

Digital Image Processing Introduction

20% Quiz + Class Assignment

30% Mid Term

50% End Term

Images Pixels

Face Recognition

Biometrics

Tracing Missing Children

Age face invariant face recognition: Irrespective of age in which the pic is taken face is recognised.

Biometric: Using some particular body trait eg fingerprint, iris.

GAIT Recognition: Recognising by the way you walk.

Signature

Faugery : Fraud Recognition

Recognition and Identification

Identification and Verification

Verification: Going to match data with data of the given person.

Identification: finding the ~~data~~ ^{person} with the given data.

Applications of Image processing.

Self Driven Car, Document Analysis, Optical Character Recognition

Auto Evaluation Medical Imaging MRI, CT Scans,

Ultrasound, Weather Forecasting (Satellite), Astronomy

Remote Sensing (Start Reading)

Industrial Inspection

What is Image?

A two dimensional light-intensity function $f(x, y)$, where the value of f at a spatial location (x, y) is the intensity (Amplitude) of the image at that point.

(x, y)

Digital Image : x, y , & amplitude values of f are finite, discrete
 → Input is just an array of brightness values. Human perceives structure in it.

Digital Image Processing : Extracting meaningful information.

Sources of Images :

Electromagnetic Energy Spectrum :

Gray Level Image : No colour in it only shades of gray.

Reduce Redundancy

Compress images

JPEG is the compressed form only.

Noise Filtering

Salt and Pepper noise : Black and white dots in the image.

These are high frequency image so filter a low pass filter applied.

Deblurring Algorithm -

Read Remote Sensing

Histograms Frequency distribution

PCB Inspection

License Plate Recognition

Low level Processing

Input : Image

Output : Image

Example : Noise removal,

Image processing.

Mid level Processing

Input : Image

Output : Attributes

Example : Object

recognition,
segmentation.

High level Process

Input : Attributes

Output : Understanding

Elements required to acquire a digital image :

- Physical device to sense EM wave.
- Digitising information received.

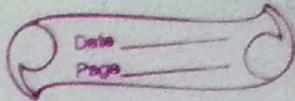


Image Sensing and acquisition.

Representation and Description

Recognition and Interpretation:

Knowledge Base

Digital Image Fundamentals

$$0 < f(x, y) < \infty \quad \text{finite}$$

$f(x, y)$ proportional to energy radiated by the physical source

$$f(x, y) = i(x, y) r(x, y)$$

$$0 < i(x, y) < \infty$$

$$0 < r(x, y) < 1$$

8 bits to represent gray scale

maximum white

$$2^8 = 256 \quad \begin{matrix} \text{black} \\ \rightarrow \\ 0 \end{matrix} \quad \begin{matrix} \text{white} \\ \rightarrow \\ 255 \end{matrix} \quad \begin{matrix} \text{black} \\ \rightarrow \\ 255 \end{matrix}$$

Intensity of a monochrome image at any coordinate (x_i, y_i) is the gray level (l)

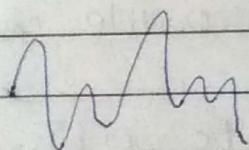
$$\text{image} \quad l_{\min} \leq l \leq l_{\max}$$

Formation The interval $[l_{\min}, l_{\max}]$ is called gray scale.

