

Reference CT Image Database for Lung Cancer Screening

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Background: Lung Cancer

- In US, there will be an estimated 157,000 lung cancer deaths in 2003
- Five year survival is 15%
- However, an individual who are diagnosed with early stage lung cancer can outlive their disease (Stage 1A, 67-83% five year survival).
- Hence, there has been considerable interest and activity in screening for lung cancer.

Background:Low Dose CT

- Low dose CT more sensitive detecting nodules than chest radiography.
- In CT screening trials radiologists identify at least one non-calcified, indeterminate nodule in about 65% of the cases. (This presentation will demonstrate that every one of our CT screening cases had a small nodule.)
- CT examination is unlikely to reliably identify lung cancer in its early stages.

Background:Low Dose CT Follow-up

- One procedure to determine whether the small nodules identified by CT are lung cancer is to repeat CT exam after sometime.
- Nodules that increase size over time are more likely to lung cancer.
- This strategy requires a comprehensive inventory of all suspicious image features. This is the topic of this presentation.

Catalogue of 4 reader reports: Reference Database

- Asked readers to identify suspicious locations on low-dose CT images from our lung cancer screening program
- Four “readers”
 - 1 - Clinical report (consensus of 2 readers)
 - 2 - 1 reader of all 28 cases using clinical PACS workstation
 - 3 - Composite of 2 readers using clinical PACS workstation
 - 4 - 1 reader of all 28 cases using workstation dedicated to the evaluation of chest CT images (Siemens LungCARE)

Case Characteristics

- 28 cases from BWH lung cancer screening program
- Asymptomatic smokers
 - Average smoking history – 39 pack-years
 - 6 to 110 pack-years
- 16 female and 12 male
- Age – average 57 years (40-81)

Siemens Volume Zoom: Scanning Technique

- 4x1-mm detector collimation
- 0.5 second per rotation
- 8 mm table feed per rotation (pitch=2.0)
- 40 mAs per rotation (20 mAs effective)
- 140 kVp
- B50f reconstruction filter (a sharp filter equivalent to BONE of GE scanners)
- 1.0-mm section increment
- Section thickness 1.25 or 2.0 mm (11 and 17 cases respectively)

Creation of database

The 3 readers who used a clinically available workstation tool were asked to tabulate the table location, lung segment, and size of each nodule candidate. Recall, one these reading was the clinical evaluation of the cases.

Creation of database

The radiologist who used the workstation dedicated to evaluate of chest CT images marked the each location using a mouse pointer of the computer workstation, the center of the each nodule candidate was selected and the location was recorded as x, y, z location by the computer. The x,y,z locations of the nodules detected using a clinical PACS workstation were also recorded by this radiologist in the same way after she finished reading all 28 cases.

Frequencies of the 368 nodule locations in database

Report Frequency	1	2	3	4
Total	240	74	34	20
Per case	8.6	2.6	1.2	0.7

128 nodule locations reported at least twice, that is, 4.6 nodule locations per case

Frequencies of the 78 clinically reported nodule locations

Report Frequency	1	2	3	4
Total	13	24	20	20
Per case	0.5	0.9	0.7	0.7

13 nodule locations only identified during the clinical evaluation

Size of the 273 nodules
that were measured

Report Frequency	1	2	3	4
Total	150	69	34	20
Mean diameter (mm)	4.5	4.0	3.7	3.8
Diameter st. dev. (mm)	4.5	2.1	1.2	1.1
Median diameter (mm)	3.5	3.4	3.8	3.5
Minimum diameter (mm)	1.0	1.2	1.3	2.5
Maximum diameter (mm)	46	11	6.3	6.8

