Image Enhancement and color Image processing

1. Introduction

Improvement in the quality of any degraded images can be achieved by the application of enhancement technique. When no knowledge about the degradation process is available the quality of an image may be improved for specific application by some ad-hoc process called **image enhancement**. Here, image enhancement means improvement of the appearance of an image by increasing dominance of some features or decreasing ambiguity between different regions of the image.

Color image processing is one of the newest and most exciting areas of image processing. One of the initial studies of color was processed by Sir Isaac Newton in 1966 and concluded that same colors were needed to represent all the combination of all colors. Colors provide a significant portion of visual information to human beings and enhance their abilities of objects detection. A systematic way of representing and describing colors is a **color model**. Most of the color models used today is either hardware or application oriented. The first model we consider RGB Model. The Table-I shows the model name and their applications.

Table-I: Color Model and uses

Model	**Application**
RGB (Red, Green, Blue)	For color monitor and broad class of color video camera.
CMY (Cyan, Magenta, Yellow) CMYK (Cyan, Magenta, Yellow, and Black)	For color printing
HIS (Hue, Saturation, Intensity)	For corresponds with human perception and interpret color.

Another important model YIQ is used for TV broadcasting. Other two most popular user oriented models are HSV and HLS.

2 Point Processing

Point wise operations provide a mean of making an image lighter or darker, otherwise enhancing feature cannot be observed. A point operation takes a single input into a single output. The point processing is sometimes called by other names, including contrast enhancement, contrast stretching and gray-scale transformation.

(i) **Point Transformation:**

Point transformations modify the input images and produce the output image using the following equation.

$$S = T(r)$$

Where *T* is the transform operation with input pixel value *r* and *S* is the resultant output of the image.

(ii) **Linear Transformation:**

There are two types of linear transformation

(a) Identity Transformation- Image itself

(b) Negative Transformation- opposite to original

The negative image can be presented as

$$S = (L-1)-r$$

Where *L* is the total number of gray level

(iii) **Log Transform:**

A general equation of log transformation is given by

$$S = c \log(1+r)$$

Where c = constant

$r \geq 0$

(iv) **Power Law Transform:**

The basic equation of power Law transformation is

$$S = cr^{\delta}$$

When $\delta>1$, it is n^{th} power

$\delta<1$, it is n^{th} root pixel

3 Spatial Filtering

Spatial filtering of an image means removing noise from the image and sharpening blurred image.

3.1 Smoothing spatial filtering

The basic use of smoothing spatial filtering is for blurring and for noise reduction.

(i) **Mean Filter:**

In mean filtering, the value of every pixel in an image is replaced by the average or arithmetic mean of the gray levels of neighbourhood defined by the filter mark.

Common mask used for noise cleaning by moving the following average filtering as

$\frac{1}{4}$

1	1
1	1

(a)

$\frac{1}{9}$

1	1	1
1	1	1
1	1	1

(b)

$\frac{1}{16}$

1	2	1
2	4	2
1	2	1

(c)

The advantage of mean filtering is that the very small irrelevant areas of images are removed. The disadvantage is that we may loose the edges of an image.

(ii) **Median filter:**

One of the most popular order statistic filter is the median filter. It is very effective to remove impulsive noise. Let S_{xy} represent the set co-ordinates is a rectangular mask of size m*n centred at point (x, y). The given image is ***g(x, y)***. Then median is given by

$$R = Median\ \{g\ (s, t)\}$$
$$(s, t) \in S_{x\,y}$$

Thus now each pixel of ***g(x, y)*** is replaced by the median of its neighbourhood pixel under the mask.

(iii)**Maximum and Minimum Filtering:**

The maximum and minimum filtering are performed as per the following equation

$$R = max\ \{g\ (s, t)\}$$
$$(s, t) \in S_{x,y}$$
$$R = min\ \{g\ (s, t)\}$$
$$(s, t) \in S_{x,y}$$

The maximum filter is useful to find brightest point of an image and minimum filter is useful to find the darkest point of an images.

3.2 Sharpening Spatial Filtering

Sharpening is the process to highlight fine details of an image. The opposite of blurring is called sharpening. So, the difference between blurring and sharpening are given bellow.

Blurring = Average of neighbour pixel = Integration

Sharpening = Differentiating pixel value = Derivatives

Foundation:

The derivatives of an image are defined by the differences. The first order derivative of $f(x)$is

$$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$

And the second order derivatives of $f(x)$ can be defined by

$$\frac{\partial^2 f}{\partial y^2} = f(x+1) + f(x-1) - 2f(x)$$

We have used partial derivatives because of image function as two variables $f(x,y)$.

Second order derivative of Image Sharpening:

The Laplacian is defined for an image $f(x,y)$ of two variables as follows:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

In the x-direction,

$$\frac{\partial^2 f}{\partial x^2} = f(x+1,y) + f(x-1,y) - 2f(x,y)$$

In the y-direction,

$$\frac{\partial^2 f}{\partial x^2} = f(x,y+1) + f(x,y-1) - 2f(x,y)$$

After combing we get,

$$\nabla^2 f = f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,y-1) - 4f(x,y).$$

This equation can be represented as filter max as shown bellow

0	1	0
1	-4	1
0	1	0

The Laplacian is a derivative operation which can be used for highlighting intensity discontinuities of an image.

