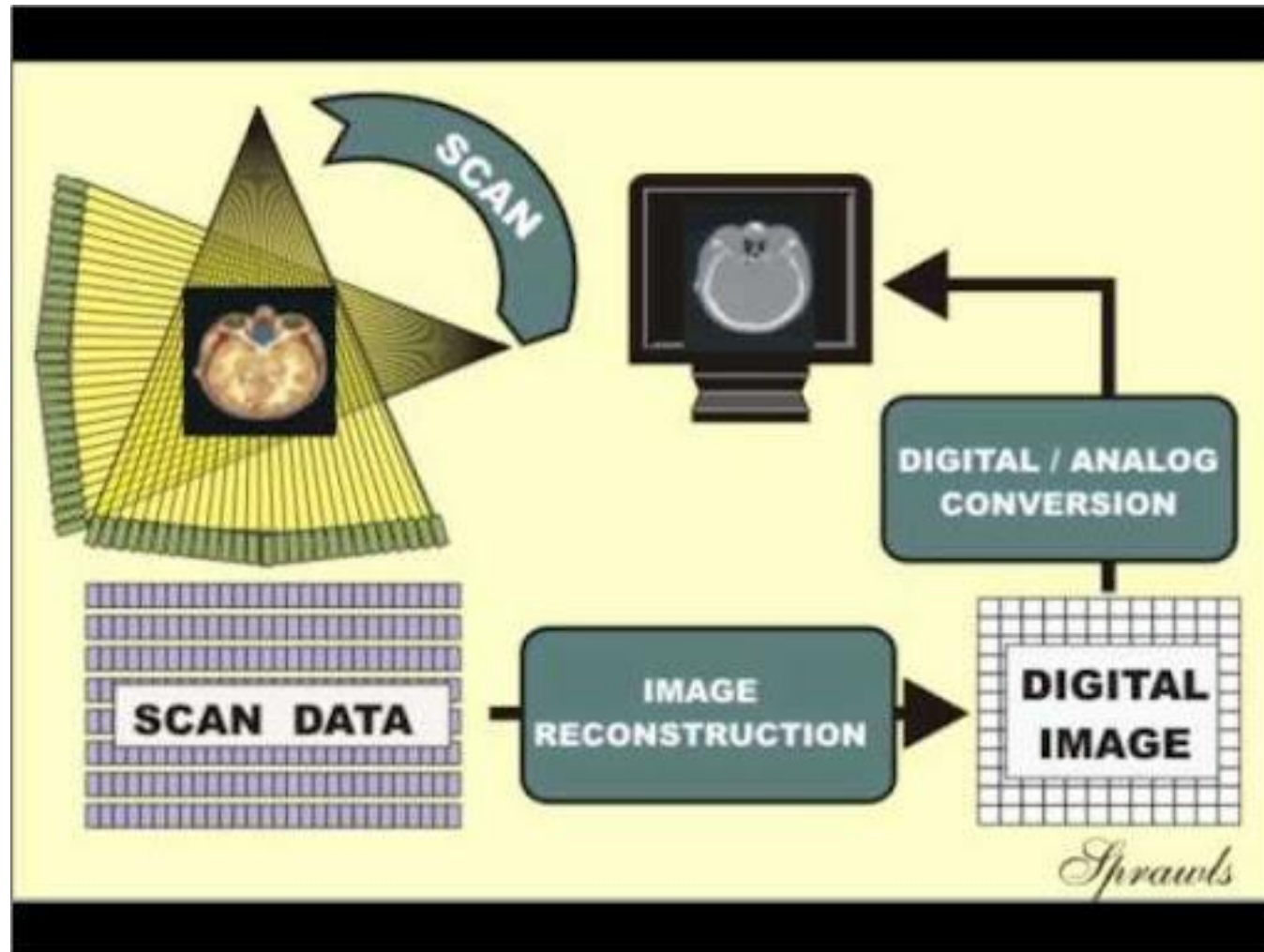


Digital Imaging - Image Formation - 4



What is Digital Imaging

Digital imaging or Digital Image Acquisition

- Is the creation of a representation of the visual characteristics of an object, such as a physical scene or the interior structure of an object.
- A key advantage of a digital image, versus an analog image is the ability to digitally make copies and copies of copies indefinitely without any loss of image quality.
- Digital imaging can be classified by the type of electromagnetic radiation or other waves whose variable attenuation, as they pass through or reflect off objects, conveys the information that constitutes the image.
- In all classes of digital imaging, the information is converted by image sensors into digital signals that are processed by a computer and made output as a visible-light image.
- For example - X-rays allow digital X-ray imaging (digital radiography, fluoroscopy, and CT), and gamma rays allow digital gamma ray imaging (digital scintigraphy, SPECT, and PET).
