UNIVERSITY OF HAWAIʻI
CANCER CENTER

Fiducial Point Placement on Total-Body DXA Scans with Deep Learning

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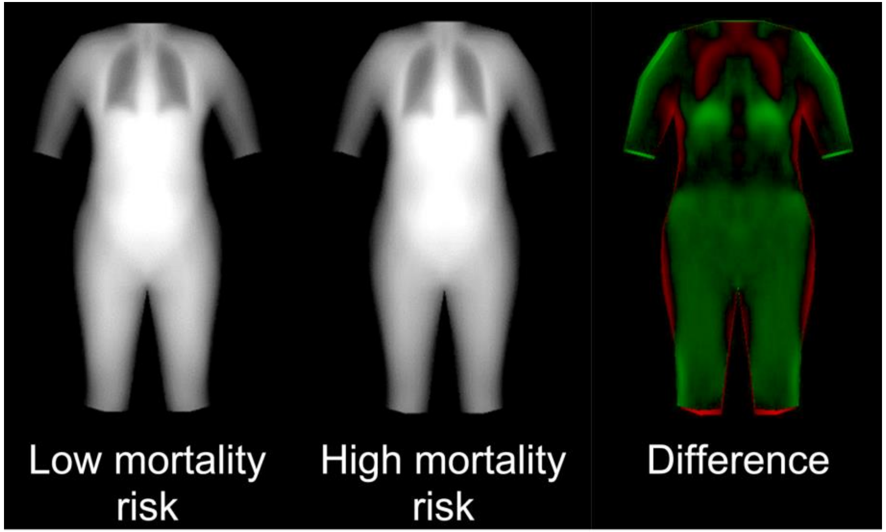
Background

- Dual-Energy X-ray Absorptiometry (DXA) scans can be used to quantify body composition and bone density for the whole body or specific regions.

- Pixel-wise body composition may provide a more sensitive way to **diagnose, predict and monitor disease** but represents a **significant computational constraint**.

- Shape and Appearance Modeling (SAM) is a viable alternative, but needs manual templating of 105 fiducial landmarks.

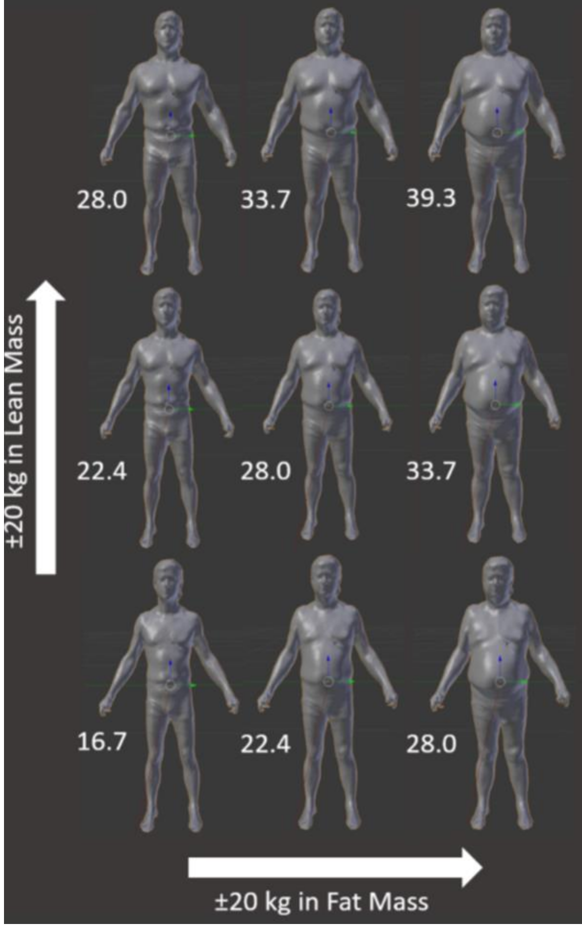


Shepherd, John A., et al. "Modeling the shape and composition of the human body using dual energy X-ray absorptiometry images." *PloS one* 12.4 (2017): e0175857.

Objective

To establish an artificial intelligence (AI) model which predicts 105 fiducial landmarks in whole-body DXA imaging.