Different Laplacian mask can be used for image derivatives such as,

0	1	0
1	-4	1
0	1	0

(a)

1	1	1
1	-8	1
1	1	1

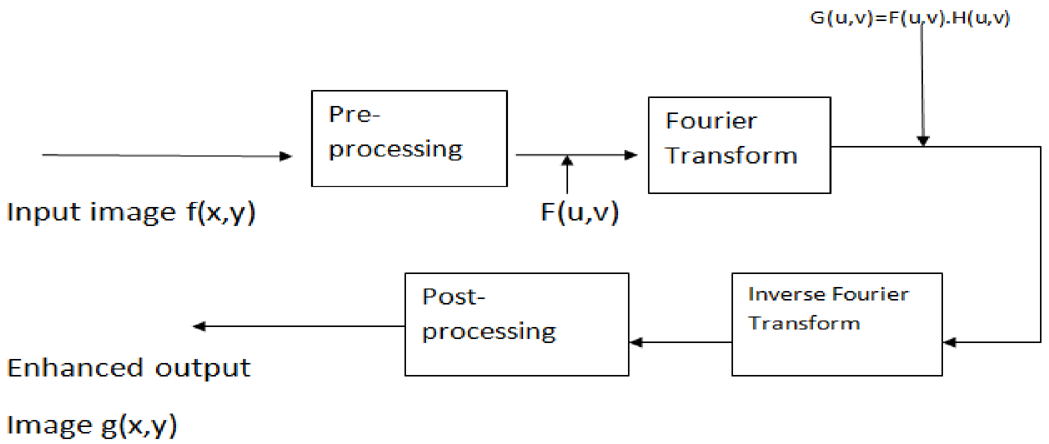
(b)

-1	-1	-1
-1	8	-1
-1	-1	-1

(c)

4 Frequency domain Filtering

The basic frequency domain filtering processes are done in following steps:



Frequency domain filtering is two types-
Smoothing frequency domain filtering and sharpening frequency domain filtering

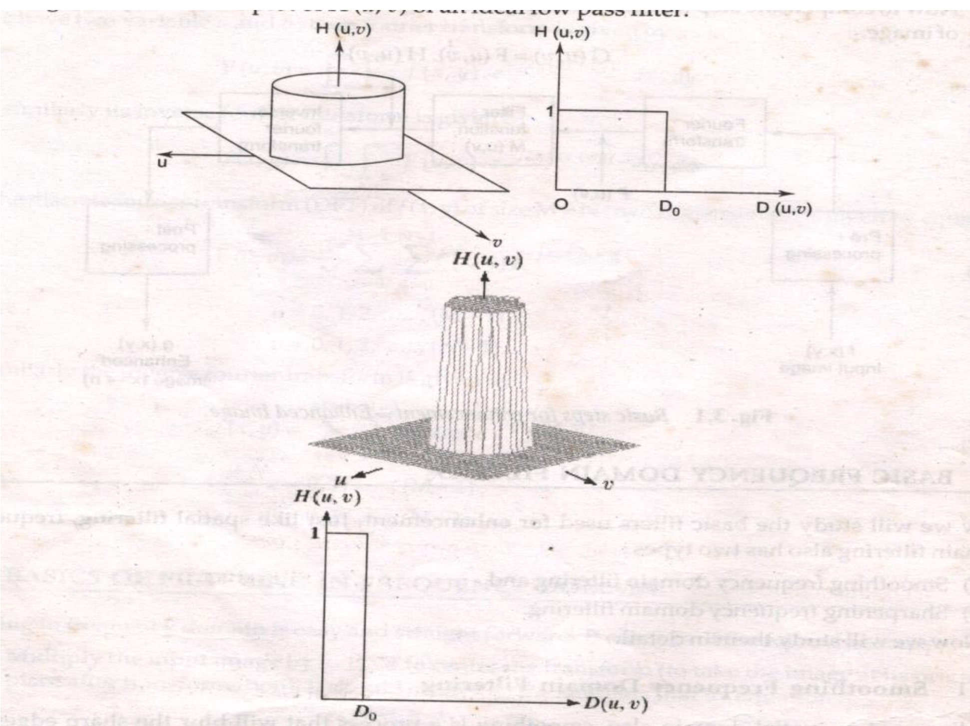
Smoothing frequency domain filtering

a) Low pass filter:

A 2-D ideal low-pass filter passes the frequencies below the cut-off frequency D_0 and attenuates the frequency component above the cut-off frequency.

$$H(u,v)=\begin{cases} 1 \text{ if } D(u,v) \le Do \\ 0 \text{ if } D(u,v) > Do \end{cases}$$

Where $D(u,v) = [u^2 + v^2]$ is the distance from point (u,v) to the origin of the frequency. Due to sharp cut-off, ideal low pass filter introduce ringing artefacts is the filtered image. To solve the problem, Butter worth filter has been used.



