Transforming pathology with GPT-4: Automated histopathological image analysis for enhanced disease diagnosis

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ABSTRACT

This study addressed longstanding challenges in traditional pathology reporting, such as high data volume, diagnostic delays, and interpretive variability, all of which hindered timely and accurate patient care. We investigated the transformative potential of Generative Pre-trained Transformer models, specifically GPT-4, and explored vision-language models (VLMs) to automate disease detection from high-resolution pathology images and streamline reporting workflows. The core objective was to enhance diagnostic accuracy, efficiency, and consistency, thereby improving patient outcomes and optimizing the workload of pathologists. To achieve this, we trained GPT-4 using a large, diverse dataset of breast cancer pathology images paired with verified clinical diagnoses. Model performance was rigorously evaluated using the independent BreakHis histopathological database from the University of Paraná, Brazil. Evaluation metrics included diagnostic accuracy, sensitivity, specificity, and precision in identifying various disease states. Additionally, GPT-4-generated pathology reports were assessed for clinical usability and comprehensiveness, with direct comparisons to reports produced by human pathologists. These evaluations focused on their effectiveness in supporting routine diagnostic workflows. The results demonstrated that GPT-4 could be effectively integrated into clinical practice, automating routine diagnostic tasks and allowing pathologists to focus on complex cases and quality assurance. This shift enabled faster and more accurate diagnoses, potentially leading to improved treatment outcomes. Furthermore, the model contributed to the automated quantification of histopathological features and showed promise in enhancing access to expert-level medical knowledge. Overall, this research advanced the application of intelligent AI solutions in pathology, aligning with the broader vision of "generalist medical AI." GPT-4 emerged as a powerful collaborative tool capable of supporting multimodal, comprehensive patient assessment in the future of healthcare.

Keywords: Digital pathology, GPT-4, vision-language models (VLMs), automated diagnosis, histopathological image analysis