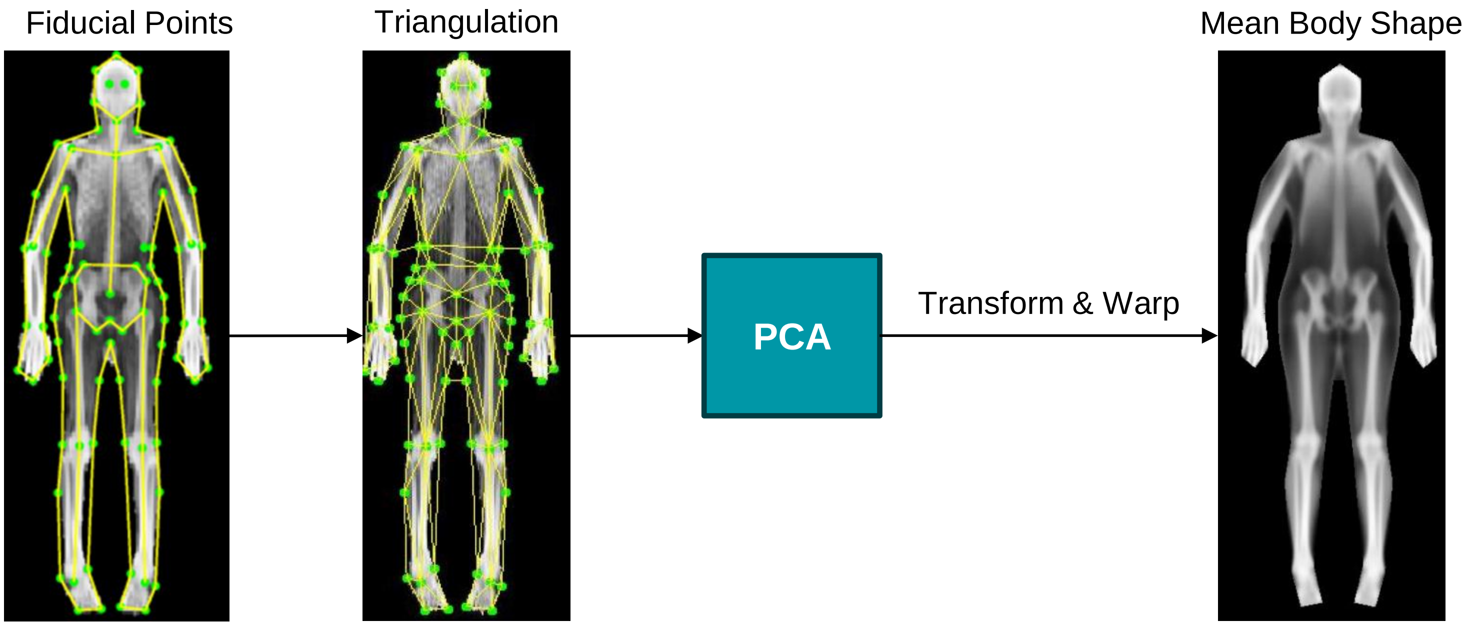
We hypothesize that **AI can place fiducial landmarks with high accuracy without human intervention,** enabling the use of SAM models on large repositories of DXA scans to establish models of disease.



Shepherd, John A., et al. "Evaluating the Accuracy of an Hallucinatory Algorithm to Predict Body Shape Changes from Dieting and Physical Activity."

Statistical appearance modeling

SAM from DXA allows us to examine directions of variability in body composition and body shape across the entire population and in subgroups of interest.



Shepherd, John A., et al. "Modeling the shape and composition of the human body using dual energy X-ray absorptiometry images." *PloS one* 12.4 (2017): e0175857.

DXA Dataset

Development Data

- 480 scans from Shape Up! Adults (SUA)
- 385 scans from Bone Mineral Density in Childhood (SUK)
- 409 scans from Multi-Ethnic Cohort (MEC)

Testing Data

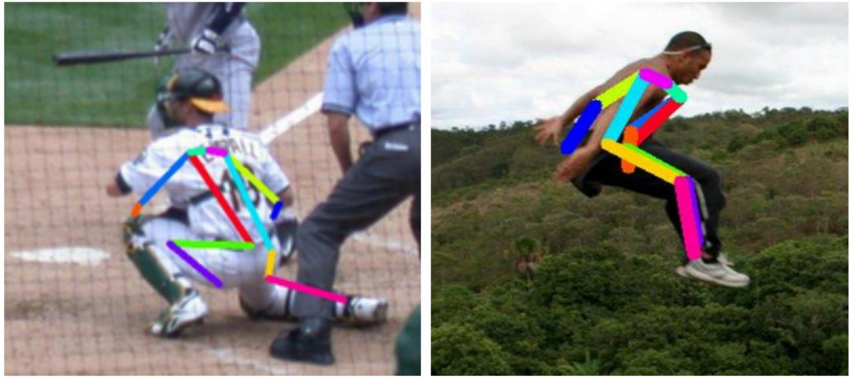
- 126 scans from Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS)

All scans are expert-annotated with fiducial points for performance computation.

