Image Processing

- Preprocessing (Image Rectification & Restoration)
  - Geometric Correction
  - Radiometric Corrections
- Image Enhancement
  - Contrast Stretching
    - Linear Stretch
    - Histogram Equalization
    - Gaussian Stretch
  - Spatial Filtering
- Image Transformation
  - Classification
  - Vectorization

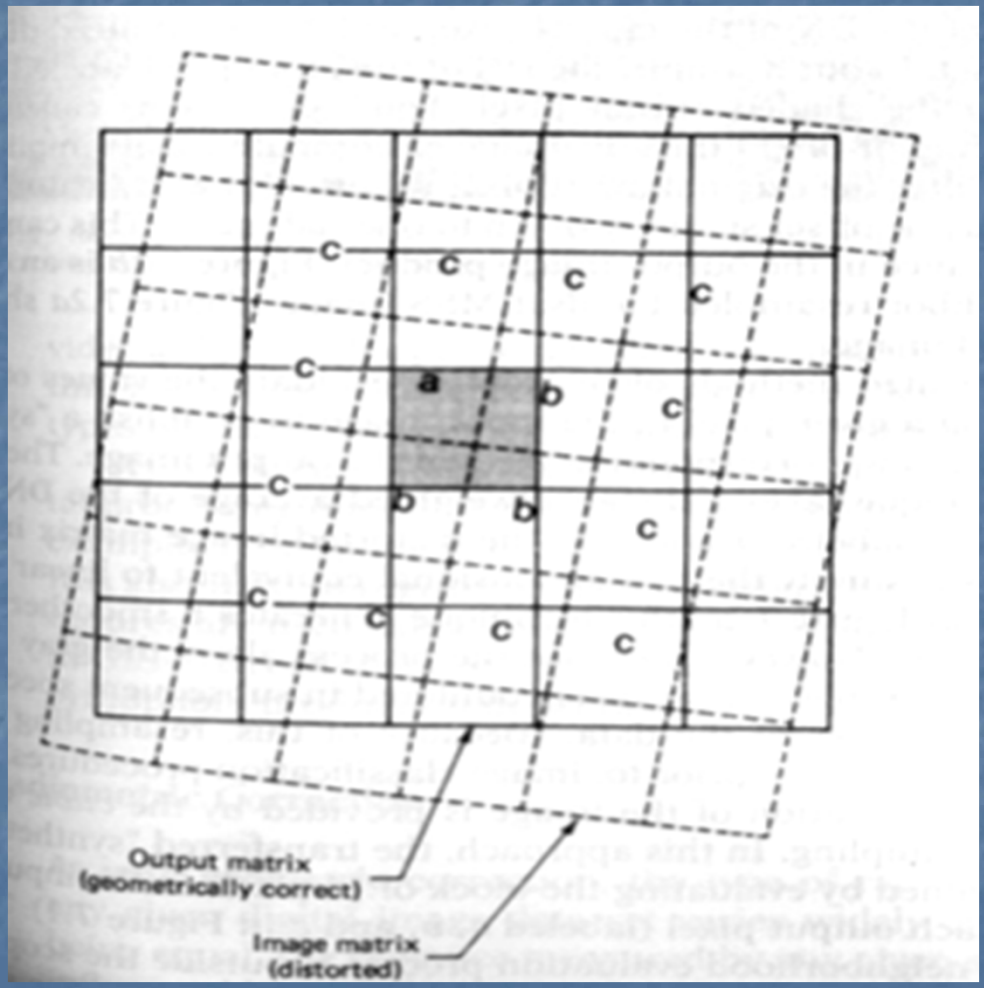
Geometric Correction

- Systematic Errors
  - Skewness of image due to Earth Rotation

  (Removed by Moving each Scan Line in Opposite Direction)
- Random Errors

  (Removed by Selecting Ground Control Points)

