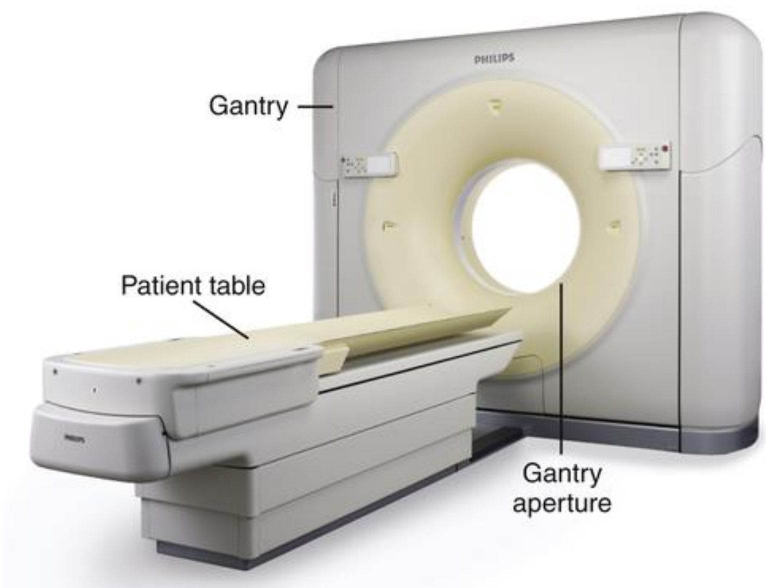
COMPUTED TOMOGRAPHY

The origin of the word "tomography" is from 2 Greek words

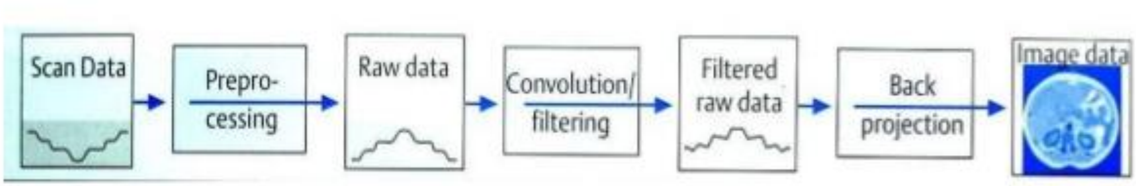
(1) ‘Tomos’ meaning ‘Slice’ or ‘Section’
(2) ‘Graphe’ meaning ‘Drawing’ .

CT is based on the absorption of X-rays (which hit a slice from various angles to cover the whole slice) by different tissues. Computed tomography (CT) imaging, also known as "CAT scanning" (Computerized Axial Tomography), provides a different form of imaging known as cross-sectional imaging.



- **BASIC PRINCIPLE:**
- **The basic principle behind CT is that the internal structure of an object can be reconstructed from multiple projections of the object.**

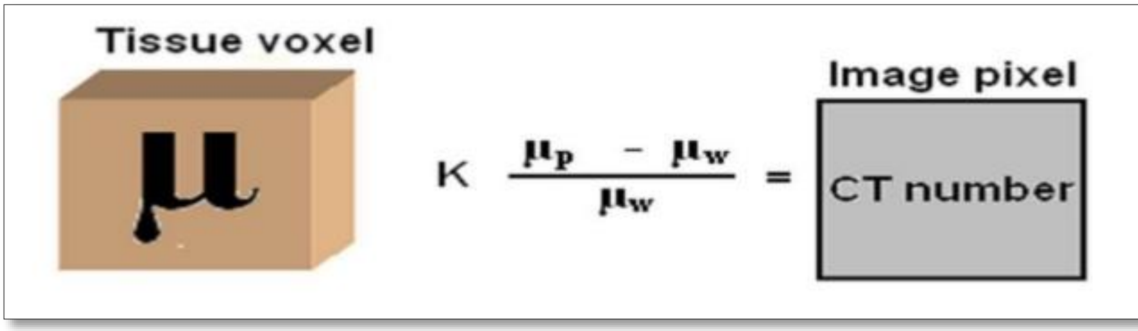
- **The ray projections are formed by scanning a thin cross section of the body with a narrow x-ray beam and measuring the transmitted radiation sensitive radiation detector.**
- **CT scanning is a systematic collection and representation of projection data**



- <u>COMPOSITION OF GANTRY</u>

1.The gantry houses the key components of the scanner.
2. Production of the x-ray beam and detection and acquisition of the beam must be located within the rotating portion of the gantry.
3. The fan-beam x-ray tube sits opposite the detector array within the rotating gantry.
4. The three-phase power generator is also within the gantrymodule.
5. The x-ray tube in a CT scanner is designed to produce a fan beam of x-rays that is approximately as wide as the body.
6. Tissue attenuation is measured over a large region from oneposition of the x-ray tube.
7. On the opposite side of the patient is the detector array that measures the strength of the x-ray beam at various points laterally across the body.

