Automatic Segmentation of the Paediatric Femoral Head

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Aim To segment the paediatric femoral head from radiographs in an age group (1-16 years) where the pelvis undergoes significant development to aid in the creation of a novel objective detection metric for developmental dysplasia of the hip (DDH).

Motivation

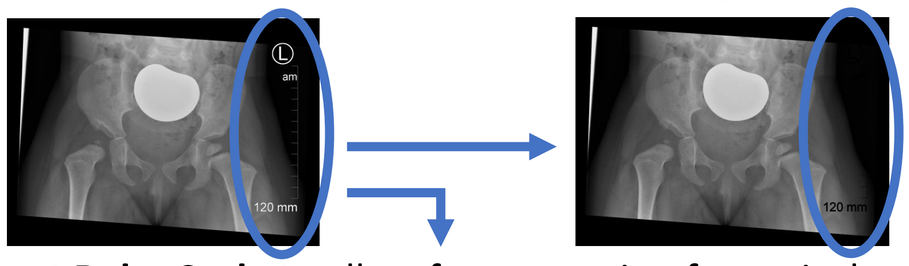
About the disease (DDH)

- ❑ An abnormal relationship between the femoral head and the acetabulum (hip socket) [1]
- ❑ Impacts the shape of the femoral head [4]
- ❑ Occurs in 0.1-3.4% of infants [1]
- ❑ Leads to osteoarthritis and total hip replacement [1]
- ❑ Early surgical intervention can treat the condition [2]
- ❑ Current definitions are subjective leading to inconsistent diagnosis [3]

→ **Segmenting the femoral head could provide valuable information to develop a novel objective metric based on femoral head shape and congruence with the acetabulum**

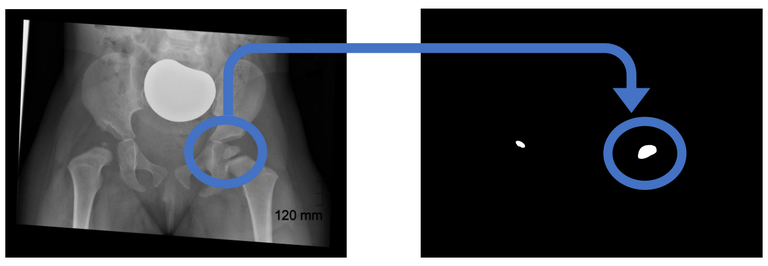
Methods

1. **Pre-process Dataset** to remove white markings

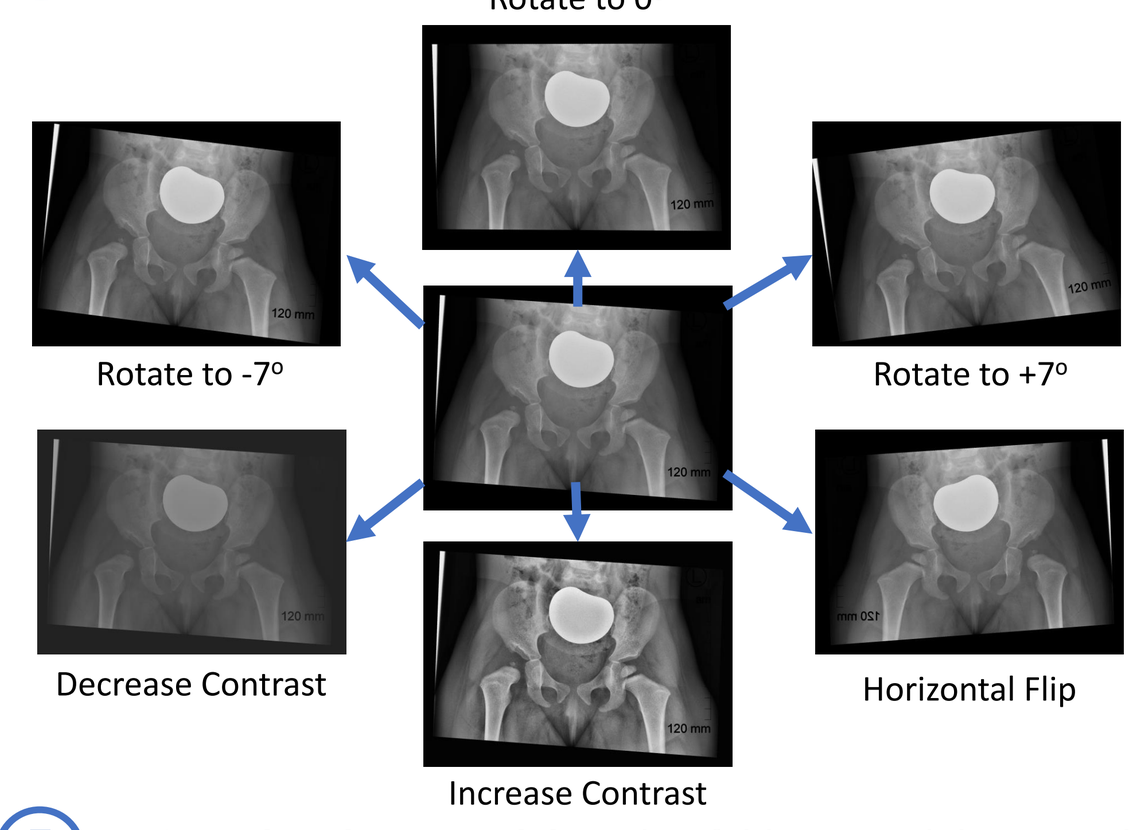


2. **Extract Ruler Scale** to allow for conversion from pixels to millimetres to best scale errors

