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Role Of Biomedical Sciences In Medical Imaging Technology: A Review

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Abstract:-

The biomedical sciences are an array of fields that utilise mathematical and natural sciences techniques to produce a range of insights, remedies, or tools for the medical or public health industries. Different technologies that are useful for healthcare are created by the biomedical sciences.

Computer generated reality (VR), expanded reality (AR), and blended reality (MR), among different kinds of perception advances, all intensely rely upon biomedical science.Computerized broadened reality (XR) advancements have been generally utilized in different areas, from amusement to training, because of their openness and cost. XR modalities make a vivid encounter without being restricted by a standard 2D presentation.

They demonstrate contextual investigations using ideas from cell science, pictures from multiplexed proteomics, information from heart medical procedure, and cardiovascular 3D models while giving a point of view on XR in present day biomedical applications.Arising issues about XR innovation are stressed with regards to unsafe impacts on wellbeing and an expense examination of different stages. The XR stages that have been given will be helpful to 3D liveliness used in biomedicine for careful direction, clinical preparation, and biomedical training.

KEYWORDS: Biomedical imagine research, 3d imagination, various optical imaging technologies of biomedical science.

Introduction:-

Biomedical science technology is the application of engineering and technology related to living or biological systems that are crucial for human health and diseases. It is the field that uses engineering and technology to tackle difficulties with human biology and medicine. They create numerous tools that are used to identify various diseases.

Biomedical science technologies transfer the discoveries of basic research into improved patient health. The objective of this strategy was to create innovative methods for the detection or treatment of previously incurable diseases[1,2].

Research and development for these new technologies are improving as demand for biomedical technology rises. This field is very broad and covers a variety of approaches that have developed over time. Some approaches are scientific in nature and require rigorous scientific research to support their validity. Some theories are scientific in nature and need thorough scientific investigation to back them up[3].

These can be with great help to those who suffer from specific diseases and wish that others could help them by employing the required technologies. It might also improve health. through improving the level of living for those who need medical care. Equipment for extended reality (XR) was also developed by the biomedical sciences, including mixed reality (MR) and augmented reality (AR). Biomedical sciences have developed a variety of powerful approaches from straightforward uses of x-rays for fracture diagnosis and foreign body detection.These methods are now employed not just in patient care but also in the research of biological structure and function and the resolution of fundamental biomedical queries.Biomedical picture handling envelops all imaging strategies utilized in medication and biotechnology, including optical microscopy, figured tomography, ultrasound, atomic medication, and attractive reverberation imaging (X-ray)[4].

Aims and Objectives:-

- Biomedical Imaging research.
- Biomedical optical imaging innovations.
- Progresses in biomedical imaging advancements.
- Artificial Intelligence In biomedical sciences.

Biomedical imaging Research:

In order to develop methods for extracting quantitative data from biomedical images that span a variety of scales, from molecular/cellular imaging to mouse imaging to large animal/human imaging, research on biomedical imaging is primarily focused on the application of mathematics, engineering, physics, and chemistry.Biomedical imaging has accelerated technological development and encouraged the emergence of a wide range of applications. Methods like utilitarian imaging, spectroscopic imaging, optical imaging, and picture directed mediations strategies (Treatment and treatment) have become increasingly more typical in various fields, from fundamental exploration to clinical applications and from the degree of individual cells to that of whole organs.Association between scholars, scientific experts, clinical physicists, pharmacologists, Biomedical Researchers, PC researchers, biomedical architects, and clinicians from various fields is fundamental in the interdisciplinary field of biomedical imaging[5].

A pivotal instrument for clinical examination, biomedical imaging is turning out to be increasingly huge. In research regions including utilitarian genomics, proteomics, and practical imaging, imaging is developing more significant as an instrument to blend, separate, and impart helpful data from gigantic multi-layered ultrasound[6].