- <u>CT NUMBER & HOUNSFIELD UNIT</u>
  - The computer calculates a relationship between the linear attenuation coefficients of the pixel and water which is given as CT number.
  - CT number is the value given to pixel and voxel

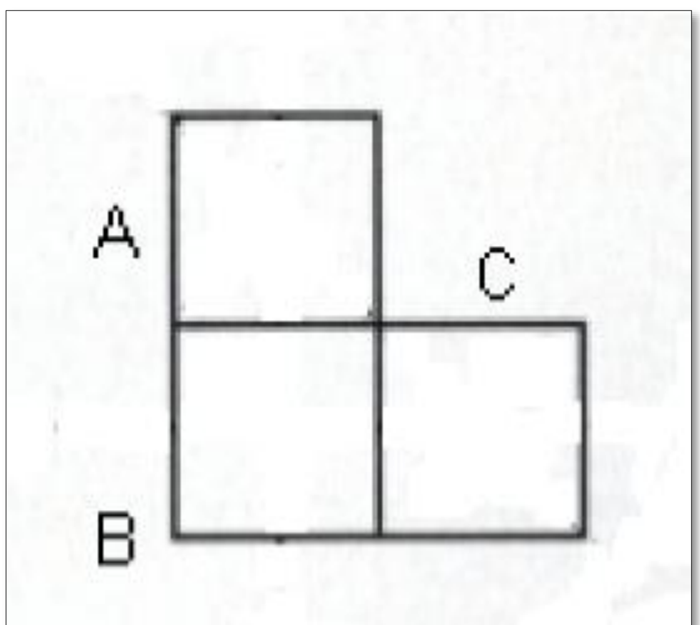


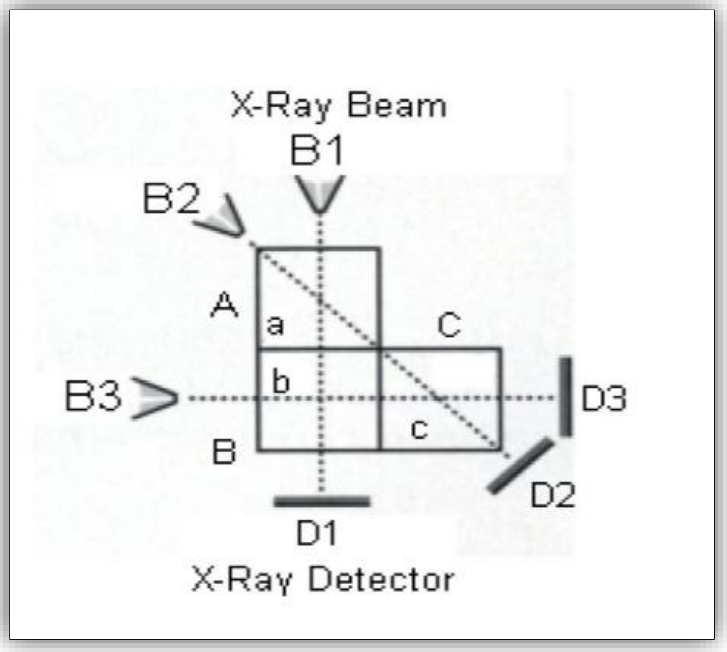
- **<u>Values of CT Image Reconstruction</u>**
  - CT numbers (Hounsfield units) are the pixel values assigned in the image.
  - They are computed by calculating the relative difference between the linear attenuation coefficient of tissue and that of water

- <u>How it works and acquires data:</u>

When the scanner starts up, the gantry starts rotating around the patient. The X-ray source in the gantry emits beams of set intensity at various angles through the entire rotation, which are then detected by the x-ray detector set up in the gantry opposite to the source.

CT scans in cross sections, hence we must consider a single cross section and divide it in grids.





Each grid contains an object to be scanned, analyzed and identified. So, when a beam of x-ray passed through a grid cell, an amount of energy or intensity is lost. We assume the lost intensity as percent attenuation 'x' which we then convert to linear attenuation units (LAUs) using the following formula:

$L=-ln(1-x)$

where,

x=percent attenuation [x_1, x_2, x_3 ...; a, b, c , ...]

