MAGIC – Multitask Adversarial Generator of Images and Contours from CBCT for Adaptive Radiotherapy

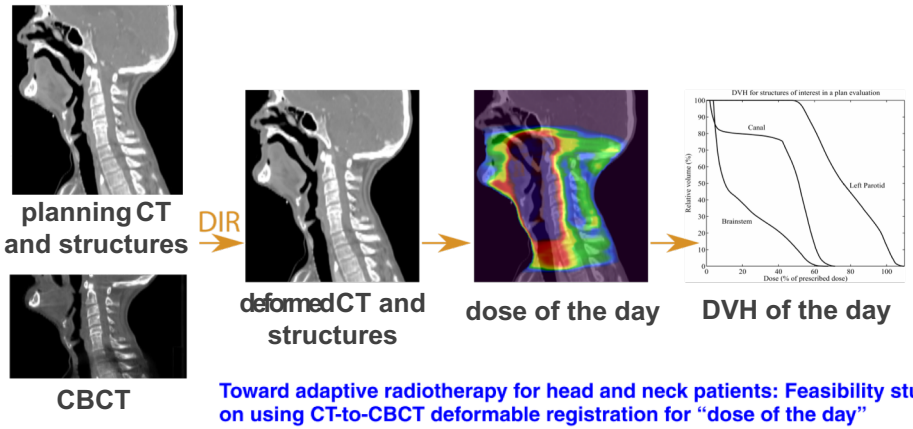
Adam Szmul, Kamalram Thippu Jayaprakash, Rajesh Jena, Andrew Hoole, Catarina Veiga, Yipeng Hu, and Jamie R. McClelland

Evaluating RT plans on daily anatomy

- CBCTs can be used to evaluate RT plans on daily anatomy
  - Facilitate adaptive RT
  - Estimate delivered dose for outcome studies

- This requires:
  - Synthetic CT (synCT) for dose calculations
  - Updated structure segmentations for DVHs

- DIR based solutions proposed ~10 years ago
  - Suitable for some anatomical sites, but not for others



Toward adaptive radiotherapy for head and neck patients: Feasibility study on using CT-to-CBCT deformable registration for "dose of the day" calculations

Catarina Veiga[a)]
Radiation Physics Group, Department of Medical Physics and Bioengineering, University College London, London WC1E 6BT, United Kingdom

Jamie McClelland
Centre for Medical Image Computing, Department of Medical Physics and Bioengineering, University College London, London WC1E 6BT, United Kingdom

Syed Moinuddin
Department of Radiotherapy, University College London Hospital, London NW1 2BU, United Kingdom

Ana Lourenço, Kate Ricketts, and James Annkah
Radiation Physics Group, Department of Medical Physics and Bioengineering, University College London, London WC1E 6BT, United Kingdom

Marc Modat and Sébastien Ourselin
Centre for Medical Image Computing, Department of Medical Physics and Bioengineering, University College London, London WC1E 6BT, United Kingdom

Derek D'Souza
Department of Radiotherapy Physics, University College London Hospital, London NW1 2PG, United Kingdom

Gary Royle
Radiation Physics Group, Department of Medical Physics and Bioengineering, University College London, London WC1E 6BT, United Kingdom

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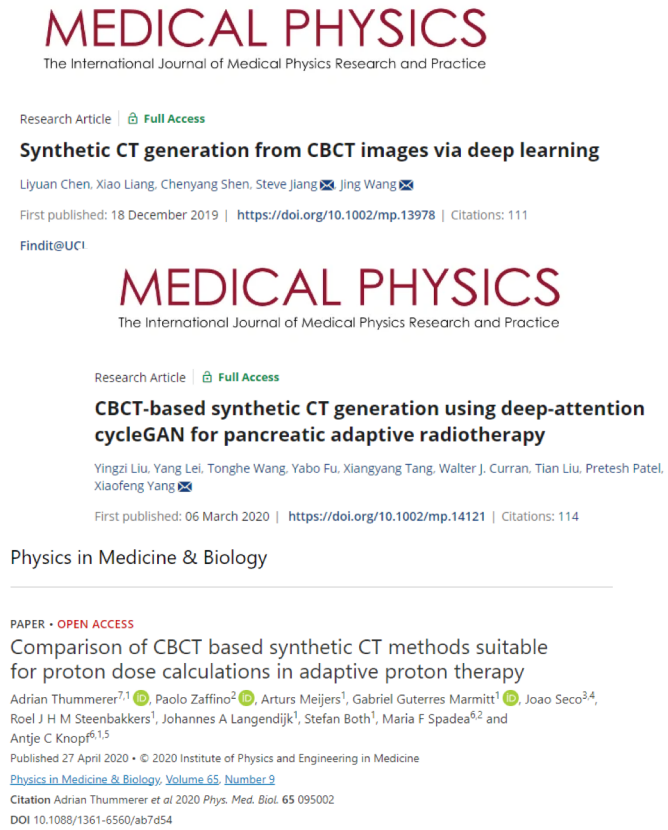
Evaluating RT plans on daily anatomy

