Challenges and Opportunities in AI4Xray

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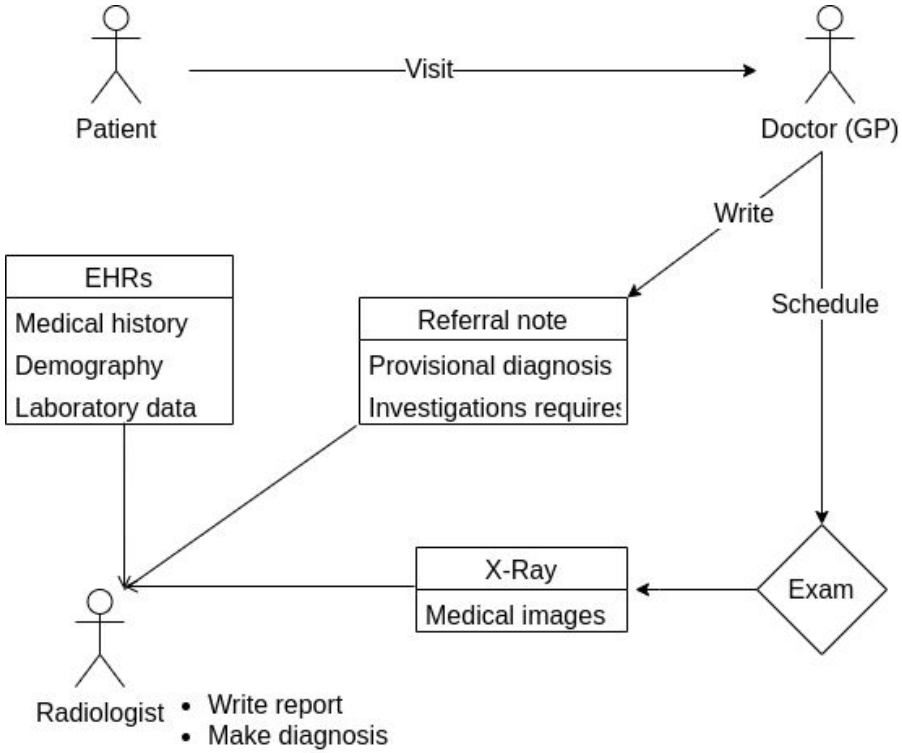
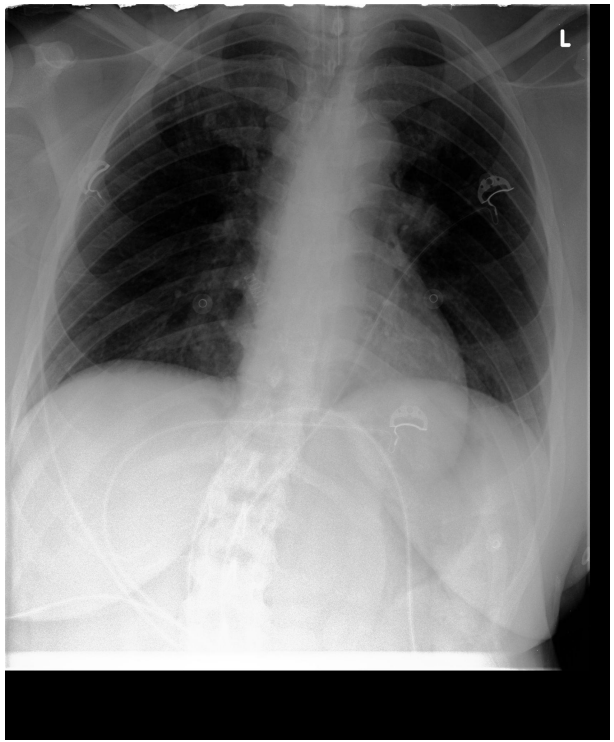
Today, analysis and prioritisation of chest X-rays are carried out manually

Source: https://di.ku.dk/english/news/2020/new-ai-system-will-detect-critical-heart-and-lung-diseases-faster/

Build AI system to help radiologists



An example image and report

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                                FINAL REPORT
AP CHEST 10:17 A.M. ___

HISTORY:  Intubated ___-year-old woman.  Check tube placement.

