IMAGE PROCESSING.

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Image Processing

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Chapter 1
Introduction

1. Define image. 2013

Answer:

An image is nothing more than a two dimensional signal. It is defined by the mathematical function f(x,y) where x and y are the two co-ordinates horizontally and vertically.

The value of f(x,y) at any point is gives the pixel value at that point of an image.

2. Define digital image. 2012

Answer:

A digital image is a numeric representation, normally binary, of a two-dimensional image. Depending on whether the image resolution is fixed, it may be of vector or raster type. By itself, the term "digital image" usually refers to raster images or bitmapped images (as opposed to vector images).

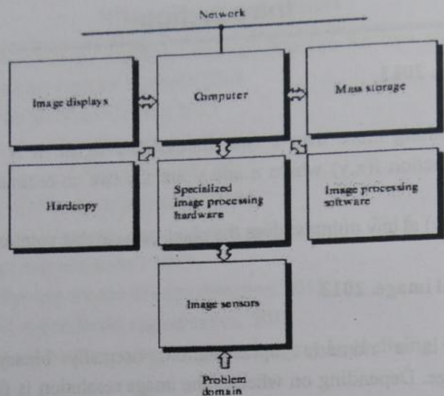
3. Define digital image processing. 2017, 2015, 2011

Answer:

Digital image processing deals with manipulation of digital images through a digital computer. It is a subfield of signals and systems but focus particularly on images. DIP focuses on developing a computer system that is able to perform processing on an image.

4. **Describe the elements of a basic image processing system. 2013**

Answer:



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.

Specialized image processing hardware usually consists of the digitizer plus hardware that performs other primitive operations such as arithmetic and logical operations (ALU). Eg. Noise reduction. This type of hardware sometimes is called a front end subsystem.

The computer is an image processing system is a general purpose to supercomputer Software which include image processing specialized modules that performs specific tasks Mass storage capability is a must in image processing applications.

Image displays in use today are mainly color TV monitors.

Hardcopy devices for recording images include laser printers, film cameras, inkjet units and CD-ROM.

5. Explain monocular and binocular vision. 2012

Answer:

binocular vision is a type of vision in which an animal having two eyes is able to perceive a single three-dimensional image of its surroundings. Neurological researcher Manfred Fahle has stated six specific advantages of having two eyes rather than just one:

1. It gives a creature a spare eye in case one is damaged.
2. It gives a wider field of view. For example, humans have a maximum horizontal field of view of approximately 190 degrees with two eyes, approximately 120 degrees of which makes up the binocular field of view (seen by both eyes) flanked by two uniocular fields (seen by only one eye) of approximately 40 degrees.
3. It can give stereopsis in which binocular disparity (or parallax) provided by the two eyes' different positions on the head gives precise depth perception. This also allows a creature to break the camouflage of another creature.
4. It allows the angles of the eyes' lines of sight, relative to each other (vergence), and those lines relative to a particular object (gaze angle) to be determined from the images in the two eyes. These properties are necessary for the third advantage.
5. It allows a creature to see more of, or all of, an object behind an obstacle. This advantage was pointed out by Leonardo da Vinci, who noted that a vertical column closer to the eyes than an object at which a creature is looking might block some of the object from the left eye but that part of the object might be visible to the right eye.
6. It gives binocular summation in which the ability to detect faint objects is enhanced.

6. **Describe the key stages of image processing. 2012**
   Or, Explain the fundamental steps of digital image processing with proper diagram. 2015,2014

Answer:

Fundamental Steps of Digital Image Processing:

There are some fundamental steps but as they are fundamental, all these steps may have sub-steps. The fundamental steps are described below with a neat diagram.

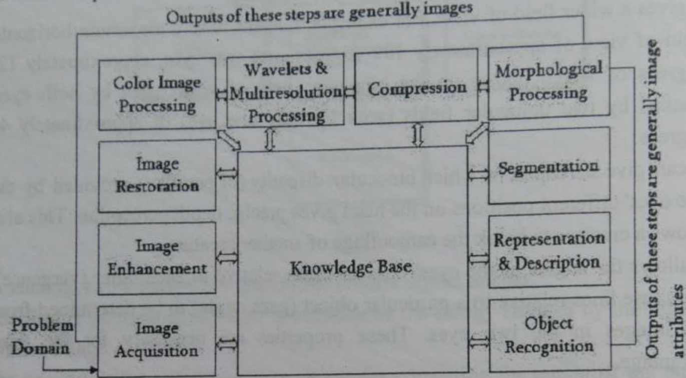


Figure 1

1. Image Acquisition:

This is the first step or process of the fundamental steps of digital image processing. Image acquisition could be as simple as being given an image that is already in digital form. Generally, the image acquisition stage involves pre-processing, such as scaling etc.

2. Image Enhancement:

Image enhancement is among the simplest and most appealing areas of digital image processing. Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. Such as, changing brightness & contrast etc.

3. Image Restoration:

Image restoration is an area that also deals with improving the appearance of an image. However, unlike enhancement, which is subjective, image restoration is objective, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.

4. Color Image Processing:

Color image processing is an area that has been gaining its importance because of the significant increase in the use of digital images over the Internet. This may include color modeling and processing in a digital domain etc.

5. Wavelets and Multi-Resolution Processing:

Wavelets are the foundation for representing images in various degrees of resolution. Images subdivision successively into smaller regions for data compression and for pyramidal representation.

6. Compression:

Compression deals with techniques for reducing the storage required to save an image or the bandwidth to transmit it. Particularly in the uses of internet it is very much necessary to compress data.

7. Morphological Processing:

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

8. Segmentation:

Segmentation procedures partition an image into its constituent parts or objects. In general, autonomous segmentation is one of the most difficult tasks in digital image processing. A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually.

9. Representation and Description:

Representation and description almost always follow the output of a segmentation stage, which usually is raw pixel data, constituting either the boundary of a region or all the points in the region itself. Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing. Description deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

10. Object recognition:

Recognition is the process that assigns a label, such as, "vehicle" to an object based on its descriptors.

11. Knowledge Base:

Knowledge may be as simple as detailing regions of an image where the information of interest is known to be located, thus limiting the search that has to be conducted in seeking that information. The knowledge base also can be quite complex, such as an interrelated list of all major possible defects in a materials inspection problem or an image database containing high-resolution satellite images of a region in connection with change-detection applications.

7. How digital images are represented? Explain in brief. 2017, 2014

Answer:

A digital image is a representation of a real image as a set of numbers that can be stored and handled by a digital computer. In order to translate the image into numbers, it is divided into small areas called **pixels** (picture elements). For each pixel, the imaging device records a number, or a small set of numbers, that describe some property of this pixel, such as its brightness (the intensity of the light) or its color. The numbers are arranged in an array of rows and columns that correspond to the vertical and horizontal positions of the pixels in the image.

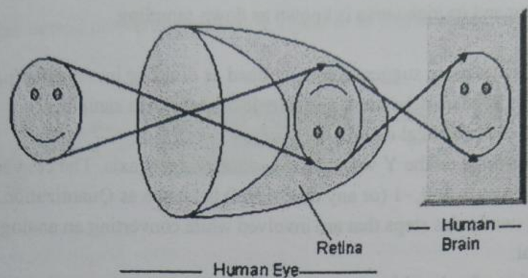
Digital images have several basic characteristics. One is the type of the image. For example, a black and white image records only the intensity of the light falling on the pixels. A color image can have three colors, normally RGB (Red, Green, Blue) or four colors, CMYK (Cyan, Magenta, Yellow, blacK). RGB images are usually used in computer monitors and scanners, while CMYK images are used in color printers.

8. Explain the process of image formation in the eye. 2015,2013, 2011

Answer:

Before we discuss , the image formation on analog and digital cameras , we have to first discuss the image formation on human eye. Because the basic principle that is followed by the cameras has been taken from the way , the human eye works.

When light falls upon the particular object , it is reflected back after striking through the object. The rays of light when passed through the lens of eye , form a particular angle , and the image is formed on the retina which is the back side of the wall. The image that is formed is inverted. This image is then interpreted by the brain and that makes us able to understand things. Due to angle formation , we are able to perceive the height and depth of the object we are seeing. This has been more explained in the tutorial of perspective transformation.



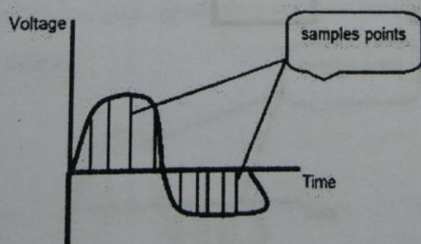
As you can see in the above figure, that when sun light falls on the object (in this case the object is a face), it is reflected back and different rays form different angle when they are passed through the lens and an invert image of the object has been formed on the back wall. The last portion of the figure denotes that the object has been interpreted by the brain and re-inverted.

9. Define image sampling and quantization. **2015, 2011**

Answer:

Sampling

Sampling as its name suggests can be defined as take samples. Take samples of a digital signal over x axis. Sampling is done on an independent variable. In case of this mathematical equation:



Sampling is done on the x variable. We can also say that the conversion of x axis (infinite values) to digital is done under sampling.

Sampling is further divide into up sampling and down sampling. If the range of values on x-axis are less then we will increase the sample of values. This is known as up sampling and its vice versa is known as down sampling.

Quantization

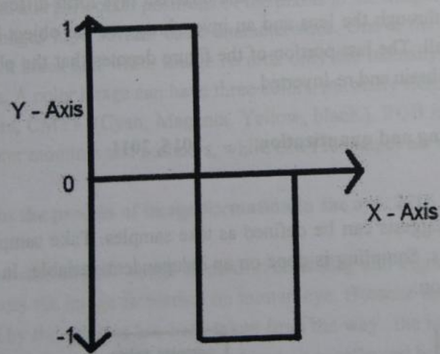
Quantization as its name suggest can be defined as dividing into quanta (partitions). Quantization is done on dependent variable. It is opposite to sampling.

In case of this mathematical equation y = sin(x)

Quantization is done on the Y variable. It is done on the y axis. The conversion of y axis infinite values to 1, 0, -1 (or any other level) is known as Quantization.

These are the two basics steps that are involved while converting an analog signal to a digital signal.

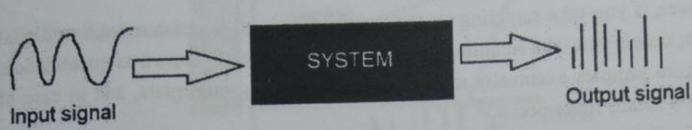
The quantization of a signal has been shown in the figure below.



10. Explain image sampling and quantization with example. **2017, 2015**

Answer:

The basic idea behind converting an analog signal to its digital signal is



to convert both of its axis (x,y) into a digital format.

Since an image is continuous not just in its co-ordinates (x axis), but also in its amplitude (y axis), so the part that deals with the digitizing of co-ordinates is known as sampling. And the part that deals with digitizing the amplitude is known as quantization.

Sampling.

Sampling has already been introduced in our tutorial of introduction to signals and system. But we are going to discuss here more.

Here what we have discussed of the sampling.

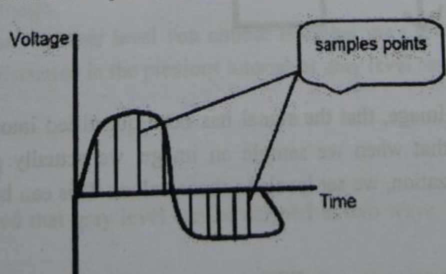
The term sampling refers to take samples

We digitize x axis in sampling

It is done on independent variable

In case of equation $y = \sin(x)$, it is done on x variable

It is further divided into two parts , up sampling and down sampling



If you will look at the above figure, you will see that there are some random variations in the signal. These variations are due to noise. In sampling we reduce this noise by taking samples. It is obvious that more samples we take, the quality of the image would be more better, the noise would be more removed and same happens vice versa.

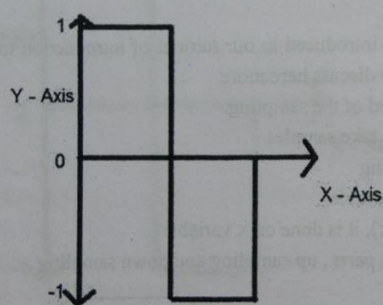
However, if you take sampling on the x axis, the signal is not converted to digital format, unless you take sampling of the y-axis too which is known as quantization. The more samples eventually means you are collecting more data, and in case of image, it means more pixels.

Quantization

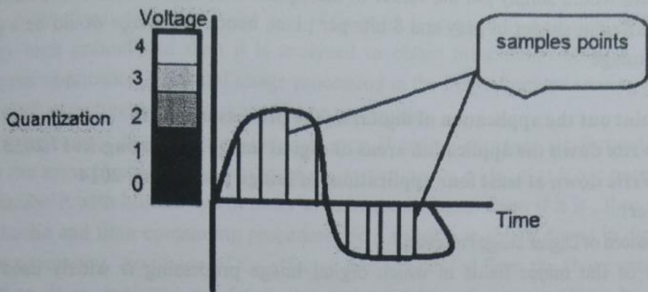
Quantization is opposite to sampling. It is done on y axis. When you are quantizing an image, you are actually dividing a signal into quanta(partitions).

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



You can see in this image, that the signal has been quantified into three different levels. That means that when we sample an image, we actually gather a lot of values, and in quantization, we set levels to these values. This can be more clear in the image below.