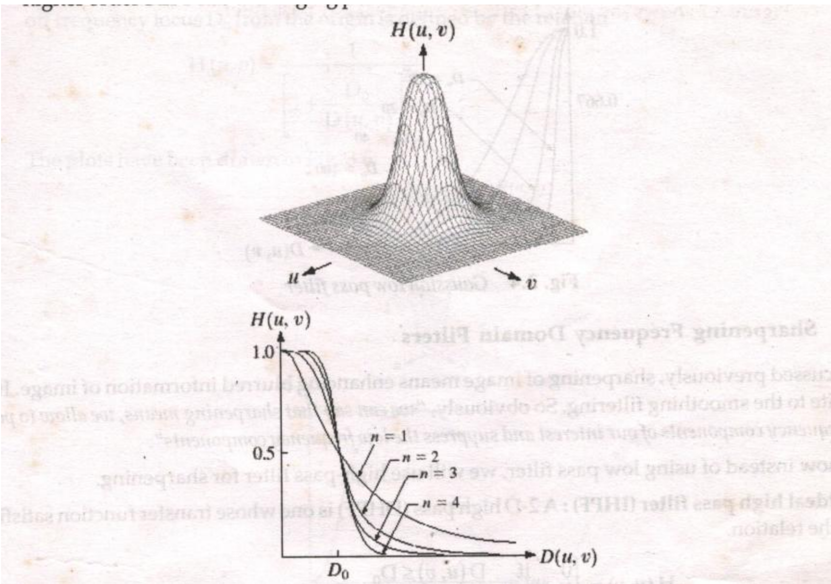
b) Butter worth low-pass filter:

The butter worth low-pass filter is given by

$$H(u,v) = \frac{1}{1+\left[\frac{D(u,v)}{D_0}\right]^{2n}}$$

Where n is the order of filter, D_0 is the cut-off frequency and $D(u,v) = [u^2 + v^2]$ is the distance from point (u, v) to the origin of the frequency.

The Butterworth offer the ability to control the rate at which the filter changes from passing frequency components to attenuating them.



c) Gaussian low-pass filter:

The Gaussian low-pass filter is given by

$$H(u,v) = e^{-D^2(u,v)/2\delta^2}$$

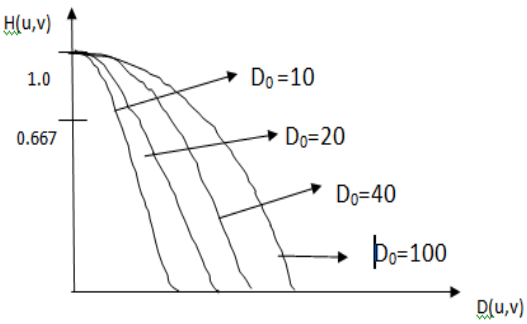
Where $D(u,v) = [u^2 + v^2]$

δ = Measure of Gaussian curve.

If $\delta = D_0$ then

$$H(u,v) = e^{-D^2(u,v)/2D_0^2}$$

The Gaussian low-pass filter not having ringing problem.



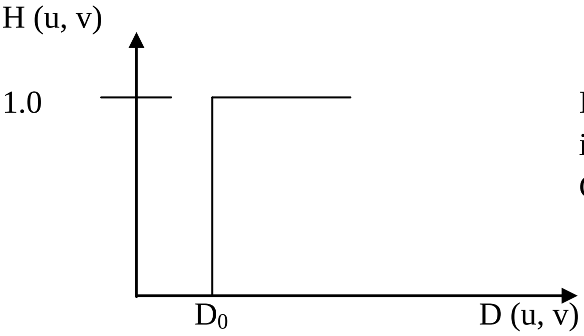
Sharpening Frequency Domain Filters

a) High pass-filter:

The ideal high pass filter is given by

$$H(u,v)=\begin{cases} 0 \text{ if } D(u,v) \le Do \\ 1 \text{ if } D(u,v) > Do \end{cases}$$

Where $D(u,v) = [u^2 + v^2]$ is the distance from point(u,v) to the origin of the frequency.



It attenuating all the frequency component inside D_0 and allows all the frequency Component passed outside D_0

b) Butterworth high-pass filter:

The function is given bellow

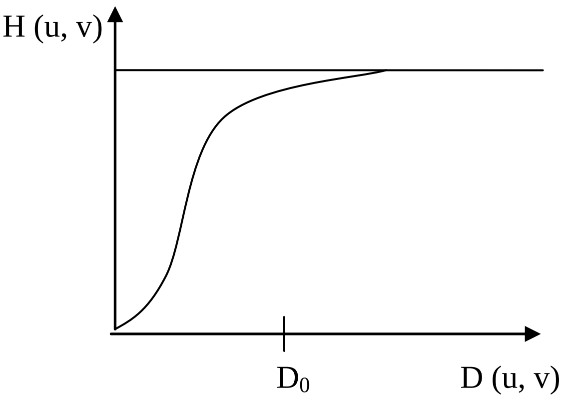
$$H(u,v)=\frac{1}{1+\left[\frac{Do}{D(u,v)}\right]^{2n}}$$

Where n is the order of filter

D_0 is the cut-off frequency

$D(u, v)=[u^2+v^2]$

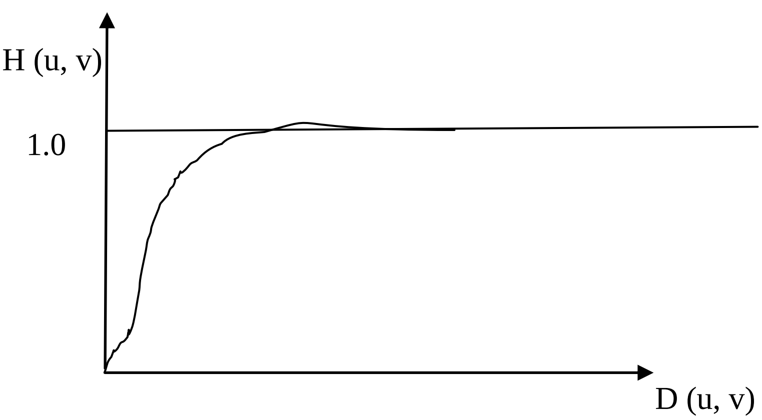
For n=∝ it becomes ideal high pass filter.