IMPRESSION:  AP chest compared to ___:

Tip of the endotracheal tube at the upper margin of the clavicles is no less
than 45 mm from the carina.  Care should be taken that the tube does not
withdraw any further.  Lungs are clear.  Cardiomediastinal and hilar
silhouettes and pleural surfaces are normal.
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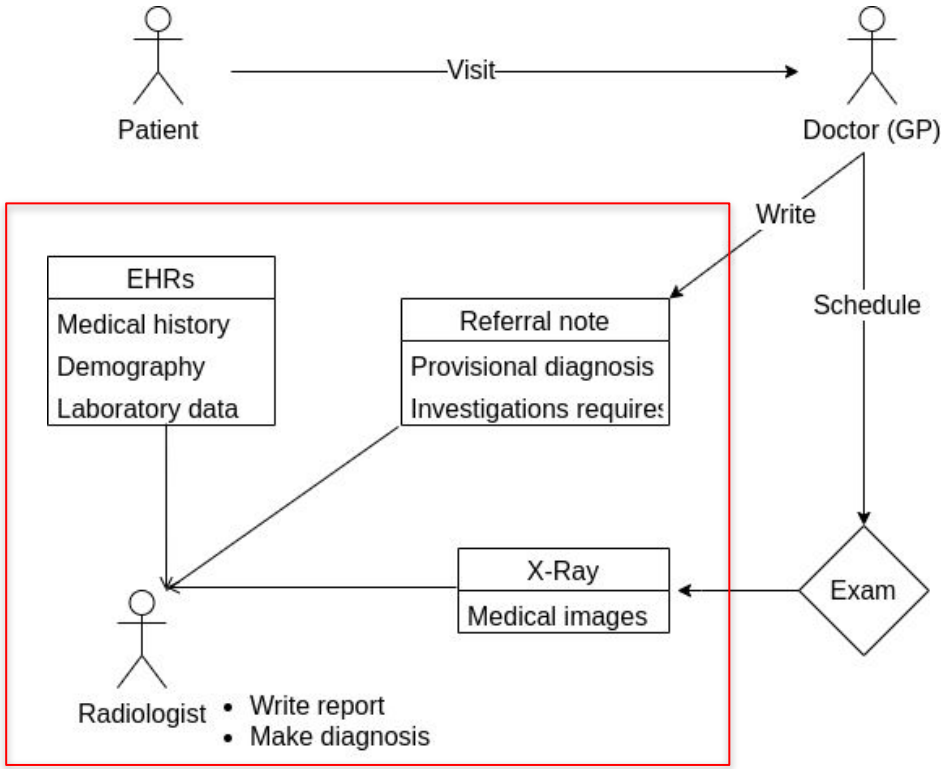
Both analysis quality and response time matter

Source: https://www.npr.org/sections/health-shots/2012/11/30/166225999/radiologists-say-its-time-to-come-out-of-the-dark?t=1633634496786

Source: https://collaborativeimaging.com/the-pros-and-cons-of-teleradiology/

As an additional radiologist

- prioritize chest X-ray images
- provide a second opinion on diagnosis



Tips for communicating with IT people: always tell them what the inputs and outputs data are

