
DIGITAL IMAGE
PROCESSING

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What is an image?

- An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of at any pair of coordinates (x, y) is called the **Intensity or gray level** of the image at that point.

- When x, y, and the amplitude values of f are all finite,discrete quantities, we call the image a **digital image.**

Digital Image Processing

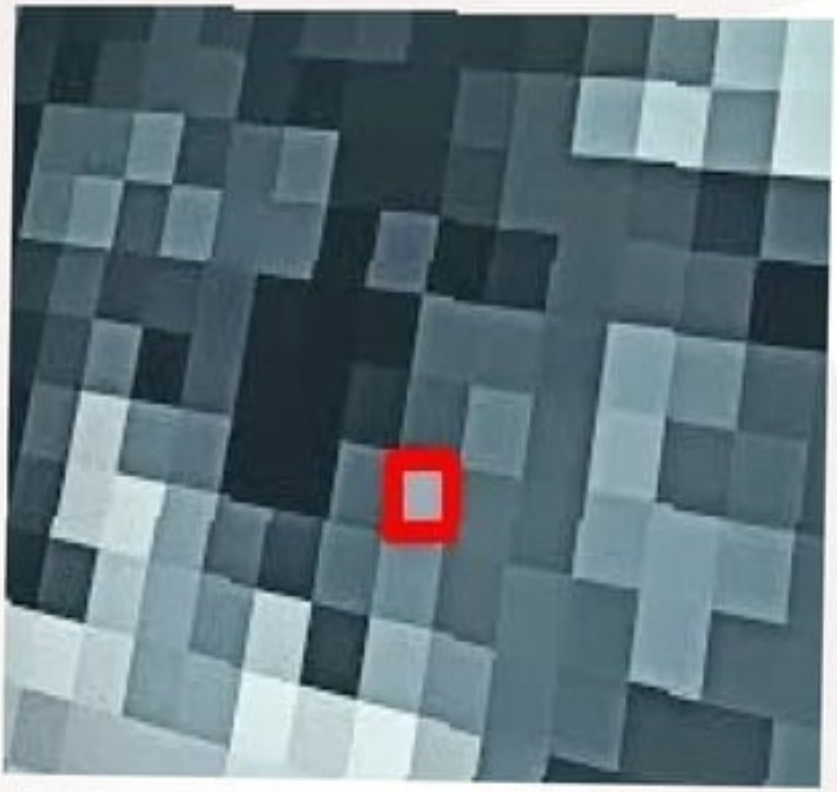
- The field of digital image processing refers to processing digital images by means of a digital computer.

Note :-

- Digital image is composed of a finite number of elements, each of which has a particular location and value.These elements are referred to as picture elements, image elements, pels and pixels.

- **Pixel** is the term most widely used to denote the elements of a digital image.

Pixel



History

- Many of the techniques of digital image processing, or digital picture processing as it often was called, were developed in the 1960s at the Jet Propulsion Laboratory, Massachusetts Institute of Technology, Bell Laboratories, University of Maryland, and a few other research facilities.

History

- With the fast computers and signal processors available in the 2000s, digital image processing has become the most common form of image processing and generally, is used because it is not only the most versatile method, but also the cheapest.

- Digital image processing technology for medical applications was inducted into the Space Foundation Space Technology Hall of Fame in 1994.

History

- In 2002 Raanan Fattal introduced Gradient domain image processing, a new way to process images in which the differences between pixels are manipulated rather than the pixel values themselves.

Age progression of missing person Aundria Bowman

Fig. Image produced using telegraphic printer

Types of computerized process

- There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: **low-, mid-, and high-level processes.**

Types of computerized process

- Low level processes involve primitive operations such as image preprocessing to reduce noise,contrast enhancement, and image sharpening.
- A low-level process is characterized by the factthat both its inputs and outputs are images.

Types of computerized process

- Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects.

- A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects).

Types of computerized process

- Higher-level processing involves "making sense" of anensemble of recognized objects, as in image analysis, and, at the far end of the continuum,performing the cognitive functions normally associated with vision and, in addition,encompasses processes that extract attributes from images, up to and including the recognition ofindividual objects.

Types of computerized process

- As a simple illustration to clarify these concepts, consider the area of automated analysis of text.