Biomedical Imaging Research Frontiers Areas:

Ultrasound CT and MRI provide various options for conducting functional assessments of several physiological systems because of recent technical advancements that have improved spatial and temporal resolution. the improvement of useful MR imaging and radionuclide imaging. The utilization of SPECT and PET sweeps has reformed examination into the activity of various physiological frameworks. Utilitarian attractive reverberation (MR) utilizes a scope of procedures to portray physiological and sub-atomic cycles before morphological changes are seen on standard imaging.Intraoperative MR directing for neurosurgery works on the evasion of cancer extraction by utilizing consolidated X-ray and SPECT information. It is felt that sub-atomic imaging is a component of MR spectadvance[7].The ability to evaluate the chemical composition of a lesion has tremendously advanced our understanding of the metabolic function of healthy and diseased tissue. The two techniques most frequently used in clinical practise are phosphor spectroscopy (1PMRS) and proton spectroscopy (also known as 1HMRS). The earlier techniques offer a wide range of information on the metabolic modification associated to creatinine and the acythelaspartate acid neuronal cell health marker. choline-related component of cell membrane turnover. Both the lipid marker of mobile lipids and the lactate marker of anaerobic metabolism. Biological processes can be seen live and in real time using powerful tools like PET and SPECT. Monitoring the existence and activity of illnesses in relation to therapies is the purpose of using PET and SPECT. Innovative approaches for metabolic and functional imaging practically in oncology. especially combination SPECT/CT. Additionally, PET/MRI provide morphological and pathological data.PET/CT is a diagnostic tool that uses a variety of imaging modalities as well as innovative diagnostic and therapeutic markers to observe cells and molecular structure in vivo[8].Compared to molecular imaging, it allows for a more accurate diagnosis and localisation of coronary artery diseases. Multiple methods by which molecular imaging assists biological research and development. The use of molecular imaging technologies in clinical settings may make it possible to identify disease processes years before symptoms manifest or they are picked up by more traditional diagnostic methods or imaging modalities.Molecular imaging makes it feasible to see molecular events and better understand how medications interact with various biological systems[9].

Biomedical Optical Imaging Technologies:

Biomedical optical imaging is one of the most broadly used and quickest developing clinical advancements for identifying and dealing with human infection.Optical imaging when combined with human eye visual assessment was the first method ever used for illness detection and diagnosis. advanced biomedical optical imaging uses to offer structural and functional data.Biomedical optical imaging is utilized to look at tissues from the degree of organelles to the level of the organ, utilizing bioluminescence or fluorescence-produced light to recognize, diagnosing, and treating illness processes in a painless or negligibly obtrusive way to the body. The goal of biomedical optical imaging is to better understand the structure and operation of life. It is an important component of optical imaging[10]. An picture is generated by a biomedical optical imaging system by modulating the excitation light and recognising signals brought on by the interaction of light and tissue. In contrast with methods that utilization ionizing radiation, similar to x-beams, optical imaging uses non-ionizing radiation, including noticeable, bright, and infrared light, which is a lot more secure for patients. Optical imaging can be utilized more than once to follow the improvement of illnesses or the adequacy of treatment. For deciding a variety of delicate tissue properties, optical imaging can be especially useful.Optical imaging can quantify metabolic changes that are early markers of strange organ and tissue capability on the grounds that different delicate tissues retain and dissipate light in a wide scope of ways. For analysts performing complex examinations or clinical experts observing complex issues, optical imaging can be joined with other imaging modalities like X-ray or x-beams to give expanded data[11,12]

- **Area of optical imaging to chip away at Biomedical Investigation and Clinical Thought:**

  Novel optical imaging for more exact glaucoma screening:

  Collagen strands changes in the sclera have a huge impact in illness processes and may act as a solid early alarm sign for glaucoma. Biomedical designers are making extraordinary optical imaging techniques to distinguish changes in the construction of the collagen filaments in the sclera of the eye.The method utilizes a computational model that interfaces explicit changes in sclera proteins to glaucoma with beginning stage. The new test will empower early, vision-saving treatment as well as continuous, harmless treatment reaction observing.

Assessing and treating neurological damage associated with cardiac arrest:

80-90% of the individuals who endure heart failure have critical neurological harm. Tending to these extreme impacts has not been attainable because of the prerequisite for imaging of the quick changes in blood stream and digestion in the mind during heart failure and crisis CPR. Biomedical architects are fostering an optical imaging gadget that gives basic ongoing imaging that actions cerebrum blood stream and metabolic movement, for example, oxygen use.To assess neurological changes brought on by blood flow blockage, electroencephalography EEG will be performed in conjunction with optical imaging. The technology will make it possible to conduct in-depth study on the effects of cardiac arrest and CPR on the brain as well as to explore real-time therapy options that could improve the odds of survival and outcomes for cardiac arrest patients.

