Computer Graphics 05101301

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CHAPTER-5

Image Operations and Image Representations

Image File Formats

- A camera raw image file contains minimally processed data from the image sensor of a digital camera.
- Raw files are named so because they are not yet processed and therefore are not ready to be printed or edited.
- Normally, the image is processed by a raw converter where precise adjustments can be made before conversion to a file format such as a TIFF or JPEG for storage, printing, or further manipulation.
- There are hundreds, of raw formats in use by different models of digital equipment.

Image source :
seekimages

BITMAP / Raster Graphics

- Raster graphics, also called bitmap graphics, are digital images that are composed of tiny rectangular pixels.
- They are arranged in a grid or raster of x and y coordinates in such a way that it forms an image. It is also referred to as bitmap since it has information that is mapped directly to the display's grid.
- The file size of a raster image depends also on the size of the image, which is determined by the number of pixels being used in the image.
- This means that an image with a 1280x720 resolution will contain 921,600 pixels while a full HD 1920x1080 image will have 2,073,600 pixels.
- Some examples of Raster Graphic File Formats are as follows:

JPEG (JOINT PHOTOGRAPHIC EXPERTS GROUP)

- A JPEG is an image file format used for compressing image files. The degree of compression can be adjusted, allowing a selectable trade off between storage size and image quality.

Advantages

- Retains up to 16,000,000 colours.
- Suitable for images, high details & quality pictures.
- It is the most used graphic file format.
- Approved as standard in 1994.

Disadvantages

- It does not support transparency.
- File size larger than GIF because of colour information.

GIF (GRAPHICS INTERCHANGE FORMAT)

A GIF is a lossless file format for image files that supports both animated and static images.

Advantages

- 256 number of colours.
- Uses lossless compression.
- Support for transparency.
- Small file format.

Disadvantages

- The oldest format for web – 1989.
- In most cases it has a bigger file size than PNG.
- Loss of colour variation.

PNG (PORTABLE NETWORK GRAPHICS)

Portable Network Graphics (PNG) is a raster graphics file format that supports lossless data compression. PNG was created as an improved replacement for GIF files and is the most widely used lossless image compression format on the internet.

Advantages

- 256 number of colours.
- Uses lossless compression.
- Suitable for flat areas of colours, logos, transparent or semi transparent images
- In most cases has a smaller file size than GIF

Disadvantages

- Relatively large file format.
- In different situations it has bigger file sizes than JPG.

TIFF (TAGGED IMAGE FILE FORMAT)

Tagged Image File Format (TIFF) is a computer file format for storing raster images, popular among the publishing industry and photographers. The TIFF format is widely supported by image manipulation applications and publishing and page layout applications.

Advantages

- No image data is lost.
- Better image quality than even the JPEG fine quality.
- Good for images that will be heavily manipulated in a photo editing program.

Disadvantages

- File size is very large.
- Still need to make sure that exposure, white balance and colour saturation are properly set because fixing these in the photo editing program will degrade the image to a certain degree

MPEG (Moving Picture Experts Group)

- It stands for Moving Picture Experts Group, and pronounced as m-peg, is a working group of the ISO.
- It refers to the family of digital video compression standards and file formats developed by the group.
- MPEG generally produces better-quality video than competing formats, such as Video for Windows and QuickTime.
- MPEG files previously on PCs needed hardware decoders (codecs) for MPEG processing. Today, however, PCs can use software-only codecs including products from RealNetworks, QuickTime or Windows Media Player.

MPEG (Moving Picture Experts Group)

- MPEG algorithms compress data to form small bits that can be easily transmitted and then decompressed.
- MPEG achieves its high compression rate by storing only the changes from one frame to another, instead of each entire frame.
- The video information is then encoded using a technique called Discrete Cosine Transform (DCT).
- MPEG uses a type of lossy compression, since some data is removed. But the diminishment of data is generally imperceptible to the human eye.

Definition

MPEG standards include the following;

- **MPEG-1**: It provides a video resolution of 352 X 240 at 30 frames per second (fps). This produces video quality slightly below the quality of conventional VCR videos. It was designed specifically for Video-CD and CD-i media.

- **MPEG-2**: Offers resolutions of 720x480 and 1280x720 at 60 fps, with full CD-quality audio. This is sufficient for all the major TV standards, including NTSC, and even HDTV. MPEG-2 is used by DVD-ROMs. MPEG-2 can compress a 2 hour video into a few gigabytes

Definition

- **MPEG-4:** It is based on MPEG-1 and MPEG-2 and Apple QuickTime technology. They are designed to transmit video and images over a narrower bandwidth and can mix video with text, graphics and 2-D and 3-D animation layers.

- **MPEG-21** provides a larger, architectural framework for the creation and delivery of multimedia.