- Digital imaging lends itself well to image analysis by software, as well as to image editing (including image manipulation).

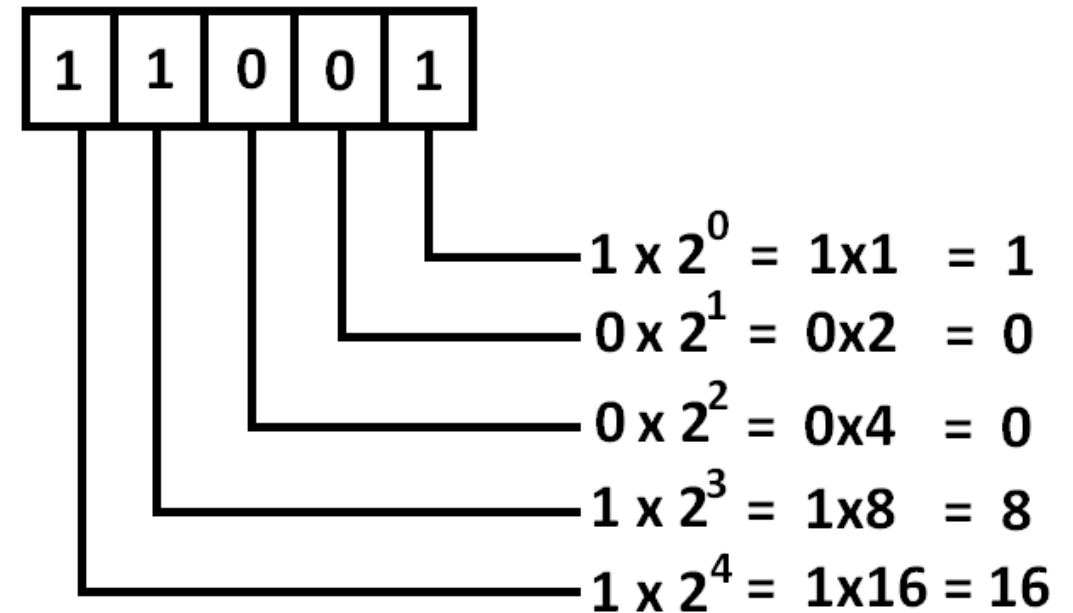
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Binary Numbers

- A **binary number** is number expressed in the **base-2 numerical system** or **binary numeral system**
- A method of mathematical expression which uses only two symbols: "0" (zero) and "1" (one).
- The computer uses the Binary number system.
- Conversion of base 10 to base 2 is beyond the scope of this class



$$1 + 0 + 0 + 8 + 16 = 25 \text{ (Base 10)}$$



Analog to Digital Conversion

The conversion of analog signals to digital information is accomplished by the ADC

- Two main characteristics are:
 - Accuracy – Poor accuracy can result in Aliasing Artifacts
 - Speed – The time it takes to convert the signal
 - These two measurements are inversely proportional
- ADC samples the analog signals at various points to measure the transmitted beam strength.
- The more points sampled – the better the representation of the signal.



