Deep Bone Extraction in X-Ray Projection Domain

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GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

Research for a Life without Cancer

Overview

Task

Decomposition of radiographs into the contributions made by bone and soft tissue respectively.

Approach

Training the Deep Bone Extraction (DBE), a CNN with UNet architecture to perform this decomposition.

Results

DBE performs a tomographically consistent, high-quality extraction of bone and soft tissue contributions.

Materials and Methods

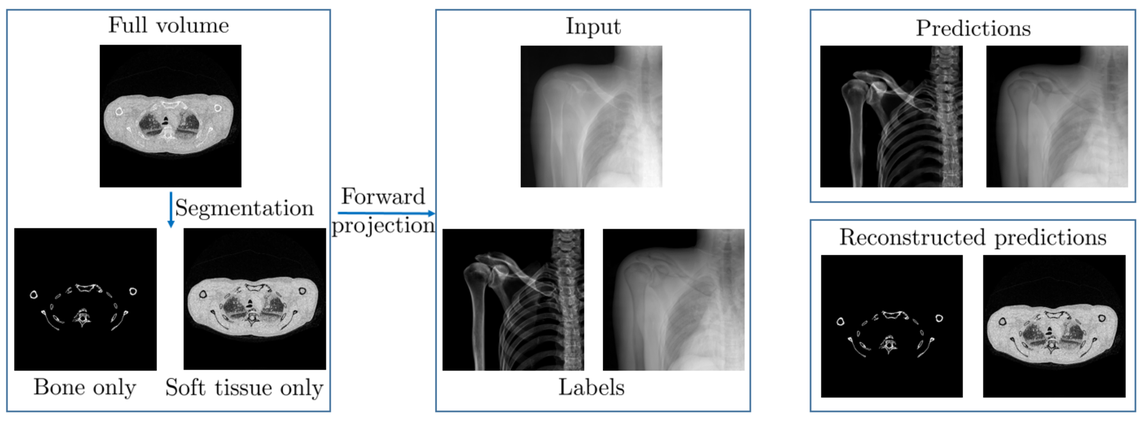

Fig. 1: General pipeline of the Deep Bone Extraction.

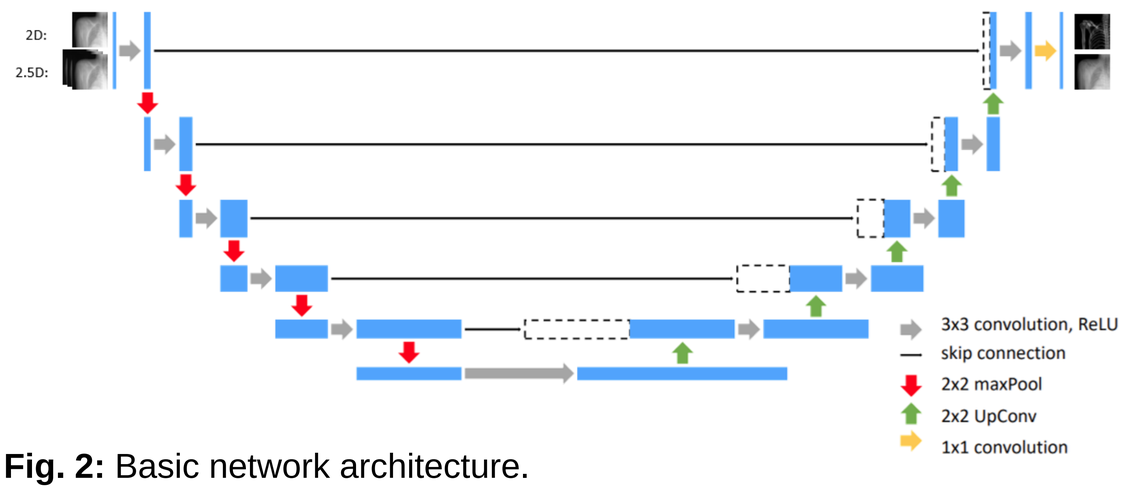

Fig. 2: Basic network architecture.

Variations of Architecture and Training Process

- Implementation as 2D and 2.5D UNet
- Projection configuration in 2.5D UNet
- Multitask vs. single-task training
- Replacing bone with different substances in the soft tissue only projections
- Prediction quality difference between AP and lateral projections

Potential Applications

- Bone suppression and enhancement in radiographs
- Improved higher-order beam-hardening correction in CT
- 2D/3D registration

Results

We evaluate our results in projection domain and their reconstructions in image domain using MSE, SSIM, and DICE.

