DTU Compute
Department of Applied Mathematics and Computer Science

Pneumonia Detection Using Mask R-CNN and ChexNet

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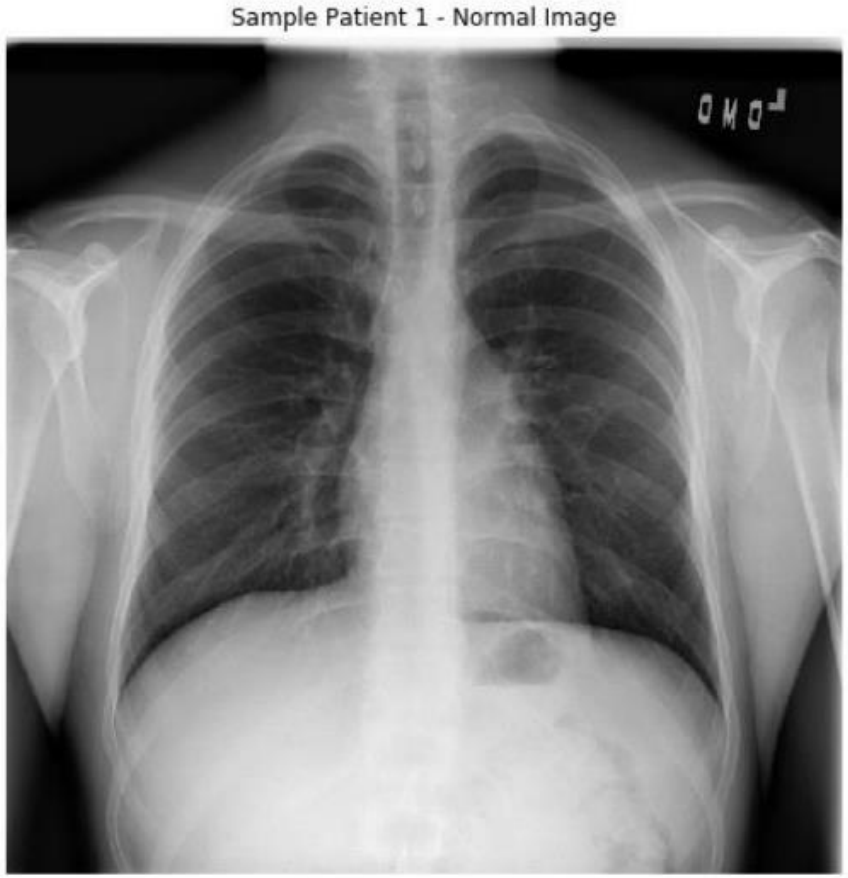
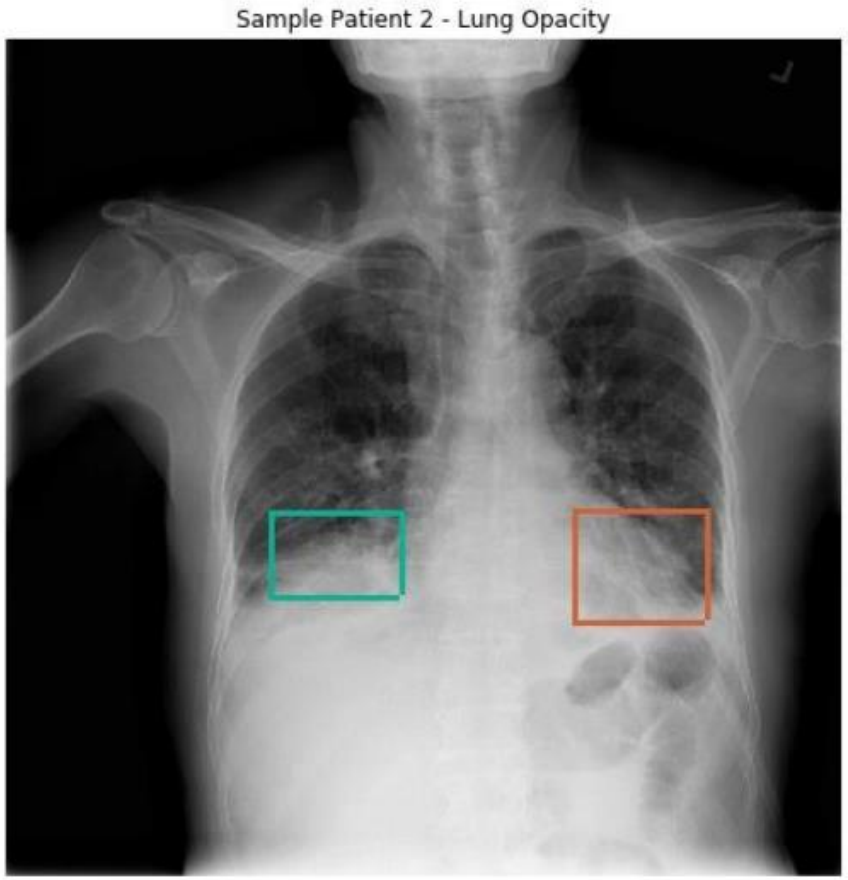
Collaborator: Unumed