Digital Image Characteristics

- **Matrix**

- Digital images are made of up of a two dimensional array of numbers called a Matrix
- Consists of rows and columns of pixels
- Technologist selects the Matrix size

Pixel

- Pixels are each square in the Matrix that contain an individual number
- Each different number represents the corresponding tissue density.

Voxel

- Describes the thickness or depth of the pixels
- Example would be the different slice thickness of the scan

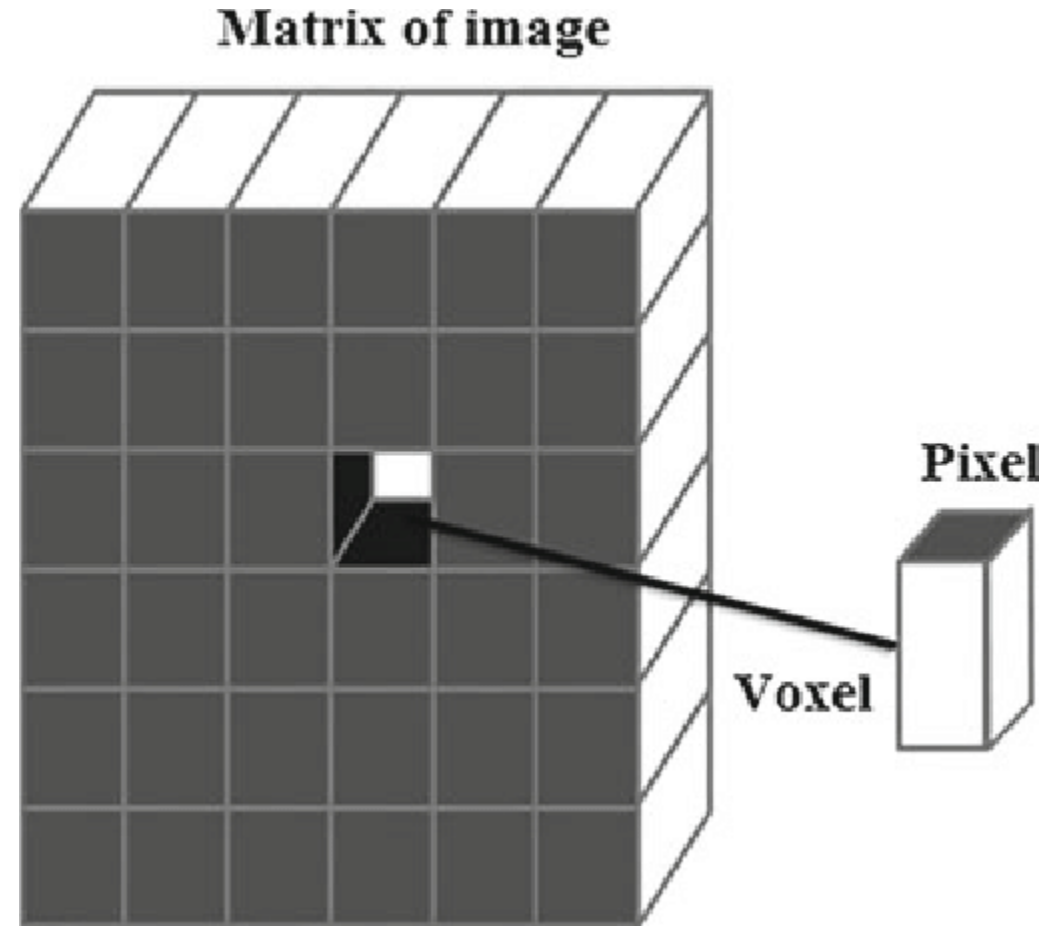
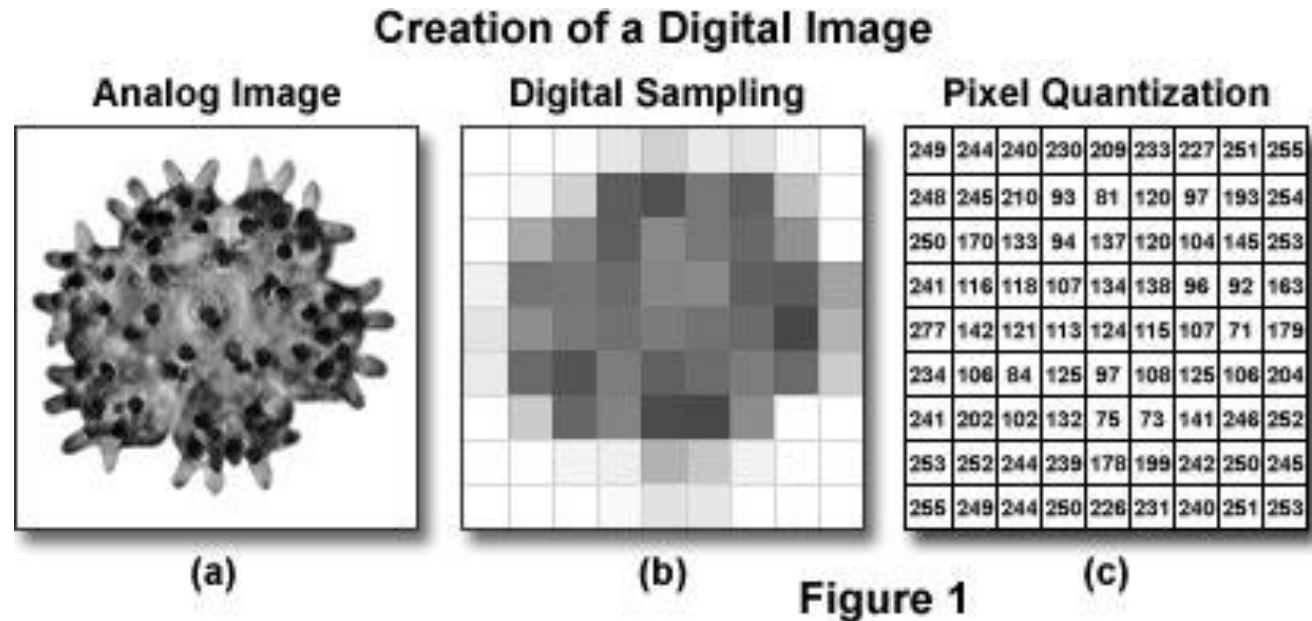


