

Multi-modal Learning with Chest Radiographs

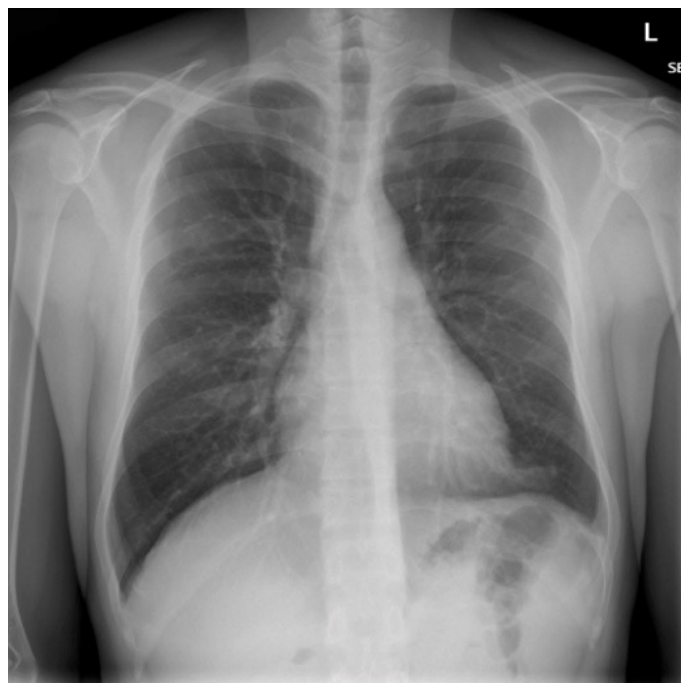
Benjamin Hou | Biomedical Image Analysis
Imperial College London



Overview

- Latent space and multi-modal learning
- Datasets available in chest radiography
- Active Projects and Research
- R.A.T.C.H.E.T. – Radiology Report Generation
 - Language Tokenization
 - Transformer Architecture and R.A.T.C.H.E.T. Model
 - Attention
 - Text Generation Process
- Results

Multi-modal in Chest X-rays



FINAL REPORT

Comparison: None

Indication: Burmese male has complete TB treatment

Findings: Both lungs are clear and expanded with no infiltrates. Basilar focal atelectasis is present in the lingula. Heart size normal. Calcified right hilar XXXX are present

Impression: No active disease.

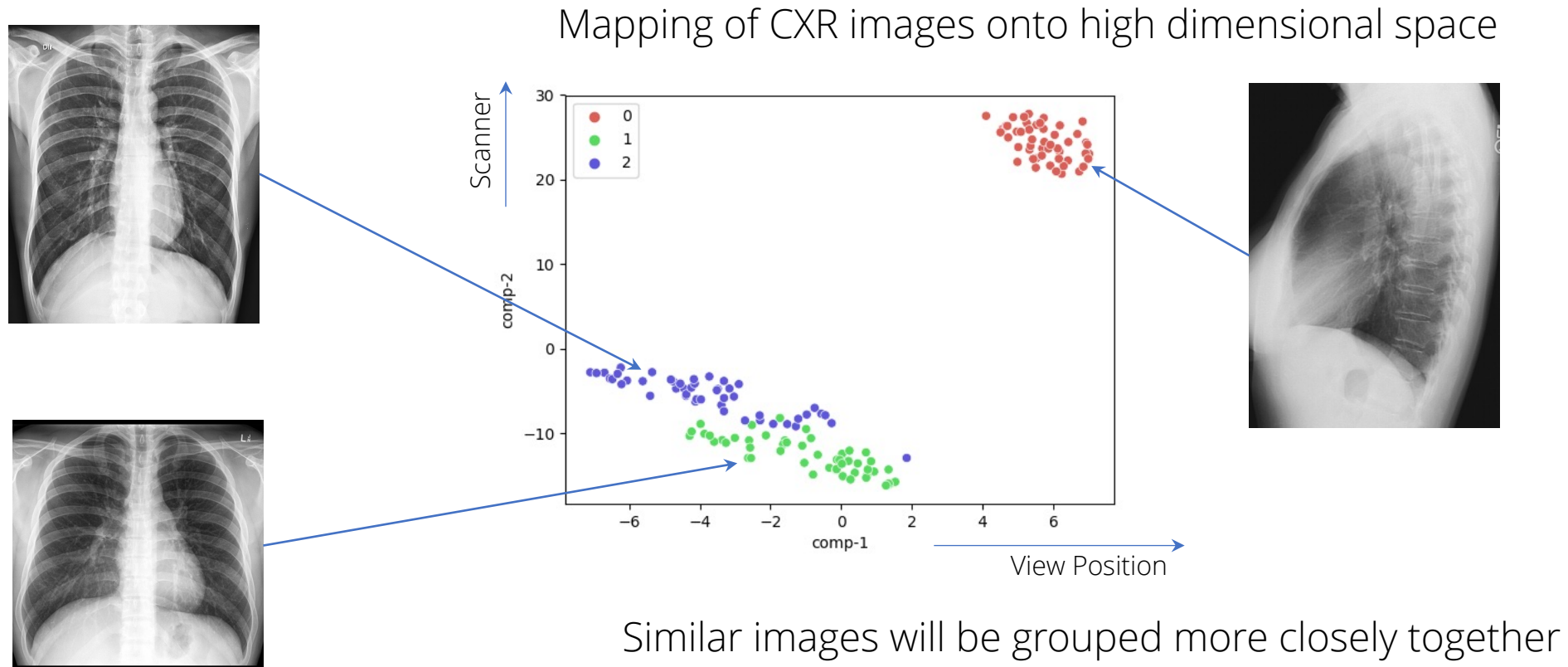
MeSH

Major: Pulmonary / Atelectasis / lingula / focal Calcinosis / lung / hilum / right

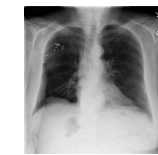
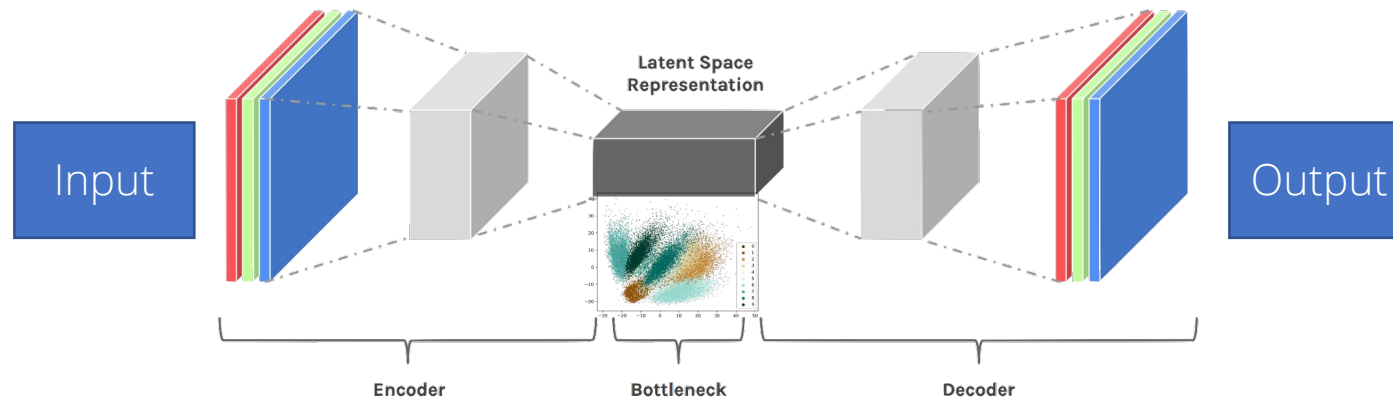
METADATA

- dicom_id
- PerformedProcedureStepDescription
- ViewPosition
- Rows
- Columns
- StudyDate
- StudyTime
- ProcedureCodeSequence
- ViewCodeSequence
- PatientOrientationCodeSequence

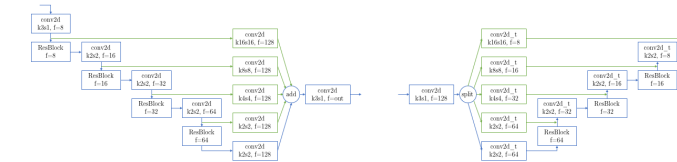
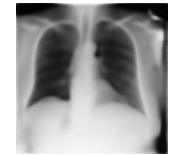
Latent Space Representation



Latent Space Representation

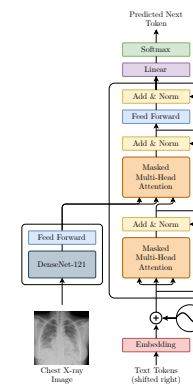


ResNet-VQVAE
Learned Image
Latent Space



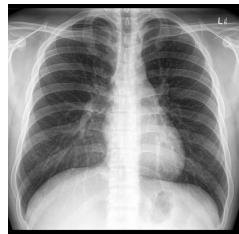
R.A.T.C.H.E.T. – Image to Text Generation

Input	Output	Task	Example
Image	Image	Image Autoencoder	ResNet-(VQ)VAE
Image	Text	Report Generation / Retrieval from Image	R.A.T.C.H.E.T.
Text	Image	Image Synthesis / Retrieval from Report	W.I.P.
Text	Text	Text Autoencoder	GPT-2/3*



