# Convolutional neural networks for image enhancement and segmentation of $^{99m}$Tc-DMSA studies

LUND UNIVERSITY

GUSTAV BROLIN[1,2], ELIN TRÄGÅRDH[2,3] AND DAVID MINARIK[1,2]

## Conclusion

Convolutional neural networks (CNNs) shows promise for segmentation and image quality improvements of $^{99m}$Tc-DMSA studies. Automated CNN-based measurements were in good agreement with clinical measurements using commercial software.

## Background and methods

Artificial intelligence, specifically convolutional neural networks (CNNs), is arguably an emerging revolution in nuclear medicine imaging. The aim of this work was to evaluate the potential of neural networks designed for image denoising (dnCNN) and image segmentation (U-net), when trained and applied on 2D gamma camera images.

The two CNNs were trained using simulated $^{99m}$Tc-DMSA studies with pristine, realistic and labelled data as shown below. The CNNs were implemented and trained in MATLAB running on a desktop computer with a high-end gaming graphics card.

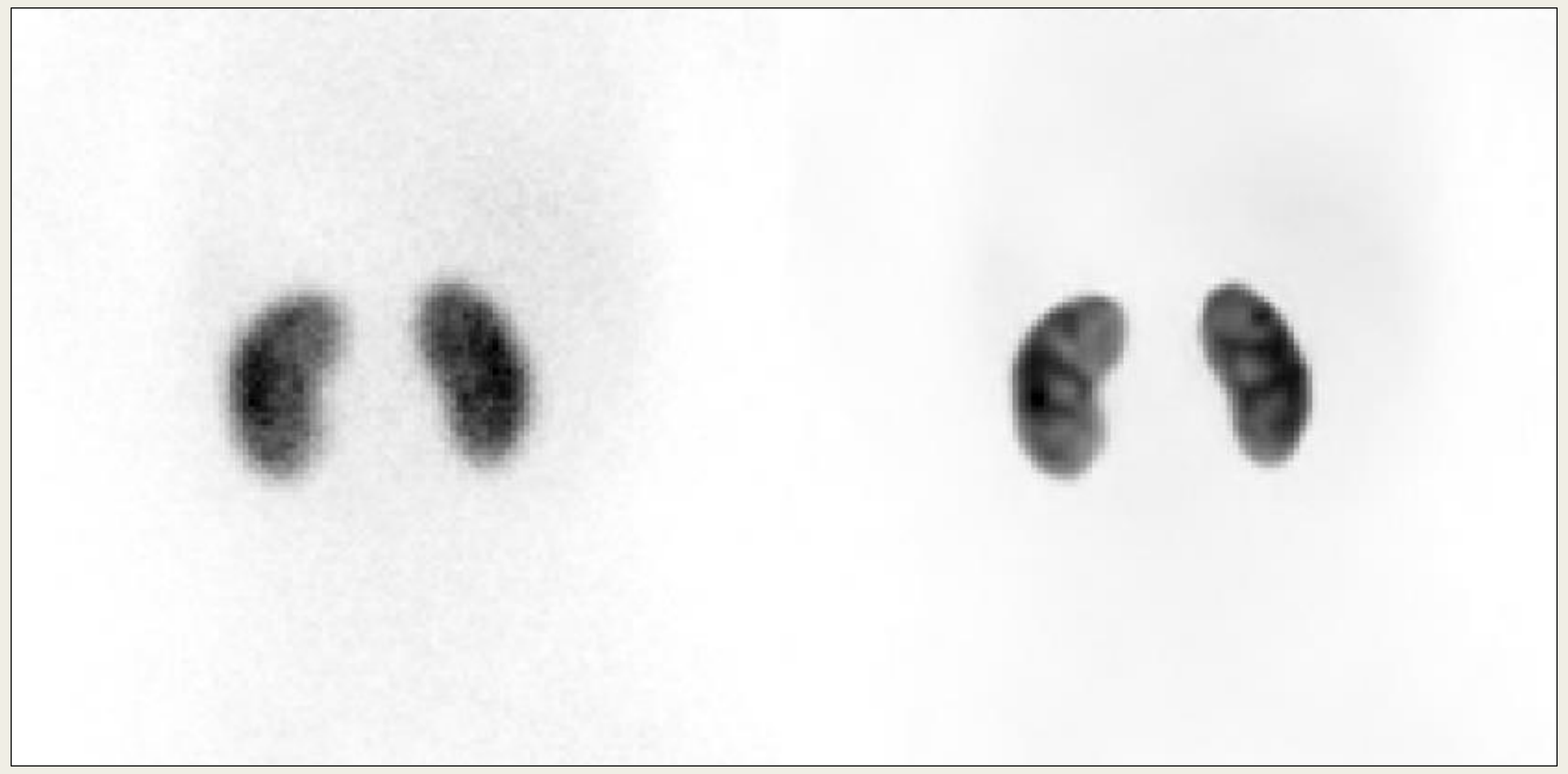


Fig 1. Example of original 99mTc-DMSA image (left) and corresponding dnCNN-processed image (right).

## Evaluation

The two CNNs were applied on images from 32 patients. A MATLAB program was written to (i) automatically generate renal ROIs from the output classification map, and (ii) measuring renal counts and lengths. The results were compared against existing results from previous clinical evaluations using cDMSA (Hermes).

### CNN TRAINING DATA

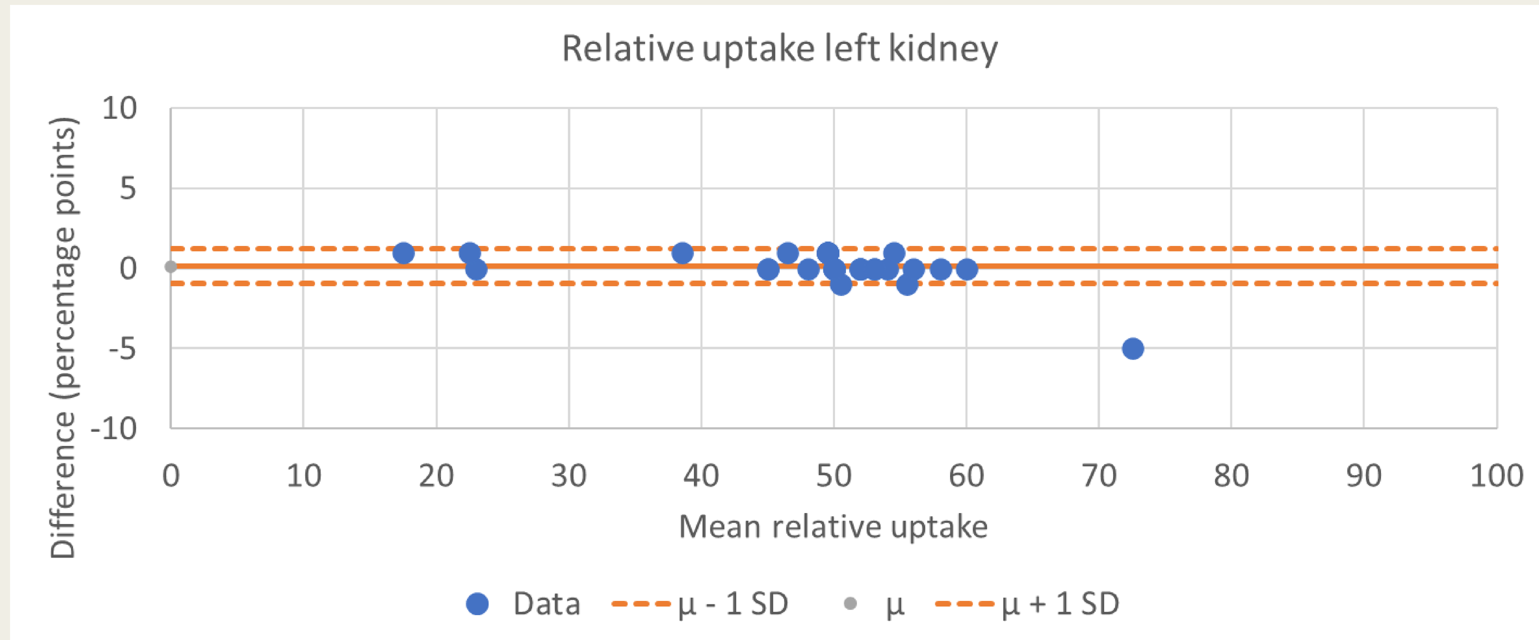
Using the XCAT phantom and Monte Carlo program SIMIND, 2500 realistic DMSA images were generated with varying anatomic features, activity distribution and renal uptake defects. For each simulated image, a corresponding pristine image and pixel classification map was generated, as shown in figure 2. Different Poission noise realisations are generated in the training process.