c) Gaussian High pass filtering:

The Gaussian high pass filtering is given by

$$H(u,v)=e^{-D^2(u,v)/2D0^2}$$



4. Multi-spectral image

A pixel value at any image can be represented as single-value between 0-255 in a 8-bit system is called gray scale image. When more than one measurement required at a point of any image is called Multi- Spectral or Multi-model image , such as color images, CT-Scan, X-ray, MRI etc. When different sensor are employed to extract multiple characteristic of an image at any point then the image is called Mufti-model image.

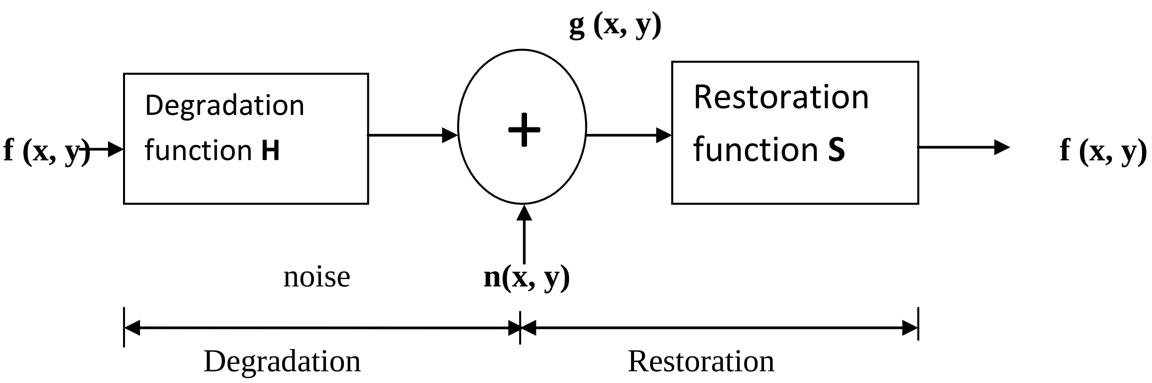
Image Restoration

The image restoration means the removal or reduces degradations and process the image in such a way that it look better than being obtain. So, the basic difference between image restoration and enhancement can be listed below.

I. Image enhancement is subjective but restoration is objective analysis.

II. Image restoration involves modelling of degradation in image and applies some mechanism to get image back. On the other hand, Image enhancement involves the process to manipulate the image in order to take the psychophysical advantage of human being.

Image degradation Model:



The input image f(x, y) is degraded by degradation function H(x, y) by in cooperating noise n(x, y) during channel transmission, thus we have

$$g(x,y) = h(x,y) * f(x,y) + n(x,y)$$

For frequency domain

$$G(u,v) = H(u,v)F(u,v) + N(u,v)$$

Thus if we have some knowledge about H(u, v) and noise n(x, y) or N(u, v) then we get an image f(x, y) that is very close to real image f(x, y).

Noise model:

Different Noise Model and their probability density function given below-

a) **Gaussian Noise:**
PDF of Gaussian function is given by

$$P(z) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(z-\mu)^2/2\sigma^2}$$

Where z = gray levels
μ= mean value of z
σ=standard deviation
σ^2=variance of z

Gaussian noise can be generated due to (i) Electronic circuit noise (ii) Server noise due to poor illumination (iii) Server noise due to high temperature.

b) **Rayleigh Noise:**
PDF of Rayleigh Noise is given by

$$P(z) = \{ {}^{\frac{2}{b}(z-a)e^{-(z-a)^2/b}}_{0} \qquad \text{For } z \geq a \quad \text{For } z < a$$

Here the value of mean

$$\mu = a + \sqrt{\frac{\pi b}{4}}$$

Variance, $\delta^2 = \frac{b(4-\pi)}{a}$

Rayleigh noise is generated due to Range imaging.

c) **Exponential Noise:**
The PDF is given by

$$P(z) = \{ {}^{ae^{-az}}_{0} \quad {}^{for\ z \geq 0}_{for\ z < o}$$

Mean $\mu = \frac{1}{a}$, variance $\sigma^2 = \frac{1}{a^2}$

d) **Uniform Noise:-** The PDF of uniform noise is given by

$$\boldsymbol{P(z) = \{ \quad \frac{1}{b-a} \quad if\ z \leq z \leq b \quad 0\ otherwise}$$

Mean $= \frac{a+b}{2}$, Variance $\sigma^2 = \frac{(b-a)^2}{12}$

e) **Impulse Noise(Salt & pepper):**
The PDF of impulse noise is given by

$$P(z) = \begin{cases} P_a for\ z = a \\ P_b forz = b \\ 0 \quad otherwise \end{cases}$$

- **Restoration is the presence of Noise only-**

We apply spatial filtering to remove additive noise.
Different types of filters are-

