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Artificial Intelligence Use in Cancer Treatment

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ABSTRACT:

Globally, cancer is one of the biggest medical issues. Kapkivoc, the Greek word for cancer, originally meant both "tumor" and "crab." Cancer has been associated with cells that develop abnormally and have the ability to infiltrate or spread to other parts of the body ever since it was discovered in the 1600s. Unchecked cell proliferation that starts in one part of the body and spreads to other parts is known as cancer metastasis. Since early cancer detection is associated with better patient outcomes from treatment, there has been a lot of interest in using artificial intelligence (AI) technology to image recognition-based cancer screening and detection. The goal is to improve diagnostic accuracy and speed up diagnosis times. Artificial intelligence is said to have originated with the Dartmouth summit in 1956 and it also makes predictions about the behavior and prognosis of cancer patients using mathematical methodologies. The aim of artificial intelligence was to build robots that have the same basic cognitive capacities as people, i.e., machines capable of reasoning through complex situations. The digital data era has brought awareness to the need for clinicians to use AI innovations such as deep learning and machine learning. AI is used in treatment of various types of cancers like lung cancer, breast cancer, CNS tumor and prostate cancer. Here in this review article we have discussed about how AI is useful in cancer treatment including its limitations and future prospects.

Keyword: Cancer, Artificial Intelligence, Machine Learning, Deep Learning, Future prospects.

1. Introduction

The Greek term for cancer, kapkivoc, originally meant "tumor" and "crab." Since its discovery in the 1600s, cancer has been linked to cells that grow abnormally and have the potential to invade or spread to other parts of the body [1]. Cancer metastasis is the term for the unchecked cell proliferation that begins at one location in the body and extends to other body areas [2, 3]. Benign and malignant cancer cells are two different types of cancer cells. Whereas malignant cells spread and are thought to be more harmful, benign cells do not spread to other areas. Its treatment regimen is extremely time-consuming and expensive because of the high death and recurrence rates. To increase the survival rate of cancer patients, a precise early diagnosis is necessary. It is a hereditary illness brought on by genetic changes that alter how our cells behave, particularly in terms of growth and division. More alterations will take place when the tumor cells proliferate. To put it briefly, compared to normal cells, cancer cells have more genetic alterations, such as DNA mutations [4,5]. Considerable interest has been shown in applying artificial intelligence (AI) technology to image recognition-based cancer screening and detection in the hopes of speeding up diagnosis times and improving diagnostic accuracy, as early detection of cancer is linked to better treatment outcomes for the patient [6].

In disciplines including biology, medicine, and cancer research, AI has significantly advanced. Artificial Intelligence utilizes mathematical techniques to predict the behavior and prognosis of cancer patients. These techniques support decision-making and action based on effective adaptability, logical thinking, and autonomy [7-9]. Human-made machines that exhibit intelligence are referred to as artificial intelligence (AI) machines. Neurophysiology, computer science, cybernetics, psychology, and linguistics are all included in this comprehensive discipline. The Dartmouth meeting in 1956 is credited with giving rise to artificial intelligence. The term "artificial intelligence" (AI) has undergone significant expansion in the last few decades, encompassing machine learning, deep learning, artificial neural networks, and other related technologies [10–12]. This holds immense importance for the prompt identification of malignancies using imaging data. AI can aid in the detection and management of cancers. With its robust capacity for logical reasoning and learning, artificial intelligence (AI) frequently uses multi-layer neural network structures to replicate human thought processes [13, 14]. The future of cancer care is predicted to be significantly altered by the incorporation of AI, as is the case in many other healthcare domains [15]. There are various application prospects of AI in tumor i.e drug development and validation, accurate diagnosis, customized treatment, virtual assistant, risk screening, remote heath monitoring, prognosis prediction and development of clinical DSS.

2. Basics of Artificial Intelligence

When artificial intelligence (AI) was first proposed in 1956, the goal was to create robots with the same fundamental cognitive abilities as humans—that is, machines that could think and reason through complicated problems. Since then, artificial intelligence (AI) has advanced significantly as AI theories and applications have progressively come to pass in academic research facilities. Figure 1 presents an overview of the major turning points in the history of AI research and contrasts the benefits and drawbacks of the various ML and DL operating principles. These approaches can be used in a variety of fields and have different basic properties. These methods have been created and the vast learning system for cancer precision medicine introduced by researchers in recent years. In this review, we provide an overview of these AI techniques, methodically highlighting their distinctions and applications for clinical professionals conducting cancer analyses. Expert systems, machine learning, fuzzy logic, computer vision, natural language processing, and recommendation systems are just a few of the subfields of artificial intelligence that are now seeing a growth in study.

