

# An open-source framework for multi-modal pulmonary image analysis

*ITK-Lung: A Software Framework for Lung Image Processing and Analysis*  
(R01 HL133889-01A1)

## The 2017 International Workshop on Pulmonary Imaging

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# Why should you care?

# List of collaborators

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Eduardo Barbosa	Hans-Ulrich Kauczor
Warren Gefter	Jim Wild
David Mankoff	Mark Scheibler
Sean Fain	Eric Hoffman

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*“More widespread use of all [pulmonary] imaging biomarkers has been limited for a number of key reasons, including: 1) lack of support to harmonize image acquisition software; 2) **universally available image analysis software**; 3) regulatory boundaries for emerging approaches; and 4) historically weak links between respiratory and radiology clinical programs.”*

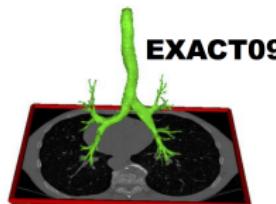
— E. A. Hoffman et al., JMRI 2015.

# “publications = advertisements”

*“An article about computational science in a scientific publication is not the scholarship itself, it is merely advertising of the scholarship. The actual scholarship is the complete software development environment and the complete set of instructions which generated the figures.”*

— Jonathan Buckheit and David Donoho (Jon Claerbout)

# Competitions

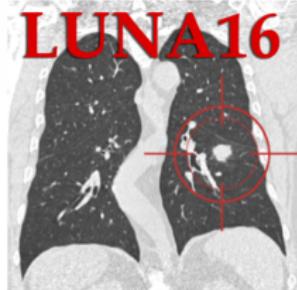


EMPIRE10

LOLA11

VESSEL12★

LUNA16

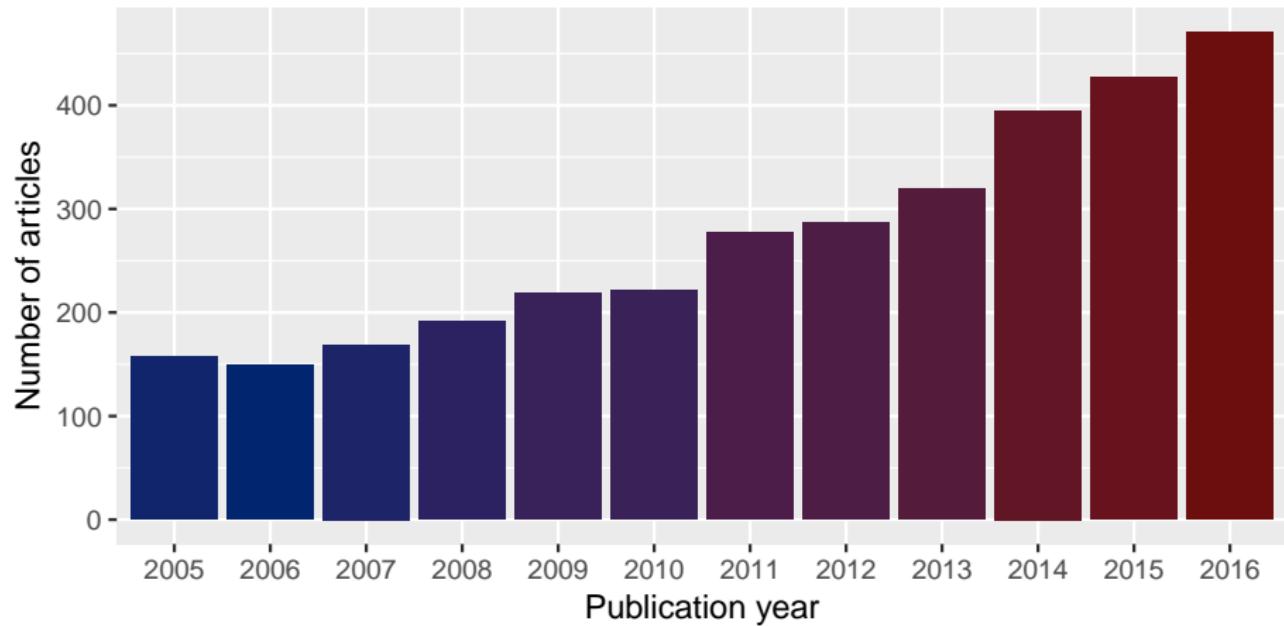


# What does the neuroimaging community offer?

Great packages such as:

- AFNI
- FSL
- FreeSurfer → NeuroQuant®
- SPM
- ANTs

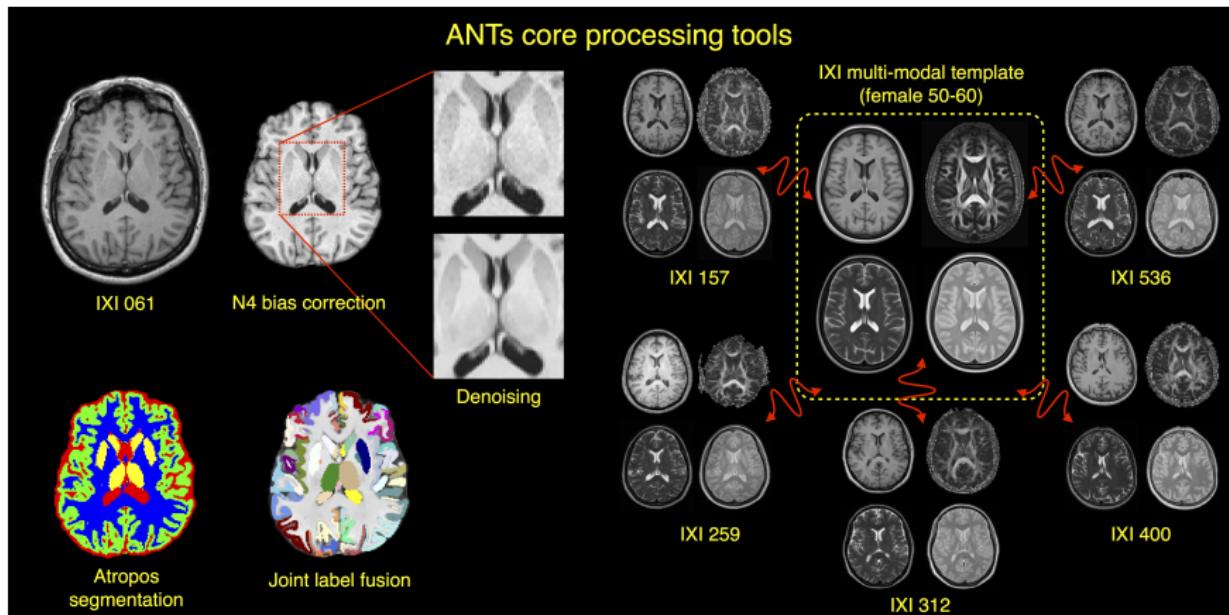
# Public & robust software → research output



# Benefits of open-source:

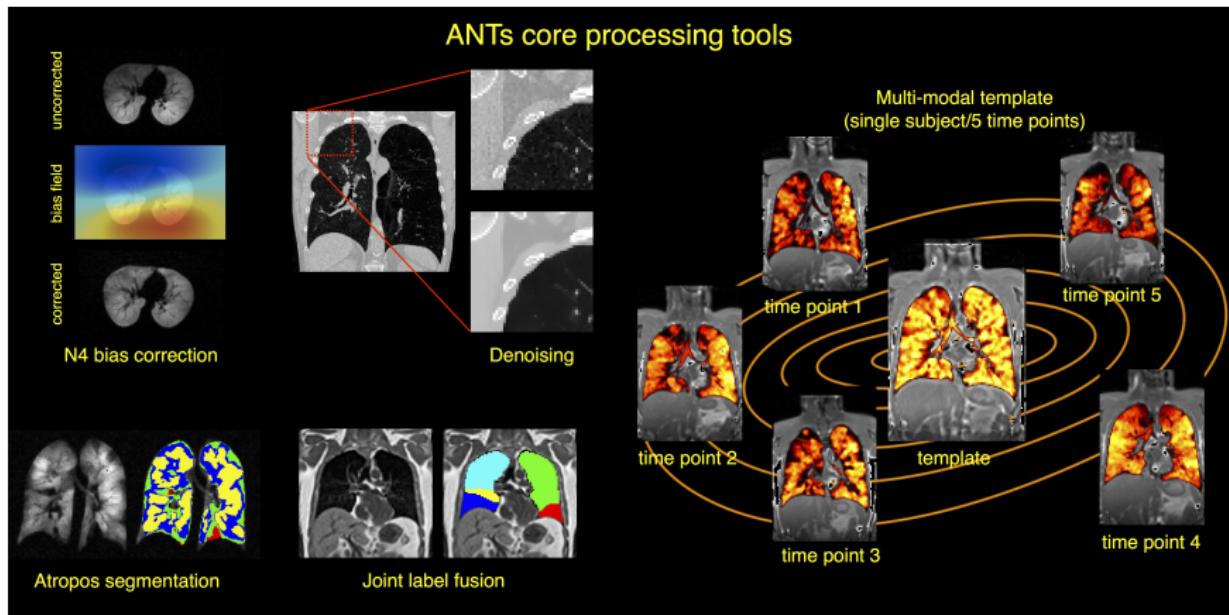
- Motivates community-based support:
  - bug fixes (*“Given enough eyeballs, all bugs are shallow.”*),
  - new features,
  - reproducibility, and
  - community tech support.
- Learn directly from journal manuscripts *and* implementations.
- Tremendous cost-savings.
- *“Don’t reinvent the wheel.”*

