Chapter 2: "Getting Started with Digital Image Processing"

Part 1 out of 3

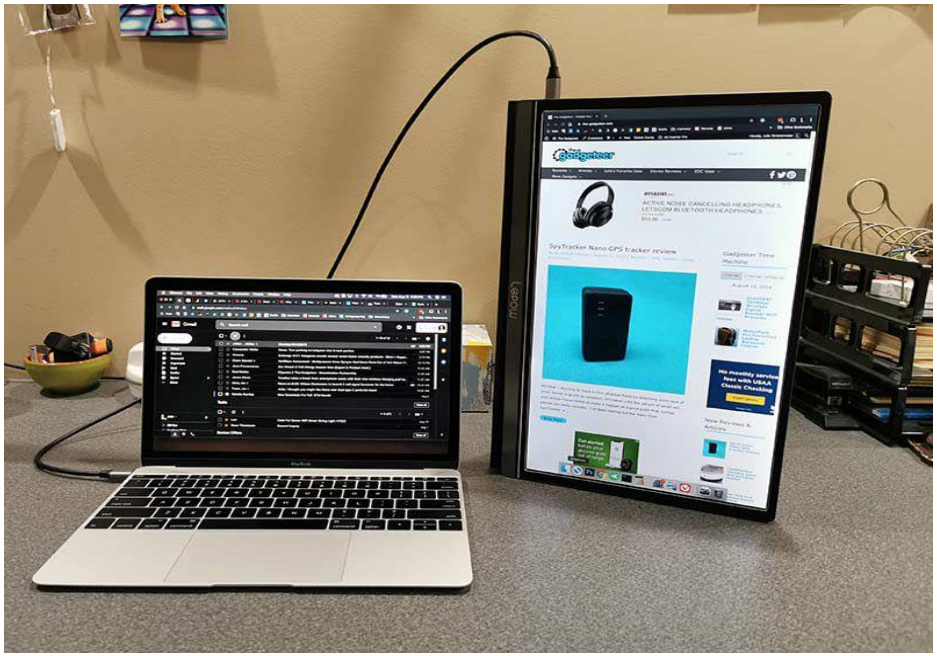

Image Display:

Image display is one of the fundamentals of digital image processing. When displaying an image, the intensity of each point on the screen is controlled by the value of the corresponding pixel in the image.

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Image Display: ***(continue)***

- *Image might be displayed as monochromatic, shades of gray, or in colors.*
- *A monochromatic display of an image has one component that may be controlled for each point. On the contrast, a color display has three components at each point; red, green, & blue were each component is independently controlled.*

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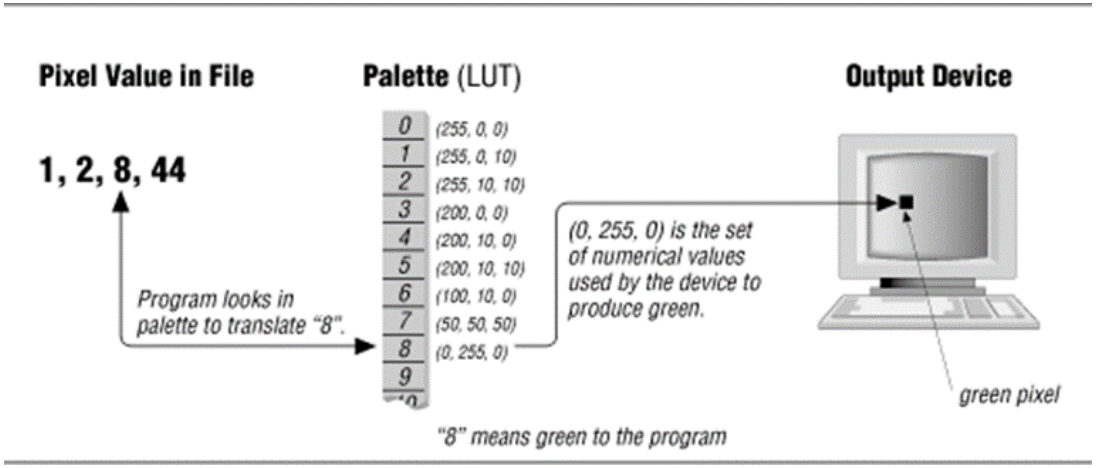

Image Display: (continue)

- When displaying an image, the ranges of image values have to be mapped to the range of screen values. The mappings are almost always implemented as a Table-look-up operation applied to the data "on the fly" as it is being displayed. This requires a hardware look up table (LUT), which is a standard on almost all images displaying screen.

