Motion Estimation in Medical Images

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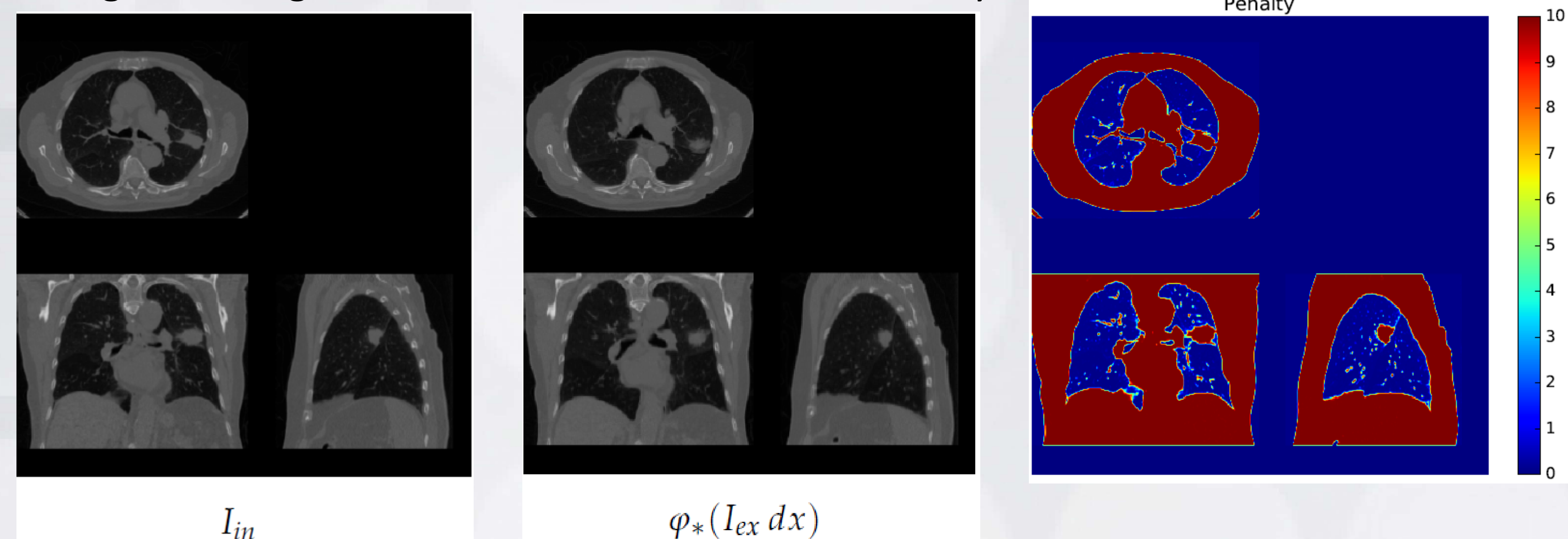2 – University of Maryland School of Medicine, Baltimore, MD, USA
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Motion in medical images