JYOTI NIVAS COLLEGE

POST GRADUATE CENTRE

DEPARTMENT OF MCA

TECH-ON-TAP

TECH-ON-TAP

E- JOURNAL ON
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Image Acquisition

Image Acquisition in Digital Image Processing

- Image Acquisition is the first step in any image processing system.
- The general aim of any image acquisition is to transform an optical
- Image (real-world data)into an array of numerical data which could be later manipulated on a computer.
- Image acquisition is achieved by suitable cameras.
- Now the incoming energy is transformed into a voltage by the combination of input electrical power and sensor material of the camera.

Image Acquisition Sensors:

- Single Sensor
- Line Sensor
- Array Sensor

Image Acquisition Using Single Sensor:

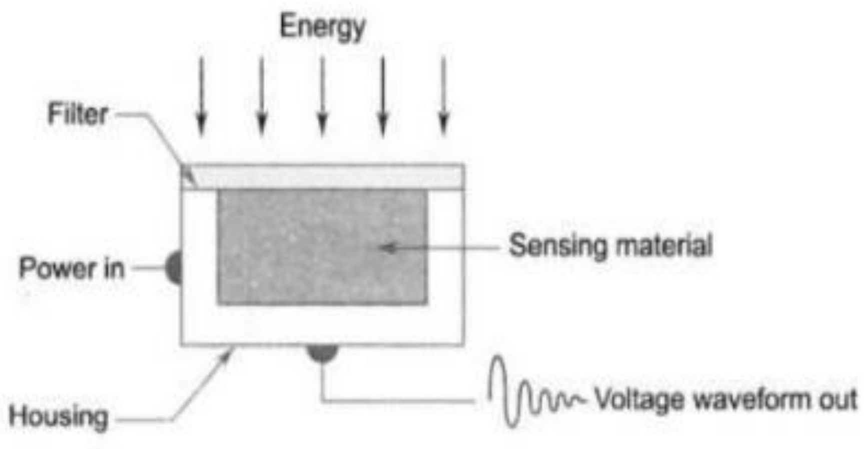

Fig: Single image sensor

An Example of a single sensor is a photo diode .Now to obtain a two-dimensional image using a single sensor, the motion should be in both x and y direction.

- Rotation provides motion in one direction.
- Linear motion provides in the perpendicular direction.

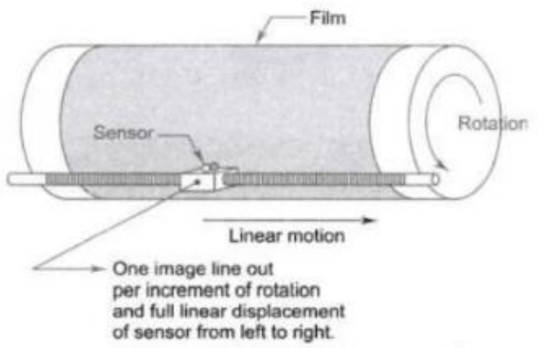

Fig: Combining a single sensor with motion to generate a 2D image

This is an in expensive method and we can obtain high-resolution images with high precision control.

Image Acquisition using a line sensor:

- The sensor strip provides imaging in one direction.
- Motion perpendicular to the strip provides imaging in other direction.
- This type of arrangement is used in most of the flat bed sensors.

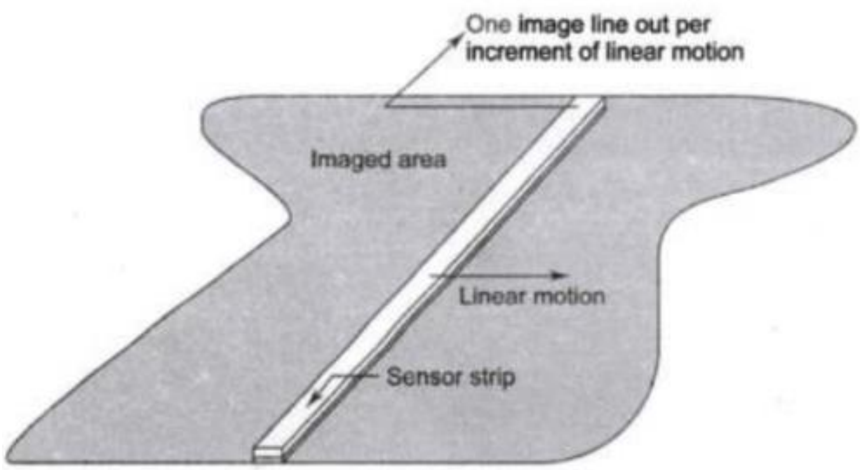

Fig: Linear sensor strip

Image Acquisition using array sensor:

- In this,individual sensor are arranged in form of 2-D array
- This type of arrangement is found in digital cameras CCD array
- In this,the response of each sensor is proportional to the integral of the light energy projected onto the surface of the sensor.
- Noise reduction is achieved by letting the sensor integrate the input light signal over minutes or even hours.

Reference

https://www.studocu.com/in/document/anna-university/digital-image-processing/image-acquisition-in-digital-image-processing/29810630

Calibration In Image Processing

Rakshitha J
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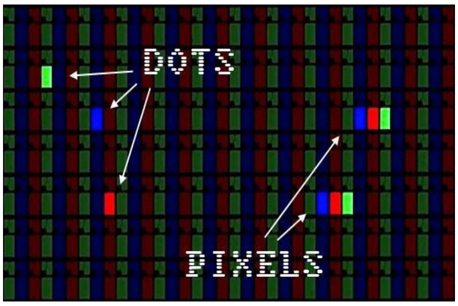
Image calibration provides a pixel-to-real-distance conversion factor (i.e. the calibration factor, pixels/cm), that allows image scaling to metric units. This information can be then used throughout the analysis to convert pixel measurements performed on the image to their corresponding values in the real world. Each image or extracted bounding box can have different specifications and metadata.

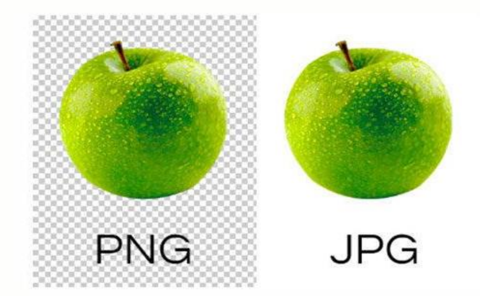
For Example: i) 250 mm in JPG format can be different from 250 mm in PNG format.
ii) 250 mm in JPG format at 140 DPI can be different from 250 mm in JPG at 144 DPI.

