X-ray Machines integration with AI

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Abstract—**Artificial Intelligence is making tremendous progress in the past few years, Especially in the Medical Sector. The paper mainly focuses on the ways X-ray machines have been integrated with AI and how AI detects the X-rays and predicts the results correctly. The paper will begin with a brief introduction of why this is the right time to try hands in AI and how it will help the radiologists in easing their lives. The paper will then explain how Artificial Intelligence can be implemented in X-rays using Machine learning techniques and Deep learning algorithms. Moving forward, the paper will then explain about the existing systems made by companies or universities where each system has their own unique speed, features and advantages/disadvantages. Further the paper will inform how AI can help and reduce the risk of social contacting while testing for the COVID test.**

Keywords—Artificial Intelligence, Deep learning, Machine Learning, Radiology, X rays, Information technology.

I. INTRODUCTION

Artificial intelligence is one of the most fast-growing technologies. AI is serving in many different fields such as Automobile, Robotics, Teaching and so on. Nowadays AI is completing Humans and can work the same as humans or better than Humans in some cases. Artificial intelligence is a branch of computer science which deals with building smart machines that are capable of making decisions and performing tasks that require human intelligence. AI systems are generally categorized into 3 types i.e. Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), Artificial Super Intelligence (ASI). A goal-oriented system which is programmed to perform a single task comes under Artificial Narrow Intelligence. Artificial General Intelligence refers to the systems which have the ability to learn, understand and act the same way as humans do. The third category of AI is a hypothetical AI where machines are capable of exhibiting intelligence that surpasses brightest humans.
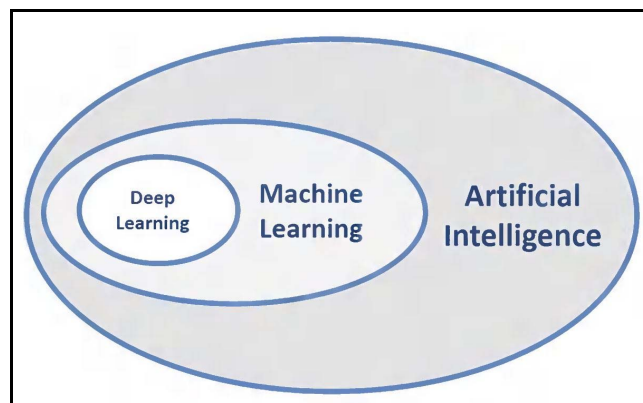

fig 1 Hierarchy of AI, ML and DL

Machine learning is a subset of Artificial Intelligence. It uses statistical learning algorithms to build smart systems. A classic example of ML is the recommendations feature while watching videos or listening to songs.

This subset of AI is a technique that is inspired by the way a human brain filters information. It is associated with learning from examples. DL systems help a computer model to filter the input data through layers to predict and classify information. Deep Learning processes information in the same manner as the human brain. A Good example of Deep learning is a driverless car.

Artificial intelligence has gained a tremendous amount of success in a few years, especially in the Medical field. In the covid19 situation the need for AI in the Medical field especially in X-ray Machines have increased as it helps the medical specialists to work keeping social distancing with the patient.[1] Radiological imaging data continues to grow at a very large rate in comparison with the amount of available trained readers, and therefore the decline in imaging reimbursements has forced health-care providers to compensate by increasing productivity. These factors have contributed to a dramatic increase in radiologists' workloads. As per the studies because of the increasing workload studies suggest that the average time a radiologist must interpret one image is 3-4 seconds if he's employed for 8 hours each day . As radiology involves beholding also as deciding under uncertainty, errors are inevitable — especially under such constrained conditions. Thus, using AI can reduce the workload of Radiologists and every one the other concerned authorities.[2]

II. ARTIFICIAL INTILLIGIENT X-RAYS

There are two different ways through which Artificial Intelligence can be implemented in X-rays. One is through traditional Machine learning algorithms and other is through Deep learning.
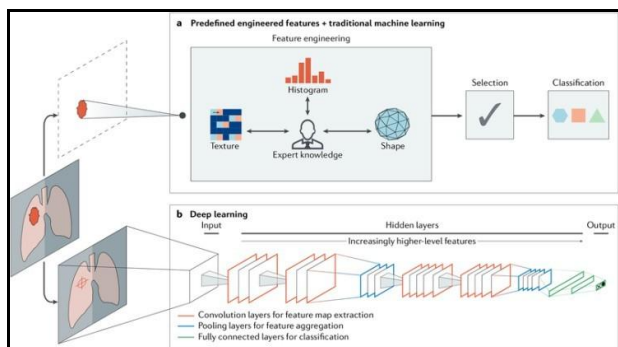

fig 2 Ways to implement AI in X-rays [3]

The primary method is via using Machine learning algorithms. In this method, based on domain knowledge, attributes are extracted from the region of Interest. For example, If a cancer categorization model is trained using Machine Learning algorithms, then the attributes such as tumor volume, shape, texture, intensity and location will be considered. The foremost robust attributes are selected and fed into machine learning classifiers. The second method uses deep learning. It comprises several neural network layers which are generally classified into 3 main layers i.e. input layer, hidden layer and output layer.