- The processes of acquiring an image of the area containing the text,preprocessing that image, extracting (segmenting) the individual characters, describing the characters in a form suitable for computer processing and recognizing those individual characters are in the scope of what we call **digital image processing.**

Fundamental steps in image processing

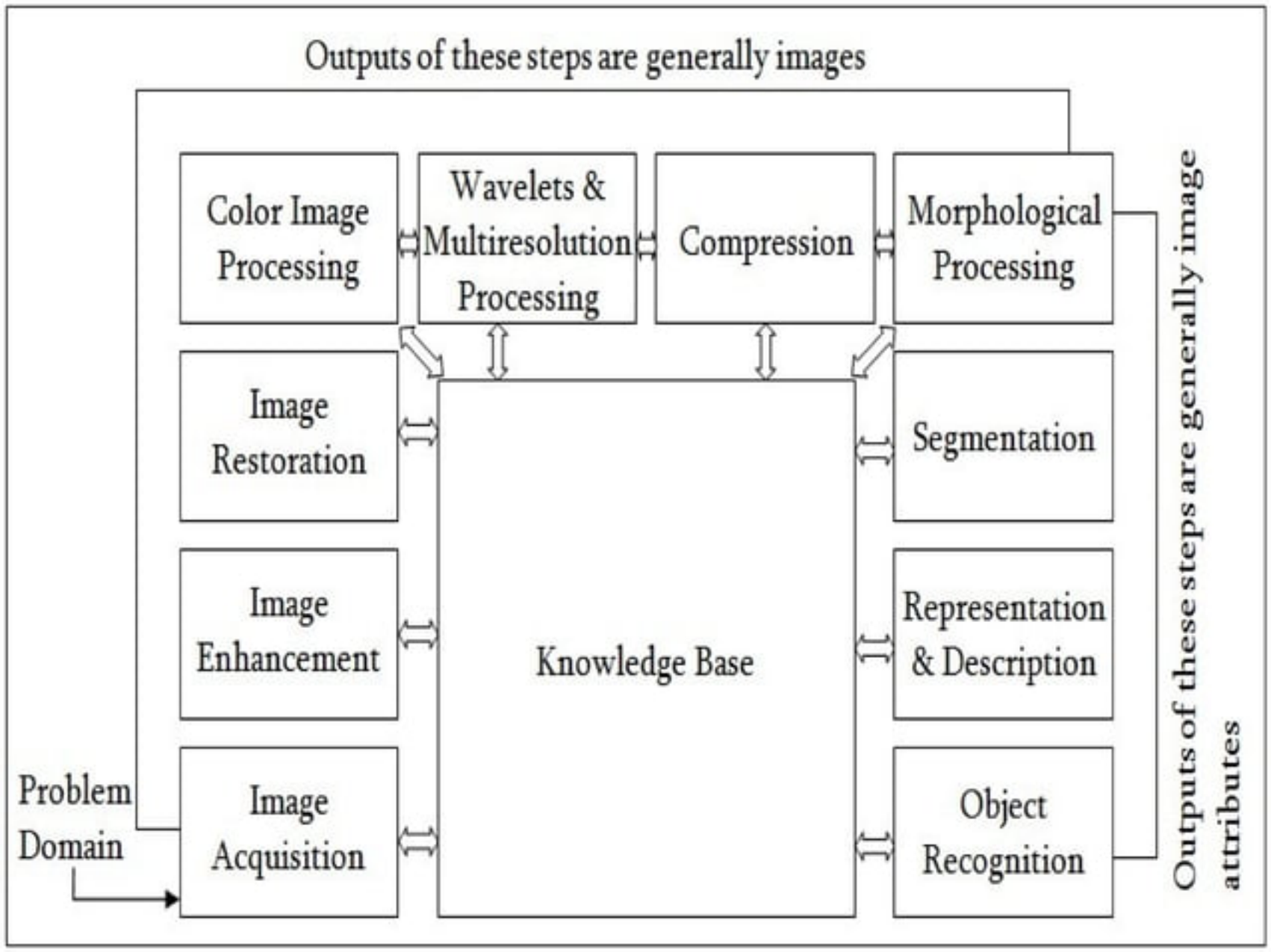
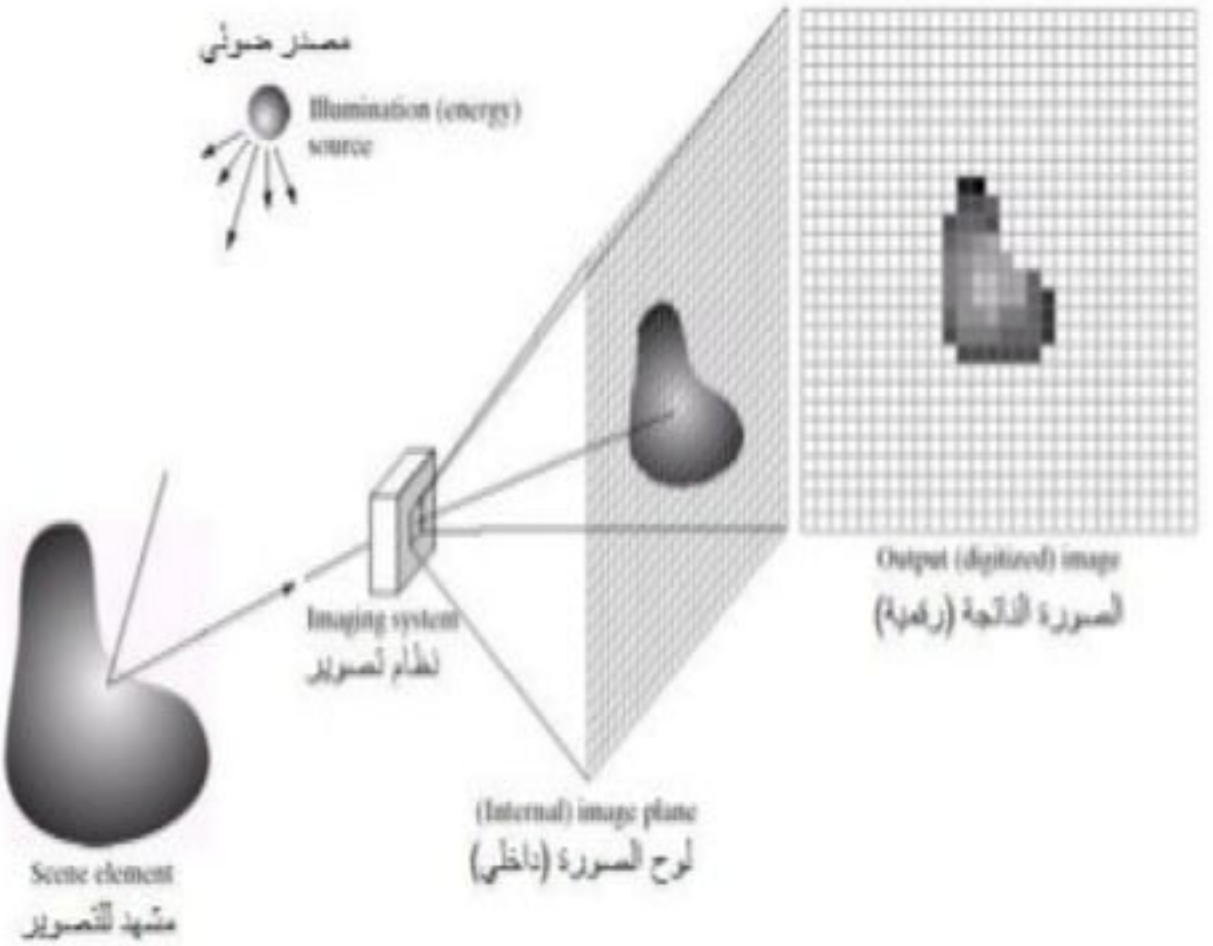

Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Segmentation
Image Enhancement
Knowledge Base
Representation & Description
Problem Domain
Image Acquisition
Object Recognition
Outputs of these steps are generally image attributes

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 preprocessing, such as scaling etc.


مصدر ضوئي
Illumination (energy)
source
Imaging system
نظام تصوير
Output (digitized) image
الصورة الناتجة (رقمية)
(Internal) image plane
لوح الصورة (داخلي)
Scene element
مشهد للتصوير

Topics:-

- Basic digital image concepts
- Preprocessing stages
- Visual perception
- Sampling
- Quantization
- Pixel operations

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.

- Enhancement in the spatial domain
- Point processing
  - Log transformation
  - Power law transformation
- Spatial filtering process
- Smoothing filters
- Frequency Domain Filtering
  - The Fourier transform
  - Filtering in the frequency domain
  - Low pass filters - High pass filters
    - ->Ideal low pass filter
    - ->Butterworth low pass filter
    - ->Gaussian low pass filter

Image Enhancement

Low contrast Image

Enhanced Image

One of the most common uses of DIP techniques:

- improve quality,
- remove noise.. etc

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.

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.

Topics:

- Color fundamentals
- Color models
- Color transformations
- Smoothing and sharpening
- Color segmentation
- Noise in color images

Wavelets &Multiresolution 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.