- **Resolution:** In layman's words, higher the resolution, higher the details and depth of image. How detailed data image holds is the resolution. Edges & features of images are blurred in low resolution images and that's why we lose clarity.
- **PPI:** PPI of Image stands for Pixels Per Inch .Screen resolution is measured in PPI.A pixel is a tiny square of color. A monitor uses tiny pixels to assemble text and images on screen.



- **DPI:** Dpi of image image stands for dots per inch. How much dots are included per 1 DPI is describe by DPI. 300 DPI means that a printer will output 300 tiny dots of ink to fill every inch of the Print.
- **JPG:** JPG is image format which means "Joint Photographic Experts Group". Most of links assume JPG and JPEG format as same.
- **PNG:** "Portable Network Graphics" is a raster-graphics file formats that supports lossless data compression.

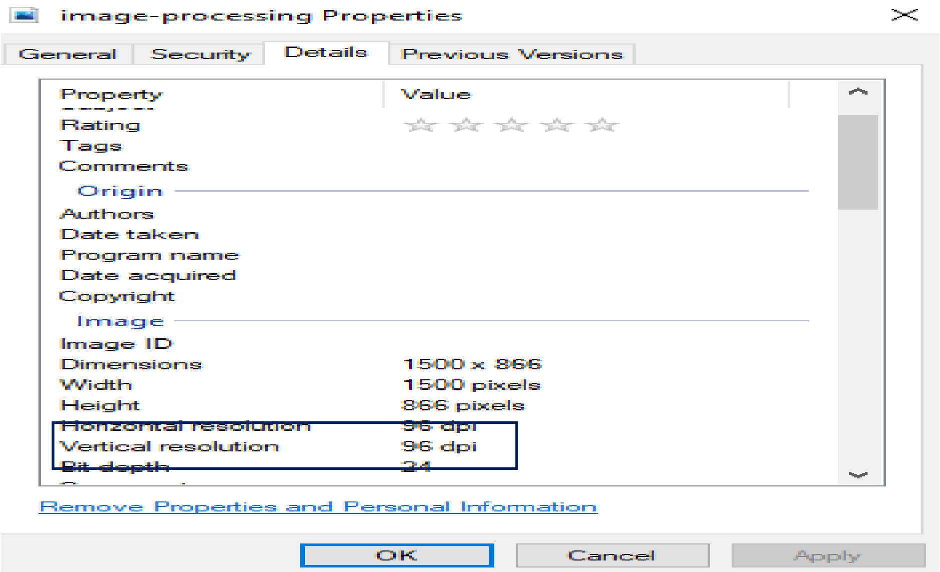
There are many differences in JPG and PNG format but the important difference is their compressing or converting algorithm that they used. Test cases found where JPG lost some amount of data while processing or conversion but PNG didn't lose. So,PNG is also known as lossless conversion technique.



- **Calibration starts with checking DPI of Image.**

  Steps:1. Right click on your image

  2. Go to properties
  3. In properties, go in details
  4. The sizes in pixel and DPI of image is mentioned over there.



References:

i) https://medium.com/@BH_Chinmay/calibration-in-image-processing

ii)Image Calibration.

DIGITAL IMAGE STEGANOGRAPHY

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Steganography is the art and science of invisible communication. This is accomplished through hiding information in other information, thus hiding the existence of the communicated information. The word steganography is derived from the Greek words "stegos" meaning "cover" and "grafia" meaning "writing" defining it as "covered writing".

In image steganography the information is hidden exclusively in images. Digital Image Steganography system allows an average user to securely transfer text messages by hiding them in a digital image file. A combination of Steganography and encryption algorithms provides a strong backbone for its security. Digital Image Steganography system features innovative techniques for hiding text in a digital image file or even using it as a key to the encryption.

Steganography is the art and science of writing hidden messages in such a way that no one apart from the sender and intended recipient even realizes there is a hidden message. By contrast, cryptography obscures the meaning of a message, but it does not conceal the fact that there is a message.

Today, the term steganography includes the concealment of digital information within computer files. For example, the sender might start with an ordinarylooking image file, and then adjust the colour of every 100th pixel to correspond to a letter in the alphabet -- a change so subtle that no one who isn't actively looking for it is likely to notice it.

STEGANOGRAPHIC TECHNIQUES

- Chaffing and winnowing
- Invisible ink
- Null ciphers
- Concealed messages in tampered executable files.
- Embedded pictures in video material (optionally played at slower or faster speed).

MAIN FUNCTIONALITIES

Digital image steganography system is a stand-alone application that combines steganography and encryption to enhance the confidentiality of intended message. The user's intended message is first encrypted to create unintelligible cipher text. Then the cipher text will be hidden within an image file in such a way as to minimize the perceived loss in quality. The recipient of the image is able to retrieve the hidden message back from the image with this system.

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Lakshmi hruthi J
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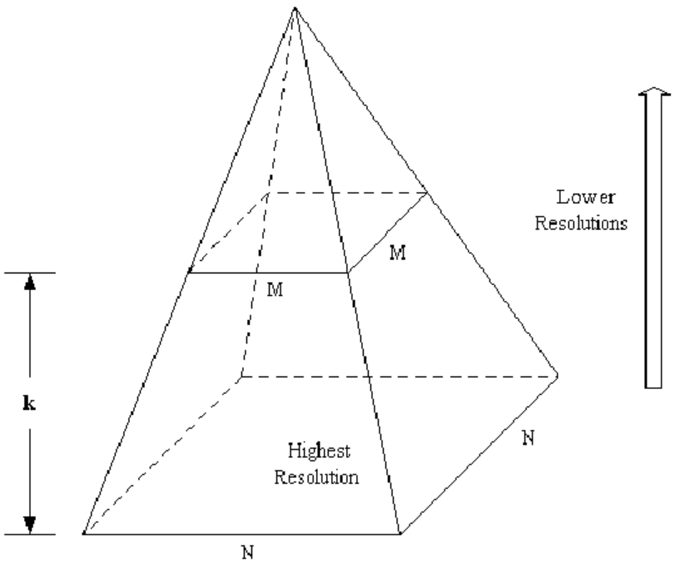
Multiresolution Techniques in Digital Image Processing



Multiresolution Techniques span an exceptionally broad range of algorithms, models, methods, and concepts. Central to the multiresolution approach is to somehow express short-range, mid-range, and long-range relationships explicitly. The main reasons for a multiresolution approach is one of:

- improving performance, by capturing long-range phenomena that would otherwise not be utilized
- reducing computational complexity, by allowing algorithms to work on both fine and coarse scales, rather than waiting for local pixel-level operations to converge at large scales
- improving numerical robustness (reducing problem conditioning), whereby a multiresolution transformation is essentially an algebraic pre-conditioner
- simplifying the algorithm, by making accessible long-range features that might, in some problems, be much easier to work with than pixel-level features
- improving intuition, by modeling or analyzing the problem over multiple scales, getting deeper insights into the phenomenon at hand.

