Image Preparation (Pre-Processing) for Machine Learning

Assoc. Prof. Dr. Kamil Dimililer

Near East University – Nicosia
Northern Cyprus

Outline

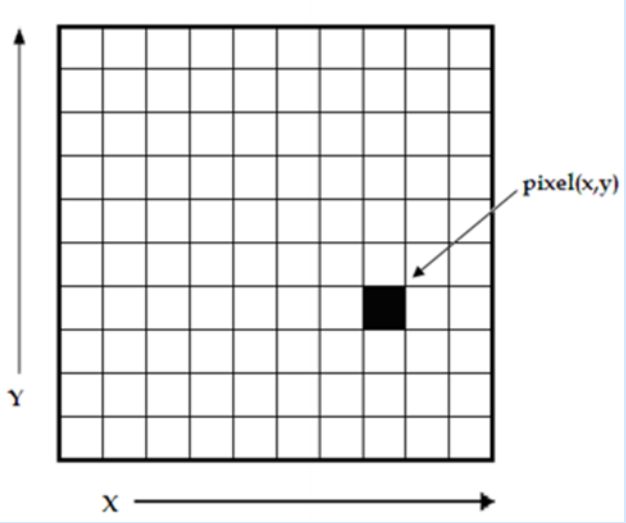
- What is an Image?
- Image Analysis/Processing
- Image Acquisition
- Image Processing Techniques
- Image Enhancement
- Image Restoration
- Image Segmentation

Outline

- Image Resizing
- Image Compression
- Feature Extraction
- Binarization
- Morphological Image Processing
- Image Recognition
- Applications of Image Processing
- Benefits of Image procesing

What is an Image?

An image is defined as a two-dimensional function, **F(x,y)**, where x and y are spatial coordinates, and the amplitude of **F** at any pair of coordinates (x,y) is called the **intensity** of that image at that point.



Why Grayscale?

- Colour image data might be too much and affect the processing speed.
- Due to speed of current PCs or systems.
- Speed (CPU Time) is necessary for output. It saves processing time, especially in medical imaging.

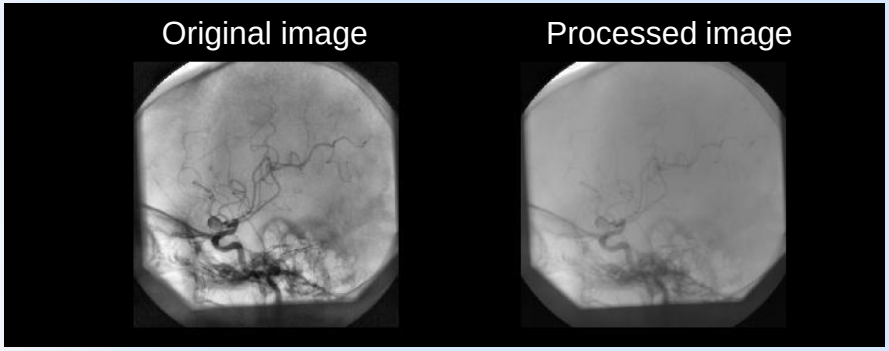
Numerical Parameters of Images

Some numerical parameters of images include:

- Brightness
- Contrast
- Entropy
- SSIM

Image Analysis/Processing

Image analysis involves processing an image into fundamental components in order to extract statistical data. Image analysis can include tasks such as finding shapes (line detection), detecting edges, removing noise, counting objects, and measuring region and image properties of an object.



Why is Image Processing Necessary?

- Improvement of pictorial information for human interpretation.
- Processing of a scene data for an autonomous machine perception.
- It is used to solve a wide variety of problems and obtain good results.
- Excess (unnecessary) data can be removed to speed up the process.

Image Processing

Image processing methods include:

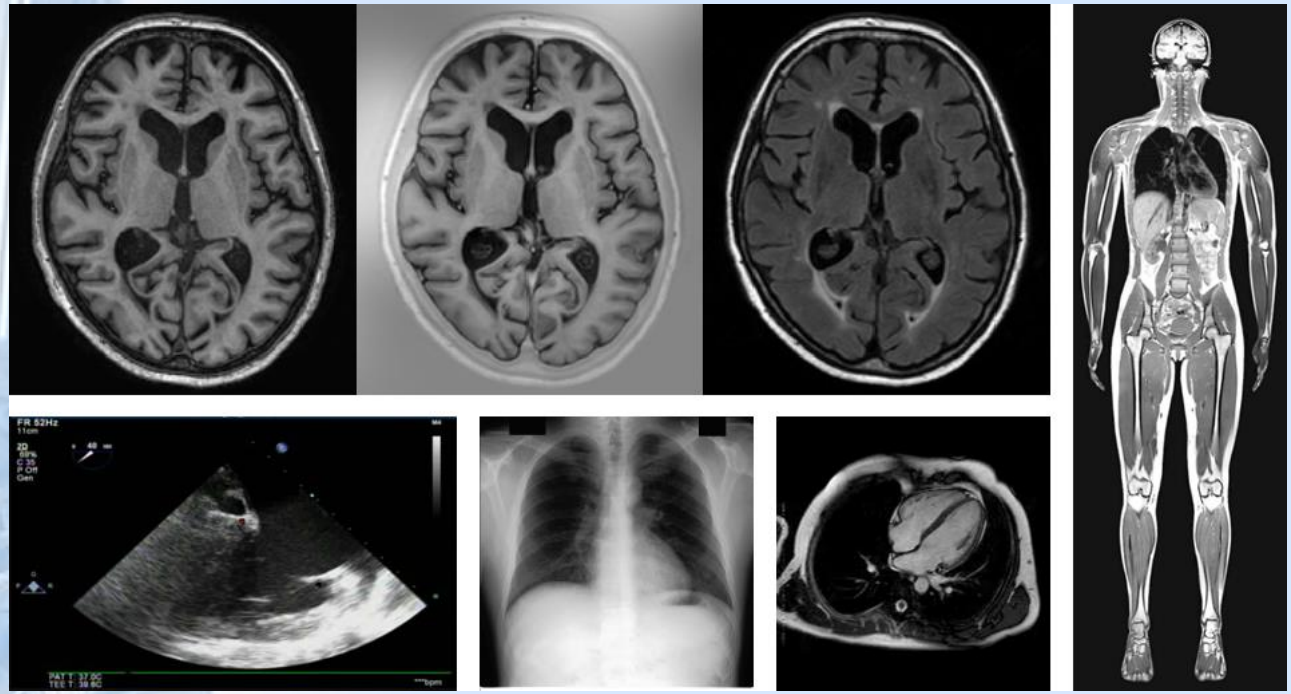
- **Analogue image processing -** can be used for the hard copies like printouts and photographs. Examples include television images, photographs, paintings, and **medical images,** etc.
- **Digital image processing -** techniques help in manipulation of the digital images by using computers. Examples include: colour processing, image recognition, video processing, etc.

Image Processing

The steps for image processing include:

- **Importing** the image using an optical scanner or digital photography.
- **Analyzing and manipulating** the image. Here, data is compressed, image is enhanced and patterns that are not visible to the human eyes are spotted.
- Finally, an altered image or report based on the analysis is retrieved as **output**.

Image Processing



Assoc. Prof. Dr. Kamil Dimililer - Near East University, 2019

Purpose of Image Processing

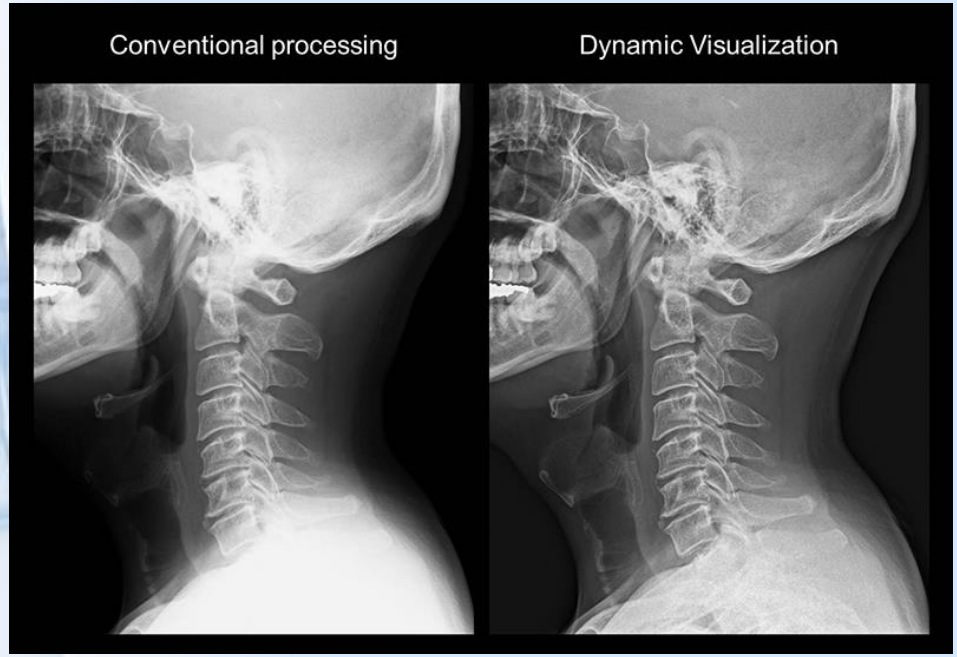
The purpose of image processing can be divided into 5 groups in general. They are:

- Visualization
- Image sharpening and restoration
- Image retrieval
- Measurement of pattern
- Pattern Recognition

Purpose of Image Processing

Visualization

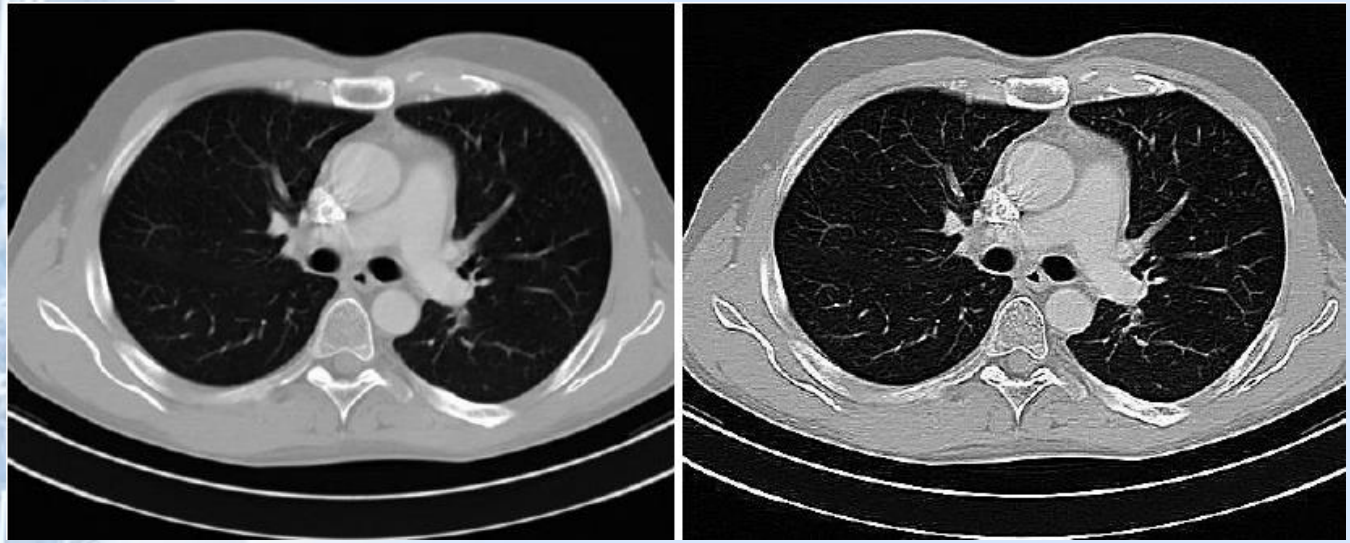
Observe the objects that are not visible.



Purpose of Image Processing

Image sharpening and restoration

To create a better image.



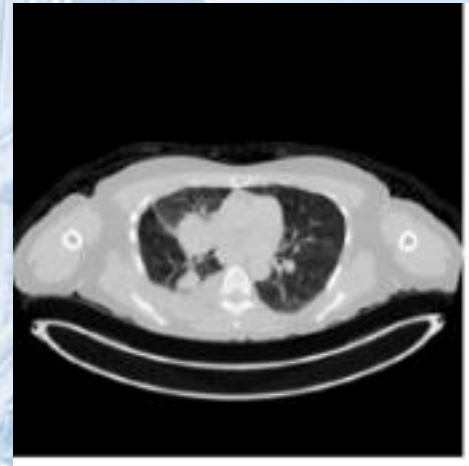
Original image

Sharpened and restored image

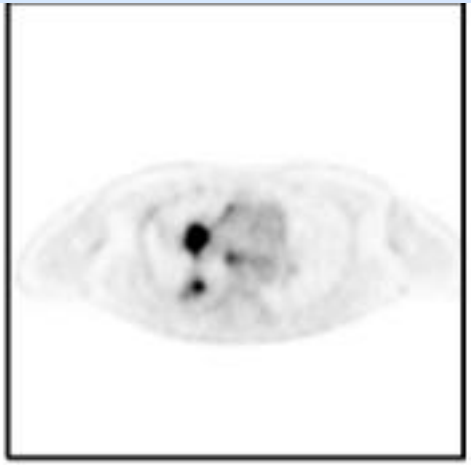
Purpose of Image Processing

Image retrieval

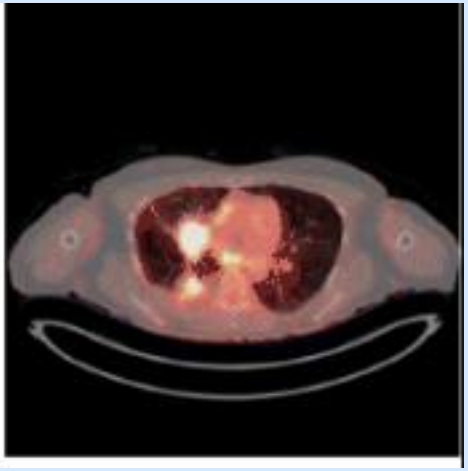
Seek for the image of interest.



Axial CT slice



Axial PET slice

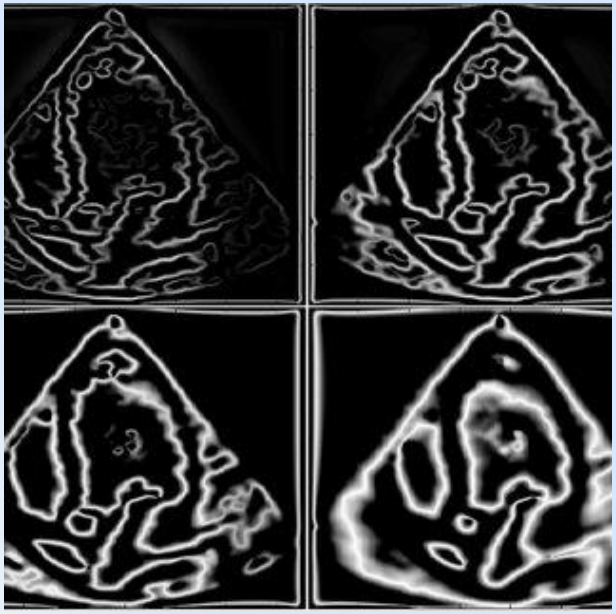


Axial fused PET-CT slice

Purpose of Image Processing

Measurement of pattern

Measures various objects in an image.



Purpose of Image Processing

Pattern Recognition

Distinguish the objects in an image.

Image Acquisition

A digital image is produced by one or several image sensors, which, besides various types of light-sensitive cameras, include range sensors, tomography devices, radar, ultra-sonic cameras, etc.