1. Mean filters:
   (i) Arithmetic mean filter
   (ii) Geometric mean filter
   (iii) Harmonic mean filter
   (iv) Contra harmonic mean filter
2. Order-Statistic Filter:
   (i) Median Filter
   (ii) Max and Min filter
   (iii) Mid-Point filter
   (iv) Alpha-trimmed mean filter
3. Adaptive Filter:
   (i) Adaptive local noise reduction filter
   (ii) Adaptive filter

5. Color representation

Three basic quantities are used to describe the quality of a chromatic light source

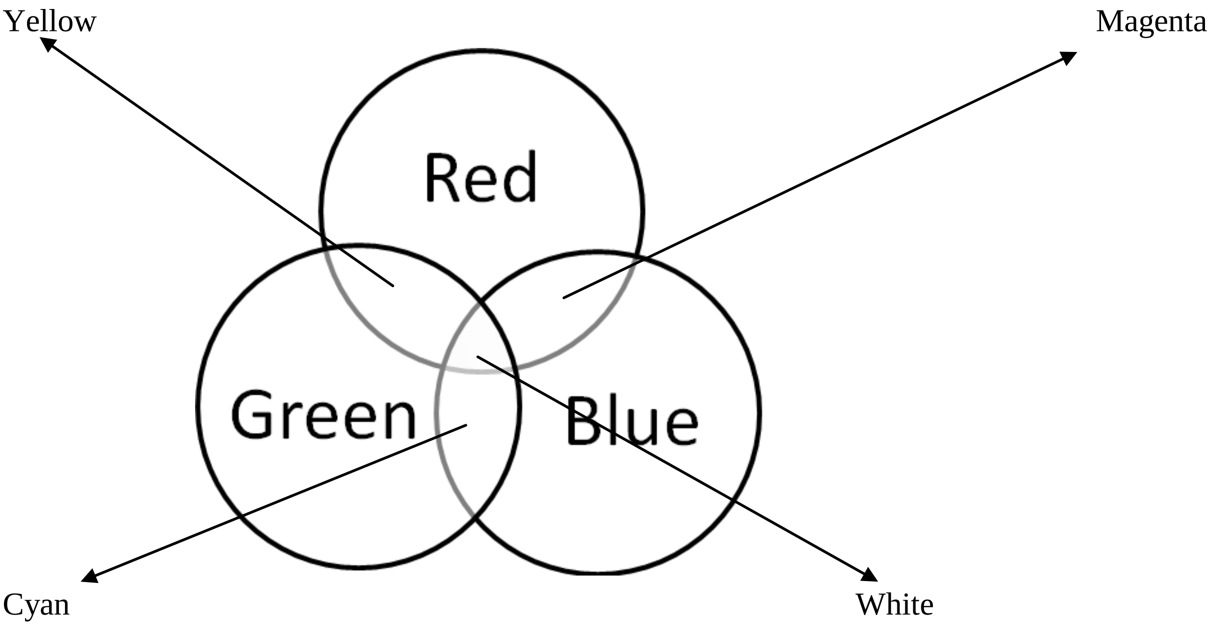
- **Radiance:** Radiance is the total amount of energy that flows from light source. It is measure in watts.
- **Luminance:** Luminance gives the measure of energy that an observer perceives from the source. It is measured in Lumens.
- **Brightness:** It is subjective description that is practically impossible to measure.

Experimentally it has been observed that 6-7 million Cones is human eyes can be divided into three basic reusing categories, corresponding roughly to red, green and blue. 65% Cones are sensitive for red, 33% Cones are sensitive to green and 2% Cones are sensitive for blue.

Laws of color matching

Due to this sensitivity of human eyes with respect to colors. Red, green and blue are considered as primary color.
Primary color can be added to get secondary color

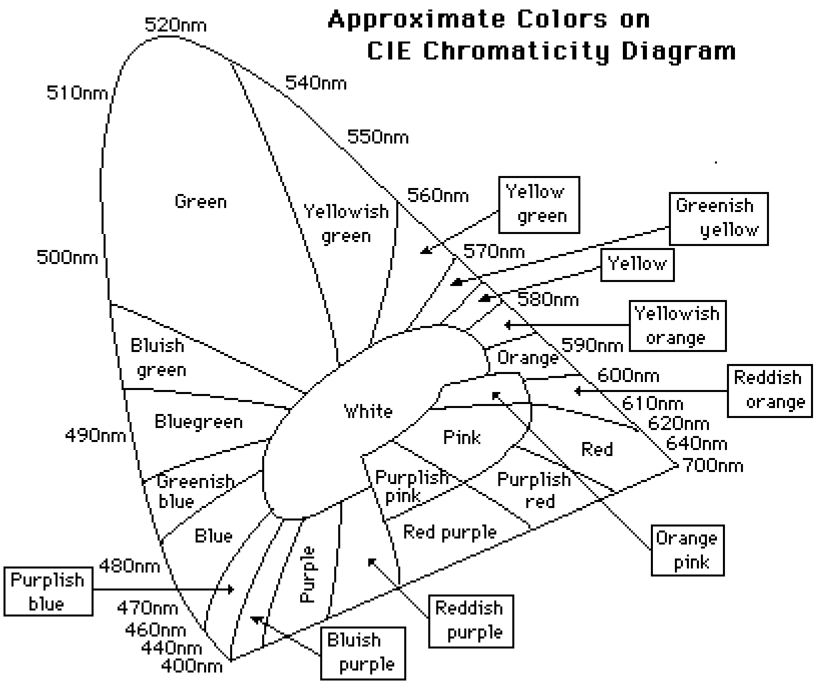
Magenta= Red + Blue
Cyan= Green + Blue
Yellow= Red + Green



Primary and secondary color

Chromaticity diagram

Another approach to specify color through Chromaticity diagram. Which shows color composition as a function of red and green indicated as x, and y respectively. Then blue (z) is obtained by the equation. Z=1-(x + y)



The chromaticity diagram is useful for color mixing because any two joining point defines all the different color variations that can be obtained by combining these two color additively.

