A novel approach for 3D reconstruction of the prostate gland that allows tumour location, volume estimation, and Gleason characterization

Oliveira P.S.O.[1], Meena A.[2], Bonthu S.[2], Singhal N.[2], Sachdeva A.[1], Jain Y.[1], Ramani V.[1]

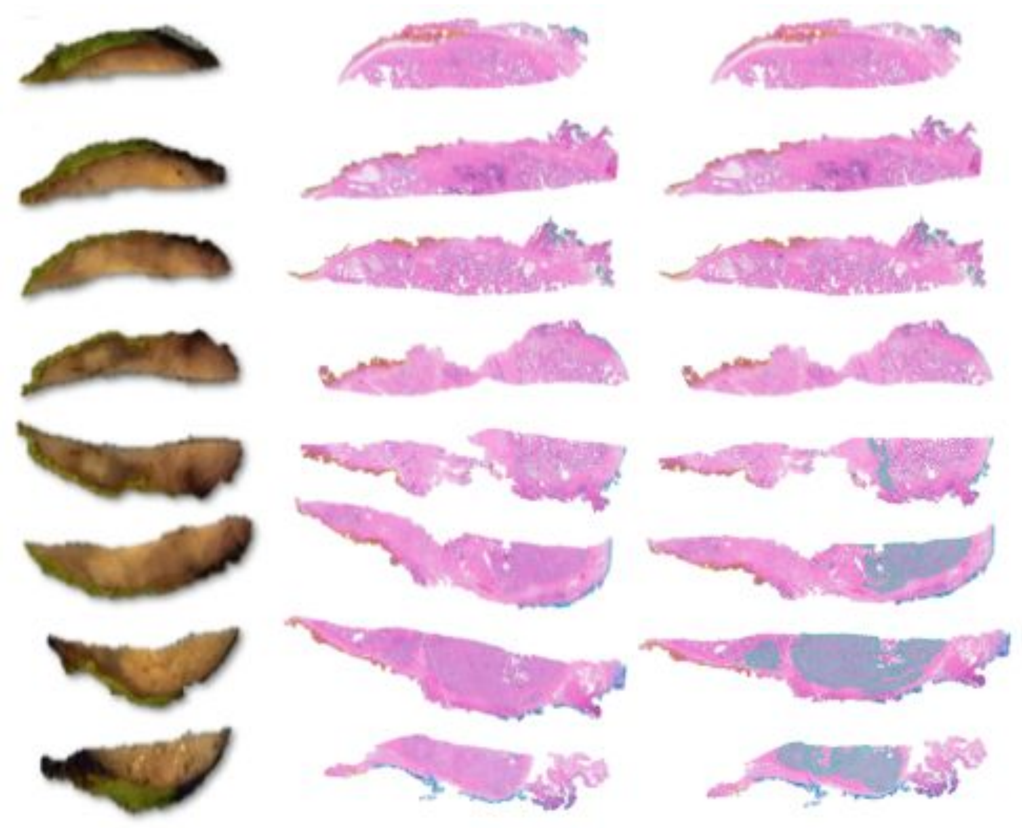
[1] The Christie Hospital, Manchester UK; The University of Manchester
[2]AIRA MATRIX Private Limited, Mumbai, India

