

<https://pin.it/38FjhfC>

## Incorporating Expert Knowledge

**Problem:** Medical imaging poses unique challenges like small datasets, complex 3D anatomical relationships, and disease-related ambiguities that confuse algorithms.

**Solution:** Incorporate expert knowledge to improve ML performance. E.g., Leverage taxonomical relation between different labels

- ✓ Harnesses the hierarchical relationships of diseases encoded in a taxonomic structure.
  - This guides the model where labeled data is limited, improving accuracy and interpretability.
  - Enhances the accuracy of disease classification
- ✓ It allows radiologists' experience to offset data constraints.

# Chest Radiograph Datasets



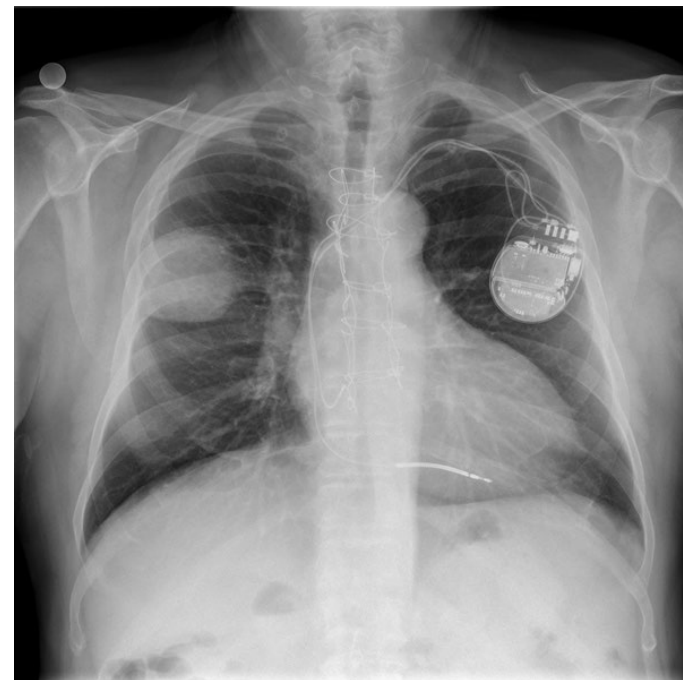
224,316 chest radiographs of 65,240 patients, labeled with 14 radiographic findings

## PADCHEST

160,000 chest radiographs of 67,000 patients, annotated with 174 radiographic findings.



112,120 chest radiographs of 30,805 patients labeled with 14 categories of thoracic diseases.



# Taxonomy

## Problem & Assumptions

- CXR interpretation is challenging due to disease similarities.
- Current systems struggle with multi-label classification.
- CXRs have hierarchical disease relationships, a fact under-utilized in current methods.

## Our Contribution

A hierarchical framework for multi-label classification.

- **Logit:** Modify predicted logits to improve accuracy without extensive computational investment.
- **Loss:** Integrate taxonomy into loss function. Ideal when ground truth is available



# Update Logit Values By Leveraging Taxonomy Structure

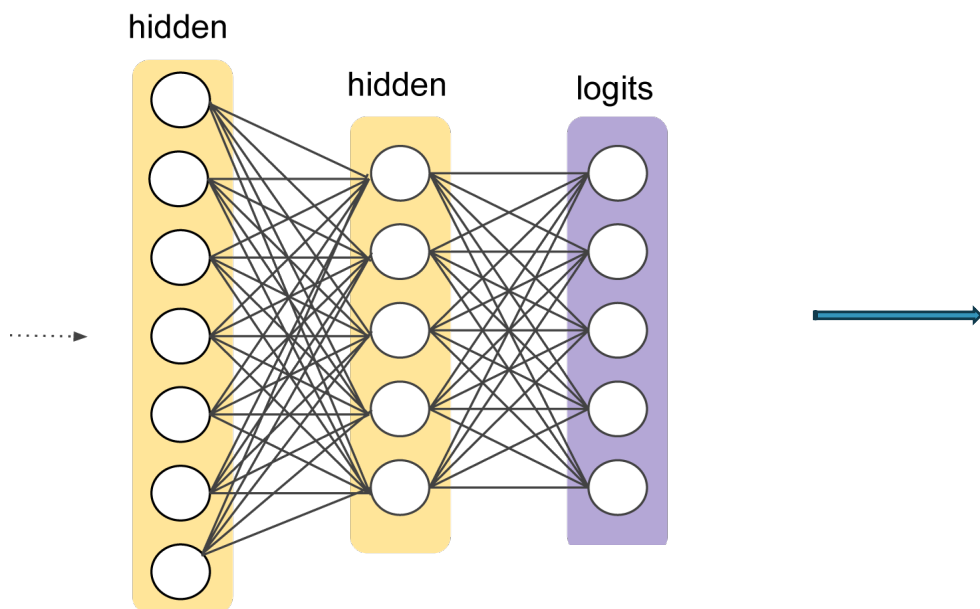
## ❑ What is Logit ( $q$ )

- In statistics, the logit function corresponds to the of the standard logistic distribution's quantile function.
- It ranges from  $-\infty$  to  $+\infty$ .
- It has numerous applications in data analysis and machine learning, particularly in data transformations.

## ❑ Sigmoid (aka Logistic) Activation Function

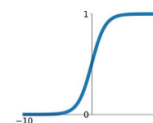
$$\sigma(q) = \frac{1}{1+e^{-q}}$$

- A mathematical function that has a characteristic "S"-shaped curve
- Takes any real number as input and outputs a value between 0 and 1



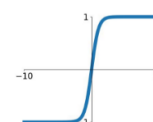
### Sigmoid

$$\sigma(x) = \frac{1}{1+e^{-x}}$$



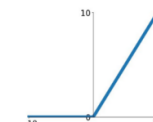
### tanh

$$\tanh(x)$$



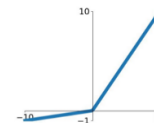
### ReLU

$$\max(0, x)$$



### Leaky ReLU

$$\max(0.1x, x)$$

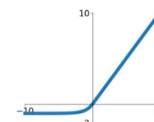


### Maxout

$$\max(w_1^T x + b_1, w_2^T x + b_2)$$

### ELU

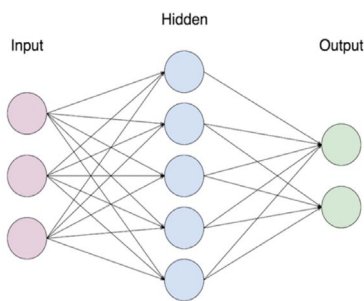
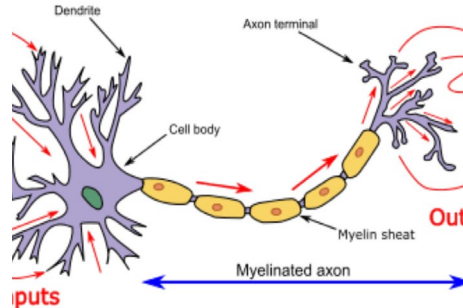
$$\begin{cases} x & x \geq 0 \\ \alpha(e^x - 1) & x < 0 \end{cases}$$





## Image Transformation

All training images underwent transformations, including up to 45° rotation, 15% translation, and 10% scaling.



## Baseline Network

DenseNet121

## Loss function

### Loss & Optimization

Binary Cross-Entropy loss was used with Adam optimizer.



### Dataset

Subsets of CheXpert, NIH, and PADCHEST for 18 thoracic diseases

Stage 1: Model Optimization (Training & Validation)

Stage 2: Taxonomy Parameter Optimization (Training & Test)