The input layer consists of the input data and the output layer provides the predicted output. The hidden layer can be in the range of 0 to N layers. The complexity of the model depends on the number of hidden layers present. During the training process it goes through feature extraction, selection and supreme classification simultaneously. As the hidden layers learn, the deep learning model provides more accurate output. For example, Earlier layers might learn abstract shapes like lines and shadows, while other deeper layers might learn entire organs or objects. Both methods fall into radiomics, the data-centric, radiology-based research field.[3][4]

III. EXISTING WORK

A. Intel and GE Healthcare's X-ray machine.

GE Healthcare with the collaboration of Intel created a group of AI algorithms which are capable of detecting Chest X-rays, to cope up with the increasing demands of its customers. This is available on GE's Optima XR240amx systems.

A very unique feature of GE Healthcare is that it has all the algorithms in the same device which is also capturing the images i.e. The company has embedded all the algorithms on the imaging device itself. Another unique feature is that it does not use cloud as the data is stored in the system itself. This adds a lot of security as there is no way data can be leaked. Also, this reduces the extra cost of managing the cloud. It can detect and inform about the priority critical conditions which can speed up the process. The company has done a rigorous test on the model by testing it on life-threatening pneumothorax. It causes lung collapse whenever

air or gas enters the cavity present between lungs and the chest wall.[5]

Most of the hospitals and clinics which use AI technology use Cloud servers. GE Healthcare built this system with the objective to reduce the cost and most importantly time.[6] Company believes that every second in the hospital can be precious as it can affect the lives of people. The goal of the System is to optimize the frontal chest and lung field position in X-rays while expediting delivery of the results of the pneumothorax inferencing once the image has been captured.

The main aim of moving the Intelligence to machine level was to help the radiologists and concerned authority for fast decision-making process and rapid progress for patients.

For the support towards the success of the product, the company partnered with Intel and its computer vision tools. Intel committed GE Healthcare to speed the GE X-ray devices and deliver higher-quality X-ray images.[7][8][9]

B. Siemens Healthineers Ysio X.pree.

Ysio X.pree is being introduced by Siemens Healthineers. It is said to be first-of-its-kind smart AI Integrated X-ray system. Its main goal is helping radiologists in their everyday scheduled preprocessing of image acquisition in radiography. Company similarly offers its CE-labeled AI- Rad Companion Chest X-Ray. It is an AI software which will help the hospitals and clinics to guide and help in the decision-making process on upright thorax images.[10]

Ysio.pree has won The Red Dot Design Award. It helps prepare for X-ray image acquisition utilizing AI. The photos are created using a 3D camera. Viewing the photos based on AI algorithms, it can automatically detect thorax and thus sets the optimal acquisition area for this – the so-called collimation. The aim is to gather all the important and necessary information with the lowest exposure possible. Thus, the radiation is targeted only on necessary areas. A live touch screen monitor is present so that the user can adjust the collimation area anytime the user wants on the patient's image. The system has full-spine and long-leg exposure with the support of live image given by 3D camera, the user has the privilege to easily lower the quantity of images needed which can further reduce the dose.[11]

Key features:

- It has a unique automation which is fast, reliable and easier the workflow.

- It gives a very good image quality therefore is very helpful for the staff.

- It is a customizable system with more than 60 configurations.

- It gives maximum effect to multiply gains.

C. Stanford University's CheXpert.

CheXpert is a huge dataset of chest X-rays and competition for automated chest x-ray interpretation, which features uncertainty and radiologist labeled reference standard evaluation sets. Chest X-ray is one of the most typical tests in the medical field which can identify many threatening diseases including COVID19. Automated chest radiograph can be very beneficial to the radiologists as well as the patients as it can improve and speed the workflow and

can also help in a good decision-making process.[12] CheXpert is a cloud-based technology which is combined with a mobile app. To achieve progress in both development and validation of automated algorithms, a huge labeled dataset is required which has accurate and strong reference standards, and also expert humans who can perform metrics for comparison.