Image Acquisition Process

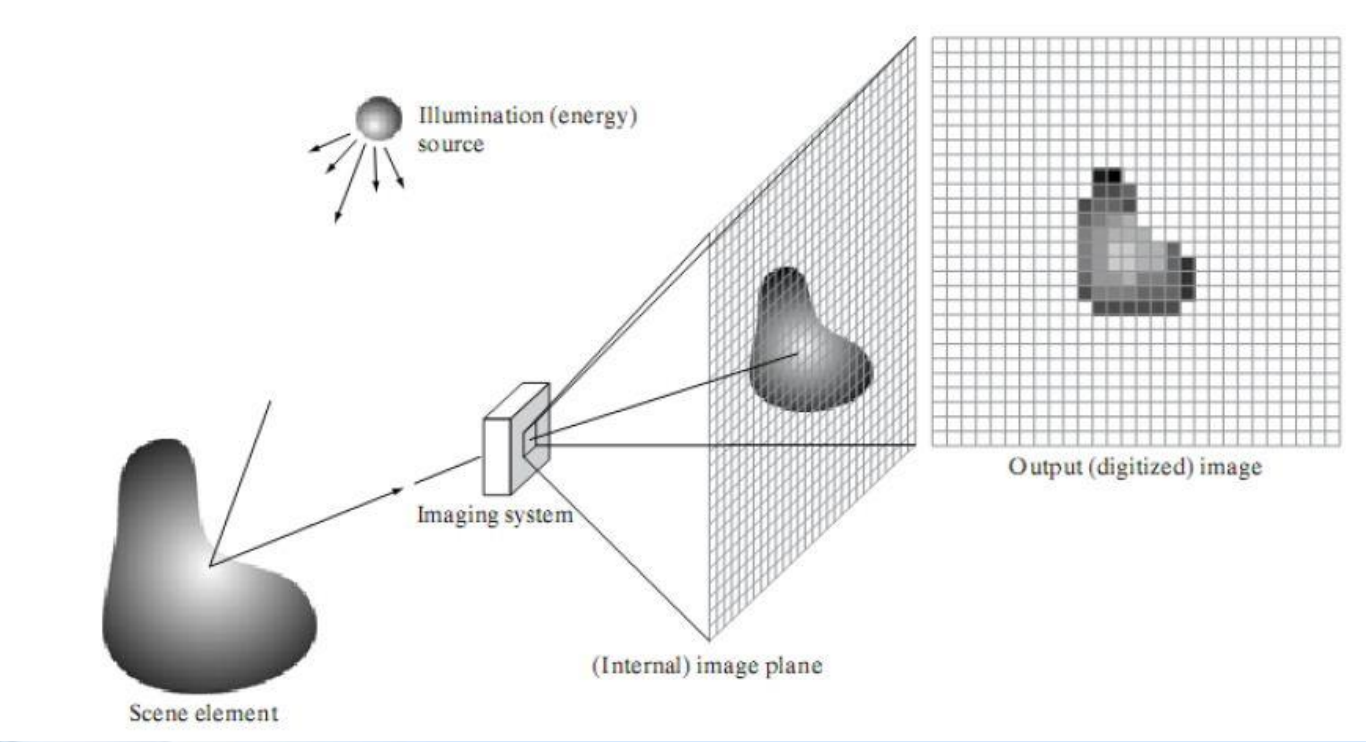


Image Acquisition Process

Some important parameters for image acquisition include:

- Brightness
- Contrast
- Entropy

Image Acquisition Examples

- **Computed Tomography (CT):** is the usual method for imaging bone structures and contrast enhanced vasculature.
- In the dental field and for oral and maxillofacial surgery, in-office **Cone-beam Computed Tomography** is used.
- **Magnetic resonance imaging (MRI):** is useful for soft tissue structures, solid organs, and cancerous lesions.

Image Processing Techniques

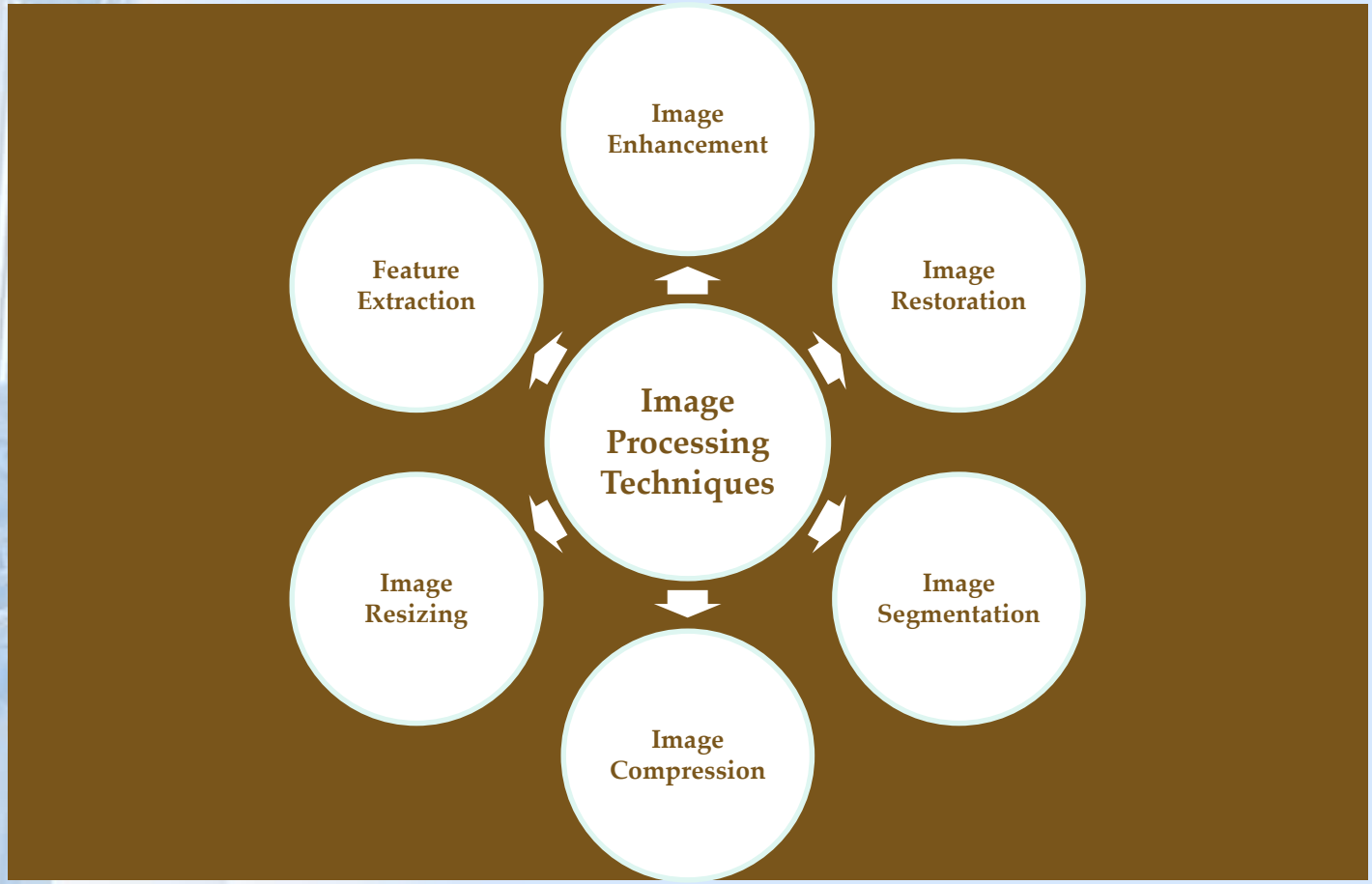


Image Enhancement

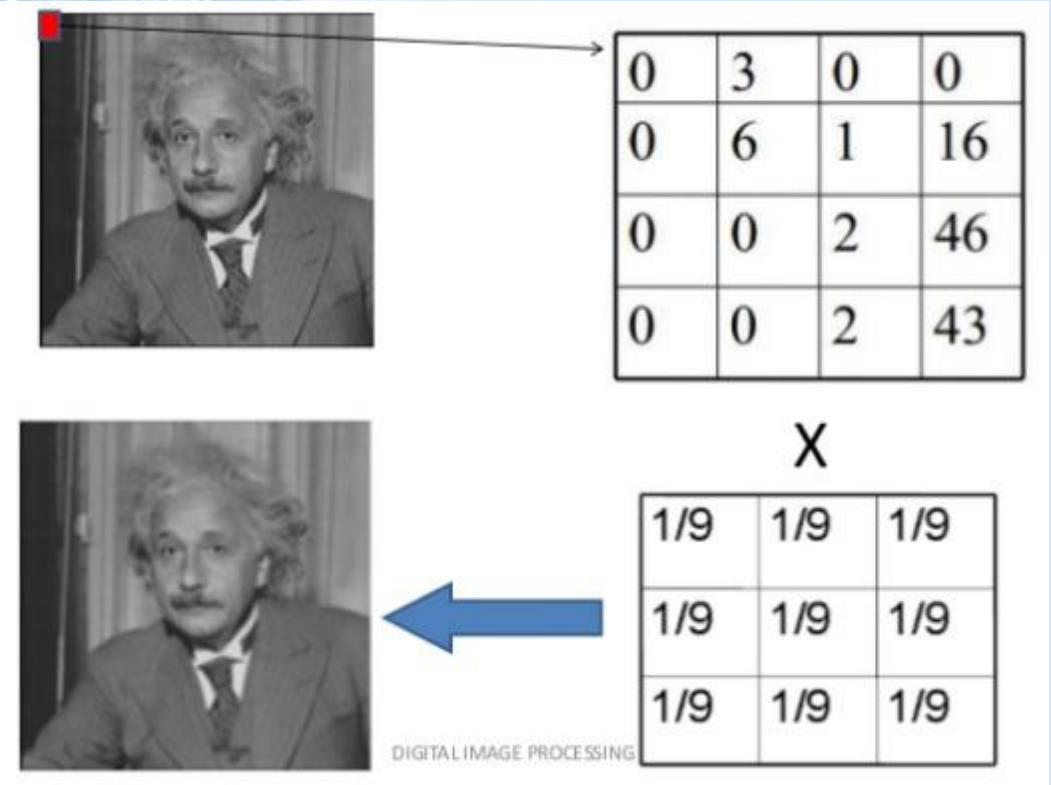
Image enhancement technique improves the perception of information in images to make visualization better. The Medical Image Enhancement plays a vital role and targets the problems of low contrast and high-level noise in accurate diagnosis of particular disease.