- Learning based solutions proposed in recent years:
  - Several promising methods for synCT proposed in literature
  - Far less published work for auto-segmentation from CBCT

- Lack of training data for supervised methods
  - CBCTs not routinely segmented
  - Image quality can make manual segmentation challenging

- Potential approaches:
  - Generate synCT then auto-segment using network trained in planning CTs
  - Simulate CBCTs from planning CTs then train network on simulated data
  - Multi-task unsupervised learning approach



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Synthetic CT generation from CBCT images via deep learning

Liyuan Chen, Xiao Liang, Chenyang Shen, Steve Jiang, Jing Wang

First published: 18 December 2019 | https://doi.org/10.1002/mp.13978 | Citations: 111

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CBCT-based synthetic CT generation using deep-attention cycleGAN for pancreatic adaptive radiotherapy

Yingzi Liu, Yang Lei, Tonghe Wang, Yabo Fu, Xiangyang Tang, Walter J. Curran, Tian Liu, Pretesh Patel, Xiaofeng Yang

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Physics in Medicine & Biology

PAPER • OPEN ACCESS

Comparison of CBCT based synthetic CT methods suitable for proton dose calculations in adaptive proton therapy

Adrian Thummerer, Paolo Zaffino, Arturs Meijers, Gabriel Guterres Marmitt, Joao Seco, Roel J H M Steenbakkers, Johannes A Langendijk, Stefan Both, Maria F Spadea and Antje C Knopf

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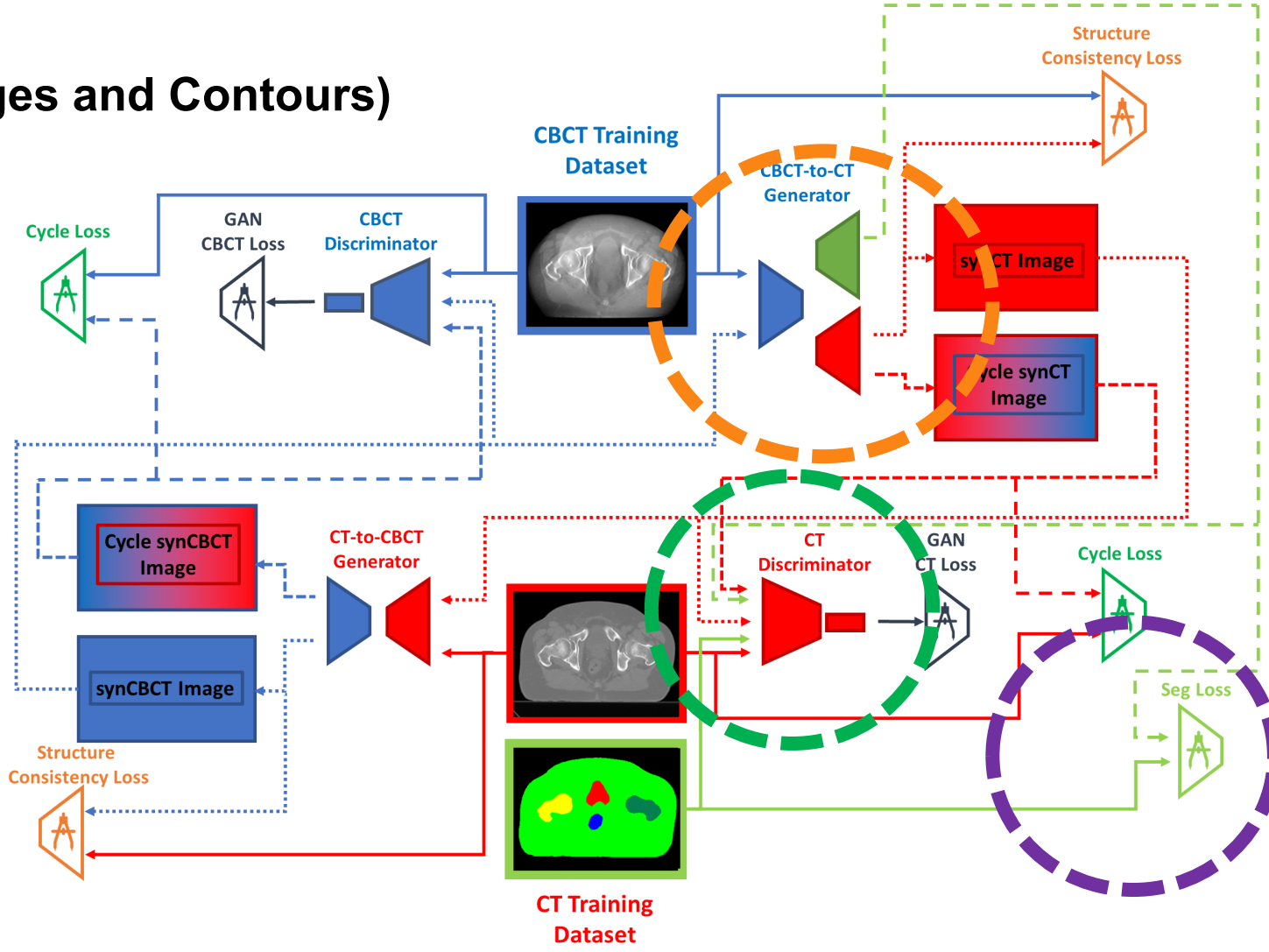
MAGIC

