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AI Empowered of Advancements in Microbial and Tumor Cell Image Labeling for Enhanced Medical Insights

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Abstract: ***The traditional diagnosis model of tumor pathology depends on the experience of the doctor, which is inevitably subjective. With the rapid development of modern medical imaging, medical imaging technology has formed a medical imaging system composed of UI, CT, CR, DR, MRI, PET, PET-CT, digital subtraction angiography and PACS by traditional single ordinary X-ray and angiography. The continuous enrichment of imaging technology has changed medical imaging from "auxiliary examination means" to the most important clinical diagnosis and differential diagnosis method in modern medicine. With the application of digital scan sections in clinicopathology, the computer technology of artificial intelligence (AI) assisted diagnosis has developed rapidly in the analysis of tumor tissue images. This paper summarizes the application progress of AI in tumor pathology, and describes the exploration and application of AI in the field of quantitative analysis of histopathological molecular markers closely related to clinical diagnosis and treatment in recent years, so as to provide useful reference for the development of tumor intelligent diagnosis and treatment model.***

Keywords: Tumor tissue; Pathological image; Modern medicine; Intelligent diagnosis.

1. INTRODUCTION

Over the past few decades, AI algorithms in image processing have evolved from traditional machine learning (ML) to deep learning (DL). DL is an important branch of ML that originated in the study of artificial neural networks by stacking layer structures to form a deep feedforward neural network, thereby combining low-level features into more abstract high-level features. Compared with other ML algorithms, DL has stronger feature extraction ability for image data. Among them, the deep convolutional neural network is one of the commonly used network structures in the computer recognition of histopathological images, which can extract and analyze the features of the digital pathological images obtained by scanning, so as to organically combine tumor pathological diagnosis with computer technology, and perform the output of pathological diagnosis tasks such as target detection, classification diagnosis and quantitative analysis. At present, DL has made remarkable progress in tumor classification, cell detection, mutation prediction and prognosis analysis, thus providing a new diagnostic model for clinical tumor pathology. Medical imaging refers to the technology and process of obtaining internal tissue images of the human body or a part of the human body in a non-invasive way for medical treatment or medical research. It consists of two relatively independent research areas: medical imaging Systems and medical image processing. The former refers to the process of image formation, including the research of imaging mechanism, imaging equipment, imaging system analysis and so on. The latter refers to the further processing of the image that has been obtained, whose purpose is either to restore the original image that is not clear enough, or to highlight some feature information in the image, or to do pattern classification of the image and so on. Therefore, tumor targeted therapy and immunotherapy have greatly promoted the development of precision therapy. Individualized tumor therapy depends on accurate tumor concomitant diagnosis (CD). Concomitant diagnostics can provide tumor patients with information about their response to therapeutic drugs. Prior to clinical treatment decisions, it is often necessary to detect specific tumor tissue biomarkers to screen patients for benefit and develop an individualized treatment plan.

2. RELATED WORK

Big data artificial intelligence analysis technology makes medical image diagnosis software and hardware more intelligent. Using deep learning to analyze medical images and videos is a new research direction. Through the trained convolutional neural network, you can quickly build and train your own deep learning system. Before clinical treatment, it has become necessary to detect the expression status of some tumor molecular pathological markers. At present, there are relatively many researches on AI application and representative molecular indicators of tumor tissues, such as image analysis of human epidermal growth factor receptor-2 (Her-2), cell proliferation-associated antigen (Ki-67) and programmed cell death ligand-1 (PD-L1).

2.1 HER-2

In the neoadjuvant treatment of HER-2 positive patients, trastuzumab combined with chemotherapy can significantly increase the pCR rate compared with chemotherapy alone, which establishes the standard position of trastuzumab in the neoadjuvant treatment of HER-2 positive breast cancer. With the advent of the dual-targeting era, the expert group generally recognized that in the neoadjuvant therapy stage, all patients who meet the single-targeted therapy can consider dual-targeted therapy.

The treatment principle is that the surface of the normal cell membrane of the human body has a membrane protein called "HER" called human epidermal growth factor receptor.

There are many members of the human epidermal growth factor receptor (HER) family, including HER-1, HER-2, HER-3 and HER-4, and HER-2 is only one of the members of HER family.

HER-2 not only appears on the cell membrane of normal cells, but also on the membrane of cancer cells. When cancer cells overexpress HER-2 (clinically called HER-2 positive), HER-2 will stimulate the crazy proliferation of cancer cells, and such breast cancer with overexpression of HER-2 is called HER-2 positive breast cancer.

Her2-positive breast cancer accounts for about 20% to 30% of all breast cancer. Compared with HER2-negative breast cancer, HER2-positive breast cancer has the following biological characteristics: high degree of malignancy, rapid growth of cancer cells, easy recurrence and metastasis, and insensitive to conventional chemotherapy and radiotherapy.