Image Processing

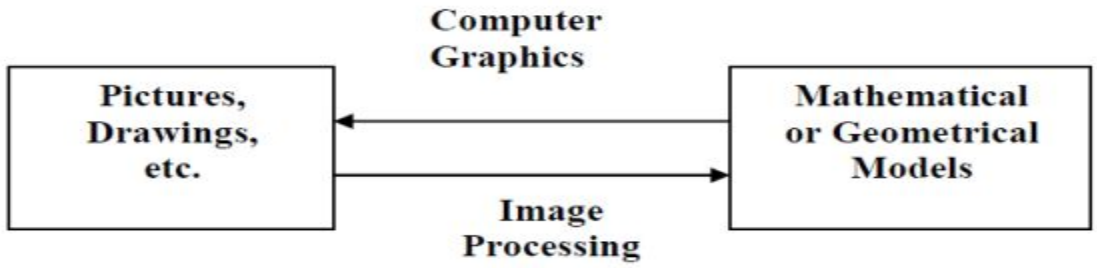
Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it.

- Includes treating images as two dimensional signals while applying already set signal processing methods to them.
- Image processing basically includes the following three steps.
  - Importing the image with optical scanner or by digital photography.
  - Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.
  - Output is the last stage in which result can be altered image or report that is based on image analysis.

Purpose of Image Processing

The purpose of image processing is divided into 5 groups. They are:

1. Visualization - Observe the objects that are not visible.
2. Image sharpening and restoration - To create a better image.
3. Image retrieval - Seek for the image of interest.
4. Measurement of pattern – Measures various objects in an image.
5. Image Recognition – Distinguish the objects in an image.



Types of Image Processing

The two types of methods used for Image Processing are

1) Analog Image Processing.

2) Digital Image Processing.

1)Analog image processing

- can be used for the hard copies like printouts and photographs.
- Analog image processing is done on analog signals.
- It includes processing on two dimensional analog signals.
- Here the images are manipulated by electrical means by varying the electrical signal. The common example include is the television image.

Digital Image Processing

2) Digital Image Processing

- It helps in manipulation of the digital images by using computers.
- The digital image processing deals with developing a digital system that performs operations on an digital image.
- As raw data from imaging sensors from satellite platform contains deficiencies. To get originality of information, it has to undergo various phases of processing.
- The three general phases that all types of data have to undergo while using digital technique are

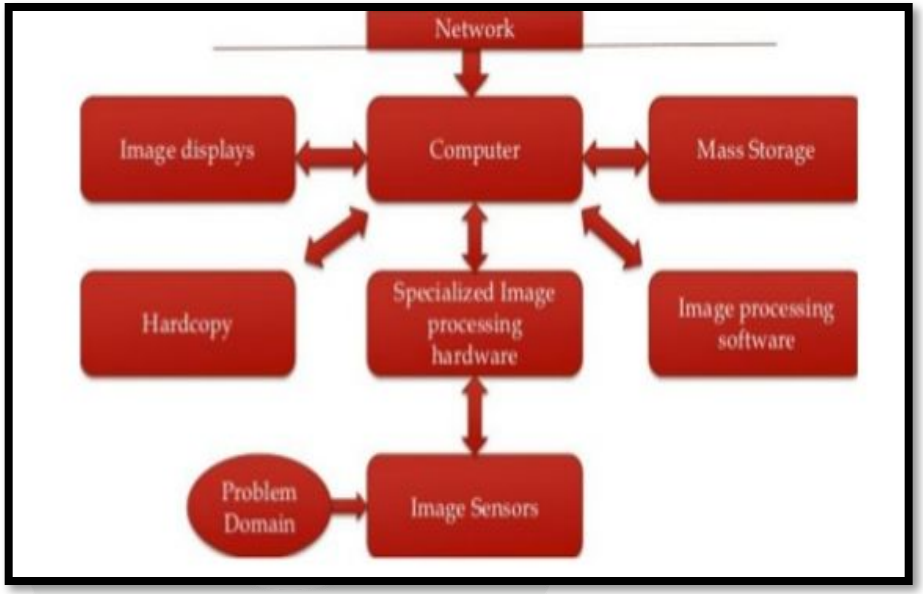
1) Pre-processing,

2) Enhancement and display,

3) Information extraction.

Components of an image processing system:

1. In sensing, two elements are required# to acquire digital images. The first is physical device that is sensitive to the energy radiated by the object we wish to image. The second called **a digitizer, is a device for converting the output of the physical sensing device into digital form.**



2. Specialized image processing hardware usually consists of the digitizer plus hardware that performs other primitive operations such as arithmetic and logical operations (ALU).

Components of an image processing system:

Eg. Noise reduction. This type of hardware sometimes is called **a front end subsystem**.

3. Software which include image processing specialized modules that perform a specific tasks.
4. Mass storage capability is a must in image processing applications.
5. Image displays in use today are mainly color TV monitors.
6. Hardcopy devices for recording images include laser printers, film cameras, inkjet units and CDROM.
7. Networking for communication.

