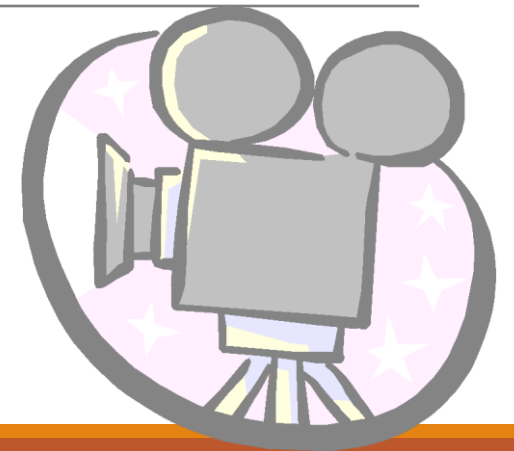


Image Processing

CS-317/CS-341



Outline

- Origin of Digital Image Processing (DIP)
- Fields that use DIP
- Fundamental steps in DIP

Origin of Digital Image Processing (DIP)

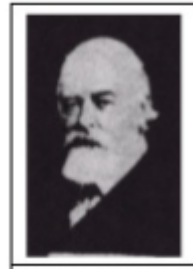
-
- First applications of digital images was in newspaper industry, when pictures were first sent by **submarine cable** between London and New York.
 - In the early 1920s, **Bartlane cable picture transmission system**, reduces the transmission time across Atlantic from more than a week to less than three hours.
 - The transmitted pictures can be reproduced using telegraph printer with special typeface.
 - This method was abandoned towards the end of 1921, in favor of a technique based on photographic reproduction made from tapes

Origin of Digital Image Processing (DIP) (Cont..)

- Early **Bartlane cable picture transmission systems** were capable of coding images in five distinct levels of gray.
- This capacity was increased to 15 levels in 1929.
- Although the examples just cited involve digital images not digital image processing because computers were not involved in their creation.
- The progress in the field of DIP has been dependent on the development of digital computers and the supporting technologies that include data storage, display and transmission.



Fig. 1 Digital picture produced in 1921 from a coded tape by telegraph printer with special type faces



Digital picture made in 1922



Fig. 2 Untouched picture of Generals Pershing And Foch transmitted in 1929 between London and New York by 15 tone equipment

Origin of Digital Image Processing (DIP) (Cont..)

- The basis of modern digital computer dates back to only the 1940s with the introduction by John von Neumann of two key concepts:
 - A memory to hold a stored program and data.
 - Conditional branching
 - These two idea are the foundation of CPU.

Origin of Digital Image Processing (DIP) (Cont..)

- The key advances that led to computers powerful enough to be used in DIP are:
 - Invention of Transistor at Bell Lab in 1948.
 - High level Programming languages in 1950s to 1960s.
 - Invention of Ics at Texas in 1958s.
 - Development of OS in 1960s.
 - Development of microprocessor by Intel in the early 1970s.
 - Introduction of personal computer by IBM in 1981.
 - Large scale Ics in late 1970s
 - VLSI Ics in 1980s (Ultra large scale integration (ULSI) present)

Origin of Digital Image Processing (DIP) (Cont..)

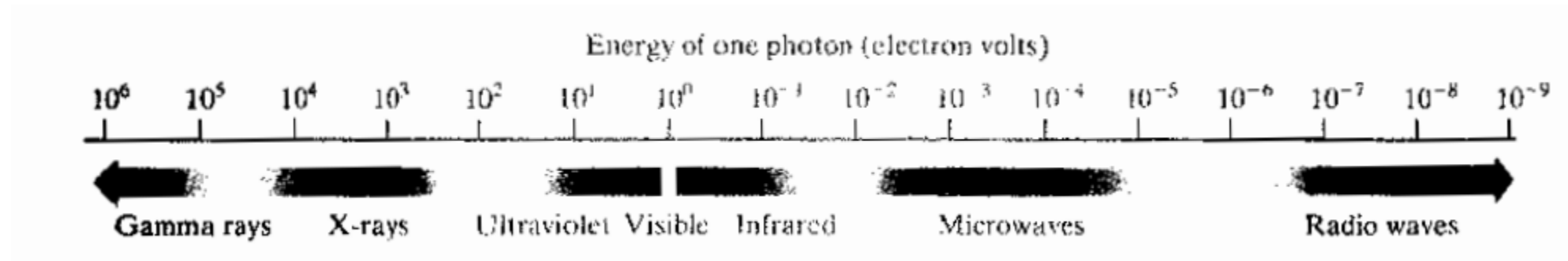
- First Computer was powerful enough to carry image processing task appeared in the early 1960s.
- First picture of moon transmitted by U.S. Spacecraft. Ranger 7 took this picture on July 31 1964.