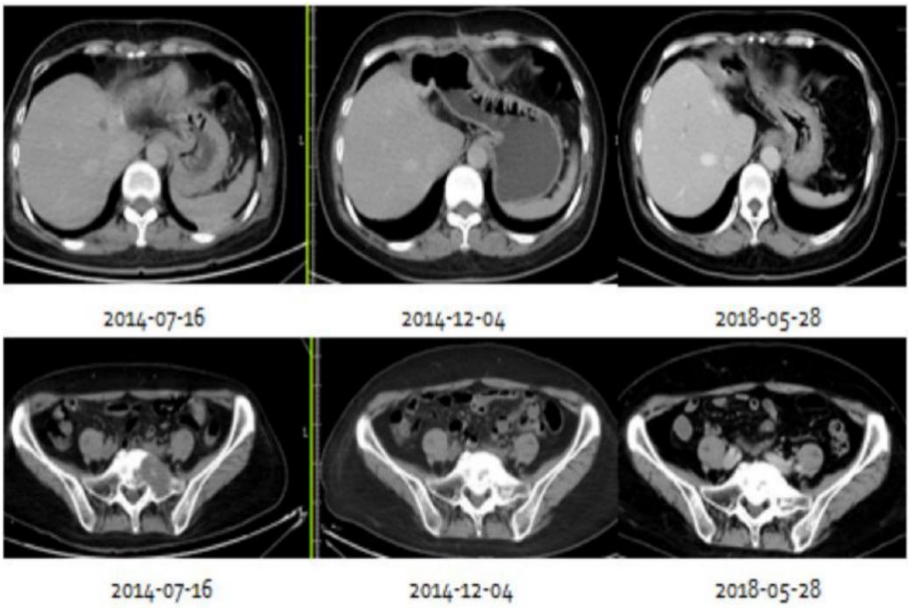

Figure 1: HER-2 positive medical image

The application of computer-aided diagnosis in the Her-2 staining scoring algorithm has demonstrated the great potential of AI in accurate quantitative scoring of molecular pathological indicators. Yue et al. 's multi-center application test showed that the accuracy and reliability of pathologists' evaluation of Her-2 can be significantly improved by using the Her-2 scoring algorithm based on cell-level classification and the microscope real-time augmented reality system. Vandenberghe et al. 's research shows that AI-assisted diagnosis can assist the clinical diagnosis and treatment of breast cancer by identifying cases with high risk of misdiagnosis and significantly reducing the bias caused by the subjectivity of manual scoring. In addition to breast cancer, Her-2 is also widely used in the screening of patients benefiting from targeted therapy for gastric cancer and other tumors, but at present, there are few reports on AI interpretation of Her-2 in other cancer types.

2.2 Artificial intelligence assisted Ki-67

In 1983, this antibody was first discovered in the department of Pathology at the University of Kiel in Germany, and when it was discovered, its corresponding original clone number was 67, hence the name KI-67.

Ki-67 protein is a cellular marker of proliferation and one of the important immunohistochemical markers. It is closely related to cell proliferation. In the interphase, Ki-67 antigen can only be detected within the nucleus, whereas in mitosis, most of the protein is relocated to the chromosome surface. Ki-67 protein is present in all active phases of the cell cycle (G1, S, G2, and mitosis), but not in resting (G0 phase) cells. The cellular content of Ki-67 protein is significantly increased during cell progression in the S phase of the cell cycle. Therefore, the level of Ki-67 expression can indicate whether the cell proliferation is in an active state. When the level of Ki-67 is high, it indicates that the cell division and proliferation activity is very active.