Image Digitization

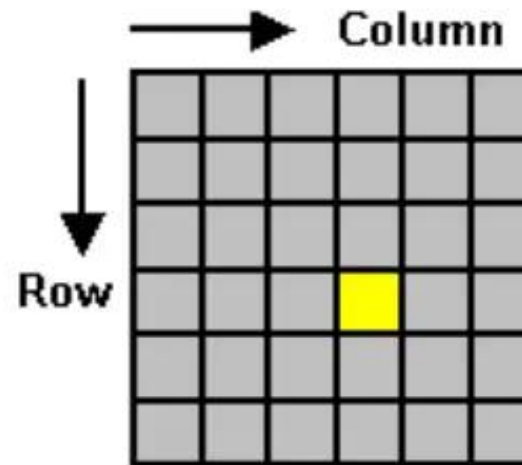
- Objective of digitization is to convert an analog image into numerical data for processing by a computer.
- 3 Steps
 - Scanning
 - Sampling
 - Quantization



Scanning

- Step one is division of the image into small regions
- Pixels are small picture elements.
- Pixels are formed into a grid called a Matrix
- Each Pixel represents a particular space in the grid

Digital Image



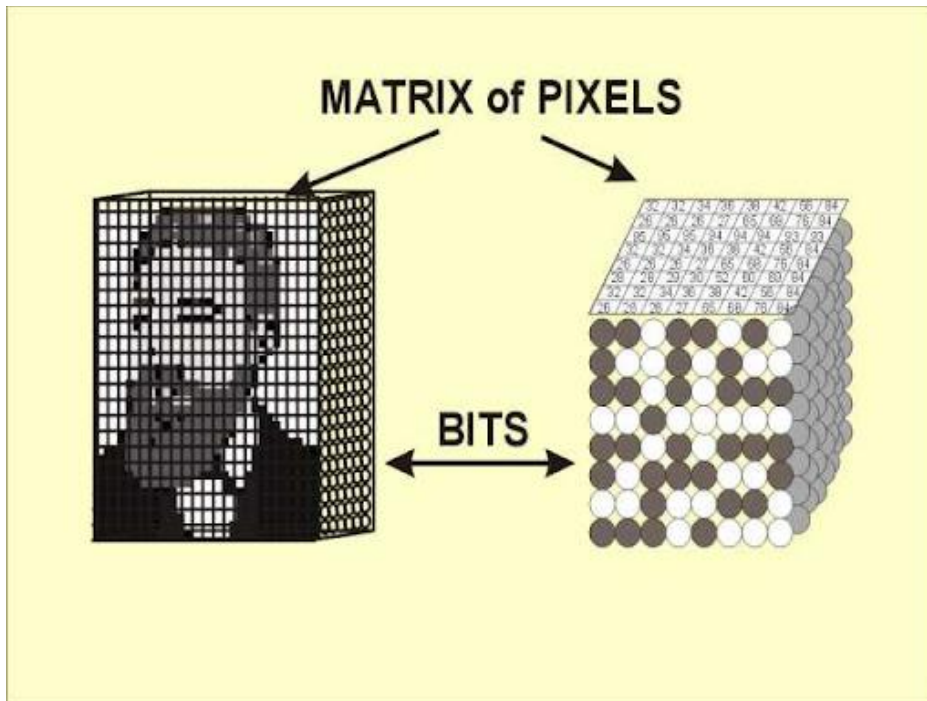
➡ **Digital image** is a two-dimensional array of pixels.

➡ Each pixel has an **intensity value** (represented by a *digital number*) and a **location address** (referenced by its *row* and *column* numbers).

