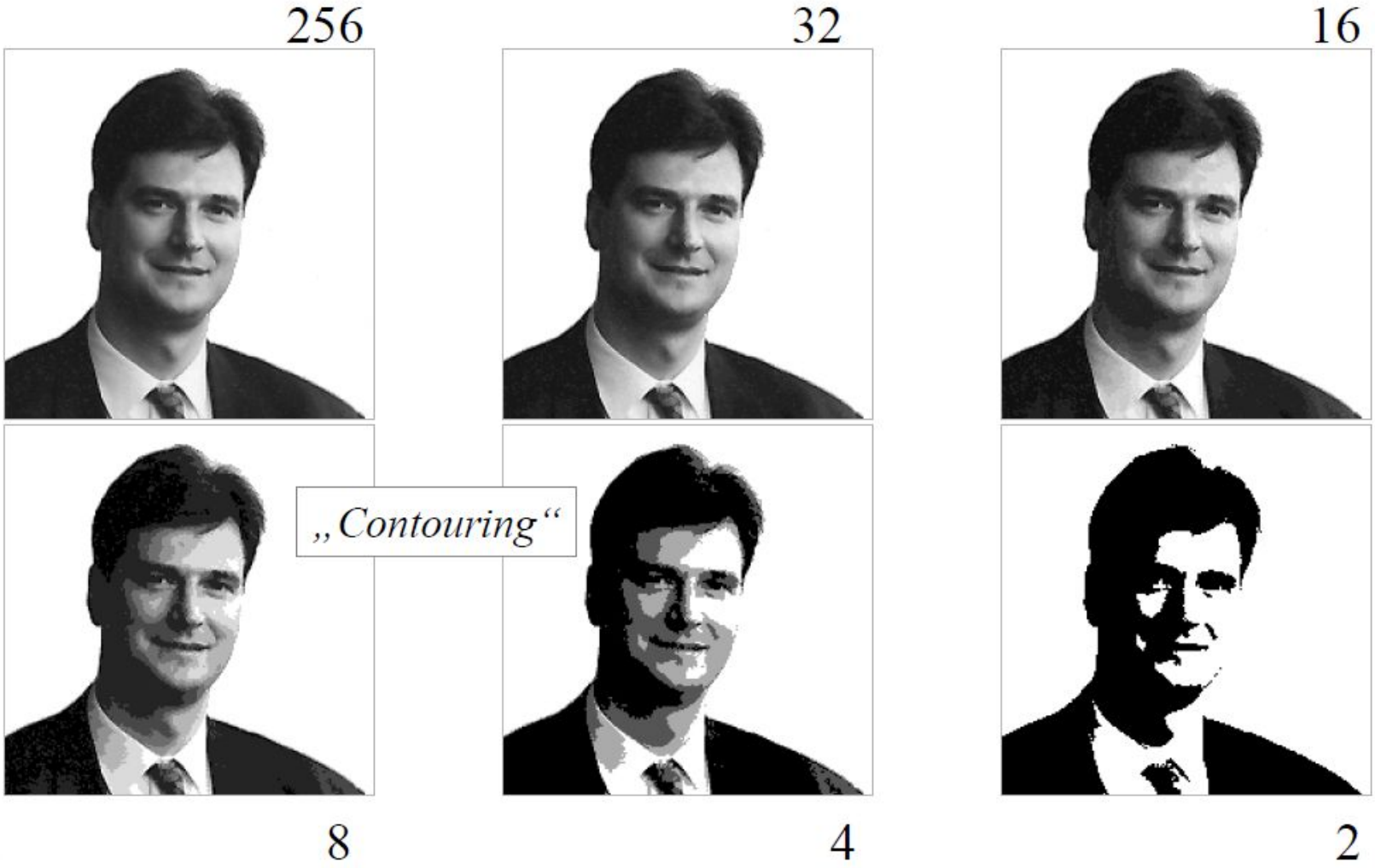
$$\mathbf{A} = \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\ \vdots & \vdots & & \vdots \\ a_{M-1,0} & a_{M-1,1} & \cdots & a_{M-1,N-1} \end{bmatrix}.$$

The sampling process may be viewed as partitioning the *xy* plane into a grid, with the coordinates of the center of each grid. For a colour image, *f* might be one of the components.

Colour Components

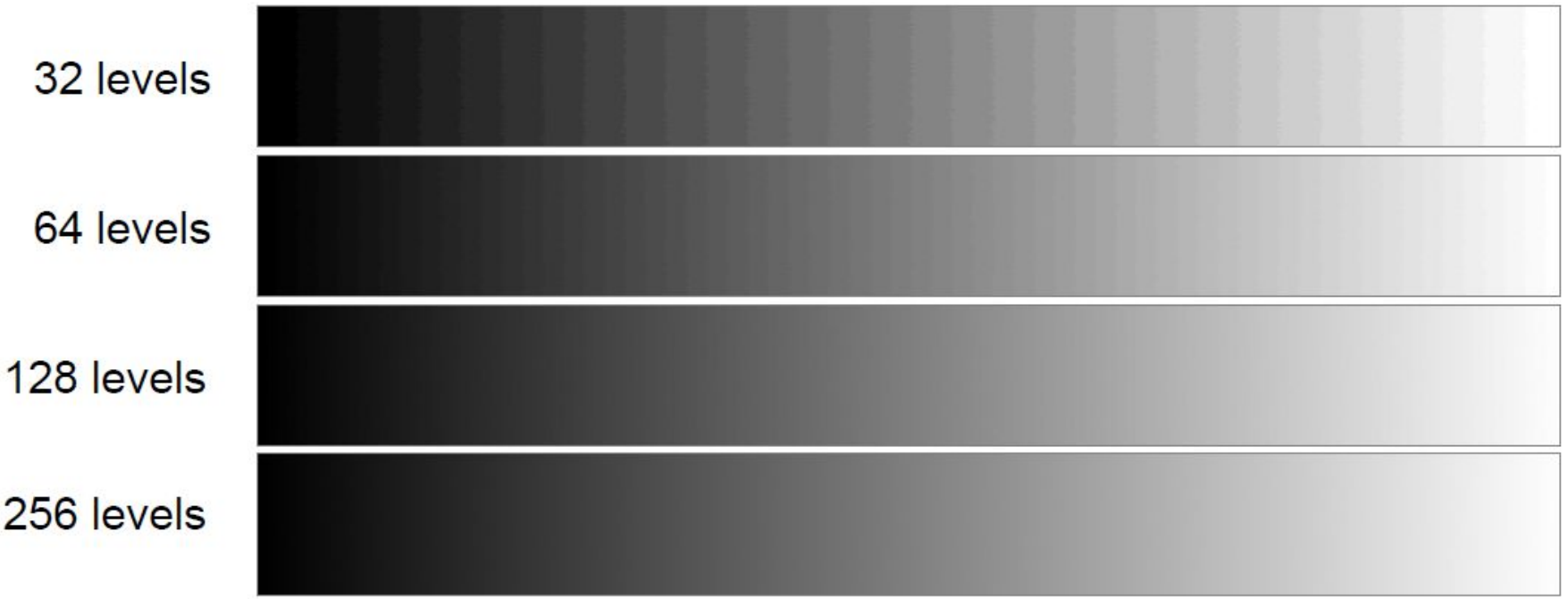


Different numbers of gray levels



How many gray levels are required?

- Contouring is most visible for a ramp



- Digital images typically are quantized to 256 gray levels.

Image Manipulation with Python (Matplotib Library)