- **Non-invasive imaging to monitor breast cancer chemotherapy:**

Biomedical engineers are developing non-invasive optical imaging techniques that can rapidly spot the 20% of breast tumours that are resistant to chemotherapy while additionally maintaining control of cancer chemotherapy. Through the use of non-painful near-infrared light-based probes, blood vessel development, measurements of fat content and oxygen levels are obtained. These results reveal whether or not the chemotherapy is starting to shrink the tumour at an early stage of the treatment process. With this knowledge, clinicians will be able to modify a patient's chemotherapy treatment or discontinue it altogether if they notice that the patient is not responding to it. making it possible to provide breast cancer treatments more successfully.

New advances in Biomedical Imaging Technology:

Biomedical sciences have greatly advanced biomedical imaging technology by creating techniques that reduce the negative effects of applied energy, miniaturising detectors, improving system design, accelerating computational analysis, and enhancing sensitivity and resolution (nanomaterials, labelled small and large molecules, and fluorescent proteins). to improve the specificity of molecules, cells, and tissues. In three separate biomedical domains, imaging is now advancing quickly. Molecular biomarker imaging or involvement in biomarker analysis. imaging treatments, imaging of a single cell, and imaging of two. The development of amazing tools in biomedicine[17].

- **Clinical Imaging System:**

Modern imaging systems have come a long way since the first imaging apparatus was invented. For instance, contemporary three-dimensional computed tomography scanners use X-rays to find pulmonary modules in high-risk populations that are as small as a millimetre. Modern imaging systems have come a long way since the first imaging apparatus was invented.For instance, advanced three-dimensional computed tomography scanners use X-rays to find pulmonary modules in high-risk populations that are as small as a millimetre. The expansion of imaging innovations has likewise created integral data in light of the fact that the energy-matter cooperation delivers an assortment of differentiation components, including attractive relativity, vulnerability dissemination, temperature, versatility, electrical impedance, radiation retention, dispersing, and fluorescence. Imaging systems can be divided into categories based on their energy source (for example, X-rays, positrons, photons, or sound waves) and spatial resolution (for example, macromolecules and macromolecules).the sorts of information that were acquired (physiological, cellular, anatomical, and molecular) Nowadays, clinical and preclinical usage of macroscopic imaging systems that offer anatomical and physiological information is very common. In contrast, systems with microscopic resolution are heavily utilised in basic research. Although the technological advancements in imaging systems today regularly astound, their potential for the future is equally exciting. Microscopy on a living thing is one example. likewise imaging with extremely high resolution in living cells[13].

- **Research Imaging:**

The invention of microscopes that enable imaging in live animals has enabled the discovery of cancer biology, immunology, and brain function. Research microscopy systems usually start with confocal or multiphoton scopes with extended working distance objectives, specialised lasers, and cutting-edge motion correction methods. Additionally, improvements in optical and detector technology. Imaging studies are now possible because to fluorescent proteins and fast improving processing capacity. Fluorescent proteins contributed to the advancement of high-resolution microscopy methods.

- **Chemical Tools for Biomolecular imaging:**

Substance approaches are turning out to be progressively significant in both clinical and research imaging since they can upgrade the extraction of physiological information and add sub-atomic and cell particularity.Although the two are frequently combined, chemical imaging agents have two important advantages over fluorescent proteins. Chemical methods make it possible to image people, doing away with the need for genetically modified mouse models. Nanoparticles are particularly promising because they usually assemble innate immunocytes in large numbers, which are frequently the first to react to disease conditions. Nanoparticle pharmacokinetics differ from other substances. They circulate longer and are not instantly eliminated, can be targeted to certain organs, cells, or proteins, and can be longer-lasting. Magnetic resonance can image magnetic nanoparticles and detect them[14].

- **Imaging Biomarkers and Cellular Biomarkers:**

The analysis of hard-to-biopsy regions (such the brain), the early diagnosis of malignancies, and the mapping of disease severity and distribution are the three most important uses of in vivo imaging of molecular and cellular biomarkers. The main sources of inspiration for the creation of molecular biomarkers were omics techniques and immunopathological research. Developing new imaging targets will presumably require a combination of multiplexed imaging techniques and cytometry-based methods. And finally, by providing further information, clinical imaging can support biomarker data.

