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A REVIEW ARTICLE ON THE ROLE OF ARTIFICIAL INTELLIGENCE IN CANCER CARE AND RESEARCH

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ABSTRACT

Cancer is a progressive disease with a low median survival rate. Ironically, the high recurrence and mortality rates make the treatment process long and very costly. Accurate early diagnosis and prediction of cancer is essential to improve patient survival. Developments in statistics and computing over the years have led many scientists to use computational techniques such as multivariate statistical analysis to analyze disease prognosis, and the accuracy of such analyzes has exceeded the accuracy of empirical predictions. was also significantly higher. In recent years, the power of cancer prediction has reached new heights as artificial intelligence (AI), especially machine learning and deep learning, has found common applications in clinical cancer research. This article reviews the literature on the application of AI in cancer diagnosis and prognosis and summarizes its benefits. Explore how AI can support cancer diagnosis and prognosis. Especially considering its unprecedented accuracy, which is even higher than common statistical applications in oncology. It also shows how these methods advance the fields. Finally, we discuss opportunities and challenges in clinical implementation of AI. Therefore, this article provides a new perspective on how AI technology can improve cancer diagnosis and prognosis and further improve human health in the future.

KEYWORDS: Cancer diagnosis, Prognosis prediction, Deep learning, Machine learning.

INTRODUCTION

The Artificial intelligence is a discipline of researcher wherein computer systems device are used to imitate human intelligence.[1] Machine studying is a subfield of Artificial intelligence wherein mathematical and statistical procedures are carried out to enhance the overall performance of computer systems. Deep studying is a subfield of device studying characterised through the operation of multilayered synthetic neural networks. The term "deep studying" refers to a fixed of recent strategies that collectively have proven marked enhancement in overall performance in comparison with present best-in-elegance device studying algorithms in numerous disciplines. For instance, those techniques have revolutionized picture category and speech popularity because of their flexibility and excessive accuracy.[2] These breakthroughs have allowed deep studying to be followed as an method which can correctly resolve diverse troubles in biomedicine. The fundamental software of deep studying to the prognosis of illnesses on the idea of the category of radiological or pathological snap shots has tested a overall performance that equals or in reality exceeds that of scientific experts.[3,4] Deep studying has additionally proved rather correct withinside the detection of retinopathy from fundus photographs.[5] With excessive expectancies for this technology, it's far now being carried out to the sector of drug discovery.[6] Biology and medication are unexpectedly turning into information-in depth. Stephens et al claimed that the software of AI to genomics by myself will same or exceed that to social media, on-line motion pictures and different information-in depth disciplines in regards to information technology and evaluation withinside the subsequent 10 years.[7] Automated algorithms that extract significant styles can offer realistic expertise and alternate the manner wherein remedies are developed, sufferers are categorized and illnesses are studied. In contrast, AI might also additionally infringe on privateness due to capacity get right of entry to private statistics together with genomic sequences for the duration of information processing. Given that huge datasets with suitable information annotation are required for the software of deep studying technology, it's far important that each clinical experts and organic scientists own a primary expertise of deep studying, together with its packages and capacity drawbacks.

ARTIFICIAL INTELLIGENCE: FROM SHALLOW TO DEEP LEARNING

Firstly The idea of Artificial Intelligence Was formalized in 1950s, that described because the Capability of a system to carry out a venture generally related to human performance.[8] In this discipline the idea of system studying refers to an algorithm`s capacity to examine

records and carry out obligations with out specific programming.[9] Machine learning studies has led to improvement and use of more than a few of ``shallow`` studying algorithms, together with in advance generalized linear fashions which include logistic regression, Bayesian algorithms, selection trees, and ensemble methods.[10,11] In the best of those fashions, which include logistic regression, enter variables are assumed to be unbiased of 1 another, and man or woman weights are discovered for every variable to decide a selection boundary that optimally separates training of categorised records. More superior shallow studying algorithms, which include random forests, permit for the characterization and weighting of enter variable combos and relationships, as a result studying selection limitations that could in shape extra complicated records.

Deep studying is a more moderen subset of system studying that has the capacity to examine styles from raw, unstructured enter records through incorporating layered neural networks.[12] In supervised studying, which represents the maximum not unusualplace shape inside clinical AI, a neural community will generate a prediction from this enter records and examine it with a ``floor reality`` annotation. This discrepancy among prediction and floor reality is encapsulated in a loss function, that is then propagated lower back via the neural community, and over severa cycles the version is optimized to decrease this loss function.