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 above, 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.

The relation of quantization with gray levels has been further discussed below.

Relation of Quantization with gray level resolution:

The quantized figure shown above has 5 different levels of gray. It means that the image formed from this signal, would only have 5 different colors. It would be a black and white image more or less with some colors of gray. Now if you were to make the quality of the image more better, there is one thing you can do here. Which is, to increase the levels, or gray level resolution up. If you increase this level to 256, it means you have an gray scale image. Which is far better then simple black and white image.

Now 256, or 5 or whatever level you choose is called gray level. Remember the formula that we discussed in the previous tutorial of gray level resolution which is,

$$L = 2^k$$

We have discussed that gray level can be defined in two ways. Which were these two.

- Gray level = number of bits per pixel (BPP).(k in the equation)
- Gray level = number of levels per pixel.

In this case we have gray level is equal to 256. If we have to calculate the number of bits, we would simply put the values in the equation. In case of 256levels, we have 256 different shades of gray and 8 bits per pixel, hence the image would be a gray scale image

11. Point out the application of digital image processing. 2015

Or, Write down the application areas of digital image processing. 2017,2013

Or, Write down at least four applications of image processing. 2014

Answer:

Applications of Digital Image Processing

Some of the major fields in which digital image processing is widely used are mentioned below

- Image sharpening and restoration
- Medical field
- Remote sensing
- Transmission and encoding
- Machine/Robot vision
- Color processing
- Pattern recognition
- Video processing
- Microscopic Imaging
- Others

Image sharpening and restoration

Image sharpening and restoration refers here to process images that have been captured from the modern camera to make them a better image or to manipulate those images in way to achieve desired result. It refers to do what Photoshop usually does.

This includes Zooming, blurring , sharpening , gray scale to color conversion, detecting edges and vice versa , Image retrieval and Image recognition.

Medical field

The common applications of DIP in the field of medical is

1. Gamma ray imaging
2. PET scan
3. X Ray Imaging
4. Medical CT

5. UV imaging

UV imaging

In the field of remote sensing , the area of the earth is scanned by a satellite or from a very high ground and then it is analyzed to obtain information about it. One particular application of digital image processing in the field of remote sensing is to detect infrastructure damages caused by an earthquake.

As it takes longer time to grasp damage, even if serious damages are focused on. Since the area effected by the earthquake is sometimes so wide , that it not possible to examine it with human eye in order to estimate damages. Even if it is , then it is very hectic and time consuming procedure. So a solution to this is found in digital image processing. An image of the effected area is captured from the above ground and then it is analyzed to detect the various types of damage done by the earthquake.

The key steps include in the analysis are

1. The extraction of edges
2. Analysis and enhancement of various types of edges

Transmission and encoding

The very first image that has been transmitted over the wire was from London to New York via a submarine cable. The picture that was sent is shown below.

The picture that was sent took three hours to reach from one place to another. Now just imagine , that today we are able to see live video feed , or live cctv footage from one continent to another with just a delay of seconds. It means that a lot of work has been done in this field too. This field doesnot only focus on transmission , but also on encoding. Many different formats have been developed for high or low bandwith to encode photos and then stream it over the internet or e.t.c.

Machine/Robot vision

Apart from the many challenges that a robot face today , one of the biggest challenge still is to increase the vision of the robot. Make robot able to see things , identify them , identify the hurdles e.t.c. Much work has been contributed by this field and a complete other field of computer vision has been introduced to work on it.

Hurdle detection

Hurdle detection is one of the common task that has been done through image processing, by identifying different type of objects in the image and then calculating the distance between robot and hurdles.

Line follower robot

Most of the robots today work by following the line and thus are called line follower robots. This help a robot to move on its path and perform some tasks. This has also been achieved through image processing.

Color processing

Color processing includes processing of colored images and different color spaces that are used. For example RGB color model , YCbCr, HSV. It also involves studying transmission , storage , and encoding of these color images.

Pattern recognition

Pattern recognition involves study from image processing and from various other fields that includes machine learning (a branch of artificial intelligence). In pattern recognition , image processing is used for identifying the objects in an images and then machine learning is used to train the system for the change in pattern. Pattern recognition is used in computer aided diagnosis , recognition of handwriting , recognition of images e.t.c

Video processing

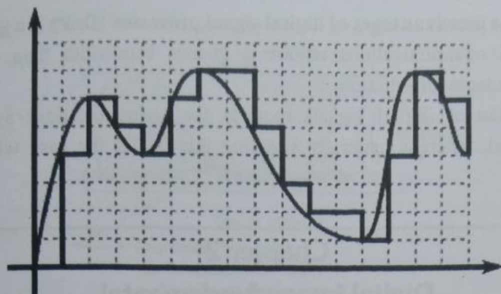
A video is nothing but just the very fast movement of pictures. The quality of the video depends on the number of frames/pictures per minute and the quality of each frame being used. Video processing involves noise reduction , detail enhancement , motion detection , frame rate conversion , aspect ratio conversion , color space conversion e.t.c.

12. Define digital signal and digital signal processing. 2017

Answer:

digital signal

A digital signal refers to an electrical signal that is converted into a pattern of bits. Unlike an analog signal, which is a continuous signal that contains time-varying quantities, a digital signal has a discrete value at each sampling point. The precision of the signal is determined by how many samples are recorded per unit of time. For example, the illustration below shows an analog pattern (represented as the curve) alongside a digital pattern (represented as the discrete lines).



A digital signal is easily represented by a computer because each sample can be defined with a series of bits that are either in the state 1 (on) or 0 (off). Digital signals can be compressed and can include additional information for error correction.

digital signal processing

Digital signal processing (DSP) is the process of analyzing and modifying a signal to optimize or improve its efficiency or performance. It involves applying various mathematical and computational algorithms to analog and digital signals to produce a signal that's of higher quality than the original signal

13. What are the advantages and disadvantages of DSP? 2017

Answer:

There are some advantages of digital signal processor (DSP) are given below,

- In DSP the digital system can be cascaded without any loading problems.
- In this digital circuits can be reproduced easily in large quantities at comparatively lower cost.
- The digital circuits are less sensitive to tolerances of component values.
- These are easily transported because the digital signals can be processed off line.
- Digital signal processing operations can be changed by changing the program in digital programmable system.
- It has a better control of accuracy in digital systems compared to analog systems.
- Sophisticated signal processing algorithms can be implemented by DSP method.
- Digital signals are easily stored on magnetic media such as magnetic tape without loss of quality of reproduction of signal.

There are some disadvantages of digital signal processor (DSP) are given below,

- The digital communications require a greater bandwidth than analogue to transmit the same information.
- The detection of digital signals requires the communications system to be synchronized, whereas generally speaking this is not the case with analogue systems.

Chapter 2
Digital image fundamental

1. Explain the sensor strip techniques for image acquisition. 2012

Answer:

(1)Image Acquisition Using a Single Sensor:

Figure 5.1 (a) shows the components of a single sensor. Perhaps the most familiar sensor of this type is the photodiode, which is constructed of silicon materials and whose output voltage waveform is proportional to light. The use of a filter in front of a sensor improves selectivity. For example, a green (pass) filter in front of a light sensor favors light in the green band of the color spectrum. As a consequence, the sensor output will be stronger for green light than for other components in the visible spectrum

In order to generate a 2-D image using a single sensor, there has to be relative displacements in both the x- and y-directions between the sensor and the area to be imaged. Figure 5.2 shows an arrangement used in high-precision scanning, where a film negative is mounted onto a drum whose mechanical rotation provides displacement in one dimension. The single sensor is mounted on a lead screw that provides motion in the perpendicular direction. Since mechanical motion can be controlled with high precision, this method is an inexpensive (but slow) way to obtain high-resolution images. Other similar mechanical arrangements use a flat bed, with the sensor moving in two linear directions. These types of mechanical digitizers sometimes are referred to as micro densitometers.

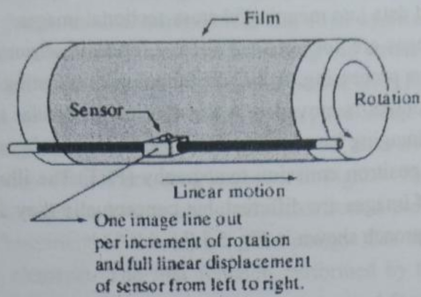


Fig.5.2. Combining a single sensor with motion to generate a 2-D image

(2) Image Acquisition Using Sensor Strips:

A geometry that is used much more frequently than single sensors consists of an in-line arrangement of sensors in the form of a sensor strip, as Fig. 5.1 (b) shows. The strip provides imaging elements in one direction. Motion perpendicular to the strip provides imaging in the other direction, as shown in Fig. 5.3 (a).This is the type of arrangement used in most flat bed scanners. Sensing devices with 4000 or more in-line sensors are possible. In-line sensors are used routinely in airborne imaging applications, in which the imaging system is mounted on an aircraft that flies at a constant altitude and speed over the geographical area to be imaged. One-dimensional imaging sensor strips that respond to various bands of the electromagnetic spectrum are mounted perpendicular to the direction of flight. The imaging strip gives one line of an image at a time, and the motion of the strip completes the other dimension of a two-dimensional image. Lenses or other focusing schemes are used to project the area to be scanned onto the sensors. Sensor strips mounted in a ring configuration are used in medical and industrial imaging to obtain cross-sectional ("slice") images of 3-D objects, as Fig. 5.3 (b) shows. A rotating X-ray source provides illumination and the portion of the sensors opposite the source collect the X-ray energy that pass through the object (the sensors obviously have to be sensitive to X-ray energy).This is the basis for medical and industrial computerized axial tomography (CAT). It is important to note that the output of the sensors must be processed by reconstruction algorithms whose objective is to transform the sensed data into meaningful cross-sectional images.

In other words, images are not obtained directly from the sensors by motion alone; they require extensive processing. A 3-D digital volume consisting of stacked images is generated as the object is moved in a direction perpendicular to the sensor ring. Other modalities of imaging based on the CAT principle include magnetic resonance imaging (MRI) and positron emission tomography (PET).The illumination sources, sensors, and types of images are different, but conceptually they are very similar to the basic imaging approach shown in Fig. 5.3 (b).

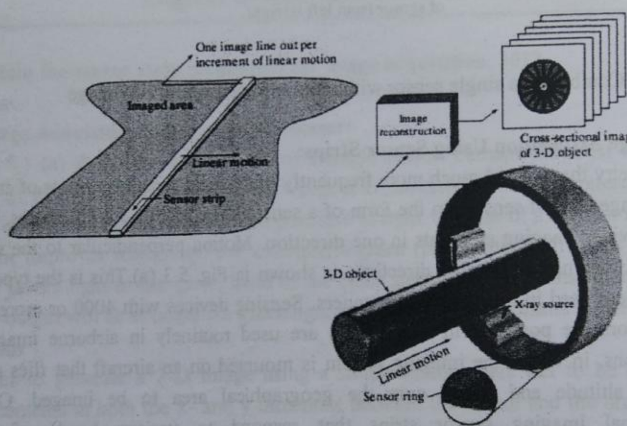


Fig.5.3 (a) Image acquisition using a linear sensor strip (b) Image acquisition using a circular sensor strip.

(3) Image Acquisition Using Sensor Arrays:

Figure 5.1 (c) shows individual sensors arranged in the form of a 2-D array. Numerous electromagnetic and some ultrasonic sensing devices frequently are arranged in an array format. This is also the predominant arrangement found in digital cameras. A typical sensor for these cameras is a CCD array, which can be manufactured with a broad range of sensing properties and can be packaged in rugged arrays of 4000 * 4000 elements or more. CCD sensors are used widely in digital cameras and other light sensing instruments. The response of each sensor is proportional to the integral of the light energy projected onto the surface of the sensor, a property that is used in astronomical and other applications requiring low noise images. Noise reduction is achieved by letting the sensor integrate the input light signal over minutes or even hours. Since the sensor array shown in Fig. 5.4 (c) is two dimensional, its key advantage is that a complete image can be obtained by focusing the energy pattern onto the surface of the array. The principal manner in which array sensors are used is shown in Fig.5.4. This figure shows the energy from an illumination source being reflected from a scene element, but, as mentioned at the beginning of this section, the energy also could be transmitted through the scene elements. The first function performed by the imaging system shown in Fig.5.4 (c) is to collect the incoming energy and focus it onto an image plane. If the illumination is light, the front end of the imaging system is a lens, which projects the viewed scene onto the lens focal plane, as Fig. 2.15(d) shows. The sensor array, which is coincident with the focal plane, produces outputs proportional to the integral of the light received at each sensor. Digital and analog circuitry sweep these outputs and converts them to a video signal, which is then digitized by another section of the imaging system. The output is a digital image, as shown diagrammatically in Fig. 5.4 (e).