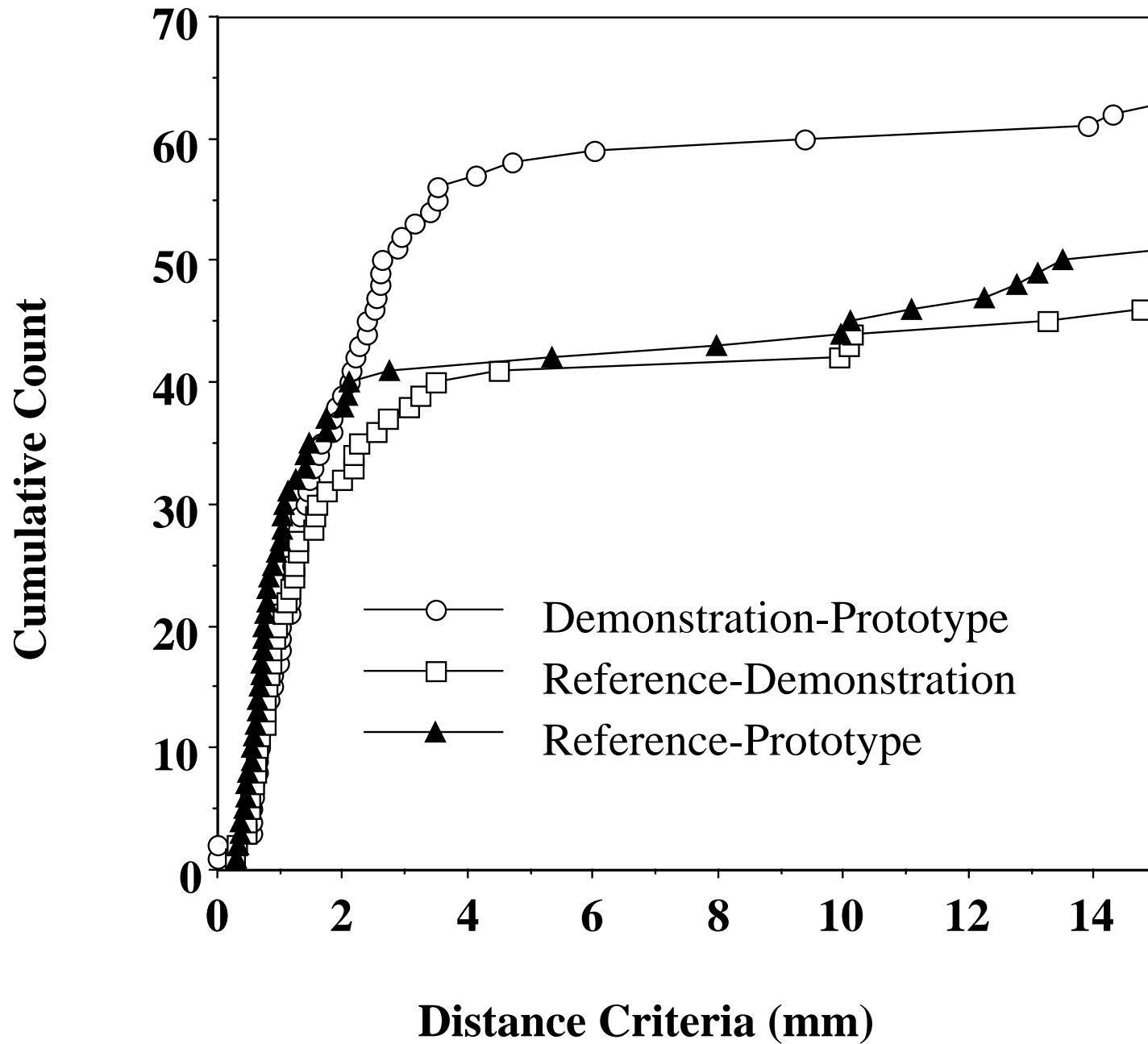
60% were less than 4 mm

Two versions of CAD software applied to the 28 cases

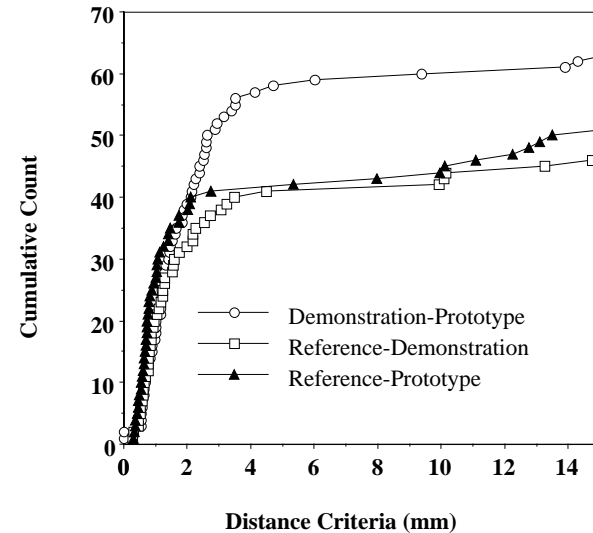
- Designation of versions of R2 software
 - **Demonstration**
 - **Prototype** (Image Check CT)
- Quantities from CAD calculations
 - x,y,z location
 - volume
 - long axis
 - perpendicular axis

Is it the same nodule?