The different applications of AI in clinical research are depicted in Figure 3. Essentially, machine learning relies on algorithms to analyze data, identify hidden patterns, and provide insights that can be used to forecast and make judgments about actual occurrences. ML "trains" and applies algorithms to vast amounts of data in order to dynamically understand how particular jobs might be completed, in contrast to traditional hard-coded software programs that tackle specific tasks. DL is not a stand-alone educational approach. A deep neural network can be trained in two different ways: supervised and unsupervised learning methods. Novel learning techniques, such the residual network, have emerged as a result of this field's recent exponential growth.

As a result, deep learning is becoming recognized as a distinct learning approach. But DL is used to put ML into practice, whereas ML is used to realize AI. Although DL has made significant progress, the following drawbacks still exist:

1. To generate a reliable model, deep learning models need a substantial quantity of training data. Some biomedical materials, however, might only be found in trace amounts in the real world.
2. Complex DL approaches are not necessary in some domains; old and simple ML methods can be employed to address problems.

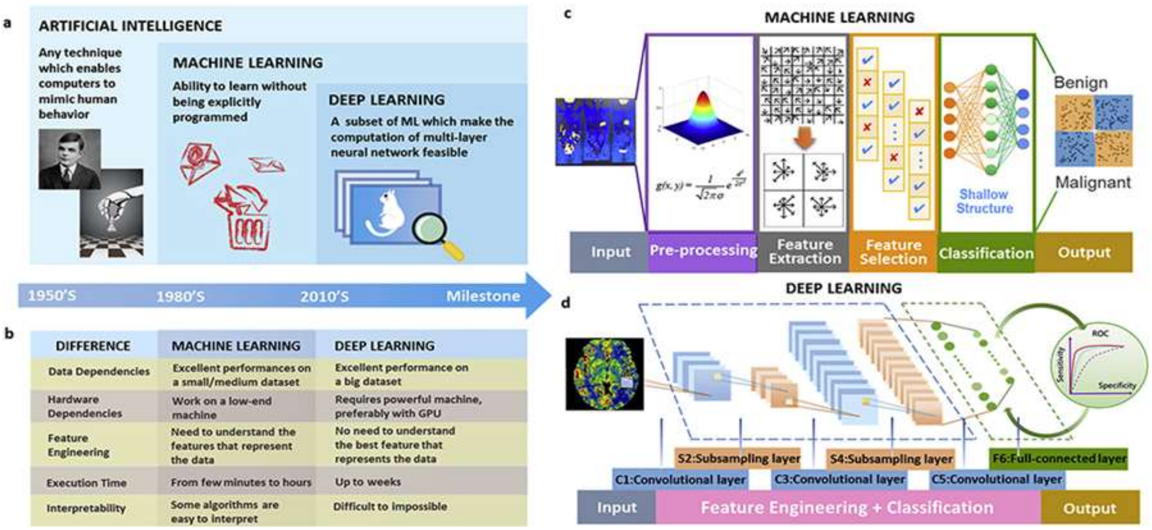

Figure 1:Concepts of AI, ML, and DL and their relationship

3. Use of AI in Cancer Prediction

In the last few years, professionals in every kind of caregiving—from specialists to paramedics—have been asked to forecast cancer prognoses based on their professional experience. The advent of the digital data era has made clinicians aware of the necessity to employ AI advancements like DL and ML [16]. They think it is hard to predict how cancer will advance since statistical analysis is so wide and complex [17]. Experts in medicine are also worried about the possibility that a patient could get sick, experience a recurrence of the tumor following therapy, or pass away. Treatment options and outcomes are significantly impacted by these factors. The truth is that a substantial amount of clinical cancer research focuses on prognostication and patient response to treatment. More precise prognoses enable patients to get more effective therapy; in practice, these options usually involve tailoring care to the specific needs of each patient. In order to anticipate cancer, AI can review and comprehend "multi-factor" data from several patient assessments and offer more accurate information about the patient's survival, prognosis, and expected course of the disease [16].

It's been demonstrated that artificial intelligence-based algorithms can accurately estimate the probability that patients will develop various illnesses, including cancer, and analyze unstructured data [18].