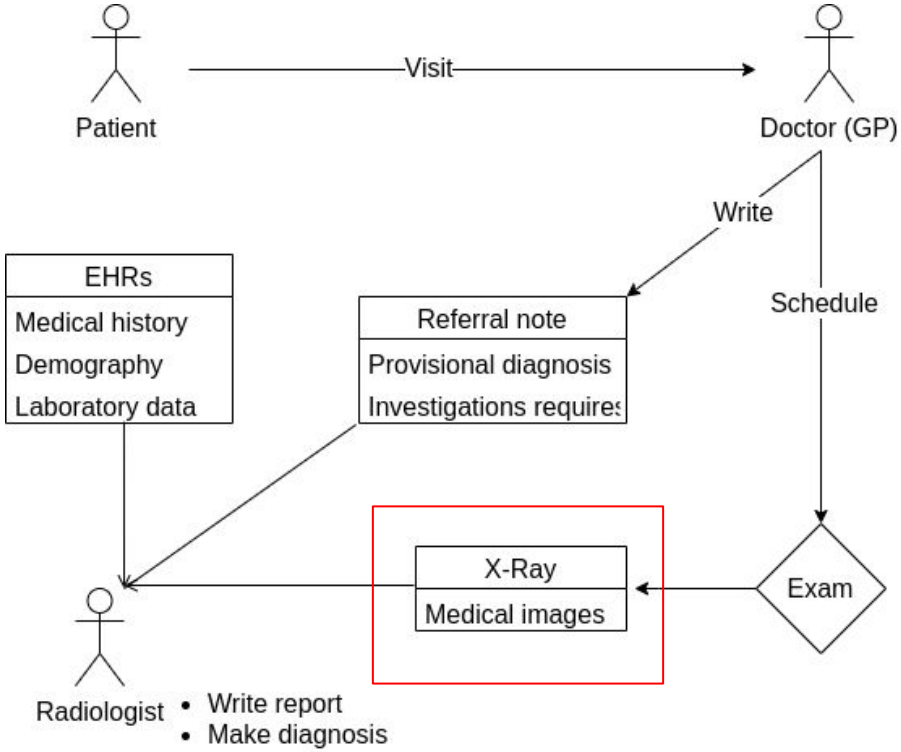
Collaboration between researchers from

- Department of Computer Science at the University of Copenhagen
  - **Medical image analysis**
  - **Natural language processing**
  - Human–computer interaction
- Rigshospitalet
- Unumed ApS

What AI can do?