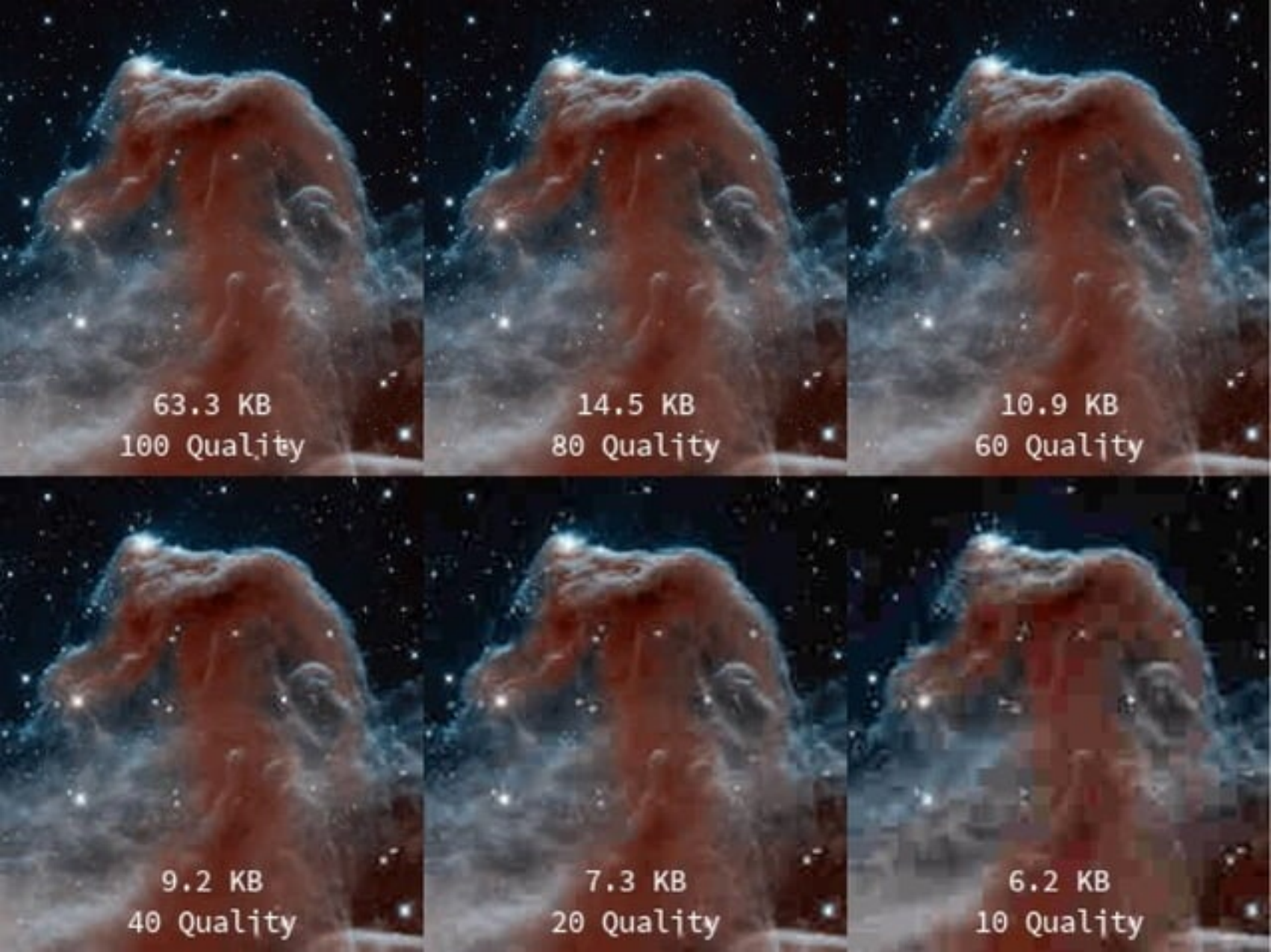
Decomposition of a grey-scale image by a morphological wavelet (max-lifting scheme). The original image is shown at the left and its decomposition into four subbands at the right.

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.

Topics:

- Coding redundancy
- Image compression models
- Error-free compression
- Lossy compression
- Image compression standards