Digitization

To create an image into an Digital form, we need to convert an continuous data into a digital form. There are two steps in which it is done

)Sampling

)Quantization

Digitization is the process of representing various types of information in a form that can be stored and processed by a digital device. It is the combined operations of sampling and quantization, also called analog-to-digital (A/D) conversion.

Sample

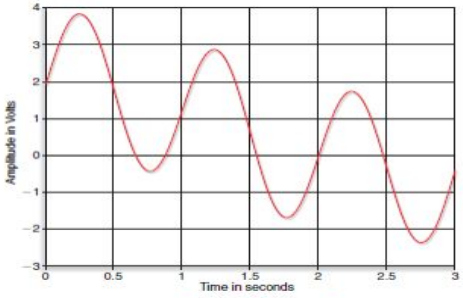
A sample is a numerical value representing the height of a waveform at a particular time, or the brightness of an image at a particular point.

Digital signal

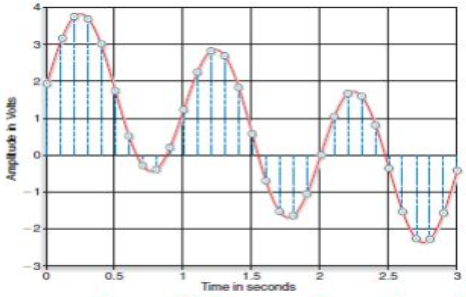
A digital signal is a set of sampled values represented in binary form as bits (binary digits) that can be turned back into the original form

Sampling

- The term sampling refers to take samples. Sampling is the process of recording values (samples) of a signal at distinct points in time or space.
- Eg. Waveforms are sampled in time, Images are sampled in space. Time-varying scenes (video) are sampled in both time and space.
- Sampling of a waveform refers to the process of recording values at distinct time points along a signal. Usually, samples of a signal are observed at uniformly-spaced time instants, e.g., every 0.1 sec, as shown below. The heights of the dots above or below the time axis (horizontal axis) represent the samples.



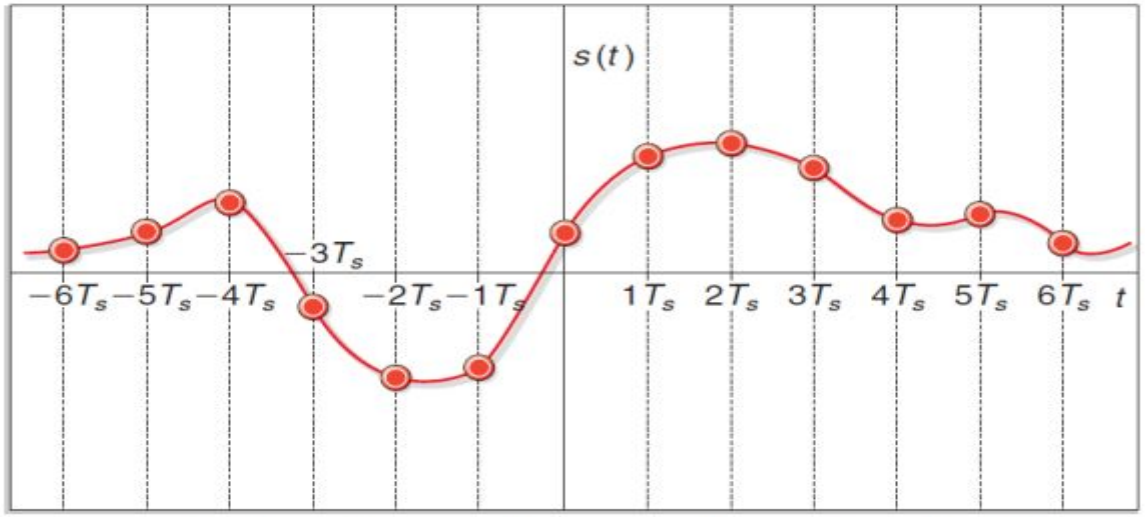
analog signal



samples of the analog signal

Sampling

An analog signal that varies quickly must be sampled more frequently than an analog signal that varies slowly. The sampling period Ts is the spacing between two adjacent samples, i.e., seconds per sample. The sampling rate or frequency fs is the number of samples per second (Hz).



sampled values of an analog signal s(t)

Digitizing a Signal

- Digitizing an analog signal into a digital, requires two basic steps.