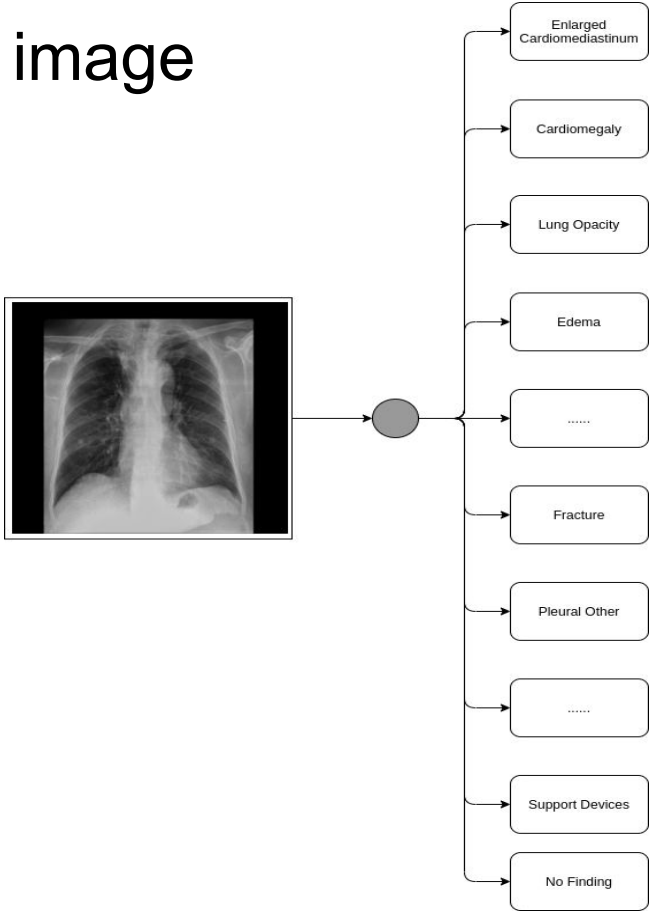
A simplest version

- Image classifier

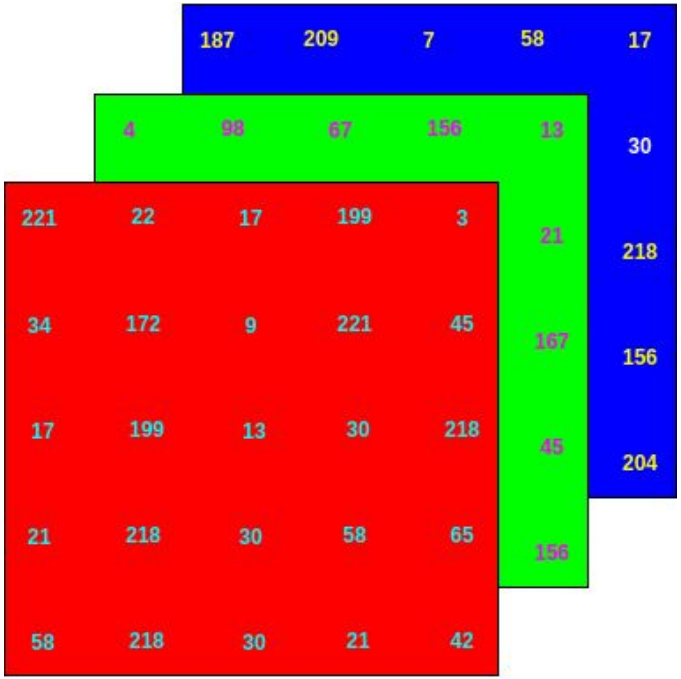


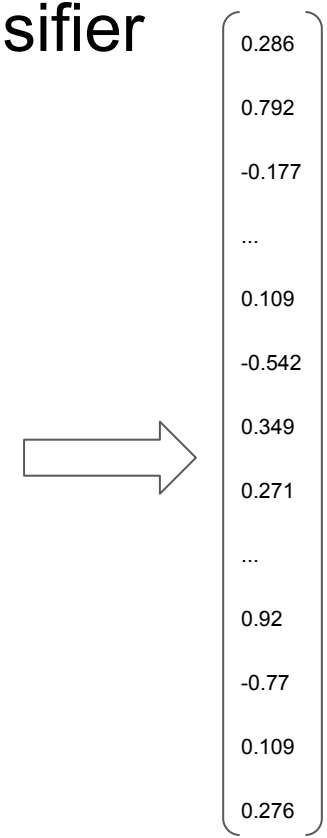
Predicts multiple labels given an image

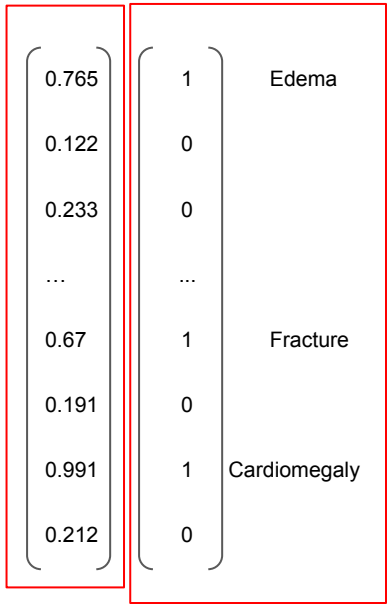
- Define a label set
- Annotate data
- Train the classifier
- Employ the classifier