Methods Of Image Enhancement

Image enhancement can be categorized in two, namely:

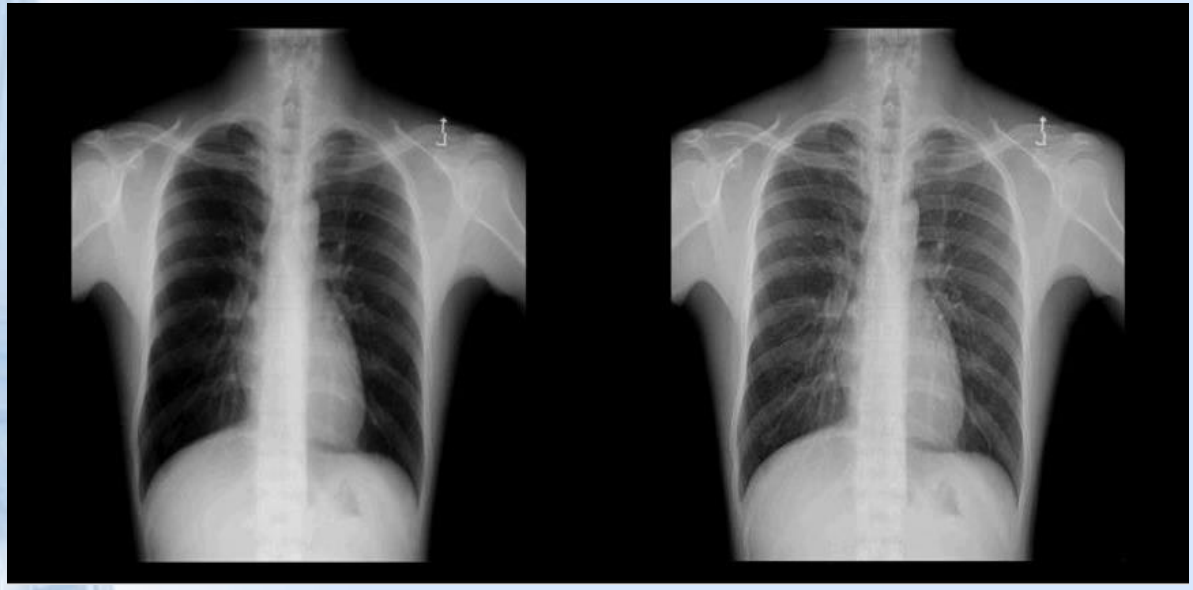
- Spatial domain – It deals with direct manipulation of pixels in an image.
- Frequency domain – It helps to modify the Fourier transform of an image.

Image Enhancement With Mask Operation



Mask is a spatial domain method that refers to a small matrix useful for blurring, sharpening, edge-detection and more. The mask may be of any dimension e.g. 3X3, 4X4, etc.

Image Enhancement



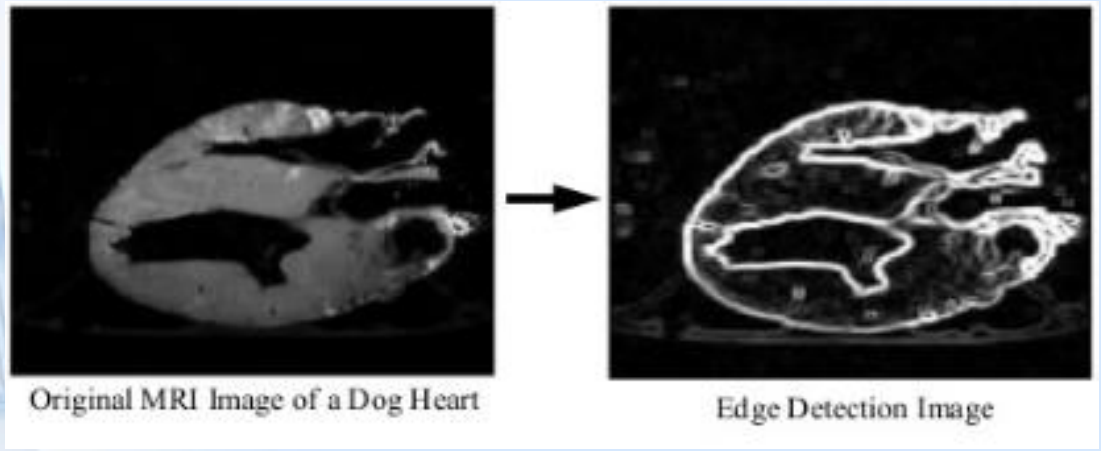
Original image

Enhanced image

The enhanced image improves the interpretability or perception of information.

Image Recognition

Image recognition refers to the classification, listing, identification and symbolic description of features or aspects of an image.



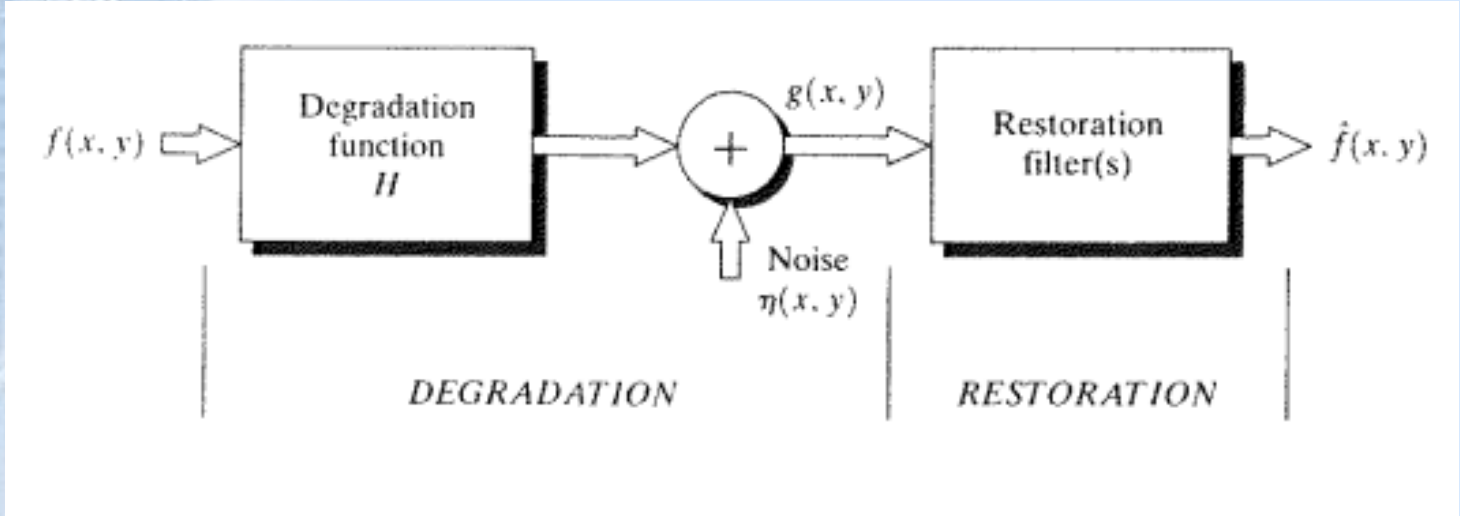
Original MRI Image of a Dog Heart

Edge Detection Image

Image Restoration

Image restoration techniques aim at processing corrupted images from which there is a statistical or mathematical description of the degradation so that it can be reverted.

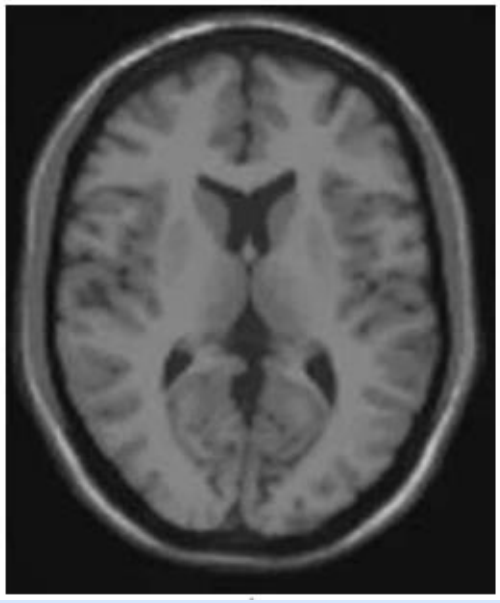
Image Degradation/Restoration Process



The initial image (source, f(x,y) undergoes degradation due to various operations, conversions and losses. This introduces Noise. This Noisy Image is further restored via restoration filters to make it visually acceptable for user.