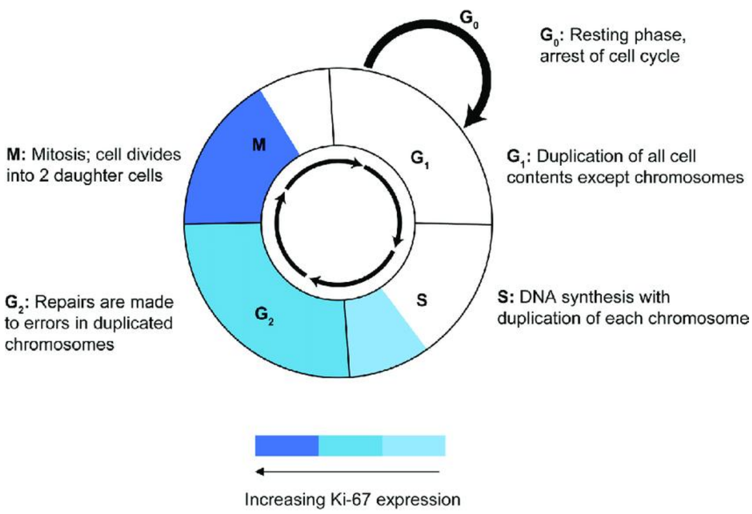

Figure 2:KI-67 frame diagram

Ki-67 can be positive in tumor cells, lymphocytes, stromal cells and other non-tumor cells. Therefore, the accuracy of computer recognition of Ki-67 positive cell categories and automatic counting of positive markers are key steps in automatic interpretation. Niazi et al. adopted transfer learning to identify tumor boundaries in Ki-67 stained section images, which showed high sensitivity and specificity for automatic interpretation of Ki-67 index. Valkonen et al., using cytokeratin (CK) -Ki-67 double stained slices as training images, developed a digital mask based on deep learning for automatic detection and differentiation of epithelial cells with good results. The computer aided Ki-67 index interpretation shows the advantages of quantitative analysis results and good reproducibility, but the realization of automatic analysis needs to be based on a good tumor cell recognition model.

2.3 PD-L1 intelligent diagnosis

PD-L1 immunohistochemical detection is a simple and effective method to predict the efficacy of PD-1 or PD-L1. It is a method to predict the efficacy of PD-L1 inhibitors by detecting the expression level of PD-L1 on the surface of tumor cells (TC) or immune cells (IC). The approved reagents for PD-L1 immunohistochemical testing correspond to different drugs, so the correlation and consistency among the detection platforms and reagents are also the focus of attention of clinicians and pathologists. There have been many studies on the correlation and consistency of PD-L1 antibody detection in NSCLC. Among The more influential are The Blueprint Project I and II, led by the International Association for Study of Lung Cancer (IASLC).

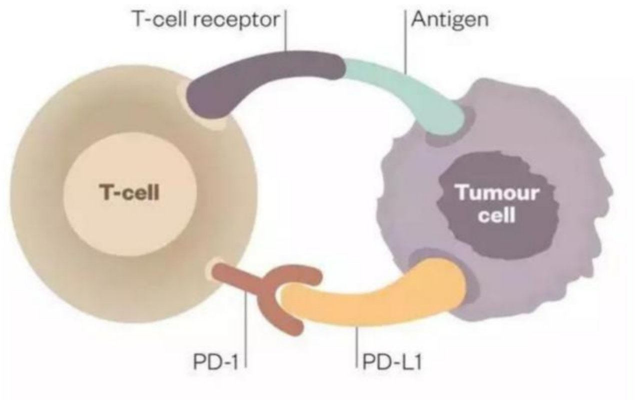

Figure 3: Mechanism of action of PD-1 / PD-L1

3. ADVANTAGES OF AI IN THE DIAGNOSIS OF TUMOR TISSUE MARKERS

With the rapid development of tumor tissue staining technology and DP, the advantages of AI in processing high-throughput and multi-dimensional image information have gradually emerged, bringing new opportunities for tumor diagnosis and treatment. Tumor concomitant diagnostic markers are closely related to treatment decisions, and clinical practice is usually strict in the interpretation of these markers, and interpretation doctors usually need multiple training. Although a series of threshold standards for manual interpretation have been established, the traditional diagnostic model still relies on the experience of the diagnostic physician, which is inevitably subjective. At the same time, the interpretation of tissue markers is usually time-consuming and laborious, which greatly increases the burden of tumor diagnosis and poses a high challenge to diagnostic physicians.

3.1 Ai-assisted automated diagnosis

Ai-assisted tumor pathological diagnosis has the characteristics of automation, high efficiency and high repeatability, especially for the quantitative interpretation of histopathological markers, so as to improve the objectivity and accuracy of tumor accompanying diagnosis. At the same time, the results of AI image analysis are easier to share and repeat in different hospitals and testing centers, thereby assisting diagnostic physicians in the standardization of pathological index detection and interpretation, and reducing the daily diagnostic load. Due to the urgent need for clinical precision therapy, AI-assisted quantitative analysis of tissue markers may be an important aspect of clinical execution applications and is likely to become part of clinical diagnostic AIDS in the near future.

To realize clinical application of AI in the field of quantitative analysis of histopathological markers, many problems still need to be solved, such as the amount of labeled data in the process of model construction, quality control of tumor staining and scan image data, and accurate cell segmentation. DL has a variety of learning modes, usually including supervised learning, unsupervised learning, and semi-supervised learning. At present, supervised ML by manual annotation by pathologists is a common method, but this method requires a large number of high-quality professional annotation images, and there are certain difficulties in research practice. Some ML models such as active learning and weakly supervised learning algorithms have also made great progress in reducing the need for manual labeling of pathological image data.

