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Nurturing Innovations - Fostering Business

Artificial Intelligence in Medical

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Introduction

One of the most promising areas of health innovations is the application of artificial intelligence (AI), primarily in medical imaging. With an irreversible increase in the amount of data and the possibility to use AI to identify findings either detectable or not by the human eye, radiology is now moving from a subjective perceptual skill to a more objective science. These technologies have the capability to: Sense, Comprehend, Act and Learn. AI is essentially a smart solution for compiling and analysing data, taking account of more variables than humans can, categorising the new data, predicting trends and ultimately identifying solutions. It may find multiple applications, from image acquisition and processing to aided reporting, follow-up planning, data storage, data mining, and many others. Due to this wide range of applications, AI is massively impacting the radiologist's daily life.

Radiologists, who were on the forefront of the digital era in medicine, can guide `the introduction of AI into healthcare. Yet, they will not be replaced because radiology includes communication of diagnosis, consideration of patient's values and preferences, medical judgment, quality assurance, education, policy-making, and interventional procedures. The higher efficiency provided by AI will allow radiologists to perform more value-added tasks, becoming more visible to patients and playing a vital role in multidisciplinary clinical teams. [1]

[1] Pesapane F, Codari M, Sardanelli F (2018) Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. Eur Radiol Exp 2:35

Artificial Intelligence in Healthcare

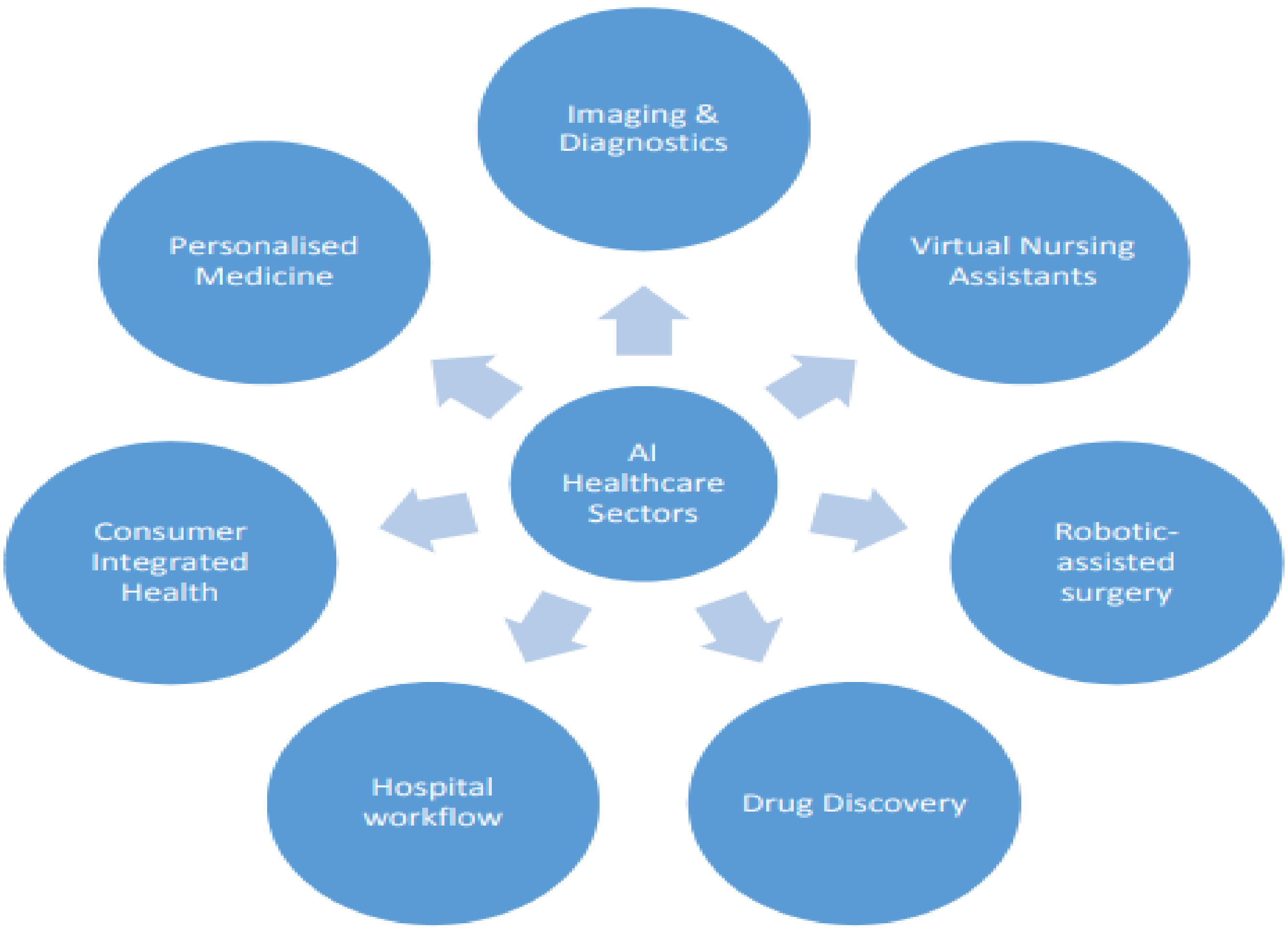
The phrase Artificial Intelligence was first coined in 1956 by computer scientists at IBM and refers to a simulation of human intelligence processes by machines, especially computer systems. The technologies which form the basis of AI which broadly fall into the following categories;

