Artificial Intelligence- Oncology and Central Nervous System Tumour Detection

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Abstract- In recent times, in this world of science and technology and recent advancements like machine learning and artificial intelligence, clinicians and medical science are supported with better treatment assistance, increased efficiency and improved methodology in the detection of even the rarest tumour in the human body. In the field of oncology, the help of AI has proved promising results. Diagnosing by imaging and detecting gliomas, its grading can be done easily and accurately. This article focuses on recent advances and technologies in the field of AI and CNS Brain tumour detection. Rare and difficult tumours hard to detect and identify can now be seen and classified with the help of these newer technologies. Pre Intra and post-operative strategies can be planned accurately and most precisely with the help of AI. It is a vast concept that helps enhance various human cognitive abilities in wide ranges.Deep Learning, one of the types of ML, has proved effective in automating many time-consuming steps, including lesion detection and segmentation. AI has several features such as detection and classification, tumour molecular properties, cancer-linked genetics, discoveries of various drugs, prediction of treatment, its outcomes as well as survival, and continued trends in personalized medicine in CNS tumours such as GBM with poor prognosis. Artificial Intelligence is a vast concept that helps enhance various human cognitive abilities in wide ranges. This review focuses on the recent advances in AI and its use in oncology, specifically in CNS, detection, and assessment planning of the underlying cause. Promises and challenges of the same are discussed below.

Keywords – Artificial intelligence, deep learning, machine learning, oncology, central nervous system, neuroimaging

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1.Introduction-

Artificial intelligence [AI] is an area where computers are such a way programmed so that they can mimic human intelligence can be replicated as it is with the help of advanced computers and types of machinery. This vast ocean of information in the medical field makes this technology the best choice for resolving difficulties with the help of machine learning. In the field of oncology, ML can be used as a source for the detection and classification of tumours; detecting them as early as possible helps in the collection of histological, pathological data and Genetics related to it. It also adds in preoperative and post-operative planning and predicts the final outcomes. Deep Learning, a form of ML, has proved effective in automatizing tedious and long-time-requiring steps, including lesion detection and segmentation. [1,2]

Since computational algorithms are becoming more prevalent, AL techniques can potentially increase the accuracy of medical diagnostic and therapeutic procedures. This transformation is set to increase the accuracy of medical diagnostic and treatment procedures, and radiomics in neuro-oncology has been and probably will remain at the forefront of this movement. The spearhead of this revolution has been and most likely will remain the field of radiomics in neuro-oncology for directing and monitoring tailored therapies. AI technologies incorporating clinical, radiomic, and genomic information into predictive models show great potential. To realize this field's potential, however, there are numerous obstacles to overcome and a lot of work that has to be done. However, as AI advances, radiologic practice will significantly change.

2.Objective:

To understand the role of Artificial intelligence in oncology, specifically CNS tumours, its detection and assessment.
Methodology:
This narrative review complies with data statements and compares data collection from various formats through PubMed.

3.Discussion:

Work process of Artificial Intelligence-
Artificial intelligence (AI) is a vast term that describes any task performed by a computer that generally requires human intelligence, with explicit rule-based systems and computer algorithms that don't require hard-coded rules. In figure1, various feedforward neural networks are depicted. Artificial Intelligence is a vast concept that helps enhance various human cognitive abilities in wide ranges. Machine learning, one of the approaches to Artificial Intelligence, includes understanding how a computer system learns to perform any work or anticipate output without undergoing any programme.[3]
For this process, a computer program will experiment with a dataset including various examples of correctly identified benign as well as malignant brain lesions and, based on this, will generate a model that can generalize it beyond this data. The computer system's ability to correctly segregate new cases of brain lesions will then be assessed by accentual methods of its activity, like accuracy and sensitivity and specificity. [4]

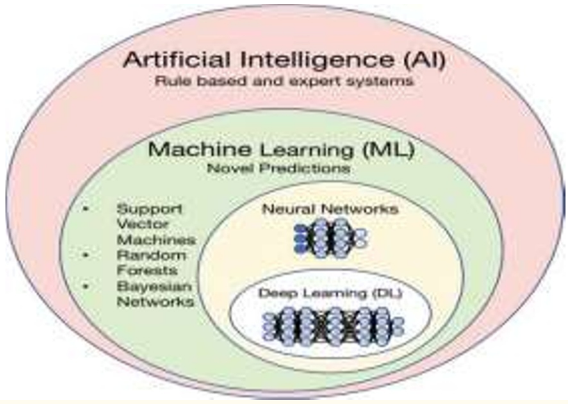

Figure1:
The diagram shows an overview of terms encompassed by artificial intelligence and their nested relationships with each other.

