Pulmonary Nodules: Challenging Cases

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Outline

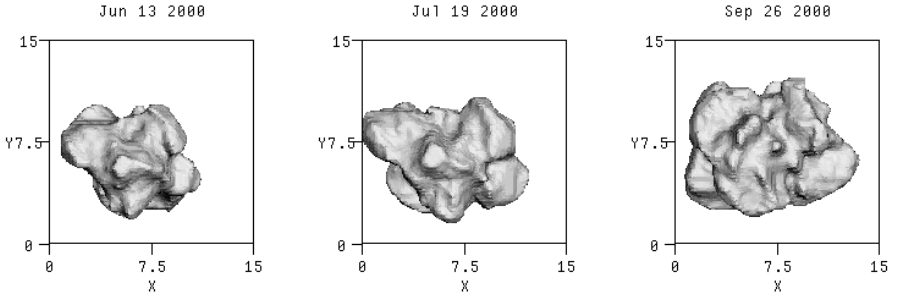
Nodule Challenges

1. Large complex lesions
2. Different scan resolutions (slice thickness)
3. Vessel attachments
4. Scanner artifacts/motion
5. Part-solid nodules
6. Size is an issue
7. Cardiac motion/respiration motion
8. Non-solid nodules

Easy Cases

Example 1 **Good** result
Axial visualizations at three times

Axial View



T1 T2 T3

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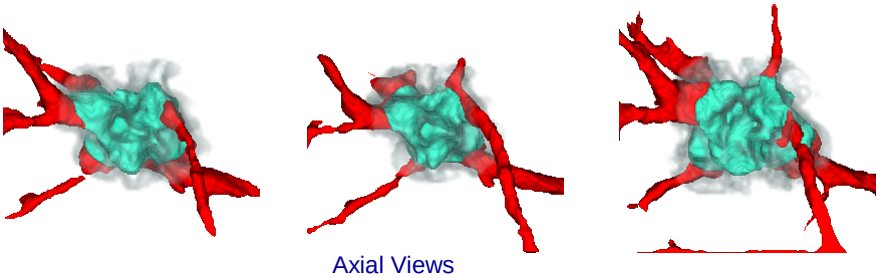
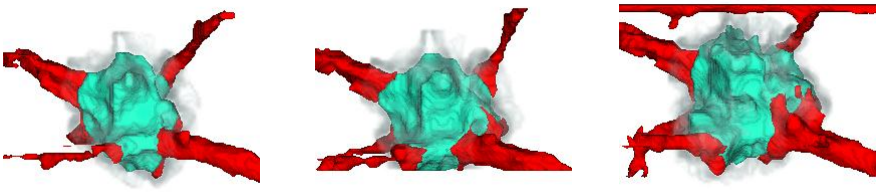
T1 T2 T3



Axial Views



Sagittal-Coronal Views

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Web-system growth tables for Case 1

Group 1: 3D automated analysis

Nodule Information

Nodule	Date	Size (mm) from X-Y Extent	Size (mm) from Volume	Volume (mm^3)	Resolution
T1	Jun 13 2000	9.38	8.63	336.19	0.1875 x 0.1875 x 1.00
T2	Jul 19 2000	10.75	9.19	406.25	0.1875 x 0.1875 x 1.00
T3	Sep 26 2000	11.63	10.48	603.27	0.1875 x 0.1875 x 1.00

Growth Information

Nodules	Date T1	Date T2	Interval (Days)	Volume			Notes
				% Change	DT	GI	
T1-T2	Jun 13 2000	Jul 19 2000	36	20.84%	131.78	17.1	
T1-T3	Jun 13 2000	Sep 26 2000	105	79.44%	124.47	18.2	
T2-T3	Jul 19 2000	Sep 26 2000	69	48.50%	120.96	18.8	

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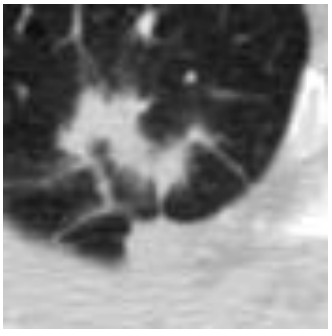
Nasty Case