Overview

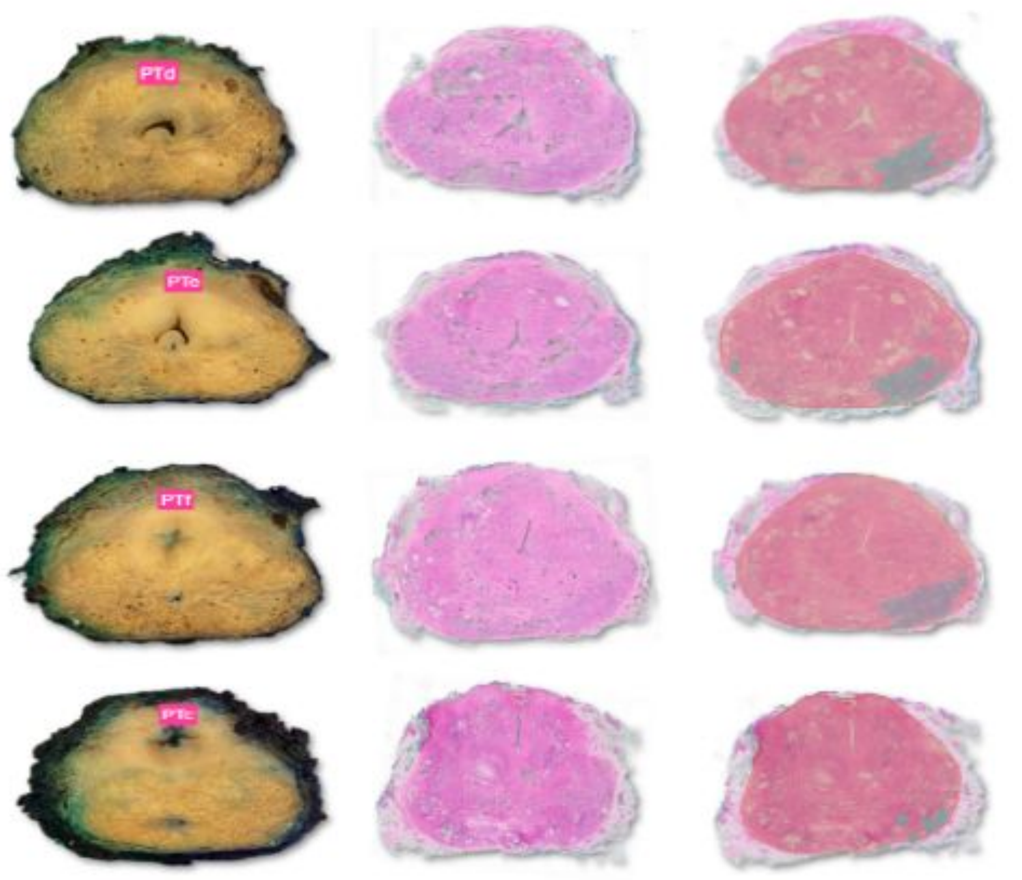
The ability to precisely define the tumour location on MRI may contribute to the development of enhanced prostate cancer interpretation tools and Deep Learning (DL) models. Radical prostatectomy specimens provide a unique opportunity to compare diagnostic mpMRI images with whole-mount histopathology images of the resected tissue, allowing accurate quantification of tumour location and volume. The extent of tumour can be immediately mapped to their matching mpMRI via registration of digital histopathology slides, resulting in accurate radiological tumour localization, including labels for tumour foci undetected by conventional mpMRI interpretation. The proposed method includes the following steps:

1. Localization of tumour in histopathology slides using DL

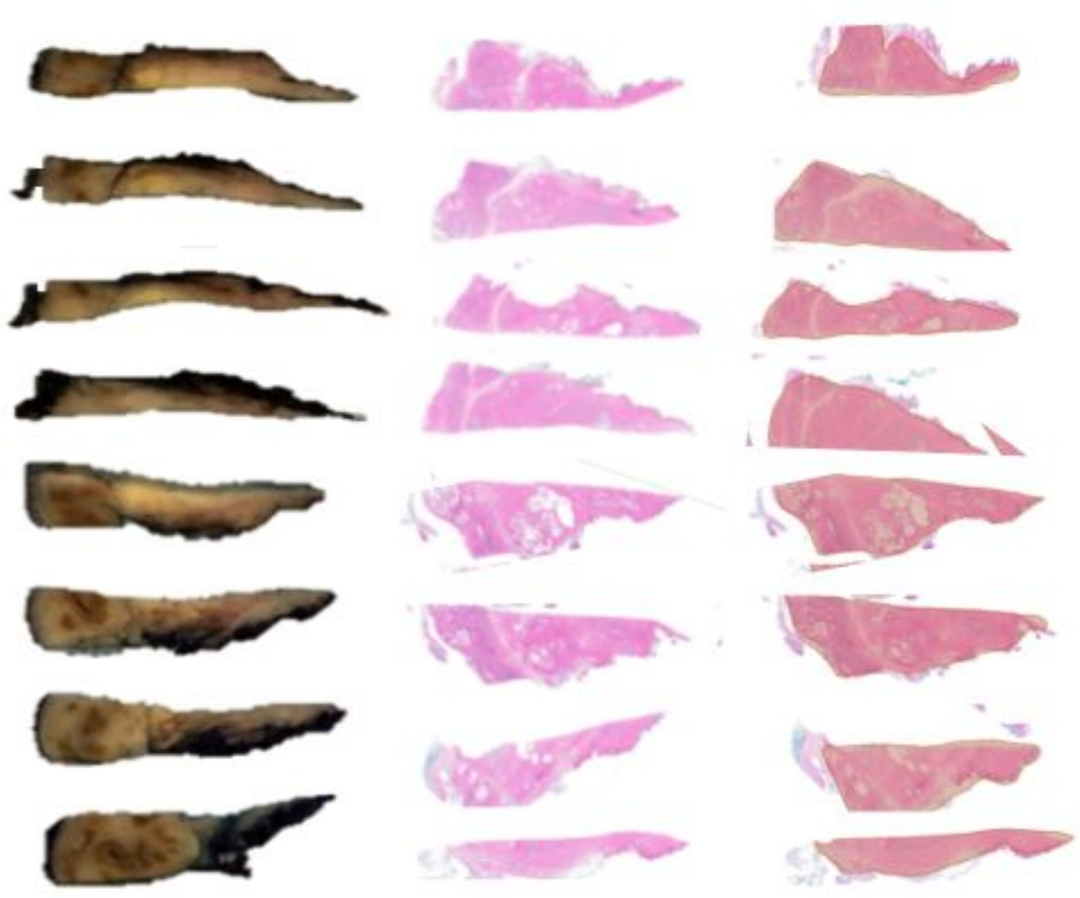
A multi magnification CNN-based model-based tumor detection on the RP images



Left, right, and top side inking were used to align and reorder apex slices.



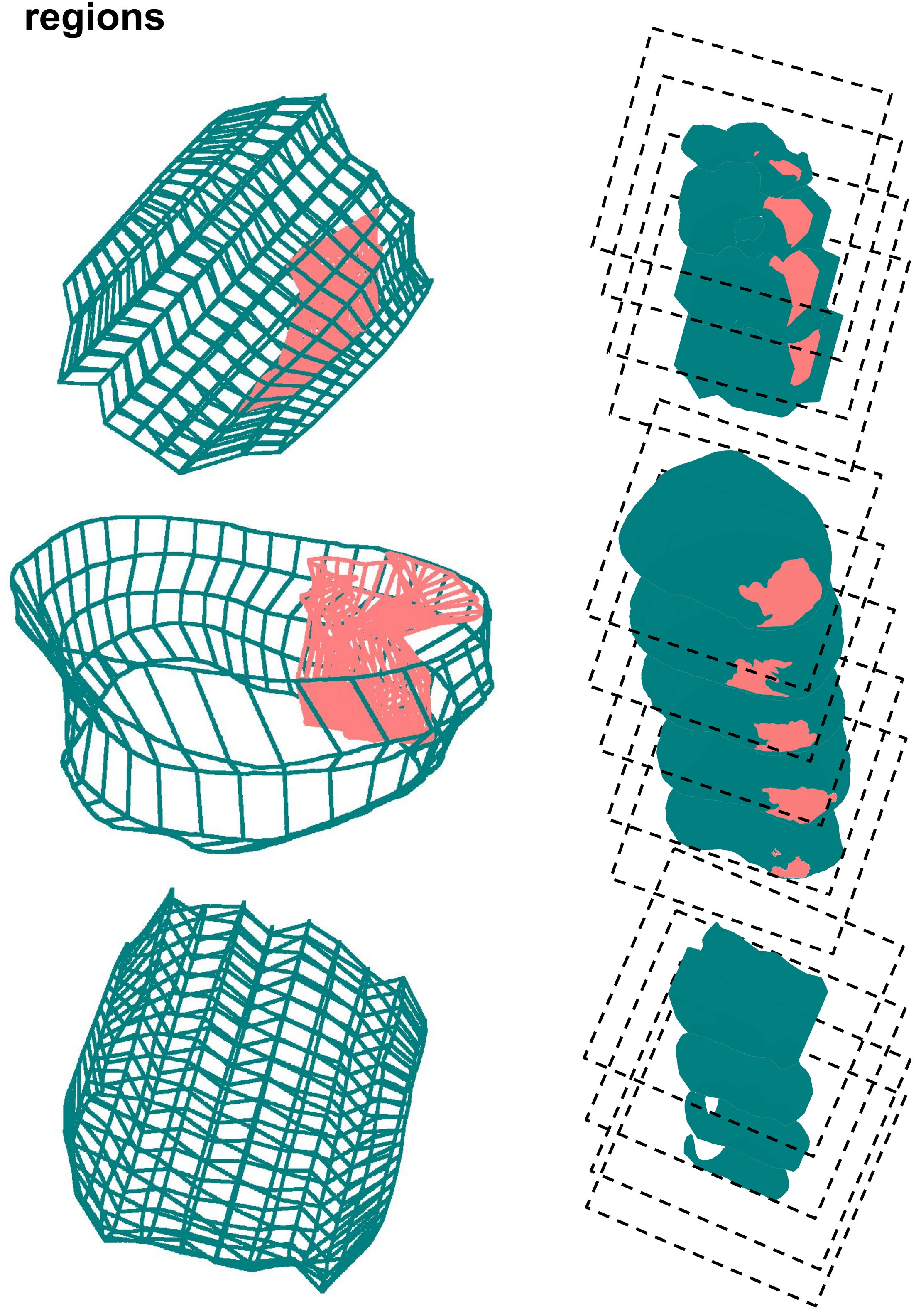
Centroids and left-right inking were used to align the middle slices.