The user can upload the image of x-ray or snap a picture on the mobile app and the user can get the results in less than 2 minutes. The image is sent to the cloud and an algorithm is run which gives results very quickly and efficiently. The app can also convey the insides of the decision making of the disease by highlighting the part of what particular part is the user looking at. The algorithm has been trained very rigorously.[13]

D. Nanox's Digital X-ray Device Accompanied by AI-based Software.

The Nanox System consists of the Nanox. Arc, a completely unique digital X-ray device and also the Nanox. Nanox is making a cloud-based software which will give an end to end service in Medical Imaging. The software will be able to incorporate image repository, offline as well as online review of diagnostics, matching radiologists etc. It will also be taking care of billing and reporting.[14]

The system will be able to identify all the early detections of a patient's condition which are discoverable by the X-ray. The corporation believes that with this unique system and its digital X-ray source technology and its planned software solutions, the system will be able to create the results at lower costs than the current medical imaging systems cost. The system will not only focus on X rays but other X-ray based imaging technologies too such as CT Scan, fluoroscopy, mammography and angiogram.[15]

E. Google's AI Algorithm.

Four types of complications were detected by the Google Health's AI team. The accuracy was found to be similar or more when compared with one of the best radiologists. The data used for building the models was from Apollo Hospitals India and National institute of Health. Once the training was completed by taking the inputs of radiologist and dataset, the AI model was prepared and also it was capable of identifying pneumothorax, nodules and masses, fractures and airspace opacities in chest X-rays. As per the Google AI blog, the authors have clearly mentioned that this model would not replace the radiologists instead it will help them for a better decision-making process.[16][17]

F. Delft Imaging's CAD4COVID.

Today most countries are suffering from COVID 19. it has affected the lives of thousands of individuals all over the globe. Symptoms of COVID 19 are often detected by CT as well as X-rays. CAD4COVID is an artificial intelligence software that triages COVID-19 suspects on chest X-rays images and indicates the affected lung tissue. X-rays are a less expensive , faster and easier way to detect the virus [18]. The other reason for selecting X-ray over CT is that it is portable and can be installed easily.

Reasons for using AI are:

- It reduces the workload of healthcare practitioners.

- It can detect faster than the conventional methods.

- It can reduce the burden of the pathology labs.

- It can lead to a fast decision-making process and therefore quick recovery with accurate results.

CAD4COVID will generate a score between 0 and 100 indicating the extent of COVID-19 related abnormalities, display such lung abnormalities through a heatmap and quantify the percentage of the lung that's affected.

CAD4COVID is a CE certified product. is the first AI software that's proved to perform at an equivalent level as human expert readers to detect COVID-19 related abnormalities on chest X-ray images.[19]

G. Blue Eye Soft Corp's BluedocAI™.

Blue Eye Soft is an IT-solution and software development company. The company with the collaboration of well-established medical image processing research scientists from University of Dayton, Ohio has created an AI based medical imaging software named BluedocAI™, to assist with the medical diagnosis such as COVID19. BluedocAI™ will help the clinics with fast decision-making processes. It uses AI Driven deep learning algorithms for its decision-making process. It is capable of analyzing chest x-ray and to detect COVID19 rapidly. It has the accuracy of more than 90%. The company is further developing tools to support medical diagnosis of many other diseases such as pneumonia, pneumothorax, tuberculosis, cancer and stroke. In addition, Blue Eye Soft has received ECCN for BluedocAI™ , giving the permission for International Export to the company.

IV.   COMPARISION TABLE

Parameters	Optima XR240amx	Ysio X.pree	CheXpert	Digital X- ray device by Nanox	Google's AI Algorithm	Cad4Covid	BluedocAI
Organization	GE Healthcare	Siemens Healthineers	Stanford University	Nanox	Google	Delft Imaging	Blue Eye Soft Corp
Tie-Up Organization/ Medical Help	Intel		Intermountain Healthcare	Foxconn	Apollo Hospitals India and National institute of Health		University of Dayton, Ohio
Cloud Services used	No	Yes	Yes	Yes	Yes	Yes	Yes
Detects COVID	No	No	No	Can't say. Product not launched yet	No	Yes	Yes
Diseases Detected	Orthopedic damage, tumors, pneumonia, foreign objects	Thorax	Pneumonia	Early detection of all medical conditions that are discoverable by X-ray	Pneumothorax, nodules and masses, fractures and airspace opacities in chest X-rays	COVID	COVID
Countries where used	India, Africa, Australia, US, Singapore, Japan, etc.	India, Africa, China, US, Canada etc.		Can't say. Product yet to launch		The Netherlands, Hungary, Peru, Indonesia, Mexico, Ghana, India, etc.	US department of Commerce and Bureau of industry and security has granted the ECCN for BluedocAI ™, clearing pathway for international export