For digitisation do

→ Sampling

→ Quantization

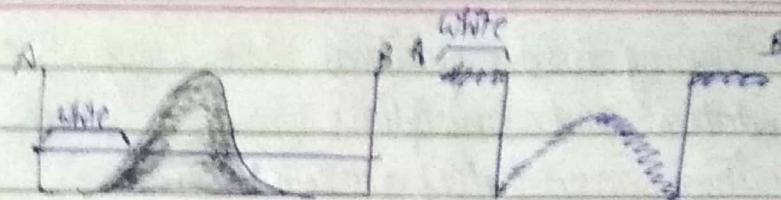


Sampling : Take samples of data

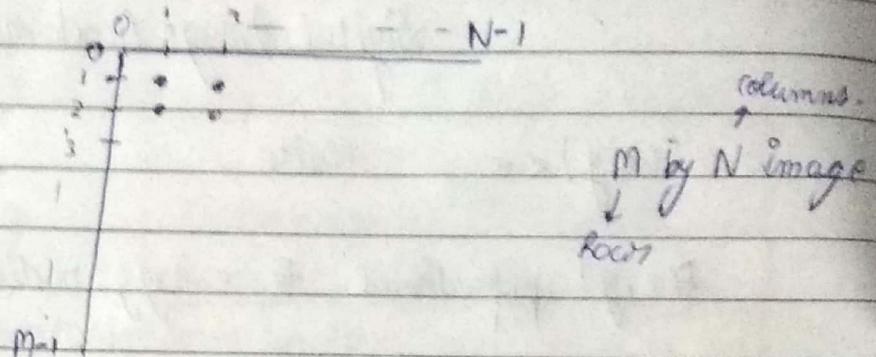
Quantify

Sampling

Image Sampling and Quantization



Digital Image
Representation



gray level image and 8 bits to represent a pixel
then $2^8 = 256$ intensity levels.

$$L = 2^k = \text{Number of gray level.}$$

bits for image = $k \times M \times N$.

Image
Resolution.

Spatial Resolution : Measure of the smallest discernible detail in an image

dpi : dots per inch.
line per unit distance.

Gray Level Resolution : The smallest discernible change in intensity level.

Stated with 8 bits, 12 bits, 16 bits

Resolution depends upon : - No. of sample in an image
- No. of gray levels in an image

1/Jan/2015

Digital Image Representation

Gray Scale Images : Having all shades of gray.

↓ Resolution → by removing alternate rows and columns
(Shrinking)

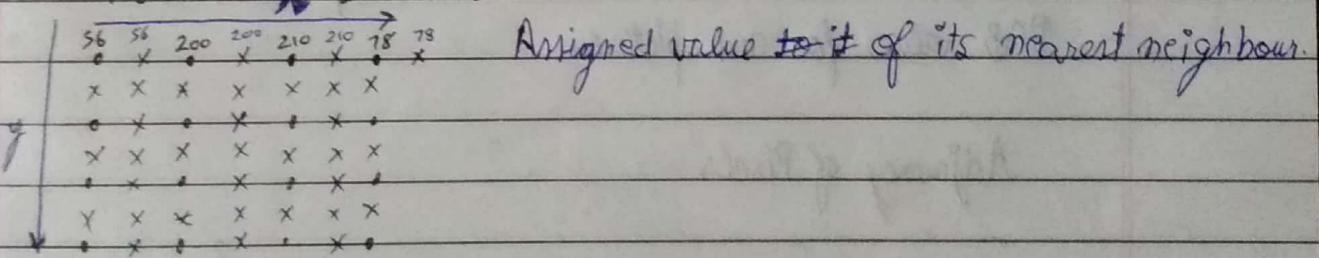
Image Interpolation

Using known data to estimate unknown value.

★ Zooming and Shrinking Images

- Zooming an image can be achieved by
 - Nearest neighbour interpolation
 - Pixel Replication
 - Bilinear Interpolation

NEAREST NEIGHBOUR INTERPOLATION



PIXEL REPPLICATION Replicating Rows and Columns

BILINEAR INTERPOLATION

Example:

$$A \frac{x_1}{x} + B \frac{x_2}{x} + C \frac{x_3}{x} + D \frac{x_4}{x}$$

Bilinear Interpolation.

FIRST ORDER

$$\begin{matrix} a & \frac{a+b}{2} \\ \frac{a+c}{2} & x & \frac{a+b+c+d}{4} & \frac{b+d}{2} \\ c & \frac{c+d}{2} & d \end{matrix}$$

Bilinear Interpolation

x_1 x_2

ZERO ORDER

$$\begin{matrix} a & a & b & b \\ a & a & b & b \\ c & c & d & d \\ c & c & d & d \end{matrix}$$

Pixel Replication

Nearest Neighbours

Pixel Neighborhood

A pixel & it's neighbors (N_{i,j})

↳ neighborhood and central neighbor
padding and neighbors

padding

Connectivity of Pixels

Connectivity of pixels is a fundamental concept that simplifies
the definition of regions and boundaries.