(Multitask Adversarial Generator for Images and Contours)

- Adapted cycleGAN used for synCT
  - Does not require paired data
  - Szmul et al 2023 PMB 68 105006
- Included two head generator on the CBCT->synCT arm for separate image and segmentation generation
- CT discriminator takes images and segmentations as input
- Cycle-consistency segmentation loss for CT structures



Materials:

CT:

- CTs from 144 patients
- Segmentations of bladder, rectum, left and right femur bones from the CTs

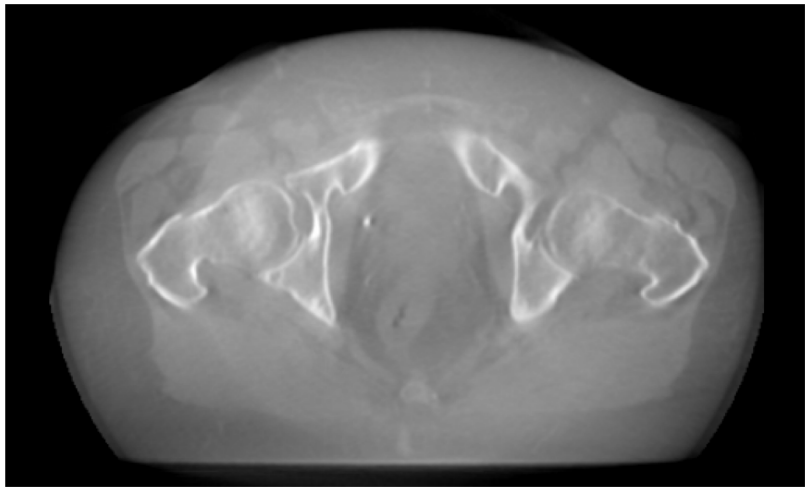
CBCT:

- CBCT from only 38 patients
- There were on average 20 CBCT scans per patient
- 29 for training 9 for testing