- In late 1960s and early 1970s DIP is used in medical imaging, remote earth resources observation, and astronomy.
- From late 1960s to present, the field of image processing has grown vigorously.

Fields that use DIP

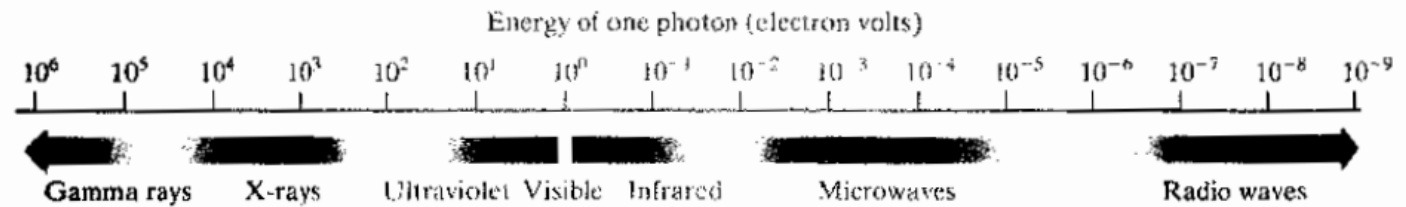
- One of the simplest ways to develop a basic understanding of the extent of image processing applications is to categorize images according to source:



Electromagnetic spectrum arranged according to energy per photon

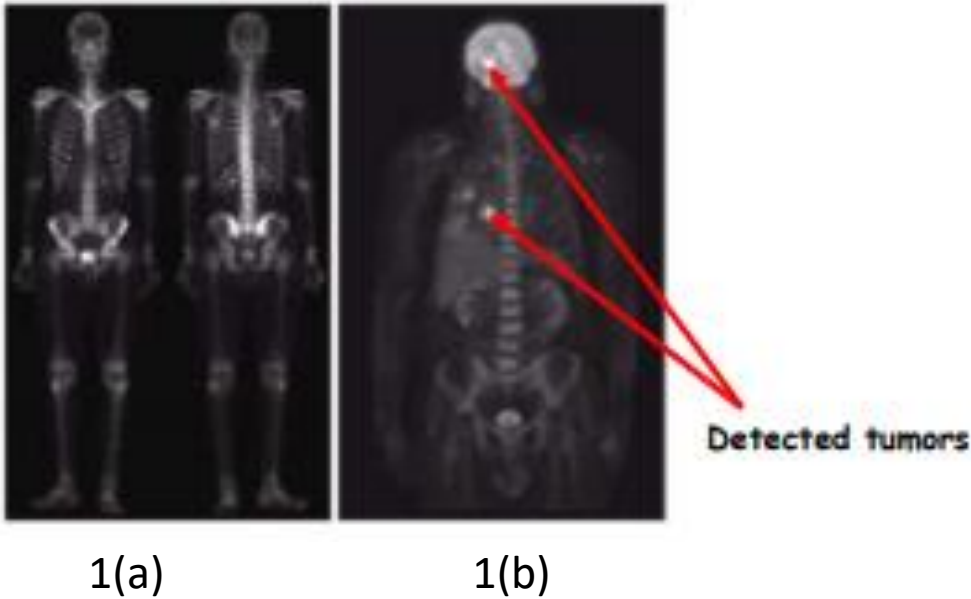
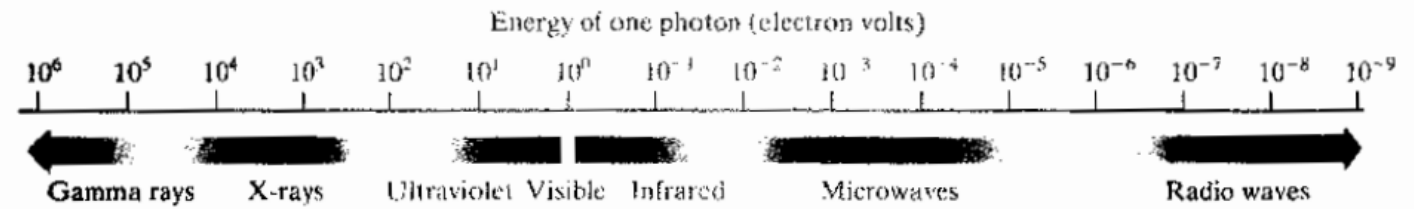
The bands are shown shaded to convey the fact that bands of electromagnetic spectrum are not distinct but rather transition smoothly from one to the other.