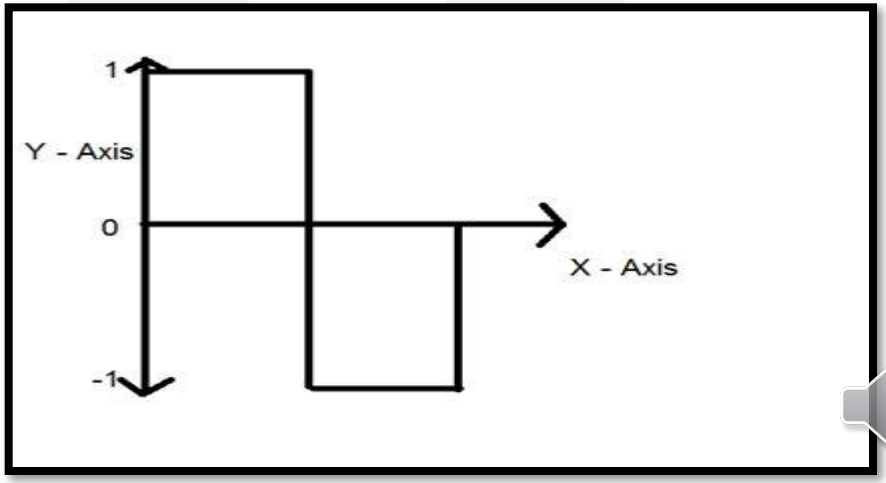
  Sampling and quantization.

- Sampling is done on x axis. It is the conversion of x axis (infinite values) to digital values.

- If you take sampling on the x axis, the signal is not converted to digital format, unless you take sampling of the y-axis too which is known as quantization. The more samples eventually mean you are collecting more data, and in case of image, it means more pixels.

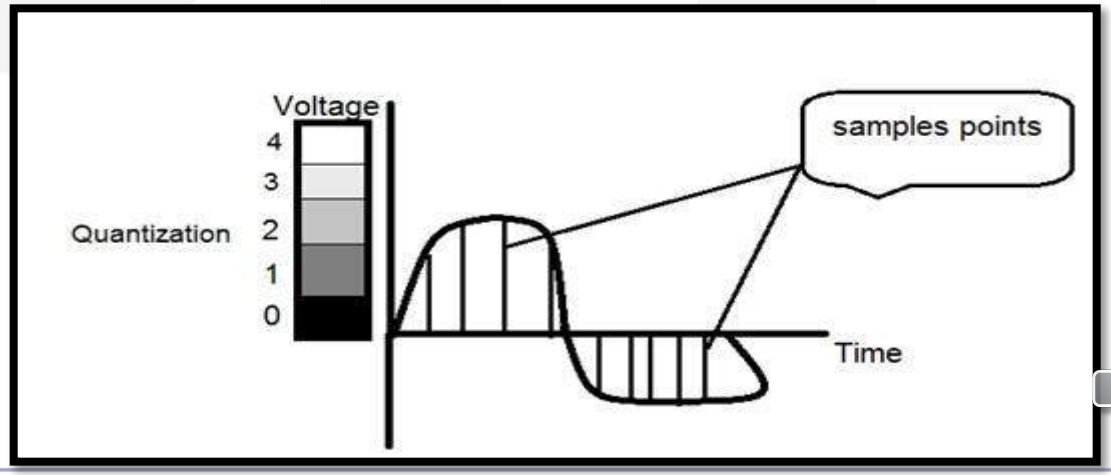
Quantization

- Quantization is opposite to sampling. It is done on y axis. When you are quantizing an image, you are actually dividing a signal into quanta (partitions).
- On the x axis of the signal, are the co-ordinate values, and on the y axis, we have amplitudes. So digitizing the amplitudes is known as Quantization.
- Here how it is done



Quantization

- In the figure shown in sampling, although the samples has been taken, but they were still spanning vertically to a continuous range of gray level values. In the figure shown below, these vertically ranging values have been quantized into 5 different levels or partitions. Ranging from 0 black to 4 white. This level could vary according to the type of image you want.



Fundamental Steps in Digital Image Processing

i) Image acquisition

It could be as simple as being given an image that is already in digital form. Generally the image acquisition stage involves processing such scaling.

ii) Image Enhancement

The idea behind this is to bring out details that are obscured or simply to highlight certain features of interest in image. Image enhancement is a very subjective area of image processing.

iii) Image Restoration –

It deals with improving the appearance of an image. It is an objective approach, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image processing. Enhancement, on the other hand is based on human subjective preferences regarding what constitutes a "good" enhancement result Fig: Fundamental Steps in DIP.