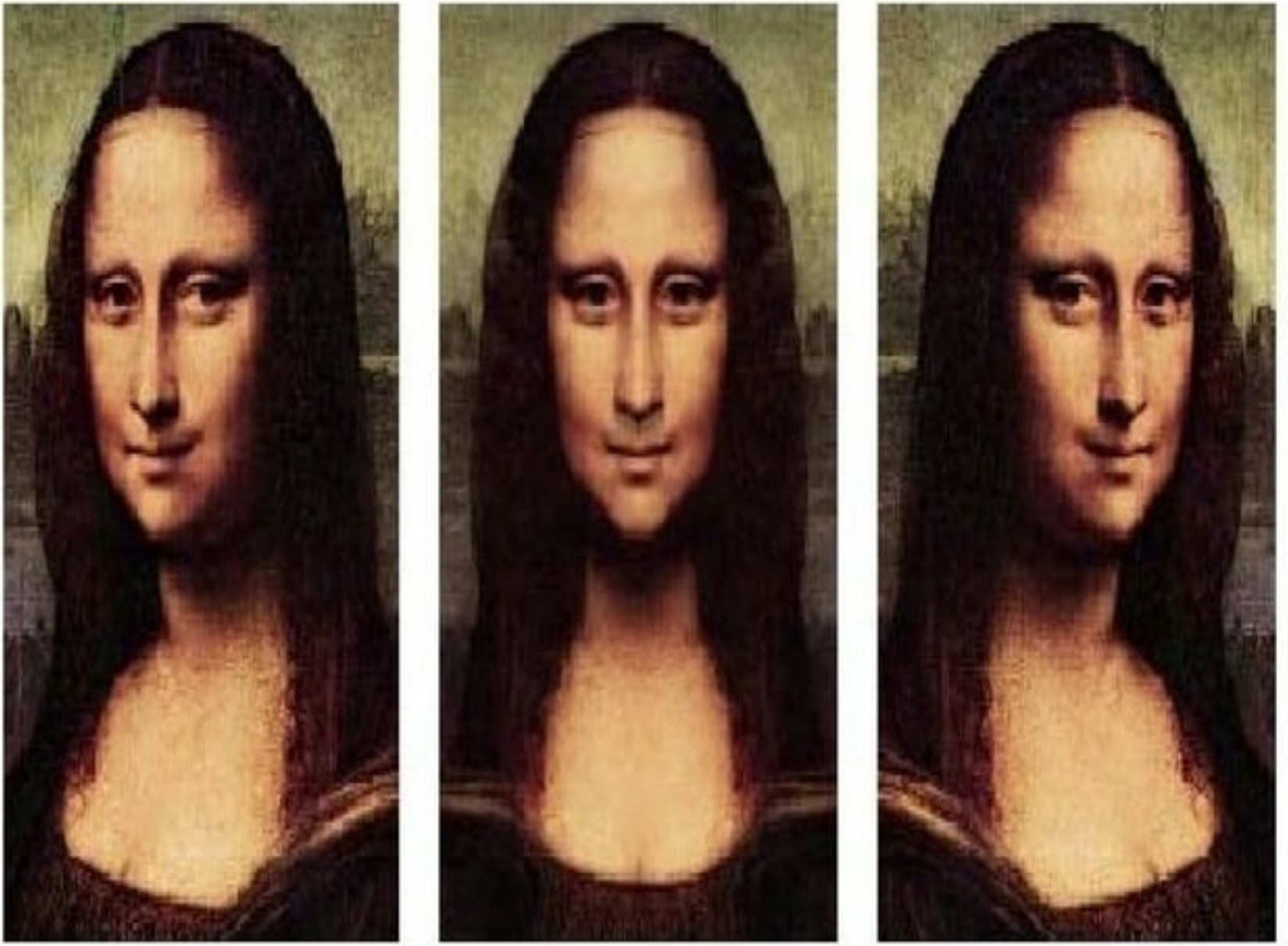

63.3 KB
100 Quality
14.5 KB
80 Quality
10.9 KB
60 Quality
9.2 KB
40 Quality
7.3 KB
20 Quality
6.2 KB
10 Quality

Morphological Processing

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

- Basic morphological concepts and operations
  - Hitting, fitting and missing
  - Erosion and dilation
  - Opening and closing

- Morphological algorithms
  - Boundary extraction
  - Region filling



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.

Main topics:

- The segmentation problem
- Importance of good thresholding
- Problems that can arise with thresholding
- The basic global thresholding algorithm
- Point- edge detection
- Region-based segmentation


Representation & 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.

