Artificial Intelligence in Cancer Drug Therapy: A New Era of Discovery

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ABSTRACT

Cancer encompasses a wide spectrum of diseases that originate in various organs or tissues, characterized by the uncontrolled growth of abnormal cells, invasion into neighboring tissues, and potential spread to distant parts of the body. This uncontrolled proliferation is particularly critical in cases such as breast and lung cancers. Artificial Intelligence (AI) has emerged as a revolutionary technology, gaining significant recognition across diverse sectors including healthcare, education, and manufacturing. In the field of oncology, AI represents a transformative tool, offering innovative solutions for cancer management. As a computerized mimicry of human intelligence, AI applies advanced algorithms and accumulated knowledge to address complex challenges. Notably, early detection of cancer is crucial for improving survival rates, making AI-driven diagnostics highly valuable. This review explores the evolving role of AI in cancer diagnosis, treatment, and the development of anticancer therapies. Emphasis is placed on its applications in chemotherapy, immunotherapy, radiotherapy, deep learning models, clinical decision support systems, and advanced technologies specifically targeting breast and lung cancer treatment.

Keywords: *Artificial intelligence, Cancer diagnosis, Breast cancer, Lung cancer.*

INTRODUCTION

AI is a field of computer science that allows for the establishment of intelligent machines that can act and think just like people and are capable of making decisions. It is the combination of artificial (produced by humans) and intellect (man-made thinking power). Artificial intelligence consists of several branches and these are listed in figure 1.

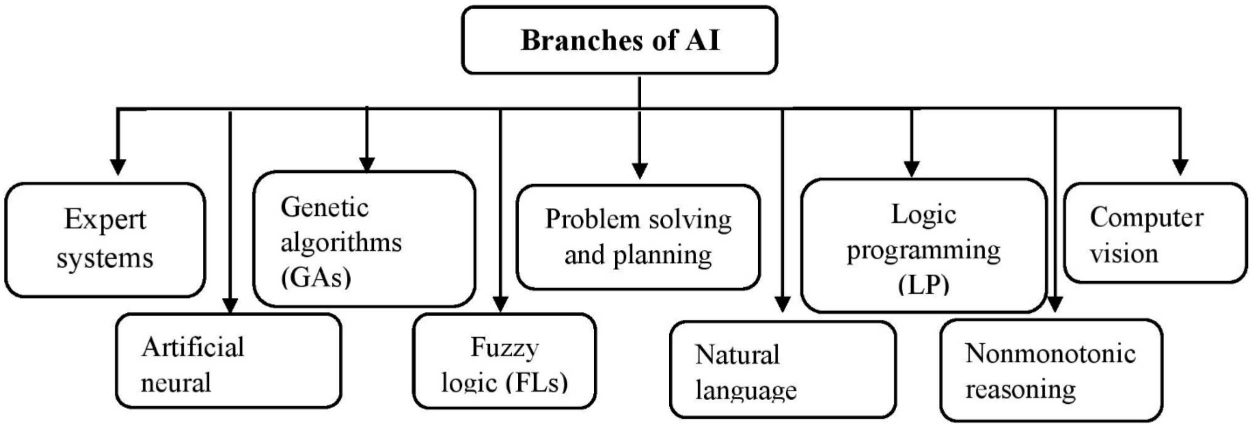

Figure 1: Several branches of AI

Cancer is a large group of diseases that can start in almost any organ or tissue of the body when abnormal cells grow uncontrollably, go beyond their usual boundaries to invade adjoining parts of the body, and/or spread to other organs. The latter process is called metastasizing and is a major cause of death from cancer [1]. The development of anticancer drugs, population cancer surveillance, computer-assisted clinical diagnosis, treatment selection, and prognosis are some of the most promising cancer applications at the moment. Other applications include medical image analysis for tumor detection, quantification, and histopathological characterization. Various Artificial intelligence disciplines are explored in figure 2.

