

RECENT ADVANCES IN RADIOLOGY

Abstract

New technologies like dual energy imaging, tomosynthesis, and computer aided diagnosis are helping the radiologists to further improve patient care and diagnostic outcomes. A dual energy CT can be a rapid KVp switching or a dual source CT scanner. Scanned data / HU values for each voxel is obtained twice and hence can be utilized to give more information of the scanned object like composition. In tomosynthesis multiple projections of breast are acquired at various angles after positioning the breast like in mammography. These images are superimposed and processed to create a 3 image of the breast. A digital image can be transferred over long distances in no time using a digital network a new concept of teleradiology is evolving which helps setting up a diagnostic facility in less budget. The use of AI in radiology has many challenges in clinical implementation. Deep learning which is basically a part of AI has added further growth in accuracy or reliability on technology with its improved capability. Recent advances in ct technology like cone beam computed tomography, extreme multidetector computed tomography, portable and dual energy computed tomography have made a significant clinical impact. These new technologies have not only led to better diagnosis but also helped in reduced the shortage of skilled manpower.

Keyword: Technology, Dual Energy, Artificial Intelligence, Mammography, Computed Tomography

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I. RECENT ADVANCES IN RADIOLOGY

In 1901 German Scientist Wilhelm Conrad roentgen was the first to be awarded nobel prize for his discovery of x-rays in 1895. Radiology has made great strides in technology since then. Today radiology imaging has been replaced by digital radiology. Most recently artificial intelligence based technology has been the buzz word in medicine and so in radiology. The x-ray film has been replaced by CCD and imaging plates. The latent image which took almost 15-30 minutes to develop can now be obtained instantly in no time and analyzed or interpreted. Additionally these images need minimal space to store and are easier to be stored or transferred via PACS or DICOM. This in turn facilitates fast processing. Newer technologies like dual energy imaging, tomosynthesis, and computer aided diagnosis are helping the radiologists to further improve patient care and diagnostic outcomes.

II. DUAL ENERGY IMAGING

Dual energy imaging is one such technology which has contributed in faster image acquisition. Low exposure dose and better image quality for patient scan. A dual energy CT comprises of 2 x-ray tubes separated at 90° with each other. One x-ray tube has a larger FOV in comparison to other. A dual energy CT can be a rapid KVp switching or a dual source CT scanner. Scanned data / HU values for each voxel is obtained twice and hence can be utilized to give more information of the scanned object like composition. Dual energy CT has found improved usefulness in renal stone and coronary artery plaque characterization in recent times.

III. TOMOSYNTHESIS

Recently digital mammography has been advocated by experts around the world due to its lower exposure advantage and improved diagnostic capabilities. Tomosynthesis in combination to conventional mammography aids in early detection of carcinoma of breast via screening. It has also shown to reduce false positive diagnosis. A digital breast tomosynthesis is different from a breast breast mammography as is a 3D computed tomography from a x-ray radiograph. Multiple projections of breast are acquired at various angles after positioning the breast like in mammography. These images are superimposed and processed to create a 3 image of the breast. This gives better as well as more information in a breast examination with a clear visualization beneath dense tissues unlike a mammograph.

IV. COMPUTED TOMOGRAPHY LASER MAMMOGRAPHY

A new technique of laser-based mammography is being developed by Imaging Diagnostic Systems Inc. These are nothing but near infrared lasers. A series of image slices are acquired and then manipulated by the computers. This technique is referred to as CT laser mammography (CTLM). The first prototype was a argon-ion-laser pumped modelocked Ti:Sapphire laser in the range of 750 to 1100 nm. To acquire image he woman is positioned prone on the table that contains imaging chamber and laser/detector array for scanning breast. A horizontal beam is projected for one breast at a time and the beam is transmitted and scattered at various angles. The average scanning time is less than 5 minutes per breast.

V. TELERADIOLOGY

As a digital image can be transferred over long distances in no time using a digital network a new concept of teleradiology comes into picture. This has led to reduced cost in setting up a diagnostic facility as well as availability of experts from primary diagnostic centres for expert opinion. This has also contributed to paperless revolution and hence reduction in carbon footprints on the environments. Now a day's voice to text systems has been introduced to generate report in no time with ease.