Although there are, for sure, many multiresolution approaches and algorithms which have been proposed, broadly these falls into a few groups:

Wavelet Methods

Problems in which a wavelet transform is used to decompose an image or video into multiple scales, very commonly for image/video denoising, or for feeding the coefficients at multiple scales into a classifier for image classification and segmentation.

Hierarchical Models

A model in which a pixelated, finest-scale random field is explicitly represented using a set of random fields over scales. In many cases the multi-scale model may be simpler, using principles of Markov decomposition to decouple the problem into pieces. A multi-scale model allows different models to be asserted at different scales, usually simpler or more meaningful than having a single-scale model which needs to assert all of the various scale-dependent behaviors simultaneously.

Hierarchical Algorithms

Even if there is no explicitly hierarchical model, it is possible for the processing algorithm to be hierarchical. Best known examples include multigrid methods, whereby a single-scale linear system is solved by casting the problem onto a hierarchy, and wavelet methods in image processing, whereby the image is transferred into a set of multiscale coefficients in the wavelet domain, in which certain operations (like image compression or image denoising) are relatively simple.

References- https://digitalcommons.lsu.edu

https://www.ece.mcmaster.com

Thresholding in image processing

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Definition:-

The simplest thresholding methods replace each pixel in an image with a black pixel if the image intensity is less than a fixed value called the threshold, or a white pixel if the pixel intensity is greater than that threshold.

Automatic thresholding:-

While in some cases, the threshold can be selected manually by the user, there are many cases where the user wants the threshold to be automatically set by an algorithm. In those cases, the threshold should be the "best" threshold in the sense that the partition of the pixels above and below the threshold should match as closely as possible the actual partition between the two classes of objects represented by those pixels.

Many types of automatic thresholding methods exist, the most famous and widely used being Otsu's method. The following list, based on the works of Seguin categorizes thresholding methods into broad groups based on the information the algorithm manipulates.

- **Histogram shape**-based methods, where, for example, the peaks, valleys and curvatures of the smoothed histogram are analyzed.Note that these methods, more than others, make certain assumptions about the image intensity probability distribution (i.e., the shape of the histogram),
- **Clustering**-based methods, where the gray-level samples are clustered in two parts as background and foreground.
- **Entropy**-based methods result in algorithms that use the entropy of the foreground and background regions, the cross-entropy between the original and binarized image, etc.
- **Object Attribute**-based methods search a measure of similarity between the gray-level and the binarized images, such as fuzzy shape similarity, edge coincidence, etc.
- **Spatial** methods use higher-order probability distribution and/or correlation between pixels.

Global vs local thresholding:-

In most methods, the same threshold is applied to all the pixel of an image. However, in some cases, it can be advantageous to apply a different threshold to different parts of the image, based on the local value of the pixels. This category of methods is called local or adaptive thresholding. They are particularly adapted to cases where images have inhomogeneous lighting, such as in the sudoku image on the right. In those cases, a neighborhood is defined and a threshold is computed for each pixel and its neighborhood. Many global thresholding methods can be adapted to work in a local way, but there are also methods developed specifically for local thresholding, such as the Niblack or the Bernsen algorithms.

Extensions of binary thresholding:-

Multi-band images

Color images can also be thresholded. One approach is to designate a separate threshold for each of the RGB components of the image and then combine them with an AND operation. This reflects the way the camera works and how the data is stored in the computer, but it does not correspond to the way that people recognize color. Therefore, the HSL and HSV color models are more often used; note that since hue is a circular quantity it requires circular thresholding. It is also possible to use the CMYK color model.

Multiple thresholds

Instead of a single threshold resulting in a binary image, it is also possible to introduce multiple increasing thresholds .In that case, implementing thresholds will result in an image with classes, where pixels with intensity such that will be assigned to class . Most of the binary automatic thresholding methods have a natural extension for multi-thresholding.

Limitations:-

- low level of noise
- higher intra-class variance than inter-class variance, i.e., pixels from a same group have closer intensities to each other than to pixels of another group,
- homogeneous lighting, etc.

Example :-

References:-

https://en.wikipedia.org/wiki/Thresholding_(image_processing)

3-D RECONSTRUCTION USING SURFACE DETECTION

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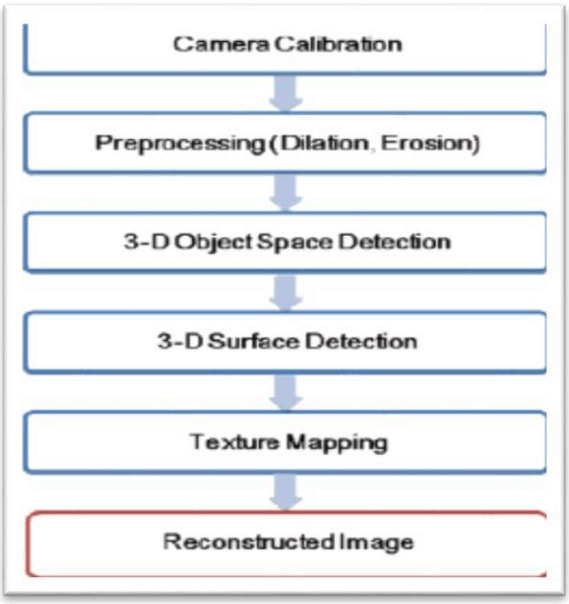
INTRODUCTION

