AI-enhanced tumor diagnosis using PATH-zle, the first user-friendly AI tool for tissue reconstruction

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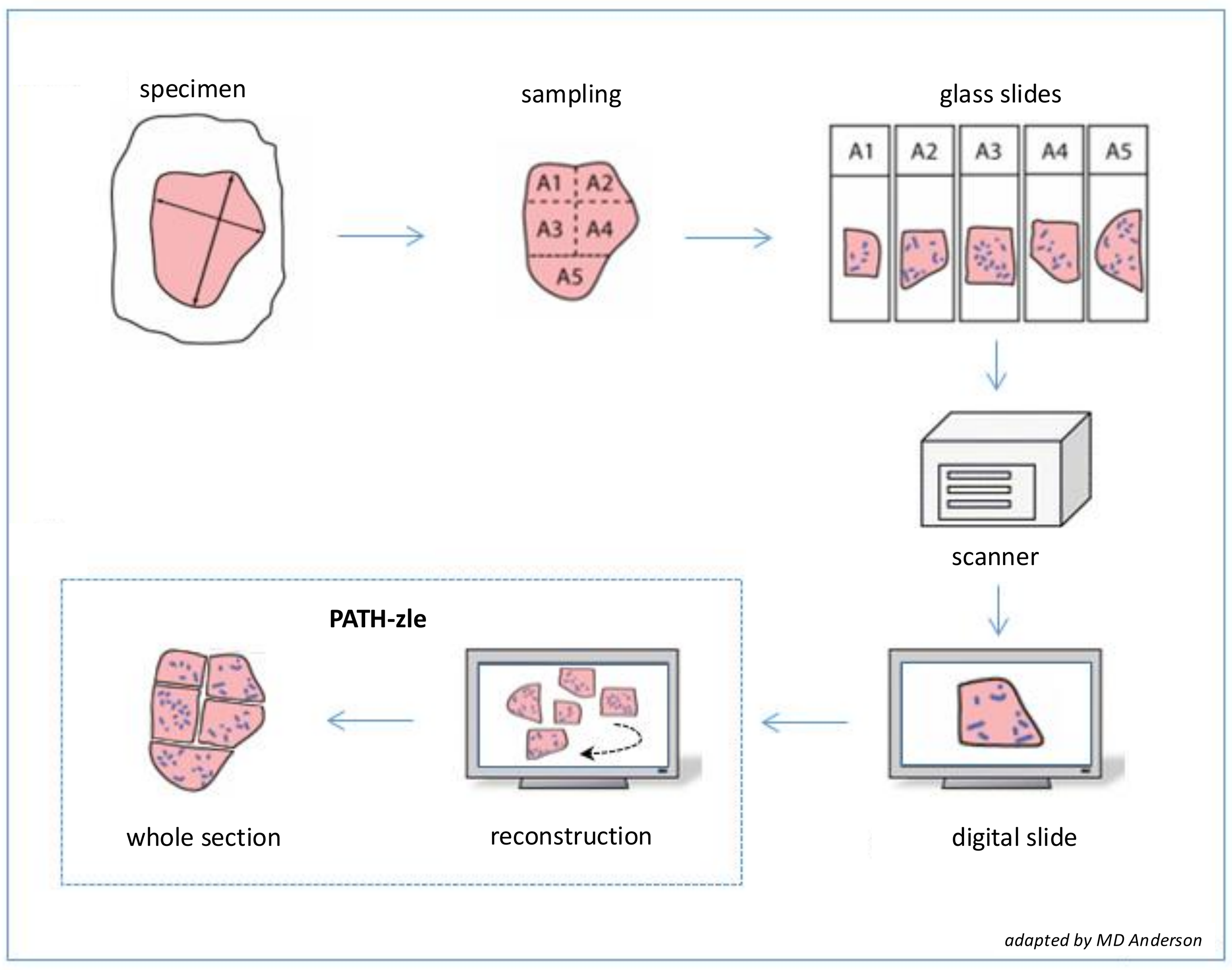
Background

Accurate and precise histopathologic diagnosis is essential for optimal therapeutic decision-making in oncology. With the rapid transition from optical microscopy to digital workflows, pathology is undergoing its game changer transformation. Digital pathology in fact enhances speed, accuracy, sharing, education, and, crucially, the integration of AI-driven tools that support the diagnostic process. In particular, in traditional analogic pathology larger tumor specimens cannot be analyzed in their entirety; during the grossing phase they must be divided into smaller tissue specimens that fit into standard paraffin blocks. Each specimen then undergoes specific preanalytical processes and is used to prepare individual histologic slides. This approach results in a loss of the overall orientation of the sample. Alternatively, it is possible to prepare macrosections from larger paraffin blocks. However, this is a technically labor-intensive process. Furthermore, the use of larger paraffin blocks and macrosections is impractical for laboratory management, as it prevents the use of standard equipment such as instruments for immunohistochemical analysis or scanners for digitizing histological sections. The aim of this study is to develop a digital support to overcome the limits of these approaches.

Methods

We implemented PATH-zle, an AI-based, user-friendly tool designed to automatically reconstruct whole-tumor digital image by stitching together multiple tissue samples mounted on separate glass slides (e.g., breast, colon, lung, and prostate cancer samples). Leveraging high-resolution digital slide inputs, PATH-zle performs automatic stitching, orientation alignment, and structural reconstruction to generate a coherent and anatomically faithful representation of the entire tumor section or specimen (see figure).



Results

By providing a single comprehensive digital reconstruction, PATH-zle eliminates the need for manual mental reconstruction traditionally performed by pathologists when reviewing slides individually. This significantly improves precision, speed, standardization, and reduces cognitive load. The single generated comprehensive digital reconstruction can be seamlessly shared, reviewed through standard digital pathology viewers, and analyzed using conventional measurement or quantification tools (e.g., tumor dimensions, depth of invasion, distance from the margins, area, cell counts). Furthermore, PATH-zle output is fully compatible with downstream AI-based analytical pipelines, facilitating multi-layered computational assessment.

Conclusions

PATH-zle enables, a full-field, spatially faithful view of the tumor and its sampled context, reflecting their original arrangement within the surgical specimen, something previously achievable only through radiological imaging modalities such as CT or MRI scans. There are numerous applications for this technology in the pathologist’s daily work. We are currently testing Path-zle on specimens from radical prostatectomies, breast tumor resections—particularly in cases following neoadjuvant therapy—and large skin excisions for neoplastic diseases.

By bridging the gap between radiologic and histologic visualization, this technology lays the foundation for future multimodal integration and image fusion. Its implementation has the potential to deeply reshape diagnostic workflows, elevate precision oncology, and accelerate the adoption of AI as a transformative force in modern pathology.

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