Image Enhancement

iv) Color image processing –

It is an area that is been gaining importance because of the use of digital images over the internet. Color image processing deals with basically color models and their implementation in image processing applications.

v) Wavelets and Multiresolution Processing –

These are the foundation for representing image in various degrees of resolution

vi) Compression –

It deals with techniques reducing the storage required to save an image, or the bandwidth required to transmit it over the network. It has two major approaches

a) Lossless Compression b) Lossy Compression

Image Enhancement

vii) Morphological processing –

It deals with tools for extracting image components that are useful in the **representation and description of shape and boundary of objects**. It is majorly used in automated inspection applications.

viii) Representation and Description –

It always follows the output of segmentation step that is, raw pixel data, constituting either the boundary of an image or points in the region itself. In either case converting the data to a form suitable for computer processing is necessary.

ix) Recognition - It is the process that assigns label to an object based on its descriptors. It is the last step of image processing which use artificial intelligence of softwares. Knowledge based

Image Enhancement

We can categorize image enhancement mainly in this two categories

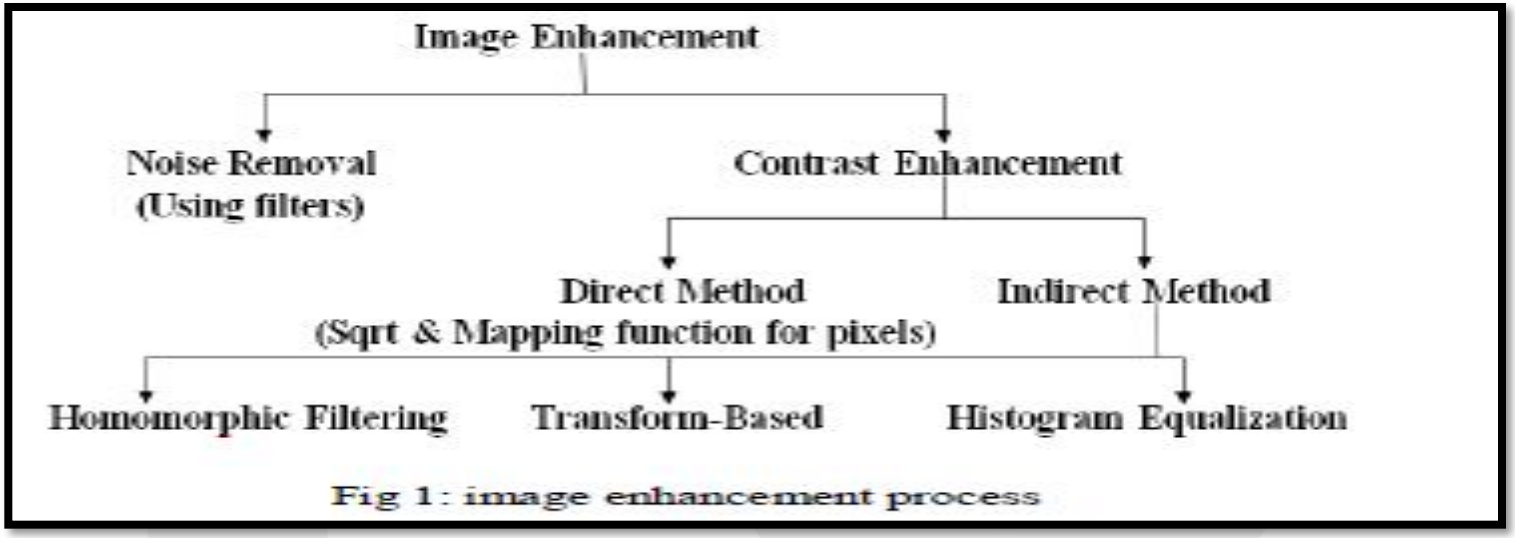


Fig 1: image enhancement process

Enhancement of an image can be implemented by using different operations of sharpening, brightness increment, noise removal or blurring. Unfortunately, there is no general theory for determining what ‘good’ image enhancement, when it comes to human sensing.

Image Enhancement

a) Noise Removal

It is an operation to remove undesirable details from an image. This detail gets attached to an Image while clicking image or acquisition process. Noise may be capturing device inability, due to environment particles, lack of experience of machine/computer operator or some other reason.

b) Contrast enhancement

Contrast is related to the color and brightness terms. It is basically improving the interpretability, Sensing of information images for human viewers and providing `better' input for other automated image processing techniques.

HISTOGRAM EQUALIZATION

- This method usually **increases the global contrast of many images**, especially when the usable data of the image is
- represented by close contrast values. **The objective of this method is to make an image apparently accepted for a specific application.**
- Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values

Image Enhancement

- HE transform the gray levels of an image to a uniform histogram based on the probability of occurring gray levels in an input image.
- The method is useful in images with backgrounds and foregrounds that are both bright or both dark.
- In particular, the method can lead to better views of bone structure in x-ray images, and to better detail in photographs that are over or under-exposed.

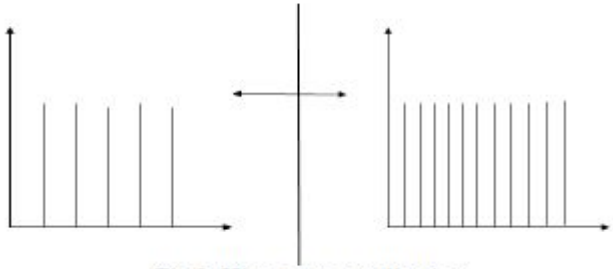


Fig 2: Histogram equalization

Image Noise

Images are noisy

Noise is anything in the image that we are not interested in

Examples: – Light fluctuations – Sensor noise – Quantization effects – Finite precision

Image noise is random (not present in the object imaged) variation of brightness or color information in images, and is usually an aspect of electronic noise.