- ~~why for~~ ~~for~~ establishing boundaries
- defining local neighborhoods
- long distance
- blue gray and white
- specific criteria

RGB values for each picture

Adjacency of Pixels

$$N_i = \{200, 201, 202, 203\}$$

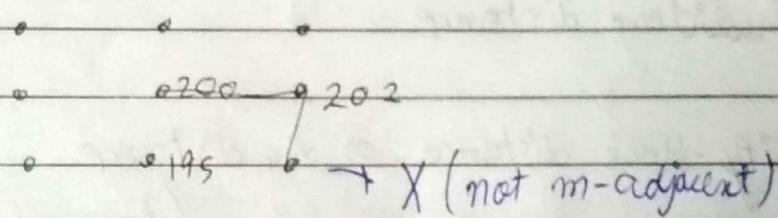
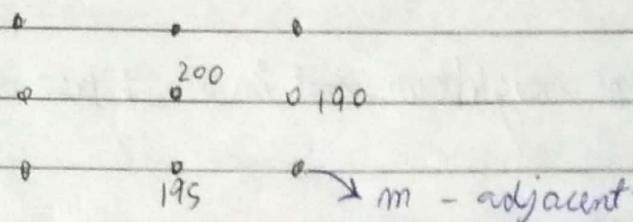
200, 201, 202

203

neighbor

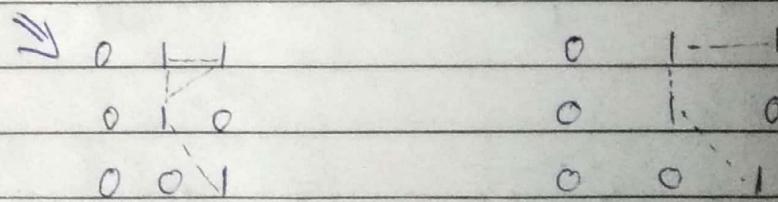
- two pixels $p_{i,j}$ & $p_{k,l}$ with values from set $N_{i,j}$ & $N_{k,l}$
with value need to differ adjacency, see 4 adjacent

- Two pixels p and q with values from set V are 8-adjacent if q is in the set $N_8(p)$.
- Two pixels p and q with values from set V are m-adjacent if
 - q is in the set $N_1(p)$ or
 - q is in $N_2(p)$ and the set $N_2(p) \cap N_4(q)$ has no pixels whose values are from V .



- Two image

Binary Image



Digital Path

A digital path or curve from pixel p with co-ordinates (x_0, y_0) with pixel q with coordinate (x_n, y_n) is a sequence of distinct pixels with co-ordinates $(x_0, y_0), (x_1, y_1), \dots, (x_n, y_n)$

Connected Pixels

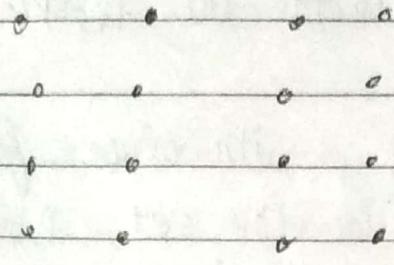


Image Regions and Boundaries

At least one neighbour not in S : boundary point

Distance Measures

- Euclidean distance
- City-block distance or ℓ_1 distance
(diamond)
- Chess board distance or ℓ_∞ distance

$$d_{\ell_\infty}(p, q) = \max(|x_p - x_q|, |y_p - y_q|) \quad (\text{square})$$

ℓ_∞ distance b/w 2 points is defined as the shortest path

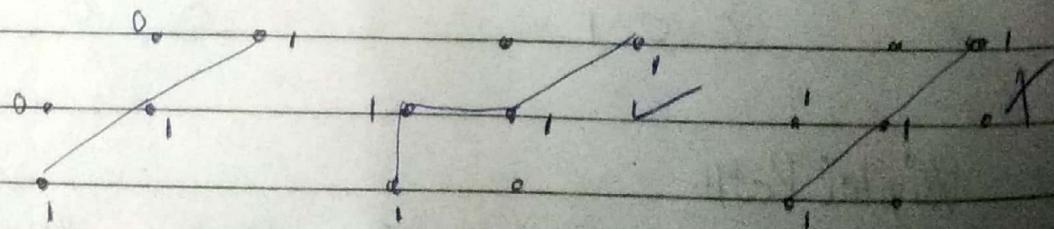


Image operations on Pixels

- Division
- Addition
- Subtraction
- Multiplication
- Linear and Non linear Operations

Image Enhancement in Spatial Domain

Spatial Domain Enhancement

- Point Processing

Modify the gray level of a pixel independent of the nature of its neighbour, e.g. thresholding, gray level transformation