Gamma-Ray Imaging

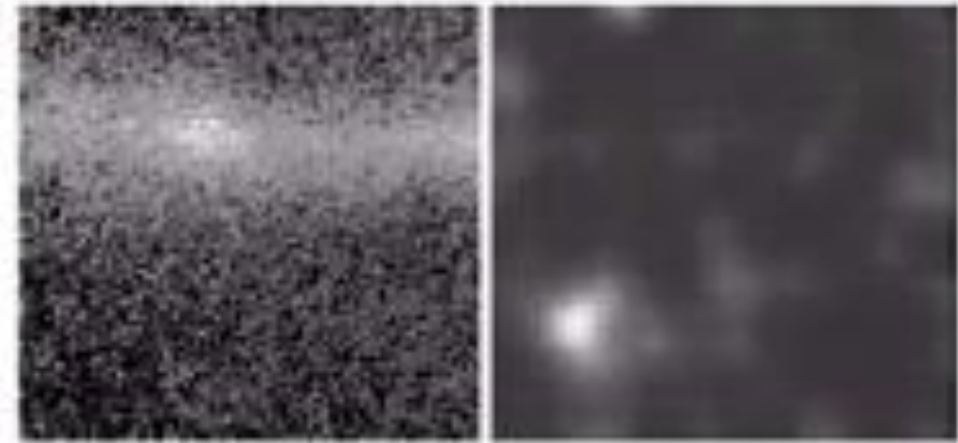


- Nuclear Medicine: Major use of imaging based on Gamma rays include nuclear medicine and astronomical observations.
 - Approach is to inject a patient with radioactive isotope that emits gamma rays as it decays
 - Images are produced from the emissions collected by gamma ray detector.
- Positron-Emission-Tomography (PET)
 - patient given radioactive isotope that emits positrons as it decays
 - When positron meets electron, both are destroyed and two gamma rays are given off
 - Gamma rays are detected and using special detectors and image is constructed

Gamma-Ray Imaging



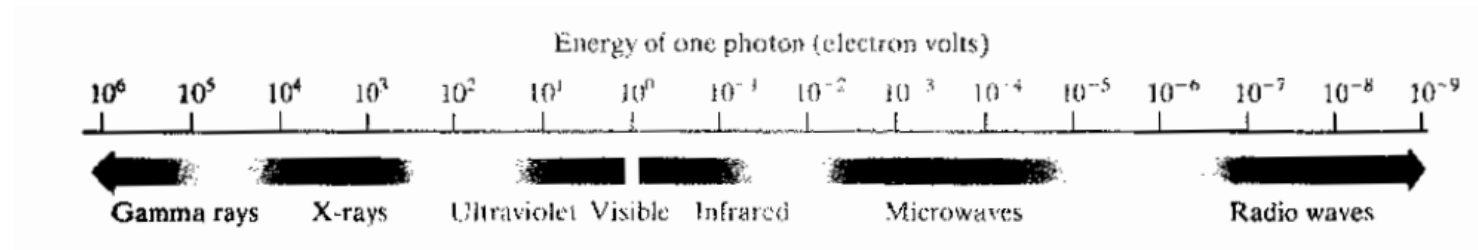
- (a) Locate sites of bone pathology, such as infection or tumors
- (b) This image shows a tumor in the brain and one in the lung



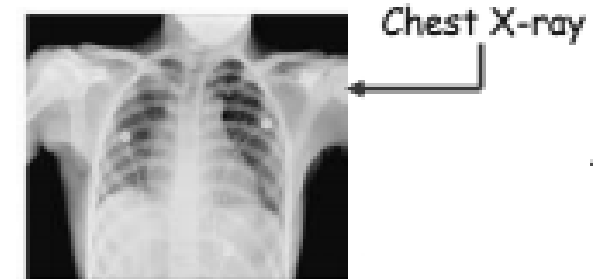
- 2(a) 2(b)
- (a) Cygnus loop in the gamma ray
 - (b) This image shows gamma radiation from a valve in a nuclear reactor.