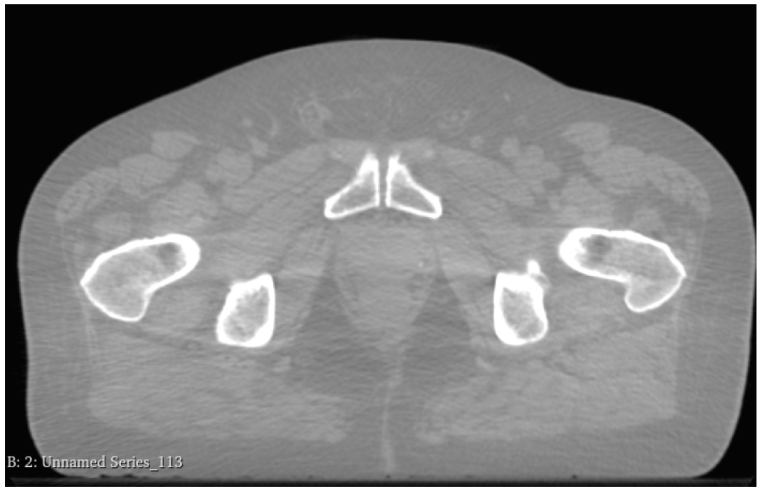
Data Challenges – CBCT field of view:

Truncated FOV

Almost full FOV

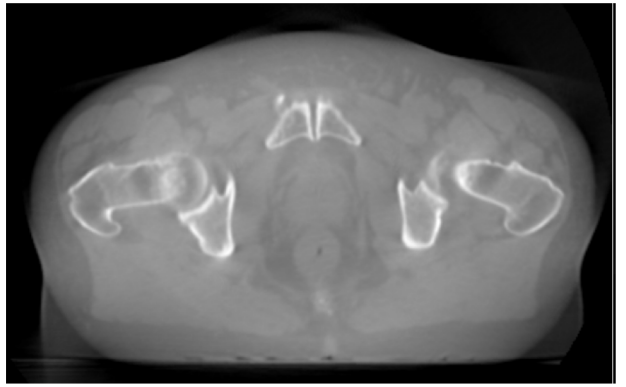


Full FOV



Evaluation:

CBCT



defCT

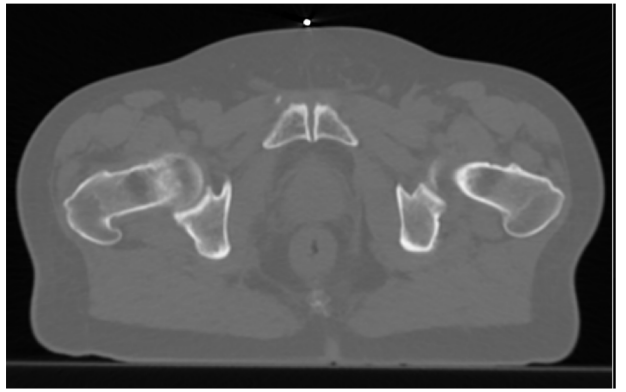


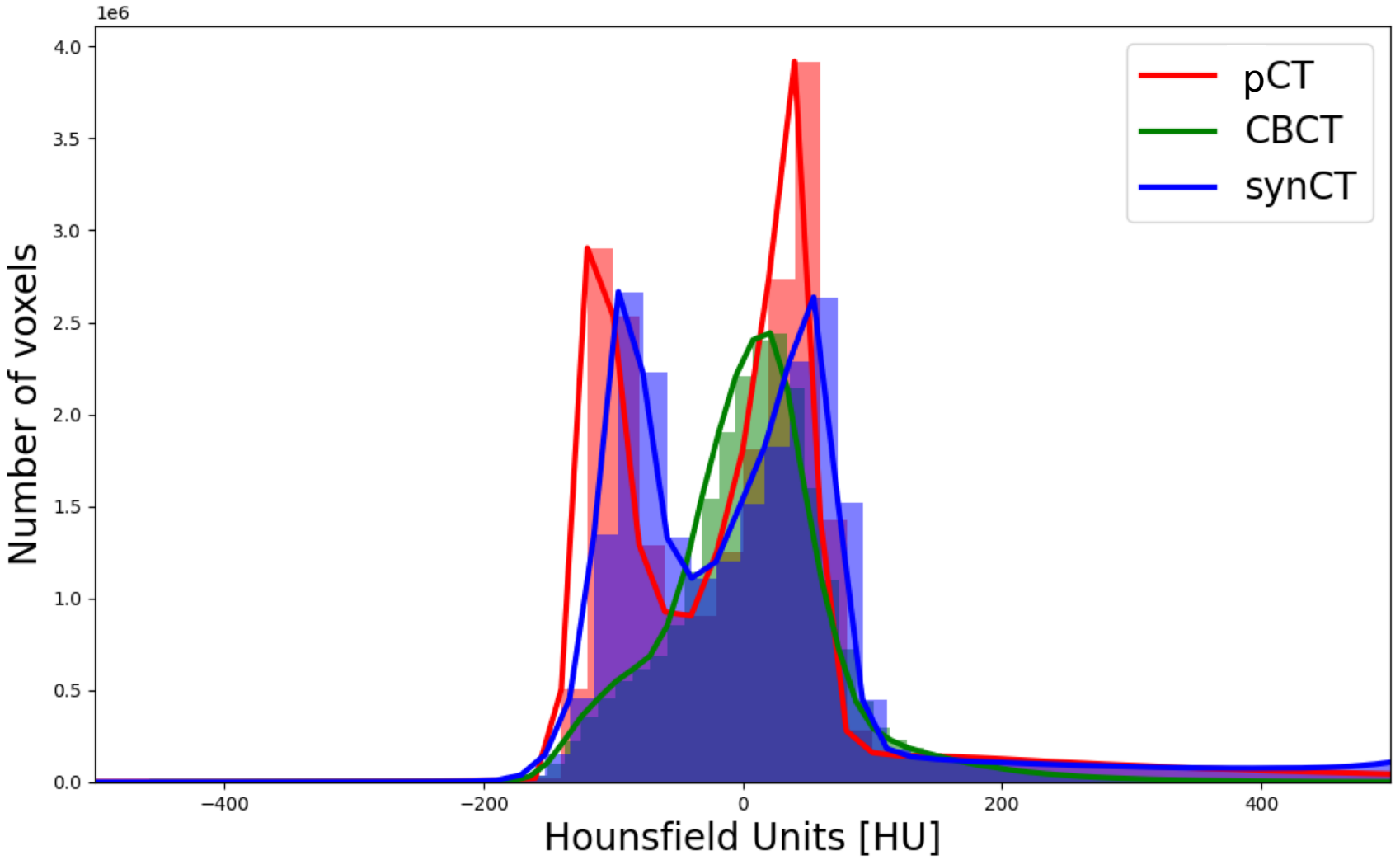
Image quality evaluation:

- L2 distance between intensity histograms
- Deformed planning CT (defCT) as ‘bronze standard’ ground truth
  - Mean Absolute Error
  - Normalised Cross Correlation

Segmentation quality evaluation:

- Qualitative evaluation (score each organ out of 4)
  - Clinically acceptable,
  - Minor edits required,
  - Major edits required,
  - Unusable.

