Variable radiologic lung nodule evaluation leads to divergent management recommendations

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Abstract

Radiologic evaluation of incidentally-detected lung nodules on computed tomography (CT) influences management. We assessed international radiologic variation in (1) pulmonary nodule characterisation; (2) hypothetical guideline-derived management, and (3) radiologists' management recommendations.

107 radiologists from 25 countries evaluated 69 CT-detected nodules, recording: i) first-choice composition (solid, part-solid [PSN] or ground-glass [GGN], with percentage confidence), ii) morphologic features, iii) dimensions, iv) recommended management and (v) decision-influencing

Compare +100 reviewers and CNN characterization

	GGN	PSN	Solid	entropy	majority
0	87	12	8	0.61	GGN
1	83	16	8	0.68	GGN
2	1	5	101	0.24	Solid
3	0	9	98	0.29	Solid
4	33	71	3	0.74	PSN
5	10	23	74	0.81	Solid
6	16	25	66	0.92	Solid

	GGN	PSN	Solid	entropy
14	33	14	60	0.95
6	16	25	66	0.92
29	65	12	30	0.90
17	13	67	27	0.90
68	25	71	11	0.85
5	10	23	74	0.81
25	72	7	28	0.80
23	0	107	0	0.00
65	107	0	0	0.00
39	107	0	0	0.00
62	0	0	107	0.00
10	107	0	0	0.00
20	0	107	0	0.00
37	0	1	106	0.05