Problem Statement of CNS tumours worldwide-

In the USA, the annual number of cases of primary CNS tumours is approximately 15 per 100,000, predominantly male and in India, it is 28000 cases yearly detection. Despite essential and classic advancements in rapid imaging, surgically well-established techniques, chemotherapy, radiation therapy, and radiation surgery, treating primary brain tumours named glioblastoma polymorphism remains difficult.[5] Glioblastoma is the most common primary intracranial tumour, which includes almost sixty per cent of all primarily occurring brain malignancies worldwide. Tumours of Primary or metastatic origin are challenging to treat due to rapid growth, extensive angiogenesis, infiltration into distant areas, and its poor response to chemotherapy treatment that crosses the blood-brain barrier. It can be managed clinically by observation, grading, access to tumour depth, its segmentation and localization, histopathological assessment, and identification of numerous molecular markers affecting it. Then after this, clinicians need to manually edit all information for confirmation for the further treatment plan. In these cases, to decrease the burden and automate, AI has proved helpful in diagnosing and treating various complicated Brain tumours.[6]

Tumour detection in CNS-

Artificial intelligence has introduced great strides in diagnosing and classifying brain malignancies. Recently the standard Gold technique for detecting and classifying various tumours is MRI [7]. Traditional MRI technologies such as T1 and T2 weighted imaging with Fluid Toxicity Inverse Recovery, known as FLAIR sequencing, have some disadvantages of enhancing nonspecific contrast and infiltrating mass lesions u can be ignored. Perfusion MRI with Dynamic Contrast Enhancement and Arterial Rotation Labelling or marking are also recently mostly used to evaluate the angiogenic functions and qualities of brain tumours such as Glioma to increase detection. In addition to identifying the minutest structure of the tissue, diffusion-weighted imaging revealed malignant infiltrates in brain regions that generally show on traditional magnetic resonating imaging. With the help of Magnetic resonance spectroscopy, one can also detect chemically active metabolites such as choline, creatine, and N-acetyl aspartic acid. They help classify gliomas and identify areas of tumour infiltration.[8]

By self-operating these steps, AI has helped in improvement in the detection ratios and efficiency of radiologists, thereby reducing the time it takes to diagnose diseases traditionally. Convolutional neural network-based DL indicates millimetre-sized CNS malignancies and can segregate GBM from cancerous and benign brain lesions. [9]

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MRI techniques help in structural information about the exact anatomy of tumours. However, tumour differentiation is still dependent on histological and pathological assessment, which is a complicated, time-consuming, and costly technique. It stays challenging to detect and locate low-stage gliomas from high-stage gliomas based on imaging, with Artificial Intelligence systems. Attention-formed modulators, newer technologies are now studied recently in classifying gliomas, and their applications could lead to betterment. [10][11]

Radiomics in AI-

The all-inclusive analysis of clinical, histological, pathological as well as radiological information integrated with ML and Deep learning processing of images has placed a new way for a modern field of translation under neurooncology known as radiomics .[12] Radiology-based AI improves non-invasive tumour characterization and identification by establishing histopathologic grading along with the classification of it in minutes, also during operation, prognosis, monitoring, along with treatment response assessment .(12)Algorithms AI can detect such images even at the pixel level, to help in identifying and providing data not seen by naked human eyes and provide more exact classification.

Radiography includes a package of processes with its manual as well as automatic, including semi-automatic segmentation. The main two Verity of radiomics are based on features; another is Deep Learning associated. Both of these give more accurate, exact & trustworthy results than that human findings. Feature-based type of radiomics findings put more value on particular subsets of similar features from underlying regions and course of interest in mathematical expressions .[13]

Histopathological Aspects and molecular markerDdetection-

To overcome various complexity in detecting the following, digitally made slide scanning types of machinery are currently being used. It transforms microscopically formed slides to image files that are elucidated by Artificial intelligence-based algorithms named SVM & decision trees. SVM has shown the best accuracy rate [98]. AI-based information detects pathological patterns of gliomas and foresees outcomes depending on genetic & molecular markers. [14]