L=Linear attenuation [L_1, L_2, L_3...]

So, after a beam passes through more than one grid cell the percentage absorbed is determined, also known as percent attenuation. Percentage attenuation is then converted to LAUs. Whole rotation can be generalized in the system of linear equations.

- Beam B1 passes through grid cells A and B where the beam, intensity reduces by $a\&b$ units, respectively.

  Therefore, $a+b=L1$

  Similarly, $a+c=L2$

  $b+c=L3$

- Hence arranging the above three equations in the proper order, we finally have acquired a system of linear equations.

$$a+b=L1$$

$$a+c=L2$$

$$b+c=L3$$

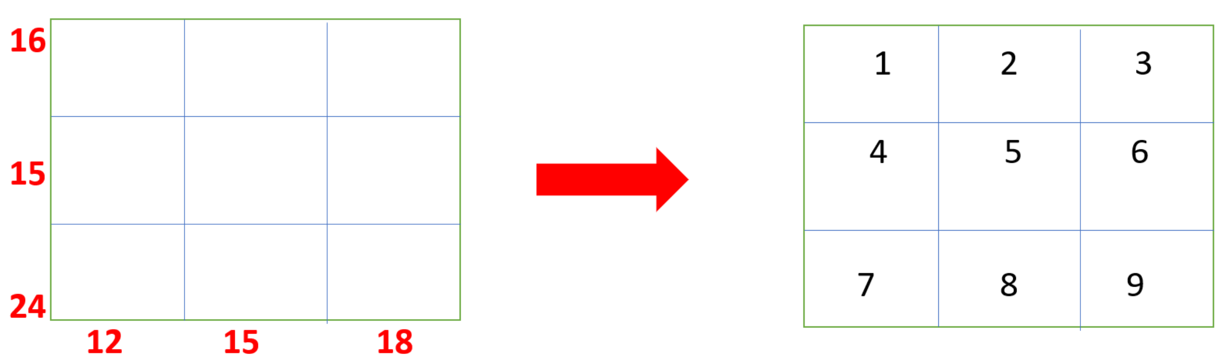
Now using the methods of Gaussian elimination, Gauss-Jordan elimination, Matrix inversion methods, etc., we can solve the system of a, b, c.

X-RAY ABSORBTION

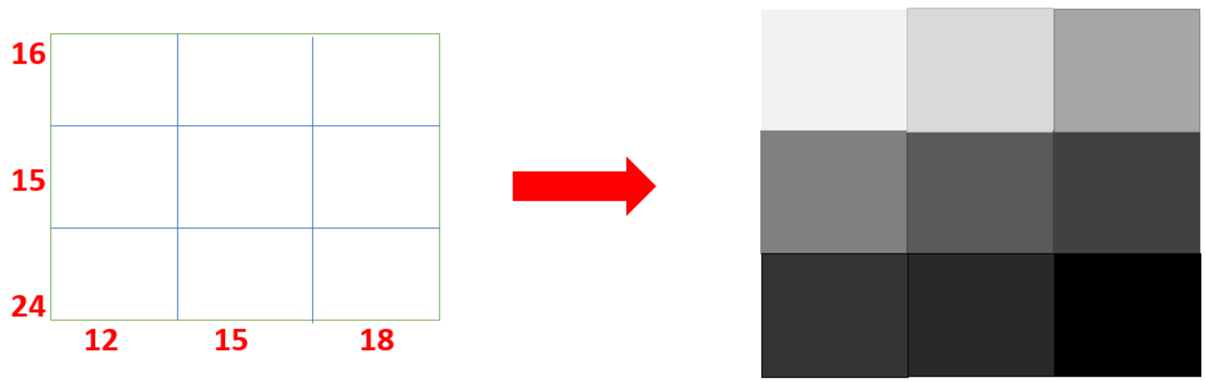
SUBSTANCE	**PERCENT OF XRAYS ABSORBED**	**LINEARR ATTENUATION VALUES**
Healthy tissues	15-25 percent	0.1625-0.2877
Tumorous tissue	23.5-32.5 percent	0.2679-0.3930
Bone	32-40 percent	0.3857-0.5108
Metal	78.6-100 percent	1.54- ∞

- **EXAMPLE:**

NUMBERS FROM 1 TO 9 :