Image Restoration

Original image

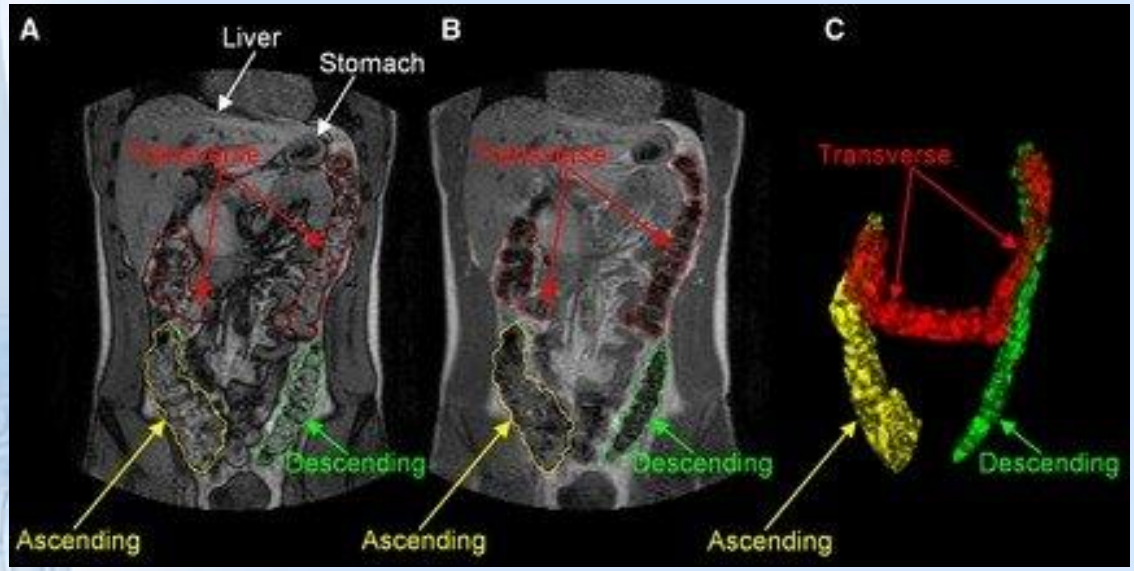


Restored image

Image Segmentation

The purpose of image segmentation is to partition an image into meaningful regions with respect to a particular application. It is based on measurements taken from the image and might be grey level, color, texture, depth or motion.

Anatomical Segmentation of the Colon with MRI



The left panel (A) shows the dual echo MRI image with water and fat imaged out-of-phase and the manual drawings of the regions of interest around the colon; the central panel (B) shows the corresponding MRI image with water and fat imaged in-phase; the right panel (C) shows the 3D reconstruction of the colon.

Image Resizing

Image resizing is a technique to change the dimension of an image. It is necessary when the total number of pixels are either to be increased or decreased.

Resizing MRI of the brain

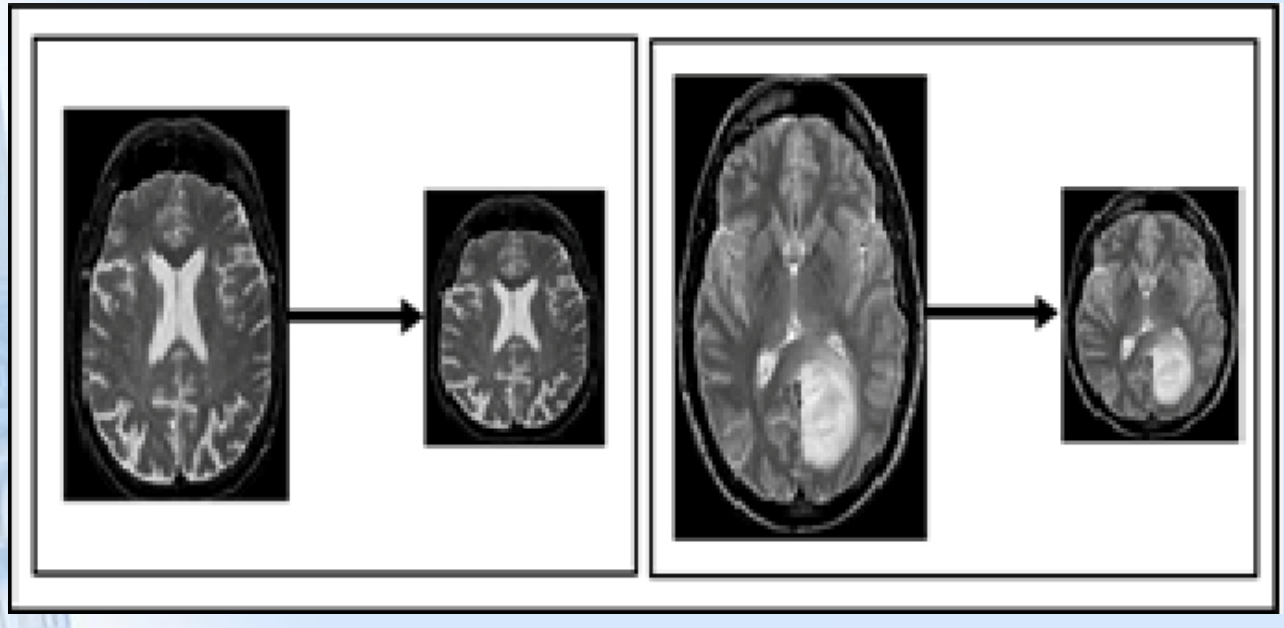
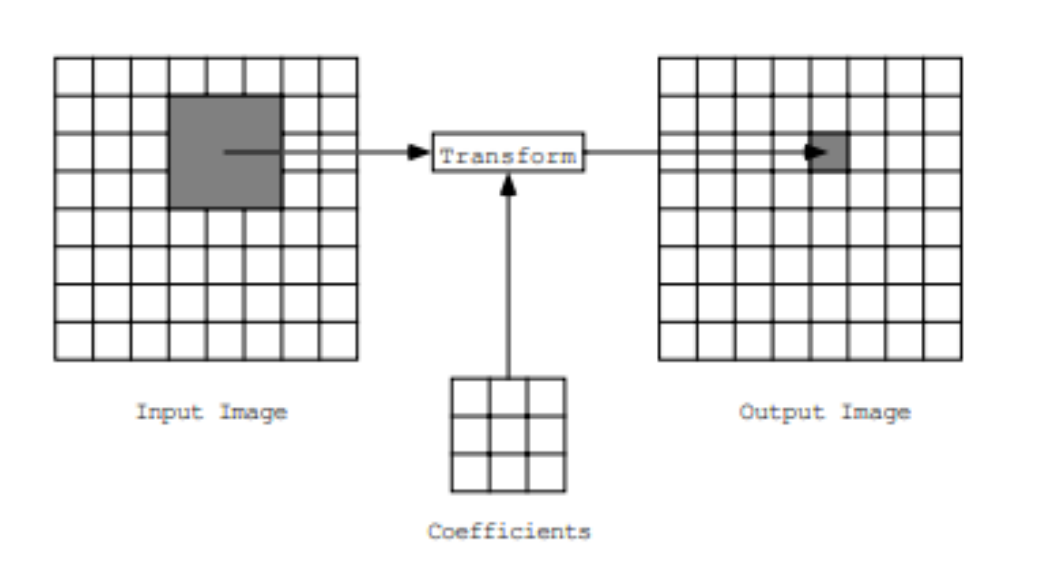


Image Resizing with Average Pixel Per Node.



A 3x3 average pixel resizing. The resized image decreases processing speed.

Image Compression

Image Compression refers to techniques for reducing the storage required to save an image, or the bandwidth required to transmit it. It can be categorized in two:

- Lossless – Information preserving, low compression rations.
- Lossy – Not information preserving, High compression ratios.

Image Compression

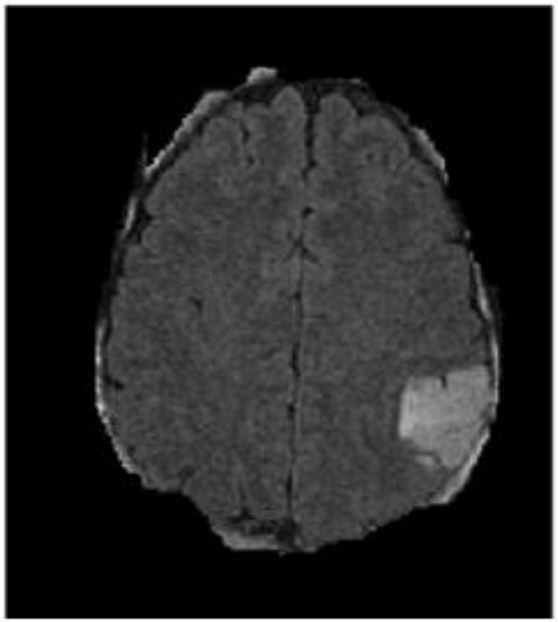
Lossless Compression

Lossy Compression

Feature Extraction

Feature extraction is a technique in which certain features of interest within an image are detected and represented for further processing. Features for extraction include color, texture and shape.