- ***Machine Learning –*** *a term introduced by Arthur Samuel in 1959 to describe a subfield of AI forms the foundation of AI that includes all those approaches that allow computers to learn from data without being explicitly programmed, this has been extensively applied to medical imaging. These systems can predict a pattern or analyse a trend in a dataset, which for healthcare can shape clinical outcomes.*
- ***Deep Learning –*** *a sub-sector of machine learning concerned with algorithms-based methods which belongs to representation-learning methods with multiple levels of representation, which process raw data to perform classification or detection tasks. Tools are being developed to process large volumes of medical data, reducing uncertainty in treatment decisions.*
- ***Computer Vision & Image Recognition –*** *Techniques such as fuzzy-logic are allowing computer-aided diagnosis by processing large amounts of medical images in a short time to derive critical insight on disease prognosis.*
- ***Natural Language Processing & Speech Recognition –*** *These technologies leverage deep neural networks and machine learning to capture speech and language of patients and clinicians, capturing information for electronic health records.*
- ***Cognitive Computing –*** *This is defined as the use of computerized models to simulate the human thought process in complicated situations where the answers may be uncertain and ambiguous.*
- ***Robotics –*** *Surgical robotic systems are leading the AI applications in healthcare, delivering improvements in precision and accuracy of surgical procedures, enhancing quality of care.*
- ***Data Mining –*** *Predictive analytics integrate advanced computing with statistical methods to predict the outcomes of care for individual patients at speeds not achievable manually.*
- ***Predictive Modelling –*** *Involves the application of mathematical models to predict patient outcomes, including evaluating potential costs or risks associates with managing a specific patient population.*
- ***Speech Recognition –*** *These technologies leverage deep neural networks and machine learning to capture speech and language of patients and clinicians, capturing information for electronic health records.* [2]

[2] Fei Jiang, Yong Jiang, et al. Artificial intelligence in healthcare: past, present and future

Role of Artificial Intelligence in Healthcare

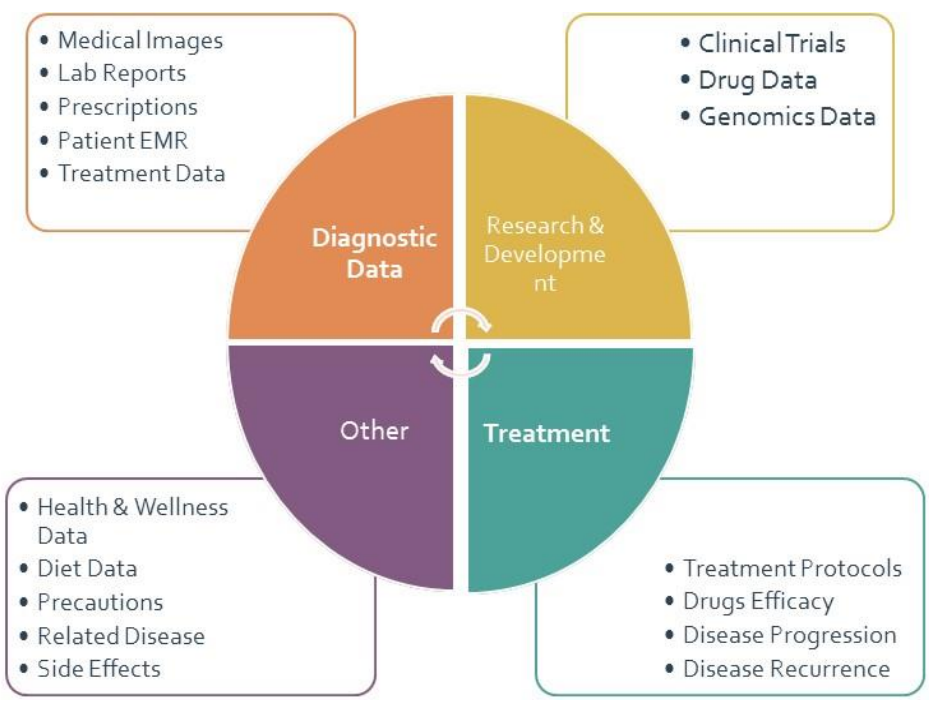
AI-enabled solutions in healthcare are based on data mining of patient information, enabling that information and making treatment decisions. Some of the healthcare sectors where AI is identified to be having an impact are



Medical applications of AI

- ***Medical image analysis —*** *This technology can identify anomalies and diseases based on medical images better than doctors.*
- ***Aids in the diagnosis of neurological conditions —*** *AI can help doctors diagnose neurological diseases like Amyotrophic Lateral Sclerosis (ALS). A study has also shown that AI was able to predict Alzheimer's disease years before it manifests.*
- ***Revealing cardiovascular abnormalities —*** *AI can measure a patient's heart structure and indicate their risk of cardiovascular disease or other problems that might require surgery. Automated AI can be used to detect abnormalities in common medical tests like chest X-ray and lead to quicker risk detection and less misdiagnosis.*
- ***Cancer Screening*** *– Early cancer diagnosis often results in a better outcome for patients. Recently, scientists created an AI based on Convolutional Neural Networks (CNN), a type of Artificial Neural Network (ANN) used to identify various types of cancer (1,2,3) with a high success rate. These experiments show that AI can decrease detection times and improve the rate of diagnosis.*[3]

Types of data that can be used as input for an AI platform



[3] https://missinglink.ai/guides/deep-learning-healthcare/ai-medical-imaging/

Medical Imaging

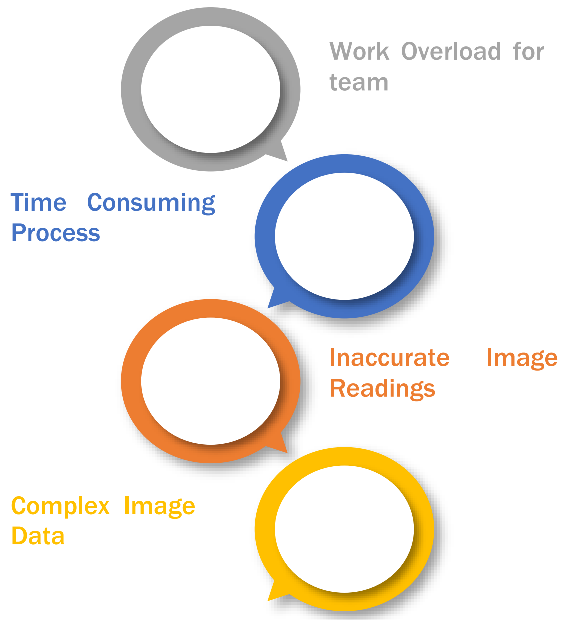
Medical imaging refers to techniques and processes used to create images of various parts of the human body for diagnostics and treatment purposes within digital health. Imaging for medical purposes involves a team which includes the service of

- *Radiologists,*
- *Radiographers (X-Ray technologist),*
- *Sonographers (ultrasound technologist),*
- *Medical physicists,*
- *Nurses,*
- *Biomedical engineers*
- *Other support staff working together to optimise the wellbeing of patients, one at a time. Appropriate use of medical imaging requires multi-disciplinary approach.*