Technology and medicine working together could revolutionize cancer care. A biopsy, histological analyses conducted under a microscope, and imaging tests including MRIs, CT scans, and PET scans were the mainstays of the old cancer diagnosis process [19]. Certain diagnostic procedures can be invasive or painful when using these conventional methods, and experts may interpret imaging data differently [20].

On the other hand, AI systems—particularly those that employ deep learning methods—are able to evaluate medical images with astounding precision. AI can identify tiny irregularities that the human eye frequently misses because it was trained on enormous public domain cancer data sets, which lowers the number of false negatives. By using extensive patient datasets, artificial intelligence (AI) has the ability to detect individuals who are more susceptible to certain cancers, such skin and breast cancer, due to factors like obesity, work-related exposure to risks, family history, or other health conditions. This could facilitate early detection and treatment.

4. Uses of Machine Learning in Cancer Prediction

Artificial intelligence (AI) is meant to address the difficult problem of precisely predicting which treatment plans are most appropriate for each patient based on their unique molecular, genetic, and tumor-based characteristics [21]. Numerous research investigations examined the uses of artificial intelligence (AI) in cancer risk assessment, diagnosis, cancer drug development, and genetic tumor characterisation in order to determine whether AI and its subfield, which includes machine learning, can aid in oncology care [22-24]. According to these researches, ML can help in cancer prediction and diagnosis by analyzing pathology profiles, imaging studies, and its ability to convert pictures to "mathematical sequences." In January 2020, researchers developed an artificial intelligence system based on a "Google DeepMind algorithm" capable of outperforming human "breast cancer" detection specialists [24,25]. An AI system-based machine learning technique with the highest accuracy in prostate cancer diagnosis was created in July 2020 by the University of Pittsburgh. Its specificity and sensitivity were 98% and 98%, respectively [26]. An enhanced ViT (Vision Transformer) architecture, dubbed ViT-Patch, was employed in a fairly recent study. The findings of the trials verified the ViT-Patch architecture on a publically accessible dataset, and they showed efficacy in both tumor localization and malignant detection [27].

5. Use of Deep learning for cancer detection

Artificial intelligence (AI) includes deep learning as a subset. One method for incorporating elements from the data—such as text, images, or audio—is called deep learning. Among AI's most important features is deep learning [28, 29]. Conventional AI approaches necessitate gathering procedures, such as pre-planning, feature extraction, cautious feature selection, learning, and request, in order to accomplish the portrayal goal [30].

Figure 2 illustrates the use of deep learning techniques for cancer detection and diagnosis through step-by-step analysis of medical imaging.

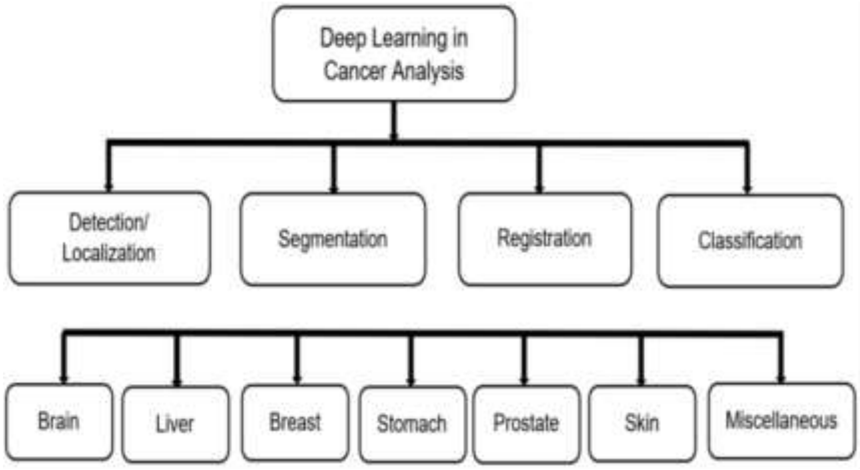

Figure 2: Deep learning process for cancer diagnosis

6. Application of AI in cancer treatment

6.1. Applications of AI in Lung Cancer

ML and biomedical imaging gave research a fresh perspective. It's always crucial to detect lung cancer in its early stages. ML improved lung cancer diagnosis and treatment response tracking by introducing new features and opportunities. Different models are being developed to spread the first detection phase and allow AI to meaningfully classify lung nodules into two groups: malignant and benign [31–33]. Using low-dose CT (LDCT) for screening led to a 20% decrease in the death rate from lung cancer in both current and former smokers, according to the National Lung Screening Trial (NLST) [34].