To determine the range of color that can be obtained from any three given colors in the chromaticity diagram, we simply draw connecting lines to each of the three color point. The result is a triangle and any color on the boundary or inside the triangle can be produced by various combinations of three initial colors. The irregular region with in the range of color(called color gamut) inside the triangle is representative of today's high-quality color printing devices. The boundary of the color printing gamut is irregular because color printing is a combination of additive and subtractive color mixing, a process that is much more difficult to control than of displaying colors of a monitor, which is based on the addition of three highly controllable light primaries.

Color enhancement

Color image smoothing for color image enhancement, at least three components of colors are needed and treated as vectors. Color images smoothing can be done by performing Spatial filtering operation in which the co-efficient of filtering mask are all 1's . as the mask is slides across the images, each pixel is replaced by the average of the pixels is the neighbours. Thus image is smoothed. This concept can be extended to the full color image on each color components of color image separately.

Let 5_{xy} denotes the set of co-ordinates defying a neighbourhood centred at(x,y) is an RGB color image.

The average of the RGB component vectors is that neighbourhood is

$$\bar{c}(x,y) = \frac{1}{k}\sum_{(x,y)\in s_{xy}} c(x,y)$$

This can be applied for color image to form vector as below

$$\bar{c}(x,y) = \begin{matrix} \frac{1}{k}\sum_{(x,y)\in S_{xy}} R(x,y) \\ \frac{1}{k}\sum_{(x,y)\in s_{xy}} G(x,y) \\ \frac{1}{k}\sum_{(x,y)\in S_{xy}} B(x,y) \end{matrix}$$

Color image Sharpening:

The color image sharpening can be done by Laplacian. The Laplacian of vector is defined as vector whose components are equal to Laplacian of individual scalar components of input vectors.

In the RGB system,

$$\nabla^2[c(x,y)] = \begin{bmatrix} \nabla^2 R(x,y) \\ \nabla^2 G(x,y) \\ \nabla^2 B(x,y) \end{bmatrix}$$

So, to compute Laplacian of a full color image, it is necessary to compute the Laplacian of each component of image individually.

Color image Segmentation

Segmentation means sub divide an image in the part which have some properties or qualities within a segment. One segment will not have any property that any other segment has. Segmentation of an image can be done by two methods-

i. By finding similarities between pixels and arranging them in a single segment.
ii. By finding differences between pixels and arranging them in different segments according to these differences.

One of the simplest ways to find the similarities between is Euclidean distance.

Average color and ability point is color space

Let z' denote an arbitrary point in RGB space and a' be the average RGB color vector.
Then the Euclidean distance between z' and a' is given by

$$D(z,a) = ||z - a||$$

$$= [(z_R - a_R)^2 + (z_G - a_G)^2 + (z_B - a_B)^2]^{1/2}$$

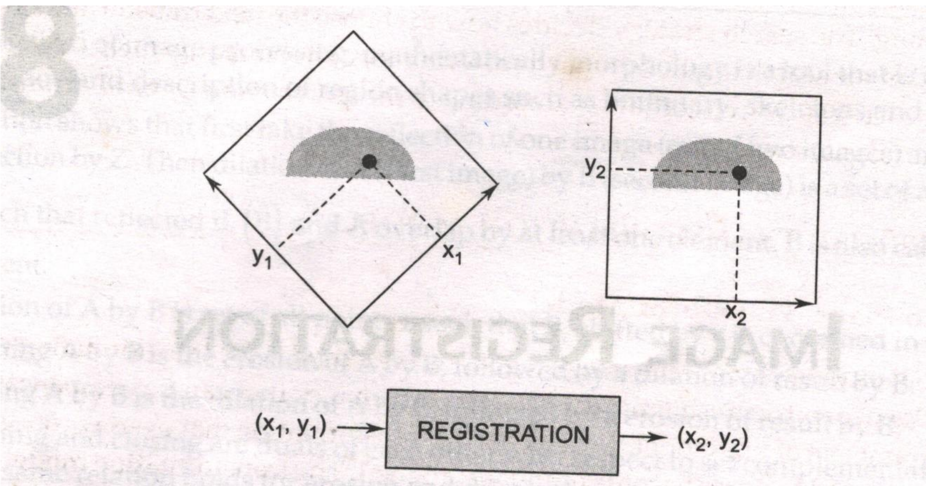
We say that z is similar to a if the distance between them is less than a specified thus hold D_0.

Image Registration

The process of aligning the images and compensating for the differences caused by different acquisition conditions is called image registration.

To perform image registration, we need some additional information from various image sources. Then we have to combine to get an image as per requirement. This is used to remote sensing, computer vision and medical imaging research areas.