Pneumonia detection using Mask R-CNN and ChexNet

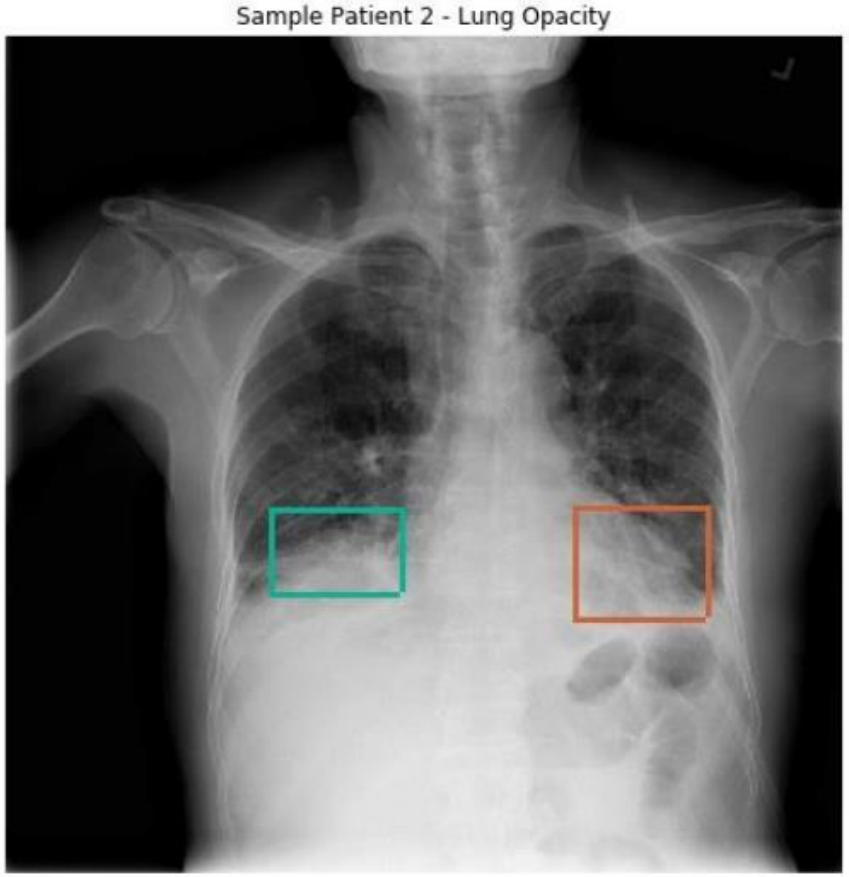
- Pneumonia is manifested by lung opacities[1]
- Causes **16%** of all deaths worldwide
- Correct diagnosis depends on the interpretation of chest X-ray images
- Pneumonia, or small lungs + enlarged heart?





Pneumonia detection using Mask R-CNN and ChexNet

- Radiologists are available in the western world, but to a smaller degree in the developing world.
- Unumed works to aid the developing parts of the world in this aspect by using, among other things, deep learning.
- We set to *explore* possible networks for Pneumonia detection.



Pneumonia **detection** using Mask R-CNN and ChexNet

- Detection means providing bounding boxes for areas of interest.
- Deep learning is artificial neural networks of more than 1 layer. Convolutional neural networks are most important within image analysis.
- Deep learning shows great promise in many areas, such as self-driving cars, speech recognition and medical imaging.

