REVIEW ARTICLE

Application and fallibility of Artificial Intelligence and machine learning in Diagnostic Pathology

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ABSTRACT

Artificial intelligence (AI) refers to the use of technology and computers to replicate behavioral intelligence and analytical reasoning that is equivalent to that of a human being. The medical sciences make substantial use of computer systems with artificial intelligence which primarily include remote patient treatment, prescription recording, increasing doctor-patient interaction, medication discovery and patient diagnosis. Its application in health care industry is mainly because of increased job demands, difficult tasks, and probable doctor weariness all have the potential to impair diagnostic performance. In this review we have enlightened the various roles of AI such as automated diagnosis, predictive analysis, image analysis, precision medicine and the biomarker development. The use of AI tools in pathology has grown significantly in recent years, and it is predicted that they will revolutionize the field in the years to come. AI tools can change how pathology functions while rendering it more efficient at meeting the demands of the modern era of precision medicine.

Keywords

Artificial intelligence, medical science, precision medicine, pathology

INTRODUCTION:

In recent years, the field of medical science has employed artificial intelligence (AI) more and more. The use of computer programmes to carry out operations that would ordinarily require human intellect, such as choice-making, pattern recognition, and natural language processing, is referred to as artificial intelligence (AI)[1]. Medical imaging is one of the main applications of AI in the medical sciences. Artificial intelligence

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(AI) is being used to examine medical pictures like computed tomography (CT) and Magnetic resonance imaging (MRI) to find anomalies and identify diseases including malignancies, heart disease, and neurological problems [2]. Additionally, AI can assist physicians in spotting small alterations in picture that a human eye could miss. Medication Discovery: By finding promising medication candidates and forecasting their safety and effectiveness, AI can assist to expedite the drug development procedure [3]. When compared to more conventional drug discovery techniques, this may conserve time and money. Electronic Health Records (EHRs): It include vast volumes of data that AI can analyse to spot trends and forecast patient outcomes. This can help doctors to make more informed decisions about treatment options. Personalized Medicine: AI can help to identify patients who are at high risk for certain conditions based on their genetic and environmental factors [4]. This can assist medical professionals in creating individualized treatment programmes for each patient. Virtual Assistants: AI-powered virtual assistants can help patients to manage their health by providing personalized advice and guidance. This can help patients to stay on track with their treatment plans and make better decisions about their health. Even though AI has the potential to revolutionize medical science, there are several issues that must be resolved, including issues with confidentiality and security of data, ethical dilemmas, and the requirement for regulation and oversight. However, AI has the ability to enhance patient satisfaction and lower healthcare costs with proper deployment and supervision [5].

Artificial Intelligence (AI) has the potential to transform many aspects of pathology, from diagnosis to treatment and research. Here are some of the key roles of AI in pathology: Automated diagnosis: AI algorithms can analyze digital pathology images and help identify patterns and anomalies that may be indicative of disease [6]. This can assist pathologists in making more accurate diagnoses, and can also speed up the diagnostic process. Predictive analytics: AI can help predict patient outcomes based on various factors, including clinical history, genetic data, and pathology results. This can help guide treatment decisions and improve patient outcomes. Image analysis: Artificial intelligence (AI) may be used to analyse a lot of pathological pictures and find small changes among them. This can help pathologists identify new patterns and markers that may be indicative of disease. Precision medicine: AI can help match patients to the most appropriate treatments based on their individual characteristics, such as genetic makeup and pathology results [7]. Research: AI may be used to analyse vast volumes of data and find novel discoveries and trends that human investigators would not instantly notice. This can help accelerate the pace of medical research and lead to new discoveries. In conclusion, the use of AI in pathology offers the potential to enhance the precision, speed, and effectiveness of evaluation, therapy, and studies, eventually improving patient outcomes [8].