In the era of digitization in medical industry, images have become largest source of data, in a variety of medical setting and at all major levels of health care. In public health and preventive medicine as well as in both curative and palliative care, though at the same time it is one of the most difficult tasks to analyse them accurately in effective time, as decisions depend on correct diagnosis. Currently the major issue medical imaging industry faces is as follows;

- *Clinicians either depend on medical image analysis performed by overworked radiologist.*

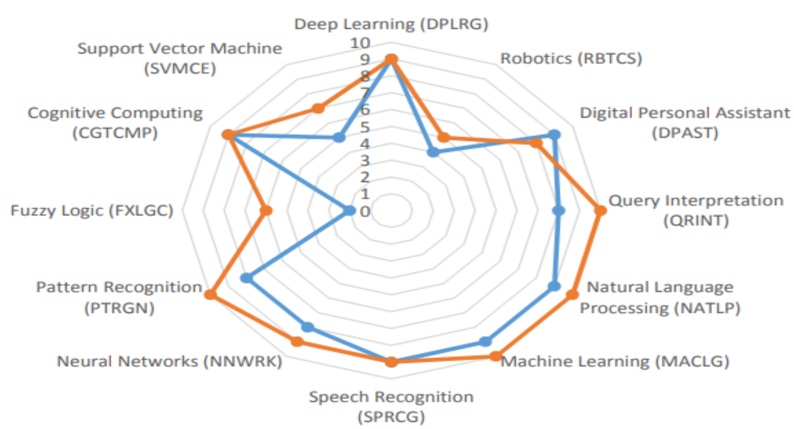
- *Sometimes they scan and analyse themselves where, almost one in four (23%) patients experience false positives on image readings*
- *One study showed that 70% of lung cancer patients survive for at least a year if diagnosed at the earliest stage, compared to just 14% for people diagnosed with the most advanced stage of disease, and it is a very difficult task to diagnose cancer at its early stages and the signs are not very clear.*



AI based Medical Imaging

- *AI-based medical imaging relies on a vast supply of medical case data to train its algorithms to and patterns in images and identify specific anatomical markers.*
- *Through rigorous analysis of patterns in each digital image, the imaging algorithms can derive metrics and output that complement the analyses made by the radiologist, which can be useful for quick diagnosis.*
- *With advanced medical imaging equipment that can process over 100 high-resolution medical images extremely fast, radiologists are now able to produce discrete assessments and spot details that are quite impossible to catch with a naked eye.*
- *acquired intelligence can then be validated by radiologists and uploaded into an electronic health record (EHR) or a picture archiving and communication system (PACS) for future reference.*
- *Provides for automated risk stratification, which can be a powerful tool for identifying high-risk patients so they can receive specialized and optimized medical care*

According to an assessment conducted in 2016 of technology readiness and technology relevance levels for the above AI platforms in the healthcare industry below is the outcome.



AI technologies in a clinical setting will strengthen the medical imaging and diagnosis processes. The study claims that AI has the potential to improve outcomes by 30-40%, whilst reducing the costs of treatment by as much as 50% with much impact in the near term coming from more effective, earlier diagnosis.
AI plays a major role in cancer diagnostic and treatment. Also focus in upcoming times would more towards detection of cancerous lesions through AI and recommending correct treatment plan.

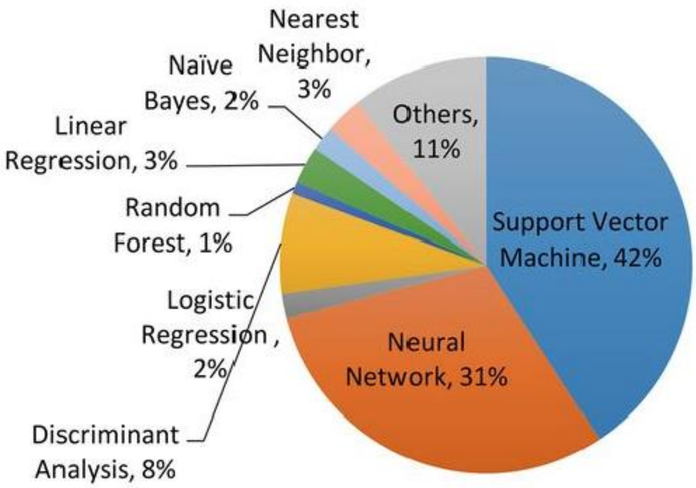
AI technologies such as natural language processing, neural-network capability and deep learning allow unstructured cancer related data to be processed for more accurate and faster diagnosis.
Major drivers for AI in diagnostics include:

- *Earlier detection of pathogenesis, recognizing small shifts from baseline state in a patient – AI has the potential to detect signs of cancer in mammograms much earlier than human clinicians can.*
- *Earlier identification of pandemics and disease progression across populations.*
- *Machine learning can enable doctors to make more personalized treatment decisions based on specific patient records.*

Diagnostic centers are leveraging deep learning and pattern recognition to reduce diagnosis turnaround time and improve pathology workflow efficiency and accuracy of diagnosis.

AI Techniques in Medical Image Analysis

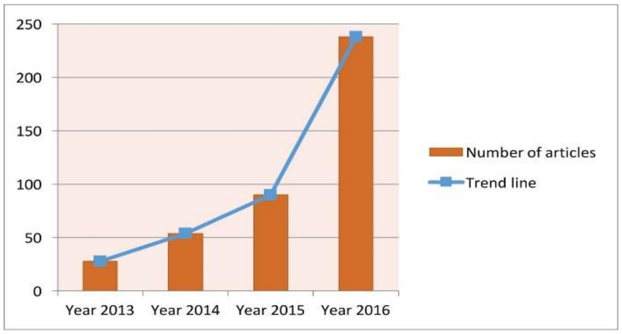
1. *Machine Learning*



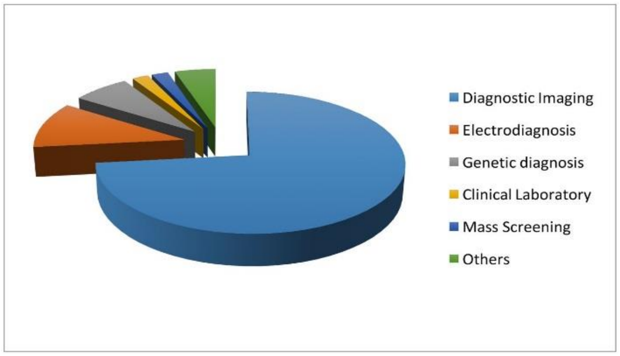
- *Machine learning (ML)constructs data analytical algorithms to extract features from data. Inputs to ML algorithms include patient 'traits' and sometimes medical outcomes of interest.*
- *A patient's traits usually include baseline data and disease-specific data.*
- *ML algorithms can be divided into two major categories: unsupervised learning and supervised learning.*
- *Unsupervised learning is well known for feature extraction, while supervised learning is suitable for predictive modelling via building some relationships between the patient traits (as input) and the outcome of interest (as output).*
- *Compared with unsupervised learning, supervised learning provides more clinically relevant results; hence AI applications in healthcare most often use supervised learning*