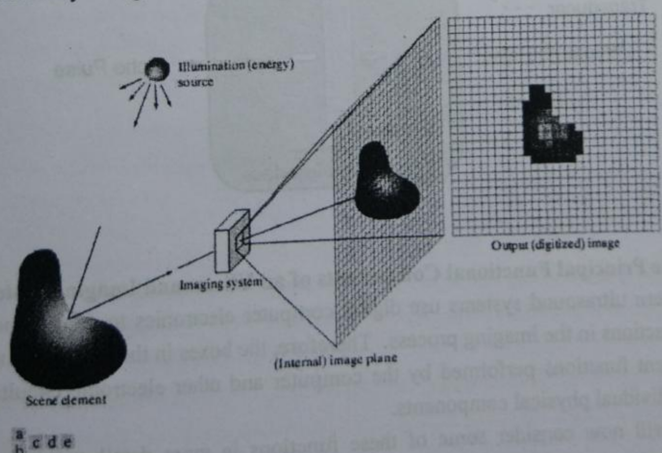


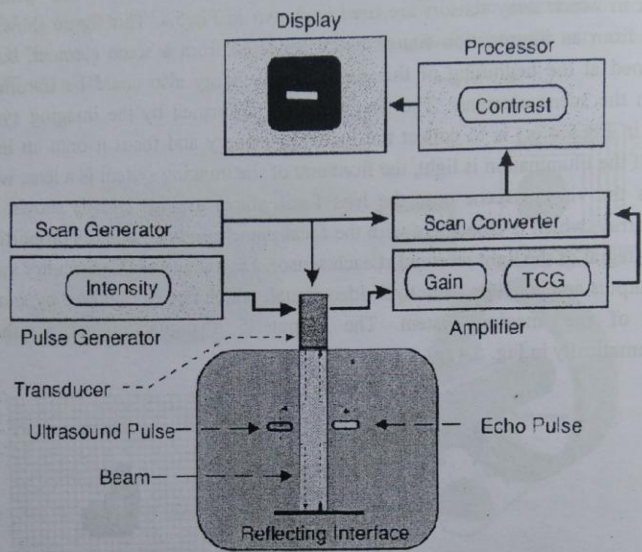
Fig.5.4 An example of the digital image acquisition process (a) Energy ("illumination") source (b) An element of a scene (c) Imaging system (d) Projection of the scene onto the image plane (e) Digitized image

2. Write down the basic procedure of ultrasound image generation. 2013

Answer:

THE ULTRASOUND IMAGING SYSTEM

The basic functional components of an ultrasound imaging system are shown below.



The Principal Functional Components of an Ultrasound Imaging System

Modern ultrasound systems use digital computer electronics to control most of the functions in the imaging process. Therefore, the boxes in the illustration above represent functions performed by the computer and other electronic circuits and not individual physical components.

We will now consider some of these functions in more detail and how they contribute to image formation.

Transducer
The transducer is the component of the ultrasound system that is placed in direct contact with the patient's body. It alternates between two major functions: (1) **producing** ultrasound pulses and (2) **receiving** or detecting the returning echoes. Within the transducer there are one or more piezoelectric elements. When an electrical pulse is applied to the piezoelectric element it vibrates and produces the ultrasound. Also, when the piezoelectric element is vibrated by the returning echo pulse it produces a pulse of electricity. The transducer also **focuses** the beam of pulses to give it a specific size and shape at various depths within the body and also **scans** the beam over the anatomical area that is being imaged.
Pulse Generator
The pulse generator produces the electrical pulses that are applied to the transducer. For conventional ultrasound imaging the pulses are produced at a rate of approximately 1,000 pulses per second. NOTE: This is the pulse rate (pulses per second) and not the frequency which is the number of cycles or vibrations per second within each pulse. The principal control associated with the pulse generator is the size of the electrical pulses that can be used to change the intensity and energy of the ultrasound beam.
Amplification
Amplification is used to increase the size of the electrical pulses coming from the transducer after an echo is received.. The amount of amplification is determined by the gain setting. The principal control associated with the amplifier is the time gain compensation (TGC), which allows the user to adjust the gain in relationship to the depth of echo sites within the body. This function will be considered in much more detail in the next section.
Scan Generator
The scan generator controls the scanning of the ultrasound beam over the body section being imaged. This is usually done by controlling the sequence in which the electrical pulses are applied to the piezoelectric elements within the

transducer. This is also considered in more detail later.
Scan Converter
Scan conversion is the function that converts from the format of the scanning ultrasound beam into a digital image matrix format for processing and display.
Image Processor
The digital image is processed to produce the desired characteristics for display. This includes giving it specific contrast characteristics and reformatting the image if necessary.
Display
The digital ultrasound images are viewed on the equipment display (monitor) and usually transferred to the physician display or work station. One component of the ultrasound imaging system that is not shown is the digital storage device that is used to store images for later viewing if that process is used.

3. Describe the light and electromagnetic spectrum with necessary figure. 2013,2015,2017

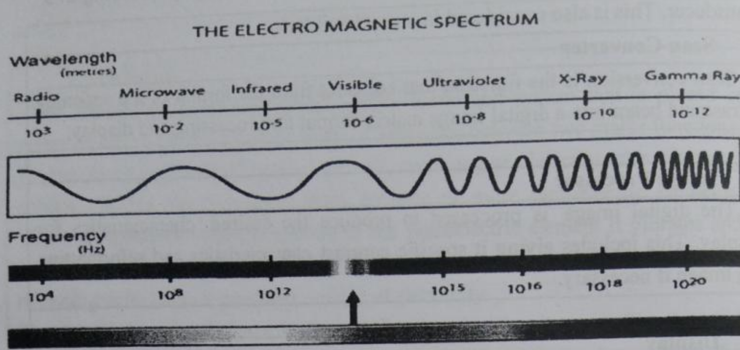
Answer:

Since digital image processing has very wide applications and almost all of the technical fields are impacted by DIP, we will just discuss some of the major applications of DIP.

Digital Image processing is not just limited to adjust the spatial resolution of the everyday images captured by the camera. It is not just limited to increase the brightness of the photo, e.t.c. Rather it is far more than that.

Electromagnetic waves can be thought of as stream of particles, where each particle is moving with the speed of light. Each particle contains a bundle of energy. This bundle of energy is called a photon.

The electromagnetic spectrum according to the energy of photon is shown below.



In this electromagnetic spectrum, we are only able to see the visible spectrum. Visible spectrum mainly includes seven different colors that are commonly term as (VIBGOYR). VIBGOYR stands for violet , indigo , blue , green , orange , yellow and Red.

But that does not nullify the existence of other stuff in the spectrum. Our human eye can only see the visible portion, in which we saw all the objects. But a camera can see the other things that a naked eye is unable to see. For example: x rays , gamma rays , e.t.c. Hence the analysis of all that stuff too is done in digital image processing.

4. You might have notice that emergency vehicles such as ambulances are often labeled on the front hood with reversed lettering(e.g ECNALUBMA). Explain why this is so. 2013

Answer:

To make AMBULANCE easier read for vehicles in front of the ambulance. Ambulance are typically in greater speed than surrounding vehicles which make the ambulance front visible in other cars rear view mirror. At least those cars that need to get away to give room for the ambulance passing through traffic.

The most common modern usage of mirror writing can be found on the front of ambulances, where the word "AMBULANCE" is often written in very large mirrored text, so that drivers see the word the right way around in their rear-view mirror.

5. Explain simple image formation model. 2011

Or, Explain the image formation model. 2014

Answer:

Image Formation Model

- Shape model: S consists of K shapes: S_k, $k = 1, \ldots, K$. (e.g. ventricles, putamen, hippocampus, ...)
- Transformation: T can be any spatial transformation within a specified set. The set can include non-linear warps with arbitrarily large number of Degrees Of Freedom. This transformation applies to all of the shapes, S_k.
- Image generation model:

  $$G(T(S)) = \sum_{m,k} \alpha_{m,k} G_m(T(S_k))$$

  where $\alpha_{m,k}$ are intensity scaling parameters and $G_m(\cdots)$ generates the m th basis image of a shape (see section 2.3).
- Image measurement model:

  $$Y = G(T(S)) + \epsilon$$

  where ϵ is a spatially uncorrelated Gaussian noise process with $E\{\epsilon\} = 0$, $\mathrm{Cov}\{\epsilon\} = \sigma^2 I$.

  Note that all images (ϵ, $G_m(T(S_k))$, Y, etc) are treated as vectors of length N, where N is the number of voxels in the image.

6. What are the differences between photopic and scotopic. 2014, 2011

Answer:

The duplex theory of vision refers to the idea that there are functionally two distinct ways that our eyes work. The first system is called the photopic and the second is the scotopic system. The photopic system is associated with the cones, and the other, the scotopic system, is associated with the rods. The duplex theory is the idea that our visual system can operate in fundamentally different ways, depending upon the conditions in the environment. Daytime is the domain of photopic vision, but nighttime is when our scotopic vision comes to the forefront. These hypothesized differences in visual function derive from the following observations. First, rods are more sensitive to light overall than cones. Second, rods are most sensitive to different wavelengths than the cones are. That is, they have a different spectral sensitivity. Third, rods and cones have different spatial and summation properties, which we discuss shortly. And finally, cones support color vision but rods do not. In general, the photopic system is associated with daytime vision, and the scotopic system is our night vision system. However, there is a range of intermediate ambient light intensity in which both systems are working. This intermediate zone is said to be mesopic vision.

7. Define aliasing?2014

Answer:

Aliasing is an effect that causes different signals to become indistinguishable from each other during sampling. Aliasing is characterized by the altering of output compared to the original signal because resampling or interpolation resulted in a lower resolution in images, a slower frame rate in terms of video or a lower wave resolution in audio. Anti-aliasing filters can be used to correct this problem.

8. What is chromatic and achromatic light? 2011

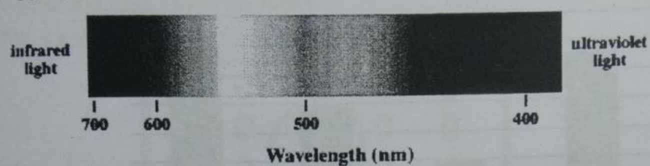
Answer:

Achromatic colors (white, grey and black) have lightness but no hue or saturation. They can be created by mixing complementary colors together. Chromatic colors, on the other hand, have characterizing hues such as red, blue and yellow, as well as saturation, which is an attribute of intensity, in addition to lightness. The elements of hue, lightness and saturation found in chromatic colors are referred to as the three attributes of color, and specific colors can be represented by stipulating the values for each of these attributes.

9. Draw the electromagnetic light of spectrum , 2011

Answer:

Electromagnetic waves are categorized according to their frequency f or, equivalently, according to their wavelength $\lambda = c/f$. Visible light has a wavelength range from ~400 nm to ~700 nm. Violet light has a wavelength of ~400 nm, and a frequency of ~$7.5*10^{14}$ Hz. Red light has a wavelength of ~700 nm, and a frequency of ~$4.3*10^{14}$ Hz.



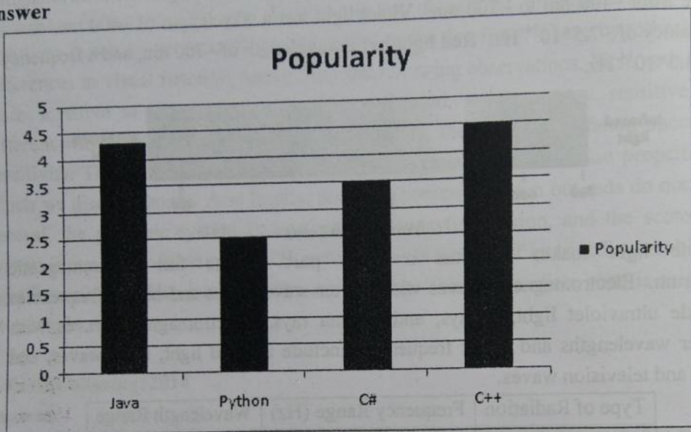
Visible light makes up just a small part of the full electromagnetic spectrum. Electromagnetic waves with shorter wavelengths and higher frequencies include ultraviolet light, X-rays, and gamma rays. Electromagnetic waves with longer wavelengths and lower frequencies include infrared light, microwaves, and radio and television waves.

Type of Radiation	Frequency Range (Hz)	Wavelength Range
gamma-rays	10^{20} - 10^{24}	< 10^{-12} m
x-rays	10^{17} - 10^{20}	1 nm - 1 pm
ultraviolet	10^{15} - 10^{17}	400 nm - 1 nm
visible	4 - $7.5*10^{14}$	750 nm - 400 nm
near-infrared	$1*10^{14}$ - $4*10^{14}$	2.5 μm - 750 nm
infrared	10^{13} - 10^{14}	25 μm - 2.5 μm
microwaves	$3*10^{11}$ - 10^{13}	1 mm - 25 μm
radio waves	< $3*10^{11}$	> 1 mm

1. **Define and derive the Discrete Fourier Transformation. 2017**
2. **Describe the properties of Z-transformation. 2017**
3. **Discuss the properties of 2D Discrete Fourier Transformation and prove the circular convulation theorem. 2013**

Chapter 3
Image enhancement

1. What is histogram? 2015
Or, What do you mean by histogram processing? 2017,2012
Answer



2. Explain histogram equalization. 2017, 2015, 2012
Answer:
Histogram equalization is a method to process images in order to adjust the contrast of an image by modifying the intensity distribution of the histogram. The objective of this technique is to give a linear trend to the cumulative probability function associated to the image.
The processing of histogram equalization relies on the use of the cumulative probability function (cdf). The cdf is a cumulative sum of all the probabilities lying in its domain and defined by:

$$cdf(x) = \sum_{k=-\infty}^{x} P(k)$$

The idea of this processing is to give to the resulting image a linear cumulative distribution function. Indeed, a linear cdf is associated to the uniform histogram that we want the resulting image to have.