An example of image classifier

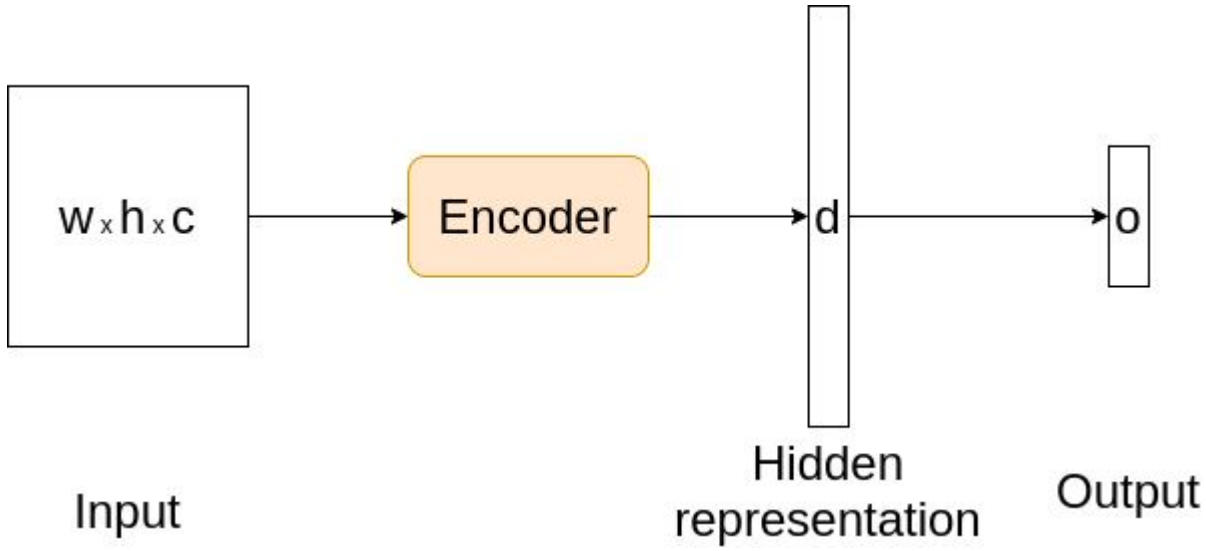






Tips for understanding deep learning: a good hidden representation of the data

A simpler version of the classifier architecture

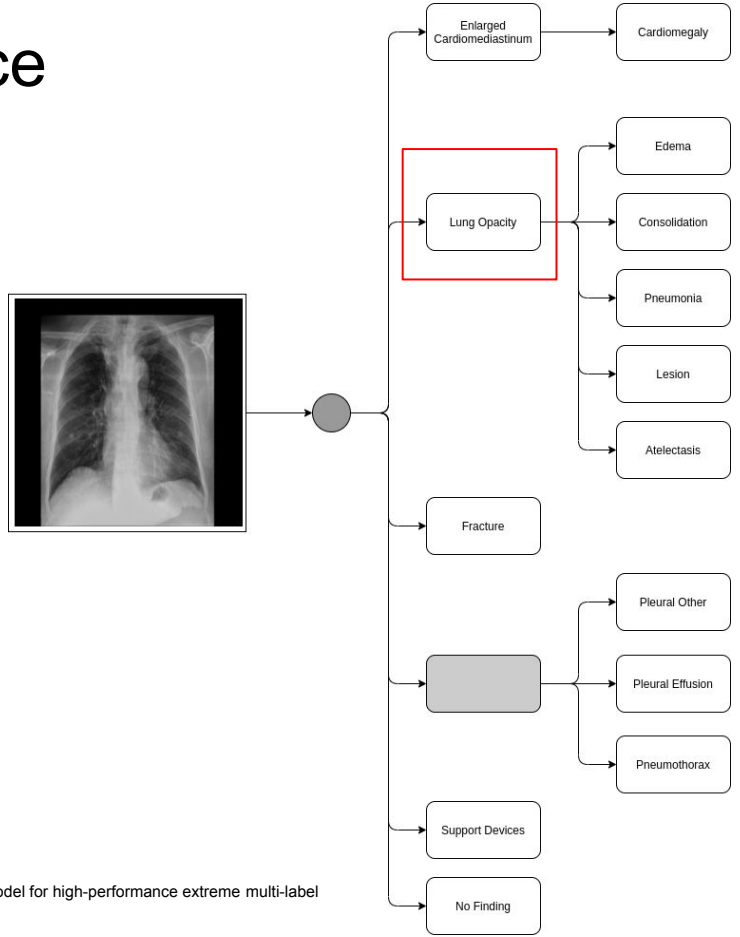


The theory sounds simple, but now let us face the real world

Challenge regarding label space

The label space can be large and it is difficult to predict rare labels