*star in the constellation of Cygnus exploded about 15000 years ago, generating a superheated gas cloud (known as Cygnus loop)

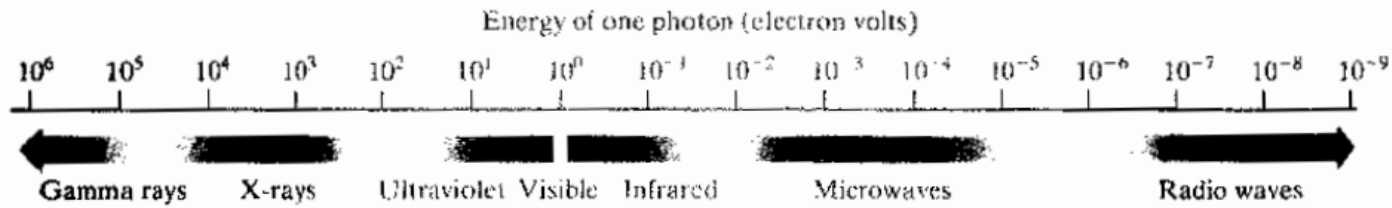
X-Ray Imaging



- X Ray Imaging: Oldest Sources of EM Radiation for Imaging
 - Best known for medical diagnostics
 - Patient placed between “X-ray tube” and special film sensitive to X-ray radiation
 - Electrons are emitted from X-ray tube and go through patient
 - Intensity of X-rays is modified by absorption as they go through patient
 - Intensity collected at film and image is then created



X-Ray Imaging

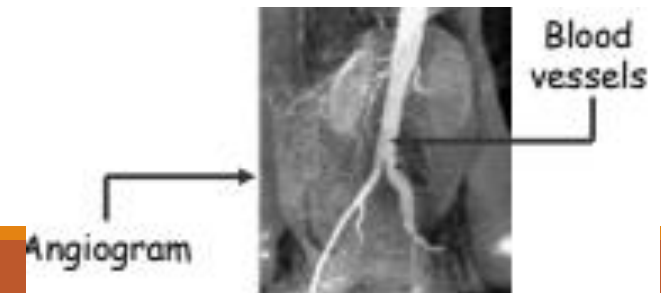


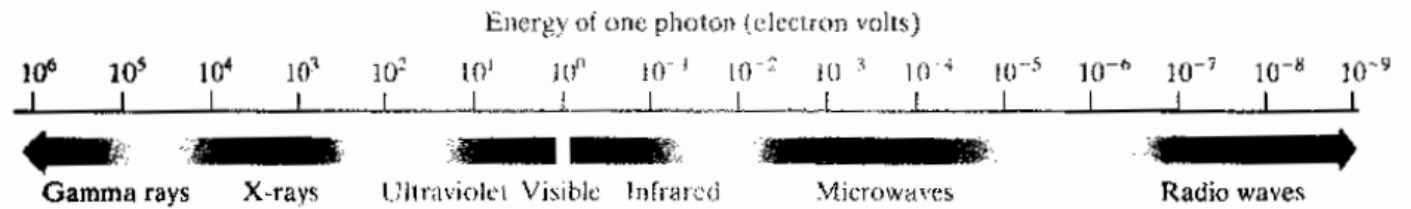
➤ Other Applications of X-ray Imaging

➤ Computerized axial tomography (CAT scan)

➤ Angiography: is another major application in an area called contrast enhancement radiography.

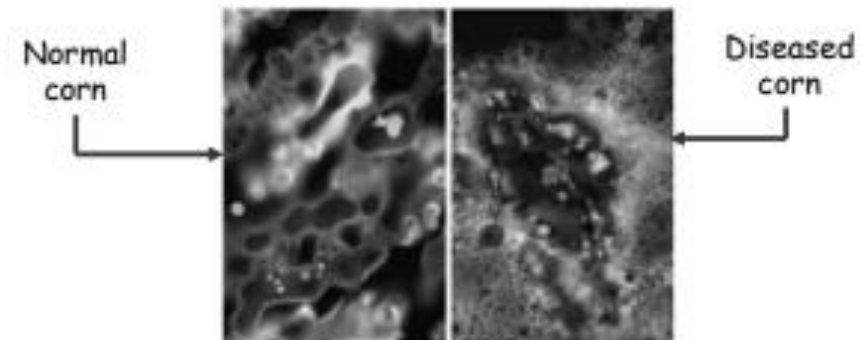
- Obtain images of blood vessels (angiograms)
- A catheter (a small, flexible, hollow tube) is inserted, for example into an artery or vein.
- X-ray contrast medium injected via catheter at appropriate location
- X-ray image obtained and blood vessels highlighted