Topics:

- Chain codes
- Skeletons
- Boundary descriptors
- Regional descriptors
- Texture

a b
d c
e f

FIGURE 9.11
(a) Noisy image. (c) Eroded image. (d) Opening of A. (d) Dilation of the opening. (e) Closing of the opening. (Original image for this example courtesy of the National Institute of Standards and Technology.)

Object recognition

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

Topics:

- Pattern classes
- Structural methods

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.

Sources for Images

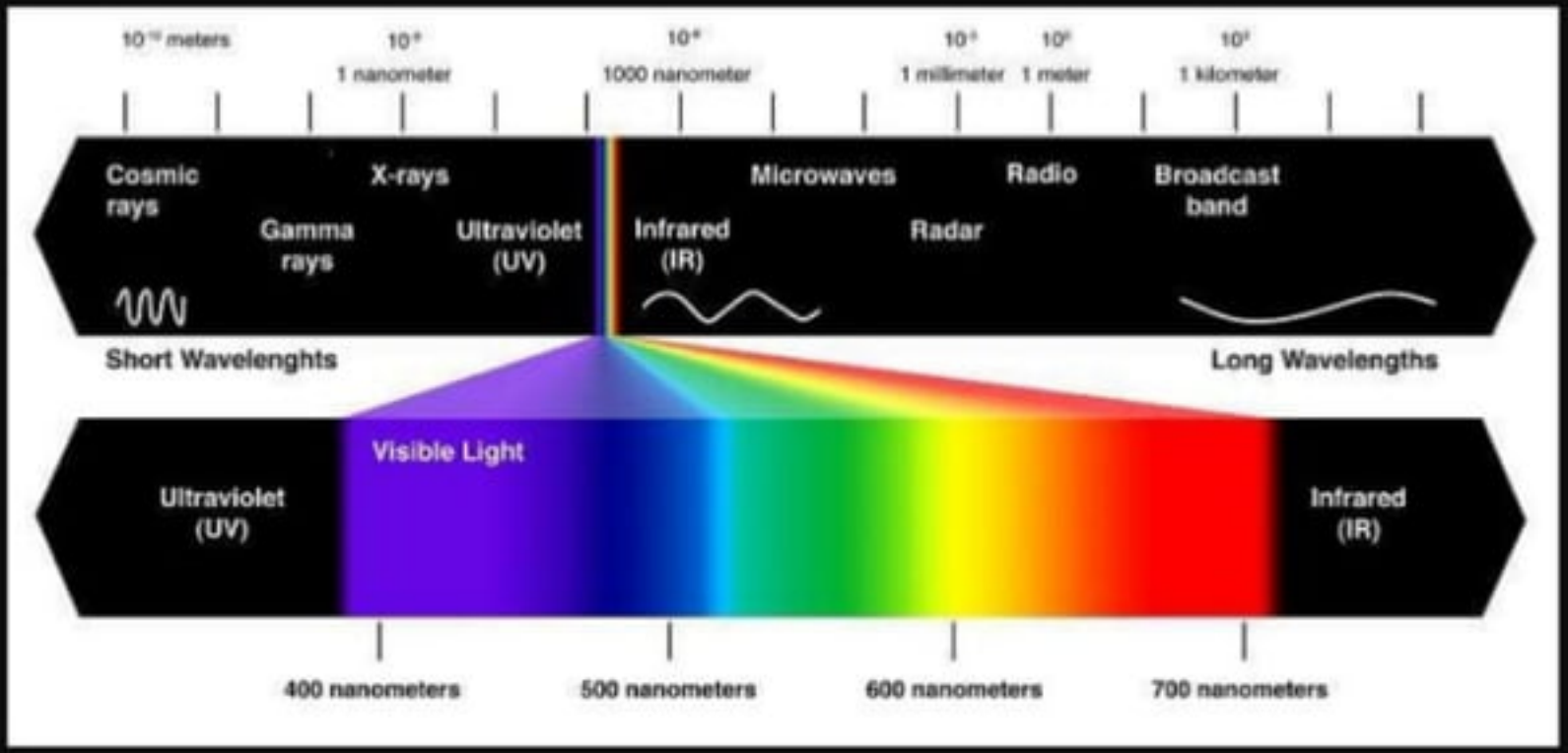
One of the simplest ways to develop a basic understanding of the extent of image processing applications is categorization according to sources.

- Electromagnetic (EM) energy spectrum
- Synthetic images produced by computer
- Acoustic
- Ultrasonic
- Electronic

Electromagnetic (EM) energy spectrum

- Images based on radiation from the EM spectrum are the most familiar to us.
- If bands are grouped according to energy per photon, we obtain the spectrum
- Em spectrum are not distinct but rather transition smoothly one to other.

Electro-Magnetic Spectrum



Uses

- **Gamma-ray imaging (highest energy):** nuclear medicine and astronomical observations
- **X-rays:** medical diagnostics, industry, and astronomy, etc.
- **Ultraviolet:** industrial inspection, microscopy, lasers, biological imaging, and astronomical observations
- **Visible and infrared bands:** light microscopy, astronomy, remote sensing, industry, and law enforcement
- **Microwave band:** radar Radio band (lowest energy) : medicine (such as MRI) and astronomy

X-Ray imaging (Medical)

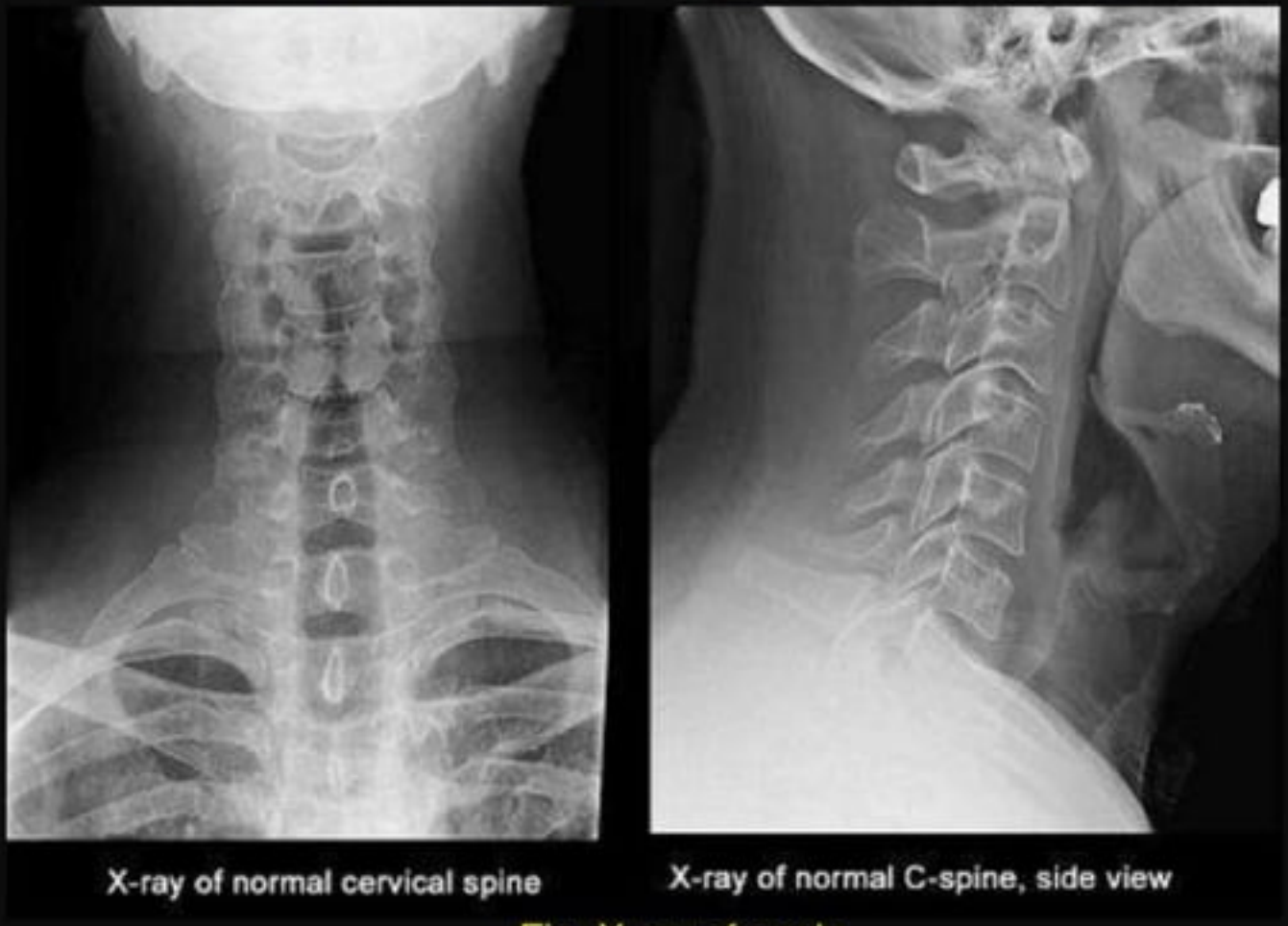


Fig. X ray of neck

Gamma-Ray imaging (Medical)

Fig. Gamma ray exposed images

APPLICATIONS

The Hubble Telescope

- Launched in 1990 the Hubble telescope can take images of very distant objects.

  However, an incorrect mirror made many of Hubble's images useless.

- Image processing techniques were used to fix this

HCI

Try to make human computer interfaces more natural.

- Face recognition
- Gesture recognition

Artistic Effects

- Artistic effects are used to make images more visually appealing, to add special effects and to make composite images.

Image Processing Examples

- Pseudocolor enhancement for security screening.
- Earthquake Analysis
- UV Imaging
- Extraction of settlement area from an aerial image
- Face Morphing
- Fingerprint Recognition
- Iris Recognition
- Hand Writing Recogition
- Face Detection

Seismic imaging (Earthquake)

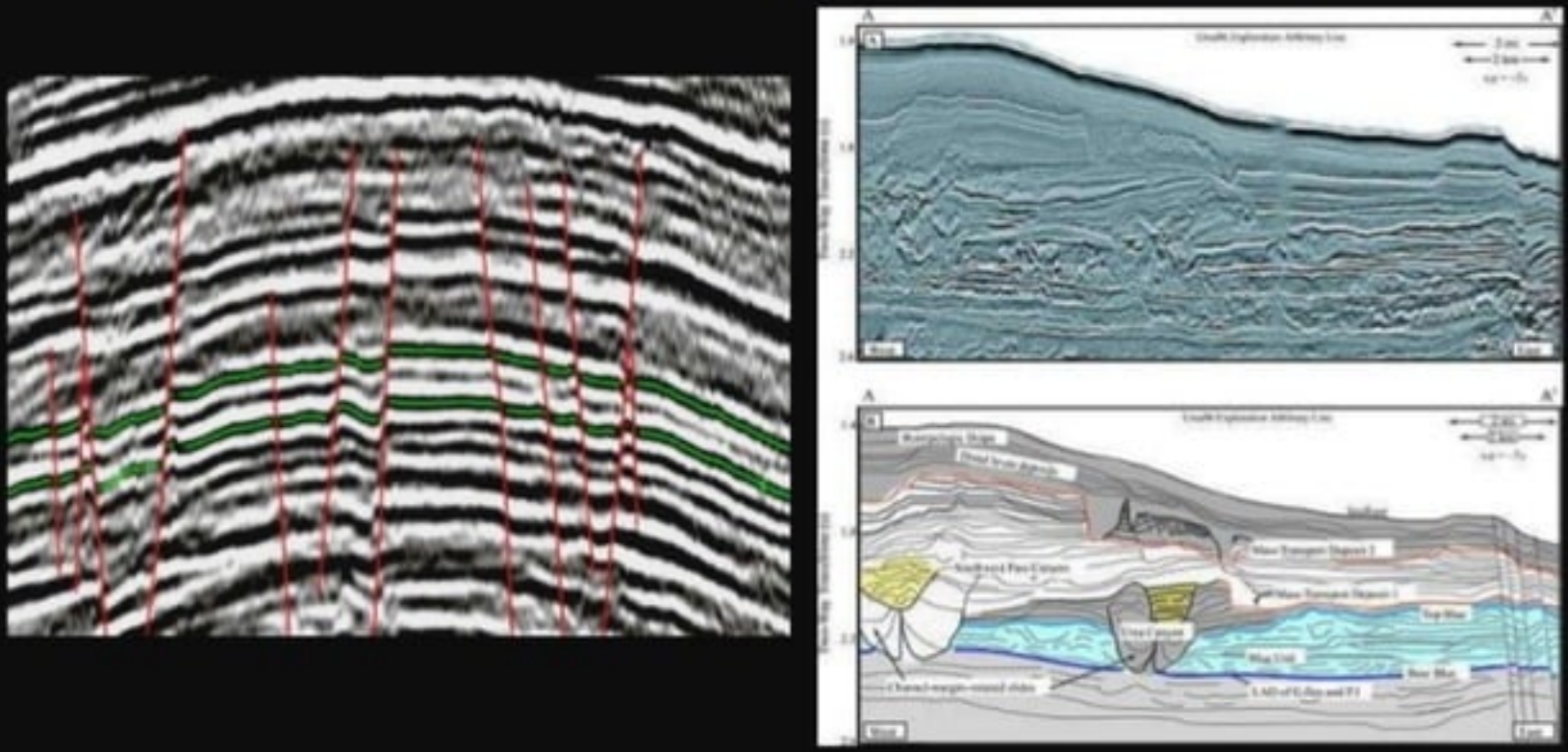


Fig. Detecting Earthquakes and its cause using cross sectional view

UV imaging (Sun spots)

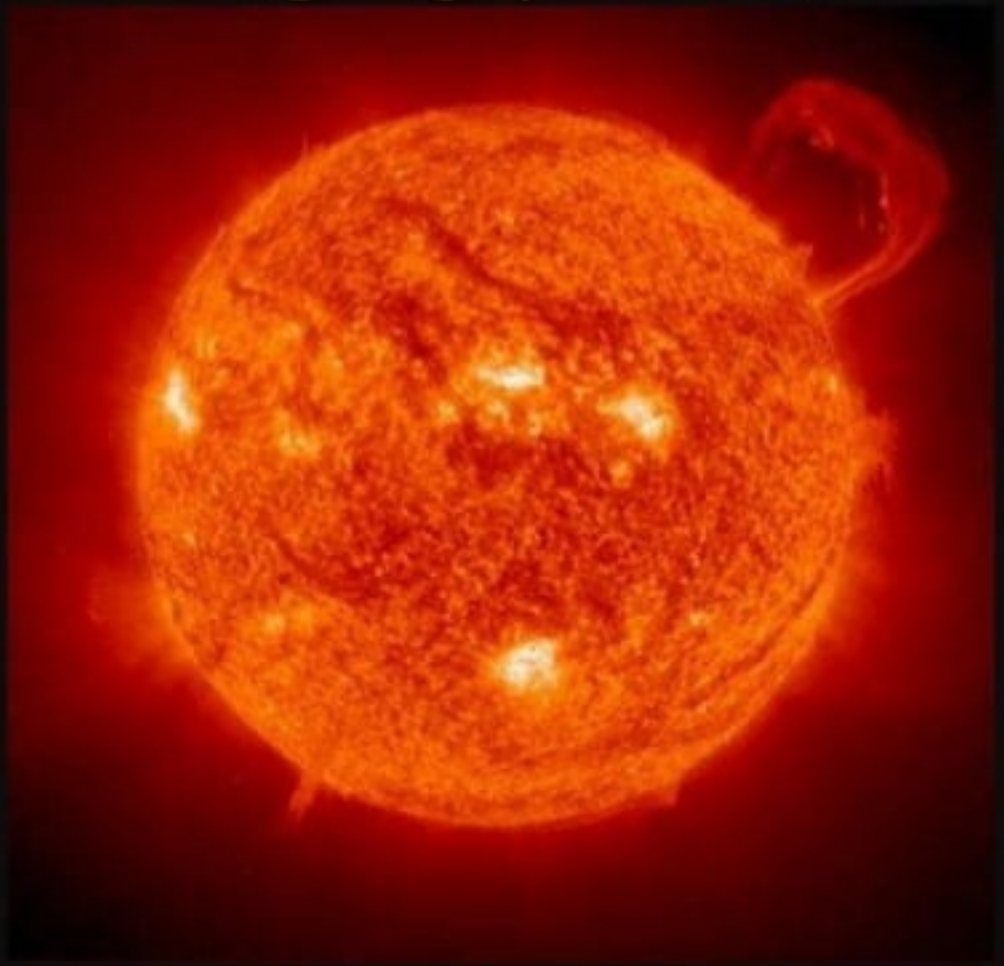


Fig. Identify sun spots

Remote Sensing

Fig. Satellite images of Mumbai suburban(Left) and Gateway of India (Right)


Thank you...