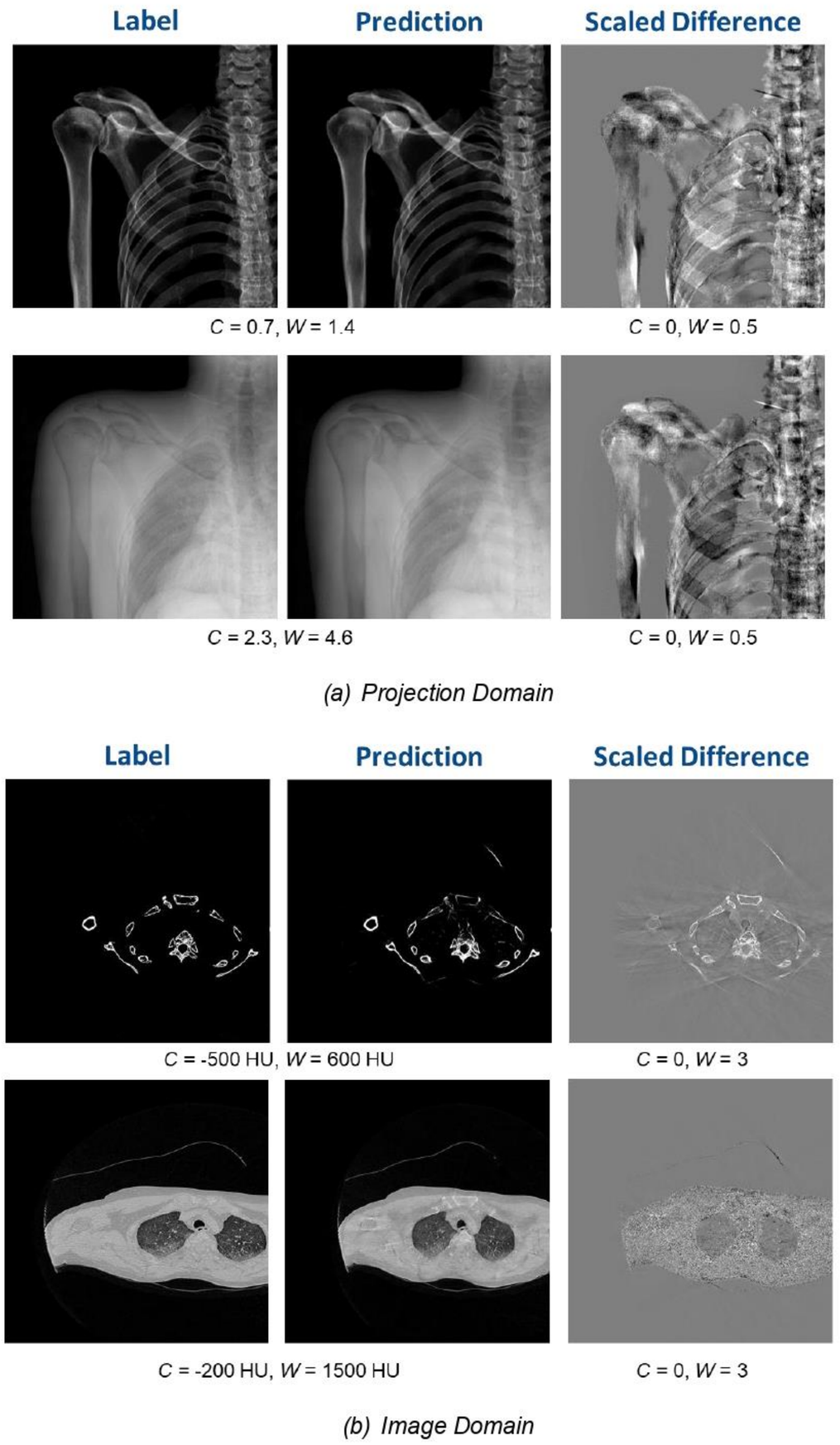

Fig. 3: Examples for the network predictions.

Best Results

Taken across all metrics in projection domain, the 2.5D UNet trained on data from all anatomical regions performs best. Across all test regions, this network achieves a MSE of 0.010±0.006, a SSIM of 0.883±0.026 and a DICE score of 0.93±0.04. The quality of the reconstructions is higher for the networks trained to predict soft tissue only labels where we replaced bone with water, leading to better edge predictions. None of the other experiments yielded consistently superior results.

Test \Train	All	Thorax	Abdomen	Legs	Architecture
Thorax	0.011 ± 0.009	0.01 ± 0.006	0.034 ± 0.026	0.067 ± 0.027	
Abdomen	0.017 ± 0.007	0.031 ± 0.016	0.017 ± 0.008	0.073 ± 0.029	2D
Legs	0.002 ± 0.002	0.01 ± 0.01	0.009 ± 0.009	0.004 ± 0.003	
Thorax	$\mathbf{0.01 \pm 0.009}$	0.01 ± 0.006	0.034 ± 0.024	0.058 ± 0.026	
Abdomen	$\mathbf{0.015 \pm 0.007}$	0.03 ± 0.015	0.019 ± 0.009	0.061 ± 0.026	2.5D
Legs	$\mathbf{0.002 \pm 0.002}$	0.008 ± 0.008	0.009 ± 0.009	0.003 ± 0.003	

Tab. 1: MSE of network predictions for the bone only label.

The cadaver measurements have been acquired in scope of a forensic study in close collaboration with the Institute of Forensic and Traffic Medicine (Prof. Sarah Heinze), Heidelberg University, Heidelberg, Germany, after being approved by the local ethics review board (S 388/2014).

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