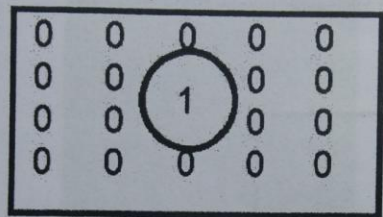
3. Why does filter necessary in image processing? Describe the high pass and low pass filter in image processing. 2017, 2012

Answer:

The high pass frequency components denotes edges whereas the low pass frequency components denotes smooth regions.

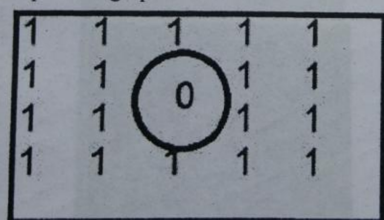
Ideal low pass and Ideal High pass filters

This is the common example of low pass filter.

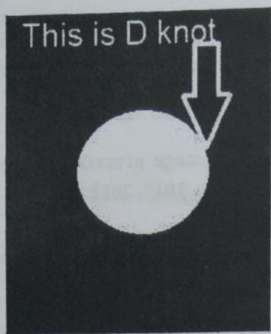


When one is placed inside and the zero is placed outside , we got a blurred image. Now as we increase the size of 1, blurring would be increased and the edge content would be reduced.

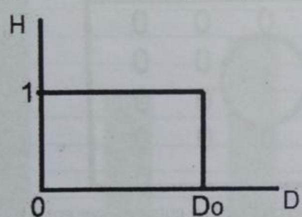
This is a common example of high pass filter.



When 0 is placed inside, we get edges, which gives us a sketched image. An ideal low pass filter in frequency domain is given below.



The ideal low pass filter can be graphically represented as



Now let's apply this filter to an actual image and let's see what we got.

Sample image

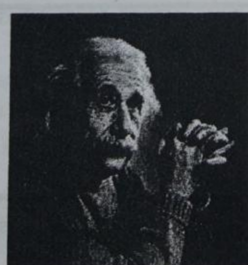
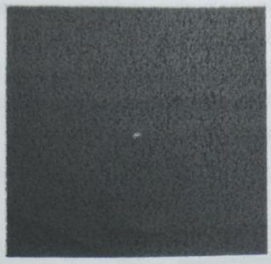
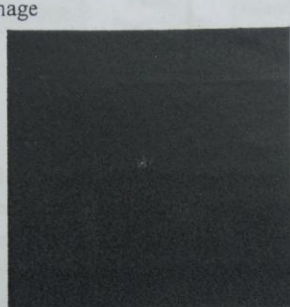


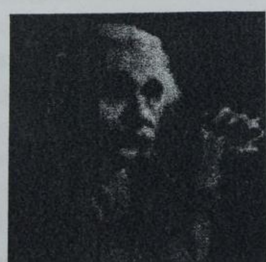
Image in frequency domain



Applying filter over this image



Resultant Image



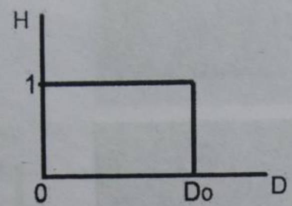
With the same way, an ideal high pass filter can be applied on an image. But obviously the results would be different as, the low pass reduces the edged content and the high pass increase it.

Gaussian Low pass and Gaussian High pass filter

Gaussian low pass and Gaussian high pass filter minimize the problem that occur in ideal low pass and high pass filter.

This problem is known as ringing effect. This is due to reason because at some points transition between one color to the other cannot be defined precisely, due to which the ringing effect appears at that point.

Have a look at this graph.



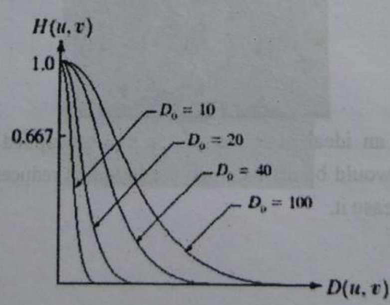
This is the representation of ideal low pass filter. Now at the exact point of Do, you cannot tell that the value would be 0 or 1. Due to which the ringing effect appears at that point.

So in order to reduce the effect that appears is ideal low pass and ideal high pass filter, the following Gaussian low pass filter and Gaussian high pass filter is introduced.

Gaussian Low pass filter

The concept of filtering and low pass remains the same, but only the transition becomes different and become more smooth.

The Gaussian low pass filter can be represented as



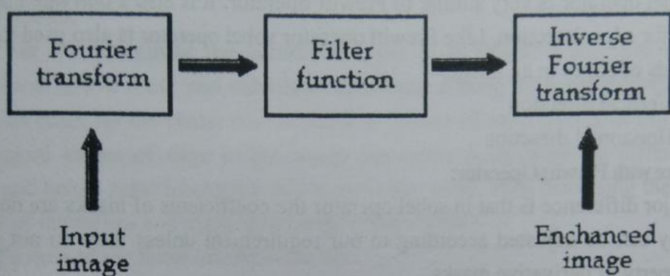
Note the smooth curve transition, due to which at each point, the value of Do, can be exactly defined.

Gaussian high pass filter

Gaussian high pass filter has the same concept as ideal high pass filter, but again the transition is more smooth as compared to the ideal one.

4. Write down the basic steps for filtering in frequency domain. 2017

Answer:



Basics steps of frequency domain filtering. The filtering in the spatial domain demands a filter mask (it is also referred as kernel or convolution filter). The filter mask is a matrix of odd usually size which is applied directly on the original data of the image. The mask is centred on each pixel of the initial image. For each position of the mask the pixel values of the image is multiplied by the corresponding values of the mask. The products of these multiplications are then added and the value of the central pixel of the original image is replaced by the sum. This must be repeated for every pixel in the image. The procedure is described schematically in Fig. 4. If the filter, by which the new pixel value was calculated, is a linear function of the entire pixel values in the filter mask (e.g. the sum of products), then the filter is called linear. If the output pixel is not a linear weighted combination of the input pixel of the image then the filtered is called non-linear. According to the range of frequencies they allow to pass through filters can be classified as low pass or high pass. Low pass filters allow the low frequencies to be retained unaltered and block the high frequencies. Low pass filtering removes noise and smooth the image but at the same time blur the image as it does not preserve the edges. High pass filters sharpness the edges of the image (areas in an image where the signal changes rapidly) and enhance object edge information. A severe disadvantage of high pass filtering is the amplification of statistical noise present in the measured counts. The next section is referred to three of the most common filters used by MatLab: the mean, median and Gaussian filter.

5. Describe the edge detection technique of Sobel and Laplacian Operator. 2017, 2014

Or, Briefly describe second order derivate of Laplacian operator for sharpening filter. 2015

Answer:

The sobel operator is very similar to Prewitt operator. It is also a derivate mask and is used for edge detection. Like Prewitt operator sobel operator is also used to detect two kinds of edges in an image:

- Vertical direction
- Horizontal direction

Difference with Prewitt Operator:

The major difference is that in sobel operator the coefficients of masks are not fixed and they can be adjusted according to our requirement unless they do not violate any property of derivative masks.

Following is the vertical Mask of Sobel Operator:

-1	0	1
-2	0	2
-1	0	1

This mask works exactly same as the Prewitt operator vertical mask. There is only one difference that is it has "2" and "-2" values in center of first and third column. When applied on an image this mask will highlight the vertical edges.

How it works:

When we apply this mask on the image it prominent vertical edges. It simply works like as first order derivate and calculates the difference of pixel intensities in a edge region.

As the center column is of zero so it does not include the original values of an image but rather it calculates the difference of right and left pixel values around that edge. Also the center values of both the first and third column is 2 and -2 respectively.

This give more weight age to the pixel values around the edge region. This increase the edge intensity and it become enhanced comparatively to the original image.

Following is the horizontal Mask of Sobel Operator:

-1	-2	-1
0	0	0
1	2	1

Above mask will find edges in horizontal direction and it is because that zeros column is in horizontal direction. When you will convolve this mask onto an image it would prominent horizontal edges in the image. The only difference between it is that it have 2 and -2 as a center element of first and third row.

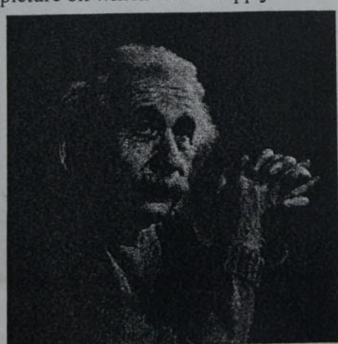
How it works:

This mask will prominent the horizontal edges in an image. It also works on the principle of above mask and calculates difference among the pixel intensities of a particular edge. As the center row of mask is consist of zeros so it does not include the original values of edge in the image but rather it calculate the difference of above and below pixel intensities of the particular edge. Thus increasing the sudden change of intensities and making the edge more visible.

Now it's time to see these masks in action:

Sample Image:

Following is a sample picture on which we will apply above two masks one at time.

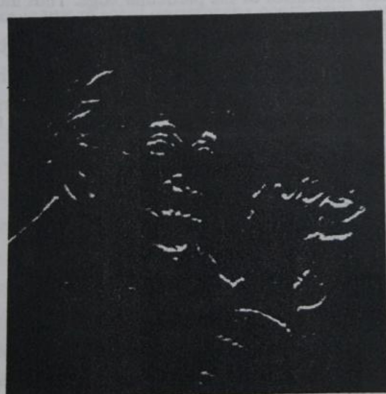


After applying Vertical Mask:

After applying vertical mask on the above sample image, following image will be obtained.

After applying Horizontal Mask:

After applying horizontal mask on the above sample image, following image will be obtained



Comparison:

As you can see that in the first picture on which we apply vertical mask, all the vertical edges are more visible than the original image. Similarly in the second picture we have applied the horizontal mask and in result all the horizontal edges are visible.

So in this way you can see that we can detect both horizontal and vertical edges from an image. Also if you compare the result of sobel operator with Prewitt operator, you will find that sobel operator finds more edges or make edges more visible as compared to Prewitt Operator.

This is because in sobel operator we have allotted more weight to the pixel intensities around the edges.

Applying more weight to mask

Now we can also see that if we apply more weight to the mask, the more edges it will get for us. Also as mentioned in the start of the tutorial that there is no fixed coefficients in sobel operator, so here is another weighted operator

-1	0	1
-5	0	5
-1	0	1

If you can compare the result of this mask with of the Prewitt vertical mask, it is clear that this mask will give out more edges as compared to Prewitt one just because we have allotted more weight in the mask.

Laplacian Operator

Laplacian Operator is also a derivative operator which is used to find edges in an image. The major difference between Laplacian and other operators like Prewitt, Sobel, Robinson and Kirsch is that these all are first order derivative masks but Laplacian is a second order derivative mask. In this mask we have two further classifications one is Positive Laplacian Operator and other is Negative Laplacian Operator.

Another difference between Laplacian and other operators is that unlike other operators Laplacian didn't take out edges in any particular direction but it take out edges in following classification.

- Inward Edges
- Outward Edges

Let's see that how Laplacian operator works.

Positive Laplacian Operator:

In Positive Laplacian we have standard mask in which center element of the mask should be negative and corner elements of mask should be zero.

0	1	0
1	-4	1
0	1	0

Positive Laplacian Operator is use to take out outward edges in an image.

Negative Laplacian Operator:

In negative Laplacian operator we also have a standard mask, in which center element should be positive. All the elements in the corner should be zero and rest of all the elements in the mask should be -1.

0	-1	0
-1	4	-1
0	-1	0

Negative Laplacian operator is use to take out inward edges in an image

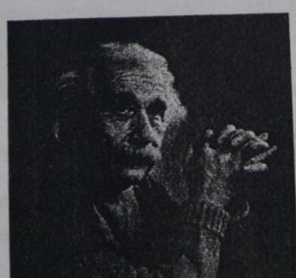
How it works:

Laplacian is a derivative operator; its uses highlight gray level discontinuities in an image and try to deemphasize regions with slowly varying gray levels. This operation in result produces such images which have grayish edge lines and other discontinuities on a dark background. This produces inward and outward edges in an image

The important thing is how to apply these filters onto image. Remember we can't apply both the positive and negative Laplacian operator on the same image. we have to apply just one but the thing to remember is that if we apply positive Laplacian operator on the image then we subtract the resultant image from the original image to get the sharpened image. Similarly if we apply negative Laplacian operator then we have to add the resultant image onto original image to get the sharpened image.

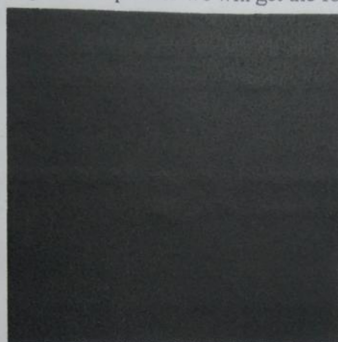
Let's apply these filters onto an image and see how it will get us inward and outward edges from an image. Suppose we have a following sample image.

Sample Image



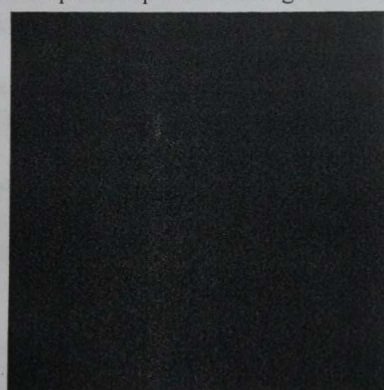
After applying Positive Laplacian Operator:

After applying positive Laplacian operator we will get the following image.