6.2. Applications of AI in Breast Cancer

Breast cancer is the most common malignancy to receive a diagnosis, according to a statistical report [35]. CADe (Computer-aided Detection) and CADx (Computer-aided Diagnosis) are imaging techniques used in breast cancer screening. Research reveals that during the past few decades, a significant amount of work has been done in this sector [36–38].

6.3. Application of AI in CNS Tumor

The occurrence of CNS tumors presents a wide range of pathological presentations, and may be more diverse than any other tumor in the human body. This wide range of diagnoses necessitates a very specific and precise estimation of imaging modalities. Isocitrate Dehydrogenase (IDH) is one of the most significant biomarkers that help determine the prognosis in CNS tumors. The presence of changes in IDH mutation can be effectively recognized using machine learning methods, such as deep CNNs trained on conventional MR images [39,40].

6.4. Applications of AI in Prostate Cancer

When it comes to identifying suspicious prostate tumors and gaining insight into tissue characteristics, multi-parametric magnetic resonance imaging (mpMRI) can depict soft-tissue contrast. According to a study, because mpMRI can detect lesions and offer surgical features, it is a promising imaging method for prostate cancer. With the development of CADe and CADx systems, flexibility in the identification and classification of prostate cancers was made possible by AI models [41].

7. Limitations and Future prospects of AI in cancer

Though there are a number of obstacles, AI has a lot of potential for use in cancer research and treatment.

7.1. Limitations

1. Data quality and availability: The quality and availability of data are crucial for AI models, particularly in the field of oncology, privacy problems, data silos, and inconsistent data formats may make it difficult to obtain sufficient volumes of high-quality data.
2. Interpretability: Doctors may find it difficult to comprehend the logic behind deep learning models' predictions since they frequently lack interpretability, which is a drawback when using AI for cancer.
3. Generalizability: AI models may not transfer effectively to other patient populations or healthcare environments if they were trained on data from particular demographics or medical facilities.
4. Regulatory challenges: The clearance process for medical devices that use artificial intelligence (AI) can be lengthy and intricate, which hinders the integration of AI research into clinical practice.
5. Ethical considerations: The use of AI in cancer treatment raises a number of ethical questions, including potential effects on doctor-patient interactions, algorithmic biases, and patient consent for data use.

7.2. Future prospects

1. Personalized medicine: AI has the potential to uncover molecular signatures and biomarkers for customized cancer medicines, resulting in more focused and efficient treatments.
2. Early detection and diagnosis: In order to detect cancer at an earlier stage, when treatment has a higher chance of success, AI algorithms can evaluate genomic and medical imaging data.
3. Drug discovery and development: Predicting drug-target interactions, finding new drug candidates, and improving drug design are three ways artificial intelligence (AI) might speed up the drug discovery process.
4. Clinical decision support: Based on information unique to each patient, AI systems can help clinicians with individualized therapy recommendations, treatment outcomes prediction, and treatment planning.
5. Remote monitoring and telemedicine: Artificial intelligence (AI)-driven solutions can facilitate teleconsultations with medical professionals and allow for the ongoing surveillance of symptoms and therapy responses for cancer patients through remote monitoring.

8. Conclusion

In conclusion, there is great potential for using AI to treat cancer, but there are also a lot of obstacles to overcome. Although artificial intelligence (AI) has shown impressive promise in areas like personalized medicine, clinical decision support, early detection, and interpretability, its widespread adoption in clinical practice is hampered by issues like data quality, interpretability, generalizability, regulatory barriers, and ethical concerns.

Despite these challenges, AI appears to have considerable potential in the treatment of cancer. There is potential to overcome current limitations with more advancements in AI algorithms and improved techniques for collecting, sharing, and standardizing data. With the development of AI technology, cancer treatment could undergo a radical change as personalized treatment regimens, more precise diagnosis, and improved patient outcomes become possible.

But in order to guarantee patient privacy, fair access, and responsible deployment, it is crucial to address the ethical, legal, and social implications of AI in cancer treatment. In order to fully utilize AI's potential to revolutionize the battle against cancer, cooperation between researchers, doctors, legislators, and industry stakeholders will be crucial in navigating these obstacles. In the end, AI holds the potential to enhance patient quality of life and survival rates globally by overcoming obstacles and seizing opportunities.

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