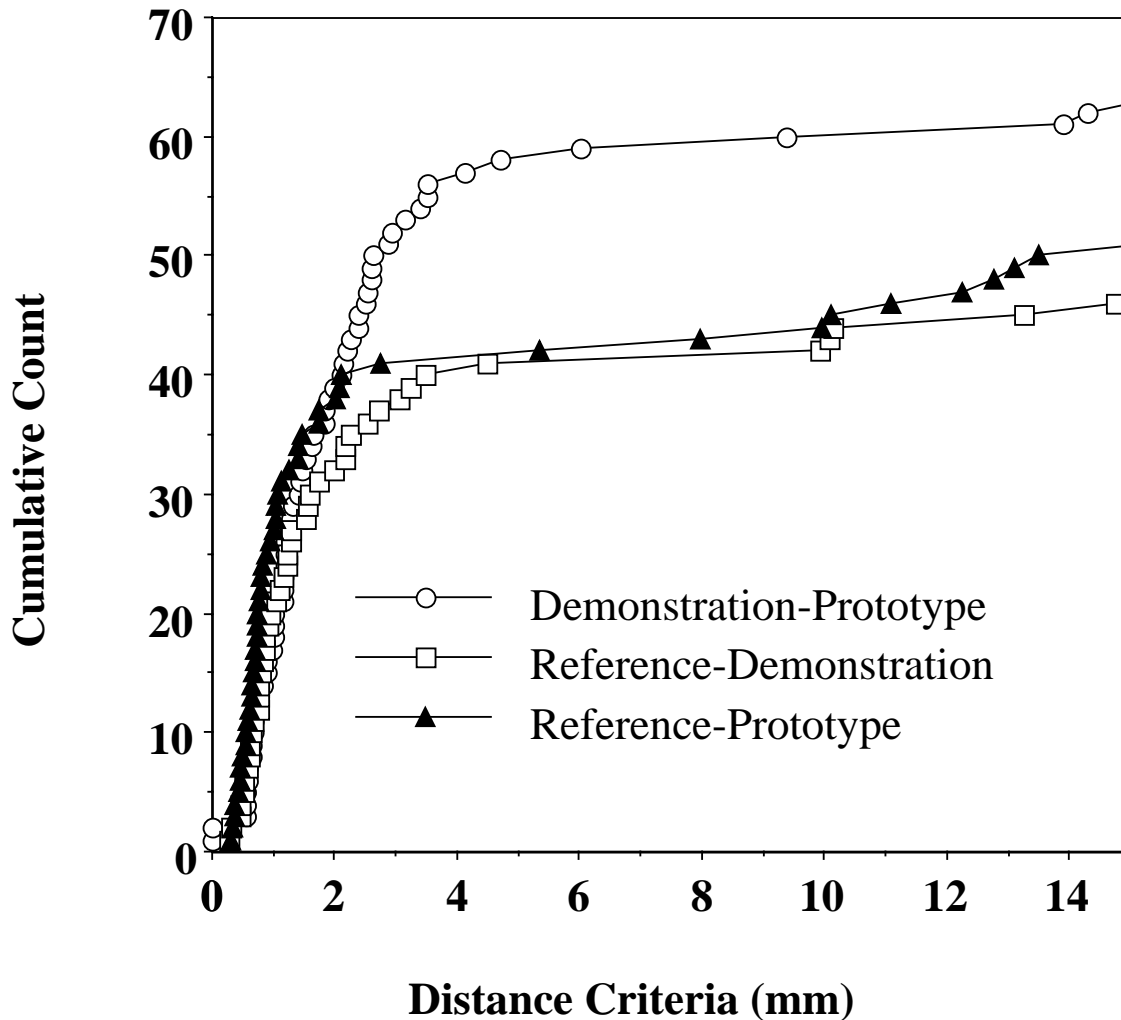
- Three sources of nodule locations:
Reference database, Demonstration CAD,
and Prototype CAD
- The distance between all possible pair of
locations was calculated
- The cumulative distribution of the pairs
whose distances that were less than a
specified value was plotted.



Is it the same nodule?



- The distributions increased rapidly from 0.0 to 3 mm then became flat.
- Above 10mm the distribution began to increase again.
- This increase was associated with random matches of different features.
- Consequently, nodule pairs with a distance of less than 5 mm identified the pairs that were considered the same feature.