Role of AI in Diagnostic and Prognostic Pathology -Automated diagnosis

It refers to the use of technology, such as artificial intelligence and machine learning algorithms, to diagnose medical conditions without the need for human intervention. This can involve the analysis of medical data such as images, lab results, and patient history, used for diagnosis. In situations when human knowledge is few or restricted, automated diagnosis has the potential to increase diagnostic speed and accuracy. Additionally, it can lessen the strain for medical staff members and enhance patient results. But it's crucial to remember that automated diagnosis is not a replacement for human doctors and medical professionals. Automated diagnosis systems can be prone to errors and may not be able to account for all variables in a patient's condition. Therefore, it is important to use automated diagnosis systems as a tool to support human decision-making rather than a substitute for it.

Automated diagnosis in pathology involves the utilization of computer algorithms and artificial intelligence (AI) techniques to aid pathologists for the assessment and interpretation of tissue samples. This approach can help to improve accuracy, consistency, and efficiency in the diagnosis of various diseases [9].

One of the main techniques used in automated diagnosis is image analysis. Pathologists can capture digital images of tissue samples and use algorithms to automatically identify and analyze various features, such as cell morphology and tissue architecture. Machine learning algorithms can then be trained on vast datasets of annotated pictures to classify tissues and identify abnormal features that may indicate disease [10]. Automated diagnosis can also involve the use of biomarkers, which are specific molecules or genetic markers that can be detected in tissue samples. By analyzing the expression levels of these biomarkers, algorithms can help to identify specific types of cancer or other diseases. Overall, automated diagnosis has the ability to greatly increase pathological diagnosis rapidity and precision while simultaneously lessening pathologist's work [11].

While this technology has the potential to improve diagnostic accuracy and speed, there are several problems associated with automated diagnosis in pathology that need to be addressed [7].

Some of the key issues include:

Data bias: Automated diagnosis systems rely on large amounts of training data to learn how to classify and diagnose tissue samples. If the training data is biased, for example, if it predominantly represents one race or ethnicity, the algorithm may not be able to accurately diagnose samples from other populations.

Lack of interpretability: Many machine learning algorithms used in automated diagnosis are considered "black box" models, which means that the reasoning behind their decisions is difficult or impossible to interpret. This can make it difficult for pathologists to understand why a particular diagnosis was made, which could lead to a lack of trust in the technology.

Variability in tissue samples: Tissue samples can vary in quality, which can affect the accuracy of automated diagnosis. In addition, tissue samples can also vary depending on the part of the body they come from, the age and sex of the patient, and other factors. These variations can make it difficult for algorithms to accurately diagnose samples.

Limited diagnostic categories: Automated diagnosis systems are currently limited to a few diagnostic categories, such as cancer and infectious diseases. This means that they may not be useful for diagnosing other types of conditions, such as autoimmune disorders or genetic diseases [7].

Regulatory challenges: The use of automated diagnosis systems in pathology is subject to regulatory oversight, and there are currently no clear guidelines for how these systems should be evaluated and approved for use. This can create uncertainty for pathologists and limit the adoption of these technologies.

Ethical concerns: The use of automated diagnosis systems raises several ethical concerns, such as privacy, data ownership, and liability for errors. These concerns will need to be addressed before these technologies can be widely adopted in pathology. Predictive analytics is a promising application of AI in diagnostic pathology, which involves analysing enormous volumes of data with machine learning techniques from medical imaging, patient records, and genetic information to predict disease outcomes and guide treatment decisions. However, there are several potential drawbacks to using AI-generated predictive analytics in this field.

