Crowd-Sourcing Quality in Imaging

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2017 Dialog For Action on Cancer Screening and Prevention
Image Quality For Lung Cancer Screening

Since 2015:
Annual Low Dose CT Screening is Reimbursed For Individuals at High Risk
Lung Cancer Screening

Late-Stage Lung Cancer

~5% five year survival

[R. Gottlieb, Roswell Park Cancer Institute]

Early Lung Cancer

~85% five year survival

[Dr. Javier Zulueta, University of Navarra]

5mm Squamous Cell Carcinoma
Pulmonary Nodules

\begin{align*}
T1 &= 668 \text{ mm}^3 \\
T2 &= 661 \text{ mm}^3 \\
\Delta V &= \text{No Change}
\end{align*}
2010: Roche ABIGAIL Study

Model A Site 1

Model A Site 2

+44% Change

1654 mm$^3$ 2379 mm$^3$

+33% Change

1601 mm$^3$ 2127 mm$^3$
Volume Measurements Over Time

+43% Change

To Appear in JMI 2016
Periodic Z Warping
• **Goal**

  – To quantitatively determine the most effective lung cancer screening CT scanners and protocols using an ultra-low cost, crowd-sourced approach.

  – In addition, to identify the best protocols for combined lung cancer and COPD screening.
Team

- **Accumetra**
  - Challenge Leadership
  - Image Assessment Technology

- **Prevent Cancer Foundation**
  - National Cancer Patient Advocacy
  - Lung Cancer Workshop XIII

- **Lung Cancer Alliance**
  - National Cancer Patient Advocacy
  - > 300 Framework Sites

- **I-ELCAP**
  - Largest Ongoing International Lung Cancer Screening Study

- **COPD Foundation**
  - National COPD Patient Advocacy
Free CT Image Quality Report

Can Be Replaced With Calibrated Object

Tech Can Do The Scan In < 5 Minutes

Email

Upload

Optimize

Accumetra.com
Radiology Focused Image Quality Reports

Protocol Settings

Analysis Status

Lung Nodule Detection

Lung Nodule Measurement

Fundamental Properties
CT Scanning Site Participants

- China
- Spain (2)
- Israel
- Switzerland

27 Sites Submitted Data
<table>
<thead>
<tr>
<th>Manufacturers</th>
<th>Models</th>
<th>4 Manufacturers</th>
<th>18 Models</th>
<th>53 CT Scanners</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE (19% = 10/53)</td>
<td>BrightSpeed8</td>
<td>8</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>LightSpeed VCT</td>
<td>64</td>
<td>5</td>
<td></td>
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<tr>
<td></td>
<td>Discovery CT750 HD</td>
<td>128</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>Revolution CT</td>
<td>256</td>
<td>2</td>
<td></td>
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<tr>
<td>Siemens (50% = 27/53)</td>
<td>Sensation 16</td>
<td>16</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biograph40</td>
<td>40</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>Sensation64</td>
<td>64</td>
<td>4</td>
<td></td>
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<td></td>
<td>SOMATOM Definition</td>
<td>64</td>
<td>4</td>
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<td></td>
<td>SOMATOM Definition AS</td>
<td>40, 64, 128</td>
<td>6</td>
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<tr>
<td></td>
<td>SOMATOM Definition AS+</td>
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<td>4</td>
<td></td>
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<tr>
<td></td>
<td>Definition AS+ 128</td>
<td>128</td>
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<td></td>
<td>Definition Edge 128</td>
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<td>SOMATOM Definition Flash</td>
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<td>4</td>
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<tr>
<td>Philips (23% = 12/53)</td>
<td>Brilliance64</td>
<td>64</td>
<td>4</td>
<td></td>
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<tr>
<td></td>
<td>IngenuityCT</td>
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<td>5</td>
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<tr>
<td></td>
<td>iCT 256</td>
<td>256</td>
<td>3</td>
<td></td>
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<tr>
<td>Toshiba (8% = 4/53)</td>
<td>Aquilion</td>
<td>64</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aquilon ONE</td>
<td>320</td>
<td>3</td>
<td></td>
</tr>
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</table>
# CT Lung Screening Protocol Guidelines

<table>
<thead>
<tr>
<th>Detectors</th>
<th>Thickness ≤</th>
<th>Spacing ≤</th>
<th>Kernel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 RSNA/QIBA Small Nodule Profile (19% to 42%)</td>
<td>16</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>2015 European Society of Radiology</td>
<td>16</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td>2015 American College of Radiology (10 Pillars Publication)</td>
<td>16</td>
<td>2.5, 1.0 pref.</td>
<td>No Pref.</td>
</tr>
<tr>
<td>2016 AAPM Lung Cancer Screening Protocols</td>
<td>16</td>
<td>2.5, 1.0 pref.</td>
<td>2.5, 1.0 pref.</td>
</tr>
</tbody>
</table>

Our Specification: >= 16 detector rows, <=1.25 thickness, <=1.25 spacing
## Detection Slice Thickness & Recon Kernel

<table>
<thead>
<tr>
<th>Slice Thickness</th>
<th>Sites</th>
<th>Soft Recon</th>
<th>Medium Recon</th>
<th>Edge En. Recon</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 0.625</td>
<td>4 (15%)</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>0.8, 1.0, 1.25</td>
<td>12 (46%)</td>
<td>6</td>
<td>2</td>
<td>4</td>
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<tr>
<td>&gt;= 1.5</td>
<td>10 (38%)</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

3 used 2mm ST & 1mm spacing
All Data

Resolution vs Noise

Image Noise (HU S)

3D PSF Sigma Volume (mm³)

Better

Best Position

Better
0.6 mm Slice Thickness x 0.3 mm Slice Spacing

All Data from One Siemens SOMATOM Definition CT Scanner
Pitch 0.8, 0.5 s/rotation, 120 kVp, 21 or 64 mA
CT Slice Thickness

0.6 mm
1.0 mm
2.0 mm
3.0 mm

$WW = 1000$
$WL = -400$
Crowd-Sourced Data
Validation Studies

- ACR Phantom and Tape Comparison

- Clinical Task Prediction Performance
New Low Cost CT IQ Phantom
2017 Lung Screening Protocol Challenge

- We will continue our crowd-sourcing study
- Clinical sites will scan scotch tape and some will use the new low cost phantom
- The goal will be to globally optimize CT scan protocols and provide guidance on minimum time needed to distinguish malignant nodule size change
Nodule Diameter Growth

What can we say if we use great CT imaging of a ~6mm nodule at baseline and again after 90 days?
• We have tested a highly efficient and scalable image quality monitoring infrastructure
  – Ultra-low cost CT phantoms requiring <= 5 min to scan
  – Web-based Calculator(s)
  – Running on the Amazon Web Services (AWS) cloud
Summary

• For the First Time, We Can Help International Screening Sites Rapidly Optimize Protocols For Lung Cancer Screening Using Crowd-Sourcing and Cloud Computing

• In the Future Sites Will Be Able To See Their Performance Versus Other Sites with Similar Equipment
  – Am I an Outlier?

• Supports Monitoring of Advancement (or Setbacks) of CT Scanner Technology Over Time

• We Are Now Working to Establish Standards and an International Infrastructure For Screening Image Quality