For the motive of scientific application, we are able to view AI as a spectrum of algorithms, the software of which might be inextricably connected to the traits of the venture below investigation. Thorough expertise of the records flow is essential to choose, develop, and optimize an algorithm. In general, deep-studying networks provide almost endless flexibility in enter, output, and architectural and parameter design, and as a result are capable of in shape extensive portions of heterogeneous and unstructured records by no means earlier than possible.[13] Specifically, deep studying has a excessive propensity to examine non-linear and excessive-dimensional relationships in multi-modal records together with time collection records, pixel-through-pixel imaging records, unstructured textual content records, audio/video records, or biometric records. Data with vast spatial and temporal heterogeneity are specifically properly perfect for deep-studying neural networks.[14] On the opposite hand, this electricity comes on the rate of restricted interpretability and a proclivity for overfitting records if now no longer skilled on a large, consultant dataset.[15] While conventional system studying and statistical modeling can carry out pretty properly at sure predictive obligations, they typically war to in shape unprocessed, unstructured, and excessive-dimensional records

as compared with deep studying. Therefore, regardless of its limitations, deep studying has opened the door to ``huge records`` evaluation in oncology and guarantees to enhance scientific oncology, so long as sure pitfalls in improvement and implementation may be overcome.

CANCER CARE AS A PROBLEM:-MATHEMATICAL OPTIMIZATION

To respect the promise surrounding AI packages for scientific oncology, it's miles important to include a mathematical lens to the affected person care direction via most cancers hazard prediction, screening, diagnosis, and treatment. From the AI perspective, the affected person direction is an optimization problem, in which heterogeneous records streams converge as inputs right into a mathematical scaffold (i.e., machine-mastering algorithms) (Figure 1). This scaffold is iteratively adjusted in the course of schooling till the favored output may be reliably anticipated and an movement may be taken. In this setting, an ever-developing listing of inputs consists of affected person scientific presentation, beyond scientific history, genomics, imaging, and biometrics, and may be more or less subdivided as tumor, host, or environmental factors. The complexity of the algorithms is regularly pushed through the quantity, heterogeneity, and dimensionality of such records. Outputs are centered, maximum broadly, on growing survival and/or exceptional of life, however are regularly evaluated through necessity as a sequence of greater granular surrogate endpoints.

DATA STREAMS FOR CLINICAL ONCOLOGY

The arc of studies in oncology, growing information generation, and advances in computational generation have together led to a frame shift from low-dimensional to more and more more high-dimensional affected person information representation. Earlier information and computational barriers regularly necessitated lowering unstructured affected person information (e.g., scientific pictures and biopsies) into a fixed of human-digestible discrete measures of disorder extent. One remarkable instance of such simplification lies inside most cancers staging systems, maximum prominently the American Joint Committee on Cancer (AJCC) TNM classification.[16] In 1977, with best 3 inputs typically available—tumor size, nodal involvement, and presence of metastasisthe primary version of AJCC TNM staging have become the same old of take care of danger stratification and selection control in oncology. Over the following many years, with the incorporation of different discrete information points, predictive nomograms can be generated the use of easy linear fashions, that have determined sensible use in positive situations.[17,18,19,20] More recently, advanced

strategies to extract and examine current information coupled with new information streams and a developing information of inter- and intra-tumoral heterogeneity have all caused the improvement of more and more more complicated and unique stratification fashions. Key examples of novel information streams delivered over the last many years are the Electronic Health Record (EHR), The Cancer Genome Atlas[21], The Cancer Imaging Archive[22] and the Project GENIE initiative.[23] Key examples of superior danger stratification and prediction fashions are the prostate most cancers Decipher score.[24] and breast most cancers OncotypeDx score,[25] which make use of discrete genomic information and shallow machine-getting to know algorithms to shape clinically verified predictive fashions. Useful oncology information streams, kind of following ancient order of availability, encompass scientific presentation, tumor stage, histopathology, qualitative imaging, tumor genomics, affected person genomics, quantitative imaging, liquid biopsies, digital scientific file mining, wearable devices, and virtual behavior (Figure 1). Furthermore, as a affected person movements alongside the most cancers care pathway, the variety of influxing, intra-affected person information streams grows. With every step via the pathway, new information are generated out of the pathway with the ability to be reincorporated at a later time again into the pathway. As our organic know-how base and information streams develop in scientific oncology, machine-getting to know algorithms may be deployed to study styles that practice to increasingly more particular affected person agencies and generate predictions to manual remedy for the next, ``unseen`` affected person. As we assimilate extra information, ultimate most cancers care, i.e. the care that outcomes withinside the quality survival and high-satisfactory of lifestyles for a affected person, unavoidably turns into precision care, assuming we've the important equipment to absolutely make use of the information. Here, at this intersection of information complexity and precision care in scientific oncology, is wherein the promise of AI has been so tantalizing, aleven though as of but unfulfilled. The arc of studies in oncology, growing information generation, and advances in computational generation have together led to a frameshift from low-dimensional to more and more more high-dimensional.