Bottom slices aligned and reordered

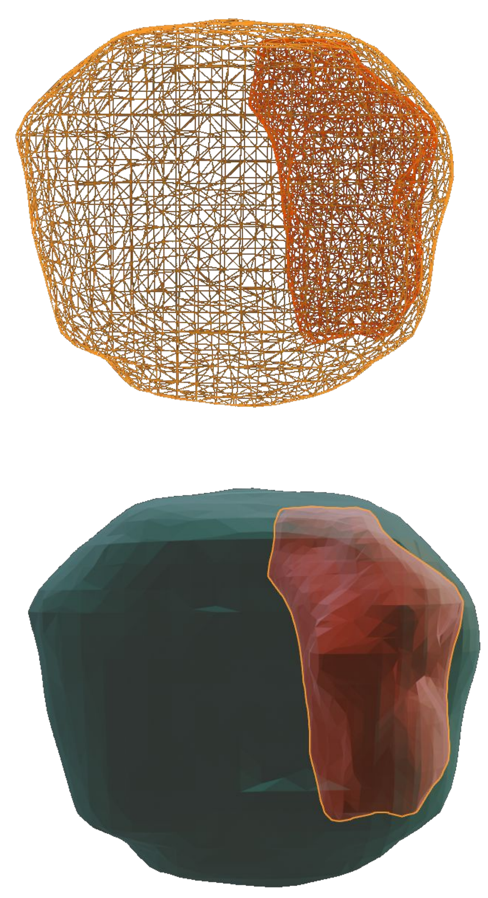
2. Reconstruction of 3D prostate volume from 2D H&E histopathology slides

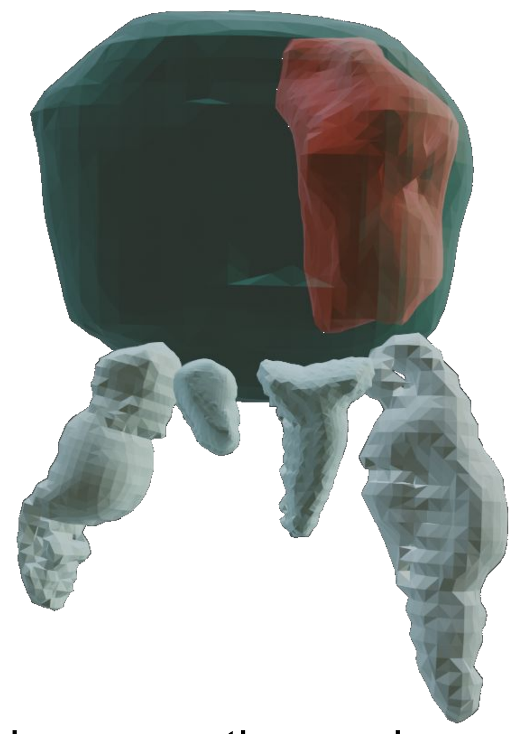
a. Simulation for intermediate prostatic and tumor regions



Using aligned slices, intermediate locations for the apex, middle part, and bottom are estimated. For plane alignment and comprehensive reconstruction, artificial slicing from reconstructed volumes is used.