AI Model

We finetune a **DeepPose** model using the MMPose open-source software library.

DeepPose was originally defined for **human pose estimation**, or the problem of localization and connection of human joints for skeleton reconstruction.



Toshev, Alexander, and Christian Szegedy. "Deeppose: Human pose estimation via deep neural networks." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2014.

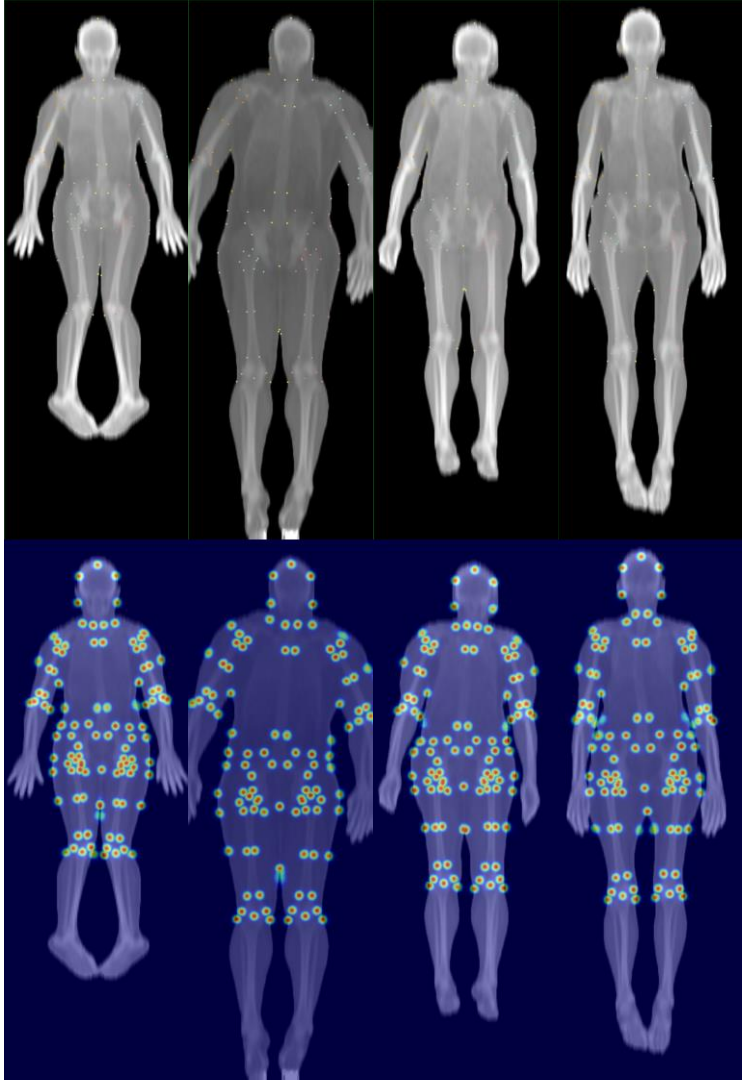
Results

Percentage of Correct Keypoints: 97.8%
End-Point Error: 20.98 pixels
Normalized Mean Error: 0.017 normalized pixels

The AI model predicts fiducial landmarks from DXA with high accuracy in unseen images.

$K = 105$ keypoints $N = 126$ test images
b_i = height of bounding box in the i-th image
d_{ij} = Euclidean distance between the predicted and ground truth locations of the j-th keypoint in the i-th image

$$EPE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{K} d_{ij}}{N \times K} \qquad NME = \frac{\sum_{i=1}^{N}\sum_{j=1}^{K} \frac{d_{ij}}{b_i}}{N \times K}$$



Questions?

Shepherd Research Lab

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Next Steps:

1. Expand held-out testing set to 500 scans
2. Map image coordinates to DXA table coordinates
3. SAM on HANDLS

Sadowski Group