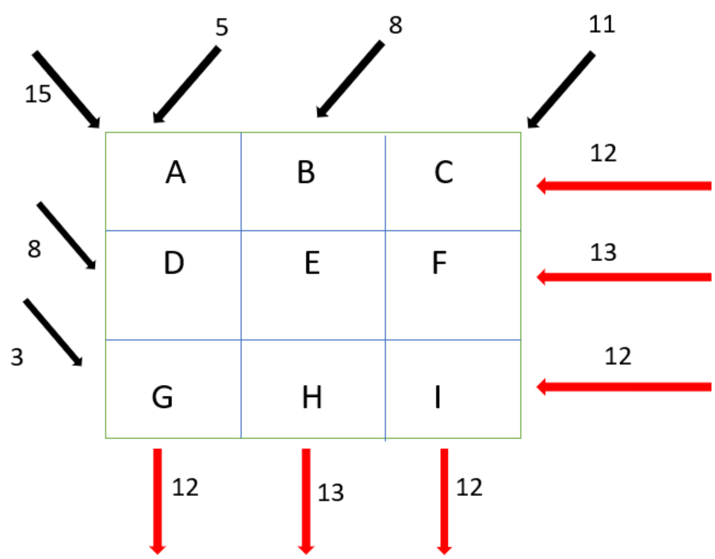


NUMBERS FROM 1 TO 9 :



Now we are going to solve a simple CT problem

- Consider a simple slice of organ
  It is divided as 3 x 3 matrix



The equations extracted from the above are

a+b+c=12

d+e+f=13

g+h+i=12

a+d+g=12

b+e+h=13

c+f+i=12

g=3

d+h=8

a+e+i=15

a=5

b+d=8

c+e+g=11

Considering a set of 9 equations and solving

$$AX=B$$

Using our known methods, we will a get a set of solutions.

If the solution set is not unique then consider the set of 9

equations and then repeat the same process.

now overlap both solutions sets.

Do the same the process until we get a unique set of solutions.

- **MATLAB CODE:**

```
%let us assume an organ which is divided into 9X9
matrix
%the values of absorbed x rays are in terms of
equations are given below
% a+b+c=12
% d+e+f=13
% g+h+i=12
% a+d+g=12
% b+e+h=13
% c+f+i=12
% g=3
% d+h=8
% a+e+i=15
% a=5
% b+d=8
%c+e+g=11
%solution for a set of 9 equations when rays are sent
in different direction
r1=[1 1 1 0 0 0 0 0 0 12];
```

```
r2=[0 0 0 1 1 1 0 0 0 13];
r3=[0 0 0 0 0 0 1 1 1 12];
r4=[1 0 0 1 0 0 1 0 0 12];
r5=[0 1 0 0 1 0 0 1 0 13];
r6=[0 0 1 0 0 1 0 0 1 12];
r7=[0 0 0 0 0 0 1 0 0 3];
r8=[0 0 0 1 0 0 0 1 0 8];
r9=[1 0 0 0 1 0 0 0 1 15];
r10=[1 0 0 0 0 0 0 0 0 5];
r11=[0 1 0 1 0 0 0 0 0 8];
r12=[0 0 1 0 1 0 1 0 0 11];
tot1=[r1;r2;r3;r4;r5;r6;r7;r8;r9];
solution1solution1=rref(tot1)
tot2=[r1;r2;r3;r4;r5;r6;r10;r11;r12];
solution2=rref(tot2)
%from the two solution sets we can get our final
overlaped values as:
% a=5;b=4;c=3
% d=4;e=5;f=4
% g=3;h=4;i=5
plot([0,5],[0,0])
hold on
plot([0,0],[0,5])
g=fill([0,1,1,0],[0,0,1,1],[0.5 0.5 0.5]);
hold on
h=fill([1,2,2,1],[0,0,1,1],[0.3 0.3 0.3]);
hold on
i=fill([2,3,3,2],[0,0,1,1],'k');
hold on
d=fill([0,1,1,0],[1,1,2,2],[0.3 0.3 0.3]);
hold on
e=fill([1,2,2,1],[1,1,2,2],'k');
hold on
f=fill([2,3,3,2],[1,1,2,2],[0.3 0.3 0.3]);
hold on
a=fill([0,1,1,0],[2,2,3,3],'k');
hold on
b=fill([1,2,2,1],[2,2,3,3],[0.3 0.3 0.3]);
hold on
c=fill([2,3,3,2],[2,2,3,3],[0.5 0.5 0.5]);
```

OUTPUT: