

X- Rays in the Service of Mankind – A Review

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ABSTRACT

This paper gives a brief account of the invention of X-rays and their first medical application. The evolution of the X-ray machines, the features in the modern machines and the emerging trends are chronologically presented. Other applications mainly in the industries are also discussed. The role of artificial intelligence and machine learning are also mentioned which are likely to play important role in the field of X-rays applications.

Keywords –X-ray, medical x-ray, x-ray device, innovations in X-ray technology, emerging trends in X-rays

I INTRODUCTION

The X-ray is a familiar term which normally relates to illness diagnostic procedure recommended by doctors. X-rays, also termed as X-radiation, were discovered on November 8, 1895 by German physics

Professor Wilhelm Roentgen. Roentgen called it "X" to indicate that it was an unknown type of radiation. The photograph of the Wilhelm Rontgen's first "medical" X-ray, of his wife's hand, taken on 22 December 1895 is shown in Figure 1.



Fig. 1: Photo of Wilhelm Rontgen's first "medical" X-ray[1]

This X-radiation has been proved as blessing in medical industry for diagnostics and treatment over the years. Although the X-rays are harmful for human body as they affect tissues of body but they are needed for medical diagnosis for many diseases.

II EVOLUTION OF X-RAYS TECHNOLOGY IN MEDICAL FIELD

- (a) **The Basics of X-ray Machine** -The X-rays are produced by X-ray machine which penetrates into the body and falls on the X-ray acquisition plate or detector. The basic X-ray machine generally consists of timing controlling circuit, filament circuit, high voltage generator, X-ray vacuum tube which produces X-rays and of course the X-ray capturing device.

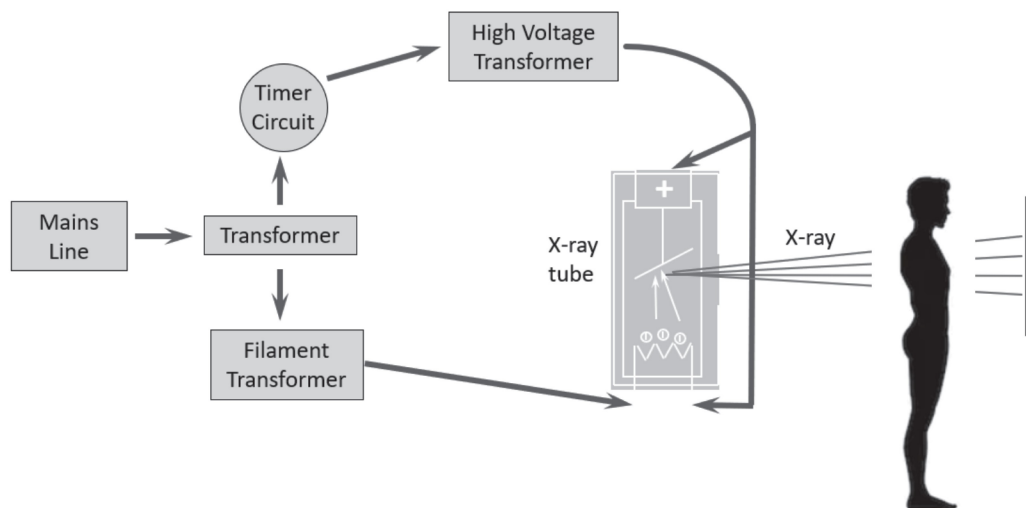


Fig. 2: Basic block diagram of X-ray machine

The X-rays are generated by supplying high voltage to X-ray tube before which the electron creation happened inside the tube by a filament. This filament current matters for electron generation, which is important for X-ray intensity, this provides appropriate contrast to the X-rays, whereas the high voltage matters for penetration of body, like higher voltage is produced for penetration in thicker objects.

Here the timer circuit is also very important to contain the X-ray generation timing so that right amount of x-rays pass through body to produce the x-ray image needed for diagnosis. Otherwise, if time is not controlled properly, then the X-ray image will be overexposed or underexposed and may not be of any use for diagnosis.

The combination of time and current to filament is also important to obtain contrast /in X-ray image.

(b) Basic X-ray machine: In the basic machines, X-ray film generation technique used to be a dark room technique similar to one where our earlier photos were created in dark room. In this dark room technique, the X-rays are taken on X-ray sensitive film which is then developed in a special liquid solution in a room which is complexly dark, only very low red light is a part of dark room so that the developer technician may work inside the dark room to carry out this process.

(c) Cassette Reader based Machines -A cassette reader-based technology came up as next improvement which reduced X-ray film generation time. In this technology, a cassette

containing imaging receptors and its processing device exists which is connected to a computer to display the image on monitor.

(d) Digital Machines - Subsequently, a digital flat detector technology was invented in which a device captures X-ray signals, converts them into electrical signals and transmits to a computer to further process based on specific software algorithm. The image is instantly displayed on monitor in the technology. This reduces the total workflow time of X-rays process significantly.

(e) Advancements in X-Ray Machines -Now a days, X-ray machines possessare having various features like motorized movements, mobile X-ray machine, fast image generation, faster workflow, easy and accurate positioning on patient's intended areaand so on. The minimum X-ray dose(exposure) to patient is a pressing need from hospitals and national regulations. Hence, the X-ray machine manufacturers are constantly working on innovating newer technologies with a focus on making the radiographer's life safer, faster workflow, minimum X-ray exposure etc. The technology is developed and getting enhanced which aims at minimizing the exposure of X-rays to minimize the harmful effects to the human body. In this technology, a device called Amplimatsenses the X-rays which falls into it before reaching to detector, then a signal will be generated by amplimatto trip the X-ray circuit to stop the radiation.

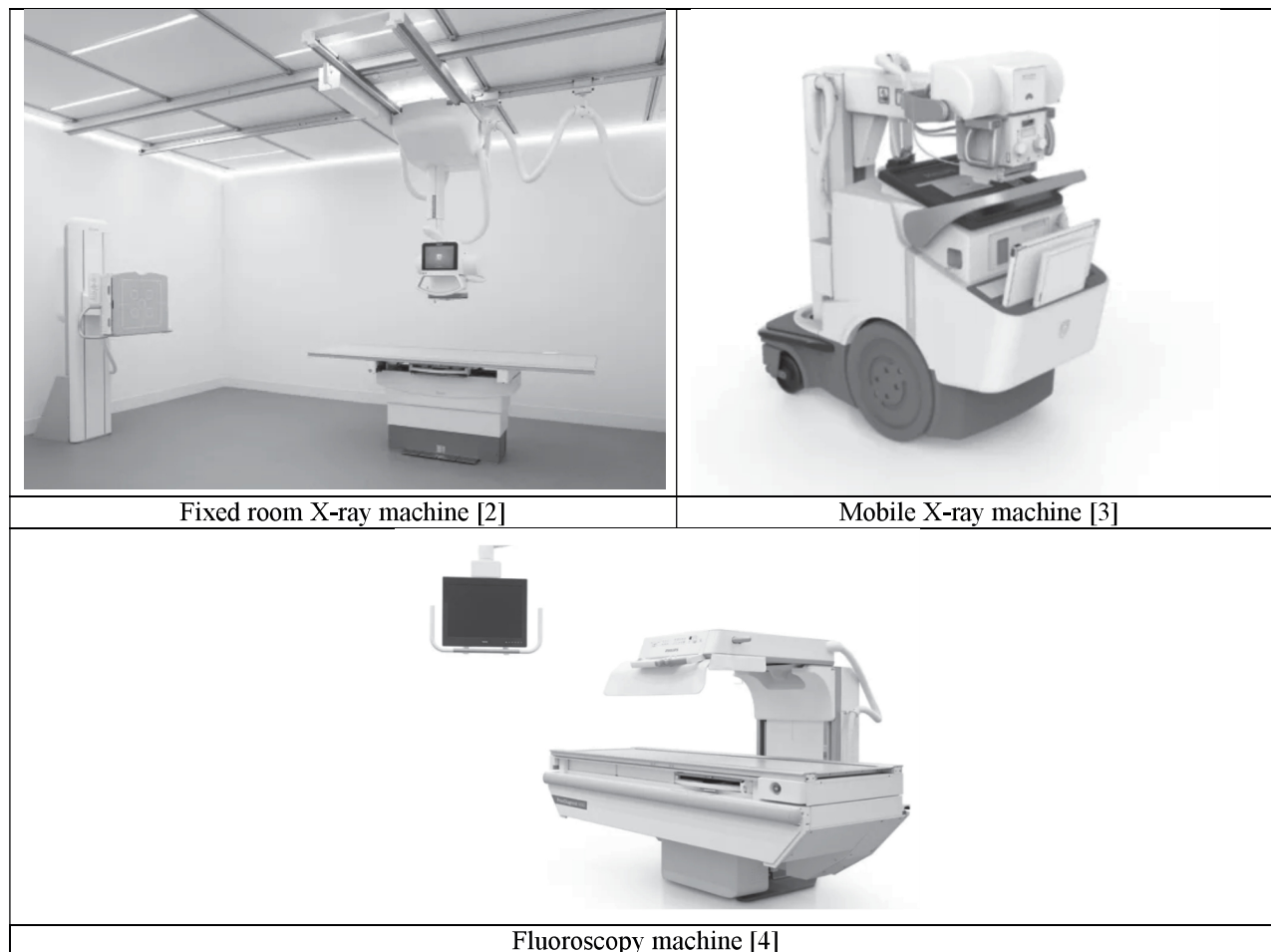


Fig. 3: Modern X-ray machines from Philips

- (f) **Computed Tomography or CT scan** – CT scan machine uses ionizing X-ray radiation in conjunction with a computing machine to create images of both soft and hard tissues. Tomo means slice because the images look as if the patient was sliced like bread. Newer versions of these machines operate with much reduced dose of radiation.
- (g) **Dual Energy X-Ray Absorptiometry (DEXA)**- It is a bone densitometry. X- rays are emitted in two narrow beams at 90° to each other to calculate the quantity of calcium in bones (bone density)
- (h) **C-Arm:** C-Arm machines produce live X-rays which are used in orthopedics related procedures like fracture treatment, joint replacement etc.
- (i) **CATH lab machines:** The CATH lab machines are used in diagnostics and treatment of cardiovascular diseases in which continuous or live X-rays are used to observe blood flow in veins and arteries.
- (j) **Fluoroscopy Machines:** Fluoroscopy machines are being used for study of gastrointestinal tract and esophagus flows with live and continuous X-

rays. Figure 3 shows a few of the photographs of such machines.

III X-RAY MACHINES - APPLICATIONS IN NON MEDICAL FIELD

X-ray machines are also being used in fields other than medical diagnostics. In recent years, several countries have introduced ionizing radiation in non-destructive mode for various industrial applications:-

- (a) **Industrial Radiography** – It is sub specialty of non destructive testing using X-ray imaging to evaluate properties of material without its destruction. This is extensively used in Forensics, Aerospace, Structural safety, shipping, Airport Security, and cargo screening etc.
- (b) **3D Imaging** – Large number of images can be aligned to reconstruct 3-D images by TXM. It can reveal non scale structural details and may be useful in research. X- Ray can be used to kill bacterial grow, to delay fruit ripening process as

per will. In geology mineral deposits can be found out.

- (c) **X- ray Astronomy** – It began when astronomers created crude sun spot image in 1963. NASA's latest X-ray observatory, Chandra, can observe X-ray from immense clouds of so large gases that they would take light 5 million year to travel from one end to other. A classic example of combination of man produced X-rays to detect the X-rays produced by nature.

IV EMERGING TRENDS

The new and emerging trend observed now a day is more towards dose reduction and easy workflow in medical X-ray field. Several manufacturers are working on new and innovative design which will help medical professionals to have quicker workflow of X-ray procedure right from patient entry for X-ray to provide final reporting. Also same focus is there for X-ray dose reduction like how the machine can obtain good and diagnosable quality X-ray image with the minimum dose. This is becoming possible by improving the image construction algorithms in the backend software as well which is being improved day by day.

A multimillion dollar machine at SLAC Natural Accelerator Laboratory in Stanford University, California can combine X-rays in to a laser beam similar to visible light laser. Unlike regular laser, laser bursts made from X-rays can be so bright and so brief that they allow researchers to create ultra fast stop motion movies of natural phenomenon with clarity that was never possible otherwise. Scientists are also combining X-rays with microscopy to pioneer newer ways of visualizing cellular structure and micro organism.

V CONCLUSION

In x-ray field, the safety of the patients and operator are very crucial for which medical equipment manufacturers are not only solely responsible party but hospital is also equally responsible while processing x-ray workflow along with patient for example, covering the area of patient which is not intended for x-ray image like if hand x-ray is requested then patient's rest of the body should be positioned away at best possible distance from X-ray source. The X – Ray machines combined with the computational power of present days is new emerging area which find applications in medical and industrial field. Application of Artificial Intelligence and machine learning in X-ray machines are becoming now most emerging field to watch.

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