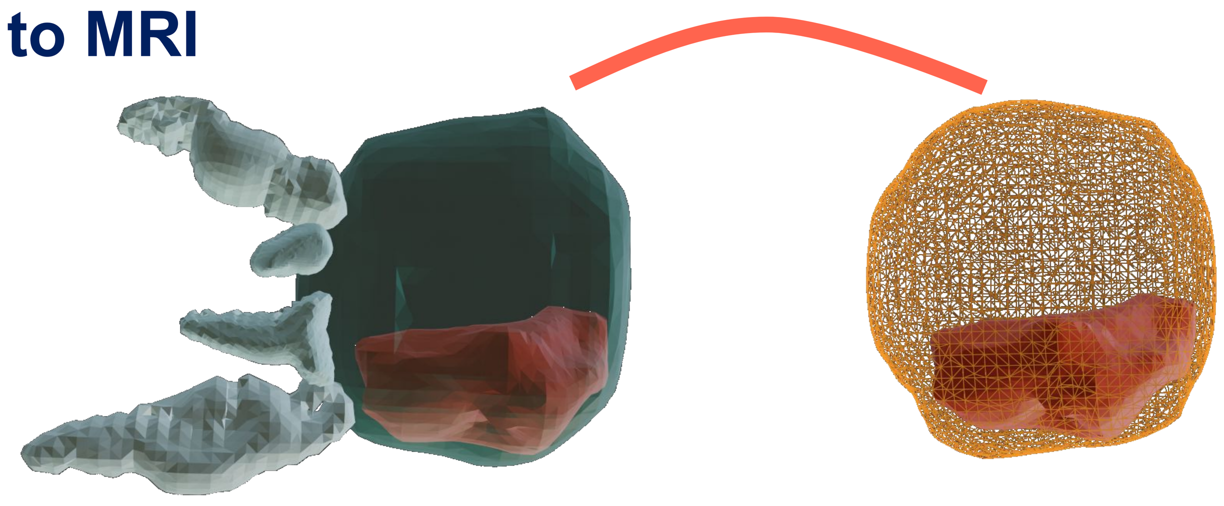
b. Triangle mesh generation using Poisson surface reconstruction





Mesh generation using point cloud system for prostatic and Tumor regions and attached reconstructed seminal vesicle

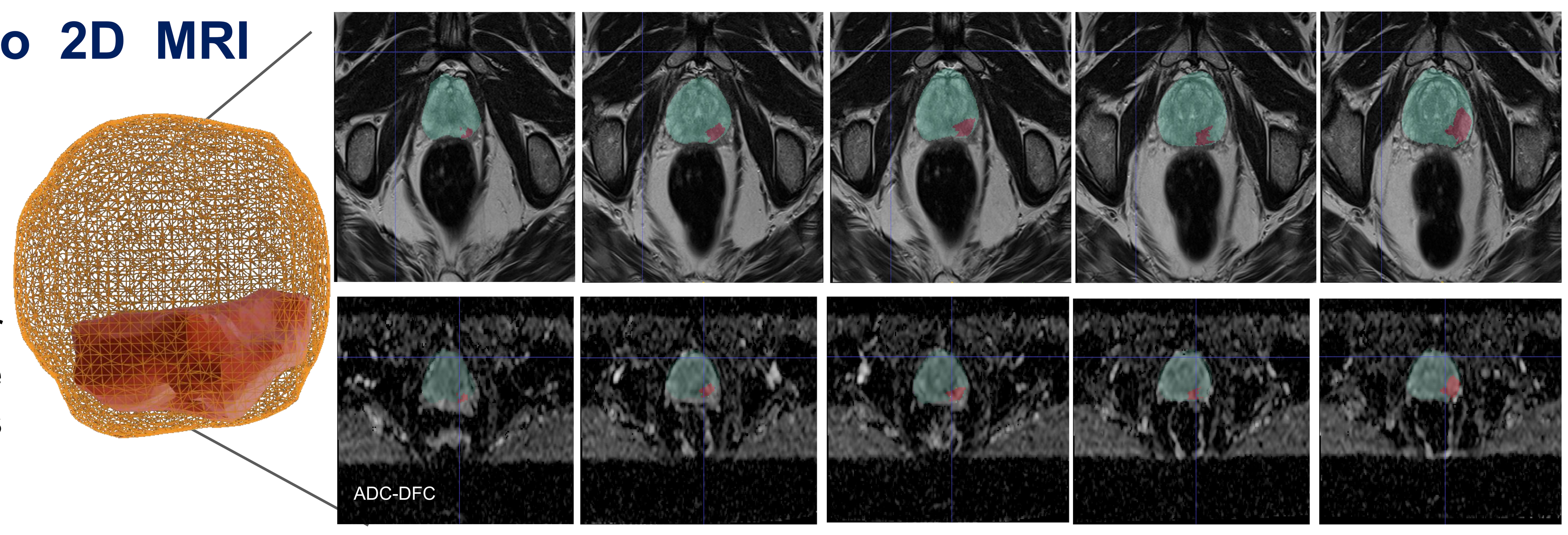
3. Transfer of tumour labels from Histology to MRI