2. Deep Learning

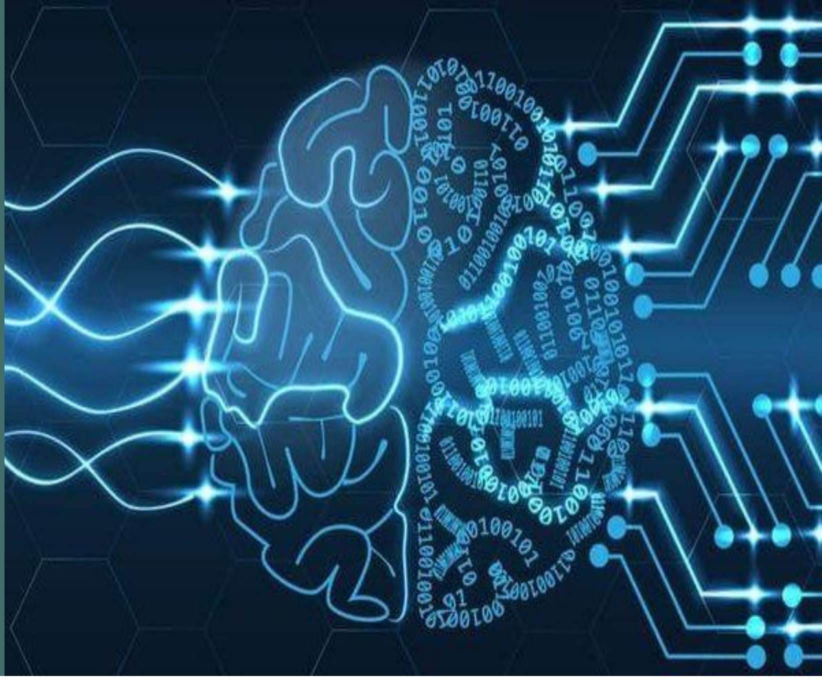
- *Deep learning (DL) is a new era of machine learning algorithm, we can view deep learning as a neural network with many layers.*
- *Rapid development of modern computing enables deep learning to build up neural networks with many layers, which is infeasible for classical neural networks.*



- *Deep learning can explore more complex non-linear patterns in the data.*
- *Figure shows that the application of deep learning in the field of medical research nearly doubled in 2016.*
- *Figure shows that a clear majority of deep learning is used in imaging analysis, which makes sense given that images are naturally complex and high volume*



Who will get benefits from AI based Medical Image Analysis?



In the current scenario, most healthcare agencies are battling with the problem of an excess of unstructured and unorganized patient data. Physical structuring and mining of such data is a overwhelming task that can seldom be managed efficiently. One large component of this data is medical imaging data. Further, clinicians are struggling with sorting this data out to identify the relevant or actionable information. The issue is further compounded due to increasing patient volumes, reimbursement procedures, bundled payment systems, and the shift from fee-for-service to a fee-for-value reimbursement system. AI is the answer. They can be easily structured and mined through Electronic Medical Record (EMR) technologies.

Implementation of Machine Learning technology to the medical image analysis will bring number of benefits to radiologists, doctors and patients.

1. ***Radiologists and Doctors***
   - *Automated image analysis will decrease the burden on radiologists everywhere, by removing the need for them to check every image in the search for anomalies. Instead, clinicians will only need to focus on images that deep learning algorithms raise for their attention.*
   - *AI may even present radiologists with suggestions as to the nature of detected abnormalities. In the fight against cancer, for instance, this might require algorithms to highlight the likelihood of a tumour being either benign or malignant. This will help doctors focus on patients who need attention while easing their diagnostic workload and supporting them in making appropriate decisions.*

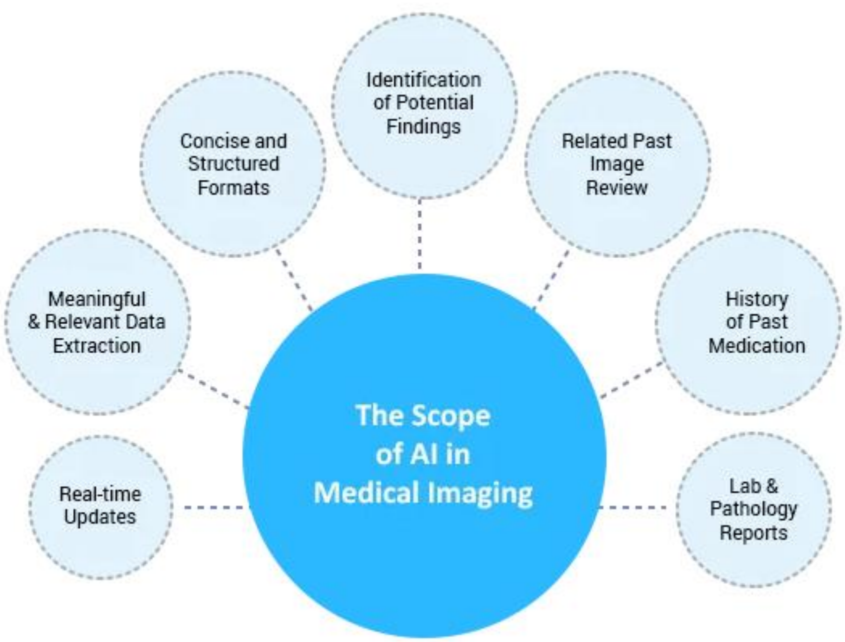
2. Patients[4]

Patient will receive timelier and more accurate diagnoses, and will no longer have to wait weeks for results of X-ray studies

The range of applications for self-monitoring will increase, including wearable self-scanning solutions. In the hospital setting, patients will be subject to fewer invasive procedures and will have less need to endure the introduction of toxic or radioactive tracer drugs into their bodies. Radiation doses from CT scans and X-rays will be reduced, and fewer scans will be necessary to diagnose or monitor each patient's condition.