- **Imaging Physiology:**

Imaging physiology has for some time been a vital part of clinical demonstrative. Using a delicate differentiation specialist that offers information on vascular qualities (thickness, penetrability, and so forth), sickness processes are oftentimes imagined.Many physiological processes simply do not occur ex vivo, making in vivo observation the sole method to fully comprehend them. One amazing example is the capacity of some leukocytes to crawl over the endothelium membrane of tiny veins, occasionally totally halting the blood flow. The identification of this patrolling behaviour required the use of recently developed imaging techniques with the sensitivity and accuracy to observe cell group interaction and distinguish it by specific reporter genetics. Non-invasive imaging, and perhaps even therapeutic imaging, will probably embrace the advantage of spectrum resolving multiple target essential features of complicated physiology and disease processes, including those that seem to conflict with one another and occur simultaneously. For instance, near infrared fluorescence imaging of the presence of macrophages during angiogenesis can offer previously unheard-of insight into pathology when entire imaging data is integrated.

- **Single Cell Imaging:**

Recent findings, such the 3D morphology of cells and their interactions with surrounding cells in their natural milieu, which can be observed by intracellular microscopy, have significant implications for understanding clinical data.

- **Immune cell imaging:**

Immunology is still being researched using genetics and flow cytometry. Single cell immunocytes imaging holds great promise for understanding the in vivo behaviour of cells in relation to disease, their geographic distribution, and their dynamic lineage.High goal imaging has as of late permitted surprising disclosures. For example, late mouse models incorporate lively fluorescence correspondent qualities[15,16].

Artificial intelligence in Biomedical Sciences:-

Biomedical artificial intelligence is used to address medical challenges, including disease prevention, diagnosis, and treatment. The biomedical sciences developed the computational pipeline that combines bio informatics and machine learning techniques to produce customised immunisations. Numerous medical research specialties, such as clinical virology, clinical epidemiology, epidemiology, medical microbiology and genetics,, are covered within the discipline of biomedical science. It also discussed the area of study whose primary interest is in the biology of human disease and health. It also places a strong emphasis on pertinent scientific fields such molecular biology, genetics, immunology, cell biology, and anatomy [17].

Medical laboratory sciences lack the economic, academic, and scientific value of biomedical sciences. In the field of biomedicine, artificial intelligence refers to the use of complex algorithmic frameworks and software to interpret composite medical data in a manner that resembles human intelligence. Artificial intelligence is the capacity of a computer algorithm to infer outcomes without direct human input. The ability of a computer algorithm to predict events without specific human input is known as artificial intelligence[18].

Man-made reasoning has been utilized to build PC programs that act and respond like individuals. These calculations can rapidly evaluate, learn, and self-right while finishing errands that are as often as possible performed by an individual, for example, perceiving individuals, items, or commotions, as well as deciding.This kind of technology is frequently faster, more sensitive, and more accurate when compared to human analysis, like looking at a brain scan. Among the latest developments in biomedical imaging covered in the most recent issues of medical and diagnostic imaging are profiles on trans oral robot-assisted high-resolution micro endoscopic imaging, more recent applications of Raman spectroscopy, computerised blood flow simulation with MRI scans, next-generation contrast agent, upper extremity MRI modality, and magnetic resonance imaging (MRI) for targeted drug delivery. the interdisciplinary engineering and scientific advancements in physics, arithmetic, material science, electrical engineering, computer science, biochemistry, and medicine that have produced today's sophisticated imaging technology and procedures.

In order to increase the use of medical imaging, biomedical science has developed new technologies in a variety of fields that make it faster, easier, more pleasant, and instructive for everyone.In order to utilise artificial intelligence in medical decision-making, new models developed by the biomedical sciences automate a crucial phase. When identifying important components in patient datasets, professionals frequently employ handles. In order to predict who has the condition and who does not, the model was able to automatically recognise the voice patterns of individuals with vocal cord nodules[19].

Biomedical Imaging Through Artificial Intelligence:

For the purpose of improving optoacoustic techniques for non-invasive continuous blood oxygenation monitoring, biomedical sciences developed a variety of machine learning approaches. The research of brain activity can be done using these methods. cancer diagnosis and the examination of blood vessels that characterise skin lesions. The number and distribution of sensors used by the device determine the quality of the generated image.

The innovative method created by biomedical researchers allows for a significant decrease in the number of sensors without compromising image quality. This enables equipment costs to be decreased, boosting imaging speed and enhancing diagnosis.