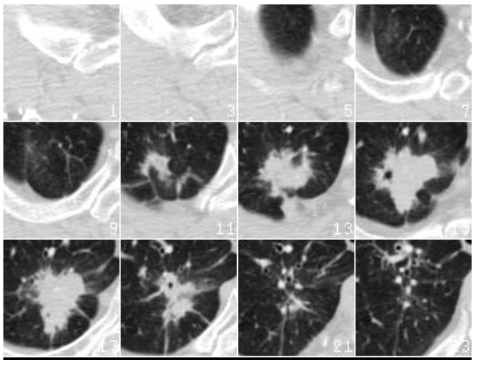
Spiculations and many vessels
T1-T2: 203 days

From the Prevent Cancer Foundation:
Public Lung Database To Address Drug Response

T1: Center + ROI



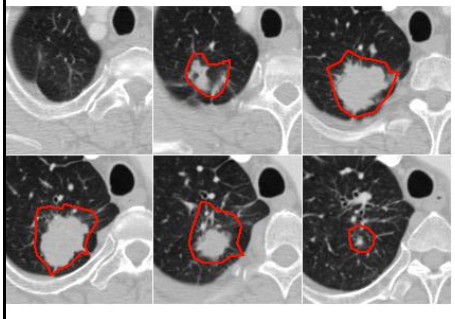
xres: 0.693 zres: 2.5 mm



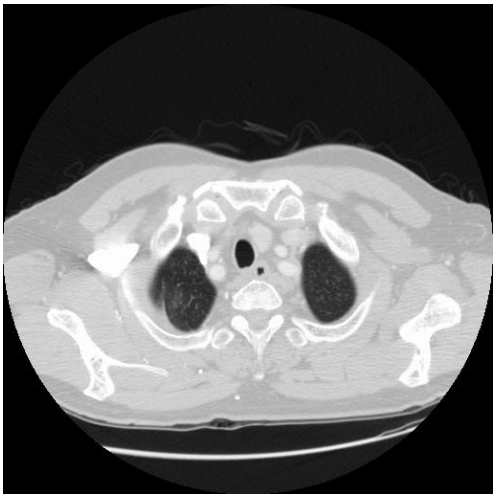
60 mm

Selected Slices

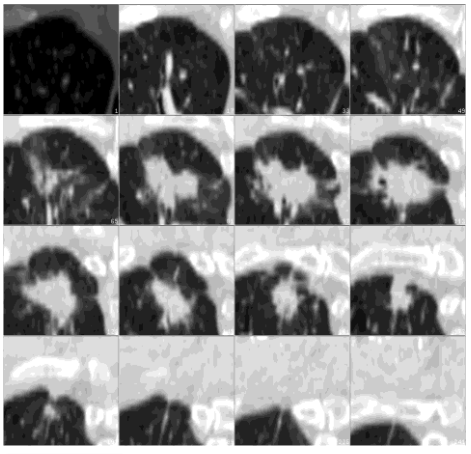
T1: Manual Marking



97 mm

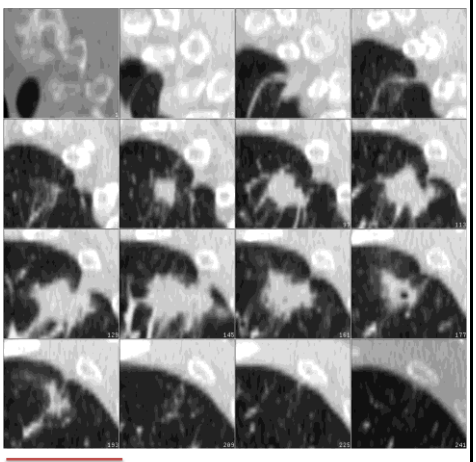


T1: Projections



60 mm

Coronal

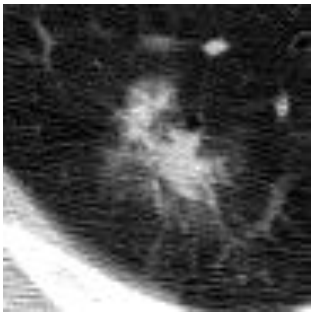


60 mm

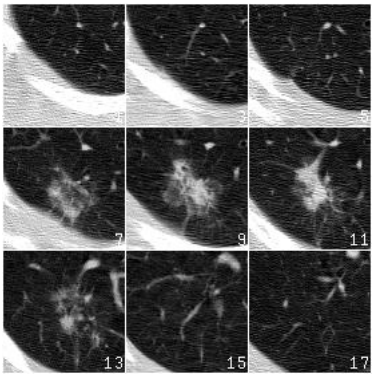
Sagittal

Large Complex Nodule