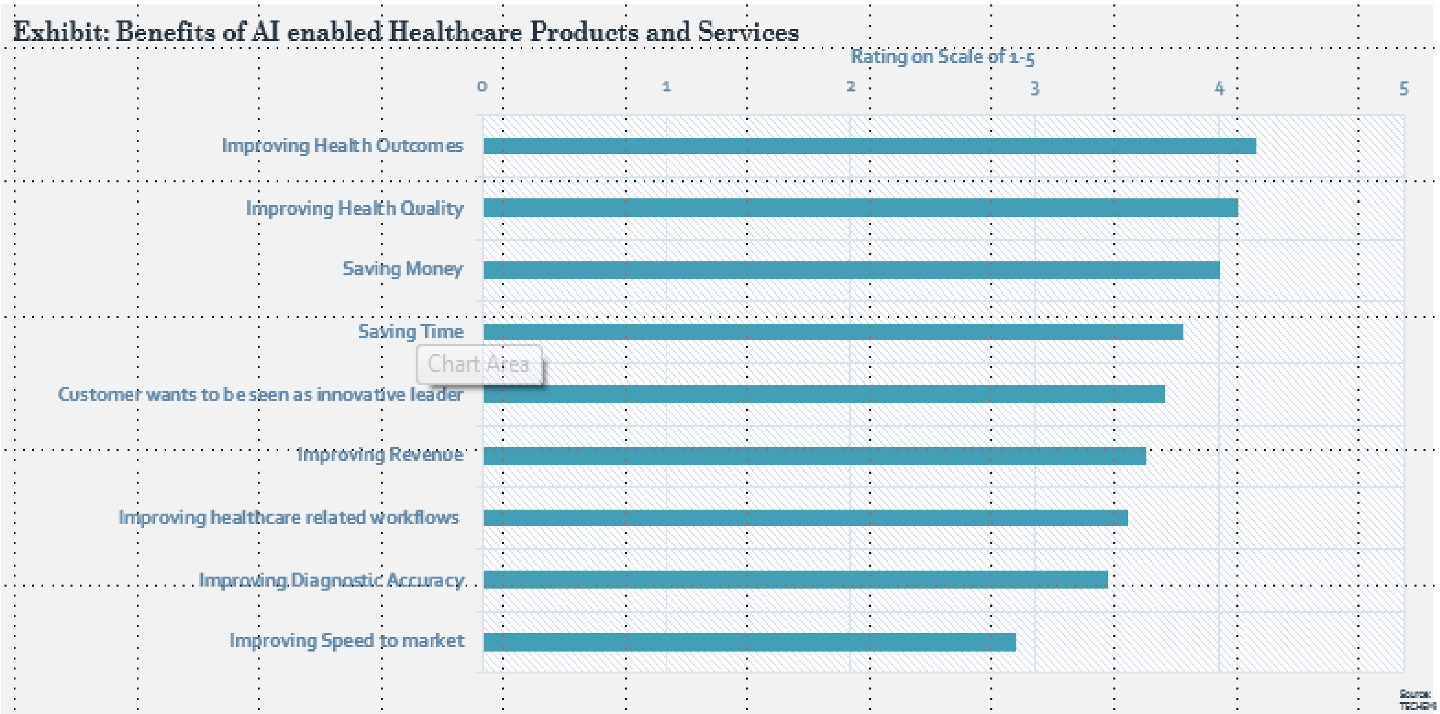
Additionally, AI has the scope to:

- *Enhance the ability of doctors to provide healthcare through real-time updates*
- *Churn out meaningful and relevant data from patients EMRs*
- *Format concise and structured data for efficient usage*
- *Medical images review and identification of potential findings*
- *Related past images will be automatically supplied*
- *Historical medication and reports can be highlighted*
- *Relevant lab and pathology reports can be collectively showcased*[5]



[4] https://www.iflexion.com/blog/medical-image-analysis
[5] https://www.osplabs.com/insights/how-ai-is-reshaping-the-medical-imaging-business/

Healthcare providers will most likely to get the below benefits if they implement AI product and services (Rated 1-5)



AI based Image Analysis Framework

1. ***Data Management***
    - *Image Acquisition in biomedical imaging is done by computed tomography, magnetic resonance imaging, x-ray, molecular imaging, ultrasound, photo-acoustic imaging, fluoroscopy, positron emission tomography-computed tomography (PET-CT).*
    - *Extraction: refers to a technique that enables to obtain useful biomedical images from the raw data and, refines them so that they can be used in the following analytic steps.*
    - *Cleaning is the process that eliminates noise on acquired images.*
    - *Annotations rely on a technique, which allows adding some information concerning the patient on images*
    - *Integration & Representation is the step which involves the automatic clustering of images in the databases.*
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2. ***Analysis & Storage***
    - *Modeling is based on mathematical models and computational algorithms. This can be used to format images in a way that is easier to understand.*
    - *Predictive and Detection, the method is based on the ML algorithm. Deep Convolutional Neural Network (CNN) is one of the most used to automate the process of diagnosing symptoms from patient information. This is because the CNN yields over 88% accuracy for diagnosis and treatment suggestion.*
    - *Validation: Validation is performed by calculating sensitivity and specificity, where true positive is the number of symptoms correctly predicted on the images, positive is the total number of symptoms shown, true negative is the number of correctly predicted benign symptoms, and negative is the number of benign symptoms shown .*
    - *Classification in machine learning concerns a problem of identifying to which set of categories a new population belongs. When category membership is known, the classification is done based on a training set of data containing observations.*
    - *Compression is representative of data reduction for big data analytics. In fact, reducing the size of data makes them analytically computational, less expensive and thus faster*
    - *Storage or Share: Cloud computing technologies can also be used to facilitate sharing of data. Cloud computing is an on-demand computing model composed of autonomous, networked IT resources.*

AI applications in Different Types of Medical Imaging

1. ***CT Scanning***

   The use of convolutional neural networks to analyse CT scans has seen much progress and growth in the last couple of years but has mainly involved 2D slices from a patient's chest, abdomen, or brain. Yet breakthroughs are on the way, as innovators have improved the performance of deep learning solutions that analyse the entire 3D image series from a CT scan.