The possibility of bias in the techniques employed to create prediction models is the first significant cause for concern. The data that AI algorithms are educated on must be as accurate as possible; else, the predictions they make may be wrong or even destructive. Secondly, there is also a risk of overreliance on AI-generated predictions, which could lead to a loss of clinical judgment and decision-making skills among healthcare providers. In some cases, doctors may become too reliant on algorithms and overlook other important factors that could influence patient outcomes. Thirdly, there are also ethical concerns around the use of AI-generated predictions in diagnostic pathology. For example, if predictive models are used to deny patients certain treatments or services based on their predicted outcomes, it could raise questions about fairness and discrimination. Finally, there is also the potential for AI-generated predictions to perpetuate existing disparities in healthcare outcomes. For example, if the data utilized for educating a computer programme is biased against particular populations, the predictions that arise might perpetuate uneven access to treatment and reinforce current health inequalities.

In conclusion, while AI-generated analytics for prediction have the potential to transform pathological diagnosis and enhance patient outcomes, there are a number of possible downsides that must be carefully explored and managed to ensure that these tools are utilized in a responsible and ethical manner.

Image Analysis and AI -

In diagnostic pathology, AI is being utilised more and more to help with picture processing. The process involves feeding large amounts of data, such as digital images of biopsies, into AI algorithms that can learn to recognize patterns and identify specific features of interest [12]. Here are a few ways AI is responsible for image analysis in diagnostic pathology:

Image Segmentation: AI can be used to segment digital pathology images into different tissue types, such as cancerous and non-cancerous tissue. This enables pathologists to focus on the most crucial elements of the picture and immediately locate regions of concern.

Image Classification: AI can also be used to classify images based on certain characteristics, such as the presence or absence of cancer cells. This can help pathologists to make more accurate diagnoses and identify potential treatment options.

Image Enhancement: AI can be used to enhance digital pathology images, improving the quality and resolution of the image. This enables pathologists to detect small alterations that the human eye would overlook in greater detail.

While AI has the potential to revolutionize image analysis in pathology, there are several potential drawbacks which includes:

Limited data availability: For AI models to be trained successfully, significant volumes of excellent quality data are required. In pathology, there may be limited availability of high-quality data, especially in rare or complex diseases.

Bias in training data: An AI model may be biased if the initial information used to construct it is biased, which might result in inaccurate diagnoses or treatment suggestions. It's important to ensure that training data is diverse and representative of the population being studied.

Lack of interpretability: Because AI models may be quite complicated, it might be challenging to comprehend how they reached at a given diagnostic or suggestion. This lack of interpretability can make it challenging for pathologists to trust the results generated by the model.

Regulatory challenges: The use of AI in pathology is subject to regulatory approval, which can be a lengthy and expensive process. Additionally, regulations may vary from country to country, making it difficult to deploy AI models globally.

Integration with existing workflows: Integrating AI into existing pathology workflows can be challenging, and may require significant changes to existing processes and infrastructure.

Ethical concerns: The application of AI in pathology raises ethical issues, as with any new technology. For example, the use of AI could lead to job losses among pathologists, or result in unequal access to healthcare if the technology is only available to certain populations.

Precision medicine in Prognostic Pathology:

Precision medicine is a method of treating patients that takes into account the individual variation in their genes, environments, and lifestyles to customize their medical care and preventative measures to their particular needs. Medical choices, procedures, and products are personalized to the specific individual in precision medicine instead of being dependent on demographic averages. Prognostic pathology is the study of the molecular and cellular basis of disease and the prediction of the disease's outcome based on its characteristics [13]. The role of precision medicine in prognostic pathology is to provide personalized treatment options that are specific to a patient's unique molecular and cellular characteristics. Precision medicine has the potential to revolutionize the practice of prognostic pathology by enabling the identification of individualized treatments for patients based on their molecular and cellular characteristics [14]. By combining data from various sources, including genomic and proteomic data, medical history, lifestyle factors, and other patient-specific information, precision medicine can provide a more accurate and comprehensive understanding of a patient's disease and its potential outcomes. In addition, precision medicine can aid in the development of new prognostic biomarkers that can help predict a patient's response to treatment and guide treatment decisions. Possible benefits of this personalized method of healthcare include better patient outcomes, less expensive medical care, and a better comprehension of the pathophysiology of various diseases.