Complex T1: Central slice + ROI

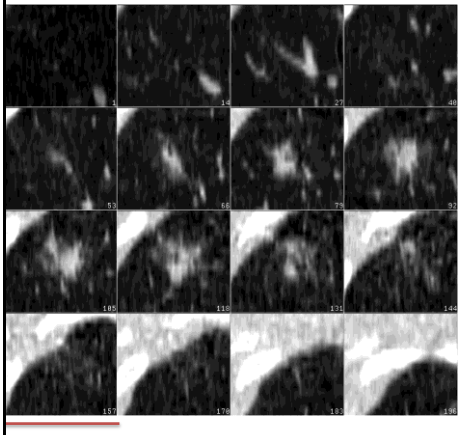


xres: 0.546 zres: 2.5 mm



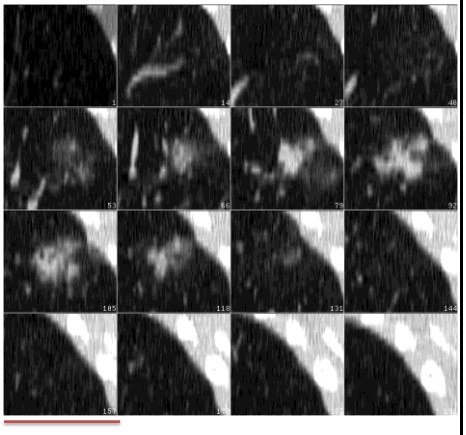
50 mm

T1: Projections



50 mm

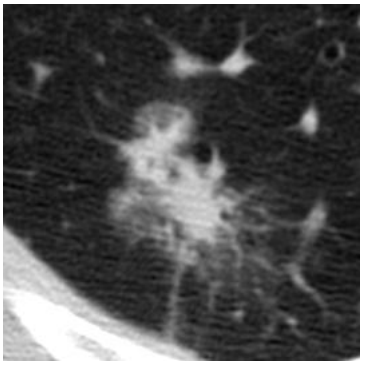
Coronal

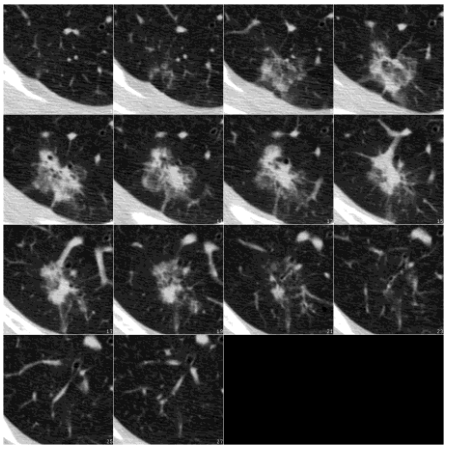


50 mm

Sagittal

T2: Central slice + ROI



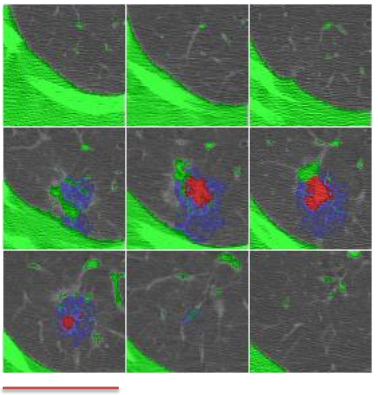


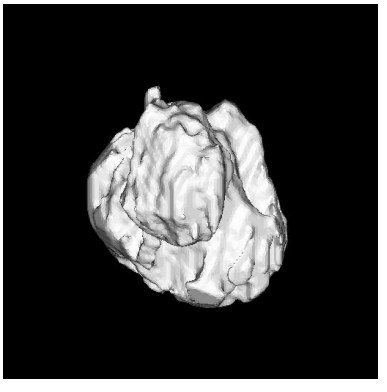
xres: 0.187 zres: 1.0

50 mm

Different scan resolutions for T1 and T2: 0.546 x 2.5 vs. 0.187 x 1.0
Voxels in T1 are 21 times larger than voxels in T2

T1: Volumetric Segmentation





50 mm