arises from breathing, heart contraction, or voluntary movement. We are interested in characterizing this motion for better treatment planning and for motion correction in time-series images.
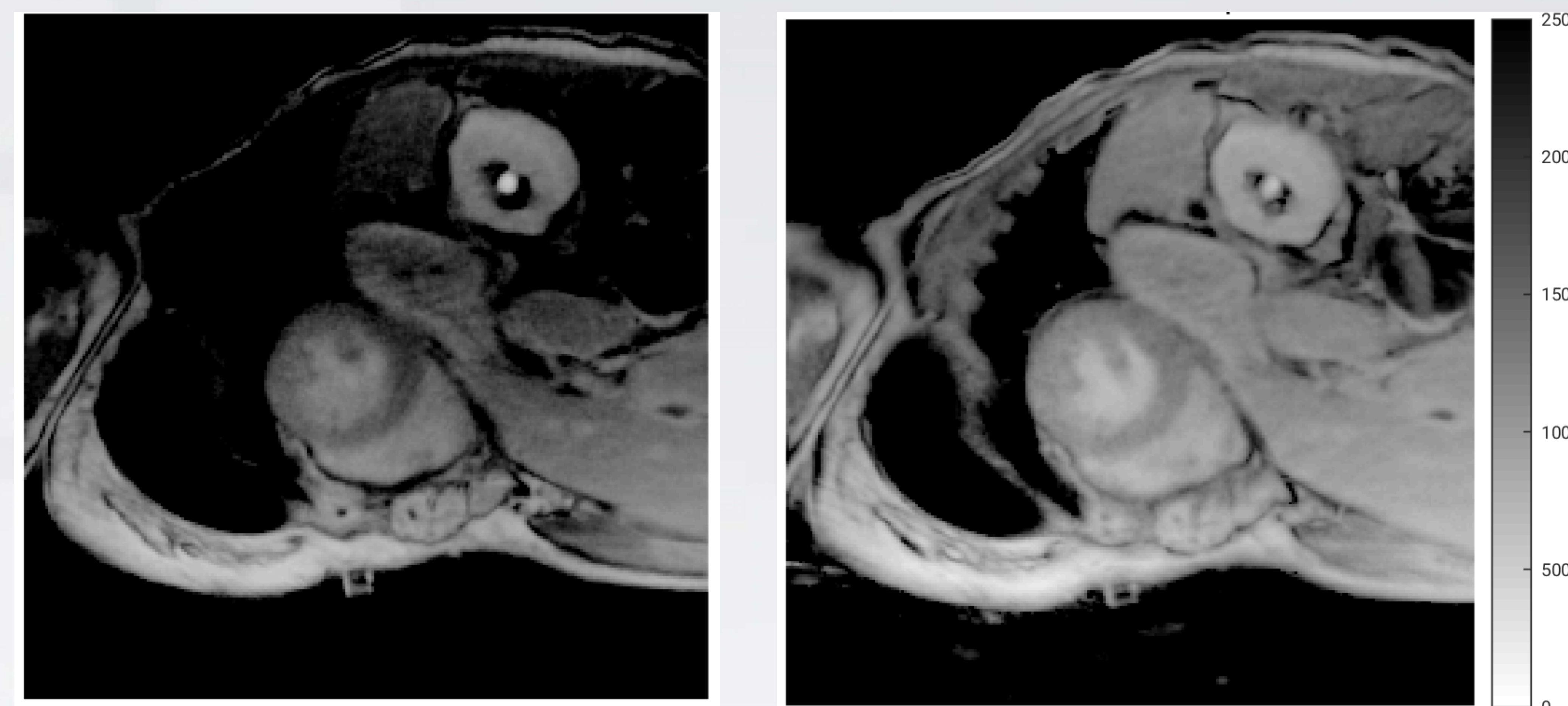
Lung Deformations in Computed Tomography:

Many lung tumors are untreatable due to large motion during breathing. CT images are used for radiation treatment planning of lung cancers. Knowledge of lung motion during breathing allows for accurate radiation delivery.

I_{in}

$\varphi_*(I_{ex}\,dx)$

Penalty

Results:

Our deformation algorithm restricts compression to occur only in the lungs. Other algorithms incorrectly show density changes in stable tissue.

Original, NIFTI and Density

Jacobian Determinant

$f(x) = \text{sig}(I_0(x))$

$f(x) = \sigma$

Jacobian Determinant

ANTs

NiftyReg

Rottman, C., Larson, B., Sabouri, P., Sawant, A. & Joshi, S. in Medical Image Computing and Computer-Assisted Intervention -- MICCAI 2016: 19th International Conference, Athens, Greece, October 17-21, 2016, Proceedings, Part III (eds. Ourselin, S., Joskowicz, L., Sabuncu, M. R., Unal, G. & Wells, W.) 46–53 (Springer International Publishing, 2016). doi:10.1007/978-3-319-46726-9_6
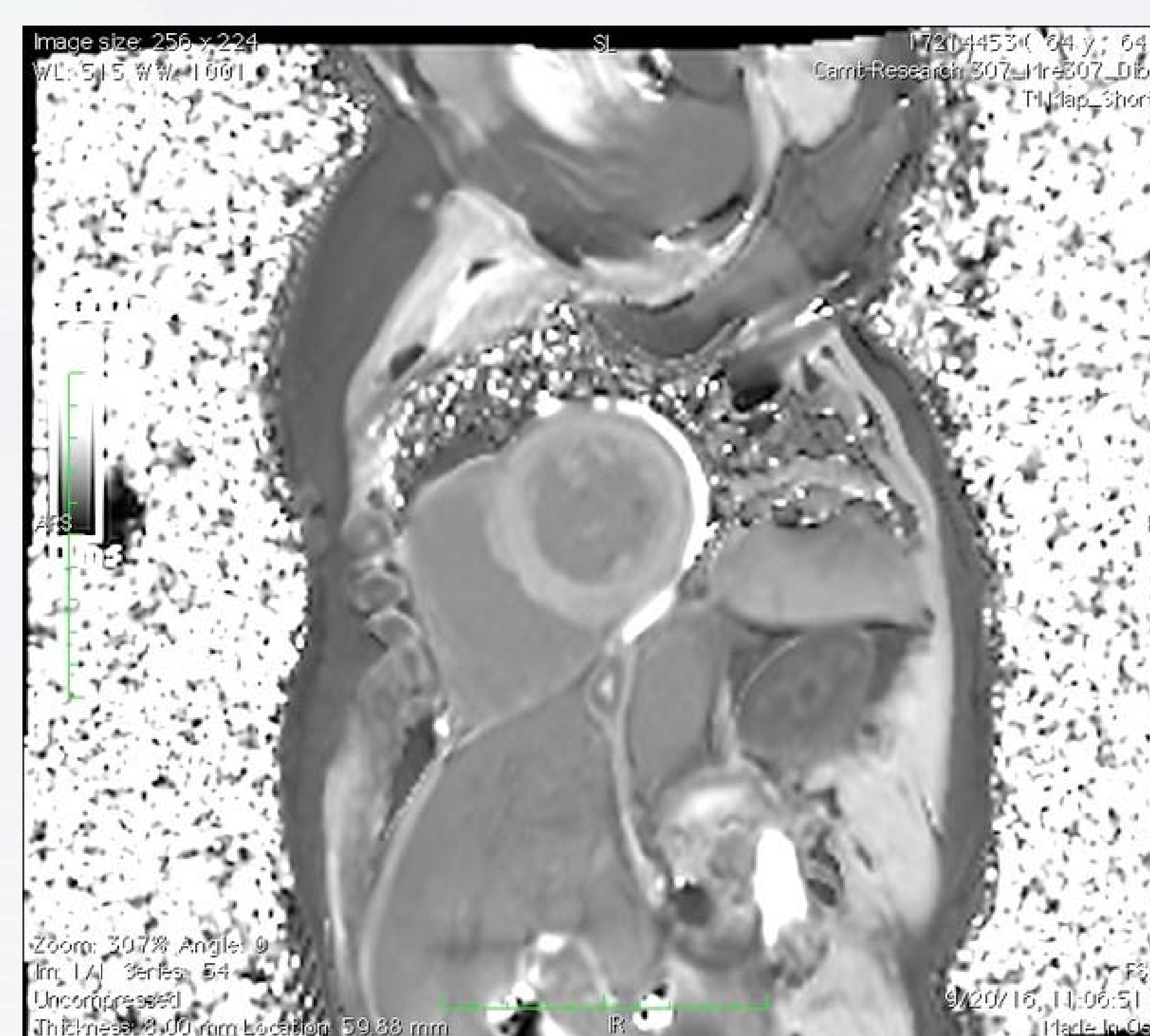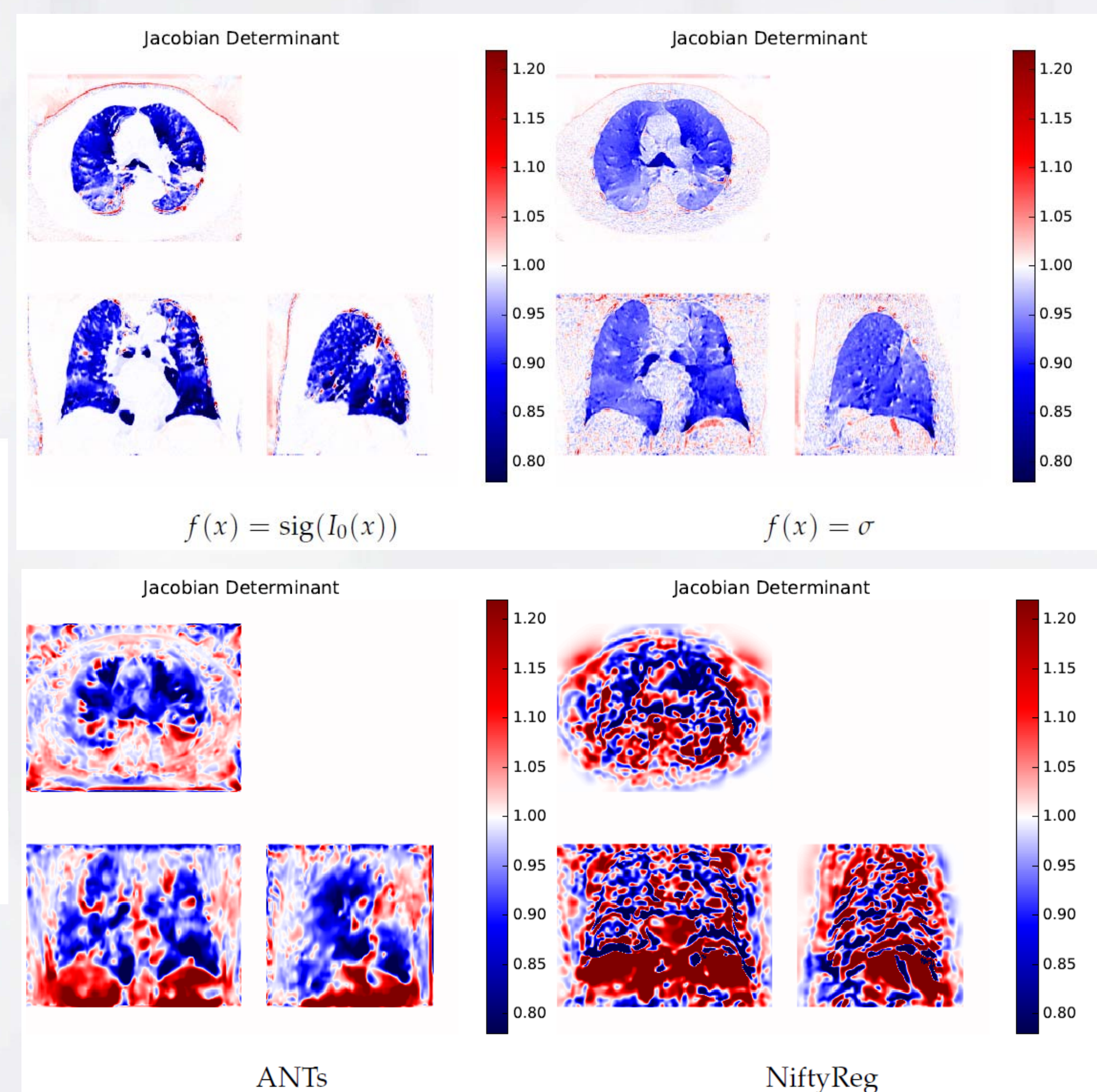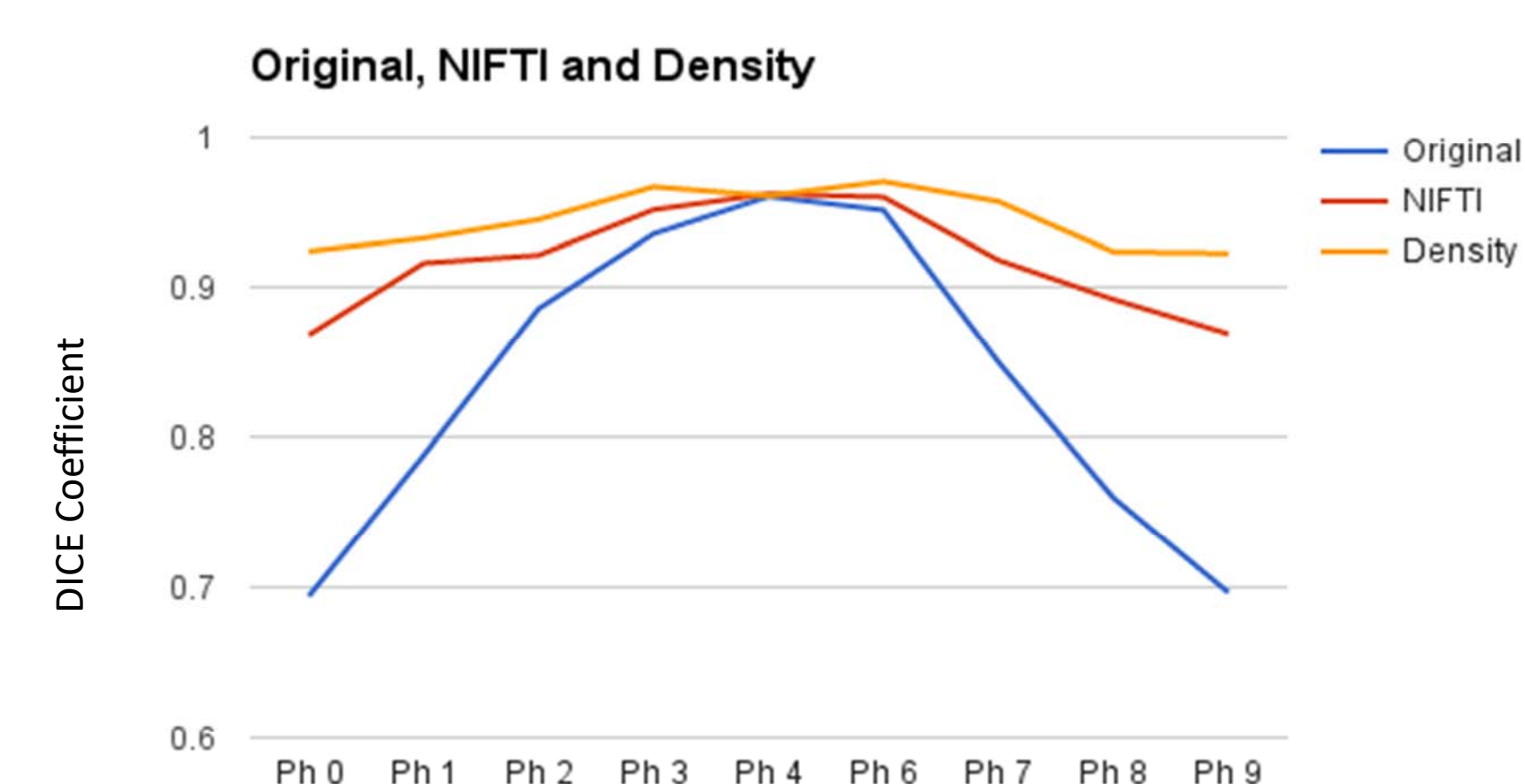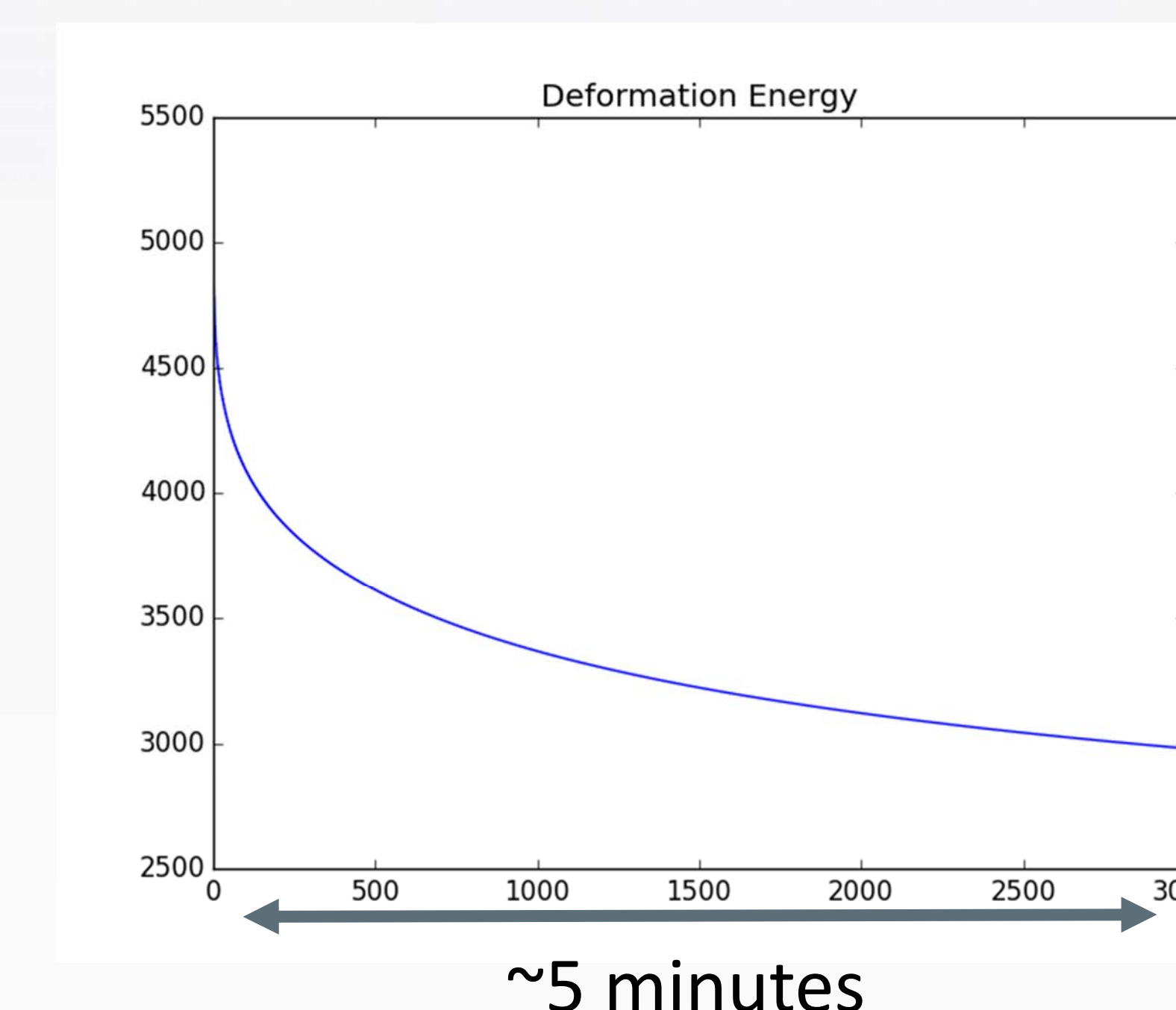
Breathing Motion in Magnetic Resonance Imaging:

T1 is an indicator of fibrosis in the heart, but is difficult to calculate due to motion. Multiple scans during a MRI study can be combined to form a T1 Map.

T1 Map with Motion Artifacts

Motion-Free Atlas T1 Map

Current Clinical Standard T1 Map

Foote, M., Adluru, G., DiBella, E. & Joshi, S. Free-Breathing Cardiac T1 Estimation Jointly with Diffeomorphic Image Registration. Submitted to *Proc. Intl. Soc. Mag. Reson. Med. 25* (2017).

Results:

Deformations are used to build a reference image without motion. The T1 Map can then be calculated without motion artifacts. GPU acceleration reduces computation time.

Deformation Energy

~5 minutes