BMD-GAN: Bone Mineral Density Estimation using X-ray Image Decomposition into Projections of Bone-segmented Quantitative Computed Tomography using Hierarchical Learning

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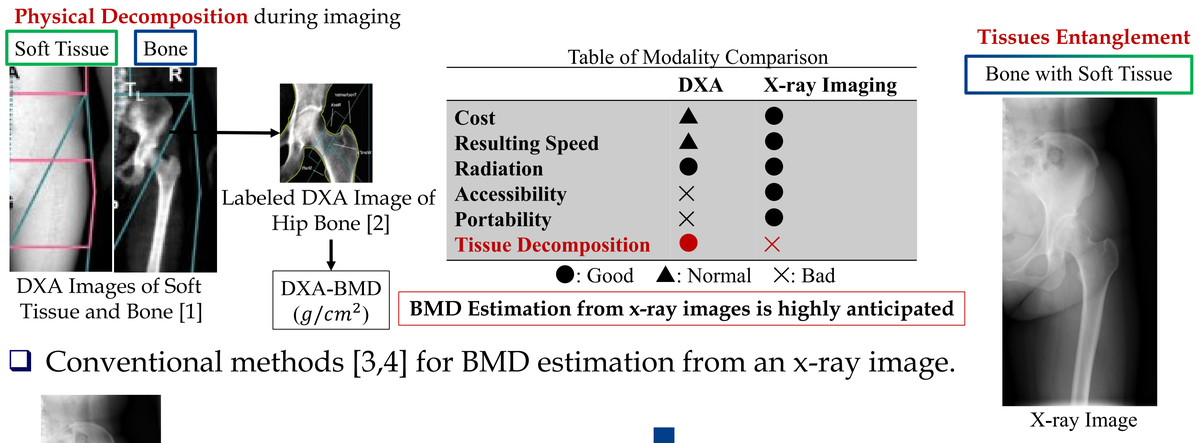
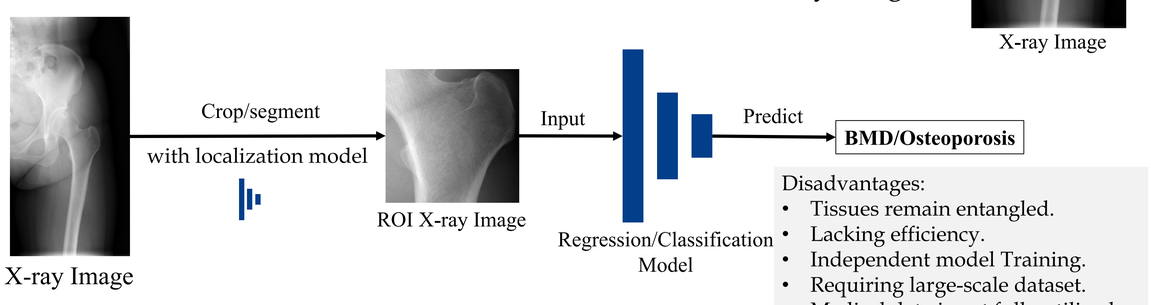
Introduction

- Dual-energy x-ray absorptiometry (DXA) is considered the goad standard for bone mineral density (BMD) estimation.
- Recent research focus on BMD estimation from X-ray images for opportunistic screening.



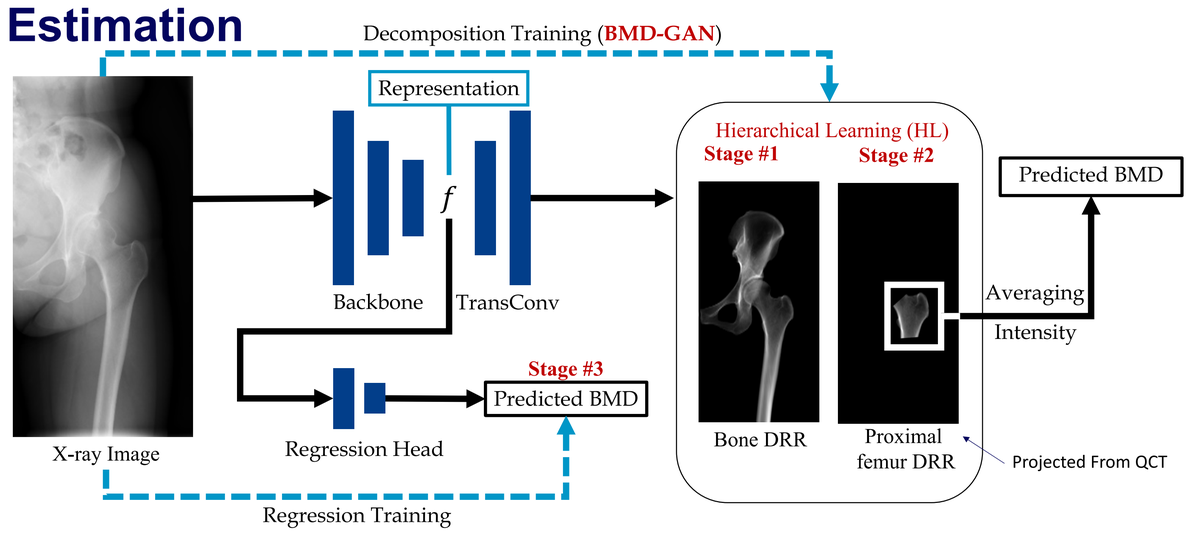
- Conventional methods [3,4] for BMD estimation from an x-ray image.