After applying Negative Laplacian Operator:

After applying negative Laplacian operator we will get the following image.



6. Discuss about inverse filtering. 2014

Answer:

In signal processing, for a filter g, an inverse filter h is one such that the sequence of applying g then h to a signal results in the original signal. Software or electronic inverse filters are often used to compensate for the effect of unwanted environmental filtering of signals

7. What are the application of log transformation and power low transformation of digital image. 2014, 2012

Answer:

Log transformation

The log transformations can be defined by this formula

$s = c\log(r + 1)$.

Where s and r are the pixel values of the output and the input image and c is a constant. The value 1 is added to each of the pixel value of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So 1 is added , to make the minimum value at least 1.

During log transformation , the dark pixels in an image are expanded as compare to the higher pixel values. The higher pixel values are kind of compressed in log transformation. This result in following image enhancement.

The value of c in the log transform adjust the kind of enhancement you are looking for.

Input Image

Log Transform Image

The inverse log transform is opposite to log transform.

Power – Law transformations

There are further two transformation is power law transformations, that include nth power and nth root transformation. These transformations can be given by the expression:

s=cr^γ

This symbol γ is called gamma, due to which this transformation is also known as gamma transformation.

Variation in the value of γ varies the enhancement of the images. Different display devices / monitors have their own gamma correction, that's why they display their image at different intensity.

This type of transformation is used for enhancing images for different type of display devices. The gamma of different display devices is different. For example Gamma of CRT lies in between of 1.8 to 2.5 , that means the image displayed on CRT is dark.

Correcting gamma.

s=cr^γ

s=cr^(1/2.5)

The same image but with different gamma values has been shown here.

For example:

Gamma = 10

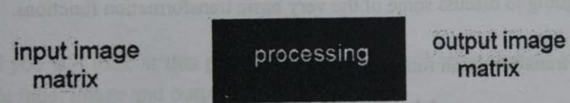
Gamma = 8

Gamma = 6

8. Define mask. 2011
Or, What is masking? 2013
Answer:
A mask is a filter. Concept of masking is also known as spatial filtering. Masking is also known as filtering. In this concept we just deal with the filtering operation that is performed directly on the image.
A sample mask has been shown below

-1	0	1
-1	0	1
-1	0	1

9. Explain the general expression for image enhancement method in special domain. How could you use it for contrast stretching. 2011
Answer:
Spatial domain



In simple spatial domain , we directly deal with the image matrix. Whereas in frequency domain , we deal an image like this.

10. What is image enhancement?2017,2014, 2013
Answer:
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.

11. Briefly explain about image transformation function. **2017**

Answer;

Image transformation.

Consider this equation

G(x,y) = T{ f(x,y) }

In this equation,

F(x,y) = input image on which transformation function has to be applied.

G(x,y) = the output image or processed image.

T is the transformation function.

This relation between input image and the processed output image can also be represented as.

s = T (r)

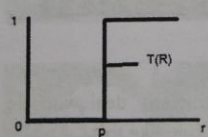
where r is actually the pixel value or gray level intensity of f(x,y) at any point. And s is the pixel value or gray level intensity of g(x,y) at any point.

The basic gray level transformation has been discussed in our tutorial of basic gray level transformations.

Now we are going to discuss some of the very basic transformation functions.

Examples

Consider this transformation function.



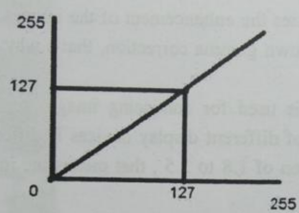
Let's take the point r to be 256, and the point p to be 127. Consider this image to be a one bpp image. That means we have only two levels of intensities that are 0 and 1. So in this case the transformation shown by the graph can be explained as.

All the pixel intensity values that are below 127 (point p) are 0, means black. And all the pixel intensity values that are greater than 127, are 1, that means white. But at the exact point of 127, there is a sudden change in transmission, so we cannot tell that at that exact point, the value would be 0 or 1.

Mathematically this transformation function can be denoted as:

$$g(x,y) = \begin{cases} 0 & f(x,y) < 127 \\ 1 & f(x,y) > 127 \end{cases}$$

Consider another transformation like this



Now if you will look at this particular graph, you will see a straight transition line between input image and output image.

It shows that for each pixel or intensity value of input image, there is a same intensity value of output image. That means the output image is exact replica of the input image.

It can be mathematically represented as:

$g(x,y) = f(x,y)$

the input and output image would be in this case are shown below.

Input image

Output image

12. What is the significance of γ in power law transformation. 2013

Answer:

Power – Law transformations

There are further two transformation is power law transformations, that include nth power and nth root transformation. These transformations can be given by the expression:

s=cr^γ

This symbol γ is called gamma, due to which this transformation is also known as gamma transformation.

Variation in the value of γ varies the enhancement of the images. Different display devices / monitors have their own gamma correction, that's why they display their image at different intensity.

This type of transformation is used for enhancing images for different type of display devices. The gamma of different display devices is different. For example Gamma of CRT lies in between of 1.8 to 2.5 , that means the image displayed on CRT is dark.

Correcting gamma.

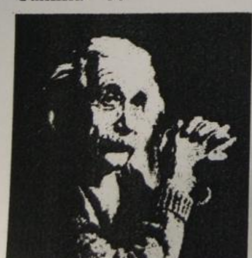
s=cr^γ

s=cr^(1/2.5)

The same image but with different gamma values has been shown here.

For example:

Gamma = 10



Gamma = 8

Gamma = 6

13. How can you balance intensity range of an image by contrast stretching? 2014

Answer:

Increasing the contrast of the image

The formula for stretching the histogram of the image to increase the contrast is

$$g(x,y) = \frac{f(x,y) - fmin}{fmax - fmin} * 2^{bpp}$$

The formula requires finding the minimum and maximum pixel intensity multiply by levels of gray. In our case the image is 8bpp, so levels of gray are 256.

The minimum value is 0 and the maximum value is 225. So the formula in our case is

$$g(x,y) = \frac{f(x,y)-0}{225-0} * 255$$

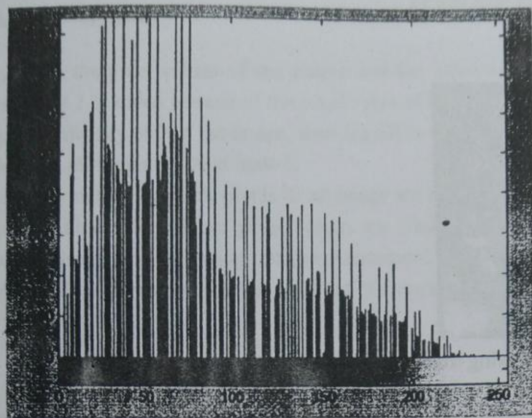
where f(x,y) denotes the value of each pixel intensity. For each f(x,y) in an image , we will calculate this formula.

After doing this, we will be able to enhance our contrast.

The following image appear after applying histogram stretching.

The stretched histogram of this image has been shown below.

Note the shape and symmetry of histogram. The histogram is now stretched or in other means expand. Have a look at it.



In this case the contrast of the image can be calculated as

Contrast = 240

Hence we can say that the contrast of the image is increased.

14. What are the formula for negative and log transformation? 2017, 2013

Answer:

Negative transformation

The second linear transformation is negative transformation, which is invert of identity transformation. In negative transformation, each value of the input image is subtracted from the L-1 and mapped onto the output image.

The result is somewhat like this.

Input Image

Output Image

In this case the following transition has been done.

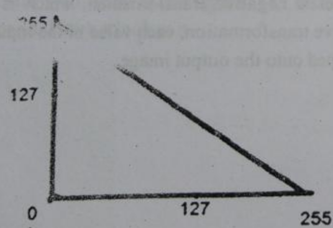
s = (L – 1) – r

since the input image of Einstein is an 8 bpp image, so the number of levels in this image are 256. Putting 256 in the equation, we get this

s = 255 – r

So each value is subtracted by 255 and the result image has been shown above. So what happens is that, the lighter pixels become dark and the darker picture becomes light. And it results in image negative.

It has been shown in the graph below.



Logarithmic transformations

Logarithmic transformation further contains two type of transformation. Log transformation and inverse log transformation.

Log transformation

The log transformations can be defined by this formula

$s = c \log(r + 1)$.

Where s and r are the pixel values of the output and the input image and c is a constant. The value 1 is added to each of the pixel value of the input image because if there is a pixel intensity of 0 in the image, then log (0) is equal to infinity. So 1 is added, to make the minimum value at least 1.

During log transformation, the dark pixels in an image are expanded as compare to the higher pixel values. The higher pixel values are kind of compressed in log transformation. This result in following image enhancement.

The value of c in the log transform adjust the kind of enhancement you are looking for.

Input Image

Log Tranform Image

The inverse log transform is opposite to log transform.

15. What is image transformation? 2014

Answer:

Consider this equation

G(x,y) = T{ f(x,y) }

In this equation,

F(x,y) = input image on which transformation function has to be applied.

G(x,y) = the output image or processed image.

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This relation between input image and the processed output image can also be represented as.

s = T (r)

where r is actually the pixel value or gray level intensity of f(x,y) at any point. And s is the pixel value or gray level intensity of g(x,y) at any point.

The basic gray level transformation has been discussed in our tutorial of basic gray level transformations.

Now we are going to discuss some of the very basic transformation functions.

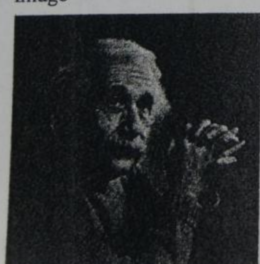
16. How can histogram equalization play major role to enhance an image. 2014

Answer:

Histogram equalization is used to enhance contrast. It is not necessary that contrast will always be increase in this. There may be some cases were histogram equalization can be worse. In that cases the contrast is decreased.

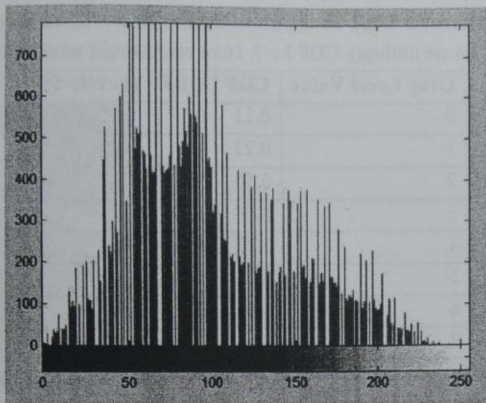
Let's start histogram equalization by taking this image below as a simple image.

Image



Histogram of this image

The histogram of this image has been shown below.



Now we will perform histogram equalization to it.

PMF

First we have to calculate the PMF (probability mass function) of all the pixels in this image. If you don't know how to calculate PMF, please visit our tutorial of PMF calculation.

CDF

Our next step involves calculation of CDF (cumulative distributive function). Again if you don't know how to calculate CDF , please visit our tutorial of CDF calculation.

Calculate CDF according to gray levels

Lets for instance consider this , that the CDF calculated in the second step looks like this.

Gray Level Value	CDF
0	0.11
1	0.22
2	0.55
3	0.66
4	0.77
5	0.88
6	0.99
7	1

Then in this step you will multiply the CDF value with (Gray levels (minus) 1) . Considering we have an 3 bpp image. Then number of levels we have are 8. And 1 subtracts 8 is 7. So we multiply CDF by 7. Here what we got after multiplying.

Gray Level Value	CDF	CDF * (Levels-1)
0	0.11	0
1	0.22	1
2	0.55	3
3	0.66	4
4	0.77	5
5	0.88	6
6	0.99	6
7	1	7

Now we have is the last step, in which we have to map the new gray level values into number of pixels.

Let's assume our old gray levels values has these number of pixels.

Gray Level Value	Frequency
0	2
1	4
2	6
3	8
4	10
5	12
6	14
7	16

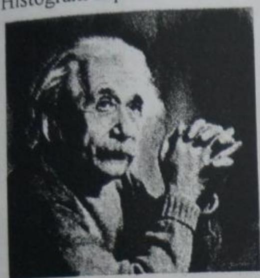
Now if we map our new values to , then this is what we got.

Gray Level Value	New Gray Level Value	Frequency
0	0	2
1	1	4
2	3	6
3	4	8
4	5	10
5	6	12
6	6	14
7	7	16

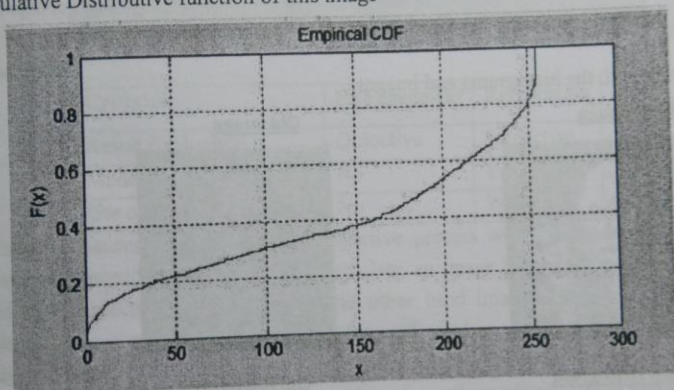
Now map these new values you are onto histogram, and you are done.