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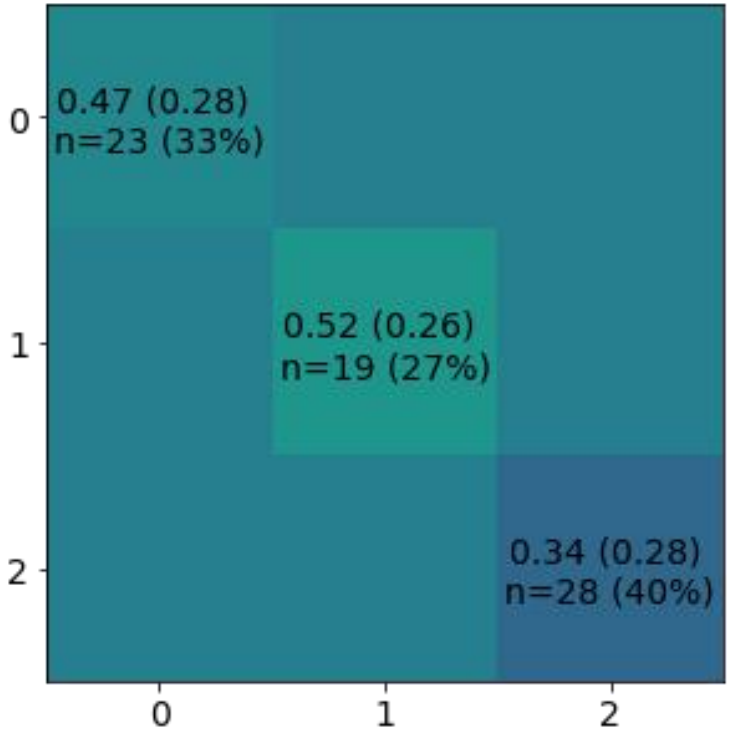
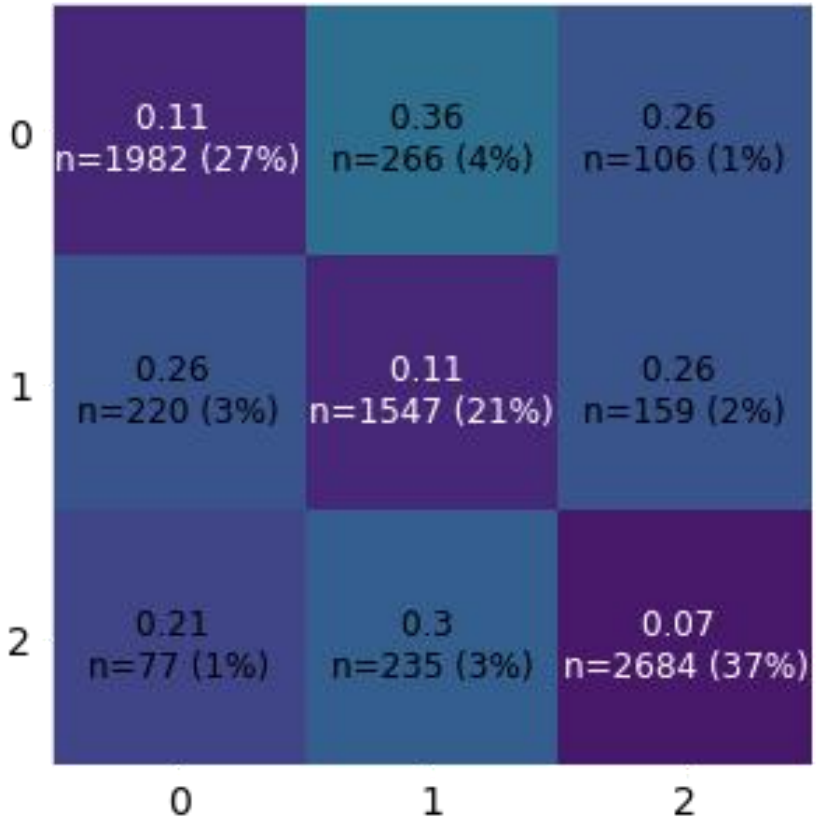
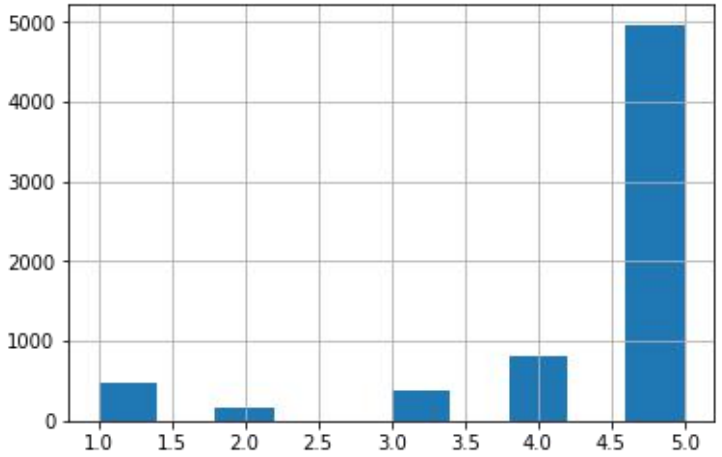
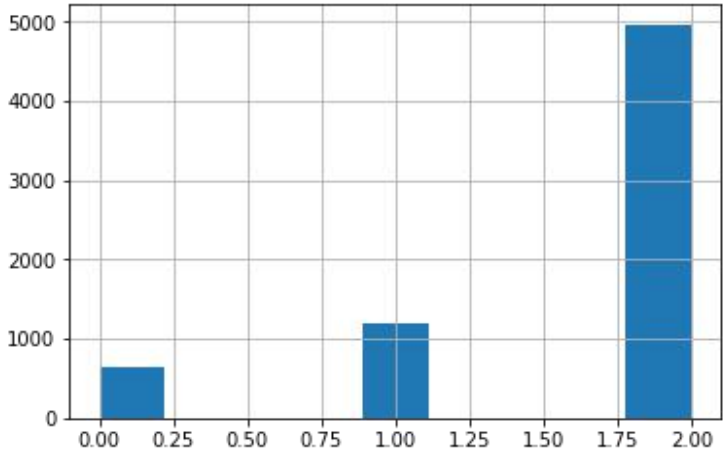


case_id	user_id	dx1	dx2	dx3	con1	con2	con3	Consensus	entropy
1.0	11.0	Pure Ground Glass	0	0	100.0	0.0	0.0	Pure Ground Glass	0.000000
2.0	11.0	Pure Ground Glass	0	0	100.0	0.0	0.0	Pure Ground Glass	0.000000
3.0	11.0	Pure Solid	0	0	100.0	0.0	0.0	Pure Solid	0.000000
4.0	11.0	Pure Solid	0	0	100.0	0.0	0.0	Pure Solid	0.000000
5.0	11.0	Part Solid	Pure Ground Glass	0	70.0	30.0	0.0	Part Solid	0.610864
6.0	11.0	Pure Solid	Part Solid	0	90.0	10.0	0.0	Pure Solid	0.325083
7.0	11.0	Pure Solid	0	0	100.0	0.0	0.0	Pure Solid	0.000000
8.0	11.0	Part Solid	Pure Solid	0	80.0	20.0	0.0	Part Solid	0.500402
9.0	11.0	Pure Solid	Part Solid	0	80.0	20.0	0.0	Pure Solid	0.500402
10.0	11.0	Part Solid	Pure Ground Glass	0	60.0	40.0	0.0	Pure Ground Glass	0.673012