   Company Name Aidoc, specializing in deep learning technology for the medical field, recently launched the first full-body solution for CT analysis, which will afford radiologists a workflow-integrated application, enabling them to analyse scans of the chest, c-spine, abdomen, and head, without the need to switch between discrete image analysis applications.

2. ***MRI***

   Unlike CT scanning, MRI presents less risk to patients, because it does not emit radiation in order to capture images. Its main drawback, however, is the long examination time. For instance, a cardiac MRI can take more than an hour to perform.

   To solve this issue, San Francisco company Arterys has developed an AI solution that not only cuts down the time needed for cardiac MRI examinations but also increases the quantity and quality of data provided. Better still, Arterys' ViosWorks application eliminates another MRI issue—the need for patients to hold their breath during certain sequences of the examination.

3. ***PET Scans***

   Research has shown that machine learning can improve the effectiveness of PET medical image analysis. Algorithms can be developed and trained to remove image noise, improve quality, and gather image data in greater quantities and at a faster rate than standard PET equipment can. Consequently, the quantities of radioactive tracer needed to capture reliable images may be reduced, which, of course, is good news for patients who must undergo PET scans.

   The reduction of toxicity is not the only benefit for cancer patients. Integration of machine learning into PET scanning

   - *Improved image quality relieves the need for follow-up scans*
   - *Instant high-quality imaging allows physicians to make decisions much earlier, even during the scanning process*
   - *Tumours can be monitored frequently and non-invasively to match chemo and radiotherapy doses to treatment response*

4. ***Ultrasound***

   The integration of new semiconductor-powered probes built as smartphone peripherals with image analysis software may soon allow patients to scan themselves and capture ultrasound data for use in their treatment or condition monitoring

One new solution uses a sophisticated probe and machine learning artificial intelligence software—dubbed ultrasound on a chip—and has already received FDA approval that Seals describes as "robust."

5. ***Breast Imaging:***
Artificial intelligence has come in handy for radiologists in the diagnosis of various medical conditions enabling healthcare facilities worldwide to provide quality breast care to their patients across the globe. Complex and innovative imaging techniques such as the Digital Breast Tomosynthesis (DBT), also referred to as 3-D mammography, has improved lesion visibility and provided a remarkable level of detail when it comes to tissue analysis. Integration of DBT with ultrasound and MRI has enhanced accuracy in clinical diagnosis thereby minimizing errors or recalls. It even helps in early detection of breast cancer and potential mammographic abnormalities more quickly and accurately. AI systems can also help radiologists categorize patients based on several data points such as breast density, individual medical history, and risk, referring them to the right interpreting radiologists thereby creating efficient workflows.

6. ***Cardiovascular Imaging:***
AI-based medical imaging is now playing a significant role in cardiology. A comprehensive cardiac examination can now be done using highly integrated and dedicated software that contains the MRI tools needed for such procedures. This has allowed invasive diagnostic procedures like cardiac catheterization, angiography and examining surgery to be avoided. For instance, through machine learning and trained models, Arterys' cardiac MRI is able to automate the steps involved in a complex cardiac analysis. RTHawk, developed HeartVista™, a platform can for creating and running cutting-edge MRI applications, is made up of several advanced MRI techniques that deliver high-quality images a lot quicker than conventional imaging techniques. All these systems are examples of how AI is helping promote rapid and more accurate cardiovascular disease diagnoses.

7. ***Lung Imaging:***
Another field that has benefited immensely from artificial intelligence is lung imaging. Doctors are now utilizing AI technology to screen and analyse detailed images of the lungs including the lung parenchyma, airways, and vasculature. This technology provides for a fast and high-resolution assessment of the lungs improving efficiency in lung cancer screening. As a result, there is increased successful detection of characteristics and lesions of lung cancer. One entity that is leading in the advancement of AI is a Chinese artificial intelligence start-up, Infervision, whose Augmented CT Screening Solution (AI—CT) can precisely grasp suspicious lung cancer lesions in CT scans. This technology has facilitated early detection and treatment of lung cancer.

8. ***Neurological Imaging:***
Also referred to as Neuroimaging or brain imaging, it is the use of various techniques to generate images of the structure and/or function of the brain or any other part of the nervous system. AI is playing a key role in the diagnosis of brain injury and trauma he diagnosis of certain diseases. This technology is being integrated with computerized tomography or computerized axial tomography (CT or CAT), and magnetic resonance imaging (MRI) to obtain a comprehensive mapping of the central nervous system.[6]

[6] https://www.predictiveanalyticstoday.com/what-is-ai-based-medical-imaging/

Companies working in AI-based Medical Imaging

1. ***ENLITIC - Imaging & Diagnostics***
   The company is using deep learning in diagnostics. It has established a partnership with Capitol Health Limited, an Australia-based diagnostic imaging services company to utilise deep learning diagnostics in analysis of medical CT images for lung cancer and bone fracture detection.[7][8]

2. ***NIRAMI - Imaging & Diagnostics***
   This is an Indian company focused on breast cancer screening using a multi-patented solution, SMILE, which harnesses high resolution thermal images and AI to provide reliable, early and accurate breast cancer screening[9]

3. ***CUREMETRIX - Imaging & Diagnostics***[10] *–*
   The California based start-up has created an algorithm for image analysis, which is presently being tested to identify lung cancer by x-rays and for breast cancer detection in mammograms.[11]

4. ***Zebra Medical Vision*** [12]*–*
   This Israel based company focuses on an AI alert for "stat" (urgent) findings of pneumothorax and validates a promising potential to substantially reduce turnaround time and increase the radiologist's confidence in making this diagnosis. Chest X-rays are one of the world's most used imaging modalities.

5. ***VoxelCloud***[13] *–*
   The company offers its service through three different channels. First, by providing service to healthcare providers through cloud-computing solutions directly integrated in the clinical workflow. Second, by partnering with established vendors to provide AI as a service. Third, by building a platform to enable third party developers to develop their own applications through the VoxelCloud medical knowledge graph API.