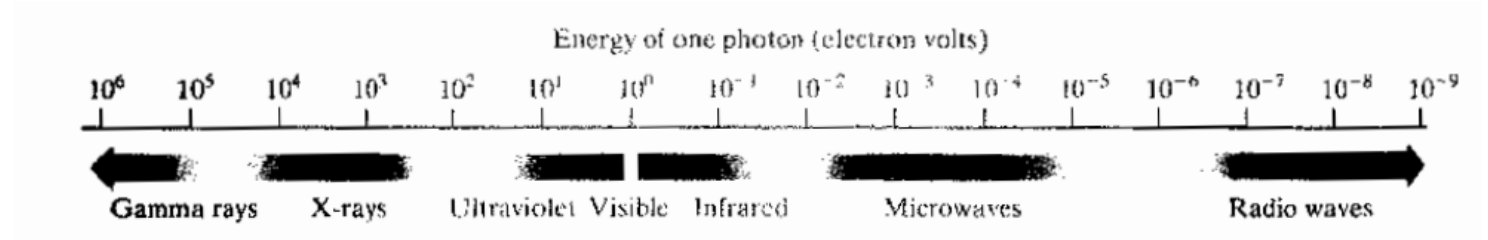
Imaging in the Ultraviolet Band

- Varied Applications
 - Industrial inspection
 - Microscopy → fluorescence microscopy one of the fastest growing fields of microscopy Lasers
 - Biological imaging
 - Astronomical observation



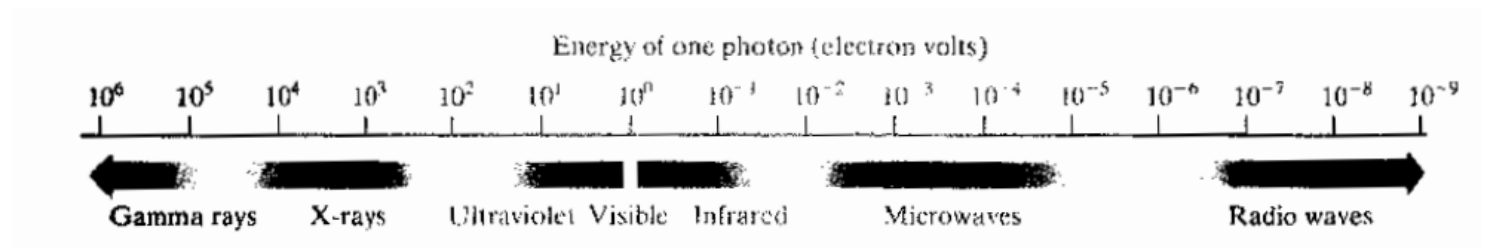
Imaging in the Visible and Infrared Bands

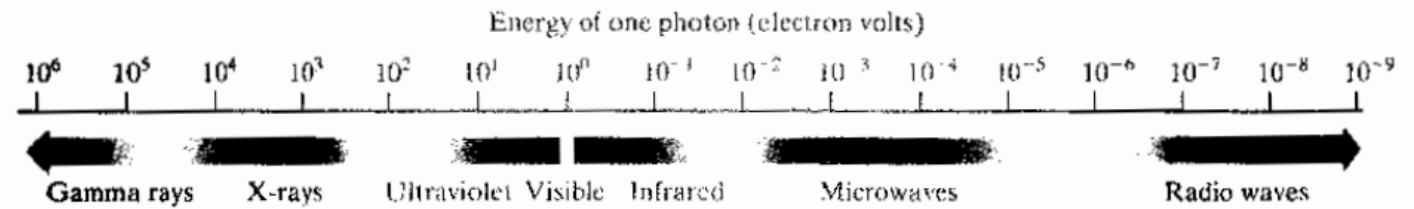
- Visual band of the spectrum is the most familiar in all our activities.
- Infrared band often used in conjunction with visual imaging.
- Various applications
 - Light microscopy, Astronomy, Industrial applications, Remote sensing