0.11
n=1982 (27%)
0.36
n=266 (4%)
0.26
n=106 (1%)
0.26
n=220 (3%)
0.11
n=1547 (21%)
0.26
n=159 (2%)
0.21
n=77 (1%)
0.3
n=235 (3%)
0.07
n=2684 (37%)
0
1
2
0
1
2



	scores	spiculation	subtlety	internal_structure	calcification	sphericity	margin	lobulation	texture	malignancy
0	1	No	Extreme	Soft tissue	Popcorn	Linear	Poorly defined	No	Non-Solid/GGO	Highly unlikely
1	2	Near no	Moderate	Fluid	Laminated	Ovoid/Linear	Near poorly defined	Nearly no	Non-Solid/Mixed	Moderately unlikely
2	3	Medium	Fairly subtle	Fat	Solid	Ovoid	Medium	Medium	Part Solid/Mixed	Indeterminate
3	4	Near marked	Moderately obvious	Air	Non-central	Ovoid/Round	Near sharp	Near marked	Solid/Mixed	Moderately
4	5	Marked	Obvious	-	Central	Round	Sharp	Marked	Solid	-
5	6	-	-	-	Absent	-	-	-	-	-



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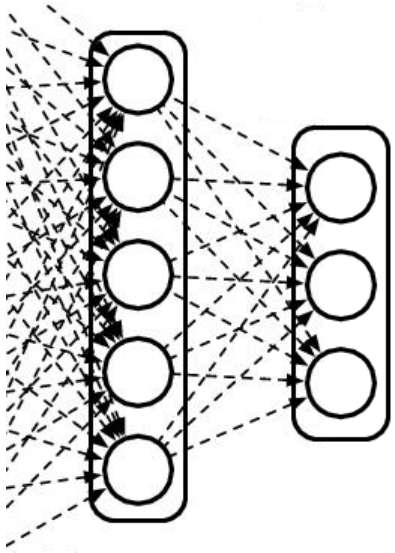
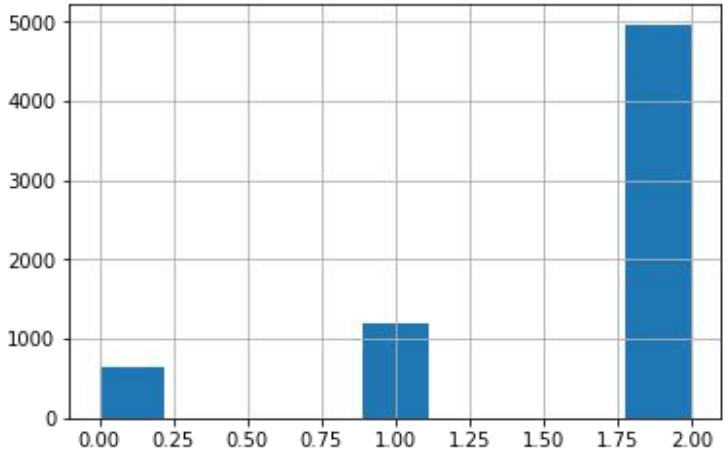
5	6	-	-	-	Absent	-	-	-	-	-