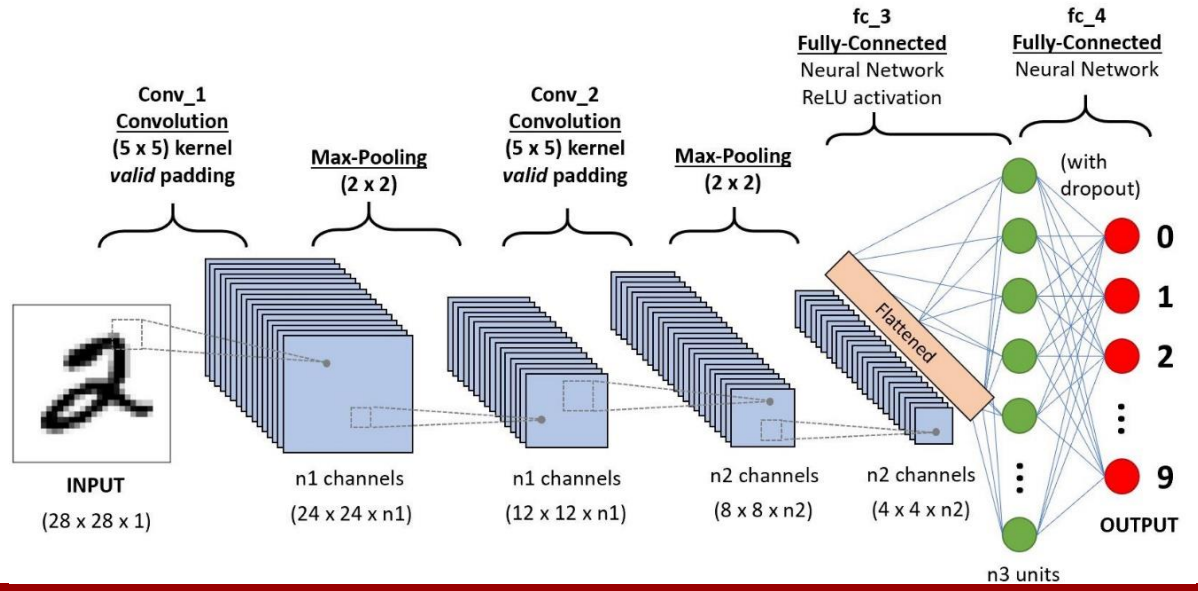
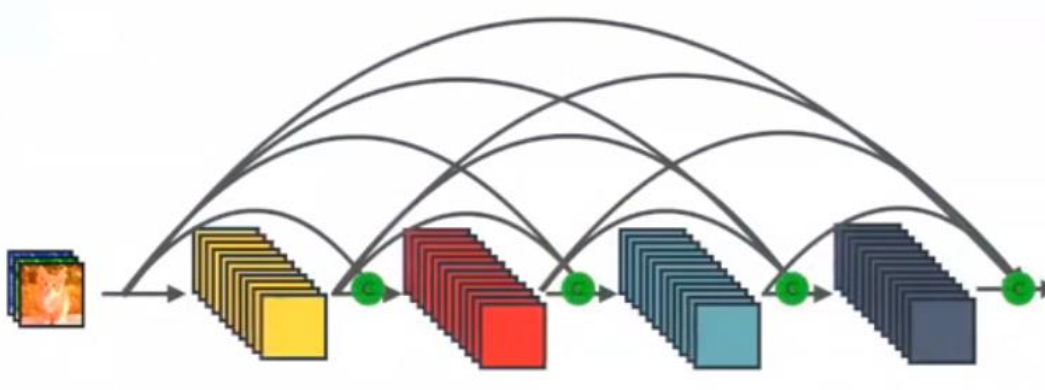
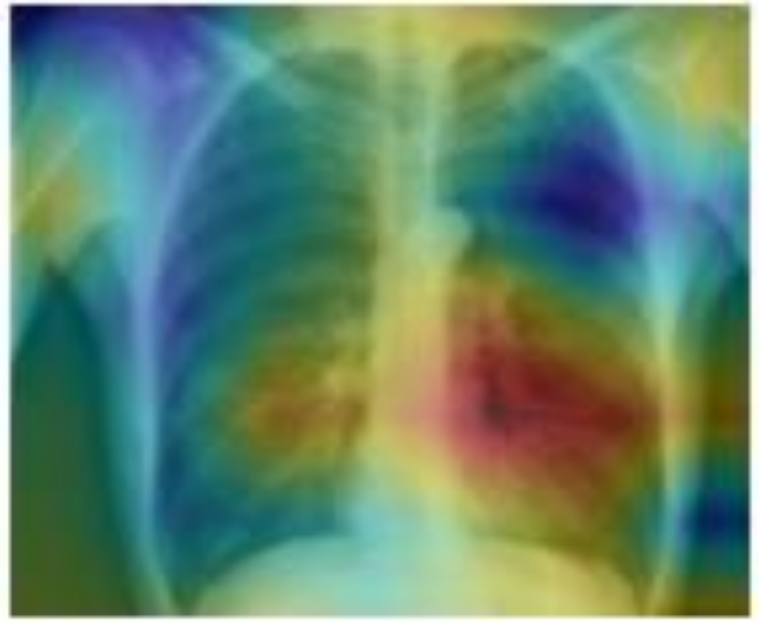


Image from [2]

Pneumonia detection using Mask R-CNN and **ChexNet**

- ChexNet is a 121-layer DenseNet from the Stanford AI group[3].
- DenseNets involve residual connections (ResNet[4]) between dense blocks[5].
- Provides a heatmap of probabilities which then have to be thresholded to create bounding boxes.
- According to the article, the classification performance of the ChexNet exceeds that of single radiologists.