- Neighbourhood Processing

Small sub-image, (mask)

padding

$\times \times \star$ → padding of zeros for spatial domain enhancement

avg of
all these

Negative

Identity transformation
Input image = output image

Some basic gray-level transformation functions used for image enhancement

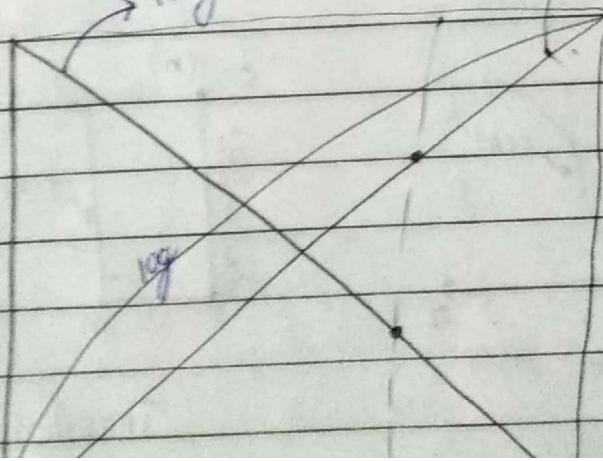


Image Negative

$$S = L - I - \alpha$$

Log Transformation

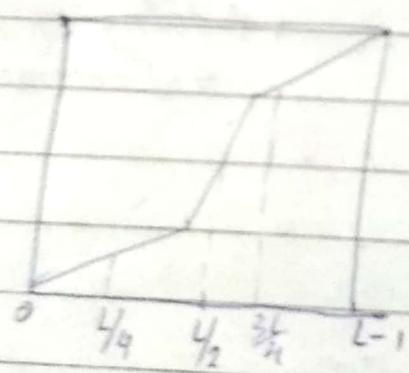
Narrow range of black \rightarrow wide range of white
wide bright image \rightarrow narrow dark side

Pseudo Transformation

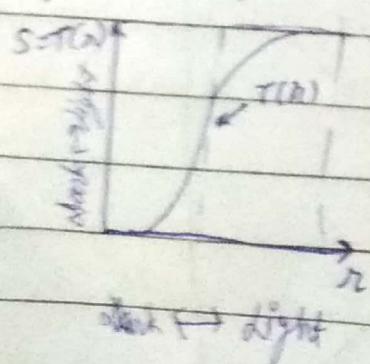
* Contrast Stretching

for contrast image: difference &
if low contrast image, contrast ~~image~~ stretching needed

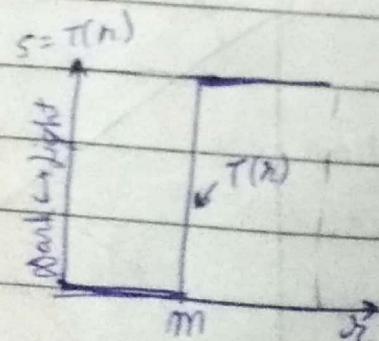
Contrast difference b/w high intensity and low intensity in an image