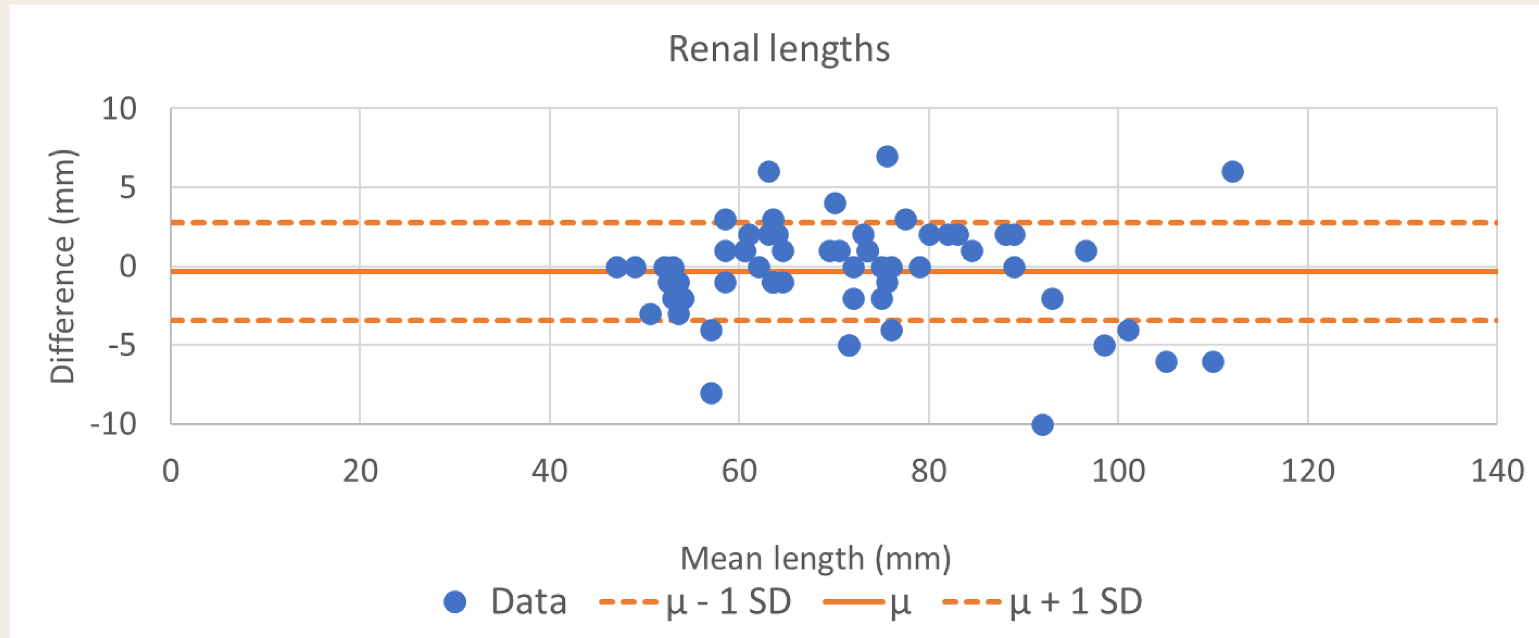
Fig 2. Example of set of images used to train the CNNs. Left: Simulated pristine image with perfect spatial resolution. Centre: Simulated image including limited spatial resolution ("blurring"). Right: Pixel classification map with labelled left and right kidney.

## Results

Images processed with the trained dnCNN showed remarkedly decreased noise levels without apparent loss of spatial resolution (figure 1).

Figure 3 shows Bland-Altman plots of the left kidney relative uptake and the renal lengths, respectively. The mean (SD) difference of the CNN-based measurements to the clinical measurements was 0.1 (1.1) percentage points for the relative uptake. For the renal lengths, the mean difference was 0.4 (3.1) mm.




1. Radiation Physics, Department of Hematology, Oncology and Radiation Physics, Skåne University Hospital, Sweden
2. Wallenberg Centre for Molecular Medicine, Lund University, Lund, Sweden
3. Clinical Physiology and Nuclear Medicine, Skåne University Hospital and Lund University, Malmö, Sweden

gustav.brolin@med.lu.se | david.minarik@med.lu.se | elin.tragardh@med.lu.se