Volumetric analysis worked for this case. It considered the central region (red) as solid and the surrounding area (blue) as sub-solid

Large Complex Nodules

- Standard volumetric methods designed for small nodules fail
- Solution: use a density based method that evaluates the change in density over a fixed size region as a surrogate for volume change
- Outcome: all nodules have successful size change estimates

Case	Interval (days)	% Size Change	GI (%/month)	DT (days)
0414	44	9.0	6.2	350
1297	56	21.2	11.0	202
2461	29	12.7	13.4	168

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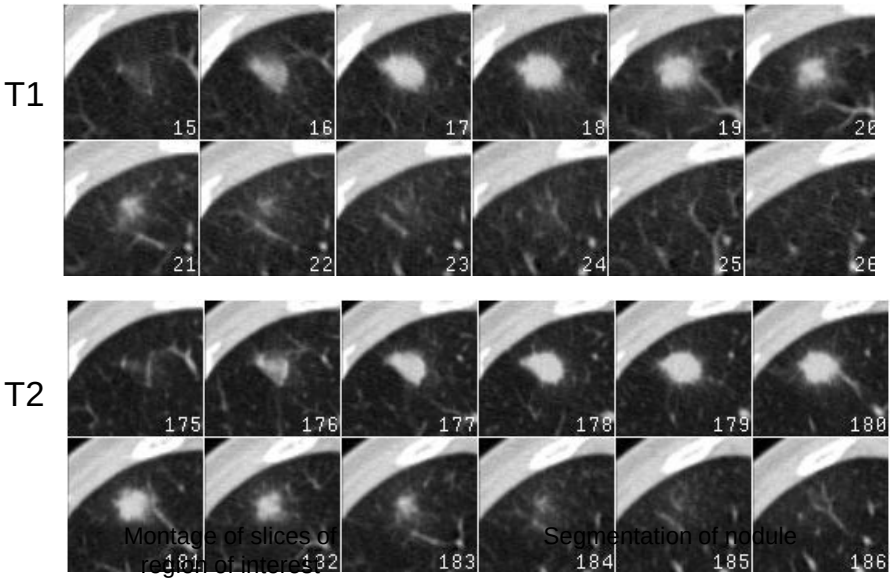
Nasty Case

