X-Ray Imaging

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Advantages

- Easy diagnosis → bone, teeth, joint etc.
- Fast diagnosis → emergency treatments with immediate diagnosis in least invasive manner
- Inexpensive → equipments, compared to CT and MRI
- Availability → majority of the facilities: hospitals, nursing homes, family physician clinics, etc.
- Minimum radiation exposure → radiation does not remain in patient’s body, precaution and care is taken
- No side effects → risk of getting cancer is very small

http://benefitof.net/benefits-of-x-rays/
Disadvantages

- High voltage → voltage breakdown can jump inches from power supply, heat
- Radiation exposure → additional radiation will increase cancer risk by 0.6-1.8% (age 75)
- Soft-tissue imaging → dense tissues appear lighter than surrounding soft tissue
- 2D imaging → limit detection ability, not enough details for diagnosis

Medical Application

- Radiography \(\rightarrow\) 2D image, find orthopedic damage, tumors, pneumonias, foreign objects, etc.
- Mammography \(\rightarrow\) capture images as mamograms of internal structures of breasts
  - Types: screen-film and full field digital

Radiography - diagnosis of Orthopedic damage
http://is.sdsmt.edu/AreasofSpecialization/PreprofessionalHealthSciences/MedicalRadiographyRequirements/
- CT → computed tomography, x rays pass through different parts of body creating cross-sectional images, later put together
- Radiation Therapy → ionizing radiation for cancer treatment
- Fluoroscopy → displaying movement of body part or instrument or dye through body
  - Examinations: view GI track, angioplasty or angiography, blood flow studies, orthopedic surgery, etc.

Fluoroscopy – pacemaker leads right atrium ventricle, Pacemaker implant procedure

http://youtu.be/RueXmL-Dz3w?t=5m28s
Non-Medical Application

- **Astronomy** → the telescopes bounce X-ray photons off curved mirrors into and from space, sun pot images
- **Industrial Imaging** → NDI examines industrial materials for defects (quality control)
- **Transportation Security** → uses back scatter X-ray for airport screening, scanned moving energy rapidly over form, the signal strength detected and allows for highly realistic image
- **Crystallography** → diffraction of X-rays through crystals causes distinct atomic patterns to emerge, determine molecular structure, distance between atoms

http://www.ehow.com/list_7553903_nonmedical-uses-xrays.html
Wilhelm Conrad Roentgen (1845 – 1923)

On November 8th, 1895, while using Crookes Tubes noted a fluorescent effect on barium platinocyanide screens.

Labeled the mysterious rays, X-Rays.


Wins Nobel Prize in Physics in 1901. The first recipient of the Nobel Prize in Physics

January 1896 ➔ Frank Austin of Dartmouth College found a discharge tube, designed by Ivan Pulyui, that produced the “x-rays”.

February 3rd, 1896 ➔ Frost brothers take image of broken wrist bone on gelatin photographic plates.

Coolidge Tube

- William D. Coolidge (1873 - 1975)
- In 1913 invents the Coolidge Tube, an improvement over the Crookes Tube.
- Cathode filament made of Tungsten
- Became commercially available by 1917

http://youtu.be/RueXmL-Dz3w?t=3m36s

http://www.orau.org/ptp/collection/xraytubescoolidge/coolidgeinformation.htm
Early in the decade

- **1896** → Thomas Edison invents a modified fluoroscope with a calcium tungstate screen.
- **1912** → the tilting table is made by Eugene W. Caldwell
- **1913** → Gustave Bucky creates the anti-scatter grid. Still the most effective device for reducing scattered radiation

http://www.jpihealthcare.com/xray-grid
1926 → Engeln Electric Co. in Cleveland Ohio introduces the *Duplex*.

1929 → First rotating anode x-ray tube by Phillips was manufactured. Named the *Rotalix*.

1945→ Westinghouse Electric Co. markets the first *phototimer*.

1948→ J.W. Coltman from Westinghouse Electric Co. develops the first *X-ray Image Intensifier*.

1953→ the *Fluorex* is introduced. First commercial image intensifier unit.
- Less scattered radiation
- Less exposure
- Less examination time

Classic papers in modern diagnostic radiology
By Adrian Thomas, Arpan K. Banerjee, Uwe Busch
X-Ray Image Intensifier

- Converts x-rays to visible light
- Requires lower doses of X-ray due to more efficient conversion of x-ray to visible light.
- CCTV in late 1950s and XRII allowed for real-time imaging through television screen viewing.

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1952 the *Imperial* unit by General Electric.
Used as both a radiographic & fluoroscopic unit.
- Provided 360° table rotation
- Power assisted table movement

In 1983, H. Kato et al. pave way for new techniques in digital radiograph at Fuji Film Co. of Japan.

The basic principle of the system is the conversion of the x-ray energy pattern into digital signals utilizing *scanning laser stimulated luminescence* (SLSL).

Eliminated the drawbacks of screen film radiography
- Digital image processing
- Digitization of the x-ray energy pattern by SLSL


Classic papers in modern diagnostic radiology
By Adrian Thomas, Arpan K. Banerjee, Uwe Busch
Scientists at UNC at Chapel Hill and Xintek, Inc. Invent new x-ray tube using carbon nanotube cathode.

Advantages:
- Programmable electron and x-ray intensity
- Ultra-fine focal spot
- Longer lifetime

Average Cost per X-Ray Scan

<table>
<thead>
<tr>
<th>X-ray Procedure</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger</td>
<td>100</td>
</tr>
<tr>
<td>Skull</td>
<td>290</td>
</tr>
<tr>
<td>Eye</td>
<td>650</td>
</tr>
<tr>
<td>Body</td>
<td>1,100</td>
</tr>
<tr>
<td>Salivary Duct</td>
<td>1,250</td>
</tr>
<tr>
<td>Brain</td>
<td>1,450</td>
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<tr>
<td>Vein in Liver</td>
<td>6,200</td>
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<tr>
<td>Vein in Neck</td>
<td>18,100</td>
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<tr>
<td>Artery in Pelvis</td>
<td>20,300</td>
</tr>
<tr>
<td>Artery in Abdomen</td>
<td>30,800</td>
</tr>
</tbody>
</table>

**Kinds of X-rays taken in 2010**

- Chest
- Abdomen/Pelvis
- Extremities
- Spine
- Other


The cost varies greatly depending on the part of the body the design is meant for.

Small devices, such as oral X-rays can range from $3000-$8000

Larger devices can cost anywhere from $12,000-$25,000 if they are film based. The cost to operate this machine and develop the film is around $400 per month.

Digital radiology machines are $50,000-$150,000, the maintenance costs that come with digital X-ray machines can reach $10,000.
In 2010, it was estimated that 182.9 million X-rays were taken in US hospitals, and 67.6 million procedures were performed in other locations which perform radiology.

That is a constant growth rate of 5.5% since 2005.