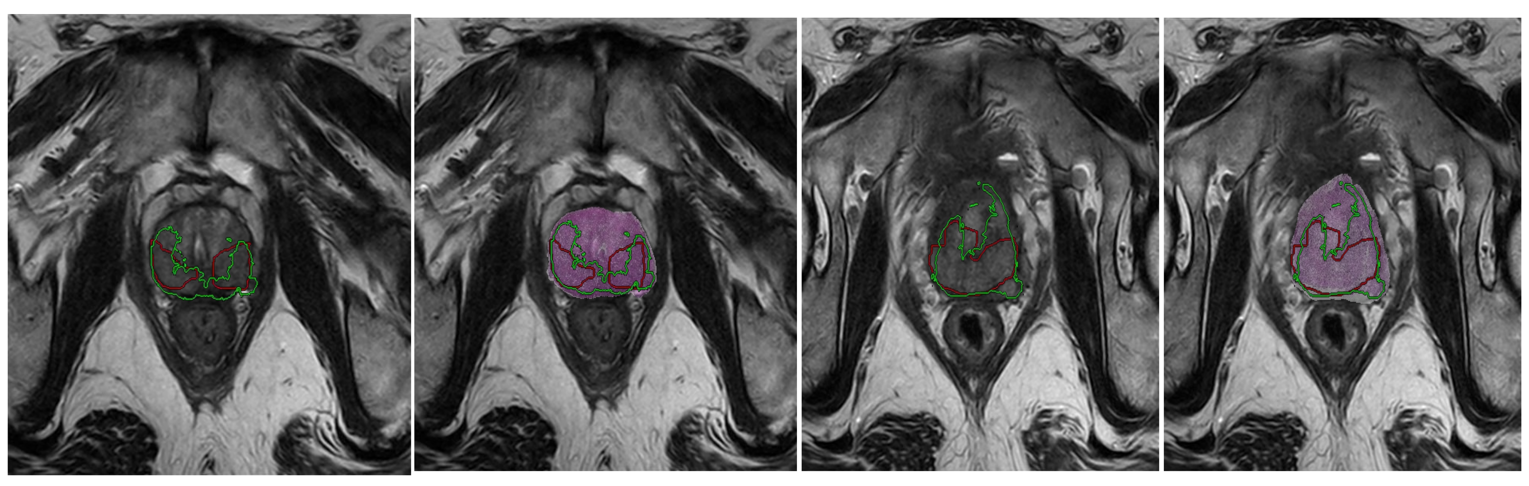
The estimated parameters to map the histology reconstructed volume over the MRI reconstructed volume are utilized to transfer the tumour label to the MRI.

4. Transfer of labels to 2D MRI slices

2D label slices were derived from the reconstructed MRI volume's transferred tumour volume. Extracted slices were mapped in several modalities using 2d slices.



5. Training a DL model for segmentation of tumour foci on MRI



Red: Boundary identified by radiologist; Green: Pathology-enhanced output for tumor identification

Training tumour model in MRI is based on transferred annotation from histology to MRI. In comparison to radiologist annotations, histology annotations provide a more refined border on MRI.

Conclusion

We present a novel method for reconstructing 3D prostate volume using 2D histopathology slides. Development of radiomics-based deep learning algorithms for unsupervised detection of tumour foci on diagnostic mpMRI will be aided by the accurate pathology-based MRI labelling using this approach.

Contact us at:
info@airamatrix.com | www.airamatrix.com

NHS The Christie NHS Foundation Trust

MANCHESTER 1824 The University of Manchester