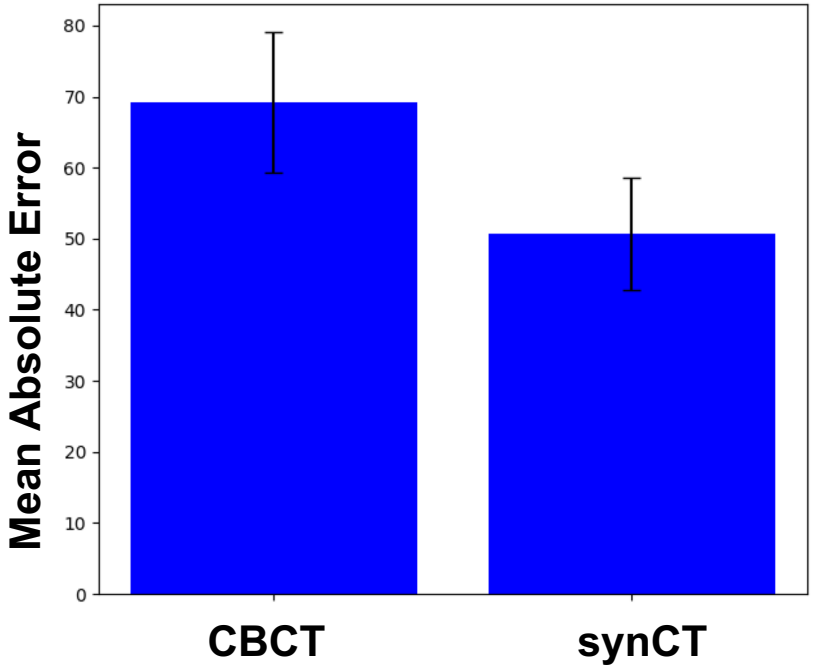
Histograms evaluation

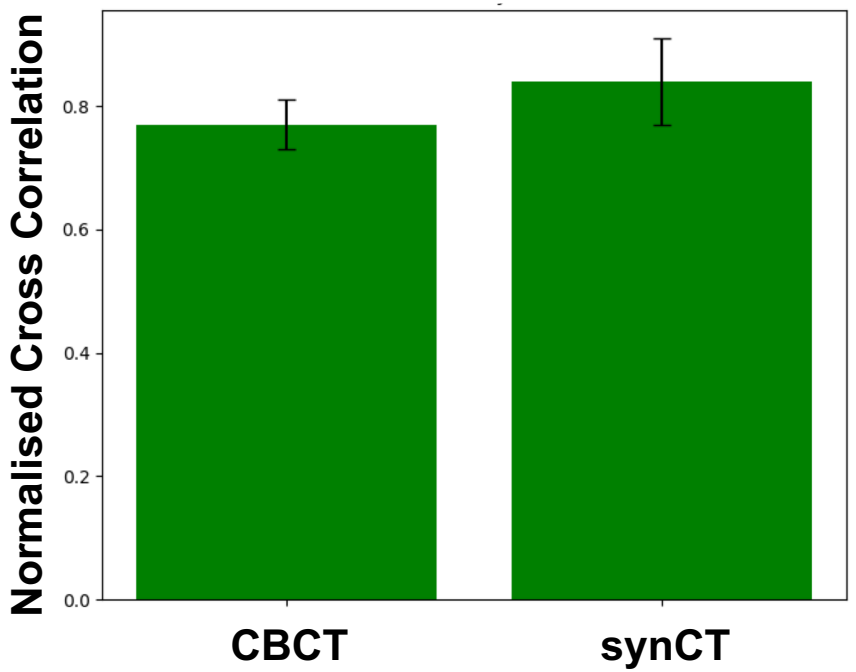


	L2 Distance
CBCT	2868
synCT	768

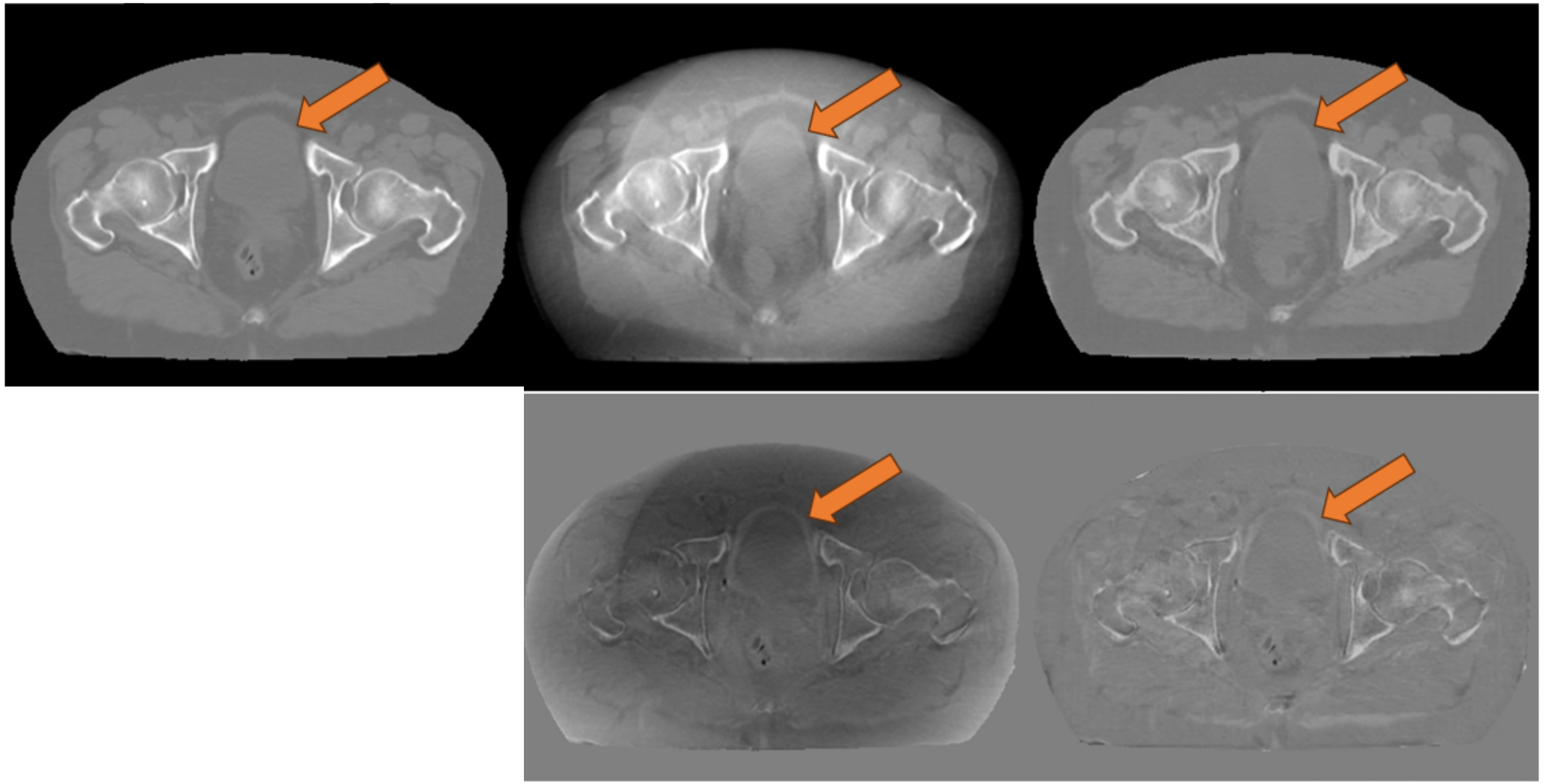
Evaluation

Synthetic CBCT image quantitative evolution





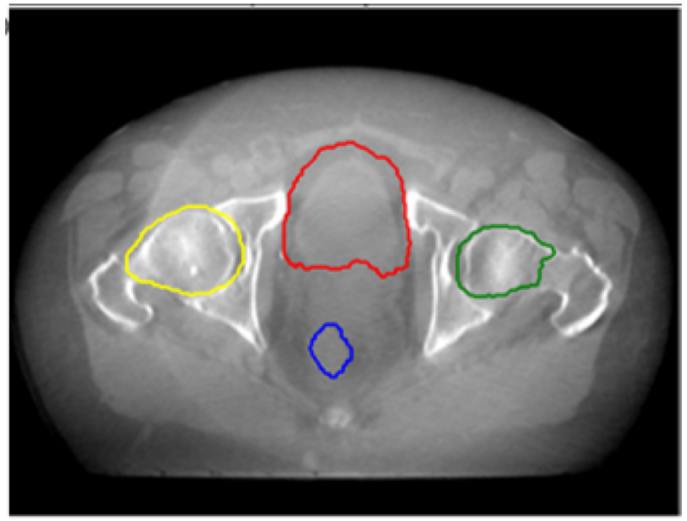
defCT CBCT synCT



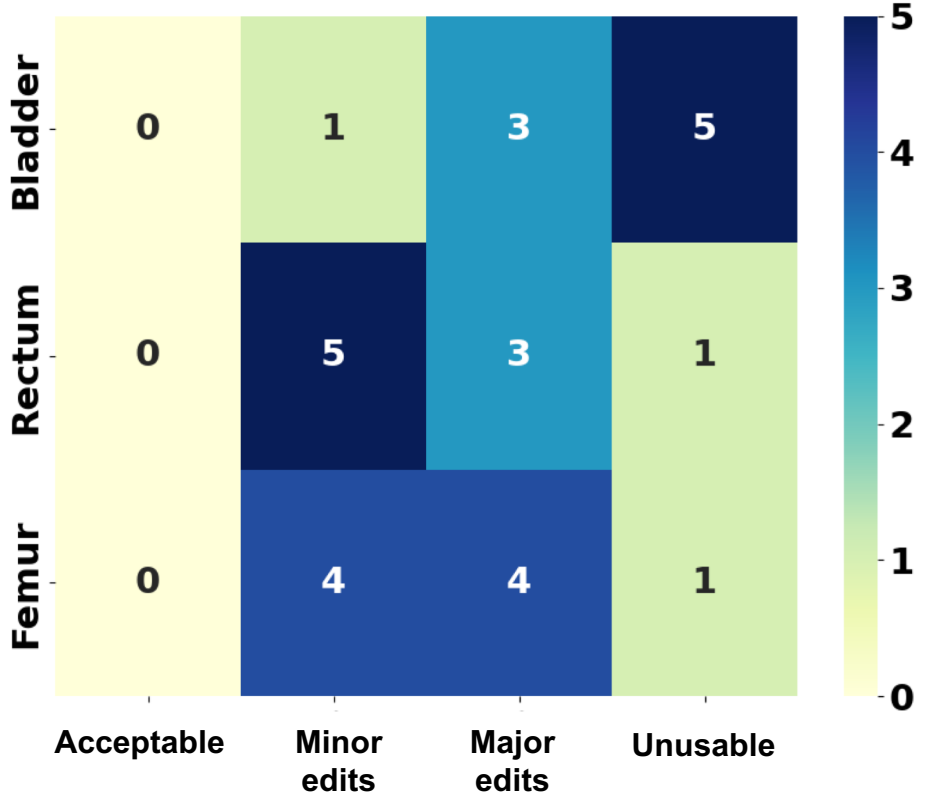