Count of findings

Reference 368

Demo 95

Proto 108

Only 60% of the finding from the two CAD programs were common, so it is of interest to compare the programs performances

Three radiologists rated CAD findings

- Inspected the CAD identified locations using 2D and 3D displays of the CAD system
- Ratings
 - definitely nodule - 1
 - could be nodule - 2
 - obvious false positive - 3
- Median of the 3 ratings used to classify CAD findings

Summary of 3 radiologists
ratings of CAD findings
(28 cases)

	Demonstration	Prototype
Definitely	38	46
Could be	4	15
Obvious FP	53	44
Total	95	108

Summary of 3 radiologists
ratings of CAD findings
(per case)

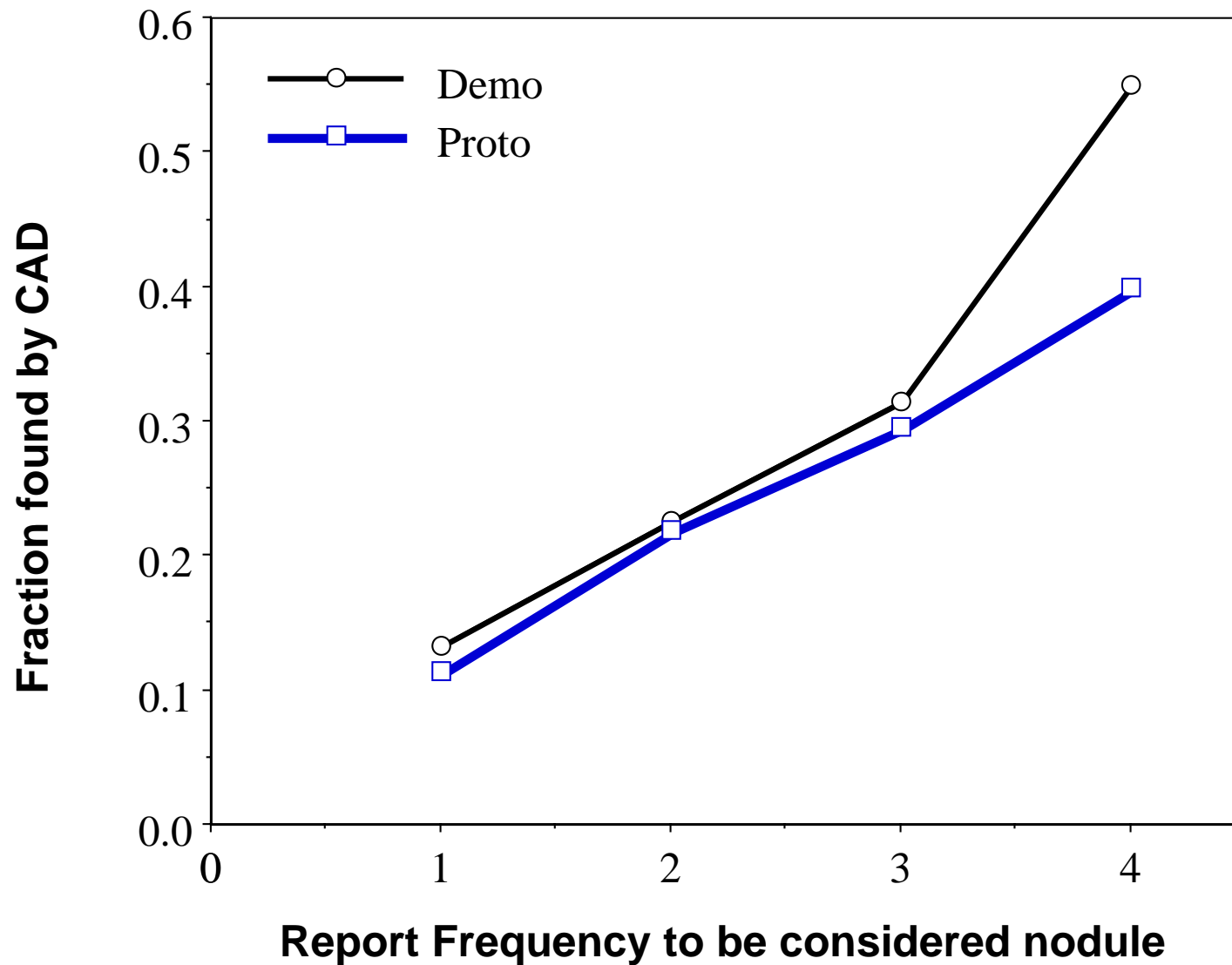
	Demonstration	Prototype
Definitely	1.4	1.6
Could be	0.1	0.5
Obvious FP	1.9	1.6
Total	3.4	3.9

Summary of 3 radiologists
ratings of CAD findings
(Not in Reference Database)