Zero-Change Dataset

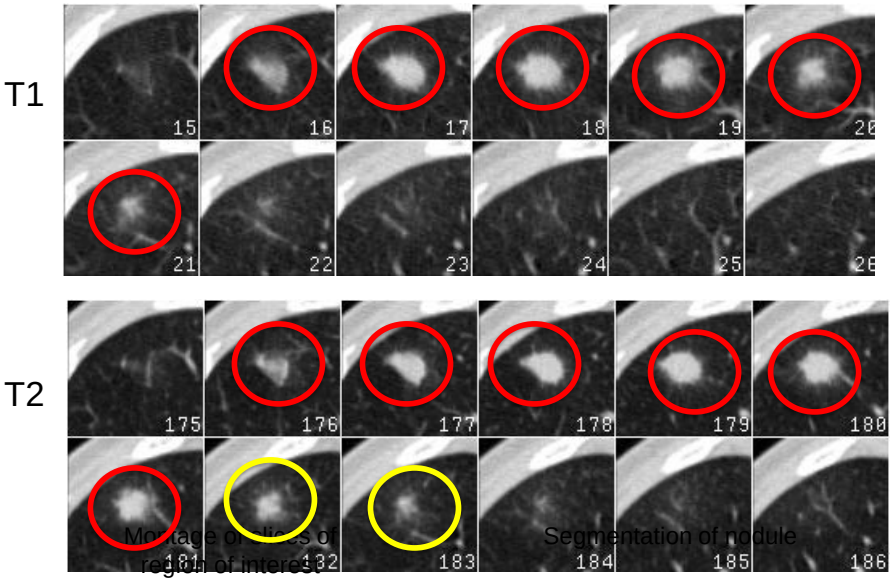
T1-T2: ~5 minutes

From the VOLCANO ‘09 Challenge

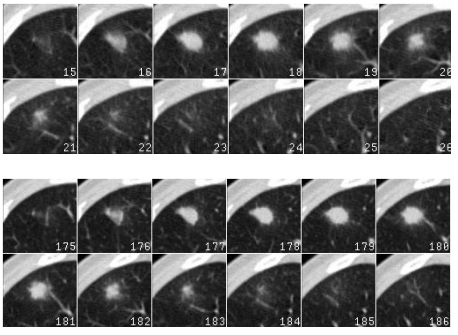
T1 and T2 1.25 mm slice thickness



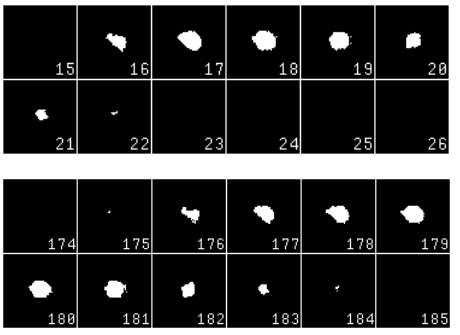
T1 and T2 1.25 mm slice thickness



Zero-change automated segmentation



Montage of slices of region of interest



Segmentation of nodule

Scanner artifacts?

Issue: Different number of slices on scanner reconstructions

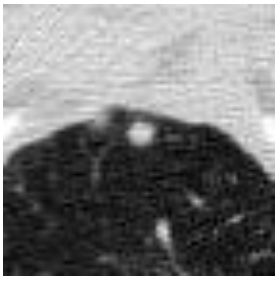
- Z-compensation method. A volumetric evaluation method that is insensitive to linear transformations in the Z dimension.

- Measured volume change:

Standard volumetric method	30.3%
Z-compensation method	12.6%

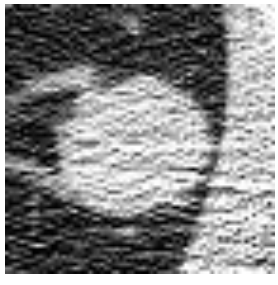
Size Range

Size Issue: two different nodules



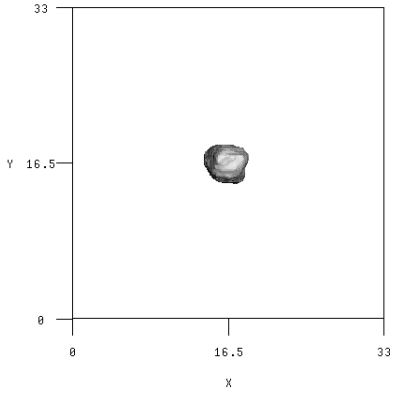
4.86 mm (60 mm^3)

