ChestX-ray8: Hospital-scale Chest X-ray Database and Benchmarks on Weakly-Supervised Classification and Localization of Common Thorax Diseases

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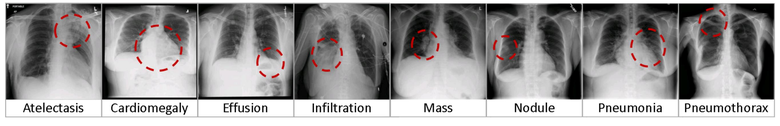
Highlights

- A new **Chest X-ray dataset** with 108,948 frontal view scans of 32,717 unique patients with the text mined disease image labels and meta info.
- A **weakly-supervised** multi-disease detection and localization framework

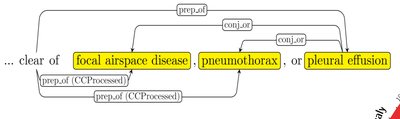
Dataset Scope: Common Thorax Diseases



2-stage Disease Label Mining via NLP

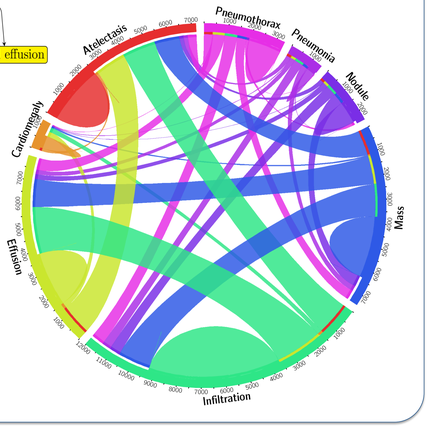
❑ **Stage 1: Pathology Detection**
- DNorm and MetaMap is used to detect disease keywords in a report using either concept in SNOMED-CT or UMLS Metathesaurus

❑ **Stage 2: Removal of negation and uncertainty**
- Rule out those negated pathological statements and uncertain mentions of findings, e.g. no $\leftarrow neg \leftarrow$ evidence $\rightarrow prep\_of \rightarrow$ DISEASE
- Defined the rules on the dependency graph, by utilizing the dependency label and direction information between words, e.g.



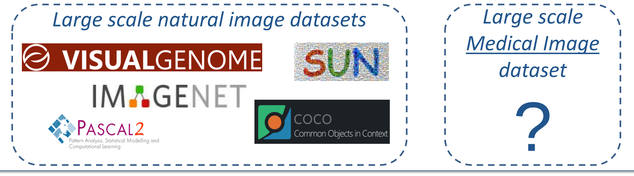
❖ Disease Category Statistics

Item #	OpenI	Ov.	ChestX-ray8	Ov.
Report	2,435	-	108,948	-
Annotations	2,435	-	-	-
Atelectasis	315	122	5,789	3,286
Cardiomegaly	345	100	1,010	475
Effusion	153	94	6,331	4,017
Infiltration	60	45	10,317	4,698
Mass	15	4	6,046	3,432
Nodule	106	18	1,971	1,041
Pneumonia	40	15	1,062	703
Pneumothorax	22	11	2,793	1,403
Normal	1,379	0	84,312	0



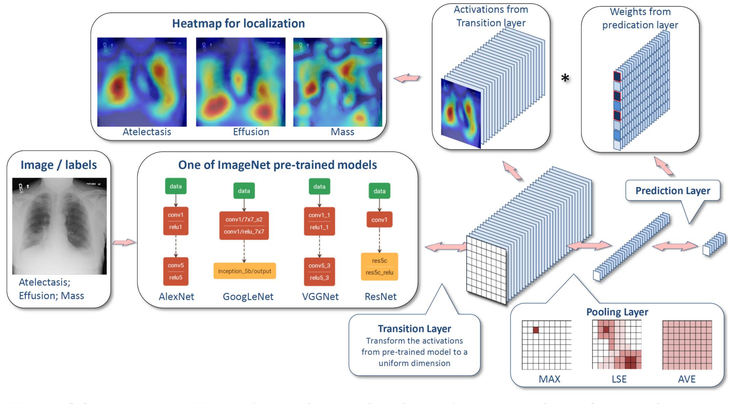
Motivation

- Well-labeled data are the key for large scale machine learning paradigms and image labeling method, e.g. AMT are NOT applicable to medical images
- Detection and localization of all common thorax diseases in one go



Multi-label Classification and Localization Framework

- **Multi-label Setting**: 8-D disease label vector, $[y_1, ..., y_c, ..., y_C], y_c \in \{0, 1\}, C = 8$



- **Transition Layer**: Transform the activations from previous layers into a uniform dimension of output $S \times S \times D, S \in \{8, 16, 32\}$
- **Multi-label Classification Loss Layer**: positive/negative balancing, e.g.