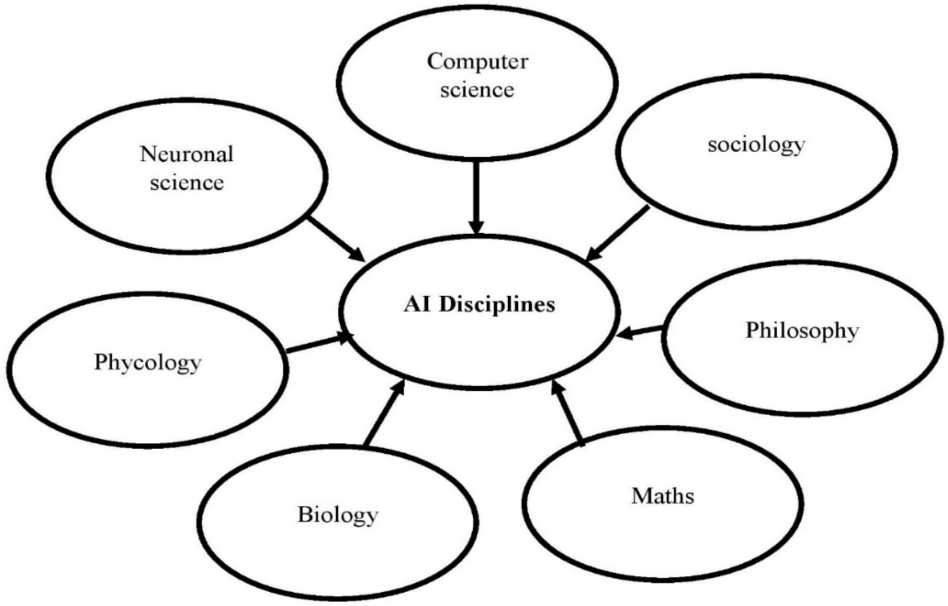

Figure 2 various Artificial intelligence disciplines

Together, these initiatives seek to fulfill the promise of precision oncology, which aims to customize cancer management based on each patient's genetic and epigenetic variability to improve early screening effectiveness, treatment responsiveness, and ultimately patient outcomes.

CLASSIFICATION OF ARTIFICIAL INTELLIGENCE

Artificial intelligence a computerized simulation of human intelligence solves complex problems by use of personified knowledge. The information is acquired and according to this information, rules are developed which are used to conclude that maybe definite or approximate self-rectification [2]. The word "artificial intelligence" was put forward at Dartmouth University in 1956 [3]. AI can be classified according to calibre or presence as demonstrated in figure 3.

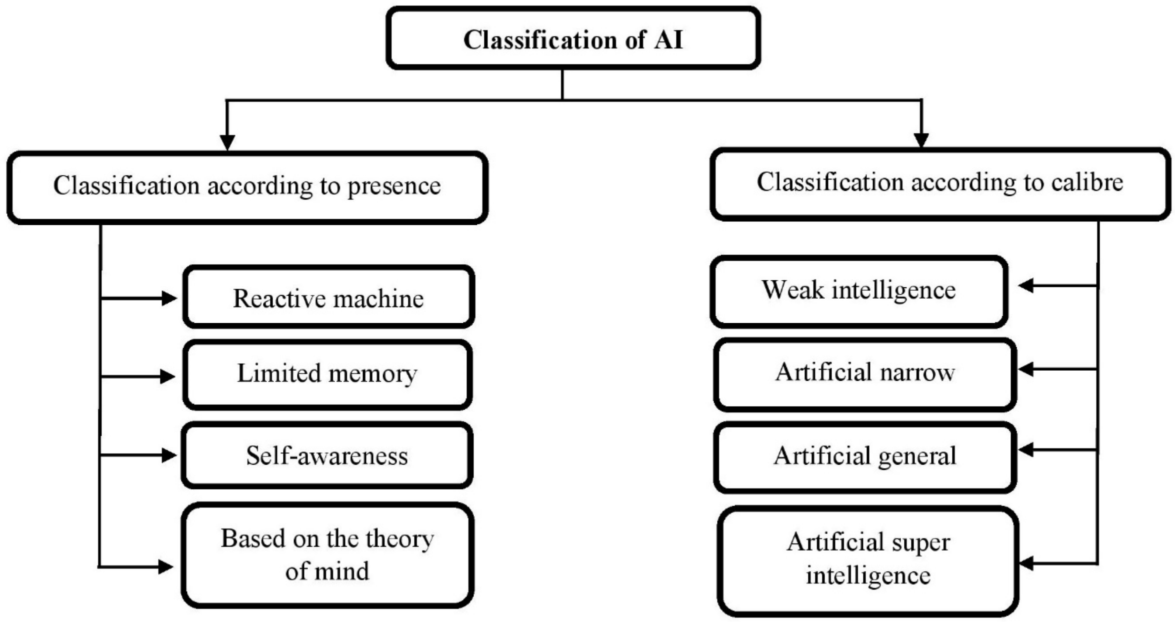

Figure 3: Artificial intelligence classification according to presence and calibre

HISTORY OF ARTIFICIAL INTELLIGENCE

It is generally agreed upon that the symposium held at Dartmouth College in July 1956, when the word "Artificial Intelligence" was first used, marked the start of the field of AI.

Many people who later became prominent in the domain, such as John McCarthy, Oliver Selfridge, Marvin Minsky, Arthur Samuel, Nathan Rochester, Allen Newell, and Herbert Simon, attended. The history of the application of AI in various fields is shown in Table 1.

Table 1: Indicates the history of AI utilization in which year is carried out.

Year	Research works	References
1943	Evolution of AI neurens	(6)
1950	Automatic machine	(7)
1956	Birth of AI: Dartmouth conference	(8)
1966	1st chatbot: ELIZA	(9)
1972	1st intelligence Robot: WABOT-1	(10)
1974	1st AI winer	(11)
1980	Intelligent system	(12)

1987	2nd AI winer	(13)
1997	IBM deep blue: the first comp to beat a world chess champion	(14)
2002	AI in home: Roomba	(15)
2011	IBM Watson: wins a quiz show	(16)
2012	Google now	(17)
2014	Chatbot Eugene Goostman: wines a Turing test	(18)
2015	Amazon Echo	(19)

AI researchers started to realize in the 1980s that developing AI was far greatly difficult than initially believed. Appropriately, Brooks concluded that the ideal way for scientists to advance our understanding of awareness was for scientists to concentrate on developing distinct modules related to various aspects of the brain, such as a design module, a memory module, and so on, which could, later on, be integrated to create intelligence [5].