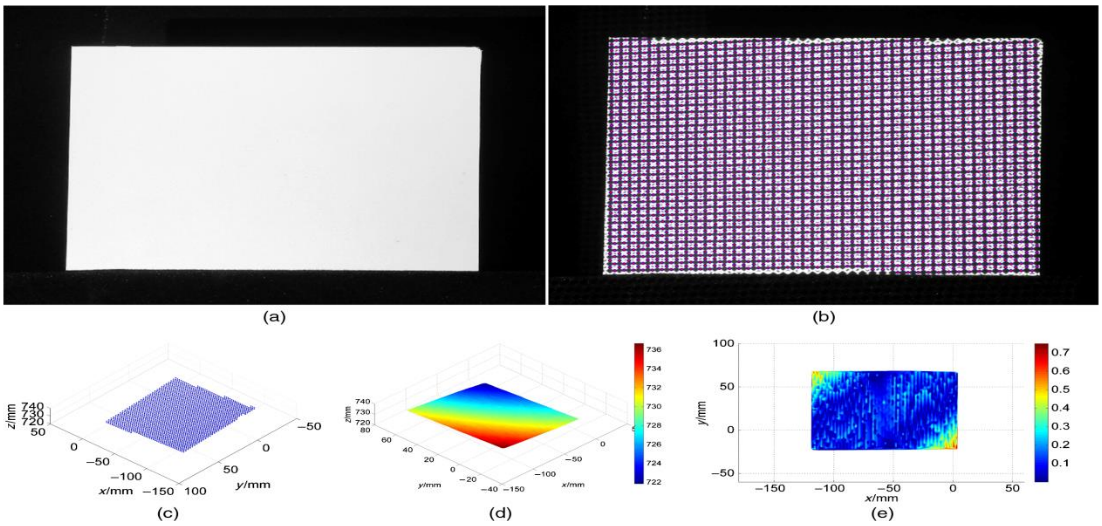
The recent advent of increasingly diverse, affordable and powerful 3D scanning devices has made it possible to conveniently gather large amounts of high resolution range data about real-world objects and environments. These devices typically operate by projecting several beams of light or radiation (e.g., laser, infrared or x-ray) onto the object or environment which needs to be scanned and then detecting the beams when they strike a surface. The exact position of the point on the surface where the beam strikes can then be determined using various techniques such as time-of-flight or triangulation. The result of this scanning process is a point cloud, a set of disjoint points in 3D space appearing where there are surfaces within the scanning range. However, the raw point cloud data generated by these devices typically needs for converted into a meaningful digital representation of the scanned objects to facilitate its use in various application domains such as CAD, medical imaging, reverse engineering, virtual reality, and architectural modelling.

SURFACE RECONSTRUCTION ALGORITHM

At first, we calibrate the cameras to find the relation between a 2-D point in the image of each camera and its 3-D point in the 3-D space. After that, pre-processing consisting of dilation and erosion more accurately separates the object from the image. The 3-D space is partitioned into small voxels. To detect the 3-D object, each voxel is projected on image plane of each camera. If the voxel is projected on the object region of the 2-D images, it is regarded as a voxel belonging to 3-D object.



EXAMPLE



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PRITY KUMARI (21MCA30)

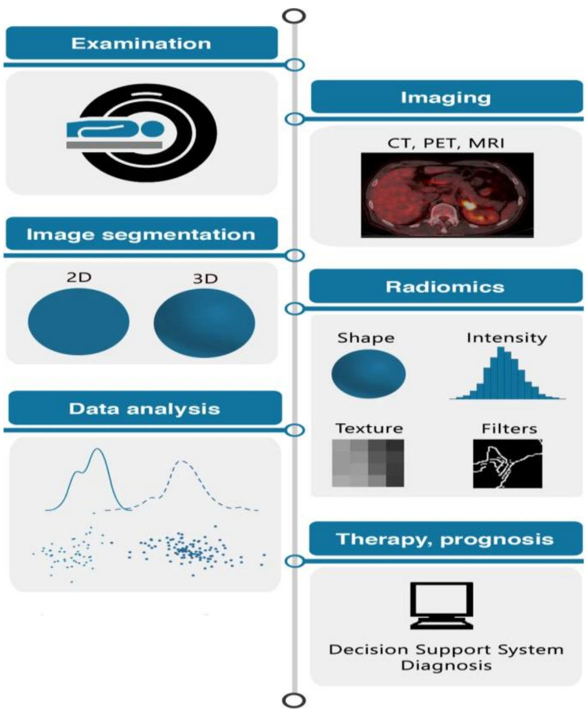
Radiomics in Medical Imaging

Like many other areas of human activity in the last decades, medicine has seen a constant increase in the digitalization of the information generated during clinical routine. As more medical data became available in digital format, new and always more sophisticated software was developed to analyse them.

In medicine, various ways to generate big data exist, including the widely known fields of genomics, proteomics, or metabolomics. Similar to these “omics” clusters, imaging has been used increasingly to generate a dedicated omics cluster itself called “radiomics”. Radiomics is a quantitative approach to medical imaging, which aims at enhancing the existing data available to clinicians by means of advanced, and sometimes non-intuitive mathematical analysis.

Radiomics analysis can be performed on medical images from different modalities, allowing for an integrated cross-modality approach using the potential additive value of imaging information extracted, e.g., from magnetic resonance imaging (MRI), computed tomography (CT), and positron-emission-tomography (PET), instead of evaluating each modality by its own. However, the current state-of-the-art of the research still shows lack of stability and generalization, and the specific study conditions and the authors’ choices have still a great influence on the results.

Radiomics Workflow



Step 1: Image Segmentation

Image segmentation might be done manually, semi-automatically (using standard image segmentation algorithms such as region-growing or thresholding), or fully automatically (nowadays using deep learning algorithms).

Step 2: Image Processing

Image processing is located between the image segmentation and feature extraction step. It represents the attempt to homogenize images from which radiomic features will be extracted with respect to pixel spacing, grey-level intensities, bins of the grey-level histogram, and so forth. Preliminary results have shown that the test-retest robustness of radiomic features extracted largely depends on the image processing settings used.

Step 3: Feature Extraction

After image segmentation and processing, extraction of radiomic features can finally be performed. Feature extraction refers to the calculation of features as a final processing step, where feature descriptors are used to quantify characteristics of the grey levels within the ROI(Region of Interest)/VOI(Volume of Interest).

Step 4: Feature Selection/Dimension reduction

Depending on the software package used for feature extraction and the number of filters applied during the process, the number of extracted features to deal with during the following step of statistical analysis and machine learning ranges between a few and, in theory, unlimited. The higher the number of features/variables in a model and/or the lower the number of cases in the groups, e.g., for a classification task, the higher the risk of model overfitting.

Current limitations in radiomics

Although radiomics has shown its potential for diagnostic, prognostic, and predictive purposes in numerous studies, the field is facing several challenges. The existing gap between knowledge and clinical needs results in studies lacking clinical utility.

In case a clinically relevant question is considered, the reproducibility of radiomic studies is often poor, due to lack of standardization, insufficient reporting, or limited open source code and data.

Due to the retrospective nature of radiomic studies, imaging protocols, including acquisition, and reconstruction settings, are often not controlled or standardized. For each image modality, multiple studies have assessed the impact of these settings on radiomic features or attempted to minimize their influence by eliminating features that are sensitive to these variabilities.

Apart from the variations in scanners and settings, radiomic feature values are also influenced by patient variabilities, e.g., geometry, which impact the levels of noise and presence of artifacts in an image. Therefore, the aim of a recent study was to quantify these so-called "non-reducible technical variations" and stabilize the radiomic features accordingly.