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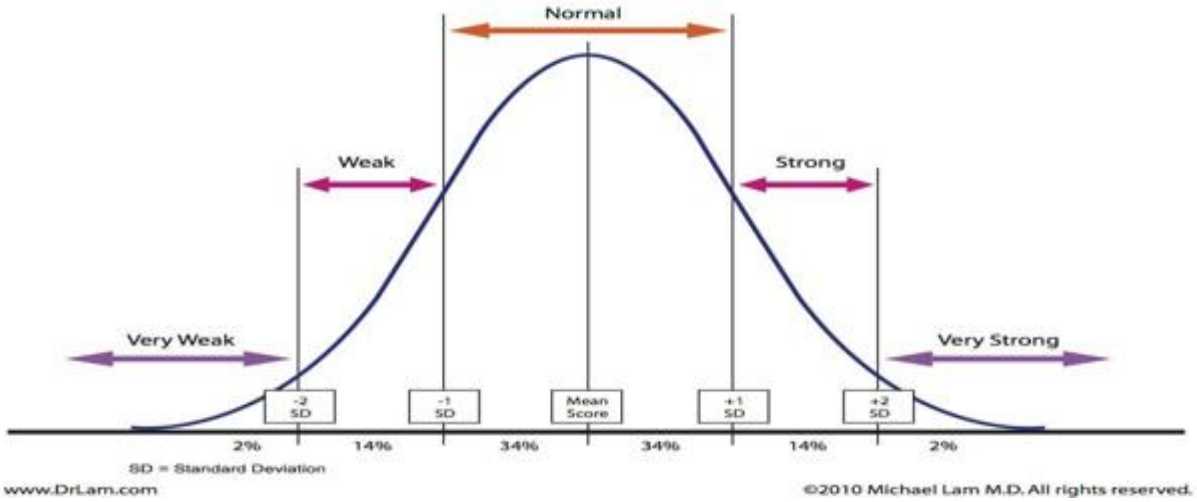
Part 2 out of 3



Initial Statistics Extraction:

Before displaying an image, almost all softwares usually calculate some fundamental statistics of the multispectral image data. This involves the minimum & the maximum values, the mean & the standard deviation of each band in the image, the variance-covariance matrix & the correlation matrix of the entire image data

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Initial Statistics Extraction: (continue)

Such statistics that provide valuable information necessary for displaying the image data are;

1. The mean of band K, "μk" = $\sum DNik / n$,

2. The standard deviation of band K,
   "δk" = $\sqrt{\{(\sum (DNik - \mu k)^2 / (n-1)\}}$,

3. The variance of band K, "υk" = $(\delta k)^2$,

4. The covariance between bands K & L,
   "Ckl" = $(\sum \{(DNik - \mu k)*(DNil - \mu l)\}) / (n-1)$

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Initial Statistics Extraction: (continue)

5. To estimate the degree of enter-relationship between image bands, the correlation coefficients, "rkl" is computed,

"rkl" =Ckl / (δk* δl),

Where, DNik is the digital value of pixel I at band K,

n is the total number of pixels in a band,

The correlation coefficient is a unit less, value that range from (+1) to (-1). A value of +1 indicates a perfect direct relationship between two bands; conversely, a correlation coefficient value of -1 indicates a perfect inverse relationship between two bands. On the other hand a correlation coefficient value of 0 suggests that there is no linear relationship between the two bands.