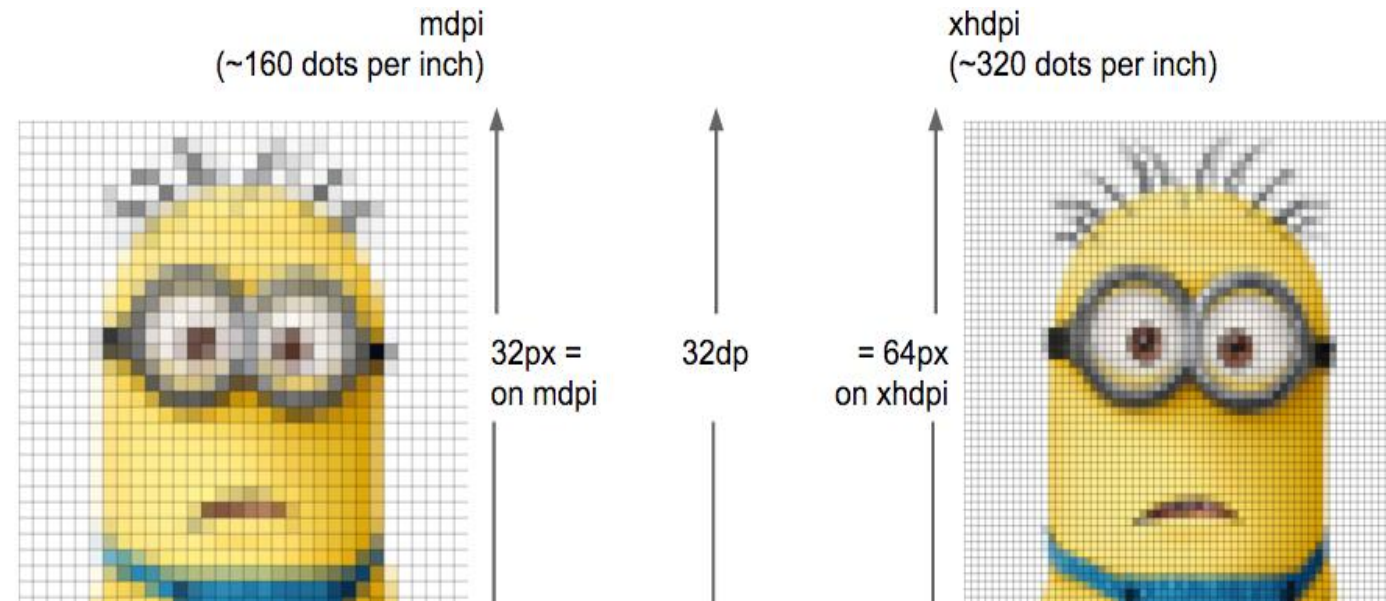


Examples of Pixels

Pixels and Matrix

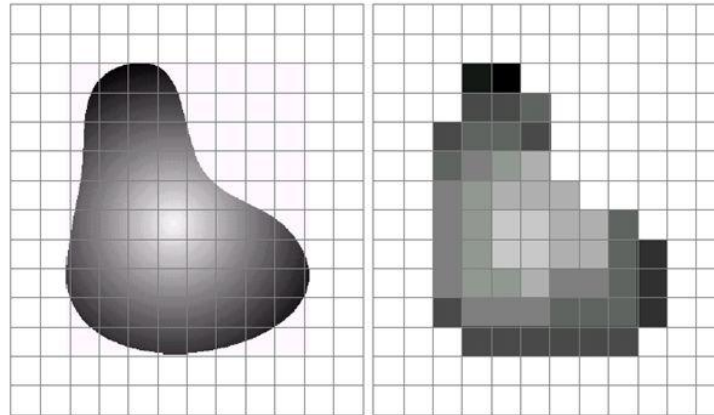


Smaller Pixels = More Detail



Sampling

- Sampling measures the brightness of each pixel
- Small light is projected thru the pixels and detected by a photomultiplier tube.
- The output of the photomultiplier tube is an electrical (analog) signal



a **b**
(a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.



Quantization

- Quantization is the final step in which each pixel is assigned an integer (o, positive or negative number) based on the strength of the signal