# ANTs core tools for neuroimage analysis



# ITK-Lung

# ANTs core tools for lung image analysis



# Proposed core functionality

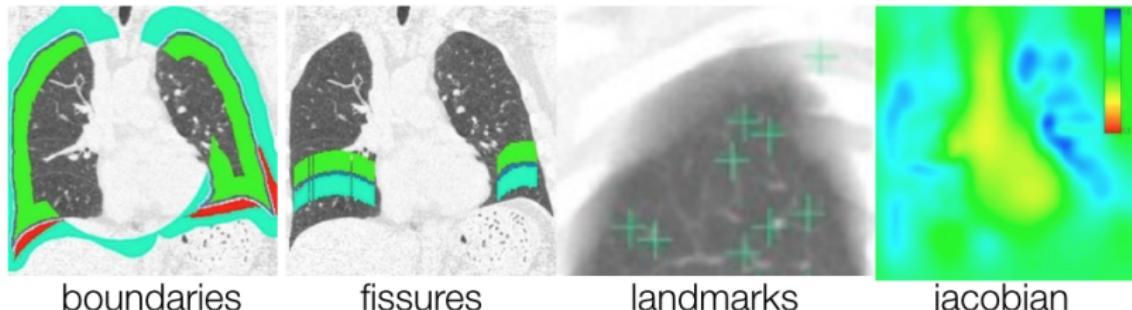
Functionality	CT	1H MRI	3He MRI	PET
registration	○	○	○	○
template generation	○	○	○	○
lung segmentation	○	○	‡	‡
lobe segmentation	○	○	‡	‡
airway segmentation	○	—	—	—
vessel segmentation	○	—	—	—
functional segmentation	*	—	○	*
feature indices	○	—	*	*

'○': previously published work

'\*': cross-modality functionality

'‡': simultaneous structural acquisitions

# EMPIRE 2010



boundaries

fissures

landmarks

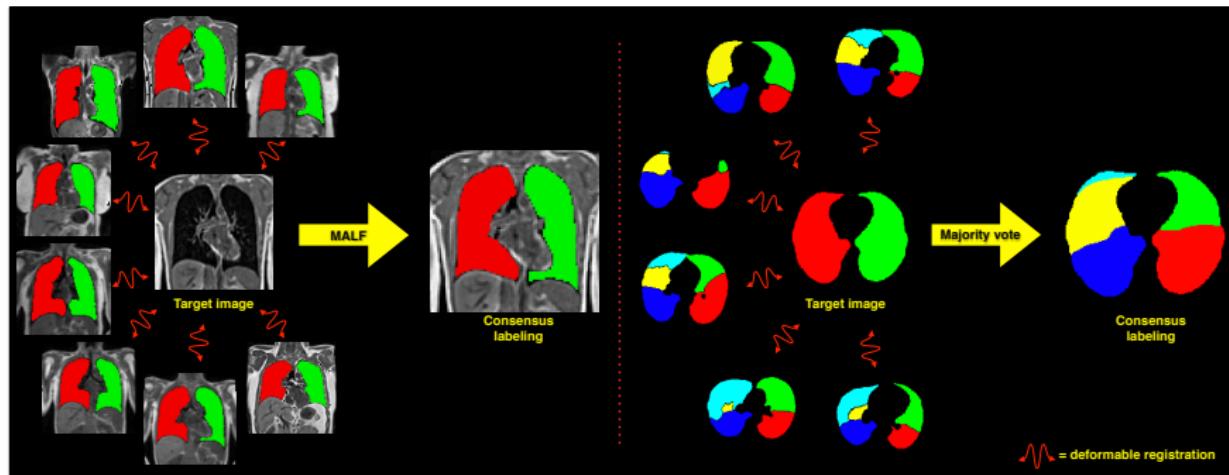
jacobian

	Lung Boundaries		Fissures		Landmarks		Folding		Overall			
Team Name	Avg Score	Avg Rank	Avg Score	Avg Rank	Avg Score	Avg Rank	Avg Score	Avg Rank	Avg Score	Placed	Last Update	Method Type
<b>picsl gsyn</b>	0.12	8.00	0.03	9.52	0.75	3.65	0.00	13.77	8.73	1	25 Jun 2010	Fully Auto
<b>Nifty Reggers</b>	0.00	7.57	0.27	12.30	0.75	7.25	0.00	12.50	9.90	2	26 Jun 2010	Fully Auto
<b>Iowa sstvd</b>	0.00	10.00	0.00	10.07	0.70	6.05	0.00	10.00	10.75	0	26 Jun	Fully