While Precision Medicine has the potential to revolutionize the field of medicine, there are some challenges and potential problems associated with its implementation which includes:

Data Privacy: Precision Medicine relies heavily on the use of personal and genetic data. There are concerns about the privacy of this data and the potential misuse of this information.

Data Quality: The accuracy and completeness of the data used in Precision Medicine are critical to its success. Incomplete or inaccurate data could lead to incorrect diagnoses or ineffective treatments.

Access to Data: The data used in Precision Medicine is often siloed and dispersed among various institutions, making it challenging to access and share. This can limit the effectiveness of Precision Medicine and impede progress in the field.

Cost: Precision Medicine can be costly due to the need for specialized testing, individualized treatments, and personalized follow-up care. This could limit its accessibility and affordability, particularly for those who are uninsured or underinsured.

Equity: There is a concern that Precision Medicine may not be accessible or equitable for all populations, particularly those from underrepresented communities. This could lead to disparities in health outcomes and exacerbate existing health inequities.

Ethical considerations: There are ethical considerations associated with Precision Medicine, including issues related to informed consent, data privacy, and the potential for stigmatization or discrimination based on genetic information.

Role of AI in Molecular Pathology Research –

Molecular pathology is a branch of pathology that involves the analysis of biological samples at the molecular level, including the study of genes, proteins, and other biomolecules. AI is increasingly being used in molecular pathology research, and its potential for advancing the field is significant [15]. Here are some ways in which AI is being used in molecular pathology research:

Genomic data analysis: AI algorithms can analyse large genomic datasets to identify patterns and mutations that may be indicative of disease. AI can help researchers identify new targets for drug development and personalize treatments based on individual genomic profiles.

Biomarker discovery: AI can be used to analyse complex bimolecular data, such as mass spectrometry data, to identify biomarkers that are indicative of disease. This information can be used to develop new diagnostic tests and to predict treatment outcomes.

Precision medicine: AI can help clinicians tailor treatments to individual patients based on their molecular profiles. Artificial intelligence (AI) can determine which therapies are most likely to be successful for a given patient by examining genomic, proteomic, and other molecular data.

Drug discovery: By analyzing massive datasets and forecasting the efficacy of possible treatment candidates, AI can assist in discovering novel therapeutic targets and maximizing medication development.

Pathology informatics: To find patterns and trends in illness prevalence and treatment results, AI may analyse electronic medical records and other forms of data. The development of novel therapies and better patient care can both benefit from this knowledge.

Biomarker Discovery and AI –Biomarker discovery is an important area of research that involves identifying biomolecules or other measurable indicators that can be used to diagnose or monitor disease. AI is increasingly being used in biomarker discovery, and its potential for advancing the field is significant [16]. Here are some ways in which AI is being used in biomarker discovery:

High-throughput screening: AI can analyse large datasets generated by high-throughput screening methods to identify potential biomarkers. This can help researchers quickly identify promising candidates and reduce the time and cost of traditional screening methods.

Data integration: AI can integrate data from multiple sources, including genomic, proteomic, and imaging data, to identify patterns and correlations that may be indicative of disease. This can help researchers identify new biomarkers and develop more accurate diagnostic tests.

Predictive modelling: Artificial intelligence (AI) may be used to create prediction models that can determine which biomarkers have the highest probability likely to be helpful for identifying or tracking a certain disease. This can help researchers prioritize biomarker candidates and accelerate the development of diagnostic tests.

Personalized medicine: AI can help clinicians tailor treatments to individual patients based on their biomarker profiles. By analyzing genomic, proteomic, and other biomarker data, AI can predict which treatments are most likely to be effective for a particular patient.

Drug discovery: By analyzing massive datasets and forecasting the effectiveness of possible treatment candidates, AI may be used to discover novel therapeutic targets and streamline drug development. This can help researchers identify biomarkers that are indicative of drug response and accelerate the development of new treatments.

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