3. **Create Binary Masks** of femoral heads



4. **Augment Data** (for one model) to compensate dataset size



5. **Train and Evaluate Models** with 5-fold cross-validation and compare using Dice coefficient

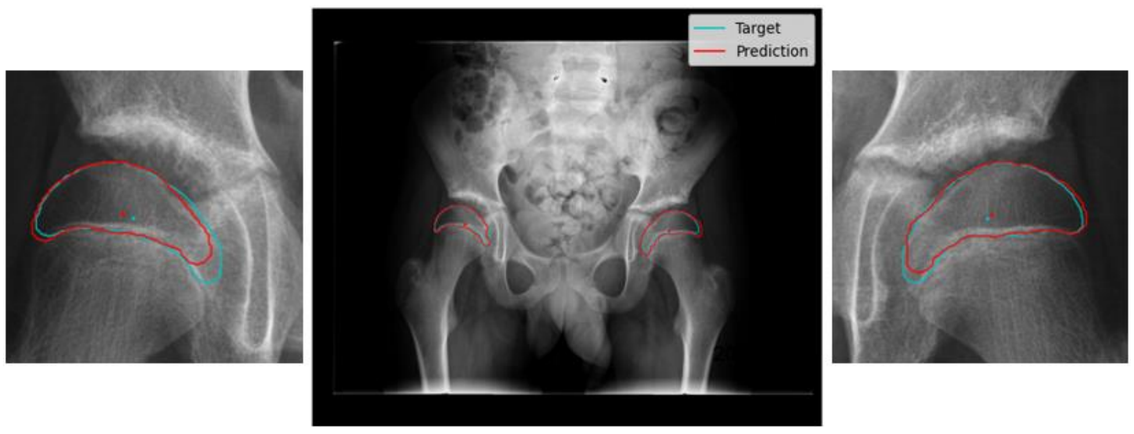
6. **Evaluate Centroid Error** using Mean Squared Error (MSE) in millimetres

Results

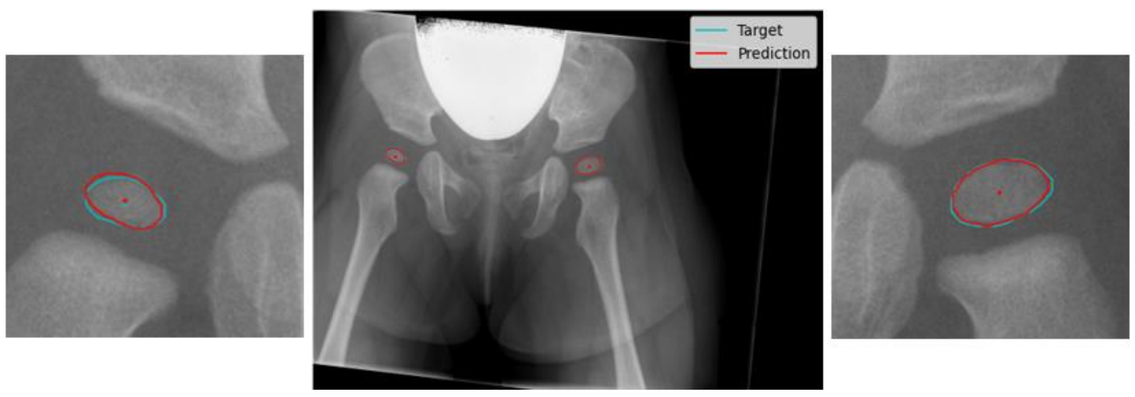
Data Augmentation	Dice Score	Centroid MSE (mm)
Yes	0.95±0.000041	0.53±0.053
No	0.92±0.022	0.60±0.72

- ❑ Paired t-test assessing model trained with and without data augmentation results in p=4.09e-23
- ❑ Results superimposed for U-Net trained with data augmentation

Older paediatric patient:



Younger paediatric patient:



Discussion

Conclusions

- ❑ Data augmentation leads to improved and statistically better ($p<0.05$) performance
- ❑ Visual inspection reveals images with ossification of the femoral physis have poorer segmentation

Limitations

- ❑ Lack of age/gender information to deal with data imbalances
- ❑ Small dataset (720 images total)

Future Work

- ❑ Develop models to annotate the images with additional clinically relevant landmarks
- ❑ Build a tool to assess the congruence between the femoral head and acetabulum in an objective, reliable way for DDH

Acknowledgments & Ethics

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