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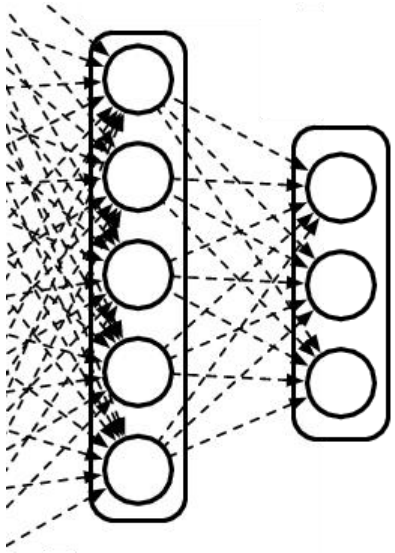
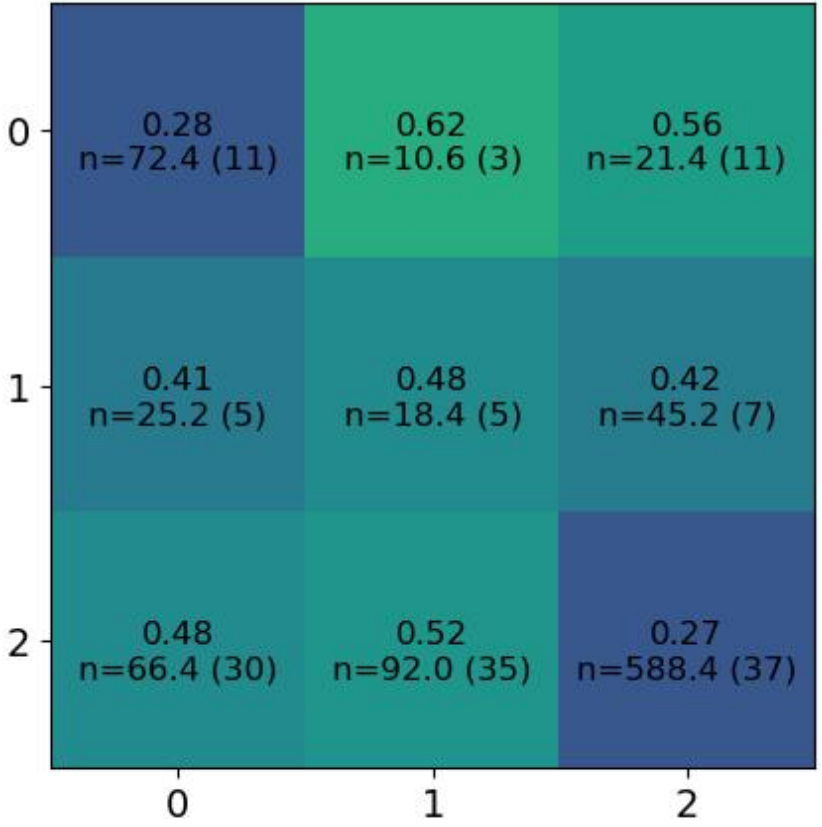
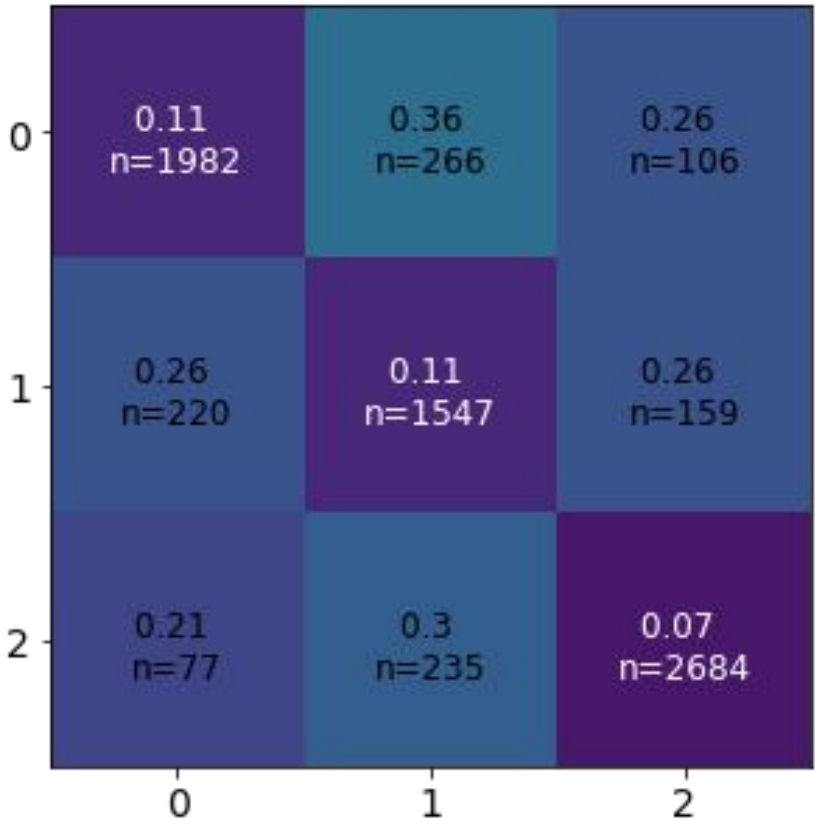
5	6	-	-	-	Absent	-	-	-	-	-




0.28
n=72.4 (11)
0.62
n=10.6 (3)
0.56
n=21.4 (11)
0.41
n=25.2 (5)
0.48
n=18.4 (5)
0.42
n=45.2 (7)
0.48
n=66.4 (30)
0.52
n=92.0 (35)
0.27
n=588.4 (37)
0
1
2
0
1
2