Image registration is the determination of one-to-one mapping between the co-ordinates in an image space and those in another, such that point is two image spaces that correspond to the same scene point are mapped to each other.



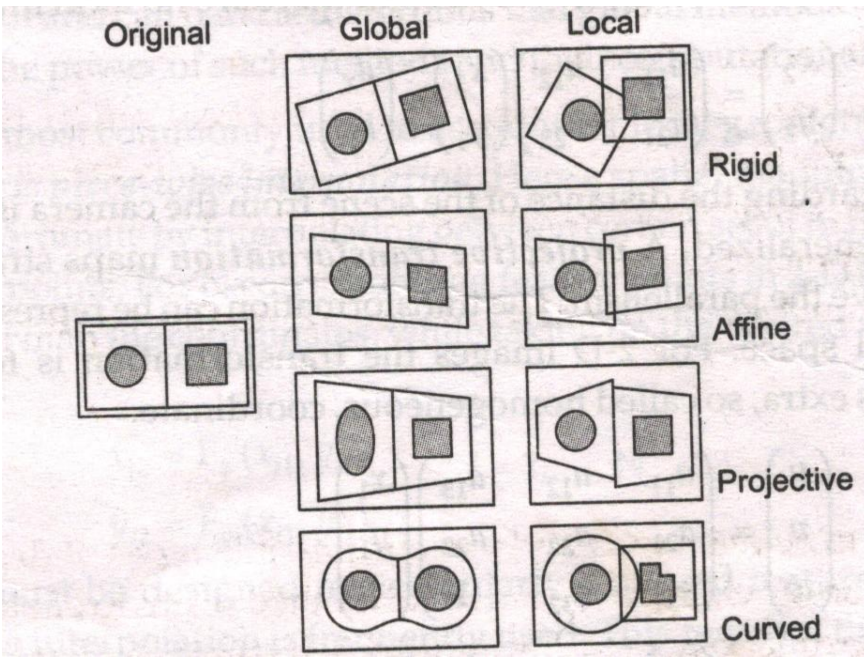
In figure above two images of the same object are presented sensed image (Image -1) and reference image (Image -2) with spatial co-ordinates(x_1, y_1) and (x_2, y_2) respectively. The images are differ by orientation and missing part. It may be taken from different view point, differ in size, taken at different time or different properties.
Now the goal of image registration is to define the mapping from co-ordinates (x_1, y_1) is the sensed image to the co-ordinate (x_2, y_2) is the reference image is such a way that they correspond to the same physical points in the scene.
There are numerous image registration approaches with four distinctive components:

i. Feature components
ii. Search space
iii. Similarity space
iv. Search strategy

Feature space represents the information that will use for image matching. Search space is the clan of transformation that are capable of aligning the image for matching. The search strategy decides how to choose the next transformation from this space, to be tested is the search for the optimal transformation. The similarity metric determines the relative merit for each test. Search continues according to the search strategy until a transformation is found whose similarity measure is satisfactory.

Transformation Model

An important constituting part of image registration method is the transformation model. The model defines the misalignment between the images that can be compensated for. By adjusting the parameters we look for transformation that overlays one image over other and the selected features become optimally aligned.
There exist several transformation models differencing based on the complexity, degree of freedom and the scope of this influence.
The figure below represents different examples of 2-D transformation.



Global transformation model applied to the whole image where local transformations vary across the image.

- **Global mapping models:**

The transformation is called global when it applies to entire image.
The transformation can be rigid, affine, projective or curved.

Rigid transformation preserves the distance of any two points in the first image, when they are mapped onto the second images.
The equation below presents rigid transform of mapping 2D-Point(x_1, y_1) from sensed image into point(x_2, y_2) in the reference image

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = S.\begin{pmatrix} \cos\varphi \mp \sin\varphi \\ \sin\varphi \pm \cos\varphi \end{pmatrix}\begin{pmatrix} x_1 \\ y_1 \end{pmatrix} + \begin{pmatrix} a_x \\ a_y \end{pmatrix}$$

Here φ denote the rotation angle, and (a_x, a_y) the translation vector. S is the scaling factor considered as unity in this case.

The affine transformation maps straight lines onto straight lines and preserves parallelism. It can be used to register images taken from different viewpoints as mentioned in the following equation.

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}\begin{pmatrix} x_1 \\ y_1 \end{pmatrix} + \begin{pmatrix} a_x \\ a_y \end{pmatrix}$$

A projective transformation maps straight lines into straight lines but does not preserve the parallelism. For 2-D images the transformation is formulated in the following equation considering homogeneous co-ordinate (w).

$$\begin{pmatrix} u \\ v \\ w \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{13} \\ a_{31} & a_{32} & a_1 \end{pmatrix}\begin{pmatrix} x_1 \\ y_1 \\ 1 \end{pmatrix}$$

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} \frac{u}{w} \\ \frac{v}{w} \end{pmatrix}$$

The most general form of transformation is called curved transform which may map straight line onto curved line. These transformations are known as transformation of polynomial. For 2-D images, a polynomial transformation is presented following equation a,b are parameters of the transformations that need to be determined.

$$x_2 = a_{00} + a_{10}x_1 + a_{01}y_1 + a_{20}x^2{}_1 + a_{11}xy + a_{02}y^2{}_1 + \cdots$$

$$y_2 = b_{00} + b_{10}x_1 + b_{01}y_1 + b_{20}x^2{}_1 + b_{11}xy + b_{02}y^2{}_1 + \cdots$$

The order of polynomial transformation depends on the trade-off between accuracy and cost of optimization. In practice, polynomials of third degree are used.