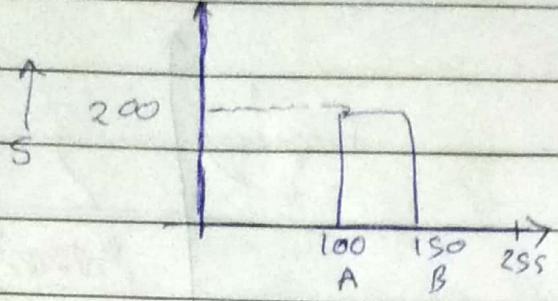
Thresholding



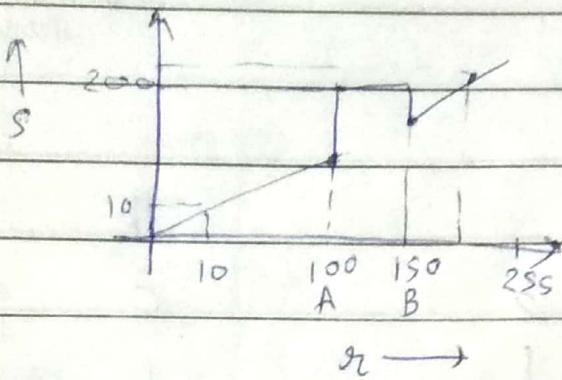
Contrast Stretching



Thresholding transformation

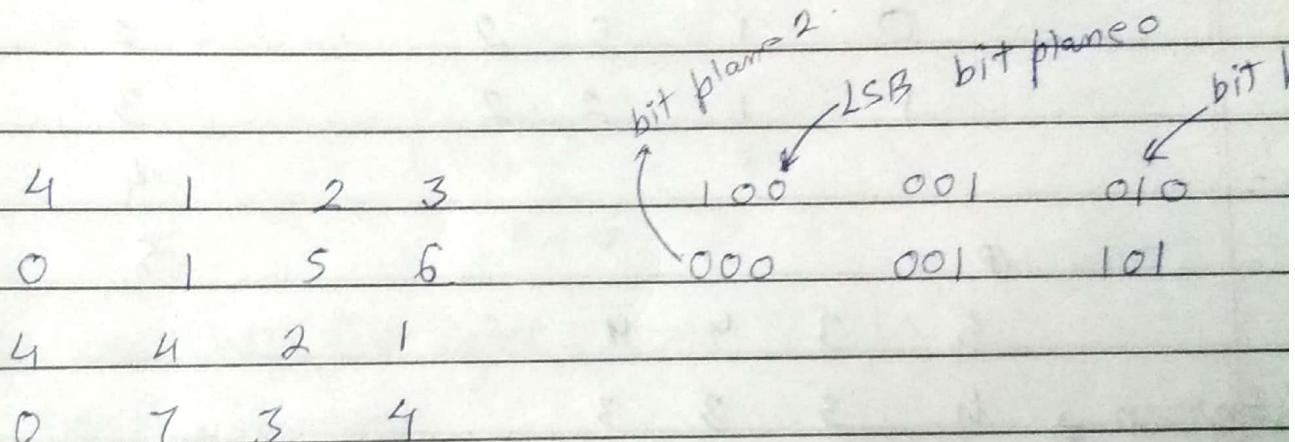


selected gray level, rest
out/subdue to black.



If we don't want to
subdue

one level
icing

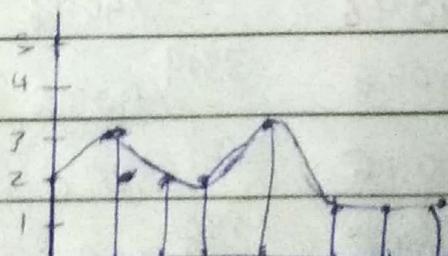


Most of the imp dat
higher plane (visually -
data)

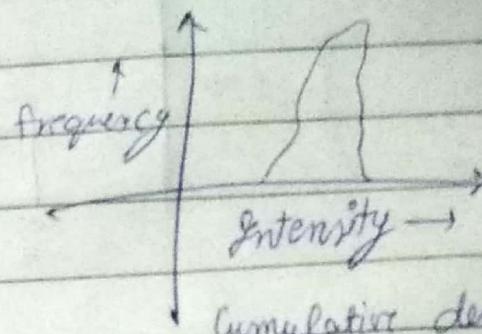
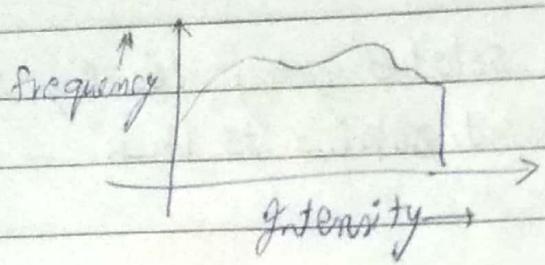
lower Bit plane (finer)

If we want to compress an image, # I can remove lower bit planes.