It can be produced by the sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector.

How to remove Image Noise

Filter is used to remove the noise from the images. Noise is present in images in the form of:

A. **White and black spots on image**
B. **In ultrasound images with black intensity**

There are different types of filters: **average filter, mean and median filter etc.**

- The filter classifies pixels as noise by comparing each pixel in the image to its surrounding neighbor pixels.
- The size of the neighborhood is adjustable, as well as the threshold for the comparison. A pixel that is different from a majority of its neighbors, as well as being not structurally aligned with those pixels to which it is similar, is designated as impulse noise.
- These noisy pixels are then replaced by the median value of the pixels in the neighborhood that have passed the noise detection test

What causes Noise

- Noise is caused by the digital sensor attempting to record tiny amounts of light.
- Basically the camera is trying to record what is too dark to record clearly and, as a result, stray electrical signals wind up on the finished picture as flecks, or noise.
- The faster ISO you set on your digital camera, the more noise increases as it picks up smaller and smaller electrical signals.

Image Enhancement

Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further image analysis. For example, you can remove noise, sharpen, or brighten an image, making it easier to identify key features.

- The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for a specific application.
- It accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis.
- The enhancement doesn't increase the content of the data, but it increases the dynamic range of the chosen features so that they can be detected easily.

Methods of Image Enhancement

- Filtering with morphological operators
- Histogram equalization
- Noise removal using a Wiener filter
- Linear contrast adjustment
- Median filtering
- Unsharp mask filtering
- Contrast-limited adaptive histogram equalization (CLAHE)

Image Smoothing

- *Smoothing*, also called *blurring*, is a simple and frequently used image processing operation
- Smoothing reduces noise within an image or is used to produce a less pixelated image.
- Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value.

- **Average Filters or Low Pass Filters**

(1) Mean Filter (simple averaging)

(2) Gaussian Filter (center pixels weighted)

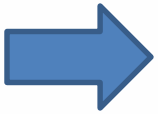
Image Smoothing

Mean Filter/ Box Filters/Average Filter

Mean filtering is to simply replace each pixel value in an image with the mean value of its neighbour, including itself.

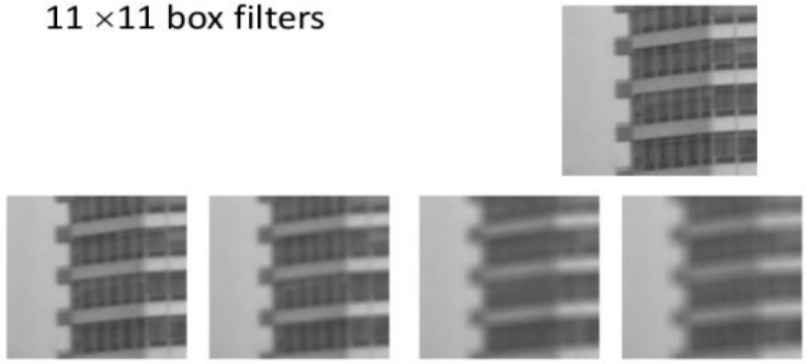
3X3 Normalised Box Filter :

20	40	10
10	20	20
10	20	30



20	40	10
10	**20**	20
10	20	30

- Image smoothed with 3×3, 5×5, 9×9 and 11 ×11 box filters



Drawback: Smoothing reduces fine image details

Gaussian Filter

- Gaussian filters smoothens an image by calculating weighted averages in a filter box.
- It is used to blur images and remove detail and noise.
- Gives more weight at the central pixels and less weight to the neighbours.
- The farther away the neighbours the smaller the weight.
- o

Original

Sigma = 3

Smoothing Non Linear Filters

- Nonlinear filters are based on ordering(ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the centre pixels with the value determined by the ranking result.

- Min and Max filter
- Median filter
- Midpoint filter

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Min and Max Filters

- The minimum filter selects the smallest value within the pixel values and maximum filter selects the largest value within of pixel values.
- Max filter is useful for finding the brightest points in an image. Eg. It removes salt noise
- Minimum filters are used for finding the darkest point in an image. Eg. Removes pepper noise

Comparision of Median and Box Filter

- Noisy image

- 5x5 median filtered

- 5x5 box filter

Midpoint Filter

The Midpoint filter blurs the image by replacing each pixel with the average of the highest pixel and the lowest pixel (with respect to intensity) within the specified window size.