0.11
n=1982
0.36
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n=106
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n=220
0.11
n=1547
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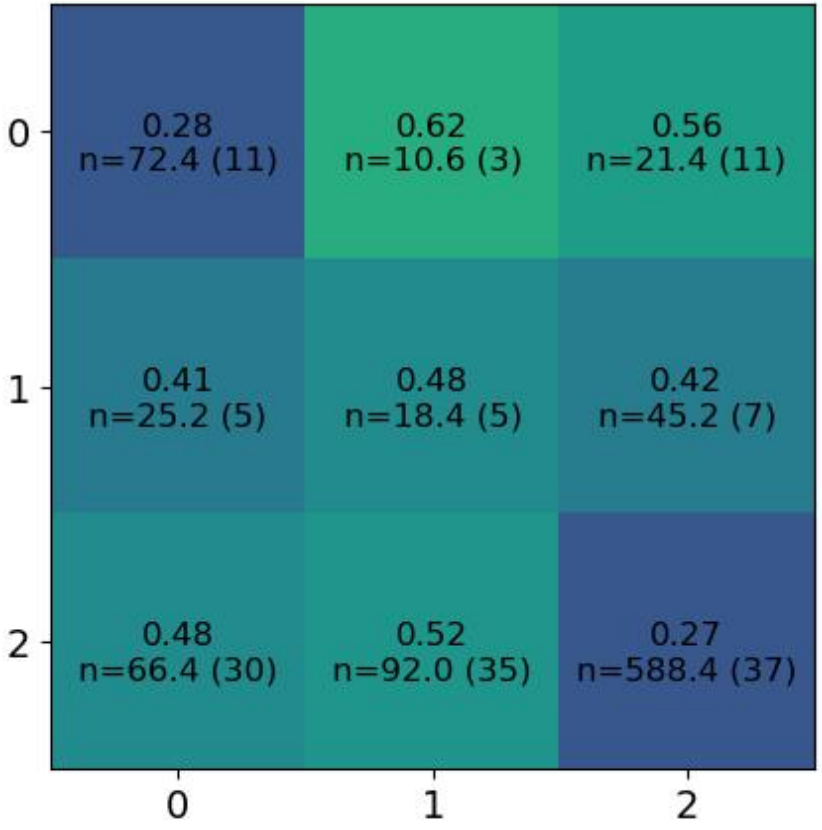
0.21
n=77
0.3
n=235
0.07
n=2684
0
1
2
0
1
2


0.28
n=72.4 (11)
0.62
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0.56
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0.41
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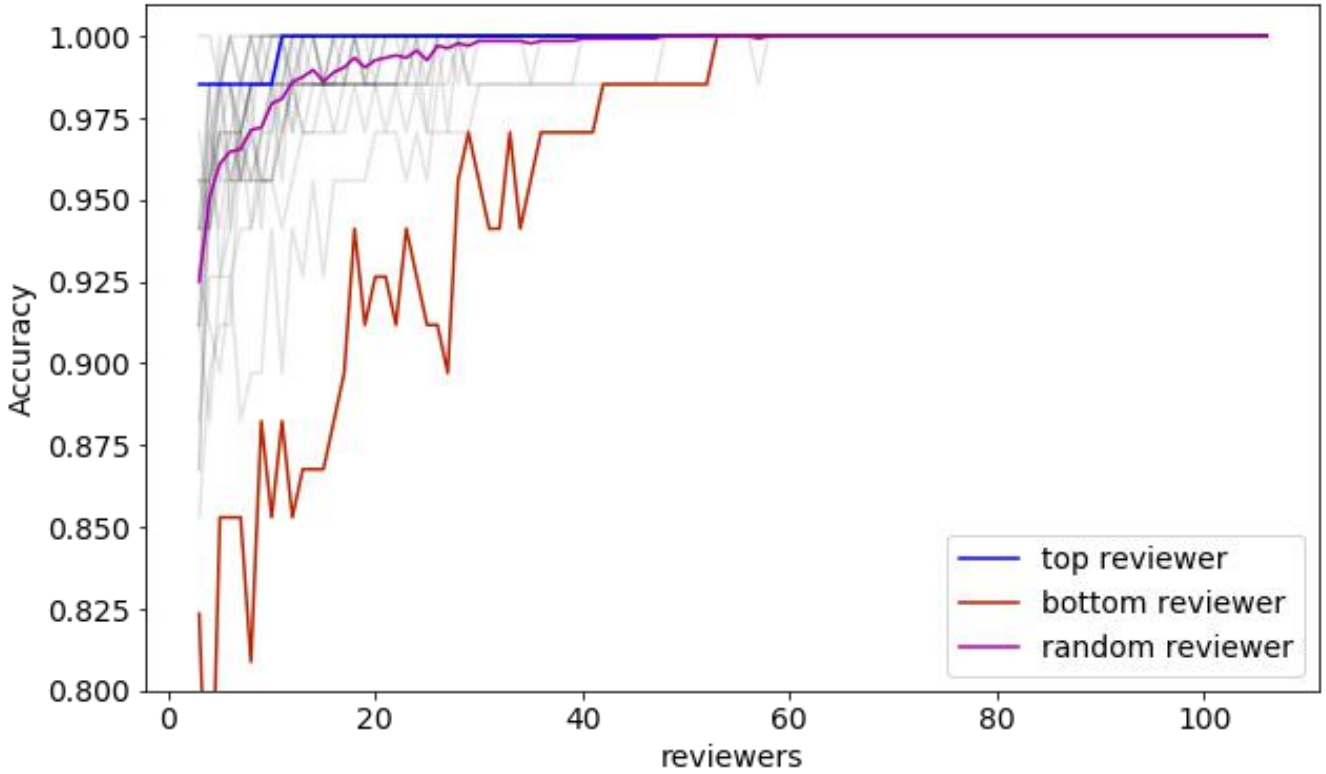
0.42
n=45.2 (7)
0.48
n=66.4 (30)
0.52
n=92.0 (35)
0.27
n=588.4 (37)
0
1
2
0
1
2

