MODULAR ARTIFICIAL INTELLIGENCE MODELS FOR BODY COMPOSITION RESEARCH

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Introduction

- Body shape and body composition are comprehensive health indicators and have strong correlations to many diseases and health states1,2.
- Artificial intelligence (AI) and deep learning are ideal tools for analyzing large sets of high dimensional structural data, like medical images.
- We seek to explore the relationships between 3D body shape and dual energy X-ray absorptiometry (DXA) body composition.
- Large datasets are required for training powerful deep neural networks however, our 3D and DXA dataset is modest.
- We explore a method for training a deep learning model to overcome the data scarcity issue.

Objective

The objective was to train a deep network to learn meaningful information from DXA scans and use the subnetworks for the following task:
1. Predicting three-dimensional (3D) anthropometry from DXA scans
2. Generating analyzable DXA images from 3D body scans.

Methods

Data:
- DXA scans (n = 20,000) were split into a train, validate, and test set

DXA Neural Network Training:
- A variational auto-encoder (VAE)3, consisting of an encoder and a decoder subnetwork, was trained using a semi-supervised schema.
- Encoder takes the DXA image and learns a meaningful embedding of the image data.
- Decoder takes the embedding and reconstructs the corresponding DXA image

3D Anthropometry Training:
- The trained encoder was further trained on a dataset (n = 1103) to predict 3D anthropometric measurements from DXA scans.

3D to DXA Training:
- The decoder network was further trained on a data set (n = 1011) to generate DXA scans from 3D body scans

Results

DXA Pretraining:
- Our semi-supervised VAE training set up (Figure 1a) resulted in two trained subnetworks with good understanding of the DXA image structure.

3D Anthropometry Network:
- Task specific training of the encoder resulted in a neural network (Figure 1b) with the ability to accurately predict 3D anthropometry (Table 1) from an unseen test set (n = 186) of DXA scans.

3D Mesh to DXA Image Network:
- Using a 3D mesh network4 with the trained decoder (Figure 1c) allowed for the prediction of DXA scan from 3D mesh/image on an unseen test set (n = 145).
- Acceptable peak signal to noise ratio (PSNR) for 16-bit images above 20 db. Structural similarity index (SSIM) measure image reconstruction quality between 0 and 1 where 1 is a perfect reconstruction5. See Table 2.
- Analysis of actual and predicted DXA was performed on clinical commercial DXA software to quantify lean and fat soft tissue quantities as well as bone quality (Table 3).

Conclusion

- Our training schema allowed us to leverage our large DXA dataset to produce a modular DXA image deep learning model in which the two trained subnetworks can be further trained for task specific problems.
- The described methods are applicable to other data domains and can be useful when training data is scares.

References