Geometric Correction



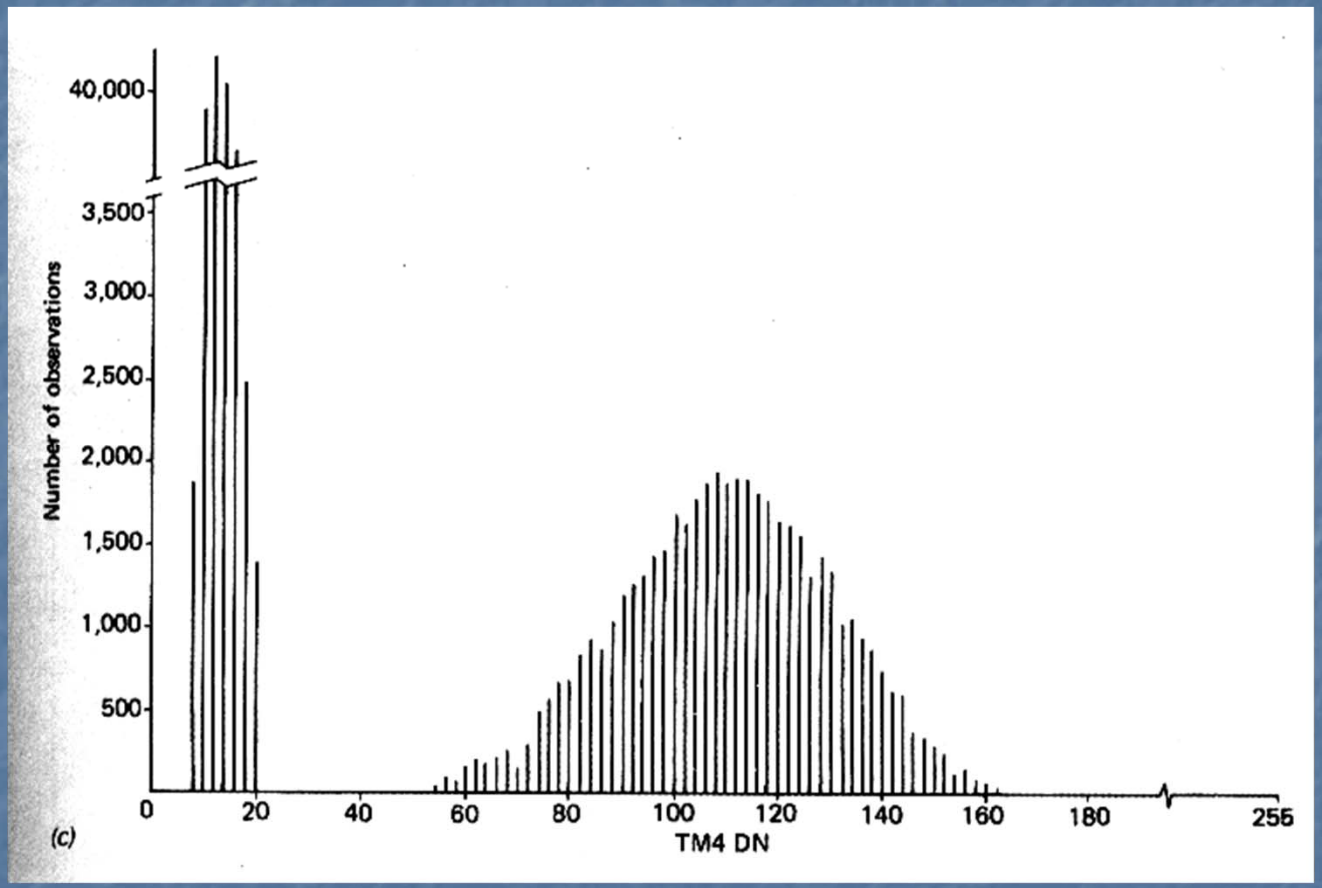
Radiometric Correction

- Atmospheric Correction
- Radiometric Calibration

Image Enhancement

- Contrast Stretching
- Spatial Filtering

Histogram DN ~ No of Pixels



Principle of Contrast Stretch Enhancement

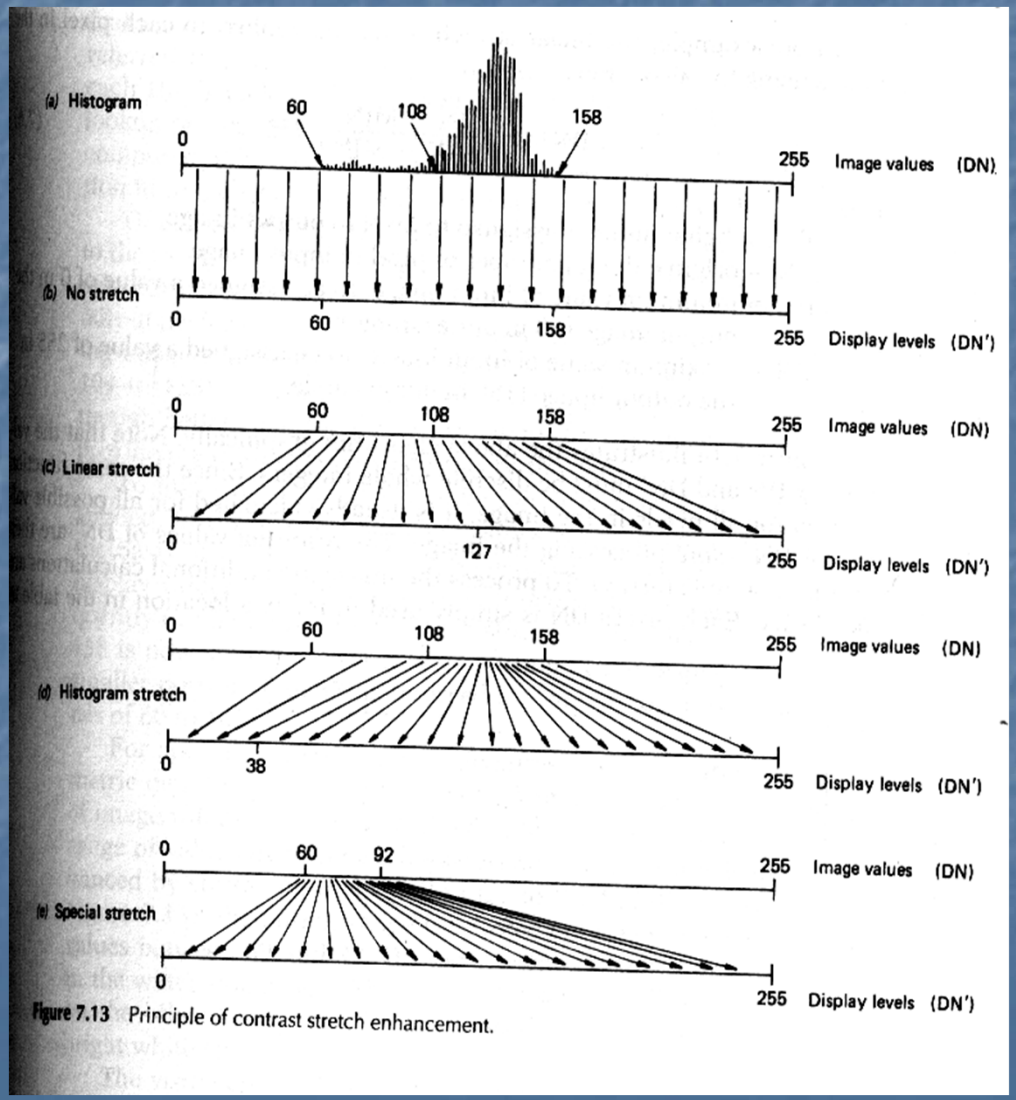


Figure 7.13 Principle of contrast stretch enhancement.

$$DN' = \left(\frac{DN - MIN}{MAX - MIN}\right) 255 \qquad (7.6$$

where

DN′ = digital number assigned to pixel in output image
DN = original digital number of pixel in input image
MIN = minimum value of input image, to be assigned a value of 0 in the output image (60 in our example)
MAX = maximum value of input image, to be assigned a value of 255 in the output image (158 in our example).