Lets apply this technique to our original image. After applying we got the following image and its following histogram.

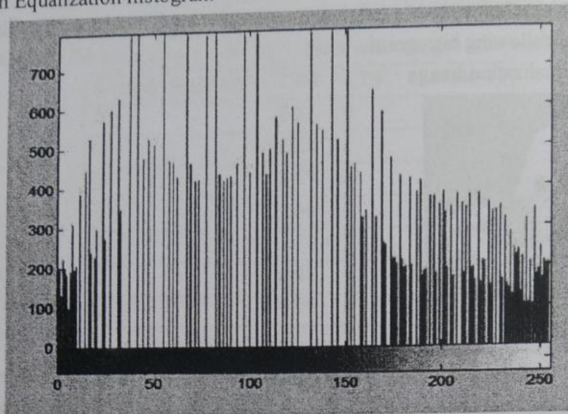
Histogram Equalization Image



Cumulative Distributive function of this image

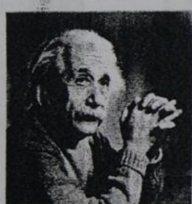


Histogram Equalization histogram



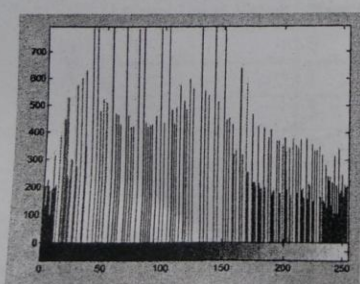
Comparing both the histograms and images

New Image

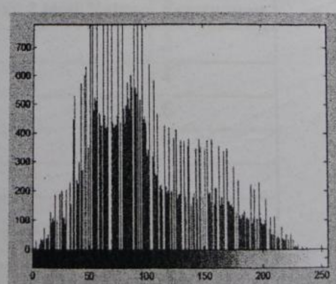


Old image

New Histogram



Old Histogram



Conclusion

As you can clearly see from the images that the new image contrast has been enhanced and its histogram has also been equalized. There is also one important thing to be note here that during histogram equalization the overall shape of the histogram changes, where as in histogram stretching the overall shape of histogram remains same.

17. Distinguish between image enhancement and image restoration technique. 2017,2014,2012

Answer:

1. Image restoration and the image enhancement techniques aim at improving the image quality and both the techniques can be performed in both spatial and frequency domains.
2. The difference between image enhancement and image restoration is given below:

Criterion	Enhancement	Restoration
Result Evaluation	Objective	Subjective
Modeling of Degradation	No	Yes
Use of Prior Knowledge	No	Yes

1. Image enhancement is largely a subjective process which means that it is a heuristic procedure designed to manipulate an image in order to achieve the pleasing aspects of a viewer. On the other hand image restoration involves formulating a criterion of goodness that will yield an optimal estimate of the desired result.
2. In image enhancement the degradation is not usually modeled. Image restoration attempts to reconstruct or recover an image that has been degraded by using the prior knowledge of the degradation. That is restoration techniques try to model the degradation and apply the inverse process in order to recover the original image.

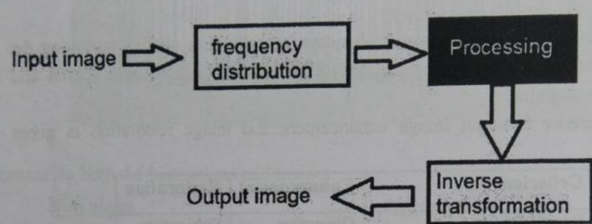
18. Write down the basic steps of filtering for frequency domain.2014

Answer:

Frequency Domain

We first transform the image to its frequency distribution. Then our black box system perform whatever processing it has to performed, and the output of the black box in this case is not an image, but a transformation. After performing inverse transformation, it is converted into an image which is then viewed in spatial domain.

It can be pictorially viewed as



19. Explain homomorphic filtering in details. 2012

Answer:

An image can be modeled as the product of an illumination function and the reflectance function at every point. Based on this fact, the simple model for an image is given by

$f(m_1, n_2) = i(n_1, n_2) \times r(n_1, n_2)$

This model is known as illumination-reflectance model. The illumination-reflectance model can be used to address the problem of improving the quality of an image that has been acquired under poor illumination conditions.

In the above equation, $f(m_1, n_2)$ represents the image, $\boxed{i(m_1, n_2)}$ represents the illumination component and $r(m_1, n_2)$ represents the reflectance component. For many images, the illumination is the primary contributor to the dynamic range and varies slowly in space, while the reflectance component $r(m_1, n_2)$ represents the details of1hc object and varies rapidly in space.

If the illumination and the reflectance components have to be handled separately, the logarithm of the input function $f(m_1, n_2)$ is taken. Because $f(m_1, n_2)$ is the product of $i(m_1, n_2)$ with $r(m_1, n_2)$, the log $f(m_1, n_2)$ separates the two components as illustrated below:

$$ln[f(m1, n2)] = ln[i(m1, n2).\, r(m1, n2)]$$
$$= ln[i(m1, n2)] + ln[r(m1, n2)]$$

Taking Fourier transform on both sides, we get

$F(k,l) = F_I(k,l) + F_R(k,l)$

where F1(k, l) and FR(k, l) arc the Fourier transform of the illumination and reflectance components respectively. Then, the desired filter function H(k.l) can be applied separately to the illumination and the reflection component separately as shown below:

$F(k,l) \times H(k,l) = F_I(k,l) \times H(k,l) + F_R(k,l) \times H(k,l)$

In order to visualize the image, inverse Fourier transform followed by exponential function is applied. First, the inverse Fourier transform is applied as shown below:

$f'(n_1, n_2) = I^{-1}[F(k,l) \times H(k,l)] = I^{-1}[F_I(k,l) \times H(k,l)] + I^{-1}[F_R(k, l \times H(k,l)]$

The desired enhanced image is obtained by taking the exponential operation as given below:

$g(n_1, n_2) = e^{f(n_1, n_2)}$

Hence, $g(m_1, n_2)$ represents the enhanced version of the original image $f(m_1, n_2)$. The sequence of operation can be represented by a block diagram as shown in fig

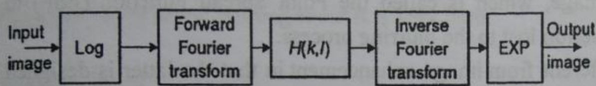


Figure 1. Homomorphic Filter

Chapter 4
Image restoration

1. What do you mean by image restoration? 2012,2017

Answer:

Image Restoration is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as motion blur, noise and camera mis-focus. Image restoration is performed by reversing the process that blurred the image and such is performed by imaging a point source and use the point source image, which is called the Point Spread Function (PSF) to restore the image information lost to the blurring process.

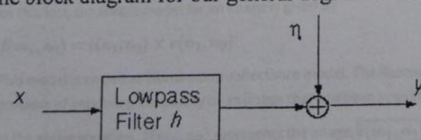
Image restoration is different from image enhancement in that the latter is designed to emphasize features of the image that make the image more pleasing to the observer, but not necessarily to produce realistic data from a scientific point of view. Image enhancement techniques (like contrast stretching or de-blurring by a nearest neighbor procedure) provided by imaging packages use no a priori model of the process that created the image.

2. Describe the image degradation process. 2017

Answer:

Degradation Model

The block diagram for our general degradation model is



where g is the corrputed image obtained by passing the original image f through a low pass filter (blurring fuction) b and adding noise to it. We present four different ways of restoring the image.

I. <u>Inverse Filter</u>

In this method we look at an image assuming a known blurring function. We will see that restoration is good when noise is not present and not so good when it is.

II. Weiner Filtering

In this section we implement image restoration using wiener filtering, which provides us with the optimal trade-off between de-noising and inverse filtering. We will see that the result is in general better than with straight inverse filtering.

III. Wavelet Restoration

We implement three wavelet bassed algorithms to restore the image.

IV. Blind De convolution

In this method, we assume nothing about the image. We do not have any information about the blurring function or on the additive noise. We will see that restoring an image when we know nothing about it is very hard.

V. Conclusions

Nothing but the conclusions.

3. List reasons for occuraring noise in an image. 2012

Answer:

What Causes Noise?

Truly knowing how to reduce or eliminate noise is better served by knowing what causes it. In photography there are several causes of noise.

The first scenario is that image sensor heat can increase enough to stimulate electrons ("Thermal Noise"). These superfluous electrons then get mixed in with the "true" photoelectrons that are the real target of our image sensor. The analog signal (which is converted to pixels by the sensor) is therefore contaminated before it even gets to that point.

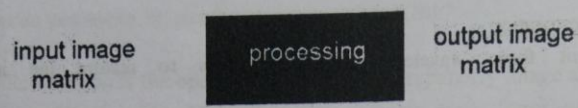
In some situations the above scenario can cause each of the photo sites on an image sensor to generate superfluous signals which can then contaminate the neighboring photo sites. On smaller image sensors which cram more photo sites into a smaller area, this effect can be magnified.

Another common cause of noise is shooting at higher ISO settings. As these settings basically magnify the light signal, they also magnify other unwanted signals such as background interference (eg. heat sources). When you are photographing an area of low light, the background signals can be strong enough to compete with the signals from the limited light of the area you are shooting.

4. Write down the spatial and frequency properties of noise. 2017,2012

Answer:

Spatial domain

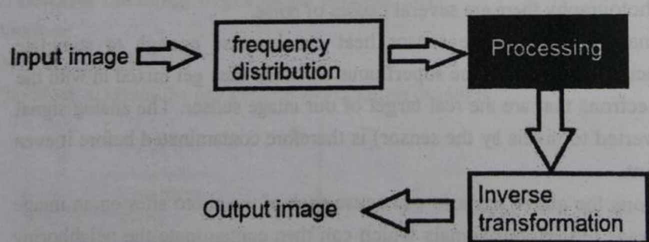


In simple spatial domain, we directly deal with the image matrix. Whereas in frequency domain, we deal an image like this.

Frequency Domain

We first transform the image to its frequency distribution. Then our black box system perform whatever processing it has to performed, and the output of the black box in this case is not an image, but a transformation. After performing inverse transformation, it is converted into an image which is then viewed in spatial domain.

It can be pictorially viewed as

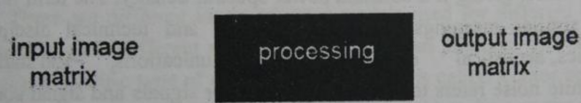


5. What is white noise? Mention the spatial and frequency properties of a noise. 2017

Answer:

In signal processing, white noise is a random signal having equal intensity at different frequencies, giving it a constant power spectral density. The term is used, with this or similar meanings, in many scientific and technical disciplines, including physics, acoustical engineering, telecommunications, and statistical forecasting. White noise refers to a statistical model for signals and signal sources, rather than to any specific signal. White noise draws its name from light, although light that appears white generally does not have a flat power spectral density over the visible band.

Spatial domain



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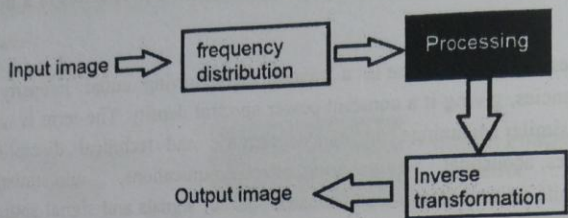

6. What is white noise? 2012

Answer:

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Chapter 5
Color image processing

1. What do you mean by color model? Write about color fundamentals. 2017

Answer:

What Is a Color Model?

Have you ever looked at the brilliant color on your computer screen or in a glossy magazine and wonder how it got there? Did you know putting the color in those mediums requires very different processes? And those processes have to start with a color model?

A color model is a system that uses three primary colors to create a larger range of colors. There are different kinds of color models used for different purposes, and each has a slightly different range of colors they can produce. The whole range of colors that a specific type of color model produces is called a color space. All color results from how our eye processes light waves, but depending on the type of media, creating that color comes from different methods.

The RGB Color Model

There are two basic kinds of color models, additive and subtractive. Let's look at an additive color model first. The most common one is Red/Green/Blue, usually referred to as RGB. This color model uses light to create color, and it is used for digital media. When you play a game on your smart phone or watch an action movie on TV, you are seeing color in an RGB color space. RGB is called an additive color model because when the three colors of light are shown in the same intensity at the same time, they produce white. If all the lights are out, they create black.

The CMYK Color Model

When printing color images, you can't use colored light, and that means images cannot be printed in RGB. That is where the other color model comes in. A subtractive color model adds pigment in the form of ink or dye that causes an absence of white. The most common subtractive color model is Cyan/Magenta/Yellow/Black, usually referred to as CMYK. It is what printers use, and you will sometimes also see it called process color because it is used in the four color printing process. To print a color image on paper, you have to use ink. Starting with the bright white paper surface, the colors are printed according to a pattern. The more color is applied, the more the white surface is masked. That is why it is called subtractive. But why the addition of black ink? Because when all the colors are mixed, they create a muddy brown. To get rich deep black, you have to use black ink.

8) What is color model. 2015

A **color model** is a system that uses three primary colors to create a larger range of colors. There are different kinds of color models used for different purposes, and each has a slightly different range of colors they can produce. The whole range of colors that a specific type of color model produces is called a **color space**. All color results from how our eye processes light waves, but depending on the type of media, creating that color comes from different methods.