Histogram



High Contrast Image



Cumulative density function

Total no of pixels

Histogram Equalization

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

⑥

5	3	4	4
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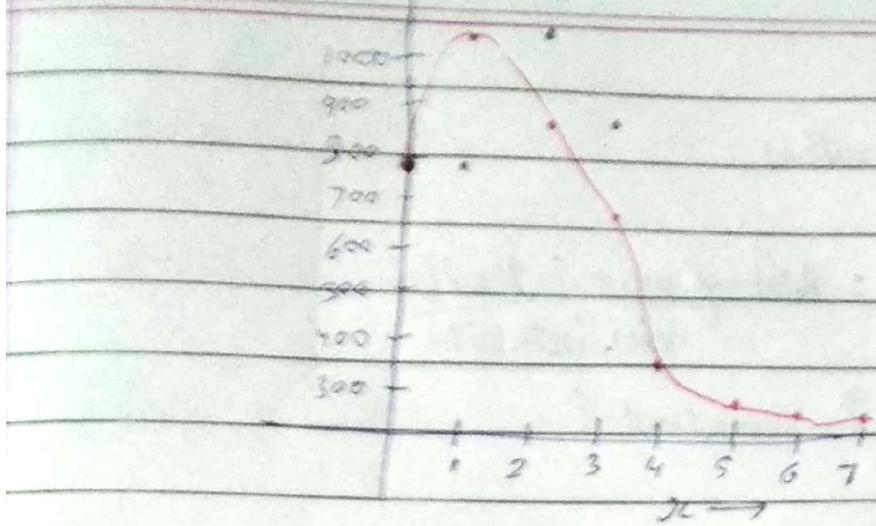
k	n_k	n_k/n	CDF
0	1	1/16	1/16
1	7	7/16	8/16
2	4	4/16	12/16
3	2	2/16	14/16
4	1	1/16	15/16
5	1	1/16	16/16

Probability

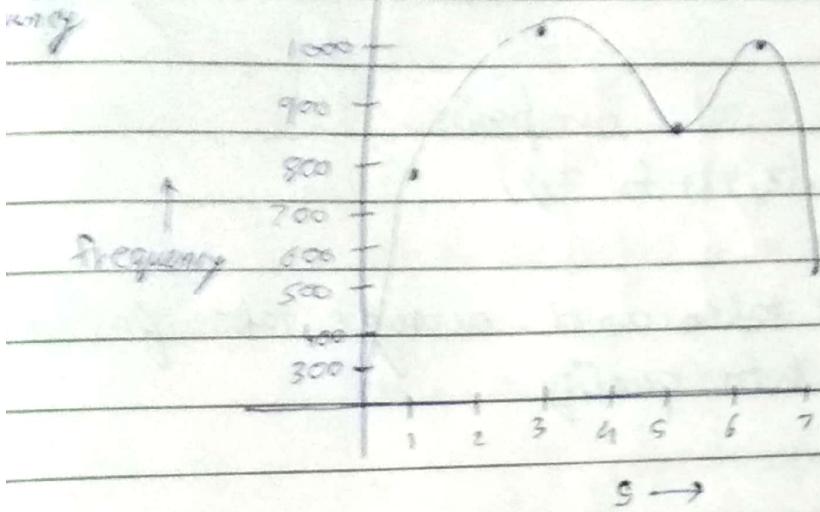
of having intensity
level k

more balanced.

k	n_k	n_k/n	CDF	S
0	790	790/4096	790/4096	1
1	1023	1023/4096	1813/4096	3
2	850	850/4096	2663/4096	5
3	656	656/4096	3319/4096	6
4	329	329/4096	3648/4096	6
5	245	245/4096	3893/4096	7
6	122	122/4096	4015/4096	7
7	81	81/4096	4096/4096	7



first
way

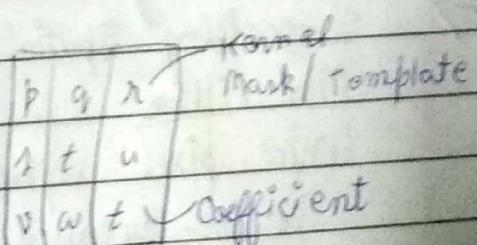


Long, low contrast, some bright, scene

5 Matlab commands

① Smoothing Filters

② Sharpening Filters



a	b	c	
d	e	f	
g	h	i	

→ Sum of Products

$$a * p + b * q + c * r$$

$$+ d * t + \dots - i * x$$

$$\frac{a * l + b * k + \dots}{d} = \text{Mean}$$

Automatic Contrast

Dynamic Range : Ratio of max intensity
min intensity

Dynamic Range \uparrow contrast \uparrow

Histogram Equalization and Contrast Stretching Difference.

Addition and to create composites

$$g(x,y) = f_1(x,y) + f_2(x,y)$$

Multiple image taken and average taken for enhancing
new image better quality

Subtraction

$$g(x,y) = |f_1(x,y) - f_2(x,y)|$$

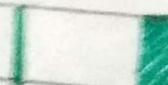
Absolute taken to avoid negative intensity.

Spatial Filtering

Smoothing Spatial Filter.

Max Filter

Smallest pixel replaced by largest pixel - darkest pixel
in the running mask window.



After replacement

Min Filter

Median Filter