Functionality	Its unique, adaptive, wireless technology enables automatic channel switching to improve image transfer and avoid wireless interference with other surgical equipment on the hospital network.	It works with the help of a 3D camera which focuses on the specific region and gives live image on a touch screen monitor	The user can upload the image of x-ray or snap a picture on the mobile app and the user can get the results in less than 2 minutes. The image is sent to the cloud and an algorithm is run which gives results very quickly and efficiently	It will be a cloud-based technology which will be able to give end to end service.	developed a separate, text-based deep learning model to extract image labels using the de-identified radiology reports associated with each X-ray. This NLP model was then applied to provide labels for over 560,000 images	CAD4COVID will generate a score between 0 and 100 indicating the extent of COVID-19 related abnormalities, display such lung abnormalities through a heatmap and quantify the percentage of the lung that is affected.	It uses AI Driven deep learning algorithms for its decision-making process. It is capable of analyzing chest x-ray and to detect COVID rapidly
Unique Feature	The company has embedded all the algorithms on the imaging device itself. It does not use cloud saving the cloud charges and preventing security vulnerabilities	The photos are created using a 3D camera. Viewing the photos based on AI algorithm, it can automatically detect thorax and thus sets the optimal acquisition area for this – the so-called collimation	It uses a mobile device where users can snap a picture or x-ray or upload the picture to get results.	It provides end to end medical service which includes image repository, radiologist matching, online and offline diagnostics review and annotation, connectivity to diagnostic assistive artificial intelligence systems, billing and reporting	It provides expert level accuracy.	It is the first AI software that is proved to perform at the same level as human expert readers to detect COVID-19 related abnormalities on chest X-ray images	It has the accuracy of more than 90%
Time of release	2019	2020	2019	Yet to announce	2019	2020	2020

V. HOW CAN AI X-RAY MACHINE HELP IN CURRENT COVID SITUATION?

Coronavirus disease 2019 (COVID-19) is caused by the novel severe acute respiratory syndrome coronavirus 2, (SARS-CoV-2). COVID-19 rapidly spread worldwide soon after it was first reported by officials in Wuhan City, China, in December 2019. Healthcare practitioners are at a very high risk as they are the first line of defense against the coronavirus. Coronavirus is a deadly disease which is spread by close contact. COVID can be detected by chest X-ray but the Conventional Imagining Workflow can be dangerous for both patients as well as healthcare practitioners. As X-ray needs close contact with the machine which can lead to spread of virus. Also, for Conventional Imaging Workflow the patient needs to maintain a particular pose which has to be explained by healthcare practitioners. Such things can be highly dangerous for patients as well as healthcare practitioners. Many modern X-ray and CT systems are equipped with cameras for patient monitoring purposes.

During the outbreak of COVID-19, those devices facilitate the implementation of a contactless scanning workflow. Technicians can monitor the patient from the room via a live video stream from the camera. However, from only the overhead view of the camera, it's still challenging for the technician to see the scanning parameters like scan range. During this case, AI is in a position to

automate the process by identifying the pose and shape of the patient from the info acquired with visual sensors like RGB, Time-of-Flight(TOF) pressure imaging or thermal (FIR) cameras. Thus, the optimal scanning parameters are often determined. Also, the speed of the Conventional process is very slow and it takes a radiologist a lot of time to Identify whether the patient is COVID positive or not. Using AI, the speed can be reduced to a minute to few minutes. This can help in a much faster decision-making process and a surety of correct decision as radiologists can get a helping hand in making a quicker and reliable decision.

VI. CONCLUSION

AI in X-ray machines is essential for a fast, accurate and reliable decision making process. Features of 8 existing machines have been discussed. All the systems have some unique features. GE Healthcare's Optima XR240amx does not use cloud services as it is one standalone system which can do all the operations and store the data internally. Some machines such as Cad4covid and BlueDocAI are designed specifically to test COVID which is of utmost importance in this pandemic situation. Siemens Healthineers Ysio X.pree uses a 3D camera to focus on a specific region of the body to detect the disease. Stanford University's CheXpert is capable of detecting the disease just by taking a snap of X-ray and uploading it into their mobile app. Nanox and Google's AI algorithms are some dynamic systems which are used to detect a variety of diseases.

ACKNOWLEDGMENT

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