References:- https://insightsimaging.springeropen.com

https://www.ncbi.nlm.nih.gov/pmc/articles/

BLOB DETECTION

DIPIKA (21MCA14)

A Binary Large Object (BLOB) is a collection of binary data stored as a single entity in a database management system. Blobs are typically images, audio or other multimedia objects , though sometimes binary executable code is stored as a blob. Database support for blobs is not universal. The name "blob" is further borrowed by the deep learning . In Computer vision, blob detection methods are aimed at detecting region in a digital image that differs in properties such as brightness or colour, compared to surrounding regions. Informally, a blob is a region of an image in which some properties are constant or approximately constant; all the points in a blob can be considered in some sense to be similar to each other. The common method for blob detection is Convolution. In OpenCV, Blob is a library for computer vision to detect connected regions in binary digital images. Given some property of interest expressed as a function of position on the image. With the more recent terminology used in the field, these detectors can also be referred to as interest point operators, or alternatively interest region operators (see also interest point detection and corner detection). There are several motivations for studying and developing blob detectors. One main reason is to provide complementary information about regions, which are not obtained from edge detectors or corner detectors. In early work in the area, blob detection was used to obtain regions of interest for further process. These regions could signal the presence of objects in the image domain with application to object recognition and/or object tracking.

WORKING OF BLOB DETECTION

The Blob detection algorithm is controlled by the following parameters;

1. Thresholding: Convert the source images to several binary images by Thresholding the source image with thresholds starting at minThreshold. These thresholds are incremented by threshold Step until maxThreshold. So, the first threshold is minThreshold, the second is minThreshold thresholdStep, the third is minThreshold, and so on.

2. **Grouping:** In each binary image, connected white pixels are grouped together.

3. Merging: The canters of the binary blobs in the binary images are computed, and blobs located closer than minDistBetweenBlobs are merged.

4. Centre & radius Calculation: and radii of the new merged blobs are computed and returned.

BLOB FILTERING

The blob detector can be set to filter by the following parameters.

By Colour: First we need to set filter Colour = 1. Set blob Colour = 0 to select darker blobs and blob Colour = 255 for lighter blobs.

By Size: We can filter the blobs based on size by setting the parameters filter and appropriate values for min E.g. setting min Area = 100 with filter out all the blobs that have less than 100 pixels.

By Shape: Now shape has three different parameters;

BLOB EXTRACTION

The purpose of BLOB extraction is to isolate the BLOBs (objects) in a binary image. A BLOB consists of a group of connected pixels. Whether or not two pixels are connected is defined by the connectivity, that is, which pixels are neighbours and which are not. The two most often applied types of connectivity 8-connectivity and 4-connectivity. The 8-connectivity is more accurate than the 4-connectivity, but the 4 connectivity often applied since it requires fewer computations, hence it can process the image faster. A number of different algorithms exist for finding the BLOBs and such algorithms are usually referred to as connected component label.

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https://etj.uotechnology.edu.iq/article_168193_1f30a7babd3fa1c2009165bd8e0df301.pdf

HIGH DYNAMIC RANGE

MEGHANA N (21MCA24)

INTRODUCTION

High-dynamic-range imaging (HDRI or HDR) is a technique used in imaging and photography to reproduce a greater dynamic range of luminosity than is possible with standard digital imaging or photographic techniques. While the human eye can adjust to a wide range of light conditions, most imaging devices use 8-bits per channel, so we are limited to only 256 levels. When we take photographs of a real world scene, bright regions may be overexposed, while the dark ones may be underexposed, so we can't capture all details using a single exposure. HDR imaging works with images that use more than 8 bits per channel, allowing much wider dynamic range.

Dynamic Range: Dynamic range of a scene refers to the range of light intensity that encompasses a scene. It can also be defined as the ratio of light to dark in an image. No camera is able to capture this complete uncapped range of illuminance in a scene. Therefore, images turn out to be either too bright (overexposed) or too dark (underexposed). These images are called *Low Dynamic Range* (LDR) images.

Image Exposure: The amount of light entering the camera (and thus, the image) is called the exposure. The exposure of the image can be controlled by three settings of a camera — the aperture, shutter speed and ISO.

Shutter speed: The speed with which the shutter of the camera closes. As the shutter speed increases, the amount of light entering the camera decreases, and vice versa. It also improves the sharpness of an image.

ISO: Sensitivity of the camera sensor to incoming light. between the camera settings and a bucket left out in the rain. Different regions of the image are captured better at different exposure values. Therefore, the idea is to merge these set of images and to recover an image with a *high dynamic range* (HDR).

Image bracketing: Bracketing refers to capturing multiple images of the same scene with different camera settings. It is usually done automatically by the camera. What happens when you use the HDR feature on your smart phone is that the phone captures 3 images at three different exposure times in quick succession. The lower the exposure time, the lesser the amount of light that gets in. These three images are merged by the camera software and are saved as a single image, in a way that the best portions of each image make it to the final image.

Image encoding: Commonly, the images that we see on our phones and computers, are 8-bit (per channel) encoded RGB images. Each pixel's value is stored using 24-bit representations, 8-bit for each channel (R, G, B). Each channel of a pixel has a range of 0–255 intensity values.

REFERENCES

https://towardsdatascience.com

Filters in Image Processing

Vaishnavi P (21MCA43)

Filtering is a technique to enhance or to modify the image for its better technical use. For example, you can apply filters to an image to highlight particular features or remove some unwanted features. Image processing with filtering includes image sharpening, image smoothing, and edge-preserving.

Types of Filtering Techniques

The image can be filtered in two ways either in the spatial domain or in the frequency filtration. The two domains of filtering are:

- Spatial domain
- Frequency domain

1.Spatial domain filtering

A technique which is applied directly to pixels of the image. A mask or kernel is created with a particular size, and the mask is moved in a way, that each pixel of the image coincides with the center of the mask.

Classification of Spatial filtering:

- Smoothing Filters
- Sharpening Filters

Smoothing Filtering

Colour image smoothing is one of the main parts of pre-processing techniques intended for removing possible noise in the image without losing image information.

Sharpening Filtering

The main purpose of the sharpening spatial filter is just the reverse of the smoothing spatial filter. It mainly focuses on highlight the edges and the removal of blurring. A sharpening filter is a derivative filter too. Sharpening filters are dependent on the first and second-order derivatives.

2.Frequency domain filtering:

This type of filter concentrates on the frequency of images. These techniques are employed for sharpening and smoothing an image by removing low and high frequencies.