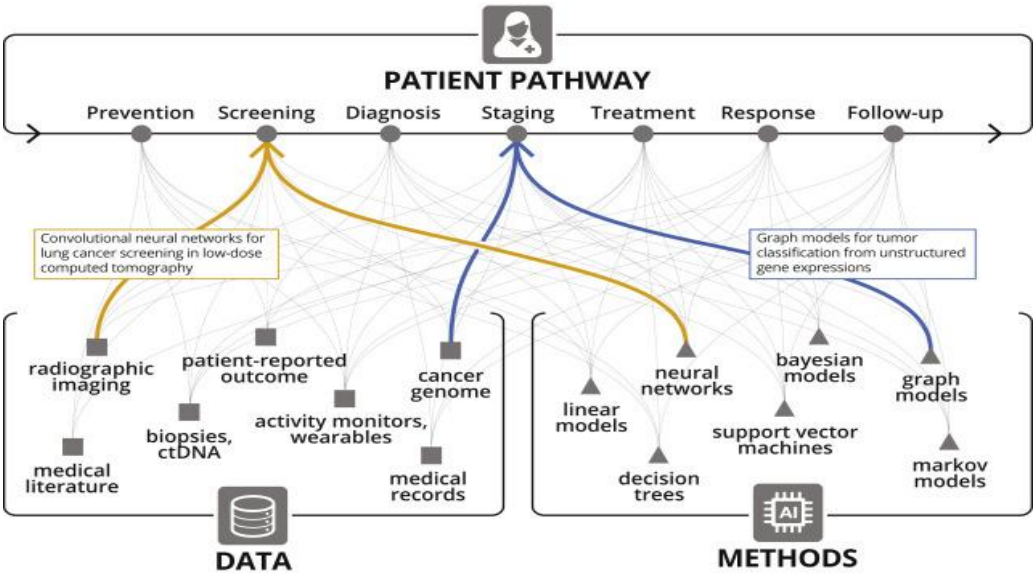

Figure 1: Narrow-task-specific AI applications addressing a specific cancer care touchpoint along the patient pathway, and utilizing a specific data type and AI method.

AI APPLICATIONS AND TOUCHPOINTS ALONG THE CLINICAL ONCOLOGY CARE PATH

We endorse that AI improvement for medical oncology have to be approached from affected person and clinician views throughout the subsequent most cancers care touchpoints: Risk Prediction, Screening, Diagnosis, Prognosis, Initial Treatment, Response Assessment, Subsequent Treatment, and Follow-up. The medical touchpoint pathway stocks capabilities with the ``most cancers continuum`` even though it includes extra granular affected person and clinician decision-orientated factors of touch for AI to feature medical benefit. Each of those touchpoints includes a crucial collection of selections for oncologists and sufferers to make and yields a use case for AI to offer an incremental benefit. Furthermore, touchpoint info will range through most cancers subtype. Within those touchpoints, best AI use instances are ones with good sized unmet want and massive to be had datasets. In the context of supervised gadget learning, those datasets require sturdy and correct annotation to shape a reliable ``floor truth`` on which the AI device can train.

NARROW-TASK AI EXAMPLES ACROSS THE CLINICAL ONCOLOGY TOUCHPOINTS

T1. Risk prediction and prevention

Given the load to humans and healthcare structures of most cancers prognosis and management, there's a vast possibility for AI to assist expect an individual`s threat of growing

most cancers, and thereby goal screening and early interventions efficiently and efficiently. In a mathematical sense, the affected person`s complete non-public records up till prognosis makes up a significant and extraordinarily heterogeneous information movement to be evaluated, positioning deep getting to know to have an impact. This is evidenced through the consistent improvement of equipment that leverage computational modeling to refine most cancers threat. In the beyond few years, numerous deep-getting to know algorithms had been investigated to similarly tailor threat prediction past conventional models. Some of those algorithms make use of novel information streams that have been now no longer to be had till recently: satellite tv for pc imagery net seek records and wearable devices. Others maximize the software of pre-present information streams, such as affected person genomics, habitual imaging, unstructured fitness report information, and deeper own circle of relatives records to enhance predictions.