VI. COMPUTER-AIDED DIAGNOSIS

Computer-aided diagnosis is a concept established by taking into account equally the role of physicians and computer. A CAD scheme that makes use of lateral chest images has the potential to improve the overall performance in the detection of lung nodule when combined with another CAD scheme for PA chest images. A major difference between CAD and computer diagnosis is the way in which the computer output is utilized for the diagnosis. With CAD, radiologists use the computer output as a "second opinion," and radiologists make the final decisions. Automated computer diagnosis, however, the performance level of the computer output is required to be very high. With automated computer diagnosis, the performance by computers needs to be comparable to or better than that by physicians. CAD is used in the diagnosis of breast cancer, lung cancer, colon cancer, prostate cancer, bone metastases, coronary artery diseases, congenital heart defect, pathological brain detection, Alzheimer's disease and diabetic retinopathy. CAD systems fundamentally work on highly complex patterns found in image. For breast cancer, it is used in screening mammography. Evaluation of CAD systems measured by two major factors, such as sensitivity and specificity, they seek for suspicious structure. CAD systems may not be 100% but their hit rate means sensitivity can be up to 98% these days.

VII. ARTIFICIAL INTELLIGENCE IN RADIOLOGY

Availability of trained manpower is a problem which many diagnostic centres have to deal with. But in recent times with the advent of AI based advanced algorithm the situation is changing rapidly. These algorithms identify the patterns based on qualitative assessments of the radiographic images. The use of AI in radiology has many challenges in clinical implementation. Deep learning which is basically a part of AI has added further growth in accuracy or reliability on technology with its improved capability. A deep learning algorithm uses a large amount of data to help the algorithm to learn and perform difficult task or differentiation with ease. AI alone may not have been as good as a human brain but deep learning certainly has challenged the limitation of a human brain. The algorithms or concepts used in deep learning have been there for decades but the availability of very advanced hardware and trained manpower have allowed the researchers to put them into better and efficient use.

As the diagnostic opinion of the physician can be subjective the advantage of artificial intelligence based diagnosis is that it is based upon quantitative analysis of data. Artificial intelligence has many applications in oncology imaging like identifying lesions and categorizing them into benign or malignant. In mammography artificial intelligence has been used for characterizing micro-calcifications in breast. In radiotherapy it can be employed to

monitor treatment progress and evaluating the efficacy of delivered treatment or radiation dose. Artificial intelligence application has also find its way into skin lesions, interpretation in dermatology, analyzing slides in pathology, DNA or RNA sequencing for cancer diagnosis and care. Radiomics as a field of medical research is being explored and used for diagnosis and clinical decision.

Due to high workload the error on the part of the radiologist is almost inevitable. Artificial intelligence not only increases efficiency but it reduces chances of errors. Artificial intelligence can be based upon deep learning or manually assigned features using mathematical tools and computational techniques. Deep learning automatically identifies the feature based upon algorithm it uses without human intervention which is more generalizable. So it cuts the pre processing effects and hence saves a lot of time and energy. In this process we tend to avoid the inter reader variation. Studies have shown that deep learning has given better and more reliable results as compared to predefined feature based methods.

The main challenge with AI based tool is its being very objective oriented, i.e., its limited intelligence. An artificial intelligence tool may only look for a specific objective and not analyse the whole image data sets for other possibilities. So we need a very comprehensive Ai system to examine or monitor multiple end points successfully. Availability of large data in not very curated manner is a other problem. Curation of data is essential for proper data selection and standard data acquisition and imaging protocols between different radiography institutions. Curation requires expert knowledge and trained manpower which makes it a expensive task. Other issues with large online data have been regulatory and ethical.