Linear Stretch Diagram

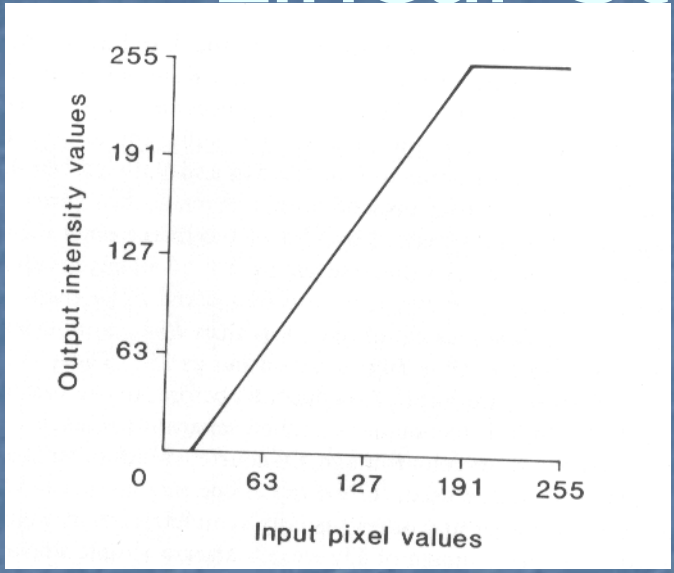


Table 5.1 Lookup table values corresponding to the graph shown in Figure 5.7.

0.. 0	1.. 0	2.. 0	3.. 0	4.. 0
5.. 0	6.. 0	7.. 0	8.. 0	9.. 0
10.. 0	11.. 0	12.. 0	13.. 0	14.. 0
15.. 0	16.. 0	17.. 1	18.. 2	19.. 4
20.. 5	21.. 7	22.. 8	23.. 10	24.. 11
25.. 13	26.. 14	27.. 16	28.. 17	29.. 18
30.. 20	31.. 21	32.. 23	33.. 24	34.. 26
35.. 27	36.. 29	37.. 30	38.. 32	39.. 33
161..211	162..212	163..214	164..215	165..217
166..218	167..220	168..221	169..222	179..224
171..225	172..227	173..228	174..230	175..231
176..233	177..234	178..236	179..237	180..231
181..240	182..241	183..243	184..244	185..246
186..247	187..249	188..250	189..252	190..253
191..255	192..255	193..255	194..255	195..255
196..255	197..255	198..255	199..255	200..255
216..255	217..255	218..255	219..255	220..255
221..255	222..255	223..255	224..255	225..255
226..255	227..255	228..255	229..255	230..255
231..255	232..255	233..255	234..255	235..255
236..255	237..255	238..255	239..255	240..255
241..255	242..255	243..255	244..255	245..255
246..255	247..255	238..255	249..255	250..255
251..255	252..255	253..255	254..255	255..255

Histogram Equalization

Table 5.2(a) Illustrating calculations involved in histogram equalization procedure. $N = 262144$, $n_t = 16384$

Old LUT value	Number in class	Cumulative number	New LUT value
0	1311	1311	0
1	2622	3933	0
2	5243	9170	0
3	9176	18352	1
4	13108	31460	1
5	24904	56364	3
6	30146	86510	5
7	45875	132385	8
8	58982	191367	11
9	48496	239863	14
10	11796	251659	15
11	3932	255591	15
12	3932	259523	15
13	2621	262144	15
14	0	262144	15
15	0	262144	15

Table 5.2(b) Number of pixels allocated to each class after the application of the equalization procedure shown in Figure 5.2(a). Note that smaller classes in the input have been amalgamated, reducing the contrast in those areas, while larger classes are more widely spaced, giving greater contrast. The numbers in each nonempty class vary considerably due to the fact that discrete classes cannot logically be split into subclasses.