T2. Screening

Cancer screening entails the enter and assessment of information at a awesome time factor to decide whether or not or now no longer extra diagnostic trying out and approaches are warranted. Data streams may be withinside the shape of serum markers, scientific imaging, or visible or endoscopic examination. Each of those modalities gives possibilities for the combination of AI to enhance the prediction of most cancers. For serum markers, which include prostate-unique antigen (PSA), early studies indicates that machine-mastering algorithms modeling PSA at one of a kind time points, along with different serum markers, can be capable of higher are expecting the presence of prostate most cancers than PSA alone. Perhaps extra than in another software, AI has determined high-effect use in scientific imaging screening. Narrow-project fashions were advanced to localize lesions and are expecting the hazard of malignancy on lung most cancers computed tomography (CT) and breast most cancers mammography with packages which have been proven to carry out on par, or now and again higher than professional diagnosticians. In those packages, uncooked pixel information of the photograph is applied as enter right into a deep-mastering convolutional neural community this is educated on the premise of radiologist-categorized ground-fact outputs. Importantly, whilst the algorithms display astounding consequences in phrases of place beneathneath the curve, sensitivity, and specificity, they do now no longer compare direct scientific endpoints, which include most cancers mortality, healthcare costs, or first-class of life. Outside of scientific imaging, AI has determined software in screening endoscopy for colorectal carcinoma, with an software that courses biopsy-webweb page

selection. Furthermore, there are possibilities to enhance diagnostic yield for different malignancies for which screening has been historically tough and unproven. This might be carried out with the aid of using AI enhancing the evaluation of pre-current information streams, which include stomach CT or magnetic resonance imaging (MRI), or through its cappotential to combine multi-modal information streams, which include EHRand genomic information. Whilecurrently the UnitedStates Preventive Services Task Force recommends in opposition to screening for manycancers, there are some of ongoing investigations to decide whether or not incorporation of AI into screening standards and era may also permit screening to be applied in a much broader array of ailment sites, which include pancreatic most cancers.

T3. Diagnosis

Diagnosing includes the exclusion of different benign sickness procedures and the characterization of most cancers with the aid of using number one site, histopathology, and, increasingly, genomic class. Diagnosis represents an AI touchpoint for those 3 domain names with the aid of using reading their respective records streams: consisting of medical exam and scientific imaging (i.e., radiomics), virtual pathology, and genomic sequencing. A key look at that found out the promise of deep confirmed that convolutional neural networks ought to obtain dermatologist-degree accuracy withinside the class of pores and skin cancers using virtual photographs. Other promising regions of research on this realm encompass gaining knowledge of for most cancers prognosis non-invasive mind tumor prognosis and prostate most cancers Gleason grading thru MRI, computerized histopathologic prognosis for breast most cancers and prostate most cancers, and usage of radiographic and histopathologic records to expect underlying genomic class. Thus far, the Screening and Diagnosis touchpoints account for almost all FDA-authorised deep gaining knowledge of programs for medical oncology, with 3 algorithms that specialize in mammography and 3 that specialize in CT-primarily based totally lesion prognosis.

T4. Risk stratification and prognosis

Historically, hazard stratification consisted of TNM staging, despite the fact that an increasing number of extra records streams inclusive of genomics, superior imaging, and serum markers have allowed for extra specific hazard stratification. Given the big heterogeneity in most cancers hazard, hazard stratification gives a relatively appealing use case for AI. Over the beyond decades, genomic classifiers, advanced with device getting to

know, had been included into hazard stratification for some of malignancies. Classifiers inclusive of OncotypeDx for breast most cancers, a logistic regression-primarily based totally classifier, and the Decipher rating, a random wooded area-primarily based totally classifier, have validated the capacity to enhance prognostication and manual treatment. The Decipher rating genomic classifier is primarily based totally on 22 genomic expression markers enter right into a random wooded area version that turned into skilled to expect metastasis after prostatectomy for sufferers with prostate most cancers at a unmarried institution. This classifier has been finally confirmed in numerous outside settings, and is now present process research in randomized managed trials (NCT04513717, NCT02783950). Deep-getting to know techniques had been explored to combine multi-omic records reassets into riskstratification fashions utilising combos of diagnostic imaging, EHR records, and genomic information. Furthermore, there may be the ability for deep getting to know to higher hazard-stratify sufferers primarily based totally on big populace databases, inclusive of the Surveillance, Epidemiology, and End Results program, with the aid of using getting to know non-linear relationships among database variables, despite the fact that initial efforts require validation.