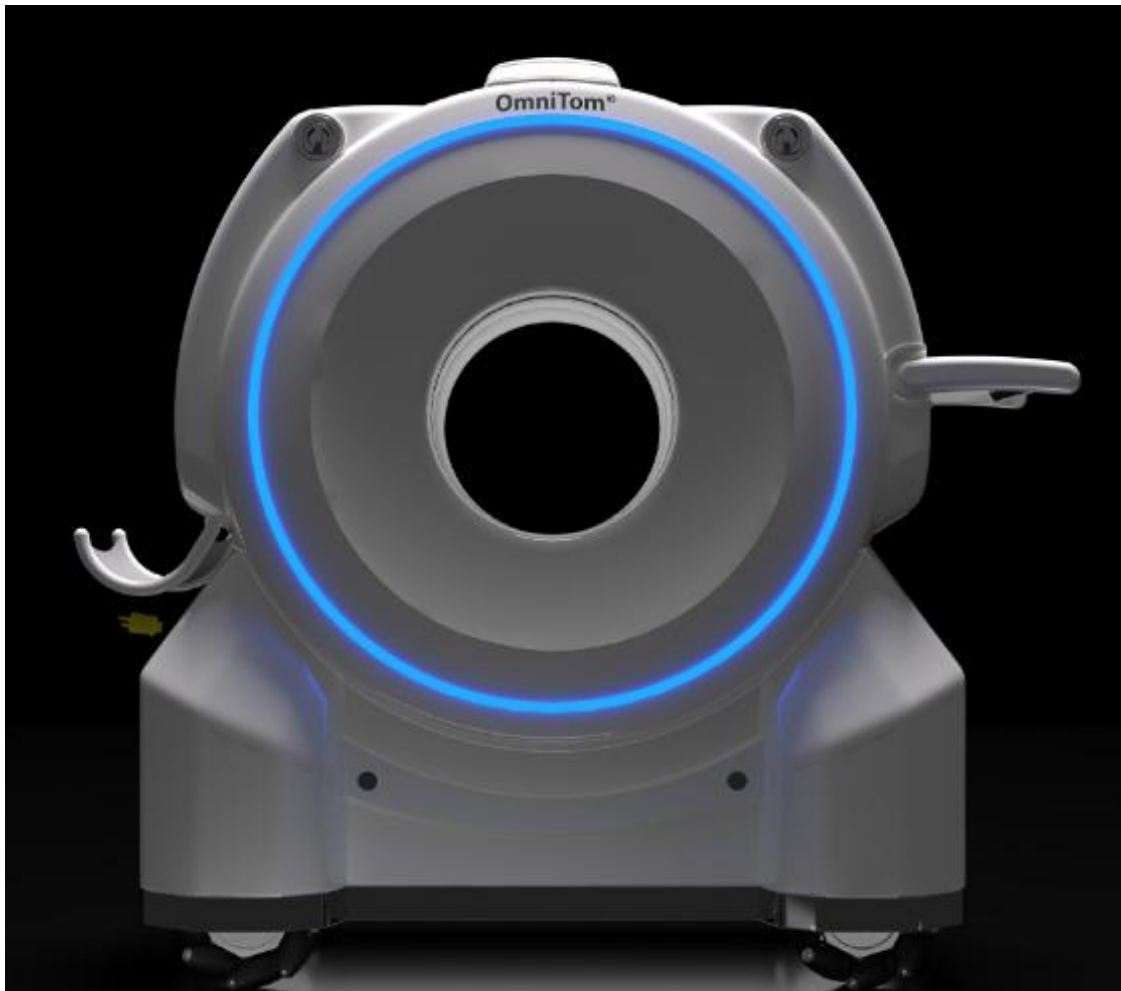
We can safely suggest that the advancement in imaging hardware have not been met with equal advancement in software. Here we need more powerful artificial intelligence tools which are a match to the state of art equipments. The feasibility of using one AI tool with other will determine the future course of efficacy of artificial intelligence in healthcare.

VIII. COMPUTED TOMOGRAPHY

Recent advances in ct technology like cone beam computed tomography, extreme multidetector computed tomography, portable and dual energy computed tomography have made a significant clinical impact. A multidetector scanner consists of mosaic of scintillator material which converts x rays to visible light which is subsequently to visible light and later converted to electrical pulse by a diode detector. These signals are further combines and processed. Extreme multidetector ct will have a role to play in following up complications after cardiac surgery. This extreme multidetector ct has very high spatial resolution which may be used for qualitative imaging like estimating tumor response during therapy by tracking tumor size in further small voxels. The capability of extreme multidetector ct can be used to derive functional information like in 4D electrocardiogram-gated extreme multidetector CTA in which the heart can be depicted throughout different portions of the cardiac cycle. The image quality of 4D multidetector ct is inferior to extreme multidetector 3D ct and also to non extreme 3D multidetector ct.

The conventional filtered back projection algorithms have been supplemented by iterative reconstruction algorithms to reduce noise in the image simultaneously with

reduction in radiation dose. This iterative reconstruction method uses trial and error correction loops between measured and calculated projections. Recently greater number of correction loops like SAPHIRE (Sinogram Affirmed Iterative Reconstruction) algorithm are made into use that are reducing noise further than the basic iterative reconstruction algorithms. Dual energy ct is a new technology which can be dual spin scanner or rapid KVp switching. Other types of dual energy ct can be dual source scanners, dual layer detectors type or photon counting detectors type.