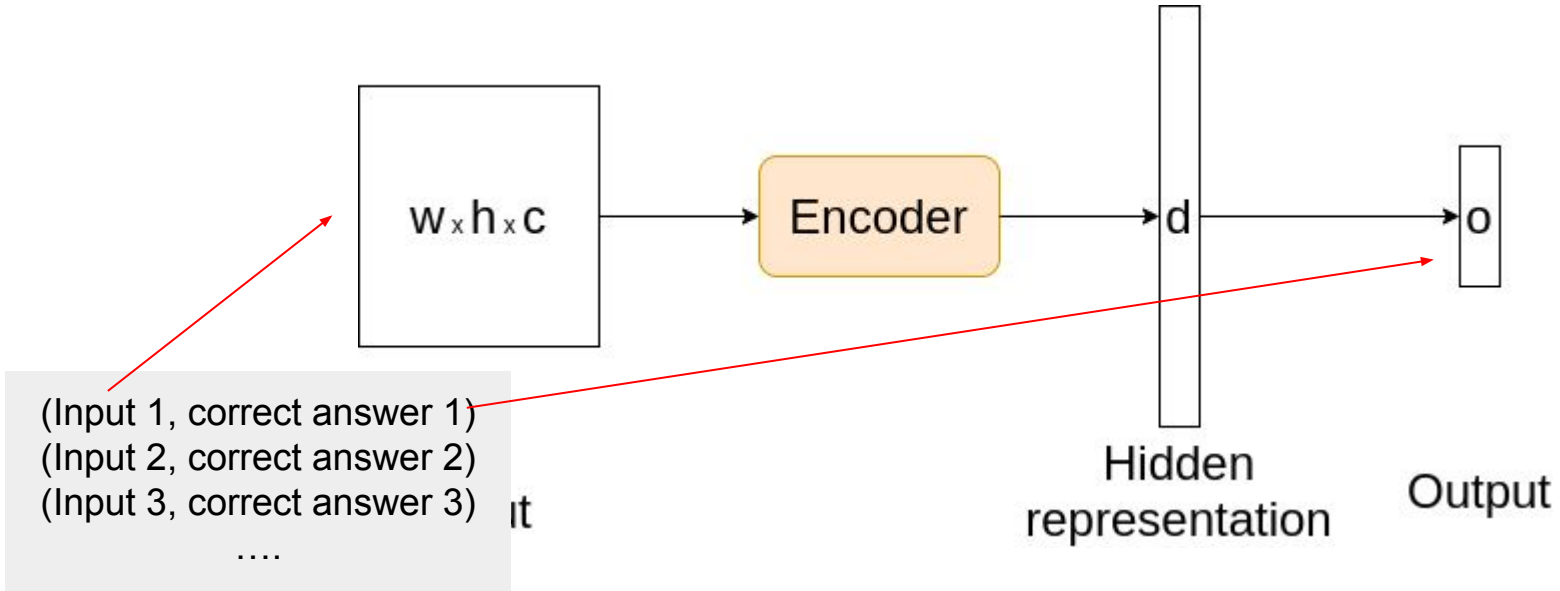
Organise labels using tree structure and employ hierarchical methods based on Probabilistic Label Trees [1]



[1] You, R., Zhang, Z., Wang, Z., Dai, S., Mamitsuka, H., & Zhu, S. (2019). AttentionXML: Label tree-based attention-aware deep model for high-performance extreme multi-label text classification. 33rd Conference on Neural Information Processing Systems (NeurIPS 2019).