Imaging in the Visible and Infrared Bands

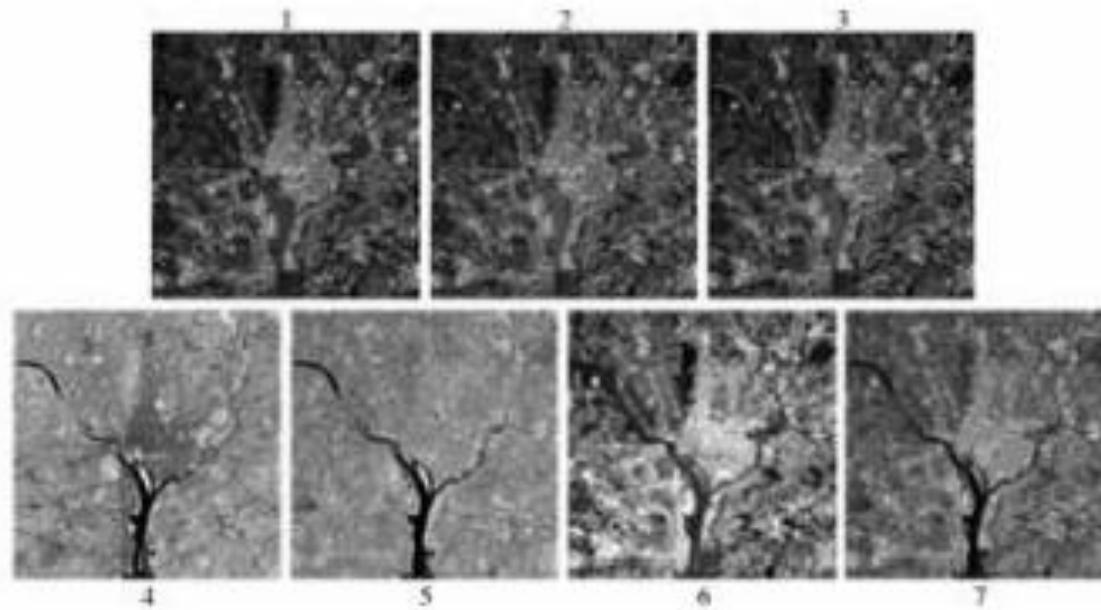
- Remote Sensing Definition: The process of obtaining data or images from a distance, as from satellites or aircraft
- Major area of visual/infrared imaging , usually covers several bands of the visual/infrared spectrum
- NASA's LANDSAT satellite
 - Primary purpose → Obtain and transmit images of earth from space for environmental monitoring purposes

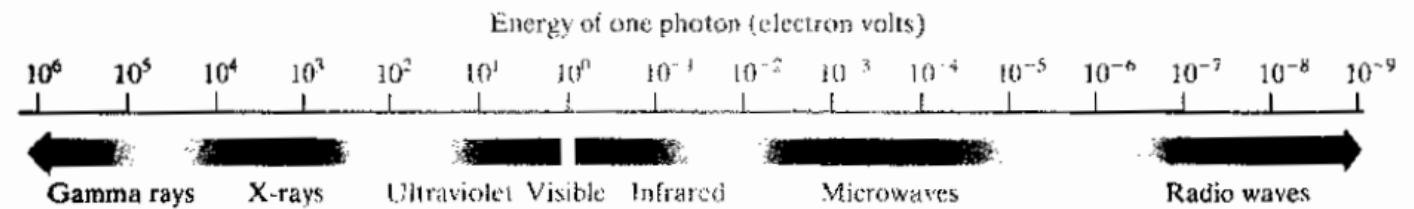




Imaging in the Visible and Infrared Bands

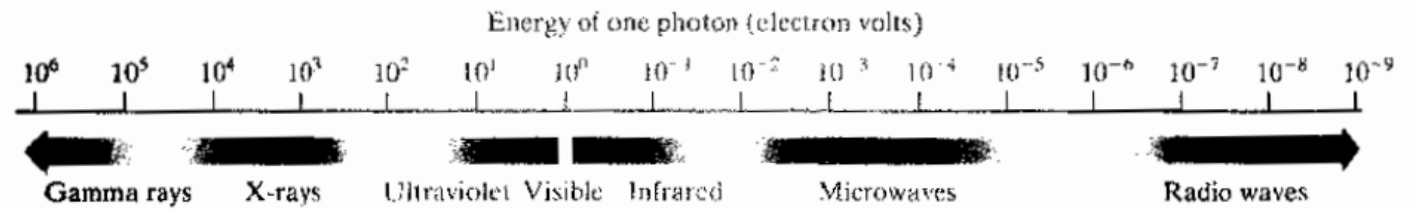
- Images Obtained from LANDSAT
 - Detect vegetation, roads, rivers, buildings etc