References:

Filters in Image Processing Using OpenCV - datamahadev.com

FREQUENCY DOMAIN

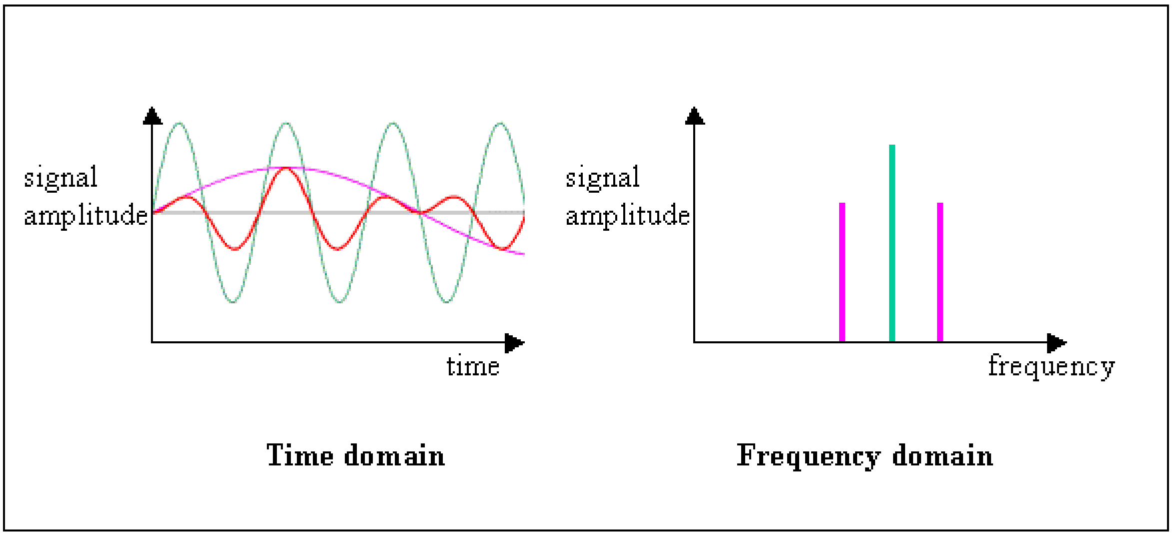
PRIYANKA N(21MCA32)

*The Frequency Domain refers to the analytic space in which mathematical functions or signals are conveyed in terms of frequency, rather than time. For example, where a time-domain graph may display changes over time, a frequency-domain graph displays how much of the signal is present among each given frequency band. It is possible, however, to convert the information from a time-domain to a frequency-domain

*In physics, electronics, control systems engineering, and statistics, the frequency domain refers to the analysis of mathematical function or signals with respect to frequency rather than time.

*****Frequency Domain graph shows how much of the signal lies within each given frequency band over a range of frequencies. A frequency-domain representation can also include information on the phase shift that must be applied to each sinusoid in order to be able to recombine the frequency components to recover the original time signal.

*A given function or signal can be converted between the time and frequency domains with a pair of mathematical operators called transform. An example is the Fourier transform, which converts a time function into a complex valued sum or integral of sine waves of different frequencies, with amplitudes and phases, each of which represents a frequency component.



Types:-

- Fourier series – periodic signals, oscillating systems.
- Fourier transform– aperiodic signals, transients.
- Laplace transform –electronic circuit and control system
- Z transform – Discrete time signals, digital signal processing.
- Wavelets transform — image analysis, data compression.

DISCRETE FREQUENCY DOMAIN:-

*A **discrete frequency domain** is a frequency domain that is discrete rather than continous. For example, the *discrete Fourier transform* maps a function having a discrete time domain into one having a discrete frequency domain. The discrete-time Fourier transform, on the other hand, maps functions with discrete time (discrete-time signals) to functions that have a continuous frequency domain.

*The Fourier transform of a period signal has energy only at a base frequency and its harmonics. Another way of saying this is that a periodic signal can be using a discrete frequency domain. Dually, a discrete time signal gives rise to a periodic frequency spectrum. Combining these two, if we start with a time signal which is both discrete and periodic, we get a frequency spectrum which is also both discrete and periodic. This is the usual context for a discrete Fourier transform.

Reference:- https://en.wikipedia.org/wiki/Frequency_domain

Image Inpainting

Shilpa.V (21MCA39)

Inpainting, the technique of modifying an image in an undetectable form, is as ancient as art itself. The goals and applications of inpainting are numerous, from the restoration of damaged paintings and photographs to the removal/replacement of selected objects.

Technological advancements led to new applications of inpainting. Widespread use of digital techniques range from entirely automatic computerized inpainting to tools used to simulate the process manually. Since the mid-1990s, the process of inpainting has evolved to include digital media. More commonly known as image or video interpolation, a form of estimation, digital inpainting includes the use of computer software that relies on algorithms to replace lost parts of the image data.

By studying the painting methods of various artists, the composition of paints used historically, and taking the time to carefully study the medium one is working with, conservators are able to, using an array of methodology, restore works very closely to their original visual appearance.

Tips of inpainting:

- The picture as a whole determines how to fill in the gap; the purpose of inpainting is to restore the unity of the work so it is crucial to know how the repaired piece will function within the rest of the image.
- The structure of the area surrounding the gap ought to be continued into the gap. Contour lines that end at the gap boundary are to be carried on into the gap.
- The different regions inside a gap, as defined by the contour lines, are filled with colors matching those of its boundary although the specific materials do not have to be identical. If alternate materials are to be used, it is important to test for potential reactivity.
- The small details are painted, i.e. "texture" is added to ensure the eye will not be drawn first to the in-painted region.

Digital Inpainting:

Many programs are able to reconstruct missing or damaged areas of digital photographs and videos. Most widely known for use with digital images is Adobe Photoshop. Since the digital files are able to be duplicated, any restorative alterations should be made to the duplicate file, while maintaining the original files in an archive. Given the various abilities of the digital camera and the digitization of old photos, inpainting has become an automatic process that can be performed on digital images. More than mere scratch removal, the inpainting techniques can also be applied to object removal, text removal, and other automatic modifications of images and videos. In video special effects inpainting is usually performed after video matting.

References

https://en.wikipedia.org/wiki/Inpainting

https://wandb.ai/ayush-thakur/image-impainting/reports/Introduction-to-Image-Inpainting-with-Deep-Learning--Vmlldzo3NDIwNA

FEBA BIJU(21MCA16)

IMAGE RESTORATION

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.

Degraded Image Quality   Image Restoration

The objective of image restoration techniques is to reduce noise and recover resolution loss. Image processing techniques are performed either in the image domain or the frequency domain. The most straightforward and a conventional technique for image restoration is deconvolution, which is performed in the frequency domain and after computing the Fourier transform of both the image and the PSF and undo the resolution loss caused by the blurring factors. This deconvolution technique, because of its direct inversion of the PSF which typically has poor matrix condition number, amplifies noise and creates an imperfect deblurred image. Also, conventionally the blurring process is assumed to be shift-invariant. Hence more sophisticated techniques, such as regularized deblurring, have been developed to offer robust recovery under different types of noises and blurring functions.