Optoacoustic tomography is used in the biomedical sciences to provide cross-sectional images of mice. utilising machine learning methods. They were able to record high-quality photos using fewer sensors[25,26].

1. **Artificial Intelligence to detect cancer Tumor:**

   Artificial intelligence techniques were created by the biomedical sciences to help with cancer screening tests for various kinds of cancer. Computer programmes built on artificial intelligence have been used to assist doctors in reading mammograms. All technologies utilising artificial intelligence are quite good at finding pancreatic cancer.

   MRI is one artificial intelligence method for finding cancerous tumours. A solid magnet and radio waves are utilized to take cuts of your body and join them to deliver an itemized picture of within your body that can distinguish the area of growths. The use of imaging tests in the diagnosis of cancer includes CT scans, bone scans, MRIs, positron emission tomography (PET), ultrasound, and x-rays.

   Imaging is the process of creating helpful visualisations of the organs and body's structure. To assess the impact of diseases and the efficacy of treatments, it is used to find tumours and other abnormalities. When doing biopsies and other surgical procedures, imaging may also be used[20,21,22].

2. **Artificial intelligence to improve diagnosis of dementia disease:**

   Dementia diagnosis will soon be made possible by artificial intelligence tools, which are increasingly becoming accepted in the clinical setting. These methods involve cerebral biomarkers that have been proven to be helpful in the diagnosis and prognosis of dementia. Machine learning algorithms that use the eyes are still in their infancy but are already as effective as those that use the brain. This is due to the fact that eye images contain a number of ophthalmic biomarkers, which are detectable by routine imaging and reflect the status of the brain[23,24].

In three ways man-made reasoning can help individuals impacted by dementia:

1. **Earlier diagnosis:**

   One of the difficulties is rapidly and precisely diagnosing dementia. The cerebrum starts to switch around to 20 years before dementia side effects show up, by which time many synapses have previously died.To find the early warning signs of dementia, the biological sciences are developing computer techniques.A complete sweep is utilized to look at a lot of information to recognize changes in the actual creation of the mind. Also, they are searching for changes in the mind's energy needs and synthetic cosmetics that are stowed away from perception. This innovation can likewise be utilized to distinguish changes in memory and comprehension designs[25].

2. **Understanding how symptoms of dementia developed:**

   Another difficulty is that dementia is a disease that increases over time. It has different impacts on different people throughout time. The researchers will forecast how the condition would physically alter the brain over time using artificial intelligence. also to anticipate how symptoms may change with time[26].

3. **Living at home for longer:**

   Artificial intelligence (AI) will never be able to fully replace human care, but when applied properly, technology can improve care and extend the time that people with dementia can live at home. They are investigating the feasibility of using sensors located throughout a person's house to track their conduct. They can act right away to help the person.

4. **Uses of artificial intelligence in Biomedical Imaging:**

   The use of artificial intelligence in biomedical imaging demonstrates how this technology can significantly improve the quality of life for people[27].

5. **Computer vision:**

   The biomedical and health care sectors are increasingly dependent on computer vision, also referred to as machine vision. Computer vision refers to the capability of computers to detect, examine, understand, and grasp features included within a visual. The utilisation of positron emission tomography, computer tomography, magnetic resonance imaging, and ultrasound imaging in the medical field generates a wealth of rich data that CV can employ. Consequently, computer vision is the ideal tool for assisting in healthcare[28].

6. **Deep learning:**

Machine learning methods were used to develop artificial neural networks that closely mimic the structure and function of the human brain. This learning technique is a ground-breaking technology because as it studies more data, the machine gets better at processing massive volumes of information. With its superior performance in tasks like segmentation, object detection, and ultimately object tracking, it is quickly being utilised to evaluate medical pictures in a range of industries[29,30].

➢ **Artificial Intelligence in Biomedical Imaging advantageous in following ways:**

1. **Dealing with large dataset:**

Operations in biotechnology and modern healthcare produce enormous amounts of data. As the equipment for taking biological and medical images advances. There are insightful details about a patient's status, the progression of diseases, or even the molecular makeup of cells. Humans are just unable to process the incredibly vast amounts of data that artificial intelligence can employ to make sense of[31].