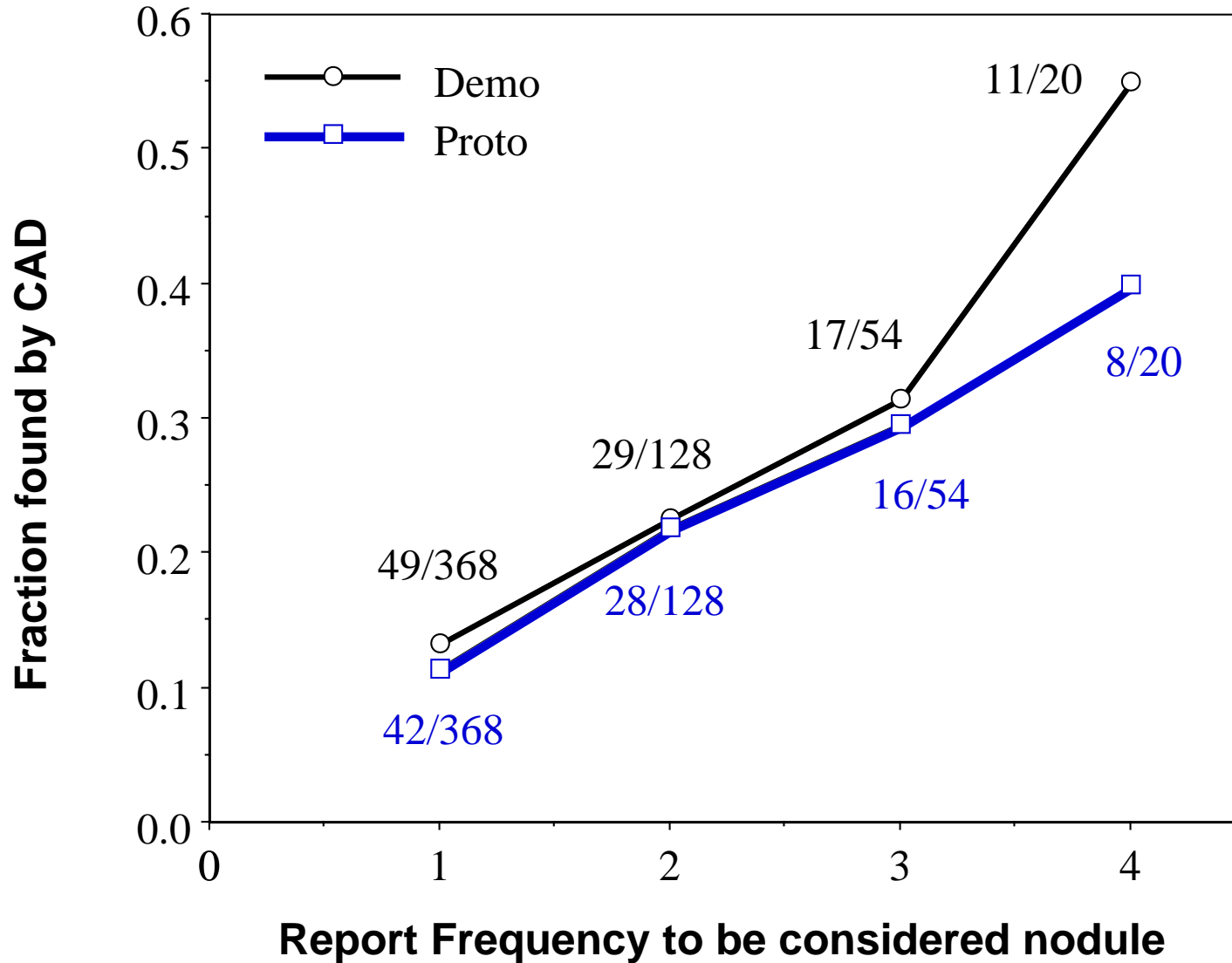
	Demonstration	Prototype
Definitely	2	15
Could be	2	11
Obvious FP	46	40
Total	50	66

**0.9 possible nodules per case found by CAD
that were never reported by 4 radiologists**

Sensitivity depends on image truth standard



Sensitivity depends on image truth standard



Conclusions

- Of the nodule locations, which were detected by the prototype CAD, 41% (0.9 locations per case) were never reported by 4 readers.
 - The creation of a comprehensive inventory of suspicious locations solely based on radiologists reports is unlikely.
- Sensitivity of the CAD programs increased as the image truth criterion based on radiologist location reports was made more stringent.
 - Evaluation of CAD programs using radiologist location reports is will be limited to comparisons using the same image databases.



The rationale for this study is Dick Swensson's research. His unified measurement model assumes that information used to localize a lesion is same information used to make the decision whether the image feature is actually a lesion. And in fact his earlier research suggest the localization can provide even more reliable information about the lesion.