It is of 3 types:
1. Geometric correction
2. radiometric correction
3. noise removal

References

https://en.wikipedia.org/wiki/Image_restoration#:~:text=Image%20restoration%20is%20performed%20by,lost%20to%20the%20blurring%20process.

https://www.owlnet.rice.edu/~elec539/Projects99/BACH/proj2/intro.html

https://www.marian.ac.in/public/images/uploads/pdf/online-class/EC370_DIP_Module%204.pdf

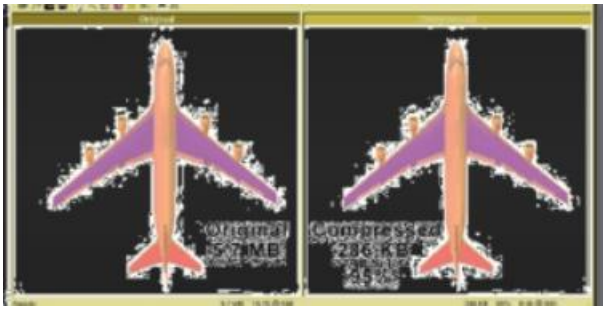
IMAGE COMPRESSION

JAISRI (21MCA21)

Compression is a way of encoding digital data so it takes up less storage space and requires less network bandwidth to be transmitted. There are two basic types of compression: lossy methods, in which some data is lost when the files are decompressed, and lossless methods, in which no data is lost when the files are restored to their original format.

Basic steps of Image Compression :

*Applying the image transform.
*Quantization of the levels.
*Encoding the sequences.



Transforms in image processing:

The image is also a function of the location of the pixels i.e.(x,y) where (x,y) are the coordinates of the pixel in the image .So we generally transform an image from the spatial domain to the frequency domain.

Quantization:

The process quantization is a vital step in which the various levels of intensity are grouped into a particular level based on the mathematical function defined on the pixels. Generally, the newer level is determined by taking a fixed filter size of “m” and dividing each of the “m” terms of the filter and rounding it its closest integer and again multiplying with “m”.

Symbol Encoding:

The symbol stage involves where the distinct characters involved in the image are encoded in a way that the no. of bits required to represent a character is optimal based on the frequency of the character’s occurrence. In simple terms, In this stage codewords are generated for the different characters present. By doing so we aim to reduce the no. of bits required to represent the intensity levels and represent them in an optimum number of bits.

There are many encoding algorithms. Some of the popular ones are:

- Huffman variable-length encoding.
- Run-length encoding.

Thus in this way, the mechanism of quantization helps in compression. When the images are once compressed its easy for them to be stored on a device or to transfer them. And based on the type of transforms used, type of quantization, and the encoding scheme the decoders are designed based on the reversed logic of the compression so that the original image can be re-built based on the data obtained out of the compressed images.

References:

- https://www.geeksforgeeks.org/what-is-image-compression/
- https://www.computerworld.com/article/2596954/data-and-image-compression.html

Morphological Image Processing

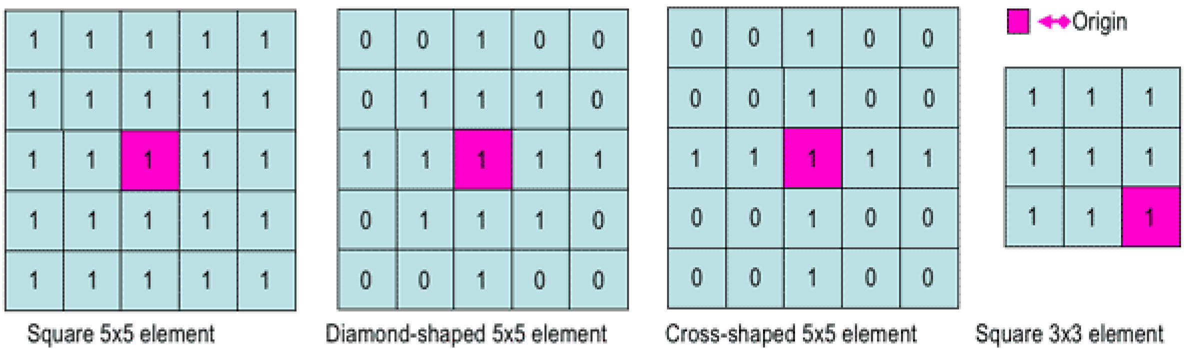
ANANYA G S (21MCA03)

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to greyscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

Morphological techniques probe an image with a small shape or template called a **structuring element**. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

The **structuring element** is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one:

- The matrix dimensions specify the *size* of the structuring element.
- The pattern of ones and zeros specifies the *shape* of the structuring element.
- An *origin* of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element.



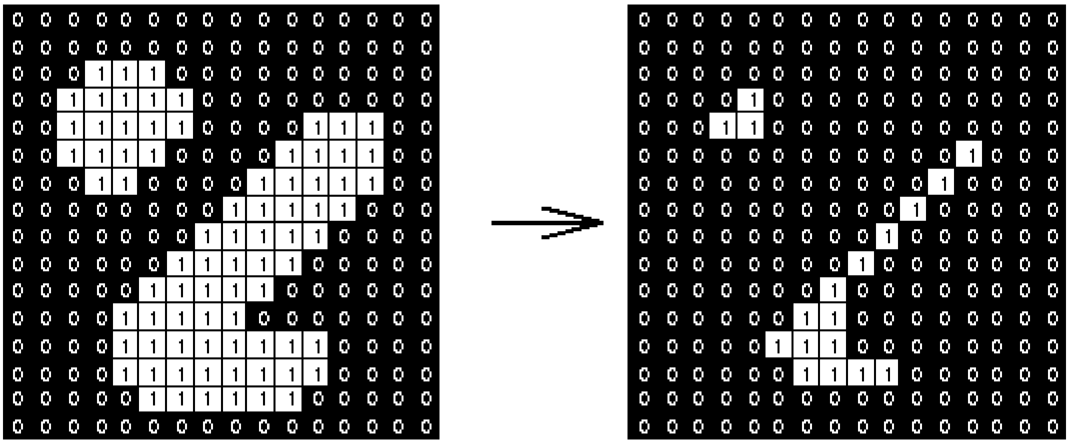
Examples of simple structuring elements.

Fundamental Operations :

Erosion:

The **erosion** of a binary image f by a structuring element s (denoted $f \ominus s$) produces a new binary image $g = f \ominus s$ with ones in all locations (x, y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. $g(x, y) = 1$ is s fits f and 0 otherwise, repeating for all pixel coordinates (x, y).