# Registration github examples

- <https://github.com/ntustison/antsCtLungRegistrationExample>
- <https://github.com/ntustison/ProtonCtLungMaskRegistration>

# Atlas-based lung and lobe estimation



# Good results on 1H MRI

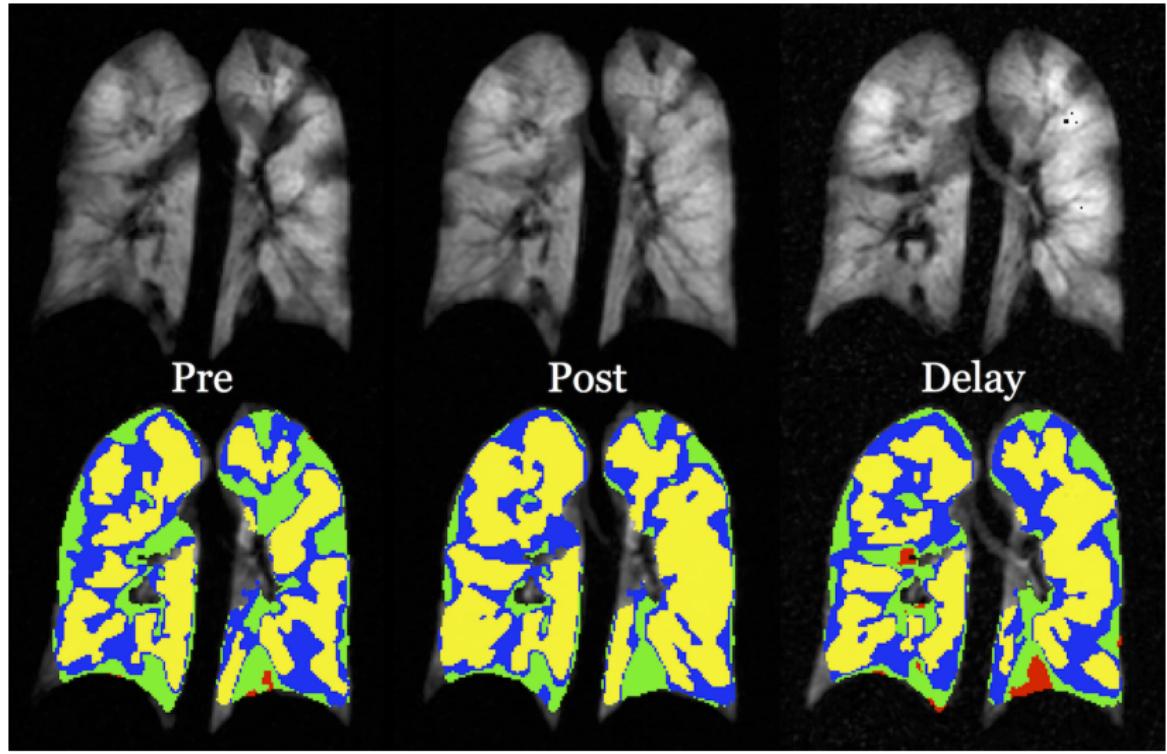
	Mean	SD	Median
<b>Left lung</b>	0.963 (0.974)	0.013 (0.097)	0.964 (0.992)
<b>Right lung</b>	0.968 (0.972)	0.012 (0.135)	0.970 (0.996)
<b>Left upper</b>	0.882 (0.922)	0.059 (0.163)	0.894 (0.978)
<b>Left lower</b>	0.868 (0.885)	0.06 (0.229)	0.892 (0.964)
<b>Right upper</b>	0.852 (0.921)	0.067 (0.088)	0.875 (0.96)
<b>Right middle</b>	0.657 (0.765)	0.130 (0.299)	0.696 (0.886)
<b>Right lower</b>	0.873 (0.914)	0.063 (0.176)	0.900 (0.968)

(\*) Comparison with state-of-the-art

# Lung and lobe estimation github example

<https://github.com/ntustison/LungAndLobeEstimationExample>

# Functional ventilation



# Functional segmentation github example

```
https:  
//github.com/ntustison/LungVentilationSegmentationExample
```

# Combining ANTs lung functionality

## Longitudinal voxelwise analysis of ventilation data