Midpoint = (darkest+Lightest)/2

Image Sharpening

Sharpening brings out detail and gives an image presence. Sharpening is done following a three step process

1) Digital images have varying degrees of sharpness when cameras or scanners create them. Overcoming the slight blurring effects of filters or sensor design is termed "**capture" sharpening.**

2) Images have different characteristics and often need more sharpening in some areas than in other areas. This is termed **"creative" or "process" sharpening.**

3) Once a digital image is a finished high resolution file, perhaps a master file, it will need a third and final sharpening which **needs to be tailored to the type of output.**

Image Sharpening

- Sharpness is a combination of two factors: resolution and acutance.
- Resolution is straightforward and not subjective.
- It's just the size, in pixels, of the image file. All other factors equal, the higher the resolution of the image—the more pixels it has—the sharper it can be.
- The only way to increase apparent sharpness is by increasing acutance(sharpness related to the edge of an image). To make the image to look sharper, you need to add edge contrast.

Need to sharpen an Image

There are three main reasons to sharpen your image:

1) to overcome blurring introduced by camera equipment,

2) to draw attention to certain areas and

3) to increase legibility.

Image Restoration

- The goal of image restoration is to **reduce or remove the degradation in the image acquisition**.
- As an image enhancement, **image restoration attempts to reconstruct or recover the original image**.
- Image restoration is to recover the image blur which is caused by some reason.
- There are three main categories of reasons of image degradation, **motion, defocus and atmospheric turbulence**.

Multi Valued Image processing (Multi-spectral & Multi-modal)

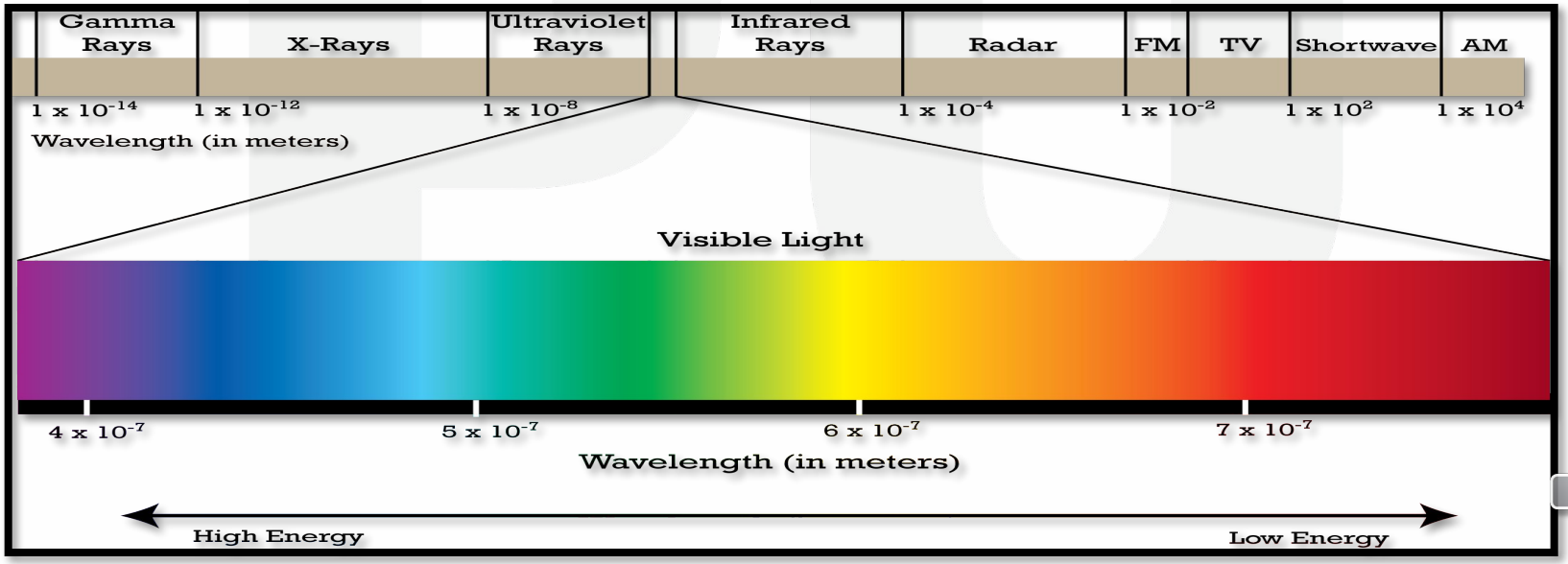
Multispectral image

- A multispectral image is one that captures image data within specific wavelength ranges across the electromagnetic spectrum.
- The wavelengths may be separated by filters or detected via the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, i.e. infrared and ultra-violet. Multispectral image: It basically involves

1)Image correction
2)Image Enhancement
3)Image Classification

Multispectral Image

- A multispectral image is one that captures image data within specific wavelength ranges across the electromagnetic spectrum. The wavelengths may be separated by filters.