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Initial Statistics Extraction: (continue)

Example 2.1: For the one line 5 pixels 4 bands sample data image represented in Table-2.1, find the minimum & the maximum values, the mean & standard deviation in each band. Also find the variance covariance matrix & the correlation matrix.

Table 2.1: a one line 5 pixels 4 bands image.

Pixel	Band1	Band2	Band3	Band4
(1, 1)	130	57	180	205
(1, 2)	165	35	215	255
(1, 3)	100	25	135	195
(1, 4)	135	50	200	220
(1, 5)	145	65	205	235

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Initial Statistics Extraction: (continue)

The minimum value in band1 is 100, the value of pixel (1, 3); likewise, the maximum value is 165, the value of pixel (1, 2); the mean for band1 can be computed as:

$$\mu_1 = (130+165+100+135+145)/5=135$$

The standard deviation for band1 can also be computed as:

$$\delta_1=\sqrt{\{((130-135)^2+(165-135)^2+\cdots +(145-135)^2)/(5-1)\}}=23.71$$

The variance for band1 can simply computed by square the value of the standard deviation:

$$\upsilon_1 = (23.71)^2 = 562.5$$

The rest of the calculated values can be found in Table-2.2.

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Initial Statistics Extraction: (continue)

Table 2.2: Statistics for the sample data image.

Band	1	2	3	4
μ_k	135	46.4	187	222
δ_k	23.71	16.27	31.74	23.87
υ_k	562.5	264.8	1007.5	570
Min.	100	25	135	195
Max.	165	65	215	255

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Initial Statistics Extraction: (continue)

Table 2.3 will show the variance-covariance matrix but we will discuss two things before we go to the table;

The first one is that variance is a special case of covariance in which it shows the relation between a band & itself.

The second is that usually the relation between two band is the same no matter which one we started with, (i.e. Ckl = Clk), therefore we can only show one diagonal half of the table.

$$C12 = C21 = ((130 - 135)(57 - 46.4) + \ldots + (145 - 135)(65 - 46.4))/((5 - 1)) = 135$$

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Initial Statistics Extraction: (continue)

Table 2.3: var-covariance matrix for the sample data image.

Band	1	2	3	4
1	562.5	(135)	(718.75)	(537.5)
2	135	264.8	(275.25)	(64)
3	718.75	275.25	1007.5	(663.75)
4	537.5	64	663.75	570

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Initial Statistics Extraction: (continue)

Likewise, the correlation matrix is scaled values of the variance-covariance matrix were all values are between +1 & -1.

Note that all values in the diagonal line in Table-2.4 are equal to 1 because in each case we divide the variance by the square of the standard deviation, which make sense because there is always a perfect relationship between a ban & itself.

$$r12 = 135 / (23.71 * 16.27) = 0.35$$

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Initial Statistics Extraction: (continue)

Table 2.4: correlation matrix for the sample data image.

Band	1	2	3	4
1	1	(0.35)	(0.95)	(0.94)
2	0.35	1	(0.53)	(0.16)
3	0.95	0.53	1	(0.87)
4	0.94	0.16	0.87	1

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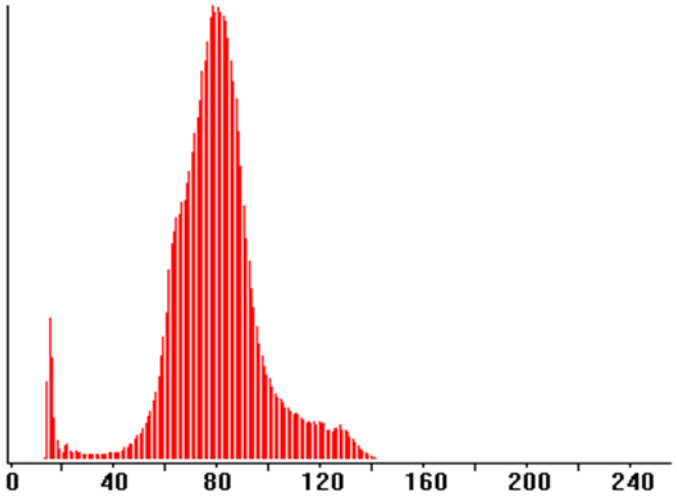
Histograms & Scattered Plots:



- A single band, k, in an image data is defined as being composed of i row & j columns, with a brightness value DNijk at each pixel location. Tabulating frequencies of occurrences for each brightness value within the image provides statistical information that can be displayed graphically in a histogram or frequencies of the brightness values in each band.