Challenge of training the classifier

- Make a guess given the input
- Calculate the **loss** between the guess and the correct answer
- **Optimize** the model to make the loss become smaller



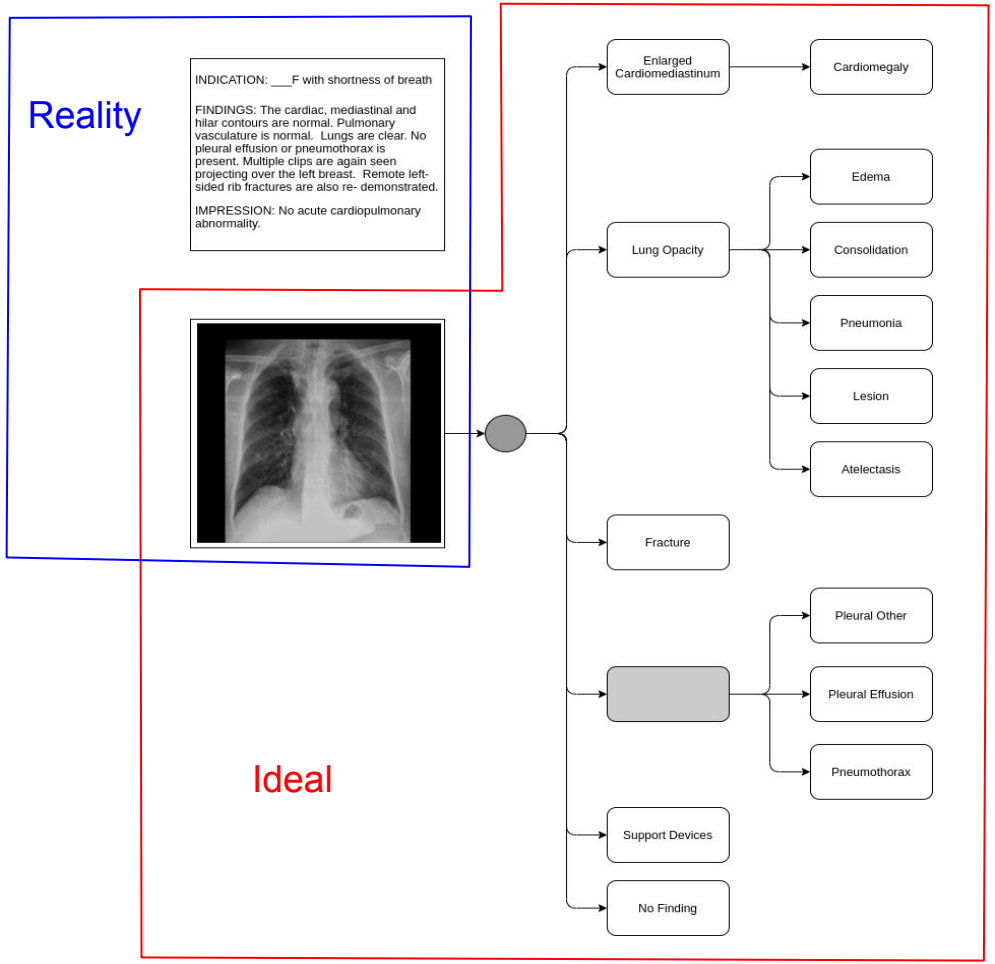
Training requires large amount of labelled data

to benchmark and evaluate recognition algorithms, at least 3-4 orders of magnitude smaller than what humans can do. To bridge this gap, we have recently put together a new image dataset called ImageNet (www.image-net.org), currently consisted of more than 10 million images across 15,000+ visual categories, all collected from the web and verified by humans. The construction of ImageNet has been a tremendously challenging process, forcing us to dive into relatively unchartered water of crowdsourcing technology. Using ImageNet as a resource, we present here a series of unpublished work in benchmarking existing algorithms