Artificial Intelligence has risen in importance in the twenty-first century, across a wide range of areas such as science, education, engineering, medicine, pharmaceutical industries, business, finance, accounting, economics, marketing, and law.

EMERGING ROLE OF AI IN CANCER DIAGNOSIS

AI and Machine learning techniques used in cancer research. This technique is used to detect and diagnose cancer like breast cancer, prostate cancer, lung cancer biomarkers, oral cancer, skin cancer, subtypes classification of cancer, enhancement/optimization of cancer treatment, and recognition of novel therapeutic targets in drug discovery/development.

Olivier Elemento (mature application of AI) has been fascinated with imaging to diagnose cancer [20]. A deep neural network analyzed radiological images and digitalized pathology slides to identify various types of cancer. For example; to detect mammographic lesions [21].

In Machine learning (algorithmic modeling), AI algorithms are applied to pathology for the diagnosis of cancer with reliability and productivity which enhance the selection of cancer therapy and prognostication of outcomes. Listed some researchers who utilized AI for the diagnosis of different types of cancer is shown in Table 2.

Table 2: Researchers list using different technologies to diagnose the different types of cancer.

Name of researchers	Technology	Cancer types	Year	Country
Xiling Shen, Dr. David Hsu, Dr. Hans Clevers	MOS(micro organo sphere)	Lung cancer	2019	US

Peter Kecskemethy, Tobias Rijken	Deep learning, Data science, Radiology	Breast cancer	2016	UK
Mircea Popa, Victor Anastasiu	AI-based algorithm	Skin cancer	2011	Netherlands
Geetha Manjunath, Nidhi Mathur	High-resolution thermal sensing device	Dense Breast tissue	2016	India

A Notable study that trained a model called (AKITA): Combining 1D epigenomic and sequencing data with 3D chromatin interaction to create a predictive model of gene regulation and this interaction identifies the model interpreted to precisely identify distal enhancers of genes and the methods may be extended to research transcriptional regulations and enhancer rewiring in cancer [22].

EMERGING ROLE OF AI IN THE DEVELOPMENT OF ANTICANCER DRUG

AI is implemented to identify anticancer drug activity or to enhance the development of an anticancer drug. For example; the Random forest model is utilized to identify the activity of anticancer drugs based on the mutation state of the cancer cell genome. AI utilized in combination therapy with anticancer drugs is shown in Figure 4.

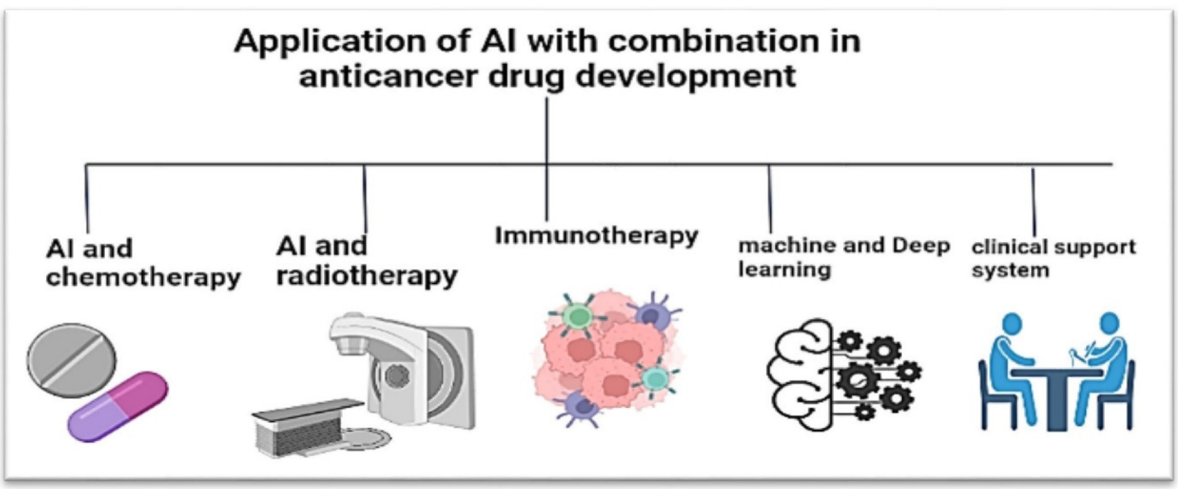

Figure 4: AI utilized in combination therapy with anticancer drug

The drug sensitivity prediction model is another method, which is developed based on a machine learning approach, used to identify the therapeutic potential of the drug in patients with gastric cancer, ovarian cancer, and endometrial cancer [23].