- The result is a digital image with a array of numbers
- This array of numbers is sent to the computer for more processing
- Each number is assigned a shade of gray.

Quantization Table

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99



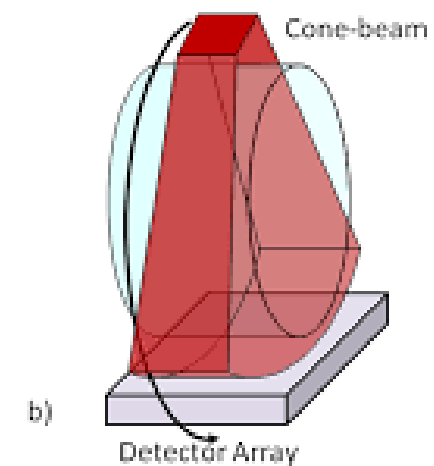
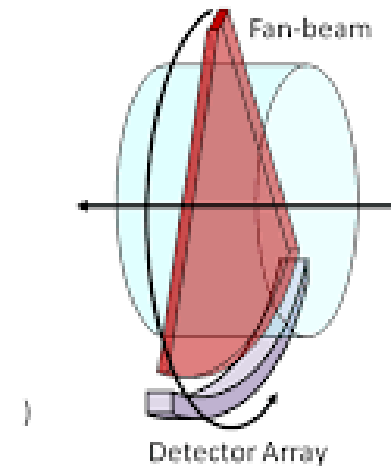
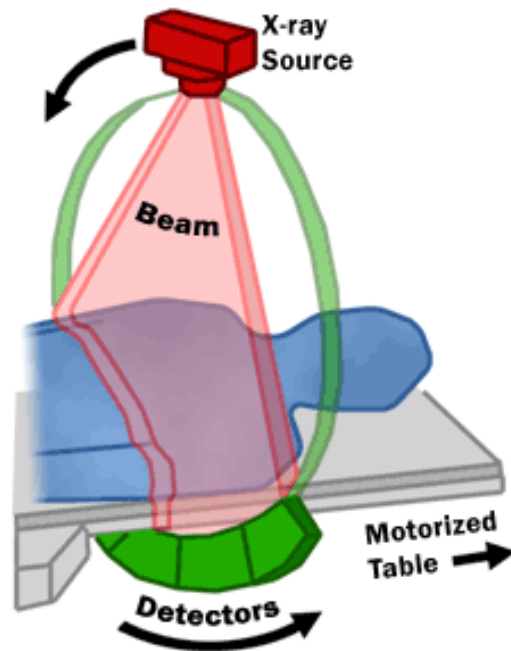
157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	105	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	105	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	215
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	123	200	175	13	96	218