defCT - CBCT defCT - synCT

Evaluation

Qualitative segmentation evaluation

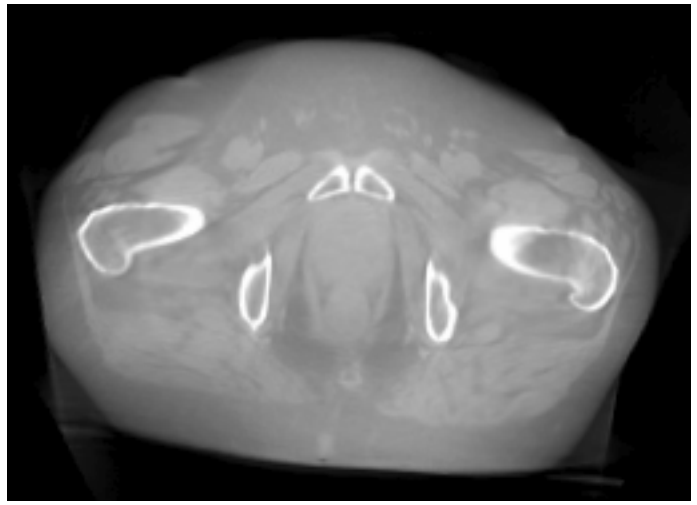


CBCT and segs

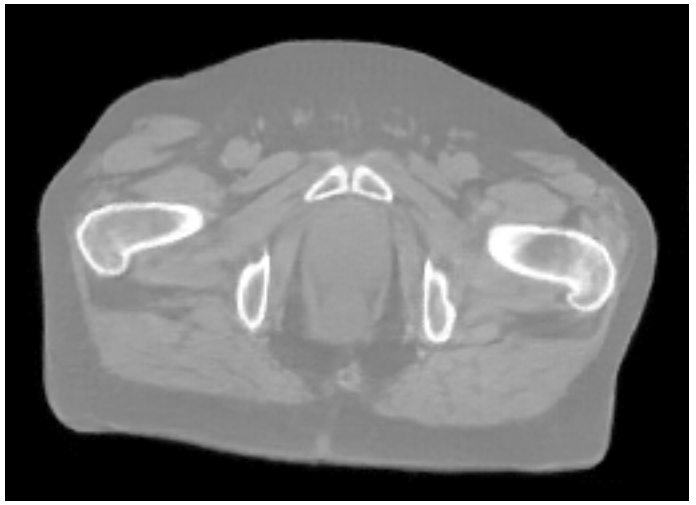


Synthetic CTs recover missing anatomy

CBCT



synCT



But it is correct?

Conclusions and future work:

- Proof of concept for joint synCT and segmentation generation from CBCT
  - Does not require paired CT-CBCT data
  - Does not require ground truth segmentation on CBCT
- Promising results
  - But need improving before ready for clinical use
- Future work:
  - Use more data
  - Further explore different network architectures and training strategies

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contact: a.szmul@ucl.ac.uk