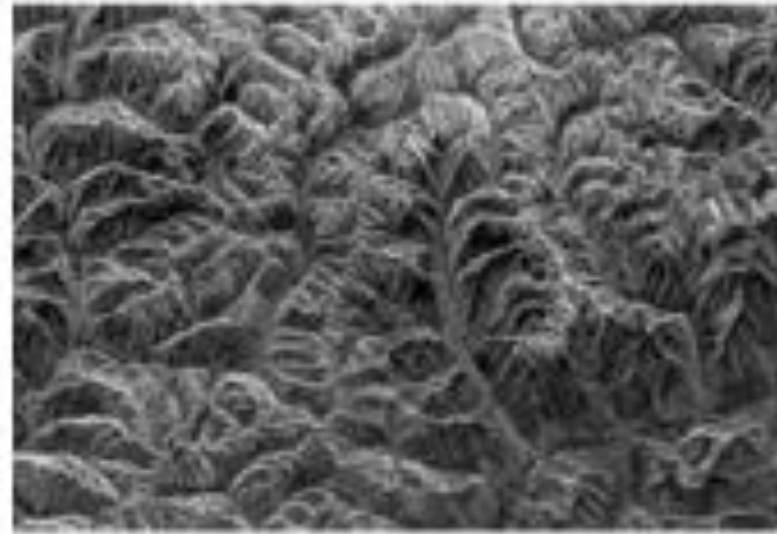
Imaging in the Microwave Band

- Dominant Use is Radar
 - Ability to collect data over virtually any region, at any time, regardless of weather conditions or ambient light conditions
 - Penetrate clouds At times, can see through vegetation, ice, sand...
- Operates similar to flash camera
 - Provides its own illumination (microwave pulses) to illuminate area of interest and then “snaps” image
 - Instead of camera lens, antenna is used

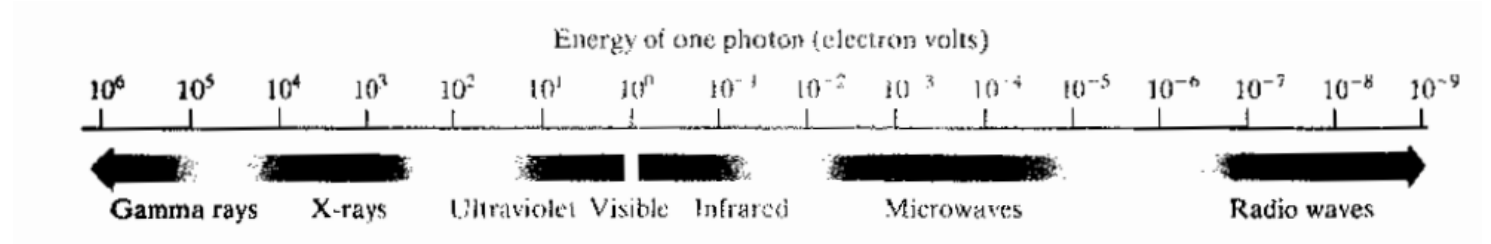


Imaging in the Microwave Band

- Image of mountainous region of Tibet obtained from space satellite

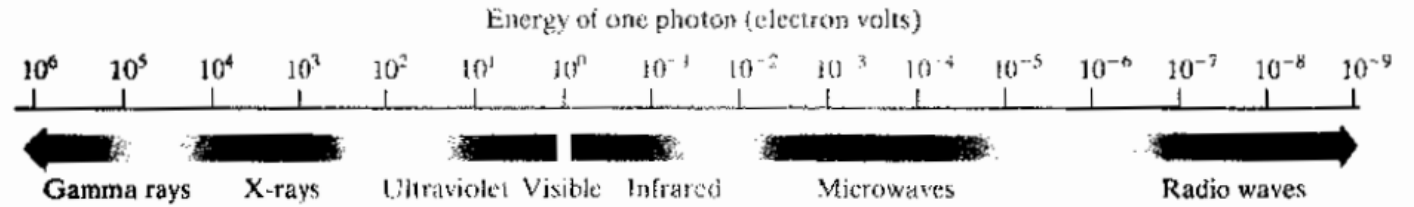


Imaging in Radio Band



- Dominant use is Medicine and Astronomy
- In medicine, popular technique is magnetic resonance imaging (MRI)
- Patient placed in powerful magnet Radio waves are passed through patient's body in short pulses
- Each pulse causes another pulse to be emitted by the patient's tissues
- Location and strength of the pulses is determined by computer and 2D image is created based on this information