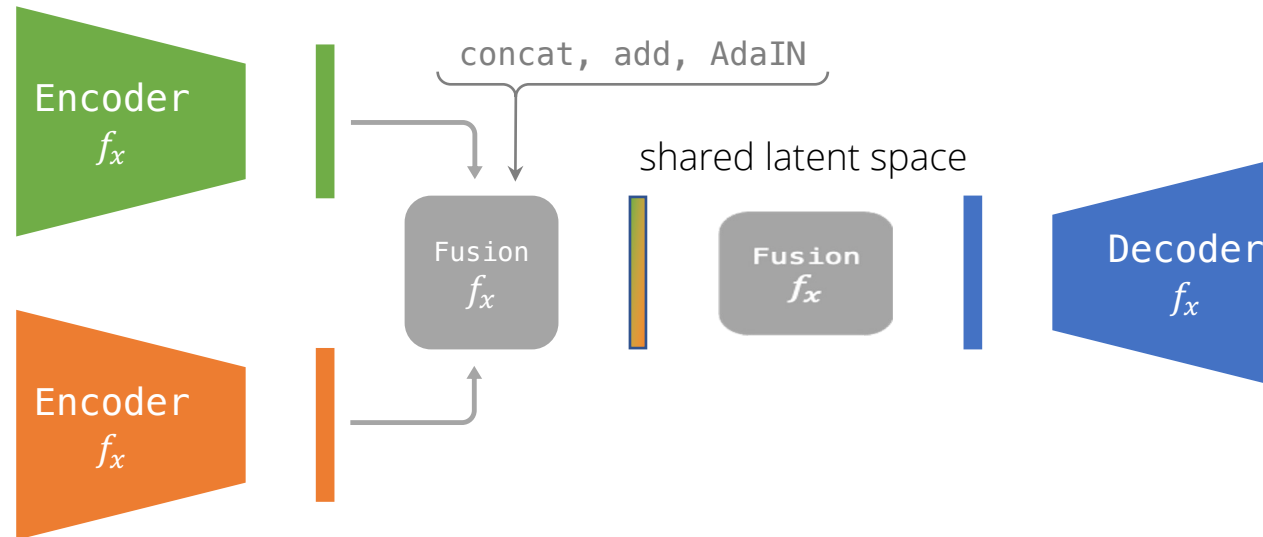
	Case 1	Case 2	Case 3	Case 4
Image				
True Text	'Stable right greater than left upper lobe fibrotic changes. New opacity in the left mid-to-lower lung raises concern for infectious process versus possibly neoplastic etiology. Recommend follow up to resolution.'	'Cardiomegaly and pulmonary edema which may have progressed since prior although some changes may be accounted for by lower lung volumes on the current exam. Left basilar opacity, potentially atelectasis noting that infectious would also be possible.'	'Known lung metastases are again noted though better assessed on prior CT. No definite signs of superimposed acute process.'	'In comparison with the study of _____ there is little change in the substantial enlargement of the cardiomediastinal silhouette and in the pulmonary edema with bilateral pleural effusions. Monitoring and support devices remain in place.'
Predicted Text	'Diffuse bilateral parenchymal opacities similar compared to the prior exam, with new focal opacity in the left upper lung field. Findings could reflect multifocal infectious, though a component of pulmonary edema is also possible.'	'1. Low lung volumes with bibasilar atelectasis. 2. Severe cardiomegaly.'	'No acute cardiopulmonary process.'	'As compared to the previous radiograph, there is no relevant change. However, comparison with bilateral pleural effusions and subsequent areas of atelectasis. The monitoring and support devices are in constant position. No new parenchymal opacities.'

Fusion of Latent Spaces



FINAL REPORT

Comparison: None
 Indication: Burmese male has complete TB treatment
 Findings: Both lungs are clear and expanded with no infiltrates. Basilar focal atelectasis is present in the lingula. Heart size normal. Calcified right hilar XXXX are present
 Impression: No active disease.



- An output task:
- Detection
 - Segmentation
 - Generation

npj | digital medicine View all journals Search Q Login

Explore content | Journal information | Publish with us

nature > npj digital medicine > review articles > article

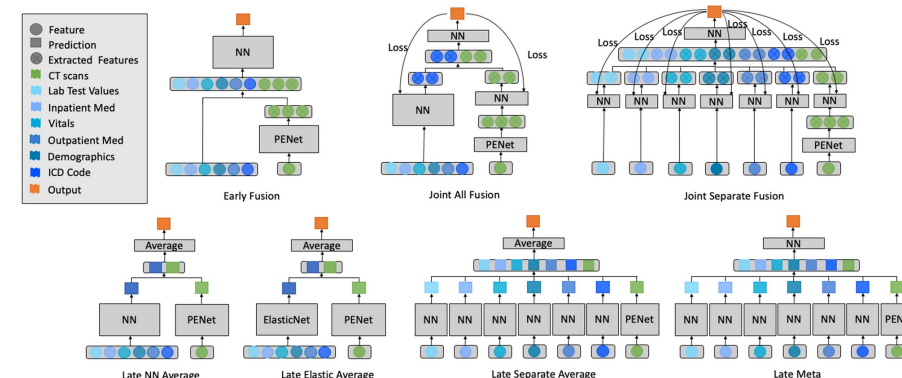
Review Article | Open Access | Published: 16 October 2020

Fusion of medical imaging and electronic health records using deep learning: a systematic review and implementation guidelines

Shih-Cheng Huang, Anuj Pareek, Saeed Seyyedi, Imon Banerjee & Matthew P. Lungren

npj Digital Medicine 3, Article number: 136 (2020) | Cite this article

9473 Accesses | 10 Citations | 56 Altmetric | Metrics



Available CXR Datasets

Dataset	Input	# Images	# Patients	Label	# Reports	N.B.
MIMIC-CXR-2.0	DICOM/PNG	473,057	63,478	Radiology Reports Class Labels	206,563	Labels Mined by NegBio ² / CheXpert NLP ¹
OpenI	DICOM/PNG	7470	3955	Radiology Reports	3955	---
PadChest	PNG	160,868	67,625	Radiology Reports Class Labels	109,931	¡En Español!
Chest-XRay8	PNG	108,948	32,717	Class Labels	0	Labels Mined by NegBio ²
CheXpert	JPG	224,316	65,240	Class Labels	0	Labels Mined by CheXpert NLP ¹

¹Irvin, J., Rajpurkar, P., Ko, M., Yu, Y., Ciurea-Ilcus, S., Chute, C., Marklund, H., Haghgoo, B., Ball, R., Shpanskaya, K., et al.: Chexpert: A large chest radiograph dataset with uncertainty labels and expert comparison. In: Thirty-Third AAAI Conference on Artificial Intelligence (2019)

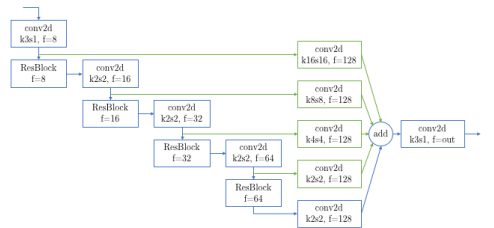
²Peng Y., Wang X., Lu L., Bagheri M., Summers R.M., Lu Z., et al.: NegBio: a high-performance tool for negation and uncertainty detection in radiology reports. In: AMIA 2018 Informatics Summit (2018)

Projects

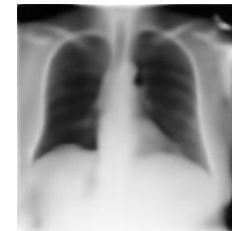
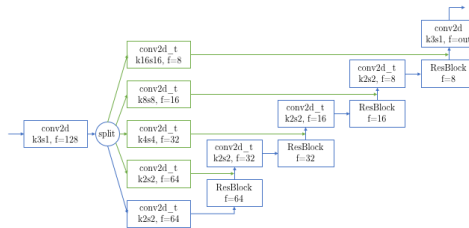
Image Similarity Search
ResNetAE




Anomaly Detection
ResNet-VQVAE




Z



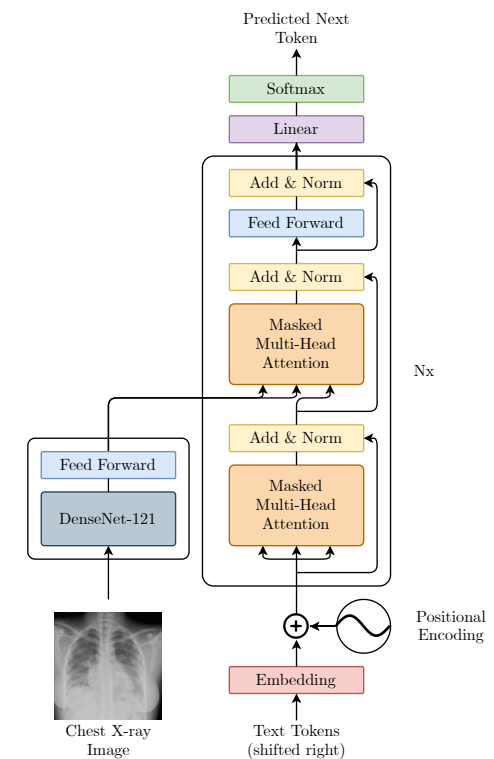
 /farrell236/ResNetAE



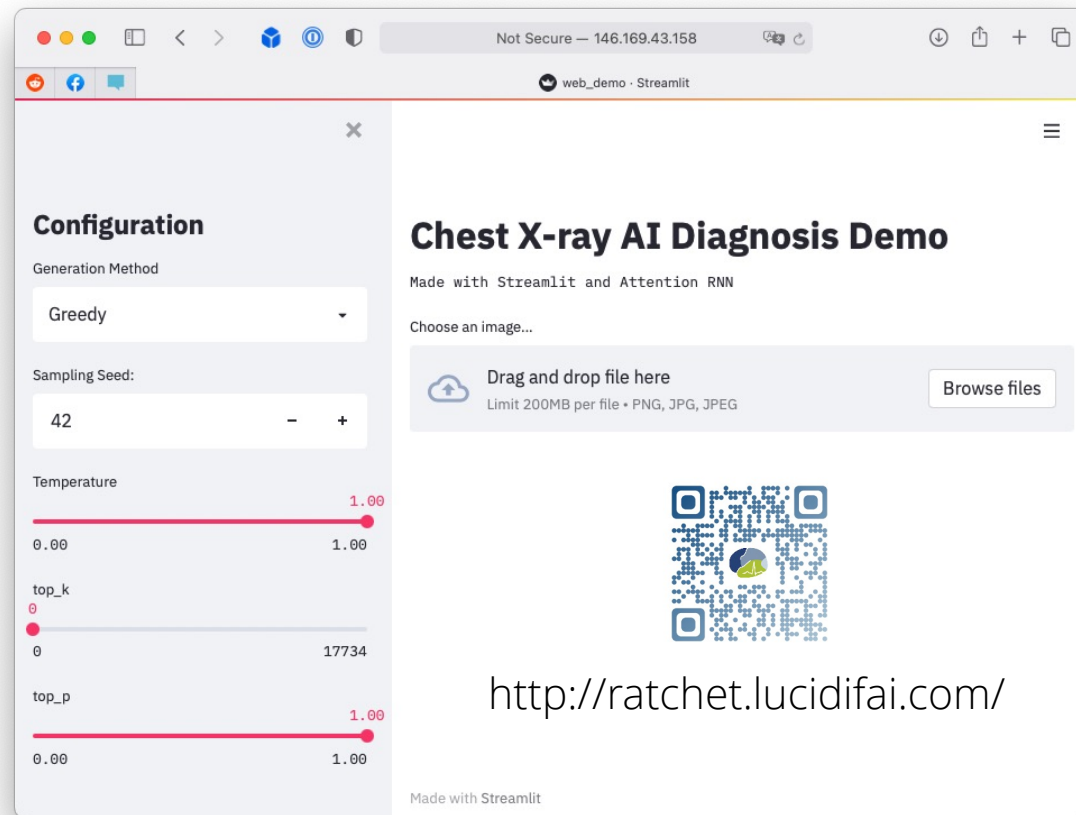
Coming Soon!