(0)	(1)	(2)	(3)	(4)	(5)	(6)
9176	22284	0	24904	0	30146	0
(7)	(8)	(9)	(10)	(11)	(12)	(13)
0	45875	0	0	58982	0	0
(14)	(15)					
48496	22281					

Gaussian Stretch

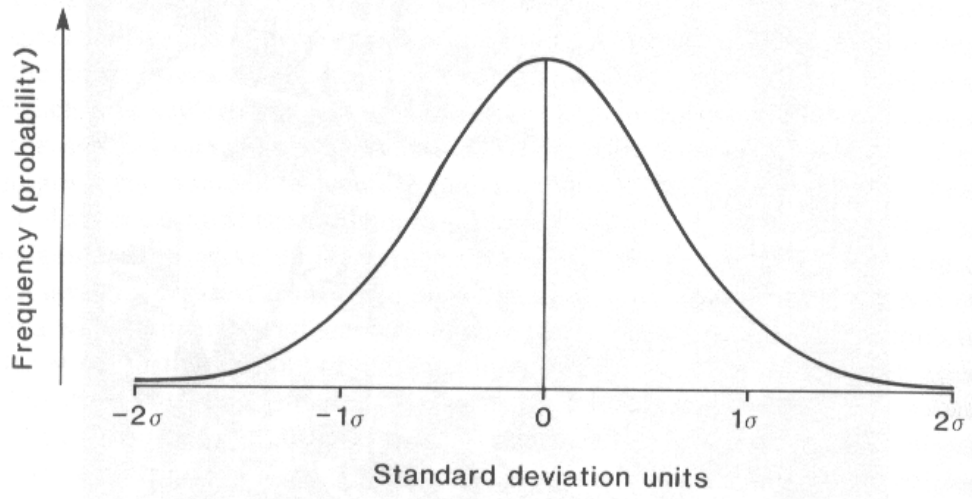


Figure 5.10 Standard normal distribution.

The probability density of the normal distribution is:

$$f(x \mid \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Where:

- μ is the mean or expectation of the distribution (and also its median and mode).
- σ is the standard deviation
- σ^2 is the variance

A random variable with a Gaussian distribution is

$$y = Ce^{-ax^2}$$

$$C = (a/\pi)^{0.5}$$

Example Procedure for Gaussian Stretch

Table 5.3(a) Fitting observed histogram of pixel values to a Gaussian histogram

(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
0	< -3.0	0.0020	530	530	1311	1311	1
1	-2.6	0.0033	868	1398	2622	3933	3
2	-2.2	0.0092	2423	3821	5243	9176	3
3	-1.8	0.0220	5774	9595	9176	18352	4
4	-1.4	0.0448	1175	21346	13108	31460	5
5	-1.0	0.0779	20421	41767	24904	56364	6
6	-0.6	0.1156	30303	72070	30146	86510	7
7	-0.2	0.1465	38401	110471	45875	132385	8
8	0.2	0.1585	41555	152026	58982	191367	10
9	0.6	0.1465	38401	190427	48496	239863	11
10	1.0	0.1156	30303	220730	11796	251659	12
11	1.4	0.0779	20421	241151	3932	255591	13
12	1.8	0.0448	11751	252902	3932	259523	14
13	2.2	0.0220	5774	258676	2621	262144	15
14	2.6	0.0092	2423	261099	0	262144	15
15	>3.0	0.0040	1045	262144	0	262144	15

(i) Original pixel value.
(ii) Standard deviations above (+) or below (−) the mean of the standard normal distribution.
(iii) Probability for each class from standard normal distribution.
(iv) Target number of pixels at each level (N = 262144).
(v) Cumulative target number of pixels.
(vi) Observed number of pixels at each level.
(vii) Cumulative observed number of pixels.
(viii) Pixel value after transformation.

Table 5.3(b) Number of pixels at each level following transformation to Gaussian model

(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	1311	0	7865	9176	13108	24904	30146
(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
45875	0	58782	48496	11796	3932	3932	2621

- New DN is given based on comparison of values in col. vii and v
- The new DN is of the First Value in Col v that exceed the value in col. vii