Photograph of Portable Computed Tomography Scanner. Picture Courtesy: Company Manual

A cone beam ct uses conical configuration instead of the conventional fan beam geometry of ct scanners. The conical angle of x-ray beam can be altered by changing the anode angle in the x-ray tube. Cone beam ct also uses technology like flat panel detectors. These detectors convert x-rays into electrical signals for digitization. A flat panel based cone beam ct can be used cardiac and radiation therapy equipments. These flat panel detectors have high spatial resolution and high voltage coverage. Portable ct scanners can be used for critically ill patients 7% of adverse events incidence has been reported in transferring critical patients out of ICU to ct scanners. X CAT ENT, Tomoscan (Philips medical Systems) are few commercially available portable ct scanners. Photoelectric effect and Compton scattering is the basis for conventional x-ray imaging. These differences in attenuation due to above two

phenomenons enables differentiation of different tissue. A phase contrast ct imaging enables high spatial resolution to the extent of sub micrometer level. Potential application of phase contrast ct is lung disease imaging in which x ray phase contrast is created at air tissue interfacing, high contrast mammography in which microstructures of soft tissues are obtained with low radiation dose.

IX. MAGNETIC RESONANCE IMAGING

Recently US food and drug administration has granted market clearance for industry's first multi contrast MRI technique which delivers 8 contrasts in a single acquisition in a fraction of the time in which conventional imaging is done. The MR images are retrospectively manipulated that leads to fewer scans and hence it is cost and time effective as well. Lung MRI which has been traditionally been problematic due to low hydrogen atom density is now gaining traction due to Ultra short Echo Time sequence for dedicated pulmonary MRI. Simultaneous multislice application by Siemens acquires MR images simultaneously as opposed to sequentially, reducing image acquisition time by a factor of 8. Recent cardiac MRI software like the Vios Works helps to automate image sequences to obtain 3D chest volume scans that include full motion of the myocardium during cardiac cycle, blood flow, time and fully automated quantification. The only problem with the Vio Works exam is it generates a average of 20 GB data as compared to the 200 MB in a conventional cardiac MRI. To take care of this data problem now the vendors have started giving their cloud services.

Now a day's MR conditional implants for knee and hip replacements, spine, pacemakers and implantable cardioverter defibrillators (ICDs) are in demand. This enables MRI scanning with certain parameters. These implants require adjustments in the scanner setup to create optimal image with complete patient safety. In October 2017 7T MRI systems was cleared by US FDA. GE has introduced a noise reduction technology called Silent Scan MRI for musculoskeleton imaging and spine imaging. This reduction in noise is achieved by gradient magnetic interaction and the mechanical vibration.

X. ULTRASOUND

Ultrasound based imaging is considered safer than x-ray based radiology. In past few decades ultrasound technology has seen tremendous advancements. Automation of time consuming tasks, quantification and picking out the ideal image set from a 3d dataset, visual mapping and annotation of screened anatomy are performed through ultrasound. A 3 d imaging gives a more usable anatomical information to plan their clinical intervention or surgery more accurately. This 3D/4D ultrasound is mostly used in maternity or obstetrics scanning. But their use is limited in other areas due to its slower frame rates and high price. The vendors are trying to improve frame rates to enable wider application of 3d ultrasound. Automation is enabled with new software features like Logiq E10 system (GE healthcare) which increases productivity. This software automatically segments on identified breasts thyroid and provides the extension in corresponding area. This also ensures consistency amongst inter user variation and reduces subjectivity in results.

The ultrasound console is getting compact and the software is getting more and more complex. Transducer is the heart of a ultrasound system/equipment. Butterfly IQ has introduced an ultrasound transducer and app to convert iphones into a usable and reliable

ultrasound system. Now a day's piezoelectric crystal transducer is a outgoing technology and may give way to a new single crystal wireless and even dual probe. A single crystal transducer has higher energy conversion efficiency and higher sensitivity than piezoelectric materials. This yields more uniformity and greater penetration. Shearwave Elastography is now being readily used to study tissue pathology that maps the elastic property of soft tissue. Elastography can differentiate healthy from a non healthy tissue for specific organ /growth for example, diseased liver is stiffer than a healthy ones. New application of ultrasound is laparoscopic ultrasound, lung ultrasound and Intravascular ultrasound.