Types of AI called supervised machine learning, including textures' features, can detect methylation states. The main analyzing component in the final CNN layer indicates that peculiar features, like nodular & heterogeneous enhancement and "mass FLAIR oedema", identified as MGMT methylation state with increased accuracy to approximately 80-84 PERCENT.[15]

Role of Artificial Intelligence in Pre- operative Intra- Operative Procedures & Post Operative Follow up-

Preoperative

In traditional radiography, contrast-enhanced radiographs are preferred to detect tumour mass or extent of disease. However, one-dimensional imaging techniques may be inaccurate in the total assessment and correct identification of heterogeneous tumours, including one of the deadly tumours consisting of GBM. Another challenge is distinguishing the tumour's boundary from the peripheral pool of oedema.[16]

AI algorithms, including random forest and CNN and SVM, must be put into tumour regions to decrease coming challenges and provide correct tumour location determination. A 2-step protocol including CNN and transfer learning models cause more accurate and exact glioma location.[17]

Intraoperative

AI-based numerous techniques have recently been formed to help surgeons simultaneously extract maximal tumour portions and normal, little unhealthy brain tissues. 3D CNNs based designs gave very promising outputs in supporting stereotactic radiotherapy arrangements. It is often tough to distinguish between primary CNS tumour lesions, lymphomas, and malignancies in the brain in certain critical situations. But now, with the help of Artificial Intelligence-based conclusions, like decision trees & multivariable logistic models for regression have developed to distinguish such systems using diffuse stress imaging and weighted MRI. sensitive dynamic functions.[18][19]

Post-operative supervision

MRI with the use of gadolinium as contrast is the gold standard tool for investigating tumour growth after the operation is done & also tumour response can be checked. CNN-associated AI techniques detect tumour size promptly compared to other conventional and linear techniques. [20]The capability of CNN-like models to dissociate actual progression and pseudo-progression & Machine Learning techniques to distinguish necrosis due to radiation from recurrence of the tumour is phenomenal. In addition, CNN and SVM create a superior technique for predicting response to treatment and subsistence outcomes from imaging, clinical, genetic& molecular information.[21]

Treatment Response Assessment in the field of Neuro-Oncology

Lesser-grade gliomas canbe managedby performing surgery and/or with chemoradiation. However, the current standards for the management of glioblastoma comprises the maximum safe resection followed by radiation withchemotherapy along withtemozolomide[22]. More recently, it has been demonstrated that adding tumour-treating fields improves glioblastoma patient survival even further. Numerous immunotherapy clinical trials, some of which target particular molecular pathways like EGFR, are being conducted to treat patients having glioblastoma [23], albeit their efficacy has not yet been established[24].

Assessment of Clinical responses

Pseudoprogression [25], which is more frequent in MGMT methylation and IDH mutated tumours, is characterized by an expanding T2/FLAIR signal anomaly with some recent or expanding areas of new betterment following a combination of radiation and also chemotherapy. In contrast, antiangiogenic drugs (such as bevacizumab) have the potential to cause pseudoresponse, which is characterized by a sharp decrease in enhancement caused by a change in the blood barrier of brain but little to no effect on the progression of the invading component and no increase in the survival [26]. Initial standards for the response evaluation adopted the Macdonald criterion [27], which took boosting component size into account. Theresponse evaluationof Neuro-Oncologyand RANO criteria [28] , which helps to do changes in increasing tissue and T2/FLAIR tissue, has been used more recently to explain how to assess therapy response. The baseline evaluation was modified to the first post-radiation therapy image rather than the post-resection image in a recent amendment to the RANO criteria, and it also includes some response assessment to help detectpseudoprogression. Despite its clinical efficacy and widespread use at most institutions, RANO is currently just a restricted tool for evaluating response since it relies on subjective, two-dimensional assessments and excludes modern imaging modalities like MRI perfusion with diffusion tensor imaging and MR spectroscopy. Evaluation of the response is made more challenging by the complicated, inflammatory reactions that some more recent immunotherapy drugs have been reported to generate [29]. In an effort to include into account immunological inflammatory-related pseudoprogression, the immunotherapy RANO criteria (30)increase the time frame for calculating progression.

Promises and Challenges of AI in imaging of Neuro-Oncologic

Because AI techniques can recognize patterns and synthesize datain such a way that humans cannot, they have enormous potential for the advancement of radiology including precision medicine. According to the movement for precision medicine, a perfect Artificial intelligence-based assessment system for neuro-oncology would combine all important multimodal imaging data along with clinical information and molecular markers to accurately predict biologicallyclinically relevant further types for a latest tumour detection[31].