Number of reviewers required for ground truth

user_id	user_acc
175.0	0.985294
197.0	0.955882
125.0	0.955882
113.0	0.941176
118.0	0.941176
...	
33.0	0.735294
43.0	0.735294
92.0	0.720588
47.0	0.691176
114.0	0.661765

	Consensus	reviewer_rank_0	reviewer_rank_1	reviewer_rank_2
0	Pure Ground Glass	Pure Ground Glass	Pure Ground Glass	Pure Ground Glass
1	Pure Ground Glass	Pure Ground Glass	Pure Ground Glass	Pure Ground Glass
2	Pure Solid	Pure Solid	Pure Solid	Pure Solid
3	Pure Solid	Pure Solid	Pure Solid	Pure Solid
4	Part Solid	Part Solid	Part Solid	Pure Ground Glass
5	Pure Solid	Pure Solid	Pure Solid	Pure Solid
6	Pure Solid	Pure Solid	Pure Ground Glass	Pure Solid


1.000
0.975
0.950
0.925
0.900
0.875
0.850
0.825
0.800
Accuracy
0
20
40
60
80
100
reviewers
top reviewer
bottom reviewer
random reviewer

Instructions

– After speaking with Arjun we did not use scan 23 (we were already not using scan 30)
– We try training a CNN based on LIDC and malignancy label (5 classes). From that CNN we get features for the 68 nodules

1) Get the 68 nodules and their dataframe with Documents/KCL/18Aug29–107_observers/localize nodules on 70 dicoms v5.ipynb
nodules_five_scans_68_cases_RGB_no23_no29.npy
Nodule Study raw data for KCL 68.csv

2) Train a CNN based on LIDC malignancy with: /Documents/KCL/18 Oct 9 – ladder on LIDC plus 70 nodules/
CNN classifier based on LIDC texture v6 – images from nodule consensus classifier again.ipynb:
In part 4 (use the pretrained network on the 70 nodules) load nodules_five_scans_68_cases_RGB_no23_no29.npy to produce
results/results CNN regression based on LIDC texture v6/features128_classification5malignancy_on68ndls.npy

3) Once we have the features for the 68 nodules we run the Documents/KCL/18 Oct 9 – ladder on LIDC plus 70 nodules/
regression on 70 nodules v0 – random forests where we load:
nodules_five_scans_68_cases_RGB_no23_no29.npy
Nodule Study raw data for KCL 68.csv

To run the entropy comparison:
– To get model uncertainty CNN classifier based on LIDC texture v6 – images from nodule consensus classifier again.ipynb, specially the Get uncertainty in the prediction section
– To get uncertainty from the reviewers run Documents/KCL/18Aug29–107_observers/reviewers uncertainty in 70 nodules v1.ip