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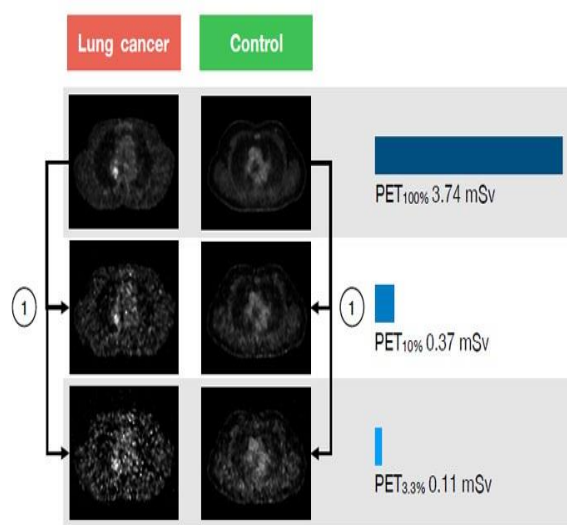
7 https://www.businesswire.com/news/home/20190404005169/en/Enlitic-Closes-Series-Funding-Advance-Artificial-Intelligence
8 https://www.enlitic.com/
9 https://www.niramai.com/
10 https://curemetrix.com/
11 https://www.disruptordaily.com/ai-in-healthcare-use-case-curemetrix/
12 https://www.zebra-med.com/
13 http://www.voxelcloud.io/en/

Recent Innovations

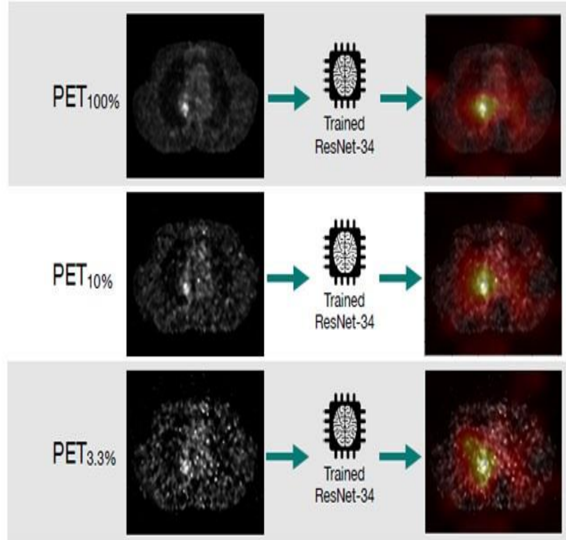
1. ***Artificial Intelligence for Alzheimer's Disease Detection***[14]
    - *In a recent research, group of researchers used a common type of brain scan to program a machine learning algorithm for early diagnosis of the Alzheimer disease.*
    - *Study, published in Radiology, the researchers combined neuroimaging with machine learning to try to predict whether a patient would develop Alzheimer's disease when they first presented with a memory impairment; this early diagnosis is the best time to intervene and restrict the symptoms.*
    - *To train the algorithm, researcher fed it images from the Alzheimer's Disease Neuroimaging Initiative (ADNI), a massive public dataset of PET scans from patients who were eventually diagnosed with either Alzheimer's disease, mild cognitive impairment or no disorder. Eventually, the algorithm began to learn on its own which features are important for predicting the diagnosis of Alzheimer's disease and which are not.*
    - *The research correctly identified 92 percent of patients who developed Alzheimer's disease in the first test set and 98 percent in the second test set.*

2. ***Machine Learning based Ultralow-dose FDG-PET gives boost to lung cancer screening:***
    - *Swiss researchers have shown that machine-learning algorithms can assist fully automated FDG-PET lung cancer detection, even at simulated very low effective radiation doses of 0.11 mSv — and this can be performed at little cost to sensitivity and specificity.*
    - *Techniques combined with artificial intelligence (AI) that can catch pulmonary lesions early while they are still curable will have a huge and widespread impact on patient outcomes and healthcare costs, according to the group.*



[14] https://www.ucsf.edu/news/2019/01/412946/artificial-intelligence-can-detect-alzheimers-disease-brain-scans-six-years

- *Hybrid PET/CT using F-18 FDG as a radiotracer is an established imaging method for staging of lung cancer, and now it has a role for screening, according to Messerli. In the first part of their retrospective study, the researchers assessed the accuracy of a deep-learning algorithm for automated detection of lung cancer using FDG-PET scans; in the second part of the study, they simulated a reduced FDG dose injection and evaluated its effect on the performance of the deep-learning algorithm for discriminating lung cancer.*[15]



3. *AI Based Aneurysm Detection*[16]

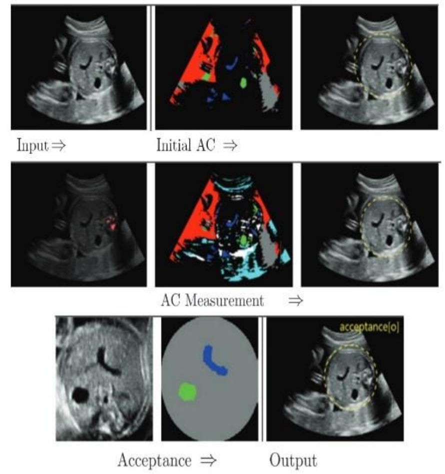
- *The AI based tool, developed by researchers at Stanford University highlights areas of a brain scan that are likely to contain an aneurysm*
- *This tool, which is built around an algorithm called HeadXNet, improved clinicians' ability to correctly identify aneurysms at a level equivalent to finding six more aneurysms in 100 scans that contain aneurysms.*
- *It also improved consensus among the interpreting clinicians. The success of HeadXNet in experiments has been promising, however, the team of researchers who have expertise in machine learning, radiology and neurosurgery claim that further investigation is needed to evaluate generalizability of the AI tool prior to real-time clinical deployment given differences in scanner hardware and imaging protocols across different hospital centres.*

4. *Artificial Intelligence Method Predicts Future Risk of Breast Cancer*[17]

- *Researchers from two major institutions have developed a new tool with advanced artificial intelligence (AI) methods to predict a woman's future risk of breast cancer.*
- *The team of researchers recently compared three different risk assessment approaches. The first model relied on traditional risk factors, the second on deep learning that used the mammogram alone, and the third on a hybrid approach that incorporated both the mammogram and traditional risk factors into the deep learning model.*
- *The deep learning models yielded substantially improved risk discrimination over the Tyrer-Cuzick model, a current clinical standard that uses breast density in factoring risk. When comparing the hybrid deep learning model against breast density, the researchers found that patients with non-dense breasts and model-assessed high risk had 3.9 times the cancer incidence of patients with dense breasts and model-assessed low risk.*