AI and chemotherapy

In this, a combination of drugs is used to treat cancer and also to enhance cancer drug development with great accuracy and efficiency. In one of the manuscript, Novel method is used based on a Deep belief network to identify/predict the drug activity for gene expression, pathway, and ontology fingerprints [24]. For example; in one of the research papers, a combination of Zen-3694 and Enzalutamide has used for cancer treatment by applying the CURATE.AI model (a deep learning and other technologies-based AI platform developed by the National University of Singapore) [23]. Different technologies used in AI and Radiotherapy have shown in Figure 5.

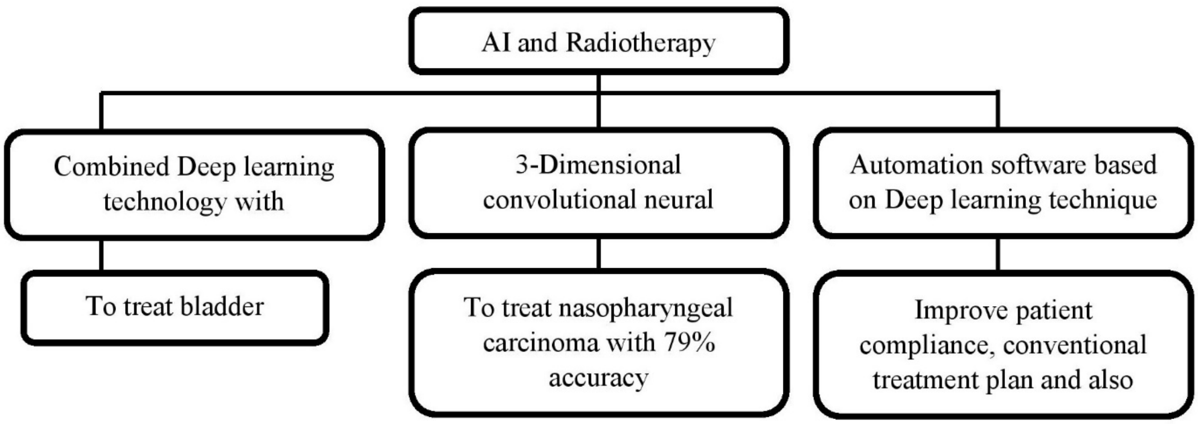

Figure 5: Different technologies used in AI and Radiotherapy

AI and immunotherapy

In one of the research papers, the machine learning method was used to estimate the therapeutic impact of cell death protein 1 (PD-1) inhibitors in patients who were sensitive to PD-1 inhibitors. Brendan bullish et.al studied the effects of Neoantigen on tumor cells. He identified Neoantigen reactive T-cells in cancer patients along with the evaluation of the model on retrospective Neoantigen T-cell data [25].

Model training correctly identified a predictive model for 53 HLA alleles utilizing a tumor HLA peptide mass spectrometry database. In these methods, developments of a new Deep learning model were used for antigen presentation in human cancer.

Machine and Deep learning

By employing machine learning to develop chemical pathways for reverse synthesis, researchers are hastening the discovery of new drugs. It also provides a fantastic opportunity to analyze chemical data and produce findings that can aid in the creation of novel medications. In one of the research papers, Simon et al. studied machine learning algorithms on the challenge of Directly Comparing Imaging-Based Diagnoses made by human clinicians [26]. Machine learning also helps to transform biomedicine (27).

ROLE OF AI IN MEDICINE

Since the turn of the century, the healthcare sector has seen significant change as a result of the development of new pharmaceuticals, therapies, and diagnostic equipment as well as the identification of viruses and bacteria. It involves the employment of robust computers (supercomputers), self-learning algorithms (deep learning), and, more broadly, a technique that makes heavy use of the cognitive skills of medical experts (AI).

Algorithms based on deep learning have been discovered to produce diagnoses that are at least as accurate as those made by medical professionals in the disciplines of oncology, dermatology, and cardiology. In 2021 top 20 companies that applied AI to improve healthcare are shown in figure 6. The winning algorithm's initial success percentage was 92.5%. When deep learning system predictions are paired with a pathologist's diagnosis, the success rate increases to 99.5% while the rate of human mistake is reduced by up to 85% [28].