With the help of this data, patients can be divided into treatment groups that are most likely to be successful. For example, determine whether a particular patient will be benefited from gold standard or ultra-total resection, targeted enhancement of radiation therapy to such areas of invasive tumours, chemotherapy, or new treatments that target more significant and precise cellular mechanisms. AI has huge potential to monitor both standard therapies and new therapies like immunotherapy. The complex inflammatory response observed in immunological therapy [32] requires further attestationof various AI models that can regulate such newer treatments but may rapidly determine therapeutic efficacy and enable the course of treatment. It allows dynamic adjustments during the period of the disease. In this regard, AI techniques applied to advanced imaging techniques may ultimately provide better-individualized predictions of treatment response than current techniques [33].

Challenges –

Key challenges of the diverse possibilities of AI in the radiology sectionhas efficient, high-quality, 100% authentic data, general and interpretable techniques and user-friendly workflow integration [34]. Concerns about the "black box" nature of these new methods arise in the following ways: A better mechanical understanding of characteristic patterns and the underlying biology contributes to both clinical acceptability and improved biological and administrative relevance of various patterns revealed by such methods. Also one of the biggest challenges in research field in AI is preparing large, annotated, resource-rich datasets. However, working with relatively small sample sizes of data may cause more measurement errors. This requires additional barriers for developing more powerful and correct algorithms in neuro-oncological imaging and general radiomics.

Path for clinical implementation of AI-

Regardless of the increasing usage of AI advances in research environments, more significant barriers for the efficient & consistent categorization of these advanced algorithms in clinical environments. To accept the system, it needs to be easily mixed into the radiologist's work (electronic medical recording system, image archive and system of communication dictation software). In addition, many radiomic techniques require manual intervention and numerous internal pipelines, which can be time-consuming. Small work has been done to create tools for easy translation and sharing of such methods.

A completely automated system that is integrated into the workflow of radiology and analyses pictures in real-time while supplying a quantitative and moreappropriate draught report may be the "holy grail" of AI in field of neuroradiology [36]. First, a more comprehensive diagnostic system for brain MR imaging might determine if a newly discovered lesion is likely to be a specific tumour or a neoplastic mimic. A design like this would advise adding more complex imaging procedures and/or sequences. This automated system might also be used for supervising treatment in "real-time," with more precise quantitative tools for reporting to track changes in both conventional and advanced imaging parameters along with patterns derived from deep learning. Until AI methods are yet to completely integrateinto daily practice, it is the role of the "centaur" radiologist, to incorporate information from images,numerous AI tools, and health records for the improvement in precision of radiology and health care. [37] .

Interpretation of Artificial intelligence performance-

For AI to work well in medical and clinical practice, there must be validation in both internal and external affairs. In internal evidence, AI precision is compared with anticipated results when these algorithms are further tested using preceding questions. The tools perform internal validation based on specificity, sensitivity, accuracy and AUC. The difficulty with interpreting the AUC is that it does not consider any of the clinical context.

For validation of external means, a representative population of patients and potentially data collected are needed for training of AI-based algorithms.[38]

4.Conclusion-

Computer systems are able to learn the task and predict outcomes without being programmed explicitly by Artificial intelligence. Deep learning, a machine learning unit, uses various neurally connected networks. To help learn complicated nonlinear shape forms of data, CNNs now are equipped to process 2D to 3D inputs like images, and RNNs can process variable length sequentially formed inputs like text data. A newly developed mindfulness-dependent DL system can selectively focus on data, improving the accuracy of cancer detection rates. AI has several features such as detection and classification of tumour molecular properties, cancer-linked genetics, discoveries of various drugs, prediction of treatment, and its outcomes. Also, survival and ongoing trends in personalized medicine in CNS tumours such as GBM with poor prognosis. It shows promising results in oncology in the field. AI-based radiomics enable tumour classification and grading within minutes, enabling tumour identification without invasive methods. Radiomics are widely used in the title and staging of CNS tumours. Analysis of histological pathological and genetic or molecular markers are easily performed using AI. Along with AI advances, oncology has entered a more personalized and normalized era. Formal integrated education for students in medicine, health informatics and in computer science has the potential to drive in furthermore advances in AI in medicine and in oncology.

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