- Our Contributions:

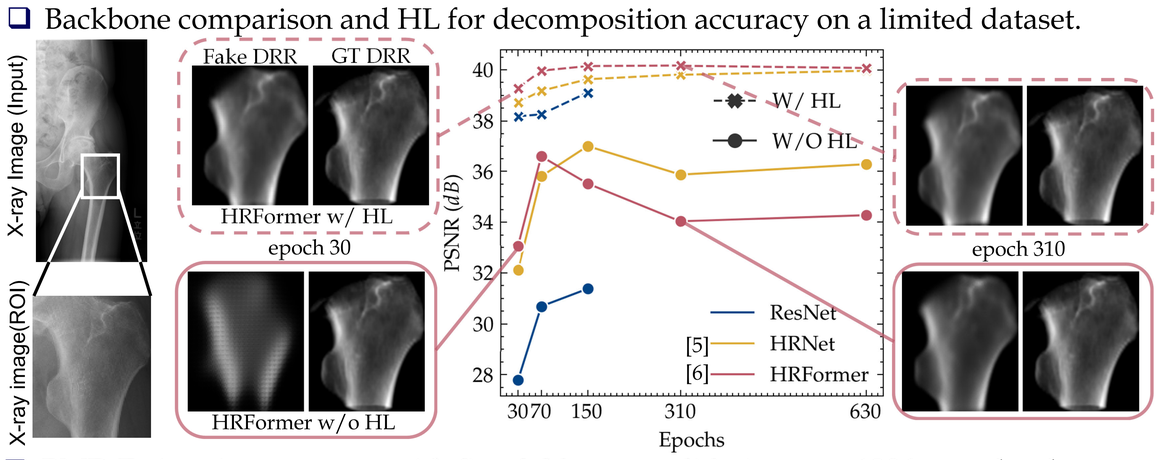
1. A method to estimate BMD from an x-ray image by decomposition using quantitative CT (QCT) under limited datasets.
2. Comparison of performance of different backbones.