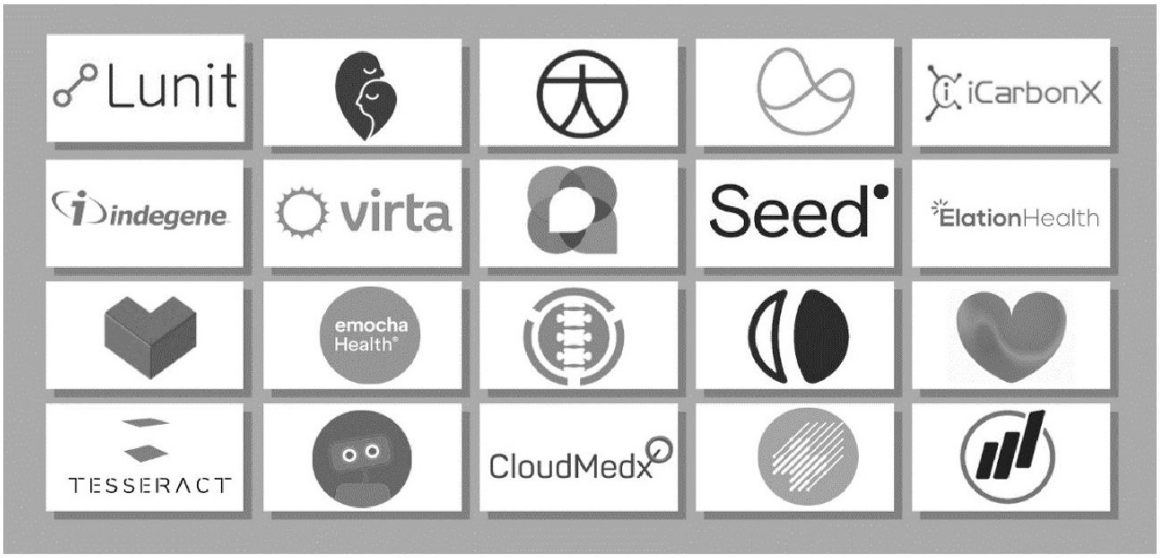

Figure 6: lists some companies using AI in healthcare as of 2021.

AI TECHNOLOGIES USED IN BREAST CANCER DETECTION

Breast cancer is the most common and leading cancer type with an increasing mortality rate year by year as compared to the other cancer type and it's not only occurring in women but also it occurs in men too and Additionally, men have a higher death risk than women due to ignorance, since they may fail to recognize a lump as breast cancer. so it is important to detect cancer at the early stage before it completely grows and spreads and becomes fatal, now several AI-based technologies and detection tools have been developed to detect cancer at the early stage [29, 30]. The most prevalent types of AI-based clinical imaging and detection methods used today for the diagnosis of breast cancer are displayed below in figure 7. [30]

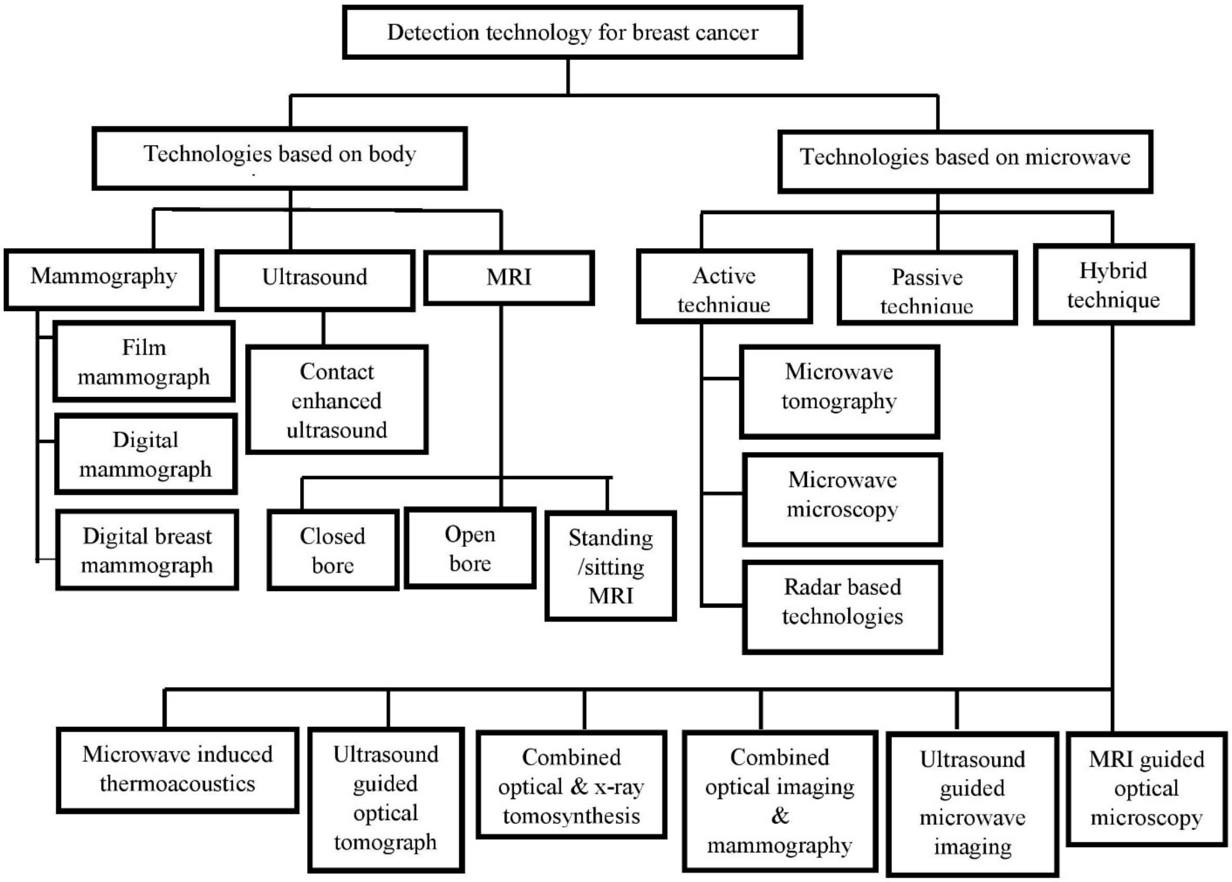

Figure 7: AI-based technologies for detection of breast cancer (30)

Technologies based on body images

Magnetic resonance imaging, mammography, and ultrasound are all body image-based technologies that provide pictures of the breast anatomy for radiologists to analyse and assess for breast abnormalities. These tools are found in the majority of clinics and hospitals.