 /farrell236/RATCHET

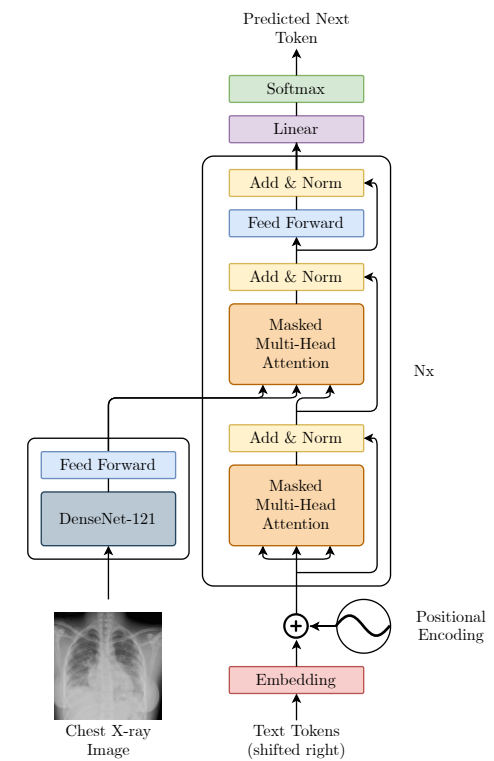
Text Generation
R.A.T.C.H.E.T.



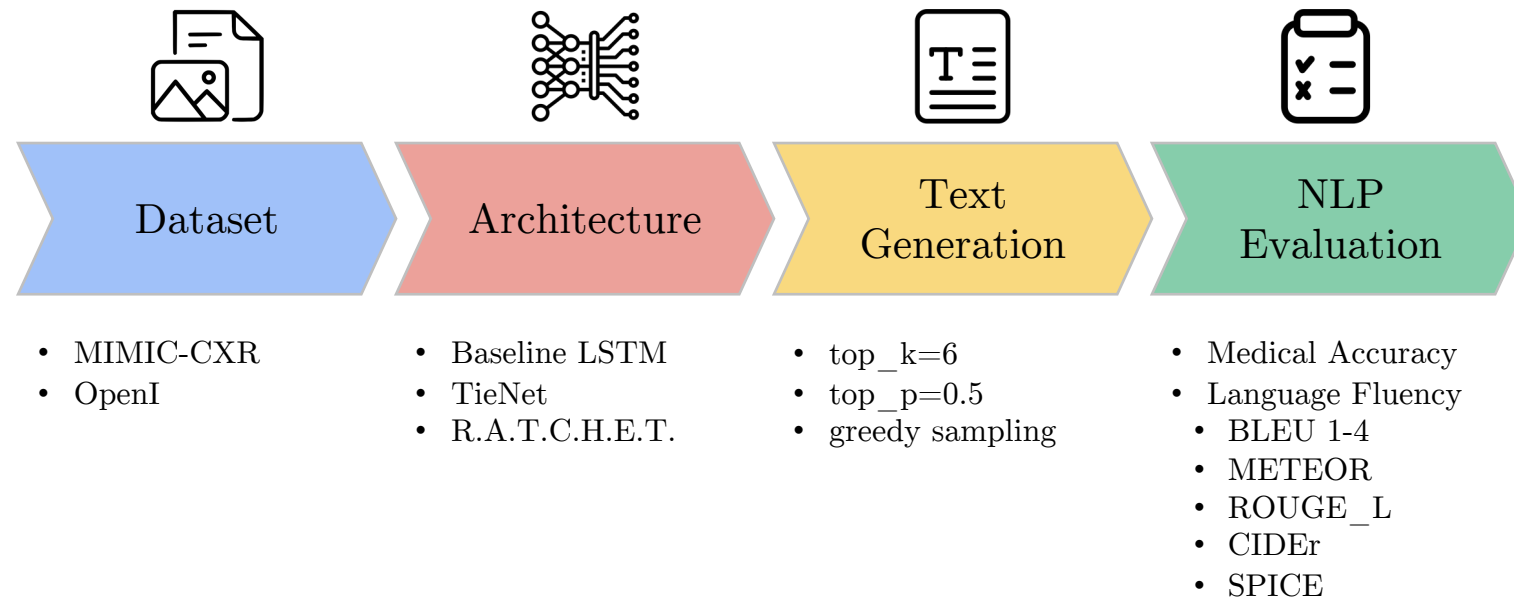
Projects



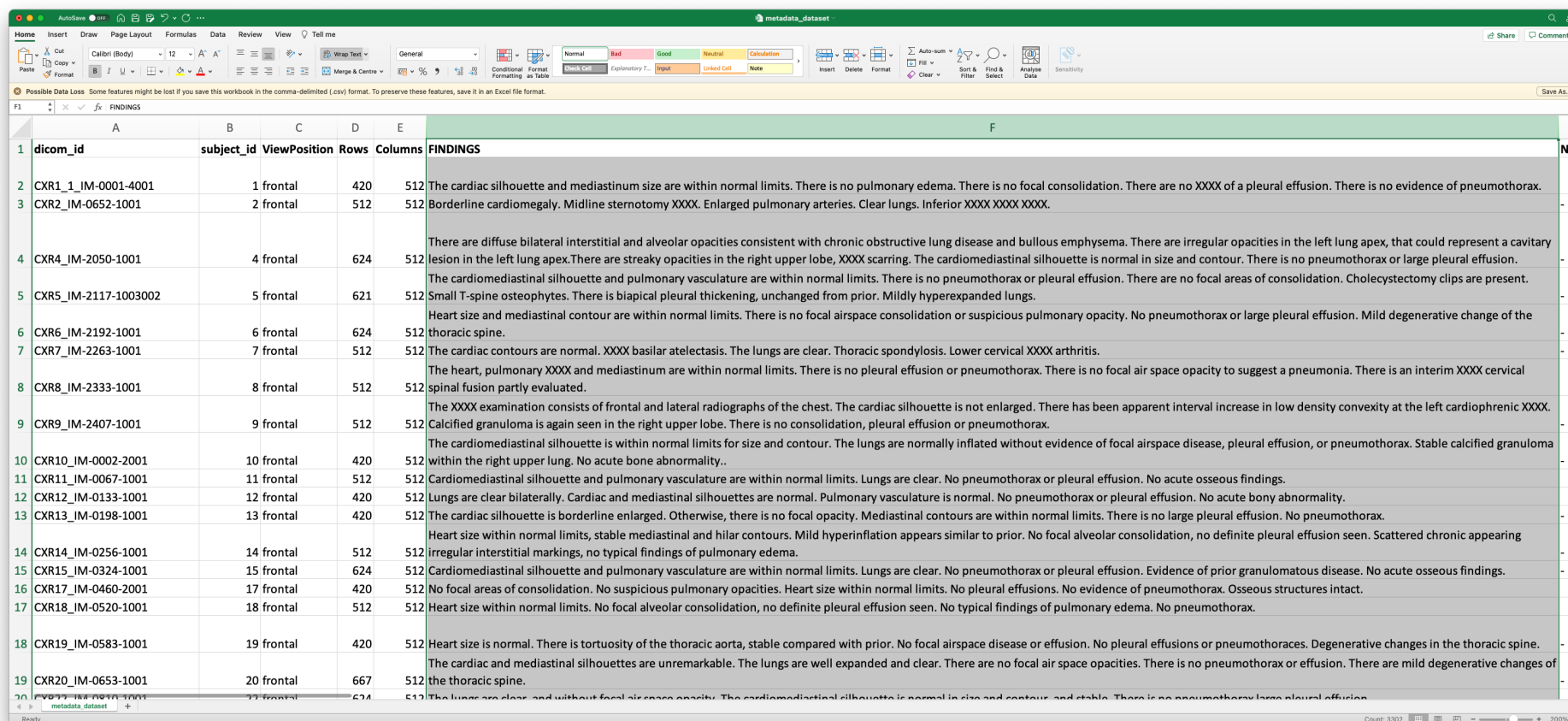
Text Generation R.A.T.C.H.E.T.



Report Generation Pipeline



Free-text Reports (OpenI)



	A	B	C	D	E	F
1	dicom_id	subject_id	ViewPosition	Rows	Columns	FINDINGS
2	CXR1_1_IM-0001-4001	1	frontal	420	512	The cardiac silhouette and mediastinum size are within normal limits. There is no pulmonary edema. There is no focal consolidation. There are no XXXX of a pleural effusion. There is no evidence of pneumothorax.
3	CXR2_IM-0652-1001	2	frontal	512	512	Borderline cardiomegaly. Midline sternotomy XXXX. Enlarged pulmonary arteries. Clear lungs. Inferior XXXX XXXX XXXX.
4	CXR4_IM-2050-1001	4	frontal	624	512	There are diffuse bilateral interstitial and alveolar opacities consistent with chronic obstructive lung disease and bullous emphysema. There are irregular opacities in the left lung apex, that could represent a cavitary lesion in the left lung apex. There are streaky opacities in the right upper lobe, XXXX scarring. The cardiomeastinal silhouette is normal in size and contour. There is no pneumothorax or large pleural effusion.
5	CXR5_IM-2117-1003002	5	frontal	621	512	The cardiomeastinal silhouette and pulmonary vasculature are within normal limits. There is no pneumothorax or pleural effusion. There are no focal areas of consolidation. Cholecystectomy clips are present. Small T-spine osteophytes. There is biapical pleural thickening, unchanged from prior. Mildly hyperexpanded lungs.
6	CXR6_IM-2192-1001	6	frontal	624	512	Heart size and mediastinal contour are within normal limits. There is no focal airspace consolidation or suspicious pulmonary opacity. No pneumothorax or large pleural effusion. Mild degenerative change of the thoracic spine.
7	CXR7_IM-2263-1001	7	frontal	512	512	The cardiac contours are normal. XXXX basilar atelectasis. The lungs are clear. Thoracic spondylosis. Lower cervical XXXX arthritis.
8	CXR8_IM-2333-1001	8	frontal	512	512	The heart, pulmonary XXXX and mediastinum are within normal limits. There is no pleural effusion or pneumothorax. There is no focal air space opacity to suggest a pneumonia. There is an interim XXXX cervical spinal fusion partly evaluated.
9	CXR9_IM-2407-1001	9	frontal	512	512	The XXXX examination consists of frontal and lateral radiographs of the chest. The cardiac silhouette is not enlarged. There has been apparent interval increase in low density convexity at the left cardiophrenic XXXX. Calcified granuloma is again seen in the right upper lobe. There is no consolidation, pleural effusion or pneumothorax.
10	CXR10_IM-0002-2001	10	frontal	420	512	The cardiomeastinal silhouette is within normal limits for size and contour. The lungs are normally inflated without evidence of focal airspace disease, pleural effusion, or pneumothorax. Stable calcified granuloma within the right upper lung. No acute bone abnormality..
11	CXR11_IM-0067-1001	11	frontal	512	512	Cardiomeastinal silhouette and pulmonary vasculature are within normal limits. Lungs are clear. No pneumothorax or pleural effusion. No acute osseous findings.
12	CXR12_IM-0133-1001	12	frontal	420	512	Lungs are clear bilaterally. Cardiac and mediastinal silhouettes are normal. Pulmonary vasculature is normal. No pneumothorax or pleural effusion. No acute bony abnormality.
13	CXR13_IM-0198-1001	13	frontal	420	512	The cardiac silhouette is borderline enlarged. Otherwise, there is no focal opacity. Mediastinal contours are within normal limits. There is no large pleural effusion. No pneumothorax.
14	CXR14_IM-0256-1001	14	frontal	512	512	Heart size within normal limits, stable mediastinal and hilar contours. Mild hyperinflation appears similar to prior. No focal alveolar consolidation, no definite pleural effusion seen. Scattered chronic appearing irregular interstitial markings, no typical findings of pulmonary edema.
15	CXR15_IM-0324-1001	15	frontal	624	512	Cardiomeastinal silhouette and pulmonary vasculature are within normal limits. Lungs are clear. No pneumothorax or pleural effusion. Evidence of prior granulomatous disease. No acute osseous findings.
16	CXR17_IM-0460-2001	17	frontal	420	512	No focal areas of consolidation. No suspicious pulmonary opacities. Heart size within normal limits. No pleural effusions. No evidence of pneumothorax. Osseous structures intact.
17	CXR18_IM-0520-1001	18	frontal	512	512	Heart size within normal limits. No focal alveolar consolidation, no definite pleural effusion seen. No typical findings of pulmonary edema. No pneumothorax.
18	CXR19_IM-0583-1001	19	frontal	420	512	Heart size is normal. There is tortuosity of the thoracic aorta, stable compared with prior. No focal airspace disease or effusion. No pleural effusions or pneumothoraces. Degenerative changes in the thoracic spine.
19	CXR20_IM-0653-1001	20	frontal	667	512	The cardiac and mediastinal silhouettes are unremarkable. The lungs are well expanded and clear. There are no focal air space opacities. There is no pneumothorax or effusion. There are mild degenerative changes of the thoracic spine.
20	CXR21_IM-0653-1001	21	frontal	624	512	The lungs are clear and without focal airspace opacity. The cardiomeastinal silhouette is normal in size and contour and stable. There is no pneumothorax, large pleural effusion.