Source: https://www.ri.cmu.edu/event/imagenet-crowdsourcing-benchmarking-and-other-cool-things/

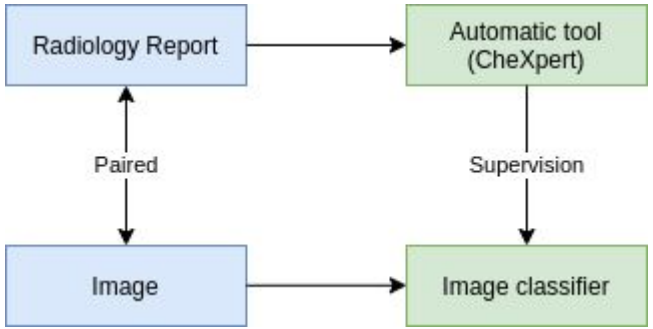
Training the classifier

Use paired images and radiology reports (my main research focus)



Distant supervision

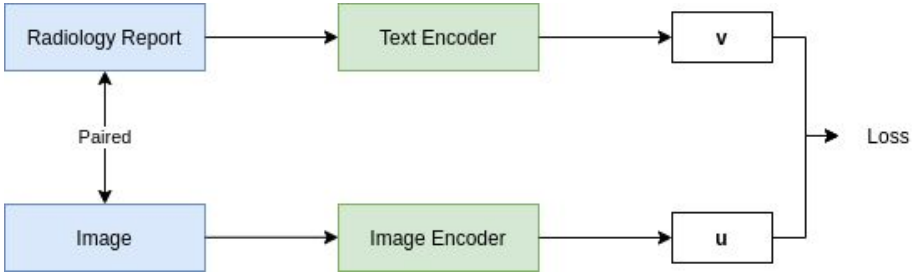
- Labels for the images can be derived from the corresponding reports
- CheXpert [1]: extraction; classification; and aggregation



[1] Irvin, J., Rajpurkar, P., Ko, M., Yu, Y., Ciurea-Ilcus, S., Chute, C., Marklund, H., Haghgoo, B., Ball, R., & Shpanskaya, K. (2019). {CheXpert}: A large chest radiograph dataset with uncertainty labels and expert comparison. *Proceedings of the AAAI Conference on Artificial Intelligence*, 590–597.

Contrastive learning

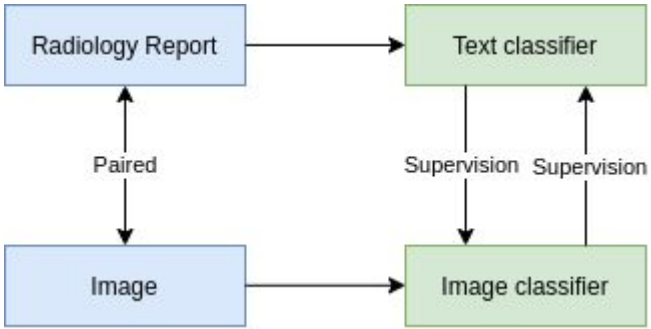
- Optimize both text encoder and image encoder so that **v** and **u** can be similar to each other



[1] Zhang, Y., Jiang, H., Miura, Y., Manning, C. D., & Langlotz, C. P. (2020). Contrastive Learning of Medical Visual Representations from Paired Images and Text. *ArXiv Preprint ArXiv:2010.00747*.

Co-training

- Start from a very small amount of labeled data
- Train text classifier and image classifier (decent performance required)
- Then let text classifier and image classifier iteratively teach each other



Future work (2021-2023)

- Long medical history
- Multimodal
- ...
- Trust
- Explainability
- ...