Mammography

It is also referred to as mastography and includes a mammography exam, referred to as mammography, which is an x-ray image of the breast, the picture is prepared by using lose-dose energy x-ray to produce images which are also called radiographs are reviewed by a radiologist who is specialized in reading medical images for possible changes in the configuration of breast tissue [31]. It is the sole USFDA-approved test for diagnosing breast cancer in women who haven't previously displayed symptoms. [30]. **Digital mammography** and breast tomosynthesis are modern mammography advancements **(3D mammography**).

Digital mammography

In digital mammography, the separation of image acquisition, presentation, and storage process enable each to be optimized individually, an electronic detector that responds accurately across a wide range of intensities absorbs radiation that is delivered through the breast, once this data has been captured it can be shown using computer image processing methods that enable variable brightness and contrast setting without subjecting the patient to additional exposure. Now, there are four varieties of digital mammography systems as mentioned in figure 8.8 from which 3 have been approved by the USFDA, and one which is the Fuji Computed Radiography system has not received final certification even though it is widely used in Europe and Japan [47].

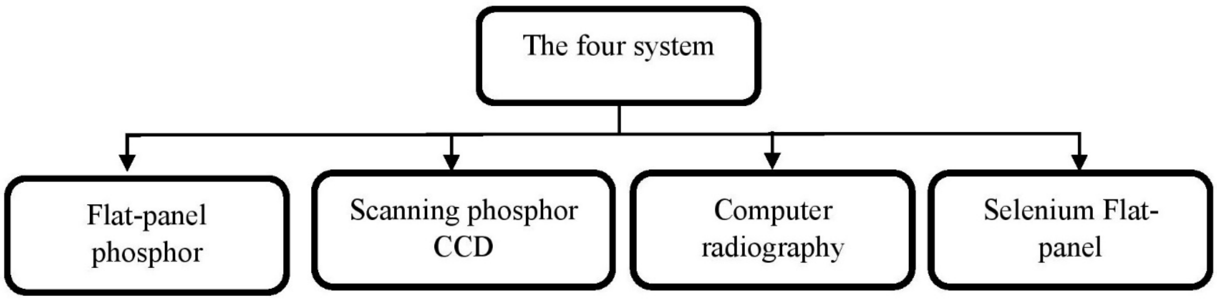

Figure 8: Digital mammography systems (Detectors)

Tomosynthesis (3-dimensional mammography)

In 2011 FDA approved 3-D mammography or tomosynthesis as an addition to standard digital mammography. It produces a sequence of low dosage x-rays from consecutive exposure in an arc over the breast to detect possible tumours and also it reduces the masking effect brought on by the overlying of breast tissue which is essential to 2D-mammography[32]. For all breast densities, tomosynthesis(3d-mammography) enhances the precision of interpretation although the impact is highest in dense breasts. Many studies have shown that using mammography in combination has lowered the recall rate and has shown an increase in the cancer detection rate [33]. But of course, tomography comes at a higher price and require longer physician interpretation while the breast positioning and intensity of compression remain equivalent to mammography this technology is becoming more accessible and is well tolerated by patient (32).

Magnetic resonance imaging (MRI)

MRI is a **non-ionizing**, three-dimensional diagnostic imaging technology with excellent resolution and perfect soft tissue contrast to diagnose lesions and monitor function. It is widely utilized in most hospitals [34]. It utilizes radio waves and high magnetic fields to create precise pictures of the body's organs and soft tissues [35]. The MRI scanner machine is a sizable horizontal tube with a circular superconducting magnet around it. One patient enters (laying down in bed), and with the help of the technician or radiographer, the magnet moves from the front and rear of the machine. While performing an MRI scan patient may feel claustrophobic because the procedure will take 30 to 45 minutes to complete the full body scan [36]. The patient's body is subjected to a radio-frequency signal that generates a strong magnetic field that compels the body's protons to align with it. After being disturbed, these protons are accelerated to realign with the static magnetic field at an angle of 90° or 180°. Even when the radio frequency is off, the scanner can still detect the energy signal sent by the patient's body. And then these impulses were utilized to produce visual representations on the computer screen. In comparison to other imaging technologies, in diagnosing structural anomalies in the body, MRI provides the highest degree of precision, accuracy, and sensitivity. However, MRI is a costly technology. Unlike mammography which uses ionizing radiation which could be hazardous MRI uses non-ionizing radiation and is a painless radiology technique [30].