T5. Initial treatment strategy

The system of preliminary remedy method is arguably the maximum pivotal touchpoint for AI withinside the most cancers pathway, because it without delay impacts affected person management. The final a long time have visible exponential increase withinside the variety and complexity of preliminary remedy alternatives for not unusualplace cancers. A not unusualplace dilemma for preliminary remedy is which aggregate of systemic therapy, radiotherapy, and surgical procedure is optimum for a given affected person. Machine-gaining knowledge of techniques using genomic and radiomic statistics had been investigated to are expecting radiation sensitivity. While immunotherapy has been followed in increasingly more disorder settings, it stays hard to are expecting reaction primarily based totally on presently to be had biomarkers, and machine-gaining knowledge of algorithms with radiomic enter have verified the cappotential to enhance reaction prediction . Furthermore, deep gaining knowledge of has verified the cappotential to research multi-modal statistics streams withinside the genomic realm: a latest evaluation verified that integration of tumor mutational burden, copy-variety alteration, and microsatellite instability code can assist are expecting reaction to immunotherapy. AI can also permit greater accurate ``evidence-primarily based totally remedy.`` Natural language processing and effective language

fashions can assist examine posted medical works and make use of current oncology literature, as an instance through extracting scientific oncology standards from EHR and linking those to a literature corpus.

T6. Response assessment

Assessment of reaction to remedy usually consists of radiographic and medical assessments. Quantitative reaction evaluation standards including Response Evaluation Criteria in Solid Tumors (RECIST) and Response Assessment in NeuroOncology (RANO) have lengthy been set up as reproducible methods to evaluate reaction to therapy, even though withinside the age of focused immunotherapies their validity has been questioned. As focused therapeutics and immunotherapies have entered the clinic, however, it has grow to be clean that reaction evaluation through RECIST is inadequate, because of phenomena including pseudo progression. Detailed reaction evaluation is mostly a time-extensive method that calls for a excessive diploma of human information and experience, now no longer to say excessive intra- and inter-reader variability. Additionally, no matter periodic evaluation and revision of those standards, they continue to be inapt at taking pictures side cases, including variable lesion reaction, withinside the case of sufferers receiving immunotherapy. Deep getting to know has established capacity for computerized reaction evaluation, consisting of computerized RANO evaluation and RECIST reaction in sufferers present process immunotherapy.

T7. Subsequent treatment strategy

When coming near AI set of rules improvement for next remedy method, there are some of precise issues that generate complexity in comparison with preliminary remedy method. To start with there are extra information streams to consider, which include previous remedies, remedy-associated toxicity, restaging imaging, and regularly more than one tissue specimens. Given the heterogeneity in information streams and the shrinking affected person populations from which to construct those models, next remedy method is a tough area for evidence-primarily based totally selection making and, in turn, for dependable AI applications. Algorithms that make use of longitudinal follow-up statistics may also assist here. In one example, AI has proven the capacity to synthesize serial CT follow-up imaging for lung most cancers sufferers put up chemoradiation and to are expecting later recurrence. An intervention which include this can manual choice for sufferers to go through consolidative remedies which include surgical treatment or immunotherapy.

T8. Follow-up

Another underexplored location for AI oncologic programs is the improvement of gear to manual precision follow-up. Diagnostic and screening algorithms might also additionally frequently be transferable to the follow-up setting, however would require retraining and validation for the project of interest. Similar to T7, the impact of previous most cancers remedy at the facts flow will frequently shift matters significantly. For example, radiomic capabilities extracted from the equal tumor, pre- and post-remedy, display giant discrepancies. These ``delta`` capabilities can be used to expect affected person recurrence danger and past due toxicity, supporting to tailor follow up plans. Appropriately triaging sufferers for escalated follow-up and interest can sell reduced morbidity and greater green healthcare useful resource utilization; AI leveraging EHR facts has verified the cappotential to perform this through choosing sufferers at excessive danger for acute-care go to even as present process most cancers remedy and assigning them to an escalated preventive care strategy. In instances wherein sufferers have untreatable relapse, end-of-existence care will become an exceptionally essential and tough process. AI has proven capacity right here as well, as a manner to triage sufferers at excessive danger of mortality and nudge physicians to speak with sufferers concerning their values, wishes, and quality-of-existence options.

CONCLUSION

AI has already had a major impact on healthcare and will continue to revolutionize medicine. Its potential is immeasurable and has applications in cancer research, early detection, diagnosis, treatment and monitoring. AI also has the potential to reduce healthcare costs and inequalities. Several tools have been developed using diverse medical data sets (including free text, laboratory results, imaging results, radiographic images, and omics data). With these goals in mind, further studies are needed to cont.

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