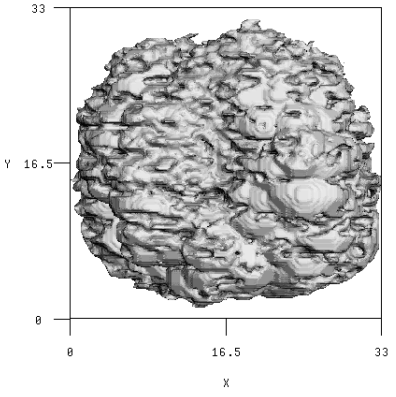
47 mm



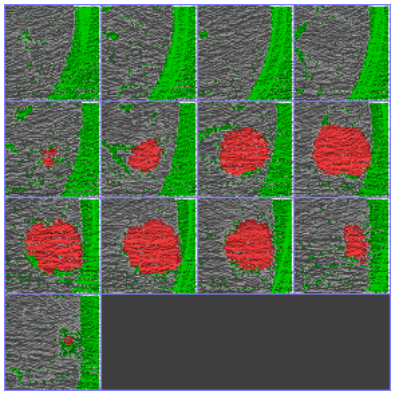
29.14 mm (12961 mm^3)

49 mm

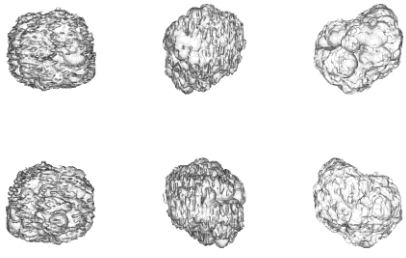




Segmentation (large)

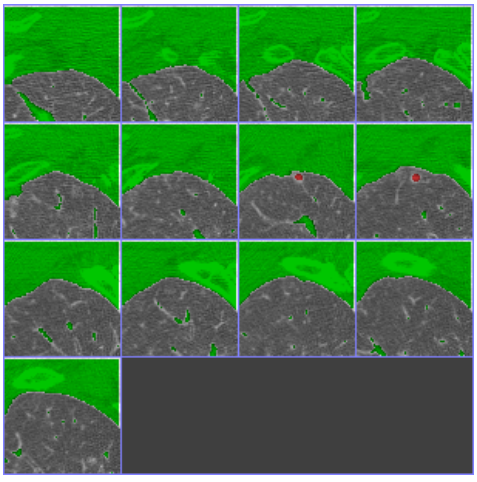


Selected slices

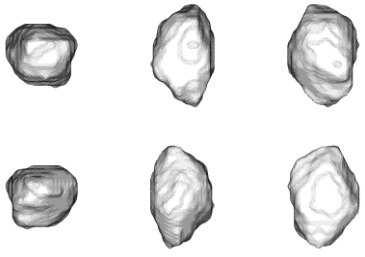


6 cardinal views

Segmentation (small)



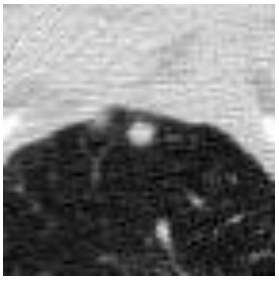
Selected slices

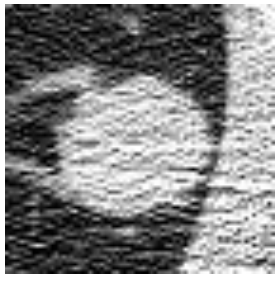


6 cardinal views

50 mm

Size Issue





49 mm

4.86 mm (60 mm^3)

29.14 mm (12961 mm^3)

1:216

20 mm^3 = 30% change

20 mm^3 = 0.14% change

Addressing Challenging Nodules

1. Issue: Very Complex Large Nodules
   - Use Density Change measurement method
2. Issue: Scanner slice variation (due to reconstruction artifacts?)
   - Use a method with Z-compensation
3. Issue: Very small Nodules
   - Use a detailed algorithm that corrects for differences in segmentation
4. Issue: Different scan parameters
   - Careful image resampling can help mitigate this issue
5. Issue: Patient/scanner motion, inconsistent data
   - Take additional scans