Ultrasound

It employs sound waves of high frequency (echoes) rather than ionizing radiation, like MRI and mammography do, to provide actual pictures of the body's interior architecture or identify abnormal nodular formations. The most common frequency range utilized in medical ultrasonography is 2 to 18 MHz [37]. There are two key applications of ultrasound for internal body diagnosis and in pregnancy. During an ultrasound, the transducer touches the patient's skin across the region being examined and the reflected acoustic impulses are then measured and utilized to form the images(30). It is a non-invasive and low-cost procedure of diagnosis for the patient. But sometimes it may fail to detect tiny masses that could produce false-positive or false-negative readings. Women having thick breast tissues and women under 45 years of age should use ultrasound for diagnosis but women beyond 60 have growing sensitivity to mammography [31].

Now some new technologies have been introduced which are used alongside ultrasound for diagnosis, the most recently used technology is **contrast-enhanced ultrasound,** here microbubbles with a diameter of 1-7um are employed as an ultrasonic contrast agent in this case. This advancement is backed by the fact that, unlike tissue, which is essentially incompressible, gases expand and contract in response to the ultrasonic beam's alternating pressure waves. These signals are isolated from tissue signals using specialized software that use several pulse sequences, and they are then shown as a split screen. This is possible at low acoustic pressures (MI 0.3) without damaging the microbubbles and enabling actual-time scanning[38].

Technologies based on microwave imaging

Given that microwave imaging techniques rely on the electrical differences between normal and tumorous breast tissues, Compared to other detection methods, they are also more sensitive and capable of detecting small breast cancers., microwave-based detection approaches have several benefits, including being, non-invasive, affordable, non-ionizing, and a pleasant type of therapy [39]. These detection methods are predicated on the idea that within the microwave band, the cancerous breast tissues have variable permittivity and conductivity than healthy breast tissues [40].

Passive microwave imaging technique

It is based on an analysis of the electromagnetic field that hot objects naturally generate [41]. The primary variable here for predicting the existence of malignancy is temperature therefore it is often called thermography [42]. Due to variations in their electrical characteristics, compared to normal tissues, the malignant cells are less capable of controlling their body's temperature because of their increased metabolic activity and heat production [43]. A device that is used to assess the temperature differential between healthy and cancerous breast tissues is radiometry by collecting the data from various antenna positions and then reconstructing it to obtain the information [41].

Active microwave imaging technique

Microwave microscopy

Here, the resonator creates an electromagnetic field that interacts with the entities beneath the skin, which could be breast tumours it results in a change in an open-ended microwave cavity resonator's resonance frequency, this principle of microwave microscopy is used in the detection of breast tumours. Since it is based on the near-field wave-tissue interaction, this technique has a superior spatial resolution. [41].

Microwave Tomography

The inverse scattering method is a new biomedical imaging technology that may be used to ascertain the tissue's dielectric properties [44]. Here, a slice-by-slice representation of a body's interior architecture is shown. [41]. The lowest and highest frequencies used in clinical microwave tomography are 500 MHz and 30 GHz, respectively, and also it is a non-invasive method [40]. The sensing system, interfacing, and image reconstruction algorithm are the three main components of microwave tomography [45]. By using inversion scattering, it produces a conductivity and permittivity chart. This technique is also used as a breast cancer research system, where the breast is placed into a cylindrical antenna system that fully encases it, and microwave measurements are obtained with as many antennas as feasible, each acting as a transmitter and receiver. As microwaves enter tissue, scatter, and reflect off of it, the wave field becomes incredibly complex. To analyse the internal dielectric characteristics of the entire body section, a unique picture reconstruction approach is used to the massive quantity of data that is created by the enormous electromagnetic field. Permittivity, conductivity, and other electrical parameters, which are dielectric properties of malignant tissue, are crucial in this diagnostic procedure. These properties were revealed to be significantly distinct from those present in normal breast tissue [30].

UWB microwave imaging technique (Radar based technique).

It works like a Ground Penetrating Radar which is utilized in the military. Here the reflected rays from the object rebuild the image [30]. This technique was used in the late nineties for breast cancer detection. In this case, a probe antenna or an array of antennas is employed to receive the emitted low-power brief pulses at different locations. Then, a 2D or 3D picture showing the position of a highly reflective object, suggestive of malignant tissue, is created by integrating the processed data from the different locations of the probe antenna or array components. Because normal and cancerous tissue differs in their dielectric properties, the tumour microwave scattering cross-section is larger than that of an equivalent volume of normal breast tissue. [41]. Due to the decreased computing demands, and relatively straightforward, and robust signal processing associated with UWB microwave imaging, quicker detection is possible [46].

ARTIFICIAL INTELLIGENCE IN LUNG CANCER DETECTION

Around 1.80 million people die from lung cancer each year worldwide, and 2.21 million new cases were diagnosed in 2020, and it became the most common type of cancer that year [47]. Therefore, an effective approach to combat lung cancer is early detection. National Lung Screening Trial (NLST) in a randomized trial found that low-dose CT would reduce mortality from lung cancer among high-risk persons as compared to chest radiography [48]. Pulmonary nodules, which are small lesions with a diameter of 3 to 30 mm and are indicative of early-stage lung cancer, can be seen on a CT scan [48]. To make these nodules automatically detectable, researchers have been working on computer algorithms since the 1990s. However, the sensitivity levels of these computer-aided systems were unsatisfactory, and they generated an excessive number of false positives [48].