2. **Improving the accuracy of medical diagnosis:**

To diagnose patients and evaluate their health, medical professionals must interpret complex images, such as those produced by x-rays, CT scans, and MRIs. AI-based solutions can be used by medical professionals to collect patient data, examine patient input, and reduce the range of probable diagnosis. In addition to analysing adjacent textural features, machine learning algorithms can build and learn to recognise patterns in disease features, such as the presence of breast cancers on mammograms. Since ML algorithms can also spot data relationships that the human eye misses, they are the perfect tool for improving medical diagnoses[32].

3. **Saving time and resources:**

Artificial intelligence (AI) used for disease detection can assist save healthcare costs, support medical professionals, and result in months of time saved before diagnosing a life-threatening condition. Artificial intelligence (AI) may be trained to recognise the most minor abnormalities, which frequently determines whether a patient survives or dies.

4. **Enhancing Processes:**

   Artificial intelligence in radiology: The field of radiology is rapidly adopting artificial intelligence technology. The Food and Drug Administration recognises one algorithm per month in the discipline of radiology. An algorithm can evaluate a patient's risk of cardiovascular pathology using a retinal scan. The model is capable of identifying changes brought on by ageing, smoking, excessive cholesterol, or high blood pressure[33].

Artificial intelligence for surgery optimization

Artificial intelligence can improve preoperative surgical planning, which is the process by which doctors map out the surgical procedure using preexisting records. Imaging is now essential to the effectiveness of the procedure. Even with artificial intelligence, the most common medical imaging modalities at the moment are x-ray, CT, ultrasound, and MRI, which can be used to plan surgery. Artificial intelligence can assist surgical procedures by improving anatomic classification, detection, segmentation, and registration between medical images (registration is the act of merging many sets of data into a single coordinate system)[34].

Conclusion:

The most crucial advancement in the medical sector for detecting many types of disorders in the human body is biomedical imaging technology, which heavily depends on biomedical science. The effective technology for visualising interior body organs and disorders associated with them is biomedical imaging. Biomedical imaging is a fast increasing interdisciplinary discipline that integrates biology, medicine, and physics. It is crucial for the diagnosis of diseases and the creation of novel treatments. The majority of people view utilising biomedical imaging to detect a variety of ailments. Biomedical imaging produced the numerous technologies for health care. The use of biomedical imaging technology speeds up disease detection. and assistance with early diagnosis.

REFERENCE :

1. John Denis Enderle; Joseph D. Bronzino ,Introduction to Biomedical Engineering. Academic Press. Pp. 16–. ISBN 978-0-12-374979-6.
2. Fakhrullin, Rawil; Lvov, Yuri, eds, Cell Surface Engineering. Smart Materials Series. Cambridge: Royal Society of Chemistry. Doi:10.1039/9781782628477.
3. Alexander R. McNeill, “Mechanics of animal movement”. Current Biology. 15 (16): R616–R619. Doi:10.1016/j.cub.2005.08.016.
4. Hatze, Herbert,. “The meaning of the term biomechanics”. Journal of Biomechanics. 7 (12): 189–190. Doi:10.1016/0021-9290(74)90060-8.
5. Rosado-De-Castro P.H., Morales M.D.P., Pimentel-Coelho P.M., Mendez-Otero R., Herranz F. Development and application of nanoparticles in biomedical imaging. Contrast Media Mol. Imaging. 2018 doi: 10.1155/2018/1403826.