9) Define HUE, Saturation and Luminance. 2015

Answer:

Hue, saturation, and brightness are aspects of color in the red, green, and blue (RGB) scheme. These terms are most often used in reference to the color of each pixel in a cathode ray tube (CRT) display. All possible colors can be specified according to hue, saturation, and brightness (also called brilliance), just as colors can be represented in terms of the R, G, and B components.

10) Define psycho-visual redundancy. 2015,2013

Answer:

Psycho visual Redundancy:

- The Psycho visual redundancies exist because human perception does not involve quantitative analysis of every pixel or luminance value in the image.
- It's elimination is real visual information is possible only because the information itself is not essential for normal visual processing.

11) Differentiate between RGB and CMY color model. 2017,2013

Answer:

1. RGB is used to create images in screens and display while CMYK is used in printing to paper or other media
2. Both reproduces colors buy placing individual colors close to each other in order to fool the eye
3. RGB is an additive color model while CMYK is a subtractive color model

4. CMYK uses an additional color which is black rather than reproducing black by combining the three colors

12) What do you mean by radiance, luminance and brightness? 2012

Answer:

In radiometry, radiance is the radiant flux emitted, reflected, transmitted or received by a given surface, per unit solid angle per unit projected area. Spectral radiance is the radiance of a surface per unit frequency or wavelength, depending on whether the spectrum is taken as a function of frequency or of wavelength.

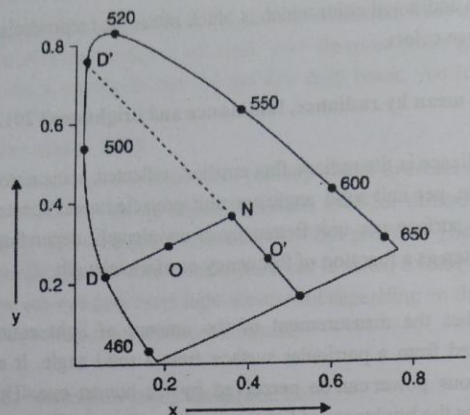
Luminance describes the measurement of the amount of light emitting, passing through or reflected from a particular surface from a solid angle. It also indicates how much luminous power can be perceived by the human eye. This means that luminance indicates the brightness of light emitted or reflected off of a surface.

Brightness is the perceived intensity of light coming from a screen. On a color screen, it is the average of the red, green and blue pixels on the screen. Brightness is important to both color perception and battery life on mobile devices. It can be adjusted manually or automatically with sensors.

13) How chromaticity diagram formed? 2012

Answer:

The chromaticity diagram provides us two measures, which approximately correlate with the perceptual attributes: hue and saturation. As shown in Fig. 7.2, a line is drawn from the neutral point N (location of the illuminant in the case of colored light, and of the perfect diffuser in the case of surface colour) O and O in the chromaticity diagram to intersect the locus of the spectrum colours. The wavelength of the monochromatic light at the point of intersection (point D) with the horseshoe-shaped curve is termed the dominant wavelength, λd, for the respective test colour.



Sign in to download full-size image

7.2. Calculation of dominant wavelength and excitation purity.

In the case of point O′, the line intersects at the non-spectral purple boundary and it is not possible to assess the dominant wavelength directly. Therefore the line is extended in the opposite direction, where it cuts the spectrum locus at D′. The wavelength at that point is known as the complementary wavelength, λ_c, for the test colour O′. The complementary wavelength is the wavelength of the spectral colour which, when additively mixed with the test colour (O′ in this case), can match the achromatic colour. Dominant or complementary wavelengths may be considered approximately correlated with the hue of the test colour. However, the loci of constant hue are not actually straight lines.

Chapter 6
Image compression

1. What is image compression? 2015

Answer:

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages.

2. Write down the difference between lossy and lossless compression method. 2015,2013

BASIS FOR COMPARISON	LOSSY COMPRESSION	LOSSLESS COMPRESSION
Basic	Lossy compression is the family of data encoding method that utilizes imprecise estimates to represent the content.	Lossless compression is a group of data compression algorithms that permits the original data to be accurately rebuilt from the compressed data.
Algorithm	Transform coding, DCT, DWT, fractal compression, RSSMS.	RLW, LZW, Arithmetic encoding, Huffman encoding, Shannon Fano coding.
Used in	Images, audio and video.	Text or program, images and sound.
Application	JPEG, GUI, MP3, MP4, OGG, H-264, MKV, etc.	RAW, BMP, PNG, WAV, FLAC, ALAC etc.
Data-holding capacity of the channel	More	Less as compared to lossy method

3. What is data redundancy?2013

Or, What do you mean by data redundancy?2014, 2012

Answer: Data redundancy is a condition created within a database or data storage technology in which the same piece of data is held in two separate places.

This can mean two different fields within a single database, or two different spots in multiple software environments or platforms. Whenever data is repeated, this basically constitutes data redundancy. This can occur by accident, but is also done deliberately for backup and recovery purposes

4. Identify the basic data redundancies. 2012

Answer:

Within the general definition of data redundancy, there are different classifications based on what is considered appropriate in database management, and what is considered excessive or wasteful. Wasteful data redundancy generally occurs when a given piece of data does not have to be repeated, but ends up being duplicated due to inefficient coding or process complexity.

A positive type of data redundancy works to safeguard data and promote consistency. Many developers consider it acceptable for data to be stored in multiple places. The key is to have a central, master field or space for this data, so that there is a way to update all of the places where data is redundant through one central access point. Otherwise, data redundancy can lead to big problems with data inconsistency, where one update does not automatically update another field. As a result, pieces of data that are supposed to be identical end up having different values.

5. Describe the subjective and objective fidelity criteria. 2013

Answer: The criteria for an assessment of a quality of an image are (i) Objective Fidelity Criteria and (ii) Subjective Fidelity Criteria.

1. **Objective Fidelity Criteria:**

- Mean Square Error (MSE): Let f(x,y) represent an input image and let f^(x,y)f^(x,y) denote an estimate or approximate of f(x,y) for any value of x and y, The mean squared error is defined as,

$$MSE = \frac{1}{MxN}\sum_{x=0}^{M-1} /sum_{y=0}^{N-1}[f(x,y)-\hat{f}(x,y)]^2$$

- Signal to Noise Ratio (SNR):

$$SNR = \frac{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y)]^2}{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y)-\hat{f}(x,y)]^2}$$

1. **Subjective Fidelity Criteria:**

- Images are viewed by human beings. Therefore measuring image quality by the subjective evaluations of a human observer is more appropriate. This can be accomplished by showing a typical decompressed image to an appropriate cross section of viewers and averaging their evaluations.
- The evaluations may be made by using an absolute rating scale or by means of side by side comparison of f(x,y)and f˜(x,y).
- Side by side comparisons can be done with the following scale: - {1, 2, 3, 4, 5, 6}to represent evaluations such as {Excellent, Fine, Passable, Marginal, Inferior, Unusable} respectively. - {-3, -2, -1, 0, 1, 2, 3} to represent subjective evaluations such as {much worse, worse, slightly worse, the same, slightly better, better, much better} respectively.

6. Explain lossy predictive coding. 2014

Or, Explain lossless predictive coding model. 2012

Answer:

. If the data we are attempting to compress consists of numerical values, such as images, using context-based approaches directly can be problematic.

ii. There are several reasons for this. Most context-based schemes exploit exact reoccurrence of patterns.

iii. Images are usually acquired using sensors that have a small amount of noise. While this noise may not be perceptible, it is sufficient to reduce the occurrence of exact repetitions of patterns.

iv. A simple alternative to using the context approach is to generate a prediction for the value to be encoded and encode the prediction error.

v. If there is considerable dependence among the values with high probability, the prediction will be close to the actual value and the prediction error will be a small number.

vi. We can encode this small number, which as it occurs with high probability will require fewer bits to encode

vii. By plotting histogram of the difference between neighbouring pixels. we can observe that small differences occur much more frequently and therefore can be encoded using fewer bits.

viii. Because of the strong correlation between pixels in a neighbourhood, predictive coding has been highly effective for image compression. It is used in the JPEG-LS, which is the standard for lossless image compression.

ix. The function of the predictor is to obtain an estimate of the current sample based on the reconstructed values of the past sample.

x. The requirement that the prediction algorithm use only the reconstructed values is to ensure that the prediction at both the encoder and the decoder are identical.

xi. The reconstructed values used by the predictor, and the prediction algorithm, are dependent on the nature of the data being encoded.

For example, for speech coding the predictor often uses the immediate past several values of the sequence, along with a sample that is a pitch period away, to form the prediction.

7. Draw an image compression system and explain how it works. 2012

Answer:

Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form

How Does Image Compression Work

There are two kinds of image compression methods - lossless vs lossy. Let's take a quick look at them both.

Lossless Compression#

Lossless compression is a method used to reduce the size of a file while maintaining the **same quality as before it was compressed**. For example, in a DSLR camera, you probably have the option to save photos as either RAW or JPEG. RAW files have no compression and are great if you're a professional photo editor. But they take up more space. JPEG, on the other hand, won't fill up your hard drive as fast, but some of the data is lost in the conversion.

Types of lossless images include:

- **RAW** - Found in many DSLRs, and keeps all the light data received from the camera's sensor. For a professional, this great news. However, these files types tend to be quite large in size. Additionally, there are different versions of RAW, and you may need certain software to edit the files.
- **PNG** - Compresses images to keep their small size by looking for patterns on a photo, and compressing them together. The compression is reversible, so once you open a PNG file, the image recovers exactly.
- **BMP** - A format found exclusively to Microsoft. It's lossless, but not frequently used.

It should also be noted that converting a lossy photo back to lossless won't restore the photo's data.

Lossy Compression#

In order to give the photo an even smaller size, lossy compression discards some parts of a photo. However, this doesn't mean the photo will look bad. Here are the two main types of lossy compression.

JPG#

Also known as JPEG, this format gets rid of bits and pieces of a photo that you may notice depending upon the level of compression you apply. A normal amount of compression will not be noticeable, while extreme compression may be obvious.

There are also other ways a JPG image's quality may be reduced. If you rotate the JPG too much, you'll notice a difference in quality. This is because the photo has to **recompress itself with every rotation**, losing some data in the process. There are however programs out there that rotate a JPG losslessly. The same degradation applies if you save a JPG multiple times.

GIF#

GIF compresses files by reducing the number of colors it has. If the photo has more than 256 colors (the maximum amount of colors older computers could have) this format will make the image look less appealing. The best use for GIFs are for images that are animated.

The example below shows a comparison between GIF images which range from 8 colors to 256 colors.

8. What is image compression? What are the application areas of image compression. 2013

Answer:

Digital images are very large in size and hence occupy larger storage space. Due to their larger size, they take larger bandwidth and more time for upload or download through the Internet. This makes it inconvenient for storage as well as file sharing. To combat with this problem, the images are compressed in size with special techniques. This compression not only helps in saving storage space but also enables easy sharing of files. Image compression applications reduce the size of an image file without causing major degradation to the quality of the image.

Image Compression Applications

Image compression applications make use of various techniques and algorithms in compressing images. The techniques thus used by image compression applications can be classified as lossless and lossy compression. The method of compression used depends on the desired quality of output. If the image compression application is expected to produce a very high quality output without any loss in fidelity, lossless compression technique is used. This technique is used where a high degree of accuracy is a must. In applications where some quality can be compromised, lossy compression technique is used. In lossy compression, there is minor loss of quality, but the loss is too little to be visible. This technique is used in applications where a little compromise on quality of image is acceptable.

9. How an image is compressed using JPEG image compression standard? 2013

Answer:

JPEG compression

JPEG stands for Joint photographic experts group. It is the first international standard in image compression. It is widely used today. It could be lossy as well as lossless . But the technique we are going to discuss here today is lossy compression technique.

How jpeg compression works

First step is to divide an image into blocks with each having dimensions of 8 x8.

Let's for the record, say that this 8x8 image contains the following values.

$$\begin{bmatrix} 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\ 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\ 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\ 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\ 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\ 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\ 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \end{bmatrix}$$

The range of the pixels intensities now are from 0 to 255. We will change the range from -128 to 127.