Free-text Reports (MIMIC-CXR)

categorisation

hyphenated
compound
words

abbreviations

```

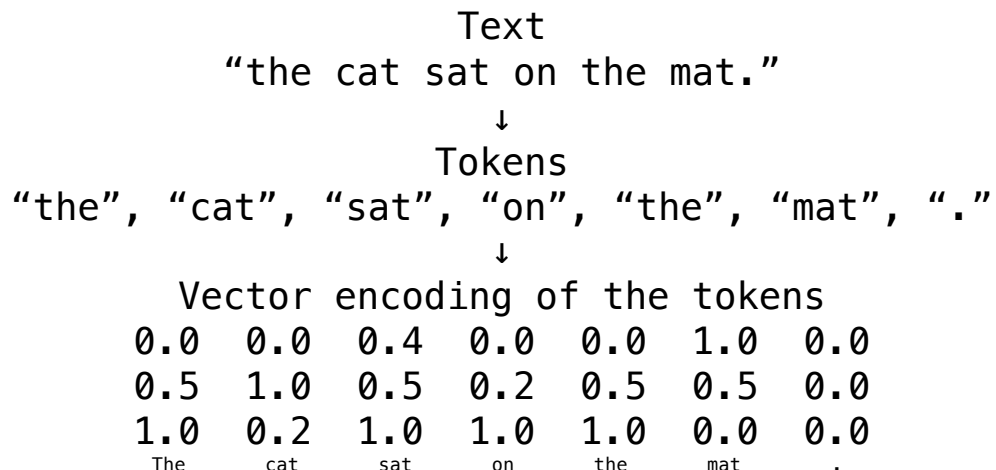
s56699142,No acute cardiopulmonary process.
s50414267,No acute cardiopulmonary process.
s53911762,No acute intrathoracic process.
s53189527,No acute cardiopulmonary abnormality.
s57375967,"Focal consolidation at the left lung base, possibly representing aspiration or pneumonia. Central vascular engorgement."
s54205396,No evidence of acute cardiopulmonary process.
s50771383,No acute intrathoracic process.
s51178377,"Increasing left lung opacification which may reflect pneumonia superimposed on metastatic disease, although other etiologies such as lymphangitic pattern of metastatic spread could be considered. CT may be helpful to evaluate further if needed clinically."
s50578979,1. Low lung volumes and mild pulmonary vascular congestion is unchanged. 2. New small right fissural pleural effusion. 3. No new focal opacities to suggest pneumonia.
s58219844,Innumerable pulmonary metastases. Possible mild pulmonary vascular congestion. Low lung volumes.
s56164612,"New nodular opacities within both upper lobes, left greater than right. Findings are compatible with metastases, as was noted in the lung bases on the subsequent CT of the abdomen and pelvis performed later the same day."
s55697293,Stable chest radiograph.
s56522600,PA and lateral upright chest radiographs were reviewed in comparison to _____. Heart size is normal. Mediastinum is normal. The post-surgical changes in the right hemithorax are stable including thickening of the pleura along the costal surface and blunting of the costophrenic sulcus. The surgical fracture of the right sixth rib is redemonstrated. No new abnormalities are demonstrated within the limitations of the chest radiograph technique. Lung volumes are preserved.
s57861150,Interval resolution of previously seen mild pulmonary edema with trace bilateral pleural effusions.
s58206436,1. New mild pulmonary edema with persistent small bilateral pleural effusions. 2. Severe cardiomegaly is likely accentuated due to low lung volumes and patient positioning.
s54980801,No acute cardiopulmonary process.
s50985099,"Compared to chest radiographs since _____, most recently one _____. Previous mild pulmonary edema and possible concurrent pneumonia has all cleared. Heart is top-normal size, improved, and pleural effusions have resolved. Right hilar vessels are still enlarged, perhaps due to pulmonary arterial hypertension. Lateral view shows atherosclerotic coronary calcification in the left circumflex."
s54935705,"Mild pulmonary edema with superimposed left upper lung consolidation, potentially more confluent edema versus superimposed infection."
s58636672,"As compared to _____, the lung volumes have slightly decreased. Signs of mild overinflation and moderate pleural effusions persist. Moderate cardiomegaly. Elongation of the descending aorta. No pneumonia."
s59988438,"Tiny pleural effusions, new. Otherwise unremarkable."
s51967283,"Right upper lobe pneumonia or mass. However, given right hilar fullness, a mass resulting in post-obstructive pneumonia is within the differential. Recommend chest CT with intravenous contrast for further assessment. Dr. _____ communicated the above results to Dr. _____ at 8:55 am on _____ by telephone."
s54577367,No radiographic evidence for pneumonia.
s58224503,No acute intrathoracic process.
s53447138,"The lung volumes are normal. No evidence of TB or other parenchymal changes. Mild elevation of the left hemidiaphragm. No pleural effusions. No pneumonia. The lateral radiograph shows evidence of anterior ligament calcification at the anterior aspect of the thoracic spine. Status post cholecystectomy."
s53957785,No acute cardiopulmonary abnormality.
s54684191,Mild pulmonary edema
s53186264,"Mild perihilar prominence, suspected to represent mildly prominent pulmonary vessels without definite pneumonia. Streaky left basilar opacification seen only on the frontal view is probably due to minor atelectasis or scarring."
s52067803,"Mild left base atelectasis. Otherwise, no acute cardiopulmonary process."
:|

```

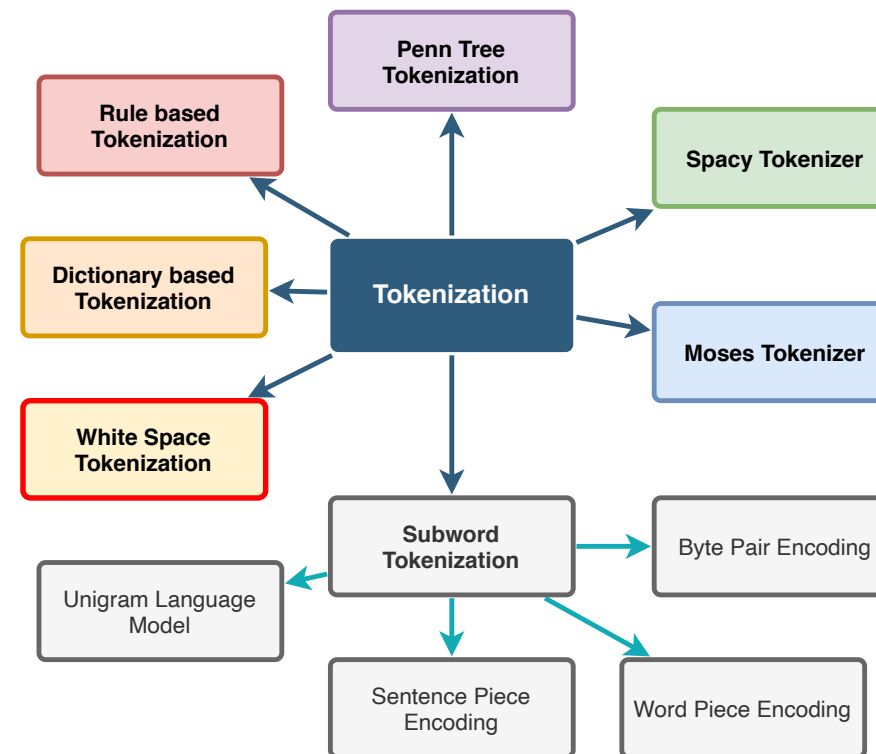
redactions

numerics

Tokenization




```
tf.keras.preprocessing.text.Tokenizer(
    num_words=None,
    filters='!"#$%&()*+,-./:;<=>?@[\\]^_`{|}~\t\n',
    lower=True, split=' ', char_level=False, oov_token=None,
    document_count=0, **kwargs
)
```



Tokenization



 /farrell236/mimic-cxr

```

208
209 def custom_mimic_cxr_rules():
210
211     typo_list = {
212         's5000708': [['atelectases', 'atelectasis']],
213         's50005834': [['dobbhoff', 'Dobbhoff']],
214         's50006811': [['dobbhoff', 'Dobbhoff']],
215         's50008252': [['dobbhoff', 'Dobbhoff']],
216         's50008334': [['atelectases', 'atelectasis']],
217         's50008514': [['obscuraion', 'obscuration']],
218         's50012485': [['isout', 'is out']],
219         's50014691': [['particulary', 'particularly']],
220         's50014720': [['telehpone', 'telephone']],
221         's50015458': [['dobbhoff', 'Dobbhoff']],
222         's50020282': [['atelectases', 'atelectasis']],
223         's50021386': [['pseudomona', 'pseudomonas']],
224         's50023538': [['hyperinf', 'hyperinflation']],
225         's50024680': [['miniscule', 'minuscule']],
226         's50027225': [['inmoderate', 'immoderate']],
227         's50028854': [['dobbhoff', 'Dobbhoff']],
228         's50029272': [['idenfited', 'identified']],
229         's50032596': [['atelectases', 'atelectasis']],
230         's50035513': [['dobbhoff', 'Dobbhoff']],
231         's50043318': [['thelower', 'the lower']],
232         's50053711': [['theright', 'the right']],
233         's50054987': [['dobbhoff', 'Dobbhoff']],
234         's50058281': [['atelectases', 'atelectasis']],
235         's50060856': [['theright', 'the right']],
236         's50060907': [['dobbhoff', 'Dobbhoff']],
237         's50062736': [['dobbhoff', 'Dobbhoff']]

```

```

# 'dobbhoff': 'dobbhoff', #2140
'dobbhoff': 'Dobbhoff', #634
'dopp off': 'Dobbhoff', #4
'dopp of': 'Dobbhoff', #4
'doboff': 'Dobbhoff', #5
'dubhoff': 'Dobbhoff', #2
'dob hoff': 'Dobbhoff', #2
'dophoff': 'Dobbhoff', #2
'dobhof': 'Dobbhoff', #1
'nondobbhoff': 'non-Dobbhoff', #1
'duboff': 'Dobbhoff', #1
'debhoff': 'Dobbhoff', #1
'dodoff': 'Dobbhoff', #1
'dobbhof': 'Dobbhoff', #1
'dovvhoff': 'Dobbhoff', #1
'dobhoffs': 'Dobbhoff', #1
'dobhoiff': 'Dobbhoff', #1

```

Subword Tokenization

Subword tokenization is **Mix of Word-Level and Character-Level Tokenization**

Neural Machine Translation with Byte-Level Subwords
Wang, Changhan, Kyunghyun Cho, and Jiatao Gu.
arXiv e-prints (2019)

Abstract

Almost all existing machine translation models are built on top of character-based vocabularies: characters, subwords or words. Rare characters from noisy text or character-rich languages such as Japanese and Chinese however can unnecessarily take up vocabulary slots and limit its compactness. Representing text at the level of bytes and using the 256 byte set as vocabulary is a potential solution to this issue. High computational cost has however prevented it from being widely deployed or used in practice. In this paper, we investigate byte-level subwords, specifically byte-level BPE (BBPE), which is compacter than character vocabulary and has no out-of-vocabulary tokens, but is more efficient than using pure bytes only is. We claim that contextualizing BBPE embeddings is necessary, which can be implemented by a convolutional or recurrent layer. Our experiments show that BBPE has comparable performance to BPE while its size is only 1/8 of that for BPE. In the multilingual setting, BBPE maximizes vocabulary sharing across many languages and achieves better translation quality. Moreover, we show that BBPE enables transferring models between languages with non-overlapping character sets.

Byte-Level Byte-Pair Encoding

```

...
Ġdevelop ed
Ġcorre lation
Ġpost operative
er y
ten ded
Ġsub cutaneous
Ġp ul
an z
Ġnod ular
ĠT ra
p read
if ied
...

```



merges.txt



vocab.json

```

[
...
"Ġacute":390,
"ia":391,
"est":392,
"telect":393,
"ema":394,
"Ġpneum":395,
...
"Ġpneumon":421,
"Ġde":422,
"Ġpre":423,
...
]

```

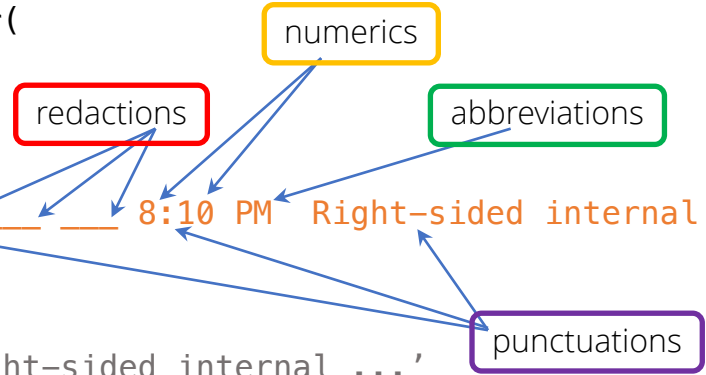
Byte-Level Byte-Pair Encoding

```
>>> from tokenizers import ByteLevelBPETokenizer
```

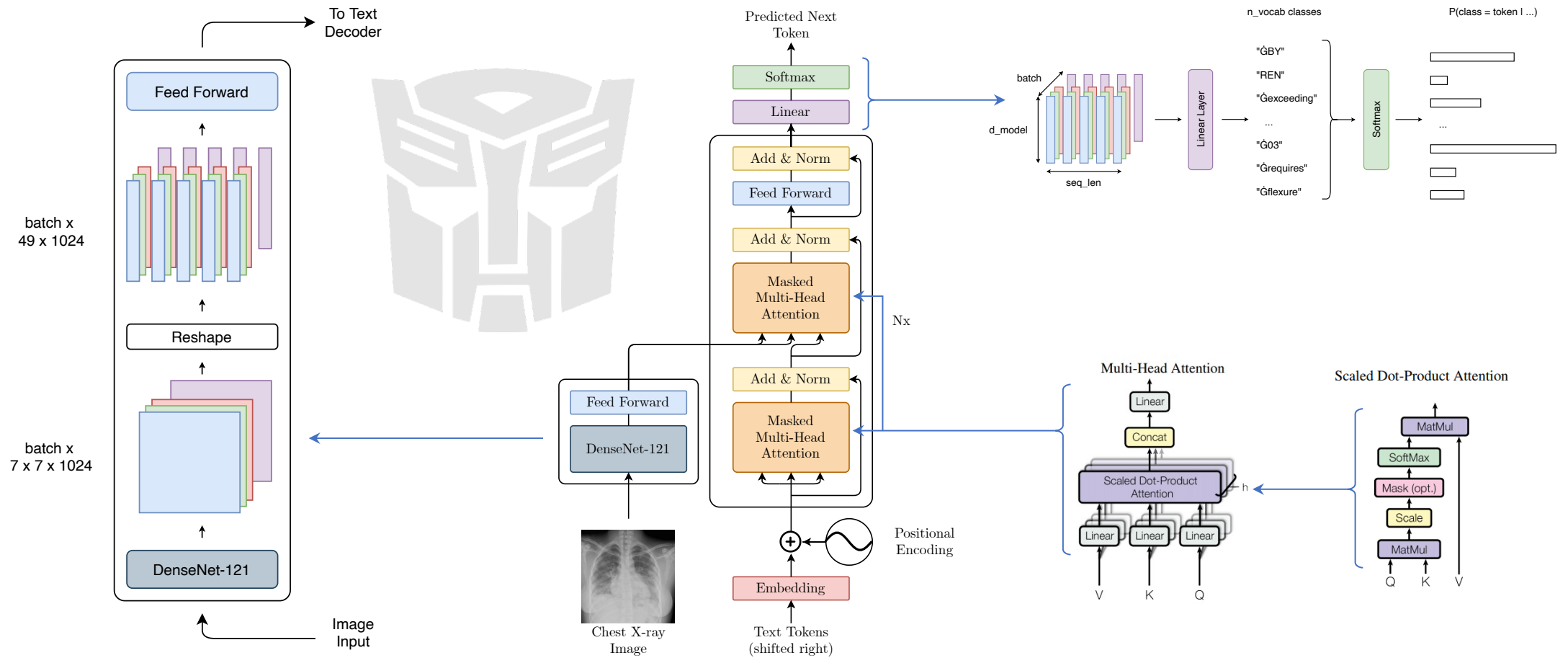
```
>>> tokenizer = ByteLevelBPETokenizer(
    'vocab.json',
    'merges.txt',
)
```

```
>>> tokenizer.encode('WET READ: ___ 8:10 PM Right-sided internal ...')
```

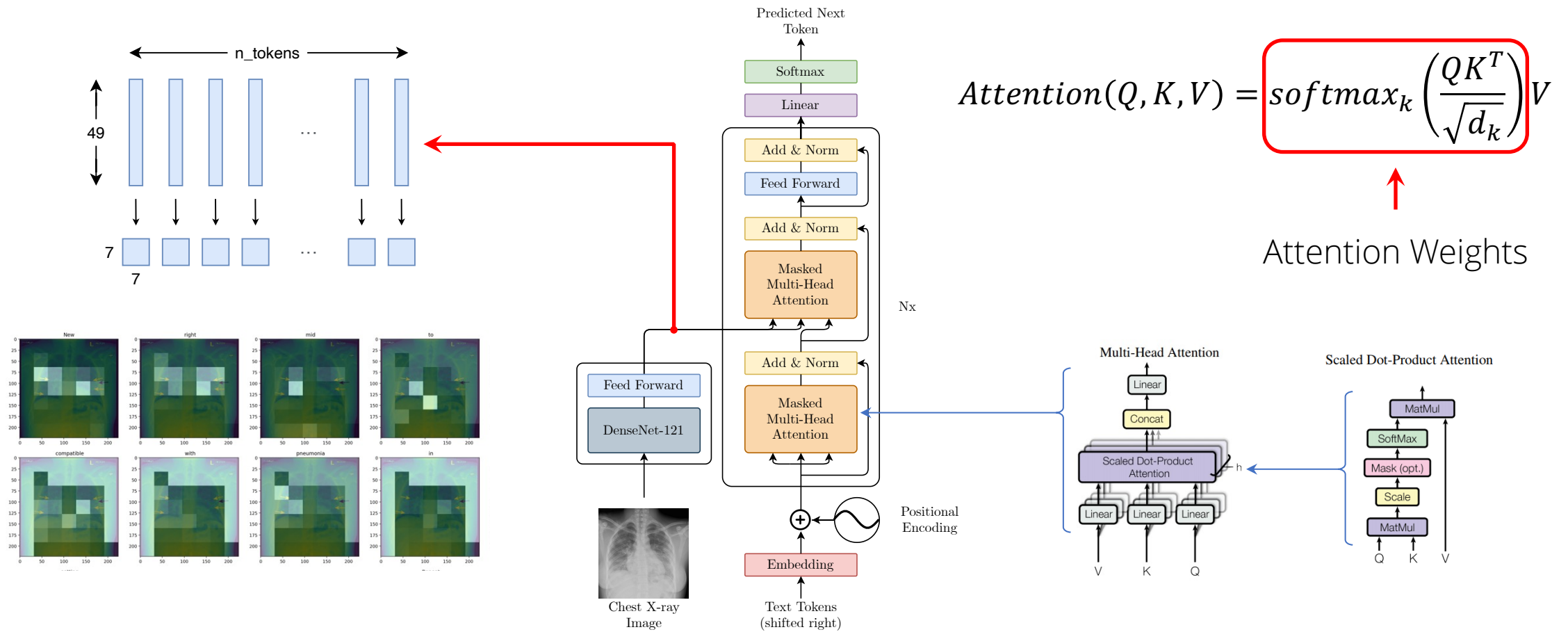
```
# 'WET' READ: ___ 8:10 PM Right-sided internal ...'
#
#   ↓ merges.txt ↓ (to tokens)
# ['W', 'ET', 'ĠREAD', 'Ġ:', 'Ġ___', 'Ġ___', 'Ġ___', 'Ġ8', 'Ġ:', 'Ġ10', 'ĠPM', 'Ġ', 'ĠRight', 'Ġ-', 'sided', 'Ġinternal', ... ]
#
#   ↓ vocab.json ↓ (to ids)
# [ 59, 1663, 9924, 30, 361, 361, 361, 1910, 30, 3031, 4294, 225, 661, 17, 866, 1030, ... ]
```



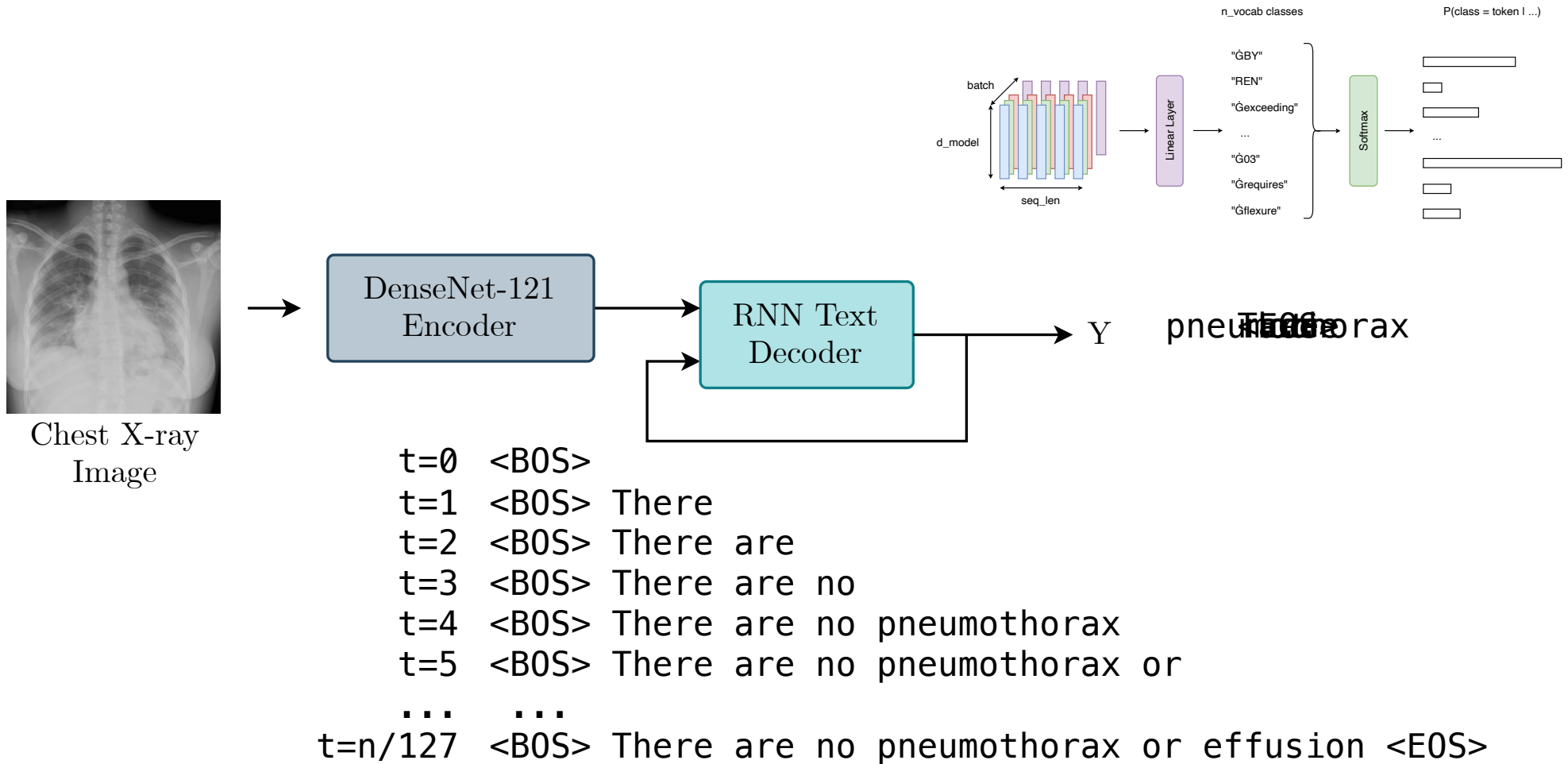
R.A.T.C.H.E.T. Architecture



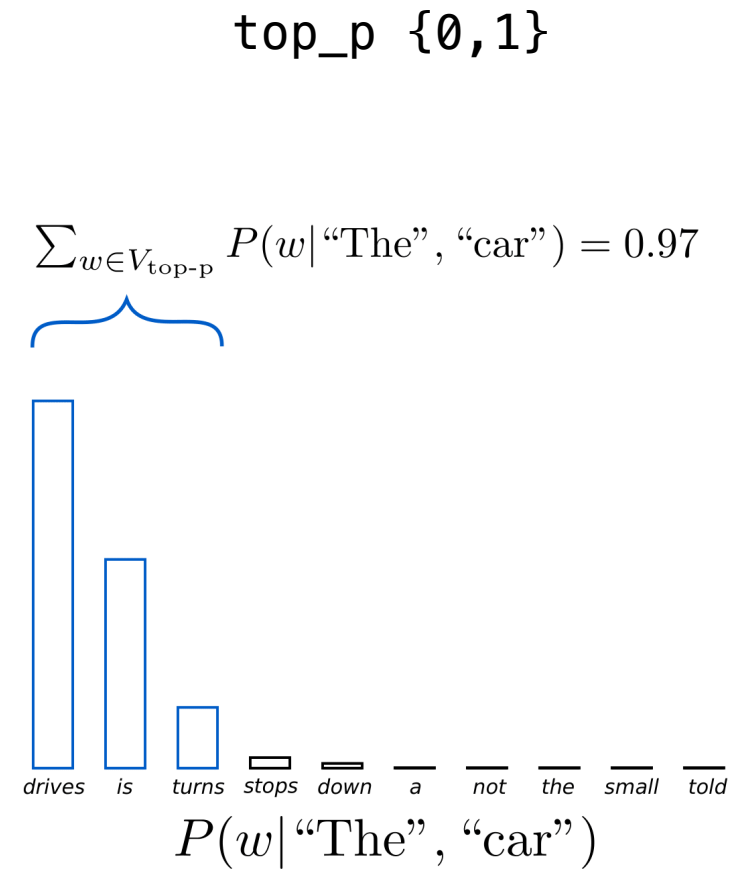
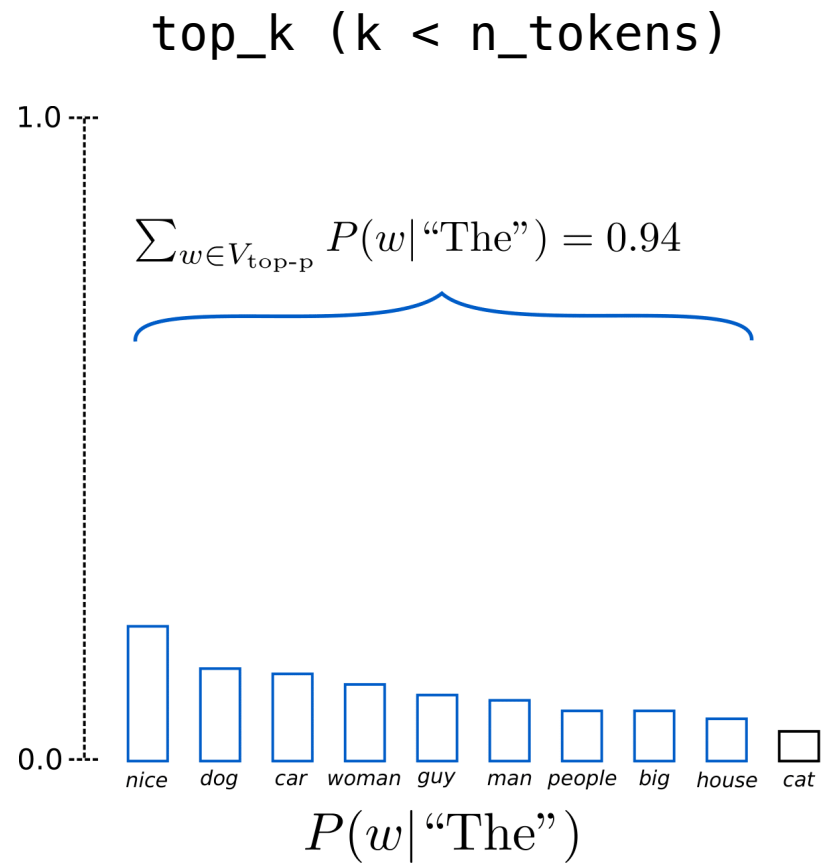
Attention!



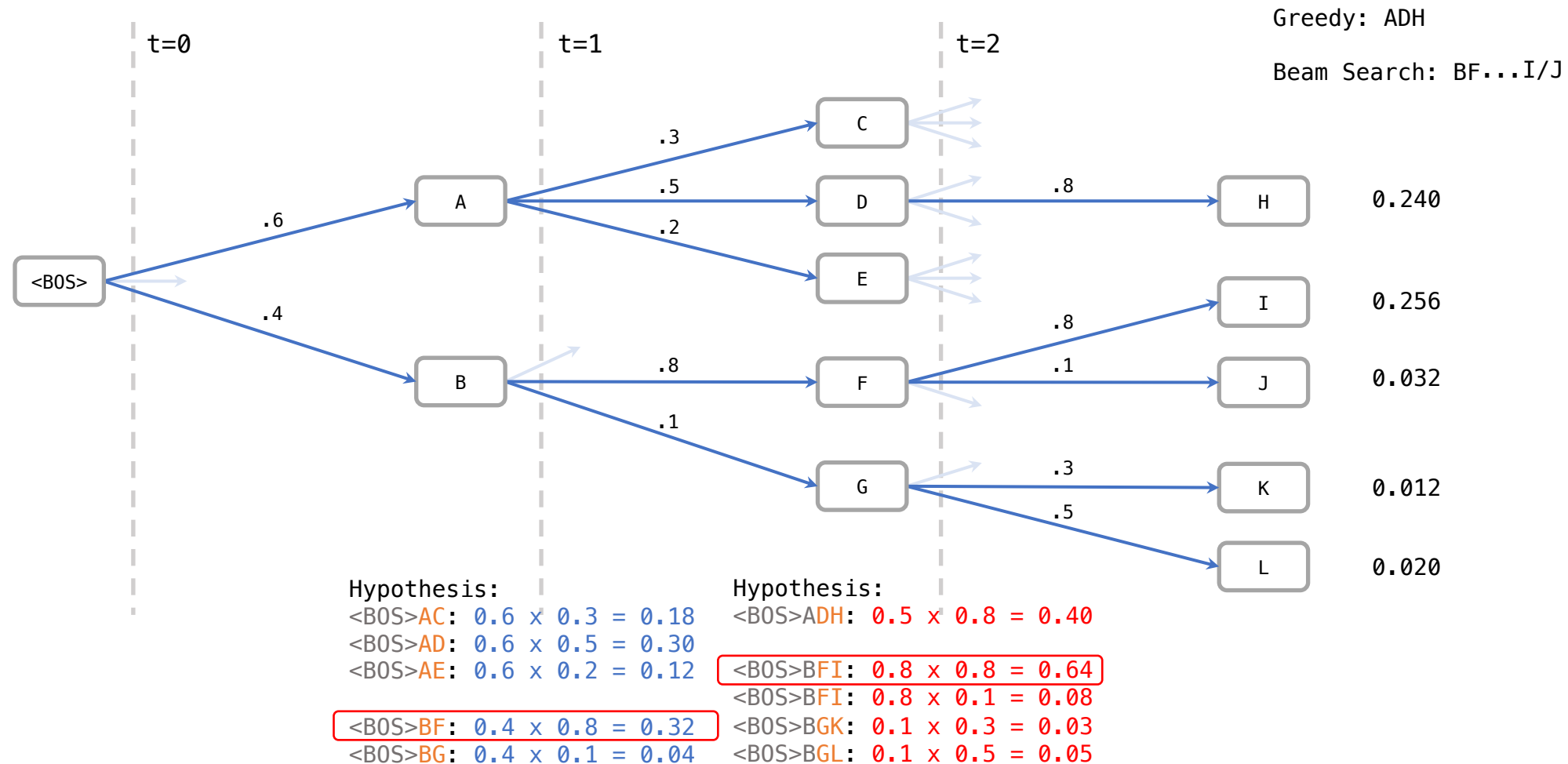
Text Generation





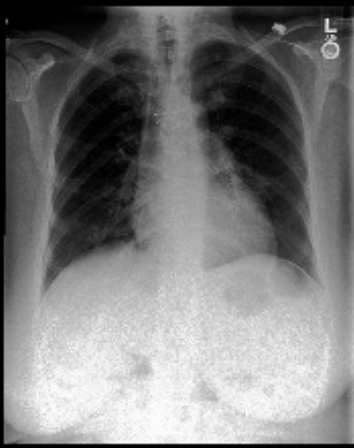
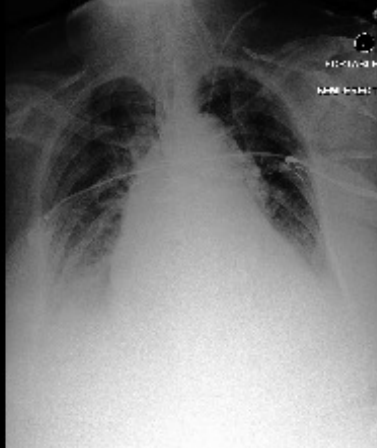
Text Generation



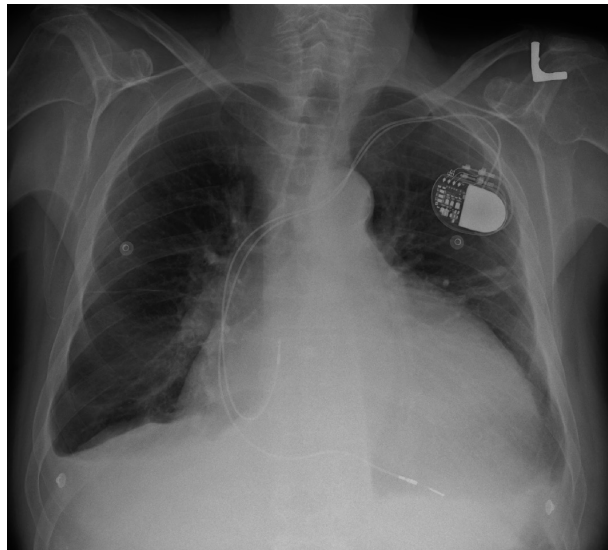
Text Generation



Results

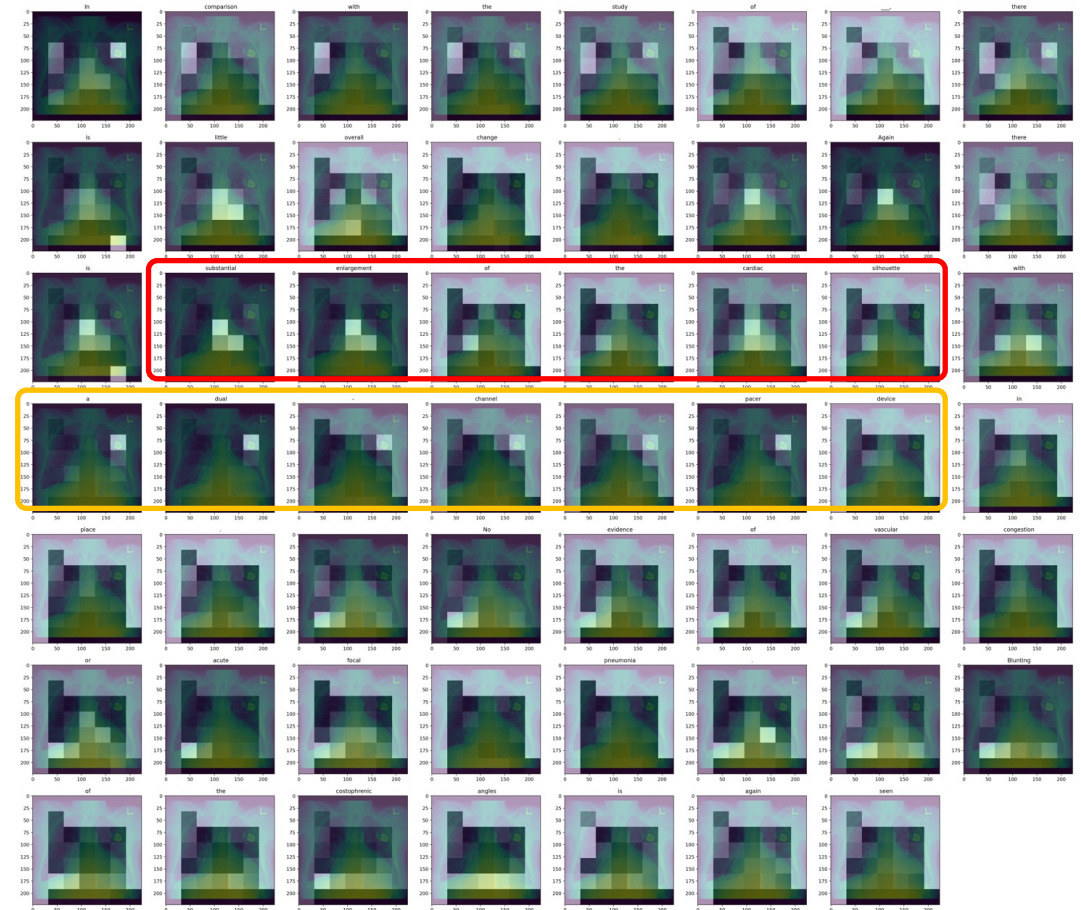
	Case 1	Case 2	Case 3	Case 4
Image				
True Text	'Stable right greater than left upper lobe fibrotic changes. New opacity in the left mid-to-lower lung raises concern for infectious process versus possibly asymmetric edema . Recommend follow up to resolution.'	' Cardiomegaly and pulmonary edema which may have progressed since prior although some changes may be accounted for by lower lung volumes on the current exam. Left basilar opacity, potentially atelectasis noting that infection would also be possible.'	'Known lung metastases are again noted though better assessed on prior CT. No definite signs of superimposed acute process. '	'In comparison with the study of ____; there is little change in the substantial enlargement of the cardiomeastinal silhouette and moderate pulmonary edema with bilateral pleural effusions . Monitoring and support devices remain in place. '
Predicted Text	'Diffuse bilateral parenchymal opacities , similar compared to the prior exam, with new focal opacity in the left upper lung field. Findings could reflect multifocal infection, though a component of pulmonary edema is also possible. '	'1. Low lung volumes with bibasilar atelectasis . 2. Severe cardiomegaly. '	' No acute cardiopulmonary process. '	'As compared to the previous radiograph, there is no relevant change . Moderate cardiomegaly with bilateral pleural effusions and subsequent areas of atelectasis. The monitoring and support devices are in constant position . No new parenchymal opacities.'

Results




Generated Report:

In comparison with the study of ____, there is little overall change. Again there is substantial enlargement of the cardiac silhouette with a dual-channel pacer device in place. No evidence of vascular congestion or acute focal pneumonia. Blunting of the costophrenic angles is again seen.



Results

 **Vladimir Haltakov**
@haltakov

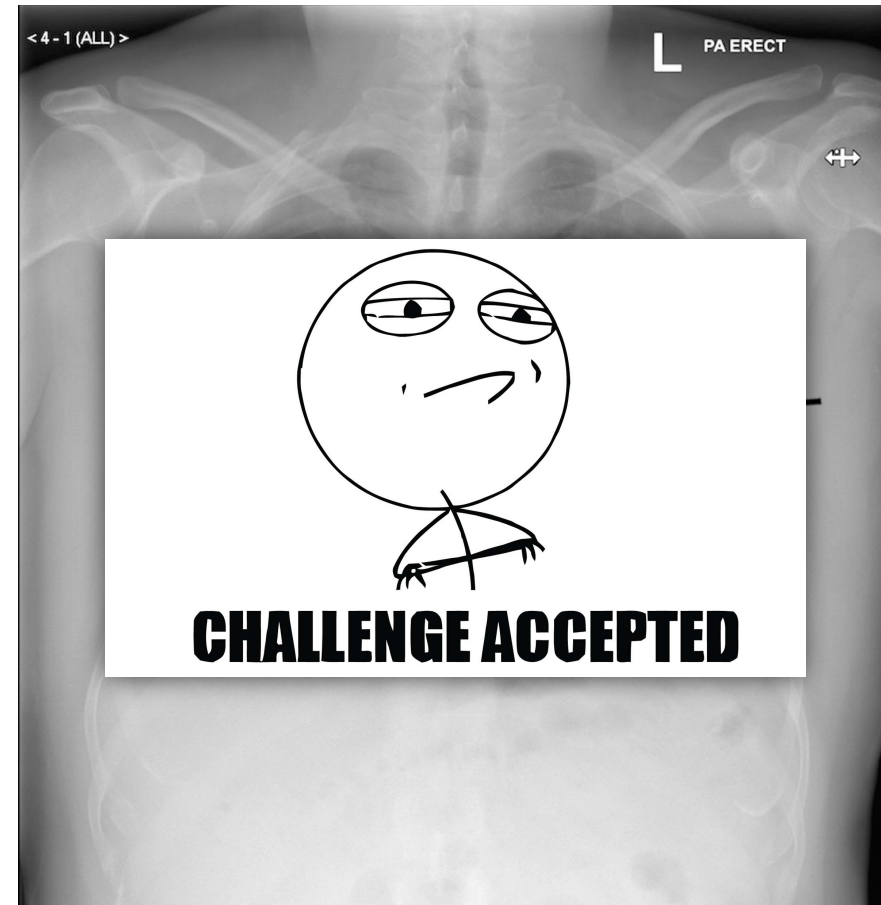
Can you detect COVID-19 using Machine Learning? 🤔

You have an X-ray or CT scan and the task is to detect if the patient has COVID-19 or not. Sounds doable, right?

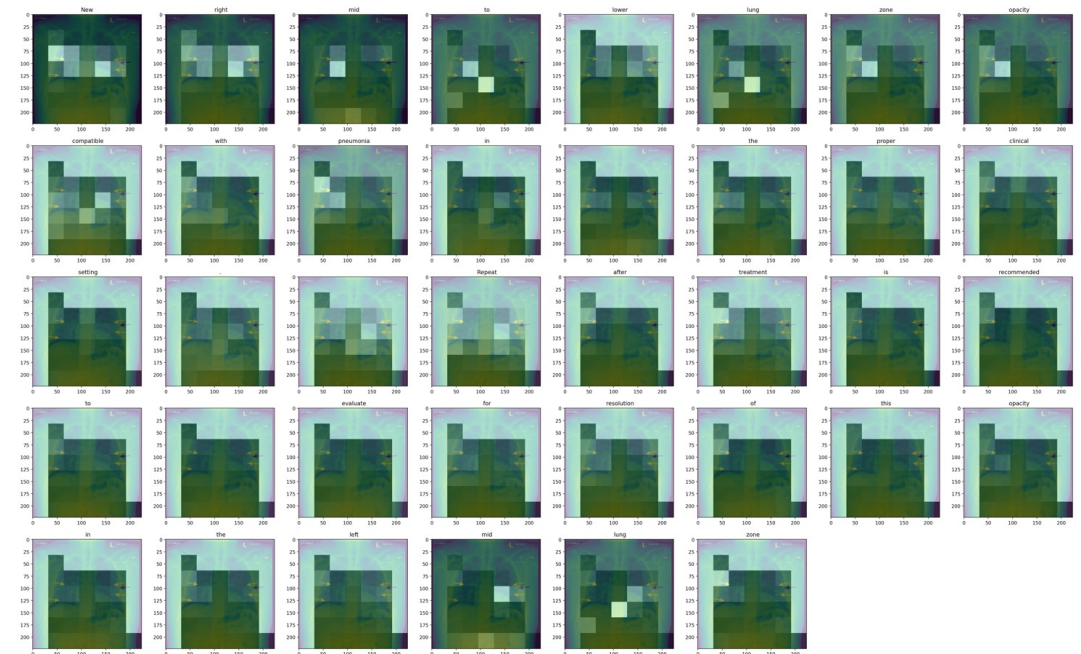
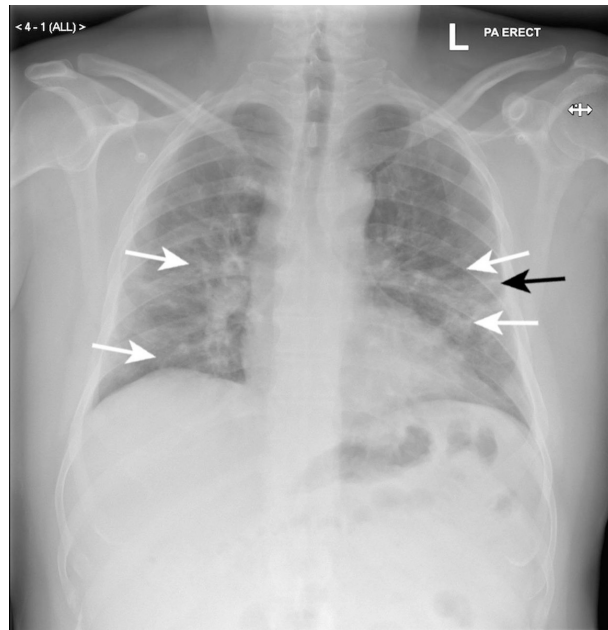
None of the 415 ML papers published on the subject in 2020 was usable. Not a single one!

Let's see why 📌

9:00 PM · Jun 9, 2021 · FeedHive.io



Results



Generated Report:

New right mid to lower lung zone opacity compatible with pneumonia in the proper clinical setting. Repeat after treatment is recommended to evaluate for resolution of this opacity in the left mid lung zone.

Results

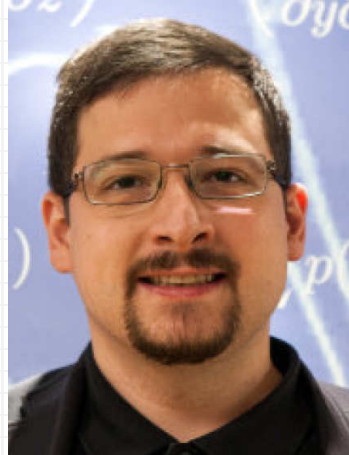
	Class Bias	CheXpert Class	CheXNet				RATCHET (NLP)			
			Accuracy	Precision	Recall	F1 Score	Accuracy	Precision	Recall	F1 Score
No Finding	0.33560		0.812	0.329	0.731	0.454	0.722	0.344	0.653	0.451
Enl. C.med.	0.07208		0.877	0.124	0.9	0.218	0.886	0.096	0.008	0.015
Cardiomegaly	0.22114	✓	0.755	0.452	0.651	0.534	0.632	0.405	0.496	0.446
Lung Lesion	0.03195		0.967	0.078	0.75	0.142	0.952	0.162	0.044	0.069
Lung Opacity	0.24030		0.690	0.629	0.441	0.519	0.654	0.500	0.262	0.344
Edema	0.17718	✓	0.769	0.549	0.875	0.674	0.722	0.582	0.312	0.407
Consolidation	0.06592	✓	0.920	0.109	0.857	0.193	0.905	0.233	0.022	0.041
Pneumonia	0.14995		0.812	0.555	0.471	0.510	0.779	0.422	0.162	0.234
Atelectasis	0.24517	✓	0.727	0.426	0.846	0.567	0.701	0.465	0.368	0.411
Pneumothorax	0.05133		0.971	0.083	0.6	0.146	0.933	0.110	0.110	0.110
Pleural Effusion	0.26115	✓	0.723	0.658	0.782	0.715	0.759	0.704	0.575	0.633
Pleural Other	0.01167		0.971	0.028	0.75	0.055	0.976	0.0	0.0	0.0
Fracture	0.02215		0.976	0.018	0.666	0.036	0.972	0.0	0.0	0.0
Support Devices	0.30134		0.784	0.710	0.72	0.715	0.757	0.628	0.783	0.697

	Baseline (NLP)				TieNet (Classification)				TieNet (NLP)			
	Accuracy	Precision	Recall	F1 Score	Accuracy	Precision	Recall	F1 Score	Accuracy	Precision	Recall	F1 Score
No Finding	0.654	0.288	0.664	0.402	0.657	0.284	0.636	0.393	0.217	0.180	0.978	0.304
Enl. C.med.	0.591	0.138	0.560	0.221	0.545	0.144	0.672	0.238	0.895	0.0	0.0	0.0
Cardiomegaly	0.601	0.391	0.623	0.481	0.593	0.390	0.650	0.488	0.696	0.365	0.033	0.061
Lung Lesion	0.960	0.0	0.0	0.0	0.562	0.032	0.345	0.059	0.960	0.0	0.0	0.0
Lung Opacity	0.650	0.393	0.033	0.061	0.561	0.404	0.571	0.474	0.656	0.5	0.002	0.005
Edema	0.715	0.583	0.183	0.279	0.604	0.417	0.751	0.536	0.704	0.729	0.026	0.050
Consolidation	0.910	0.0	0.0	0.0	0.538	0.112	0.596	0.188	0.910	0.0	0.0	0.0
Pneumonia	0.791	0.363	0.005	0.011	0.477	0.206	0.529	0.296	0.793	0.6	0.004	0.008
Atelectasis	0.717	0.470	0.085	0.144	0.590	0.371	0.644	0.471	0.720	0.5	0.003	0.006
Pneumothorax	0.961	0.307	0.031	0.057	0.630	0.055	0.551	0.100	0.962	0.0	0.0	0.0
Pleural Effusion	0.675	0.644	0.203	0.309	0.645	0.505	0.712	0.591	0.645	0.656	0.017	0.033
Pleural Other	0.978	0.0	0.0	0.0	0.500	0.022	0.5	0.043	0.978	0.0	0.0	0.0
Fracture	0.973	0.0	0.0	0.0	0.512	0.019	0.344	0.037	0.973	0.0	0.0	0.0
Support Devices	0.676	0.527	0.866	0.656	0.682	0.535	0.826	0.649	0.666	0.518	0.853	0.645

Thanks to a great team!



Prof Daniel Rueckert



Dr Bernhard Kainz



Dr Ben Glocker



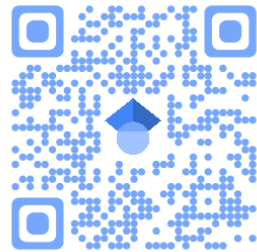
/farrell192



/farrell236



/farrell236



_c3RwQAAAAJ



bh1511@ic.ac.uk



doc.ic.ac.uk/
~bh1511



BioMedia

Thank You for Listening!

Questions?



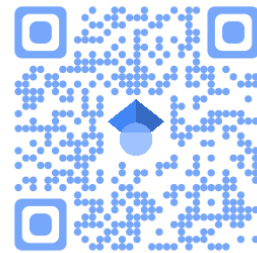
/farrell192



/farrell236



/farrell236



_c3RwQAAAAJ



bh1511@ic.ac.uk



doc.ic.ac.uk/
~bh1511



BioMedia