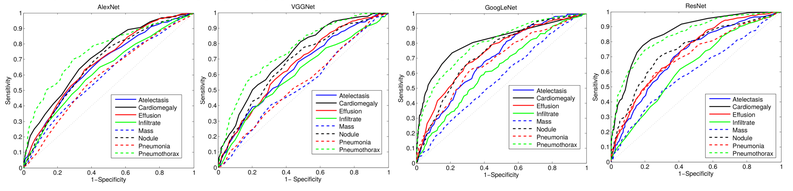
$$L_{W\text{-}CEL}(f(\vec{x}), \vec{y}) = \beta_P \sum_{y_c=1} -\ln(f(x_c)) + \beta_N \sum_{y_c=0} -\ln(1 - f(x_c)),$$

- **Global Pooling Layer**: the Log-Sum-Exp (LSE) pooling, which is defined as

$$x_p = \frac{1}{r} \cdot \log\left[\frac{1}{S} \cdot \sum_{(i,j)\in \mathbf{S}} exp(r \cdot x_{ij})\right] \quad x_p = x^* + \frac{1}{r} \cdot \log\left[\frac{1}{S} \cdot \sum_{(i,j)\in \mathbf{S}} exp(r \cdot (x_{ij} - x^*)\right]$$

where $x^* = max\{|x_{ij}|, (i, j) \in \mathbf{S}\}$.

Multi-disease Classification Results

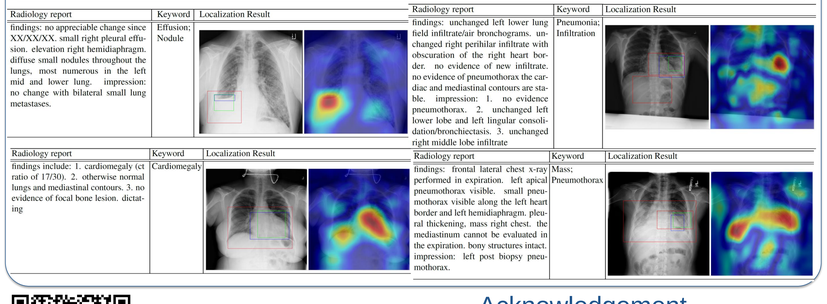


Setting	Atelectasis	Cardiomegaly	Effusion	Infiltration	Mass	Nodule	Pneumonia	Pneumothorax
Initialization with different pre-trained models								
AlexNet	0.6458	0.6925	0.6642	0.6041	**0.5644**	0.6487	0.5493	0.7425
GoogLeNet	0.6307	0.7056	0.6876	0.6088	0.5363	0.5579	0.5990	0.7824
VGGNet-16	0.6281	0.7084	0.6502	0.5896	0.5103	0.6556	0.5100	0.7516
ResNet-50	**0.7069**	**0.8141**	**0.7362**	**0.6128**	0.5609	**0.7164**	**0.6333**	**0.7891**
Different multi-label loss functions								
CEL	0.7064	0.7262	0.7351	0.6084	0.5530	0.6545	0.5164	0.7665
W-CEL	0.7069	0.8141	0.7362	0.6128	0.5609	0.7164	0.6333	0.7891

Table 3. *AUCs of ROC curves for multi-label classification in different DCNN model setting.*

Disease Localization Results

T(IoBB)	Atelectasis	Cardiomegaly	Effusion	Infiltration	Mass	Nodule	Pneumonia	Pneumothorax
T(IoBB) = 0.25 (Two times larger on both x and y axis than ground truth B-Boxes)								
Acc.	0.5500	0.9794	0.5424	0.5772	0.2823	0.0506	0.5583	0.3469
AFP	0.1666	0.1534	0.1189	0.0914	0.0975	0.0741	0.1250	0.0487
T(IoU) = 0.5								
Acc.	0.0500	0.1780	0.1111	0.0650	0.0117	0.0126	0.0333	0.0306
AFP	0.3384	0.5335	0.2510	0.2408	0.1483	0.0772	0.2926	0.0965



Download the NIH ChestX-ray dataset via Google Cloud

https://console.cloud.google.com/storage/gcs-public-data--nih/radiology_2017/ Chest_X-Ray_CVPR17/images

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