- The range of brightness values DN is provided on the abscissa, & the frequencies of occurrences are displayed on the ordinate. A scaled frequency of occurrences is displayed as follow;

$$P(DNi) = (f(DNi)/n \quad *100$$

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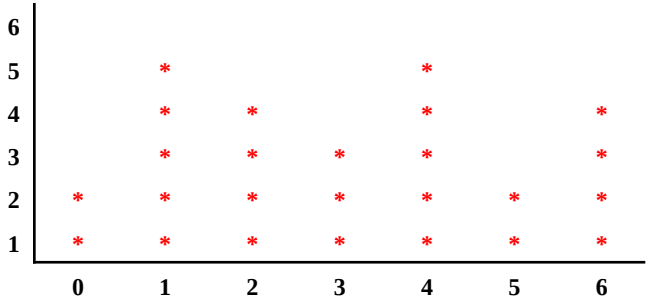
Histograms & Scattered Plots: (continue)

- A histogram is a useful graphic representation of information because it usually provides the reader with an appreciation of the quality of the original data. Another way of representing a histogram, although not as visional efficient, is in a tabular format. For instance the previous 5x5 one band sample image data can be represented in a tabular format as in Table 2.5 below.

2	2	4	4	6
1	2	4	5	6
1	1	5	6	6
0	1	3	3	4
0	1	2	3	4

5x5 one band sample image data



Histogram plot of the sample image data

One-dimensional histogram.

Table 2.5 tabular presentation of histograms

Pixel Value	0	I	2	3	4	5	6	Total
Frequency	2	5	4	3	5	2	4	25

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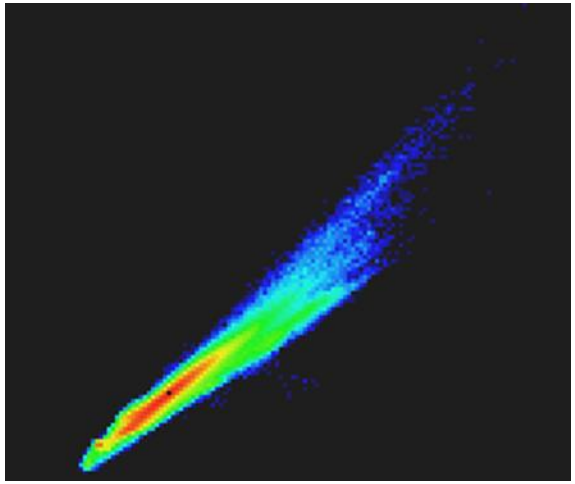
Histograms & Scattered Plots: (continue)

- Scattered plots, or multi-dimension histograms, although not as much used in image display, are very useful tools of analyses digital image were frequency are represented as numbers or colors instead of bar charts.



A scattered plot, (2-D in this case).

2	3	4	4	6
1	2	4	5	6
1	1	5	6	6
0	1	3	3	4
0	1	2	3	4

Band1

3	4	3	3	4
4	2	1	1	0
3	2	0	1	0
4	3	1	1	1
2	4	3	2	1

Band2

5x5 two-band sample image

		Band2					
Band1		0	1	2	3	4	
	0	0	0	1	0	1	
	1	0	0	1	2	2	
	2	0	0	1	2	0	
	3	0	2	1	0	1	
	4	0	3	0	2	0	
	5	1	1	0	0	0	
	6	2	1	0	0	1	
	Scattered plot, a 2-D histogram						

Chapter 1: "Introduction to Digital Image Processing"

That's the end of Chapter 2

Thank You.