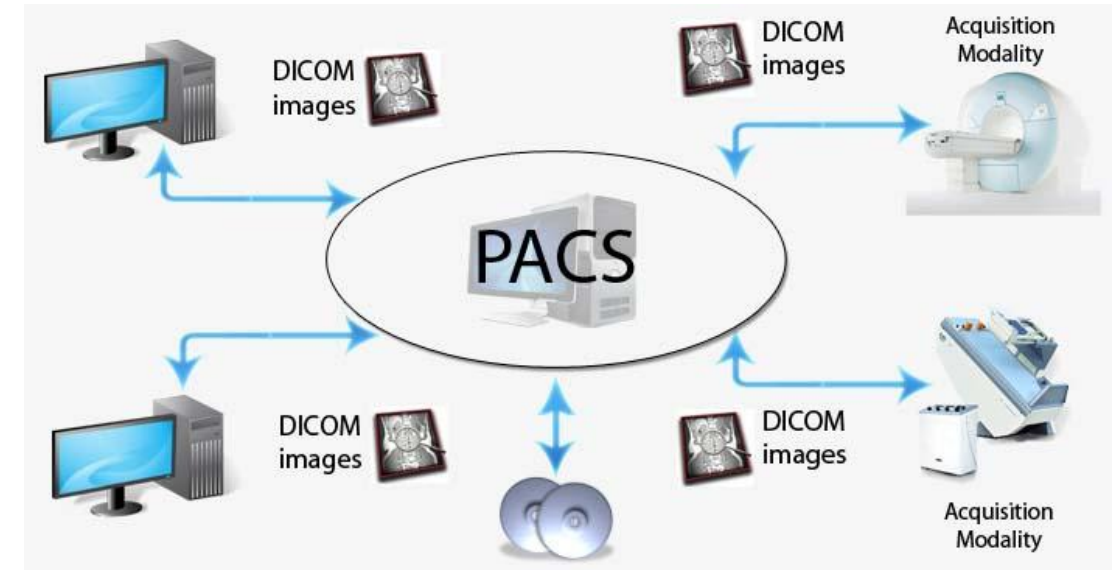
Beam Geometry

- Beam Geometry refers to the size and shape of the x-ray beam from the x-ray tube and passing thru the patient to reach the detector



PACS –Picture Archiving Communication System

- PACS is a medical imaging technology used primarily in healthcare organizations to securely store and digitally transmit electronic images and clinically-relevant reports.
- The use of PACS eliminates the need to manually file and store, retrieve and send sensitive information, films and reports.
- Instead, medical documentation and images can be securely housed in off-site servers and safely accessed essentially from anywhere in the world using PACS software, workstations and mobile devices.



DICOM SYSTEM

- There is a program called Digital Imaging in Communications and Medicine (DICOM)
- It is changing the medical world as we know it. DICOM is not only a system for taking high quality images, but also is helpful in processing those images.
- It is a universal system that incorporates image processing, sharing, and analyzing for the convenience of patient, physician and institution.



DICOM SYSTEM