Imaging in Radio Band



MRI image of a human knee and spine

Other Imaging Modalities

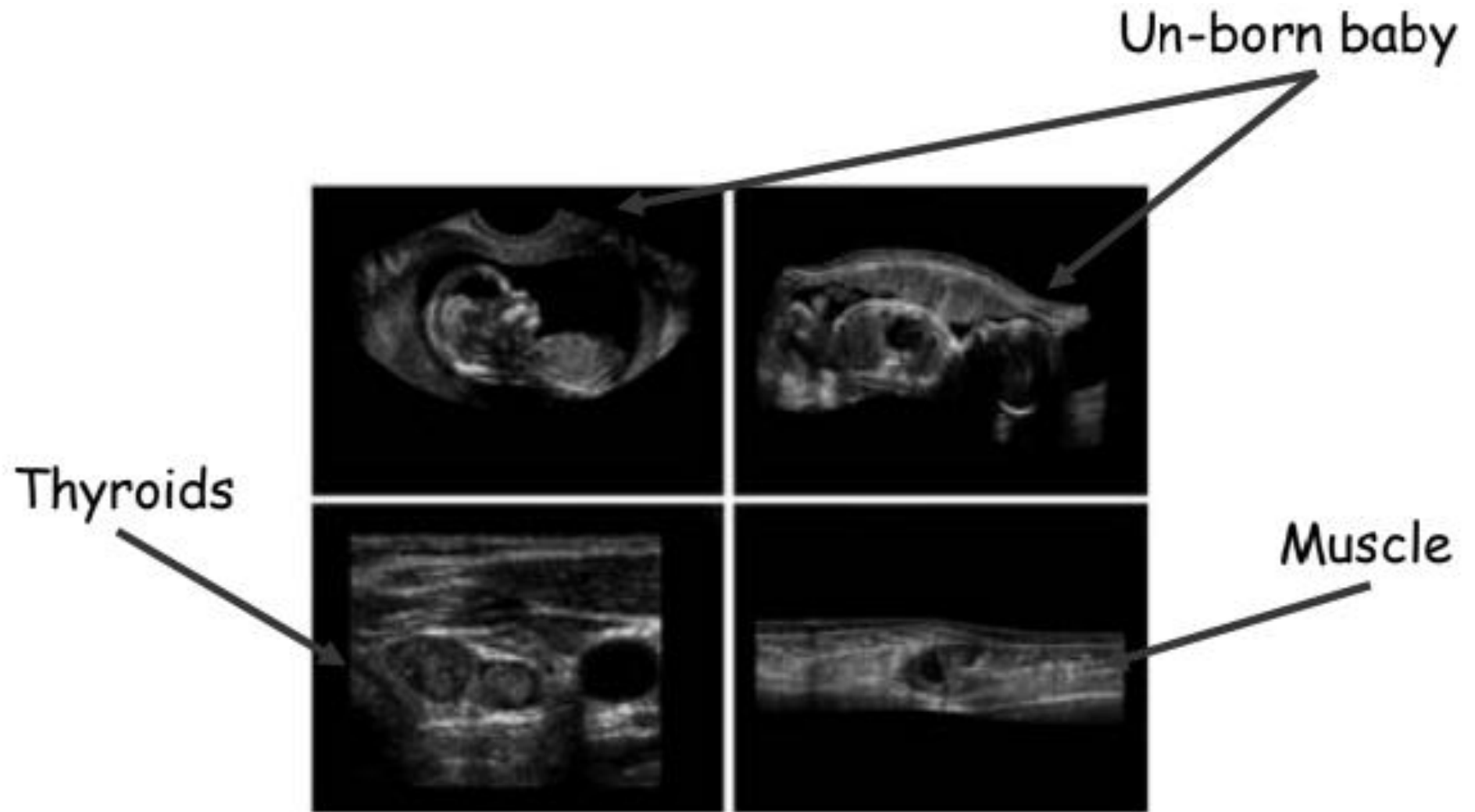
- Acoustical Imaging

- Sound waves (typically low frequency, e.g., $< 100\text{Hz}$) are emitted from transmitter
- Reflections of transmitted sound recorded by receiver
- Image constructed based on time of arrival and intensity of echoes
- Many applications
 - Geological exploration (oil and mineral exploration)
 - Industry
 - Medicine (ultrasound)

Other Imaging Modalities

- Acoustical Imaging (cont...)
 - Popular use of acoustical imaging is ultrasound
 - Viewing of unborn babies
 - Viewing other body tissues/bones
 - Can detect certain cancers
- To construct typical ultrasound image, millions of pulses and echoes are emitted and received respectively each second
- Pulses typically 1 – 5 MHz

Other Imaging Modalities



Suggested Readings

- ❑ **Digital Image Processing by Rafael Gonzalez, Richard Woods, Pearson Education India, 2017.**
- ❑ **Fundamental of Digital image processing by A. K Jain, Pearson Education India, 2015.**

Thank you