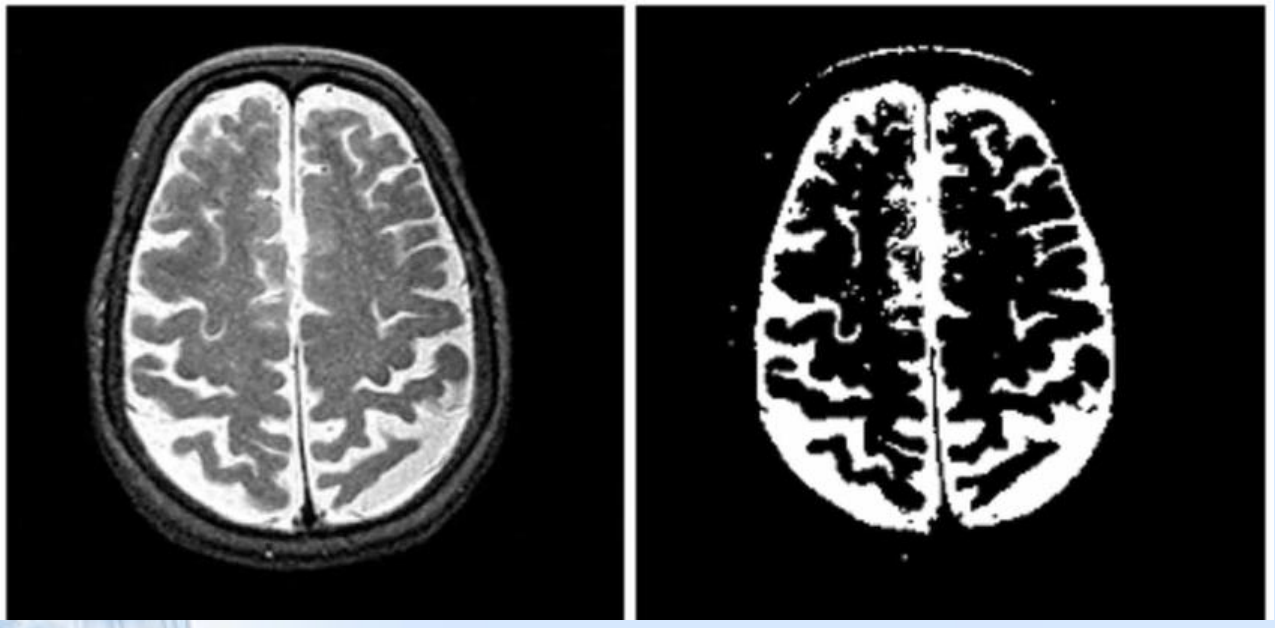
Brain Tumor Feature Extraction (Shape)



Binarization

Binarization is often recognized to be one of the most important steps in most high-level image analysis systems, particularly for object recognition. It involves representing the background with white color and the objects the black color.

Binarization



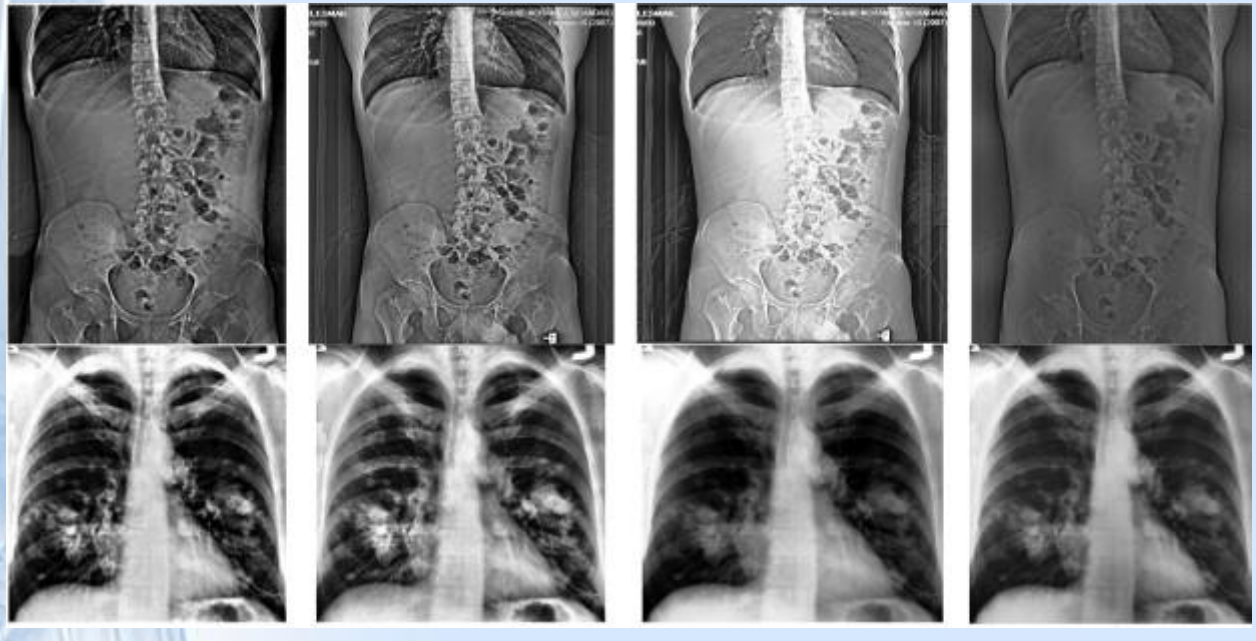
Original image

Binarized image

Morphological Image Processing

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape. morphological operations are used for revealing details in enhancement operations.

Morphological Transforms



Applications of Image Processing (In Medicine)

For medical diagnosis, different types of imaging tools such as X-ray, Ultrasound, computer aided tomography (CT) etc. are used.

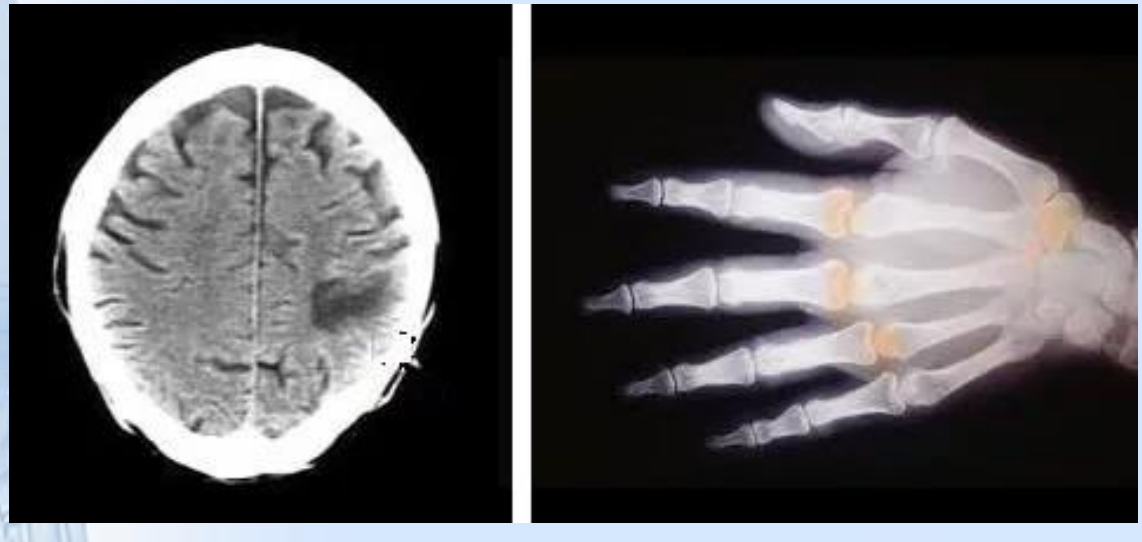
The following are biomedical applications of image processing:

- Heart disease identification
- Lung disease identification
- Lung lesion segmentation with Gaussian filter and discrete wavelet transform

Applications of Image Processing (In Medicine)

