Development and validation of a machine learning system for automated routine 2-dimensional morphometric measurements on female pelvic MRI

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IMAGENDO

Background

- Morphometric measurements in 2D and 3D assist in diagnosis and assessment of pathology on pelvic MRI. e.g.

⇒ The pubococcygeal line represents the level of the pelvic floor for grading pelvic organ prolapse [1].

⇒ A short anogenital distance is considered a strong diagnostic marker of endometriosis [2].

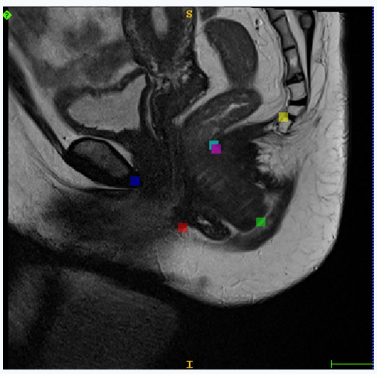
- Automating extraction of morphometric measurements can standardise and improve the efficiency of reporting.
- The purpose of this study was to develop a deep learning system to automatically perform routine morphometric measurements on female pelvic MRI.

Methods

- 300 sagittal T2 turbo spin echo (TSE) female pelvic MRI scans from the South Australia Medical Imaging (SAMI) database were extracted and split into a training/validation (200 and 50 scans) and test (50 scans) sets.
- Training/validation scans were annotated (SW) with ITK-SNAP [3] to define anogenital distance, pubococcygeal (PC) line, H-line, M-line.
- We utilised and compared image classification networks with various backbones pre-trained on the ImageNet database [4] and compared with landmark detection models based on the U-Net architecture [5].
- Data augmentation to increase training data diversity included rotations (± 30°), brightness (± 20%) and contrast (± 20%) scaling.
- Testing was performed by comparing annotations predicted by the models to those made by a Clinical Radiologist (SK).
- Measurement accuracy was assessed by comparing mean absolute error (MAE) between the ImageNet and U-Net models.

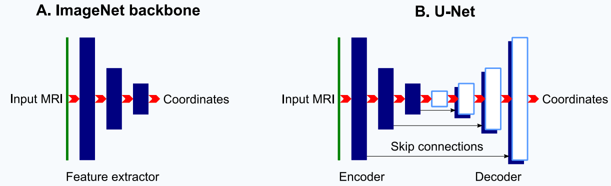
Results

1. Anatomical landmarks

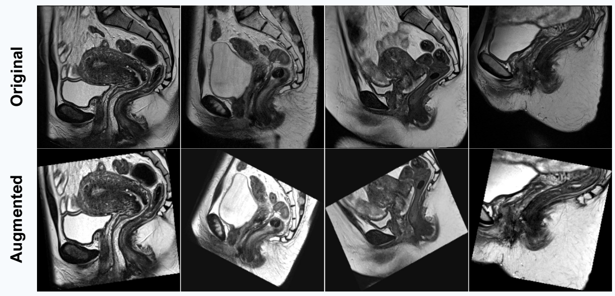


1. Fourchette (**Red**)
2. Centre anus (**Green**)
3. Posterior aspect inferior border pubic symphysis (**Dark blue**)
4. Anterior final coccygeal joint (**Yellow**)
5. Posterior aspect anorectal junction (**Light blue**)
6. Where M-line meets pubococcygeal line (**Purple**)

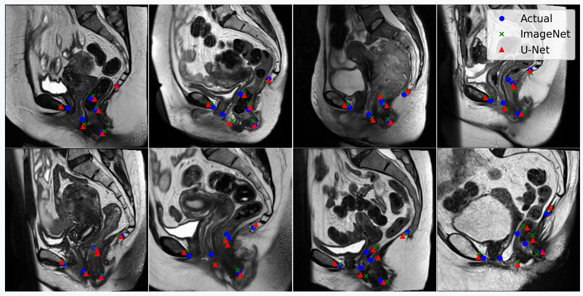
2. Neural network architectures



3. Data augmentation



4. Example predictions



5. Model performance

	Validation set			Test set		
Landmark	ImageNet MAE (mm)	U-Net MAE (mm)	P-value	ImageNet MAE (mm)	U-Net MAE (mm)	P-value
1 Fourchette	4.55	4.82	0.48	6.86	**6.57**	0.30
2 Cent anus	2.76	1.69	<0.001	3.25	**2.25**	<0.001
3 Pub symph	2.55	0.90	<0.001	**3.32**	4.85	<0.001
4 Coccyg jnt	2.390	1.89	0.0052	3.02	**2.71**	0.37
5 Anorect junc	3.18	2.88	0.23	4.71	**4.68**	0.91
6 M-line, PC	2.37	2.69	0.11	**3.25**	3.63	0.092

Conclusions

- Deep learning convolutional network models show promising performance in the automated detection and localisation of important anatomical landmarks on female pelvic MRI.
- Validation on external, multi-centre datasets containing a broad range of pathologies will enable deployment in clinical radiology workflows.

References

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