[15] https://physicsworld.com/a/ultralow-dose-fdg-pet-gives-boost-to-lung-cancer-screening/
[16] https://www.medgadget.com/2019/06/new-ai-tool-headxnet-to-help-detect-brain-aneurysms.html
[17] https://www.technologynetworks.com/cancer-research/news/using-ai-to-predict-future-risk-of-breast-cancer-319067

5. ***Machine learning identifies foetal size from ultrasound images***[18]



- *Bukweon Kim and colleagues from Yonsei University have demonstrated a machine learning-based process for automated analysis of foetal ultrasound images. Results of this study found to be of excellent levels accuracy in determining foetal biometric parameters in this way*
- *The researchers used a three-stage approach. In the first step, they obtained an initial estimate of the AC. They used a convolutional neural network (CNN) to determine the stomach bubble, amniotic fluid and umbilical vein in the ultrasound image, and from these three features, derived an estimate of the AC.*
- *The novelty of Kim's approach is contained in the second step, where the images together with the AC estimates were fed into a second CNN. This CNN then used these data to estimate the position of bony structures such as the mother's ribs. This information was then used to refine the initial AC estimate*

[18] https://physicsworld.com/a/machine-learning-identifies-foetal-size-from-ultrasound-images/

Future Challenges

1. ***Underdeveloped Infrastructure to Assess Algorithms*** *– An increasingly important challenge is that most clinical settings do not have the computational infrastructure to assess how well an algorithm is going to work in their population. Hospitals are generally not equipped to collect data to assess how well AI algorithms are working. This is a very important challenge to be addressed because if these algorithms are being used in practice, it's going to be important to know that they are effective since many AI algorithms do not necessarily generalize, as noted above.*[19]

2. ***Concerns Regarding Patient Privacy -*** *Facial recognition software has been successfully used to reidentify patients from three-dimensional reconstructions of their facial structures, posing risks to confidentiality when these datasets are released to the public poses a serious challenge. In addition, necklaces, wristbands, and other accessories may contain patients' names or be unique enough to allow patients to be recognized on volumetric images. Therefore, prior to making their datasets publicly available, many organizations manually curate each image for any potential identifiable information. This is both an expensive and labour-intensive process.*[20]

[19] http://www.global-engage.com/life-science/four-challenges-in-developing-ai-algorithms-for-medical-imaging/
[20] Prevedello, L. M., Halabi, S. S., Shih, G., Wu, C. C., Kohli, M. D., Chokshi, F. H., … Flanders, A. E. (2019). Challenges Related to Artificial Intelligence Research in Medical Imaging and the Importance of Image Analysis Competitions. Radiology: Artificial Intelligence

3. ***Data Complexity*** *– Multi-omics data are highly heterogeneous; simple concatenation of raw data or model outputs from each view will miss the opportunity to explore the potential connections and relationships across entities in different views.*[21]

4. ***Regulatory Process –*** *The regulatory process is one of the challenges that industry may have to face in coming future, there are few approved and fully commercialized products on the market, particularly deep learning-based products.*

5. ***Large-scale validation studies are required –*** *More large-scale validation studies are required to show the performance validation of machine learning algorithms in real-world radiological settings and boost radiologist's reliability on AI.*

6. ***Integration of AI tools into radiologists' workflows*** *– The results from AI-based image analysis tools need to be fully incorporate into radiologists' workflows and presented at the time of the primary check. Algorithm developers need to partner with radiology imaging equipment providers and ensure their solutions are tightly integrated.*

7. ***Platform Compatibility with Medical Device -*** *Healthcare providers are reluctant to purchase AI tools from multiple software developers due to the vendor-specific integration and implementation challenges and the administrative overhead. Algorithm developers need to establish effective routes to market, such as distribution deals with the established medical imaging vendors and the new breed of vendor-neutral AI platforms.*

[21] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6697503/

Expert Opinions in the domain of AI in Medical Imaging

- “Although advances in foundational research are occurring rapidly, translation to routine clinical practice has been slower because we must ensure AI in medical imaging is useful, safe, effective, and easily integrated into existing radiology workflows before they can be used in routine patient care” -**Bibb Allen, M.D., chief medical officer of the ACR Data Science Institute**

- “Artificial Intelligence and machine learning have the potential to fundamentally transform the delivery of health care”- **Krishna Kandarpa, M.D., Ph.D., director of research sciences and strategic directions at NIBIB**

- “Artificial Intelligence and machine learning have the potential to fundamentally transform the delivery of health care”- **Elizabeth Krupinski, professor and vice chair for research in the Department of Radiology and Imaging Sciences at Emory University in Atlanta, Georgia**

- “Artificial Intelligence and machine learning have the potential to fundamentally transform the delivery of health care”- **Former FDA Commissioner Scott Gottlieb**

- "The Center for Intelligent Imaging will serve as a hub for the multidisciplinary development of AI in imaging to meet unmet clinical needs and provide a platform to measure impact and outcomes of this technology," - **Christopher Hess, MD, PhD, chair of the UCSF Department of Radiology and Biomedical Imaging**

- "AI is one of the greatest tools of this century," - **Abdul Hamid Halabi, Director of Healthcare, NVIDIA.**

- “Using AI, you can really quickly interpret what’s going on. And the focus is on accuracy, it’s on confidence, and it’s on expanding ultrasound users,” - **Richard Fabian, CEO of Fujifilm SonoSite, a pioneer of ultrasound technologies**.

Conclusion

Artificial Intelligence will surely change the way radiology works now, and more quickly than other medical fields. It will transform the way of radiology practice more than anything since Roentgen. Radiologists can play a major role in this oncoming change.

In industry, there are experts who are claiming that AI will replace the job of radiologists, but AI is a technology which will ease the work of radiologist and will provide better results only when AI and radiologists will work together. In future, radiologists need to be aware of the basic principles of ML/DL systems, of the characteristic of datasets to train them, and their limitations. Radiologists do not need to know the deepest details of these systems, but they must learn the technical vocabulary used by data scientists to efficiently communicate with them. The time to work for and with AI in radiology is now.

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