Subtracting 128 from each pixel value yields pixel value from -128 to 127. After subtracting 128 from each of the pixel value, we got the following results.

$$\begin{bmatrix} -76 & -73 & -67 & -62 & -58 & -67 & -64 & -55 \\ -65 & -69 & -73 & -38 & -19 & -43 & -59 & -56 \\ -66 & -69 & -60 & -15 & 16 & -24 & -62 & -55 \\ -65 & -70 & -57 & -6 & 26 & -22 & -58 & -59 \\ -61 & -67 & -60 & -24 & -2 & -40 & -60 & -58 \\ -49 & -63 & -68 & -58 & -51 & -60 & -70 & -53 \\ -43 & -57 & -64 & -69 & -73 & -67 & -63 & -45 \\ -41 & -49 & -59 & -60 & -63 & -52 & -50 & -34 \end{bmatrix}$$

Now we will compute using this formula.

$$G_{u,v} = \alpha(u)\alpha(v)\sum_{x=0}^{7}\sum_{y=0}^{7} g_{x,y}\cos\left[\frac{\pi}{8}\left(x+\frac{1}{2}\right)u\right]\cos\left[\frac{\pi}{8}\left(y+\frac{1}{2}\right)v\right]$$

$$\alpha_p(n) = \begin{cases} \sqrt{\frac{1}{8}}, & \text{if } n = 0 \\ \sqrt{\frac{2}{8}}, & \text{otherwise} \end{cases}$$

The result comes from this is stored in let's say A(j,k) matrix.
There is a standard matrix that is used for computing JPEG compression, which is given by a matrix called as Luminance matrix.
This matrix is given below

$$Q_{j,k} = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Applying the following formula

$$B_{j,k} = \text{round}\left(\frac{A_{j,k}}{Q_{j,k}}\right)$$

We got this result after applying.

$$B_{j,k} = \begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Now we will perform the real trick which is done in JPEG compression which is ZIG-ZAG movement. The zig zag sequence for the above matrix is shown below. You have to perform zig zag until you find all zeroes ahead. Hence our image is now compressed.

$$B_{j,k} = \begin{bmatrix} -26 & -3 & -6 & 2 & 2 & -1 & 0 & 0 \\ 0 & -2 & -4 & 1 & 1 & 0 & 0 & 0 \\ -3 & 1 & 5 & -1 & -1 & 0 & 0 & 0 \\ -4 & 1 & 2 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Summarizing JPEG compression

The first step is to convert an image to Y'CbCr and just pick the Y' channel and break into 8 x 8 blocks. Then starting from the first block, map the range from -128 to 127. After that you have to find the discrete Fourier transform of the matrix. The result of this should be quantized. The last step is to apply encoding in the zig zag manner and do it till you find all zero.

Chapter 07

Image segmentation

1. **What do you mean by Huffman coding? Analyze the two steps of Huffman coding with an appropriate example.2014**
   Or, Explain the Huffman Coding. 2015

Answer:

Prefix Codes, means the codes (bit sequences) are assigned in such a way that the code assigned to one character is not the prefix of code assigned to any other character. This is how Huffman Coding makes sure that there is no ambiguity when decoding the generated bit stream.

Let us understand prefix codes with a counter example. Let there be four characters a, b, c and d, and their corresponding variable length codes be 00, 01, 0 and 1. This coding leads to ambiguity because code assigned to c is the prefix of codes assigned to a and b. If the compressed bit stream is 0001, the de-compressed output may be "cccd" or "ccb" or "acd" or "ab".

See this for applications of Huffman Coding.

There are mainly two major parts in Huffman Coding

1) Build a Huffman Tree from input characters.

2) Traverse the Huffman Tree and assign codes to characters.

Steps to build Huffman Tree

Input is an array of unique characters along with their frequency of occurrences and output is Huffman Tree.

1) Create a leaf node for each unique character and build a min heap of all leaf nodes (Min Heap is used as a priority queue. The value of frequency field is used to compare two nodes in min heap. Initially, the least frequent character is at root)

2) Extract two nodes with the minimum frequency from the min heap.

3) Create a new internal node with a frequency equal to the sum of the two nodes frequencies. Make the first extracted node as its left child and the other extracted node as its right child. Add this node to the min heap.

4) Repeat steps#2 and #3 until the heap contains only one node. The remaining node is the root node and the tree is complete.

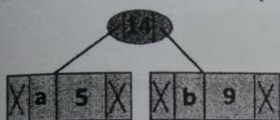
2) Let us understand the algorithm with an example:

3) character Frequency

a	5
b	9
c	12
d	13
e	16
f	45

Step 1. Build a min heap that contains 6 nodes where each node represents root of a tree with single node.

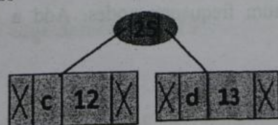
Step 2 Extract two minimum frequency nodes from min heap. Add a new internal node with frequency 5 + 9 = 14.



Now min heap contains 5 nodes where 4 nodes are roots of trees with single element each, and one heap node is root of tree with 3 elements

character	Frequency
c	12
d	13
Internal Node	14
e	16
f	45

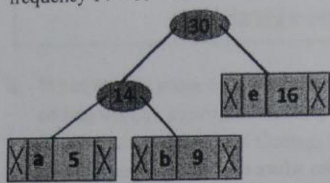
Step 3: Extract two minimum frequency nodes from heap. Add a new internal node with frequency 12 + 13 = 25



Now min heap contains 4 nodes where 2 nodes are roots of trees with single element each, and two heap nodes are root of tree with more than one nodes.

character	Frequency
Internal Node	14
e	16
Internal Node	25
f	45

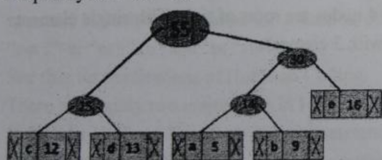
Step 4: Extract two minimum frequency nodes. Add a new internal node with frequency 14 + 16 = 30



Now min heap contains 3 nodes.

character	Frequency
Internal Node	25
Internal Node	30
f	45

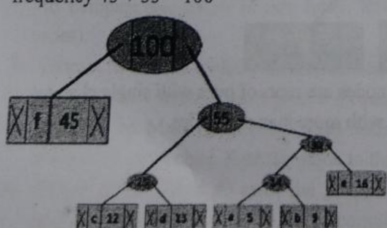
Step 5: Extract two minimum frequency nodes. Add a new internal node with frequency 25 + 30 = 55



Now min heap contains 2 nodes.

character	Frequency
f	45
Internal Node	55

Step 6: Extract two minimum frequency nodes. Add a new internal node with frequency 45 + 55 = 100



Now min heap contains only one node.

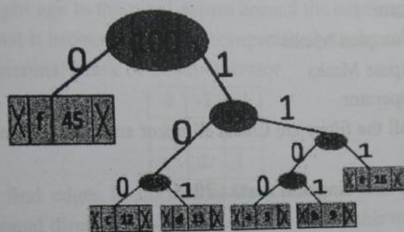
character Frequency

Internal Node 100

Since the heap contains only one node, the algorithm stops here.

Steps to print codes from Huffman Tree:

Traverse the tree formed starting from the root. Maintain an auxiliary array. While moving to the left child, write 0 to the array. While moving to the right child, write 1 to the array. Print the array when a leaf node is encountered.



The codes are as follows:

character	code-word
f	0
c	100
d	101
a	1100
b	1101
e	111

2. What do you mean by edge detection?2015

Answer:

What are edges

We can also say that sudden changes of discontinuities in an image are called as edges. Significant transitions in an image are called as edges.

Types of edges

Generally edges are of three types:

- Horizontal edges
- Vertical Edges
- Diagonal Edges

Why detect edges

Most of the shape information of an image is enclosed in edges. So first we detect these edges in an image and by using these filters and then by enhancing those areas of image which contains edges, sharpness of the image will increase and image will become clearer.

Here are some of the masks for edge detection that we will discuss in the upcoming tutorials.

- Prewitt Operator
- Sobel Operator
- Robinson Compass Masks
- Krisch Compass Masks
- Laplacian Operator.

Above mentioned all the filters are Linear filters or smoothing filters.

3. Write down the sobel diagonal masks.2015

Answer:

The sobel operator is very similar to Prewitt operator. It is also a derivate mask and is used for edge detection. Like Prewitt operator sobel operator is also used to detect two kinds of edges in an image:

- Vertical direction
- Horizontal direction

Difference with Prewitt Operator

The major difference is that in sobel operator the coefficients of masks are not fixed and they can be adjusted according to our requirement unless they do not violate any property of derivative masks.

Following is the vertical Mask of Sobel Operator:

-1	0	1
-2	0	2
-1	0	1

This mask works exactly same as the Prewitt operator vertical mask. There is only one difference that is it has "2" and "-2" values in center of first and third column. When applied on an image this mask will highlight the vertical edges.

How it works

When we apply this mask on the image it prominent vertical edges. It simply works like as first order derivate and calculates the difference of pixel intensities in a edge region.

As the center column is of zero so it does not include the original values of an image but rather it calculates the difference of right and left pixel values around that edge. Also the center values of both the first and third column is 2 and -2 respectively.

This give more weight age to the pixel values around the edge region. This increase the edge intensity and it become enhanced comparatively to the original image.

Following is the horizontal Mask of Sobel Operator

-1	-2	-1
0	0	0
1	2	1

Above mask will find edges in horizontal direction and it is because that zeros column is in horizontal direction. When you will convolve this mask onto an image it would prominent horizontal edges in the image. The only difference between it is that it have 2 and -2 as a center element of first and third row.

4. Describe the criteria for edge linking. 2015

Answer:

Edge detectors yield pixels in an image lie on edges.

The next step is to try to collect these pixels together into a set of edges.

Thus, our aim is to replace many points on edges with a few edges themselves.

The practical problem may be much more difficult than the idealised case.

- Small pieces of edges may be missing,
- Small edge segments may appear to be present due to noise where there is no real edge, etc.

In general, edge linking methods can be classified into two categories:

Local Edge Linkers

-- where edge points are grouped to form edges by considering each point's relationship to any neighboring edge points.

Global Edge Linkers

-- where all edge points in the image plane are considered at the same time and sets of edge points are sought according to some similarity constraint, such as points which share the same edge equation.

5. Explain the region growing segmentation with example. 2015

Answer:

Segmentation divides an image into its constituent parts or objects. Level of subdivision depends on the problem being solved. Segmentation stops an object of interest in an application have been isolated. Segmentation is concerned with dividing an image into meaningful regions. For example, for an air to ground target acquisition system, interest may lie in identifying vehicles on the road.

-segment the road from the image

-segment contents of the road down to objects of a range of size that corresponds to the potential vehicle

-no need to go below this level or segment outside the road boundary

Segmentation algorithm for monochrome images is based on one of the two basic properties of grey level values.

1.Discontinuity

2. Similarity

The segmentation algorithm is pixel oriented. For discontinuity the approaches to partition an image based on abrupt changes in grey level.

The region in the image is a group of connected pixels with similar properties. Each pixel is assigned to a particular object or region.

Region Growing:

Region growing is an approach to image segmentation in which neighboring pixels are examined and added to a region class if edges are detected.

This process is iterated for each boundary pixel in the region. Adjacent region is found a region merging algorithm is used in which weak edges are dissolved and strong edges are left intact.

Region growing requires a seed, to begin with. Initially, the seed would be a region, but it would be a single pixel. A new segment is grown from the seed by eliminating as many neighboring cells as possible that meet the homogeneity criteria. The resultant segment is then recovered from the process.

A new seed is chosen from the remaining pixel. This continues until all pixels have been allocated to a segment. The selection of homogeneity criteria in image growing depends not only on the problem under consideration but also on the type of image to be segmented.

Region growing algorithm varies depending on the criteria used to decide whether a pixel should be considered in the region or not. The connectivity type used to determine neighbors and the strategy used to visit neighboring pixels.

6.What is image segmentation ? 2013

Answer:

Segmentation divides an image into its constituent parts or objects. Level of subdivision depends on the problem being solved. Segmentation stops an object of interest in an application have been isolated. Segmentation is concerned with dividing an image into meaningful regions. For example, for an air to ground target acquisition system, interest may lie in identifying vehicles on the road.

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Segmentation algorithm for monochrome images is based on one of the two basic properties of grey level values.

1.Discontinuity

2. Similarity

The segmentation algorithm is pixel oriented. For discontinuity the approaches to partition an image based on abrupt changes in grey level.

7. Write down the importance of edge detection. 2013

Answer:

Most of the shape information of an image is enclosed in edges. So first we detect these edges in an image and by using these filters and then by enhancing those areas of image which contains edges, sharpness of the image will increase and image will become clearer.

Here are some of the masks for edge detection that we will discuss in the upcoming tutorials.

- Prewitt Operator
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- Krisch Compass Masks
- Laplacian Operator.

Above mentioned all the filters are Linear filters or smoothing filters.

8. Discuss about region based segmentation. 2014

Answer:

The region in the image is a group of connected pixels with similar properties. Each pixel is assigned to a particular object or region.

Region Growing:

Region growing is an approach to image segmentation in which neighboring pixels are examined and added to a region class if edges are detected.

This process is iterated for each boundary pixel in the region. Adjacent region is found a region merging algorithm is used in which weak edges are dissolved and strong edges are left intact.

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Region growing algorithm varies depending on the criteria used to decide whether a pixel should be considered in the region or not. The connectivity type used to determine neighbors and the strategy used to visit neighboring pixels.

9. Define image subtraction, image negative and gray level slicing. 2012

Image subtraction

Image subtraction or **pixel** subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for one of two reasons – leveling uneven sections of an image such as half an image having a shadow on it, or detecting changes between two images. This detection of changes can be used to tell if something in the image moved. This is commonly used in fields such as astrophotography to assist with the computerized search for asteroids or Kuiper belt objects in which the target is moving and would be in one place in one image, and another from an image one hour later and where using this technique would make the fixed stars in the background disappear leaving only the target.

image negative

In photography, a **negative** is an image, usually on a strip or sheet of transparent plastic film, in which the lightest areas of the photographed subject appear darkest and the darkest areas appear lightest. This reversed order occurs because the extremely light-sensitive chemicals a camera film must use to capture an image quickly enough for ordinary picture-taking are darkened, rather than bleached, by exposure to light and subsequent photographic processing.

In the case of color negatives, the colors are also reversed into their respective complementary colors. Typical color negatives have an overall dull orange tint due to an automatic color-masking feature that ultimately results in improved color reproduction.