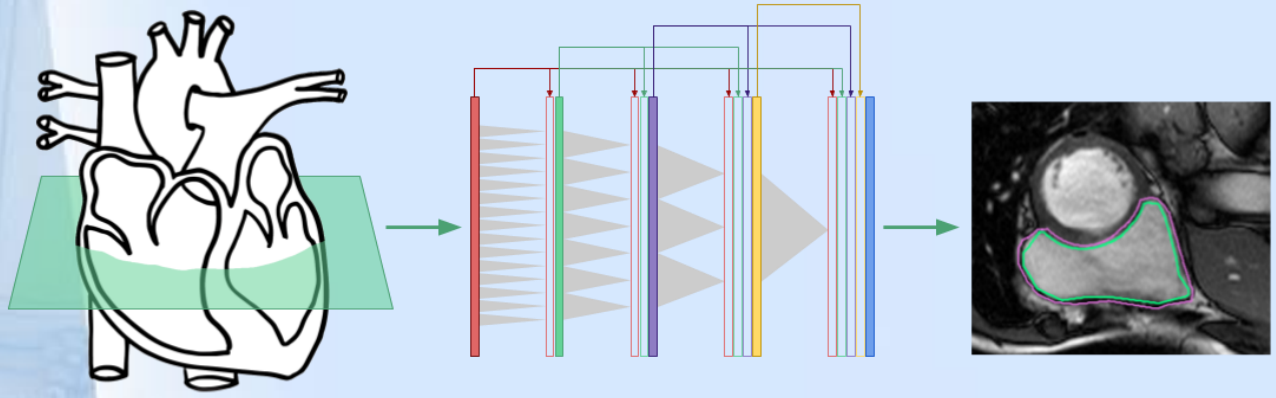
- Bone fracture detection
- Digital mammograms
- Automatic detection of Acute Myeloid leukaemia from microscopic blood smear image
- Rheumatoid arthritis identification

Applications of Image Processing (In Medicine) Cont'd



Representational Image Of X- ray, MRI, And Computer Aided Tomography (CT)

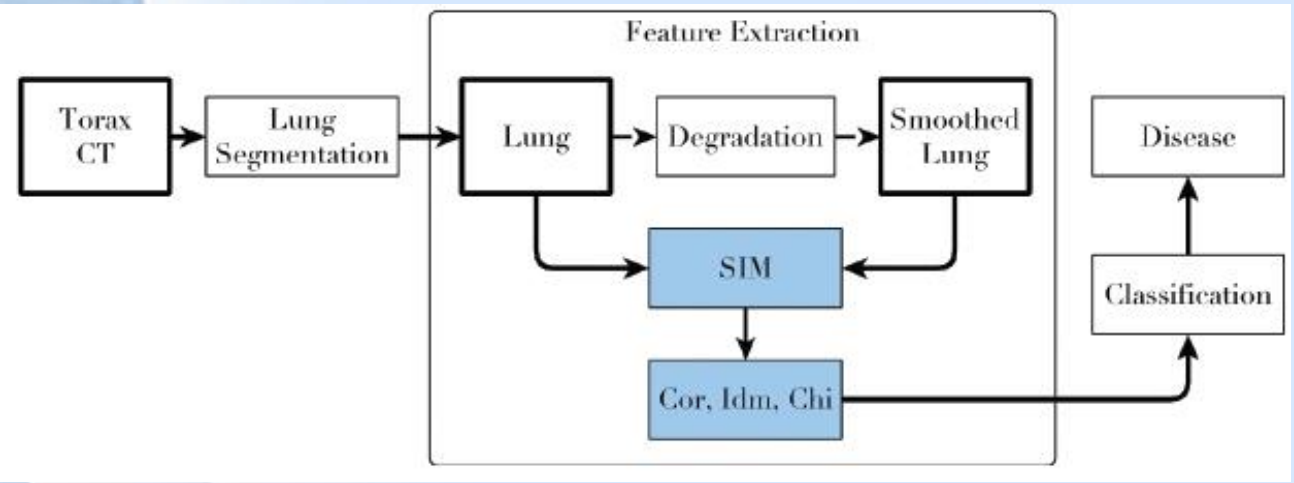
Heart Disease Identification



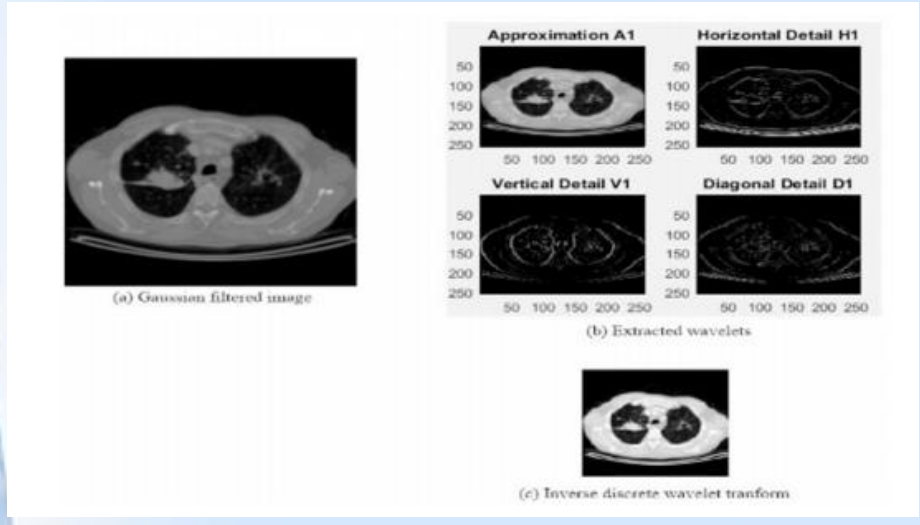
MRI image is first converted to a gray scale image to reduce the size of image and to increase the speed of detection. Then Interpolation technique is adopted for tasks such as zooming, rotating, shrinking, and for geometric corrections. Features are extracted and feed forward neural network is used to classify the heart disease.

Lung Disease Identification

Lung diseases can be detected by taking extracted features from segmented CT images and then using an extreme learning machine (ELM) to classify the lung disease. The figure below describes a model for pulmonary disease classification.



Lung Lesion Segmentation with Gaussian Filter and Discrete Wavelet Transform

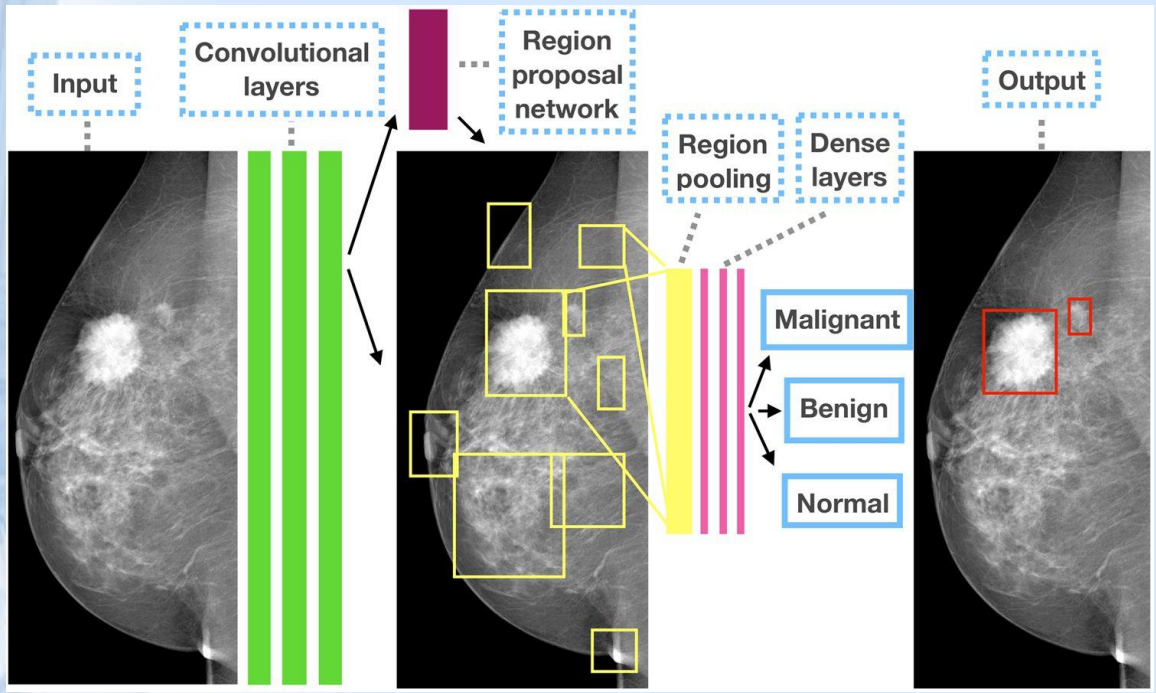


Here, the image is reconstructed using the inverse discrete wavelets transform. Then, these images are summed together to obtain a clearer and enhanced image where the tumour is well defined and separated from the other parts of the image.