The use of artificial intelligence in lung cancer diagnosis

Computer-aided design or CAD, Convolutional Neutral Network or CNN, and Generative Adversarial Networks or GAN -Based Diagnosis of Lung Cancer.

CAD

Early treatment and early diagnosis of lung cancer are crucial and associated with favourable prognoses. The use of CADe/CADx in conjunction with manual diagnosis significantly increases clinical work efficiency and lowers the rate of missed diagnoses when dealing with the significant workload associated with pulmonary nodule screening [49]. The workflow of CAD is listed in table 3.

Table 3: workflow of CAD

Lung region segmentation	Determine the CAD diagnosis area
Nodule recognition	Identify candidate nodules,
	Remove false positive nodules
Nodule feature extraction	Provide the basis for auxiliary diagnosis
Auxillary diagnosis	Assist doctors in diagnosis based on extracted features

CNN

Deep Convolutional Neural Network (CNN) has been used by some researchers to create a system for automatically identifying lung cancer tumour regions in pathological images [50]. A deep learning algorithm has been created by using Mask Regional Convolutional Neural Network (Mask R-CNN) architecture to categorize cells in the lung cancer tumour microenvironment (TME) and simultaneously extract cell features to predict prognosis [49]. When compared to the traditional machine learning approach, deep learning can detect lung nodules much more accurately, learn the characteristics of various dimensions quickly, and reduce the time required for selecting features and calculation. The convolutional neural network is a popular example of this type [49].

GAN

When only a small amount of information is needed to train deep learning models, Generative Adversarial Networks are extremely important. Studies suggest that after a significant number of images are generated by Generative Adversarial Networks, the design can be formed and trained using deep learning. The results show that about 20% accuracy of classification was increased by this method [51].

The use of AI in lung cancer treatment

Targeted therapy

By concentrating on molecules in tumour cells and creating potent inhibitors to stop the carcinogenesis process, targeted therapy is a new strategy for treating cancer with the least amount of harm to healthy tissues [52]. Targeted therapies are drugs that bind to the receptor proteins, enzymes, and genes and inhibit the growth of cancer cells are known as targeted therapies. The Epidermal Growth Factor receptor, RAS mutation, EML4-ALK fusion gene, ROS1 fusion gene, and C-MET amplification are currently being targeted as non-small-cell lung cancers [53]. The most important stage of targeted therapy is identifying the appropriate target. Sequencing has been used as the main traditional detection technique [54].

Immune Therapy

The observation of immunotherapy for immune-responsive cancers, especially lung cancer, shows significant promise [55]. To slow down tumour growth, ICIs are employed in immunotherapy to re-establish the immune response against tumour cells. PD-1/PDL-1 pathway is currently the main target of ICIs in lung cancer [55]. ICIs are effective in only about 30% of patients with lung cancer and are not functional for all patients [56]. To anticipate PD-L1 expression, some researchers combined CT imaging radionics and clinical data, and the AUC was 0.848 in the set of predictions that were verified [57]. Additionally, researchers have developed a PD-L1 prediction using clinical information, radionics from PET/CT images, and SResCNN of deep learning model. Additionally, they employed this model to forecast how immunotherapy patients would respond, with positive outcomes and an AUC of 0.82 [58].

Radiotherapy

Early-stage lung cancer treatment, Stereotactic ablative radiotherapy (SABR) is crucial for patients who cannot undergo surgery; the survival rate of three years for these non-small cell lung cancer patients who underwent Stereotactic ablative radiotherapy was 55.8%. Radiology has developed significantly as a result of the AI and radiation combination, which helps achieve precision treatment [59]. In a study, treatment planning with knowledge-based algorithms was used to create a clinical method of stereotactic body radiotherapy (SBRT) for patients suffering from lung cancer. 105 SBRT plans, including 97 IMRT, 6 VMAT, and 2 three-dimensional conformal radiation therapy plans, had been included in this study to treat patients with lung cancer (CRT). To train a knowledge-based model (KBM), the aforementioned technologies were combined. The SBRT designs for lung cancer created by the KBM were fairly similar to clinical plans, according to multiple verification results [60].

CONCLUSION

AI is a field of computer science that allows for the establishment of intelligent machines that can act and think just like people and are capable of making decisions. It is a computerized simulation of human intelligence that solves complex problems through the use of personified knowledge. AI might facilitate the discovery of novel materials, which would significantly advance the creation of anticancer medications. AI is anticipated to be a significant force in the future of human cancer research and treatment. We think that in the future, AI will significantly alter medical technology. Various AI techniques have been utilized for the early detection of breast cancer like MRI, Mammography, ultrasound, etc. Early treatment and early diagnosis of lung cancer are crucial and associated with favorable prognoses. The use of CAD, CNN, and GAN in conjunction with manual diagnosis significantly increases clinical work efficiency and lowers the rate of missed diagnoses when dealing with the significant workload associated with pulmonary nodule screening.

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