The limitations of global mapping are that it cannot consider the local geometric deformation between the images.

- **Local Mapping Model-**

The local mapping transformation varies across different regions of the image for accurating distortion which differ across the image.

Most commonly used local mapping is piece-wise interpolation.
For N-corresponding feature points in 2-D image following two functions are constructed to map the co-ordinates,

$$X_{i2} = F_x(x_{i1}, y_{i1}) \qquad i = 1, \dots, N.$$
$$Y_{i2} = F_y(x_{i1}, y_{i1})$$

A general spline approach to piece-wise interpolation can be used by the following equation

$$S(x,y) = \sum_i V_i B_i(x_1, y_1)$$

Where B_i- Basic function

V_i- feature point

Scan is representing either of the two co-ordinates, x_2 or y_2.

Stereo imaging

Stereo imaging is produced by our own eyes which generate two intensity maps of the scene is our retrial plane. Now, these two images are registered and then we generated a single intensity images. To convert two images into single image is call fusion of images.

There are two objectives of stereo imaging:

A. Find the correspondence between the pair of stereo images. This correspondence can be achieved with the help of geometrical transformation and mapping.
B. After the correspondence between both stereo images, just try to find a single image.

It is possible for us to recover the depth information of an object of an object, which otherwise is lost in the case of single image.

Finding correspondence between pairs of stereo images- Two most important aspect of image function can be used.

a) **Brighten pattern of image function:** This is gray level similarity based measurement between the pair of stereo images.
b) **Feature sets extracted from the images:** Such features could be different geometrical patterns embedded in images.

Now, we present feature matching based approach. Let the transformation between left eye image to the right eye is given by

$$M_R = RM_L + T$$

M_R and M_L are the corresponding point in the right eye and left eye images respectively. R is the rotation matrix and T is translation vector. R and L are known through eye calibration.
The steps for matching the linaer structure with the corresponding segment of the right eye image as follows:

I. First of all divide an entire images space into smaller sub-image region so that the search space for any projected feature is reduced.

II. Let f_p be the projected feature on the image R, as in our example it is a linear structure projected from left eye L. the neighbours of projected lines and their distanced are tabulated. The distance could be Euclidean distance. For a pair of feature sets S_1 and S_2 the Mahalanobis distance may plays good role in case of our eyes which is given by

$$D(S_1,S_2) = (S_1 - S_2)^1(A_1 + A_2)^{-1}(S_1 - S_2)$$

Where A_1 and A_2 are the covariance matrixces for feature sets S_1 and S_2 respectively.

III. Now for each pair of match, we calculate confidence factor. The confidence factor is given by

$$C = \frac{D(S_1,S_3) - D(S_1,S_2)}{D(S_2,S_3)}$$

The smallest magnitude of confidence factor implies that there is an ambiguity is matching and the correspondences between the candidates are rejected even if the nearest neighbours are close to the projected candidate.
Then we find the establishment of correspondence.

Computation of disparity map

Let us assume that the correspondence is established between the stereo image pair. Let the disparity between two cameras are 2d. Disparity is the distance of separation between the left and right camera. Here two images of the point $P(x, y, z)$ are formed at $(x + d)$ and $(x - d)$ location along x-axis.
If f is the focal length of pin-hole camera system and x_l and x_r are the left and right camera images respectively.

$$x_l = \frac{(x-d)f}{f-z}$$ And

$$x_r = \frac{(x+d)f}{f-z}$$

Equivalently,

$$z = f - \frac{2df}{x_r - x_l}$$

Thus, the depth of object could be recovered once the correspondence between both the images has been established.

Summary

The objective of the image enhancement is to process an image so that result is more suitable for human being. Image enhancement is categorized in two categories. Spatial and frequency domain, spatial domain enhancement is a subjective analysis. Basic purpose of spatial filtering is smoothing and sharpening of an image. Smoothing is processes that removes the noise and blur the image.

Sharpening is process that removes blurring of an image and sharps the edges of an image. In frequency domain filtering, low-pass filter used for smoothing and high pass filter is used for sharpening the image, multispectral is the color image which can be represent through different color model. Such as RGB, CMY, HIS etc. basic purpose of image restoration is to improve the quality of image by removal noise through filtering. The process of aligning the image and compensating for the differences caused by different acquisition condition is called image registration. Stereo imaging means a same image has been acquired by two cameras at different positions.

Glossary

RGB: Red, Green and Blue

CMY: Cyan, Magenta and Yellow

HSI: Hue, Saturation and Intensity

HSL: Hue, Saturation, Lightness

HSV: Hue, Saturation, Value

Self-Assignment questions

A. What are the basic gray level transformations?

B. Write short note on smoothing and sharpening spatial filtering?

C. What do you mean by blurring? How can it be removed?

D. Draw images degradation model?

E. What are different noise model?

F. Describe RGB color model? Describe HIS color model?

G. Describe color image segmentation.

H. What do you understand by image registration?

I. What do you understand by local mapping and global mapping

J. What is stereo image?