Proposed Method: Digital Decomposition for BMD Estimation

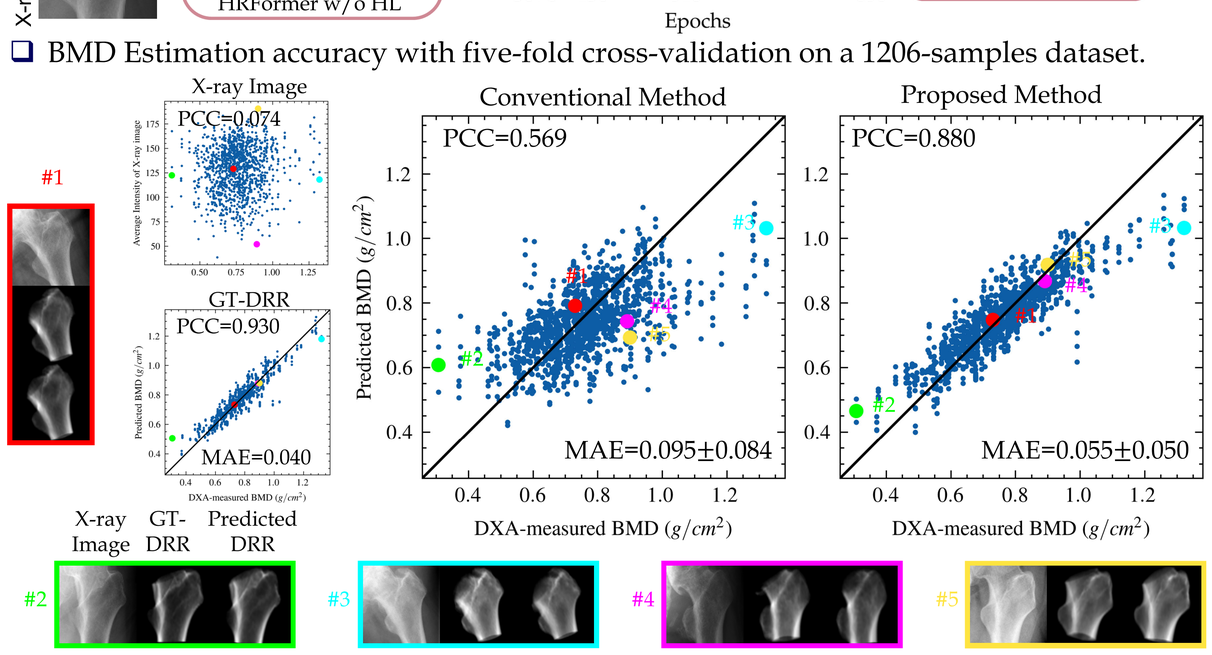


Results

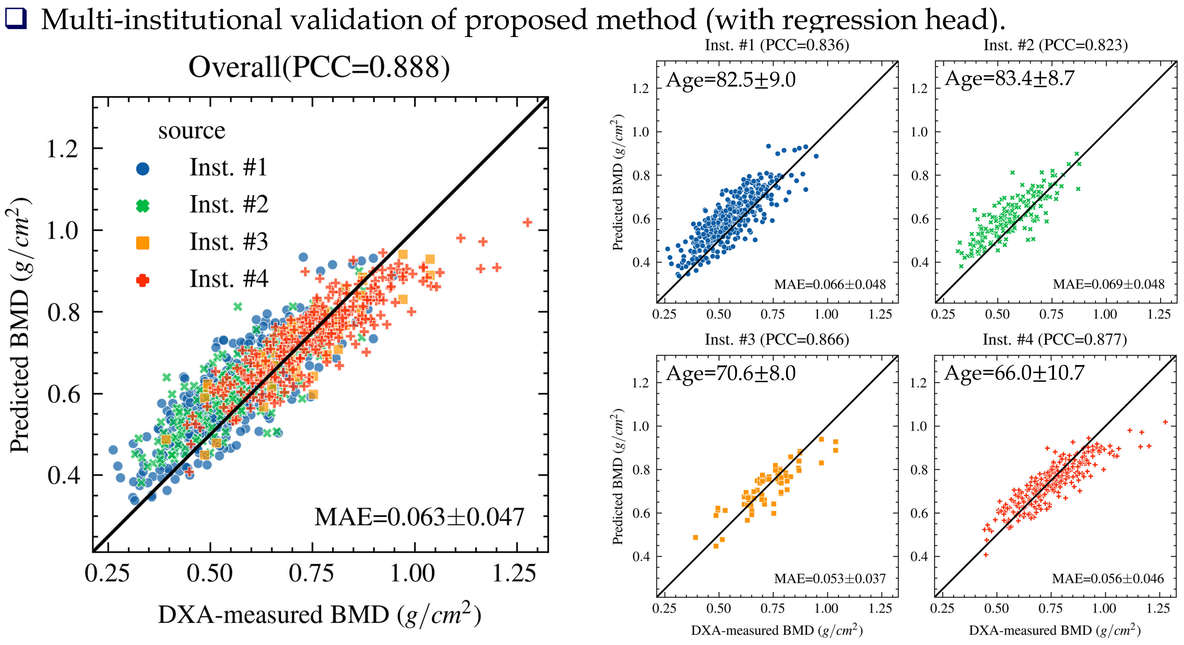
- Backbone comparison and HL for decomposition accuracy on a limited dataset.



- BMD Estimation accuracy with five-fold cross-validation on a 1206-samples dataset.