Visible Spectrum

Visible Spectrum

1) Falls between UV and IR

2) Wavelength is between 380 nm to 700 nm

3) Frequency range is between 4×10^{14} to 8×10^{14} Hz

Applications

- Most radiometers (an instrument for detecting or measuring the intensity or force of radiation.) for remote sensing (RS) acquire multispectral images.
- Dividing the spectrum into many bands, multispectral radiometers records only the total intensity of radiation falling on each pixel.
- Usually, Earth observation satellites have three or more radiometers (Landsat has seven). Each acquires one digital image (in remote sensing, called a 'scene') in a small spectral band.

Applications

- The bands are grouped into wavelength regions based on the origin of the light. The shortest wavelength region is the ultra-violett (wavelengths < 0.4 µm), followed by the visible, or VIS, region, ranging from 0.4 µm to 0.7 µm.
- Spectral imaging with more numerous bands, finer spectral resolution or wider spectral coverage may be called **hyperspectral or ultra spectral.**
- Multispectral imaging can be employed for investigation of paintings and other works of art.

Multispectral data analysis software

- **MicroMSI** is endorsed by the NGA.
- **Opticks** is an open-source remote sensing application.
- **Multispec** is freeware multispectral analysis software.
- **Gerbil** is open source multispectral visualization and analysis software.

Multispectral imaging is an important tool for better understanding of image formation and reflectance phenomena.

Multimodal Imaging

- Multimodal imaging or multiplexed imaging refers to simultaneous production of signals for more than one imaging technique.
- Multimodality imaging, a combination of imaging modalities may provide a better solution to overcome the limitations of the independent techniques. This approach may provide a large amount of information for each pre-clinical experiment. The goal of multimodal or multiplexed imaging is to improve early detection and localization of cancer.

Multimodal Imaging

- Multimodal systems can offer a flexible, efficient and usable environment allowing users to interact through input modalities, such as speech, handwriting, hand gesture and gaze, and to receive information by the system through output modalities, such as speech synthesis, smart graphics and others modalities, opportunely combined.

Advantages

- The advantage of multiple input modalities is increased usability.
- Knowledge can be automatically acquired, categorized and continuously maintained by a suite of methods that can process natural language, and recognize and analyse video content.
- Science and engineering, most notably medicine and the life sciences, will particularly benefit from these applications as the number and range of scientific publications grows.

Multimodal Imaging

Drawback:

- The weaknesses of one modality are offset by the strengths of another. On a mobile device with a small visual interface and keypad, a word may be quite difficult to type but very easy to say
- Multimodal imaging is rapidly changing the evolving field of experimental imaging of genetic expression (“molecular imaging”).
- The development of multimodality methodology based on nuclear medicine (NM), positron emission tomography (PET) imaging, magnetic resonance imaging (MRI),

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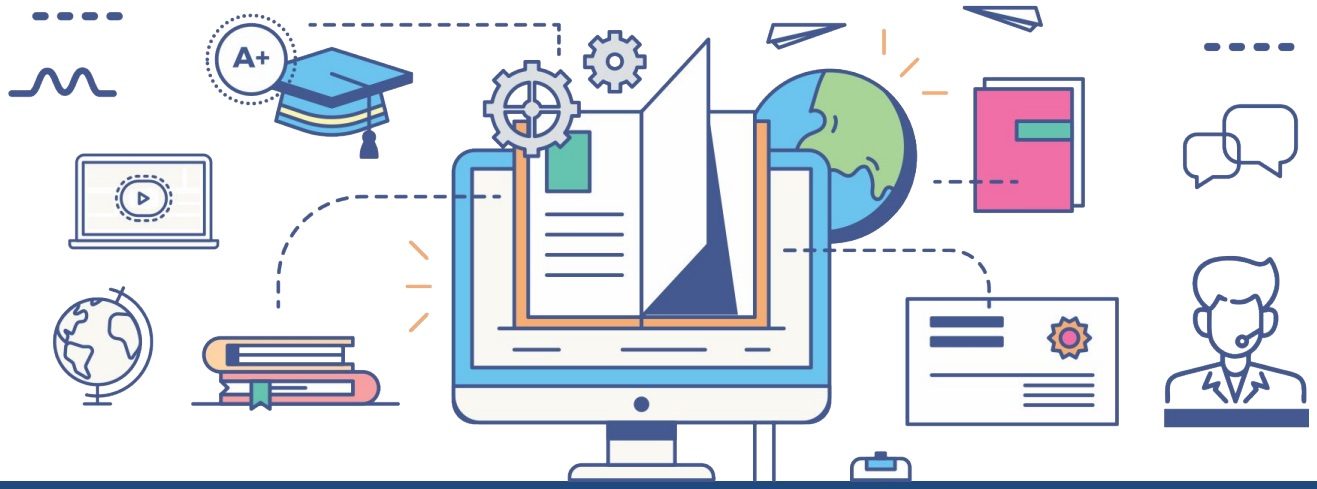

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