An automatic tissue folding detection algorithm to aid AI segmentation models.

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Background: Folded tissue is present on many core biopsy slides, typically being introduced during sectioning. There are 2 main types of folding; 'large' characterised by a large region of 2 layers of overlapping tissue and 'concertina' characterised by many small dense regions. While folding has little impact on traditional pathology reporting, AI algorithms are prone to error within affected regions. Quality control of Whole Slide Images (WSIs) is an important but time-consuming step prior to running AI algorithms. To address this need, we have developed an automated fold detection algorithm for liver biopsies.

Methods: Tiles containing known folded tissue were randomly selected from a large dataset (3 liver clinical trials) and extracted from WSIs. Tiles varied in fold type and stain (Haematoxylin and Eosin (H&E), Masson's Trichrome (TRC) and Picrosirius Red (PSR)). Each tile was converted to the HSV (Hue, Saturation and Value) colour space and colour-based thresholding was applied. A range of thresholds were used to determine the optimum one for each stain before calculating the fold as a percentage of the tissue.

Validation was performed on 45 WSIs (9 PSR, 11 TRC and 25 H&E), 40 with known folds and the remaining 5 with no observed folding. Manual annotations of folds were curated using QuPath and converted into a percentage of the total tissue. The automated method was run on the same WSIs, and fold percentage was recorded. Bland-Altman analysis was used to assess agreement between manual annotations and the algorithm.

Results: As can be seen in the Bland-Altman plot (Figure 1A), there is minimal bias (0.28) between the manually calculated tissue folding and the automated folding detection.

Of the 40 WSIs with known folding, 37 WSIs had ≤2.5% difference between the automated and annotated measurements. Of the 3 WSIs with higher differences, 2 WSIs (1H&E and 1PSR) contained multiple large folds which are typically less dense than concertina folds and as a result, have gaps within the colour-based thresholding of the fold. The third WSI had overstained TRC. Of the 5 WSIs with no folding, 4 WSIs had 0% algorithm detected folds while 1 had 1.38% detected folding on a fibrotic capsule region.

Conclusion: We can accurately determine the percentage of folded tissue present on a WSI across a range of commonly used stains from several laboratories (Figure 1B). Due to the accuracy, this can be utilised as an automated QC step in AI based pipelines in liver studies.

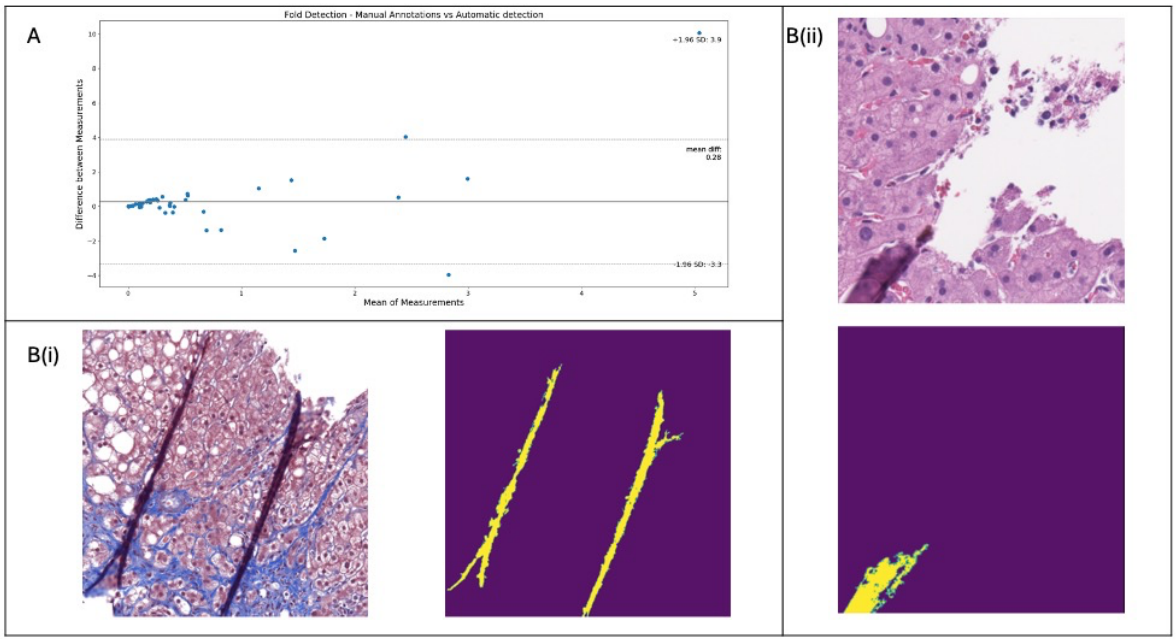

Figure 1: A - Bland-Altman plot showing agreement between Automatic and Manual detection methods. B(i) - Fold detection applied to TRC tile. B(ii) - Fold detection applied to H&E Tile.