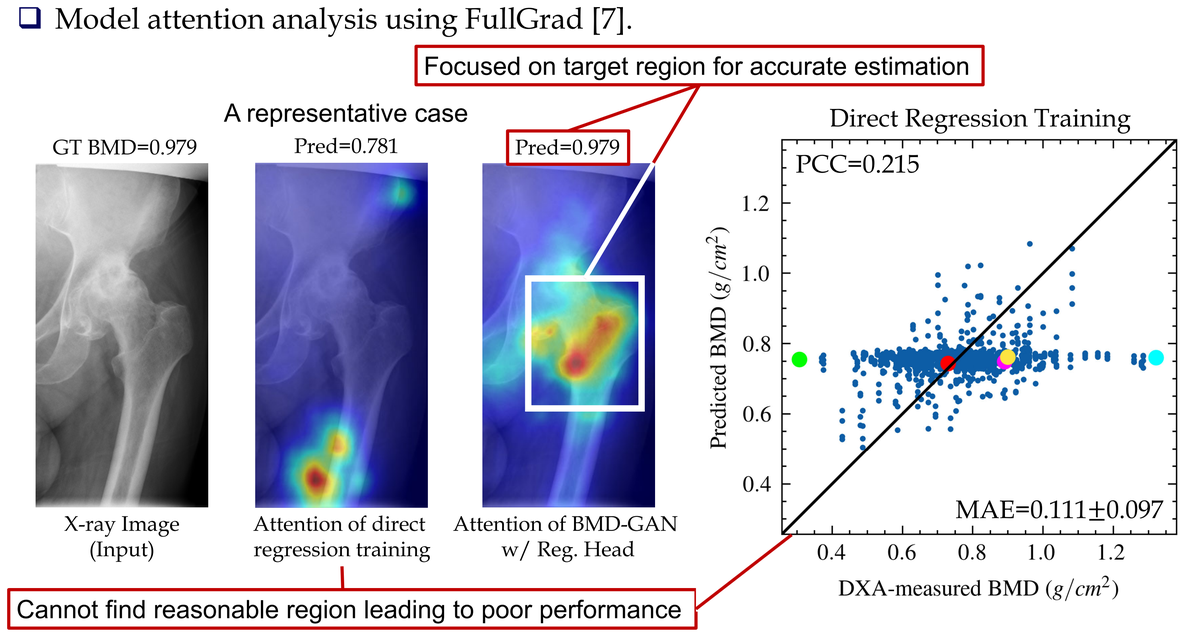


- Multi-institutional validation of proposed method (with regression head).



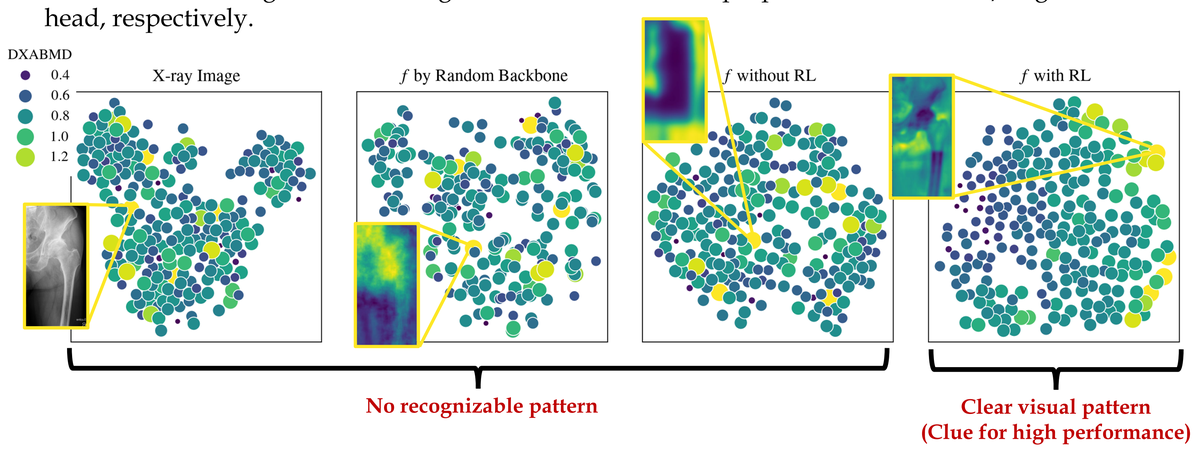
Discussion

- Model attention analysis using FullGrad [7].



- The learned representation visualized by T-SNE.

  Visualizing T-SNE of x-ray images, representations by the encoder with random initialization; the encoder of direct regression training; and the encoder of the proposed BMD-GAN w/ regression head, respectively.



Conclusion

- ✓ We proposed a decomposition method, BMD-GAN, for BMD estimation from an x-ray image utilizing CT.
- ✓ We compared the performance of Backbones, where HRFormer with the proposed HL showed best performance.
- ✓ Our method significantly outperformed the conventional method that uses multi-step inference and direct regression training.
- ✓ Further adding regression head to utilized the learned representation boosted the performance of BMD-GAN, especially for QCT-BMD estimation.
- ➢ Future works include incorporating phantom-free CT for accessing larger datasets, and contrastive learning for accuracy improvement.

References

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Code is available at https://github.com/NAIST-ICB/BMD-GAN

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