Digital Mammograms

Digital mammograms are used to detect breast tumours. Computer-aided detection system detects and classifies malignant or benign lesions on a mammogram without any human intervention, for better image recognition.

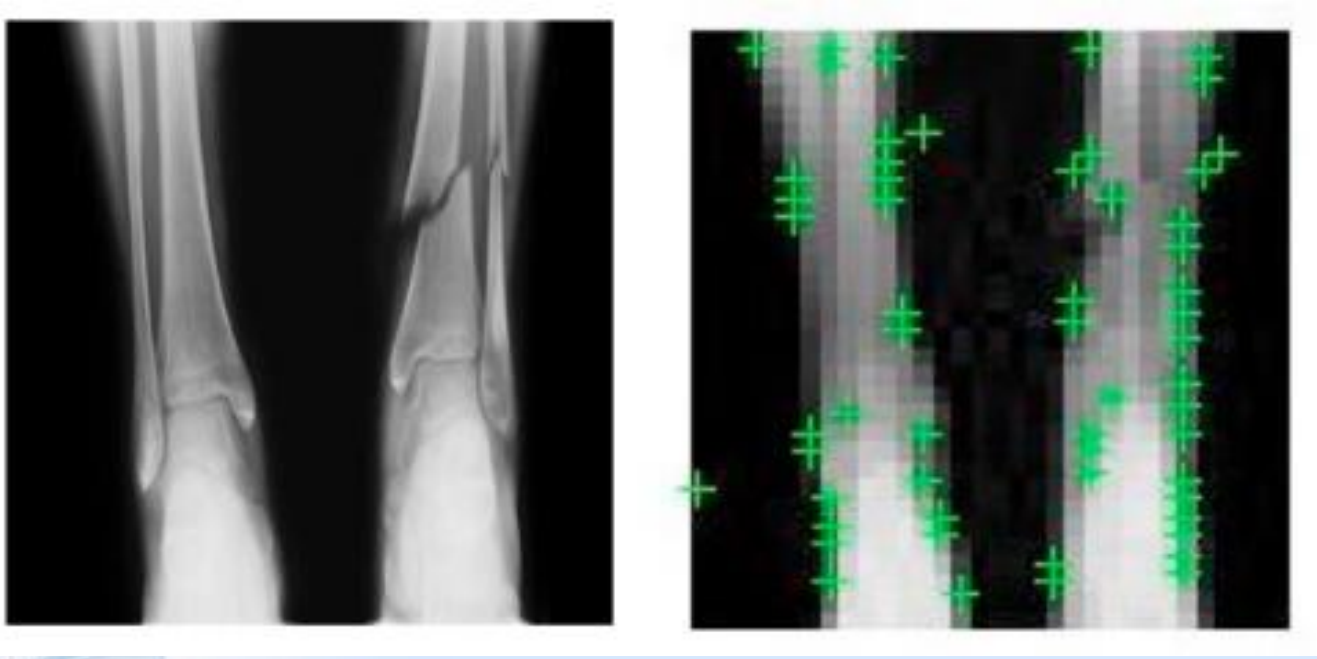
Digital Mammograms



Bone Fracture Detection

The images of the fractures are processed using different image processing techniques in order to detect their location and shapes and classified with a backpropagation neural network (BPNN).

Bone Fracture Detection with SIFT/SURF



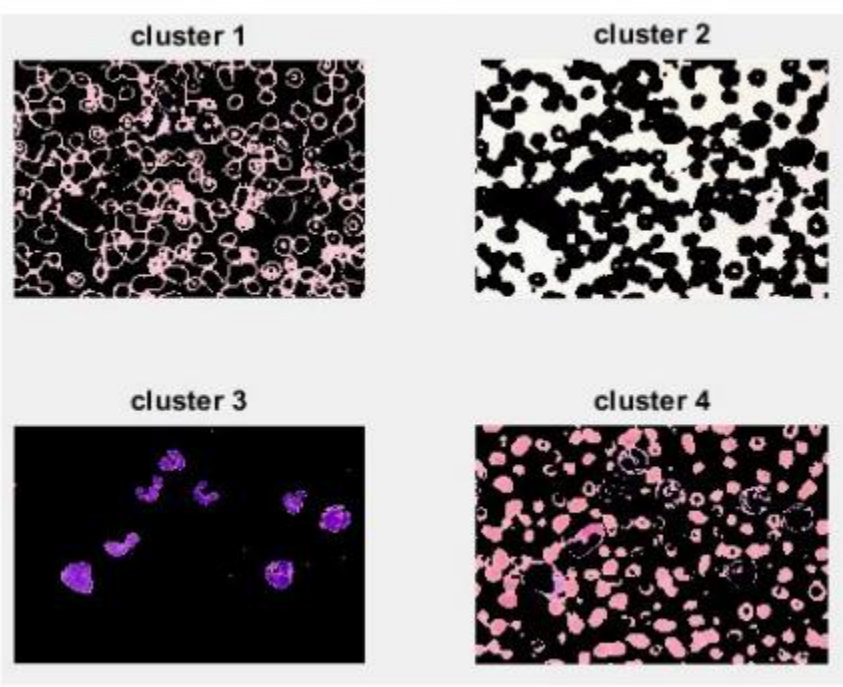
SIFT/SURF compressed image sample

Assoc. Prof. Dr. Kamil Dimililer - Near East University, 2019

Automatic Detection of Acute Myeloid Leukemia from Microscopic Blood Smear Image

The images are first pre-processed and then segmented to extract the nucleus. The shape and texture features are extracted from the segmented image in the feature extraction step. Finally the images are classified as cancerous or non-cancerous based on the extracted features.

Automatic Detection of Acute Myeloid Leukemia from Microscopic Blood Smear Image

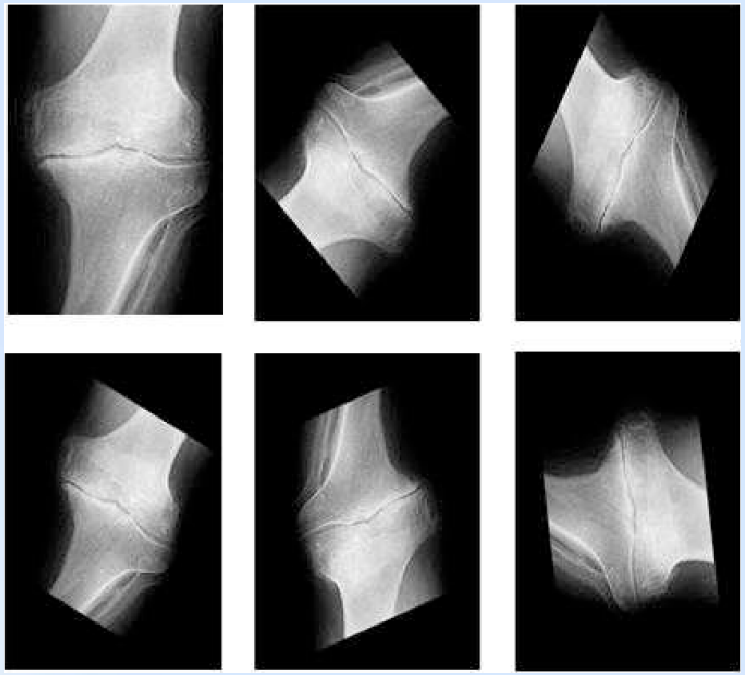


Assoc. Prof. Dr. Kamil Dimililer - Near East University, 2019

Rheumatoid Arthritis Identification

Rheumatoid arthritis is an autoimmune disease that causes chronic inflammation of the joints. Techniques used include RGB to grayscale conversion, rescaling, median filtering, background extracting, image subtracting, image segmentation, canny edge detection and feature extraction using pattern averaging to rescale the image. The extracted features are then used as inputs for the neural network, which classifies the x-ray knee images as normal or abnormal (arthritic).

Rheumatoid Arthritis Identification



Rheumatoid arthritis knee image

Assoc. Prof. Dr. Kamil Dimililer - Near East University, 2019

Other Applications of Image Processing in Medical Field

- Cell image analysis
- Surgical operations
- Diagnoses of diabetic retinopathy
- Digital pathology
- Spectral mammography

Benefits of Image Processing in Other Applications

- Image processing helps to automatically identify and analyse what might not be apparent to the human eye.
- Image processing and analysis can be used to determine the diameter, volume and vasculature of a tumor or organ.
- Image reconstruction and modelling techniques allow instant processing of 2D signals to create 3D images.
- It is used by surgeons for patient-specific measurement, navigation, surgical simulation, surface reconstruction, and implant design

THANK YOU