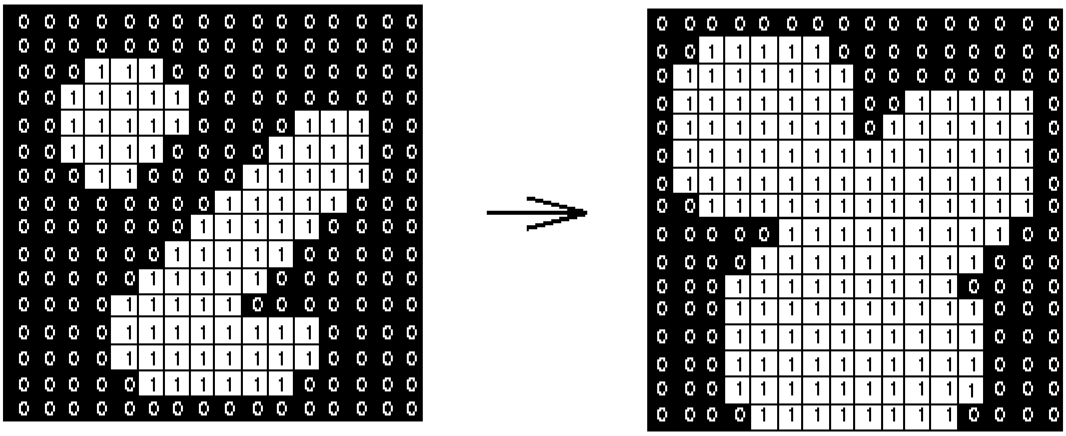
Erosion with small square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions. The holes and gaps between different regions become larger, and small details are eliminated:



Erosion: a 3×3 square structuring element

Dilation:

The **dilation** of an image f by a structuring element s (denoted $f \oplus s$) produces a new binary image $g = f \oplus s$ with ones in all locations (x, y) of a structuring element's origin at which that structuring element s hits the input image f, i.e. $g(x, y) = 1$ if s hits f and 0 otherwise, repeating for all pixel coordinates (x, y). Dilation has the opposite effect to erosion -- it adds a layer of pixels to both the inner and outer boundaries of regions.



Dilation: a 3×3 square structuring element

References:

[Morphological Image Processing (auckland.ac.nz)]

NOISE REDUCTION

AVULA LAKSHMI

21MCA08

Digital images are prone to various types of noise. **Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene.** There are several ways that noise can be introduced into an image, depending on how the image is created.

For example:

- If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself.
- If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.
- Electronic transmission of image data can introduce noise.

Different ways are used to solve Noise Reduction as follows:

1. Remove Noise by Linear Filtering
2. Remove Noise Using an Averaging Filter and a Median Filter
3. Remove Noise By Adaptive Filtering

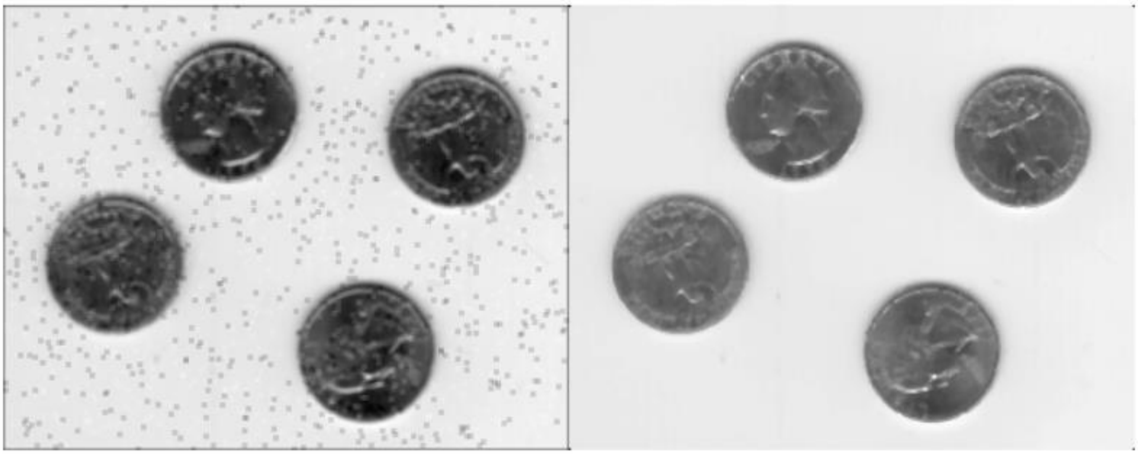
1. Remove Noise by Linear Filtering

We can use linear filtering to remove certain types of noise. Certain filters, such as averaging or Gaussian filters, are appropriate for this purpose.

For example: an averaging filter is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced.

2. Remove Noise Using an Averaging Filter and a Median Filter

The two types of filtering both set the value of the output pixel to the average of the pixel values in the neighborhood around the corresponding input pixel. However, with median filtering, the **value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean**. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image.



Before Noise removal After Noise removal

3. **Remove Noise By Adaptive Filtering**

The following example shows how to use the **wiener2 function to apply a Wiener filter (a type of linear filter) to an image adaptively.**

This approach often produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high-frequency parts of an image. In addition, there are no design tasks; the wiener2 function handles all preliminary computations and implements the filter for an input image. wiener2, however, does require more computation time than linear filtering.

Wiener2 works best when the noise is constant-power ("white") additive noise, such as Gaussian noise.

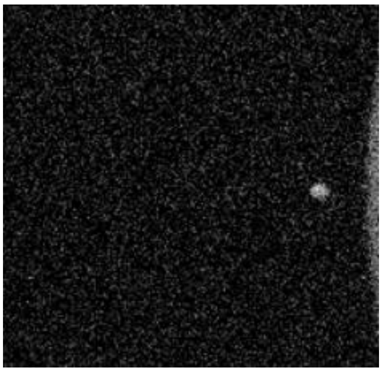
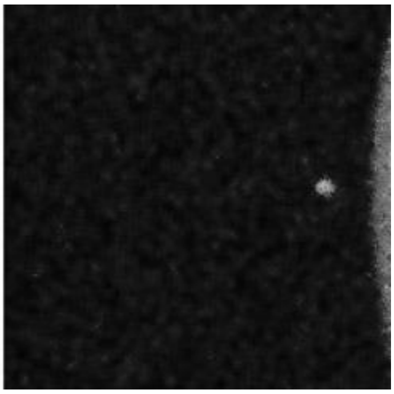


Image with Gaussian Noise



After removal of Gaussian Noise

References:

1.Gonzalez R. C., & Woods R. E. (2002) “DigitalImage Processing,” 3 rd edition., Prentice Hall, Englewood, Cliffs, NJ.

2.Parminder Kaur and Jagroop Singh. 2011.A StudyEffect of Gaussian Noise on PSNR Value for DigitalImages International journal of computer and electrical engineering