6. Lecuyer T., Teston E., Ramirez-Garcia G., Maldiney T., Viana B., Seguin J., Mignet N., Scherman D., Richard C. Chemically engineered persistent luminescence nanoprobes for bioimaging. Theranostics. 2016;6:2488. Doi: 10.7150/thno.16589.
7. Tempany CM, McNeil BJ. Advances in biomedical imaging. JAMA. 2001;285(5):562–567.
8. Hendee WR, Chien S, Maynard CD, Dean DJ. The National Institute of Biomedical Imaging and Biomedical Engineering: history, status, and potential impact. Radiology 2002;222(1):12–18.
9. Ehman RL, Hendee WR, Welch MJ, Dunnick NR, Bresolin LB, Arenson RL, Baum S, Hricak H, Thrall JH. Blueprint for imaging in biomedical research. Radiology. 2007;244(1):12–27.
10. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, Hee MR, Flotte T, Gregory K, Puliafito CA, Fujimoto JG. Optical coherence tomography. Science 1991; 254:1178–81
11. Fercher AF, Lichtenberger CK, Kamp G, Elzaiat SY. Measurement of intraocular distances by backscattering spectral interferometry. Opt Commun 1995; 117:43
12. Wojtkowski M, Leitgeb R, Kowalczyk A, Bajraszewski T, Fercher AF. In vivo human retinal imaging by Fourier domain optical coherence tomography. J Biomed Opt 2002; 7:457–63
13. Durduran T; et al, "Diffuse optics for tissue monitoring and tomography". Rep. Prog. Phys. 73 (7): 076701. doi:10.1088/0034-4885/73/7/076701. Gibson; J. Hebden; S. Arridge , "Recent advances in diffuse optical imaging" Phys. Med. Biol. 50 (4): R1–R43. Doi:10.1088/0031-9155/50/4/r01.
14. S. Farsiu; J. Christofferson; B. Eriksson; P. Milanfar; B. Friedlander; A. Shakouri; R. Nowak, "Statistical Detection and Imaging of Objects Hidden in Turbid Media Using Ballistic Photons" Applied Optics. 46 (23): 5805–5822. doi:10.1364/ao.46.005805.
15. Durduran, T; et al, "Diffuse optics for tissue monitoring and tomography". Rep. Prog. Phys. 73 (7): 076701. doi:10.1088/0034-4885/73/7/076701.
16. "Harvard,edu Diffuse Optical Imaging". Archived from the original on June 16, 2012.
17. Lihong V. Wang; Hsin-I Wu ,Biomedical Optics: Principles and Imaging. John Wiley & Sons, Pp. 3–. ISBN 978-0-470-17700-6.
18. Moravcik M, Schmid M, Burch N, Lisy V, Morrill D, Bard N, et al. (2017) DeepStack: Expert-level artificial intelligence in heads-up no-limit poker. Science 356(6337): 508-513.
19. Hosny A, Parmar C, Quackenbush J, Schwartz LH, Aerts H, Artificial intelligence in radiology. Nat Rev Cancer 18(8): 500-510.
20. Saygin AP, Cicekli I, Akman V Turing test: 50 years later. Minds and machines 10(4): 463-518.
21. Erickson, B. J., Korfiatis, P., Akkus, Z. & Kline, T. L. Machine learning for medical imaging. Radiographics 37, 505–515 .
22. Trivizakis, E. et al. Artificial intelligence radiogenomics for advancing precision and effectiveness in oncologic care (Review). Int. J. Oncol. 57, 43–53 (2020).
23. Ahmed, S, Haigh, AM, de Jager, CA and Garrard, P Connected speech as a marker of disease progression in autopsy-proven Alzheimer's disease. Brain 136(Pt 12), 3727–3737.

24. Mozley CG, Huxley P, Sutcliffe C, Bagley H, Burns A, Challis D, et al. “Not knowing where I am doesn’t mean I don’t know what I like”: Cognitive impairment and quality of life responses in elderly people. Int J Geriatr Psychiatry. 1999;14:776–83.
25. Binder RL, Guze SB, Appelbaum PS, Lieberman JA, Rabins PV, Oldham JM, et al. Guidelines for assessing the decision-making capacities of potential research subjects with cognitive impairment. Am J Psychiatry. 1998;155:1649–50.
26. Karlawish J. Measuring decision-making capacity in cognitively impaired individuals. Neurosignals. 2008;16:91–8.
27. Filakovic P, Eric AP, Mihanovic M, Glavina T, Molnar S. Dementia and legal competency. Coll Antropol. 2011;35:463–9.
28. Wong JG, Clare IC, Gunn MJ, Holland AJ. Capacity to make health care decisions: Its importance in clinical practice. 1999;29:437–46.
29. Assessment of Mental Capacity: Guidance for Doctors and Lawyers. London: British Medical Association; 2004.
30. Saygin AP, Cicekli I, Akman V Turing test: 50 years later. Minds and machines 10(4): 463-518.
31. Spector L Evolution of artificial intelligence. Artificial Intelligence 170(18).
32. Wojtusiak J, Kaufman KA, Ryszard S Michalski: The Vision and Evolution of Machine Learning. Koronacki J, Ras ZW, Wierzchon ST, Kacprzyk J (eds). Advances in Machine Learning. Springer, Verlag Berlin Heidelberg 262: 3-22.
33. Bellman R. An introduction to artificial intelligence: Can computers think? Thomson Course Technology. 1978