3.2 Abnormal tumor tissue was detected

In the localization of objects of interest in radiographs in the detection of tumor tissue abnormalities, known as computer-aided detection (CADe), AI-based detection tools can be used to reduce observational oversight and serve as primary screening to prevent omissions. Suspected lesions are characterized by defining their shape or volume, histopathological diagnosis, disease stage, or molecular profile, thereby determining prognosis or response to treatment over time during monitoring.

In addition to providing assisting information to clinicians, AI is also proving its usefulness at the clinical decision-making stage. Ai-based integrated diagnostics combine molecular and AI information with image-based findings, adding rich intelligence to results and making decisions more informed. In clinical diagnosis, the AI measures mentioned above are expected to enhance the current clinical workflow (as shown in the figure below).

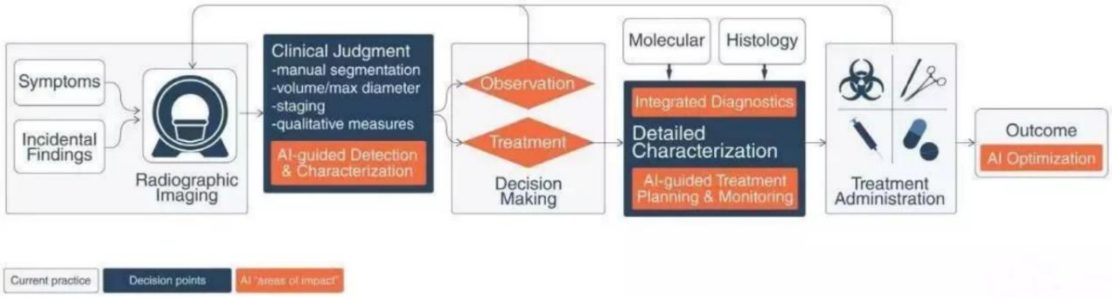

Figure 4: Anomaly detection process

In traditional therapy, initial radiological diagnosis of the tumor patient's mass is required, treatment or observation is performed according to clinical factors and the patient's condition, and the clinical outcome is determined after obtaining the tissue for clear histopathological diagnosis and molecular genotyping over a period of time. In contrast, AI-based measures offer the potential to increase clinical workflows and decision-making at different stages of oncology treatment, and continuous feedback and optimization of their results can further refine AI systems.

3.3 Challenges faced

Although the use of big data in health care promises that patient medical records and other private information could be used to train AI to make diagnoses. The company has faced controversy in the past as people become more sensitive about how their personal data is used and expect stricter ethical, regulatory, privacy and security standards.

According to the Daily Mail of London, Google's UK subsidiary DeepMind obtained 1.6 million private medical records without the consent of patients to develop an app to help monitor kidney disease, including their full medical history and whether they had been diagnosed with HIV, depression, drug or alcohol addiction and abortion, which caused a lot of controversy. Deepmind senior scientist Dominic. "Access to timely and relevant clinical data is important for healthcare professionals looking for symptoms of a patient's worsening condition," Kim said. Nephrologists believe this alert system will change treatment outcomes." But Katherine, CEO of the Patients Association. Mr Murphy said: "So much data falling into the wrong hands would have dire consequences. Patient privacy must be protected."

Therefore, the biggest difficulty in using these technologies in the field of health care is not the creation of algorithms, but the patience and determination to conduct in-depth research while adopting strict data protection measures. Using a natural language processing program, the researchers reviewed the diagnoses of brain metastases, HER-2 breast cancer, and hydronephrosis with more than 90 percent accuracy. Over the next two years, in order to apply machine learning technology to routine clinical care, the researchers will work on better ways to benefit the general public.

4. CONCLUSION

In conclusion, the traditional model of tumor pathology diagnosis, relying on subjective human expertise, is undergoing a transformative shift with the integration of artificial intelligence (AI) in medical imaging. The evolution from traditional machine learning to deep learning, particularly utilizing deep convolutional neural networks, has significantly enhanced the feature extraction capabilities for image data. The diverse range of modern medical imaging technologies, such as UI, CT, CR, DR, MRI, PET, PET-CT, digital subtraction angiography, and PACS, has collectively formed a comprehensive medical imaging system. This evolution has elevated medical imaging from a mere auxiliary examination tool to the forefront of clinical diagnosis and differential diagnosis in modern medicine.

Looking ahead, the rapid development of AI-assisted diagnosis in the analysis of tumor tissue images, especially in the field of quantitative analysis of histopathological molecular markers, holds promising potential for revolutionizing tumor pathology. The ability of AI to process vast amounts of digital scan sections and extract meaningful insights offers a more objective and efficient approach to diagnosis. As AI continues to progress, it is anticipated that intelligent diagnosis and treatment models for tumors will play a pivotal role in advancing personalized medicine, providing clinicians with valuable tools for accurate and timely diagnosis, ultimately contributing to improved patient outcomes in the realm of oncology.

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