Images from [3]

Pneumonia detection using **Mask R-CNN** and ChexNet

- Front-runners in the field of fast computer vision detection for use in self-driving cars include:
  - Mask Regional Convolutional Neural Network[6]
  - Single-Shot Multibox Detection[7] (SSD)
  - You-Only-Look-Once[8] (YOLO)

- Offers the possibility to mask out detected areas with a confidence level.

- Backbone is a fully convolutional 50-layer ResNet. The output feature layer is divided into regions of *k* different sizes. Total number of regions, with a stride of 1: $W \times H \times k$

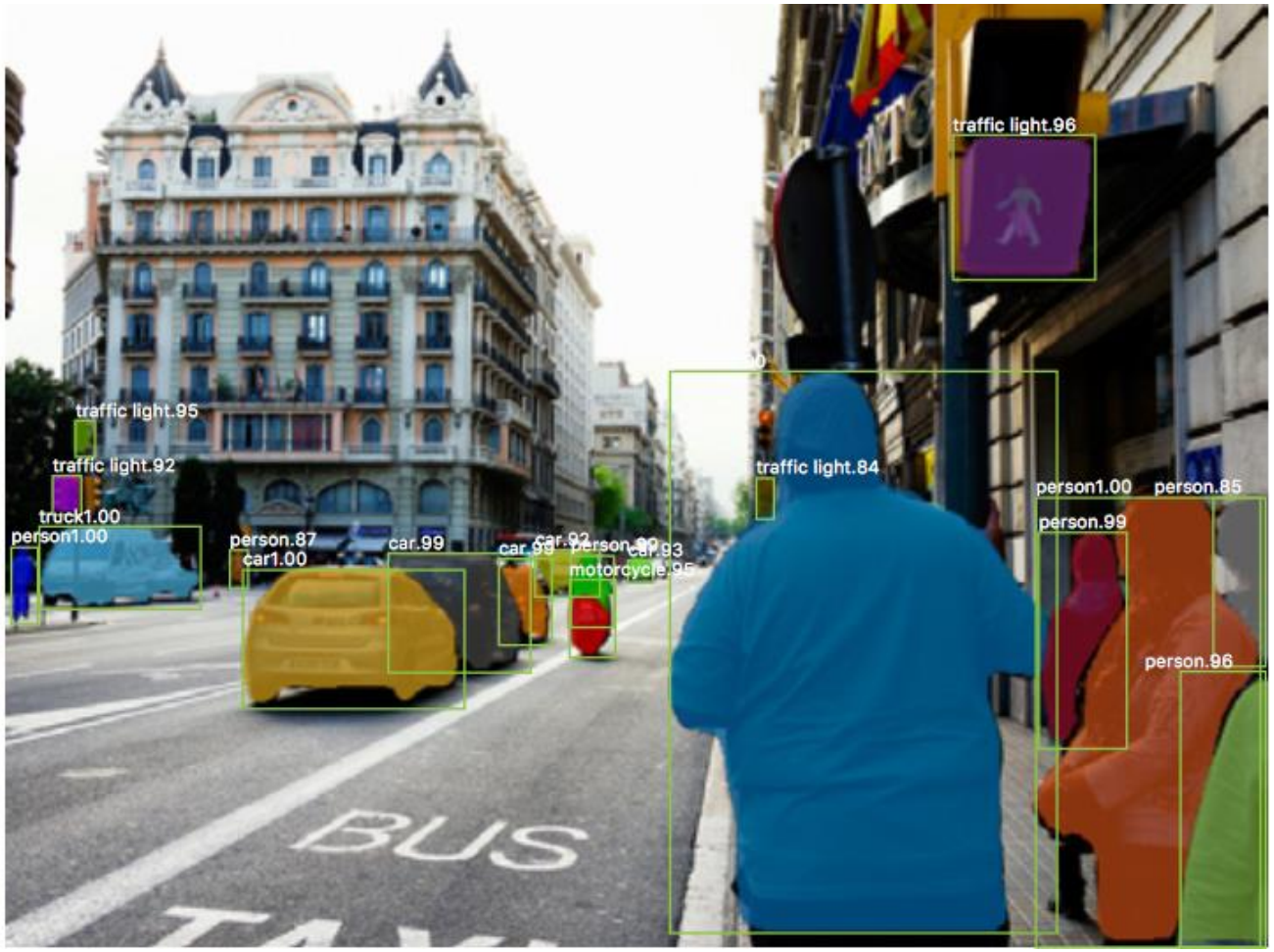


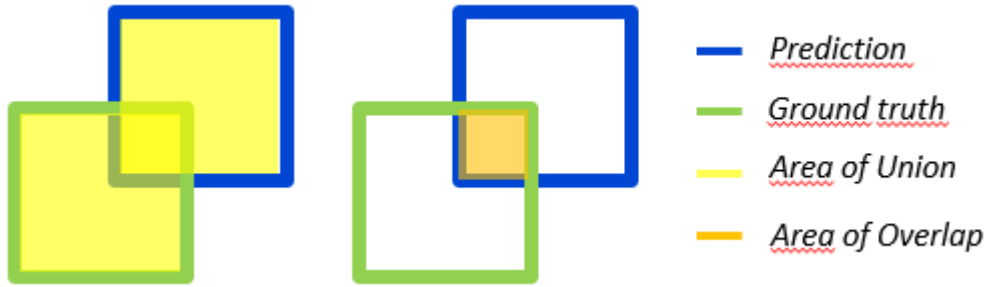
Image from [6]

Pneumonia detection using Mask R-CNN and ChexNet - Implementation and evaluation

- Data: 28.989 chest X-ray images composed of:
  – **8964** patients with pneumonia
  – **11.500** patients with other lung disease
  – **8525** patients with no lung disease
  Data made available by Radiological Society of North America (RSNA®).
  We keep **1500** images for validation and **1000** for testing.

- Models are trained using a loss function over the intersection over union (IoU).
  Results may be evaluated at any IoU – we choose 0.5 that is seen as standard.[3]

$$IoU = \frac{Area\ of\ Overlap}{Area\ of\ Union}$$

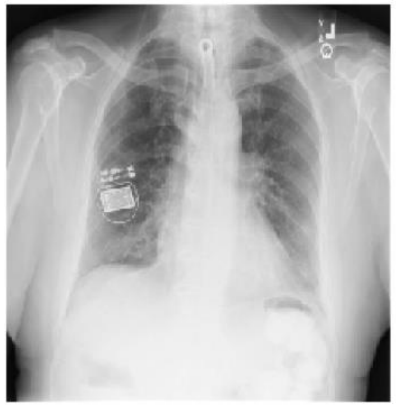


Pneumonia Detection Using Mask R-CNN and ChexNet

- Results examples

Ground truth

Mask R-CNN



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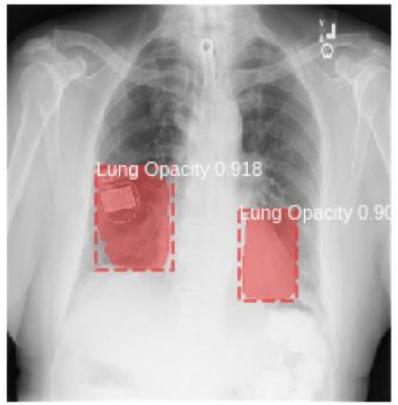
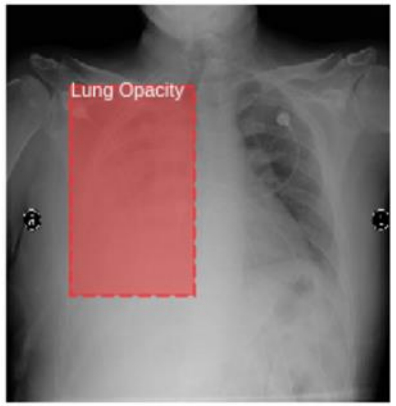
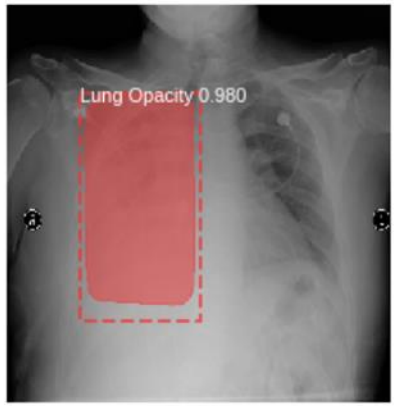


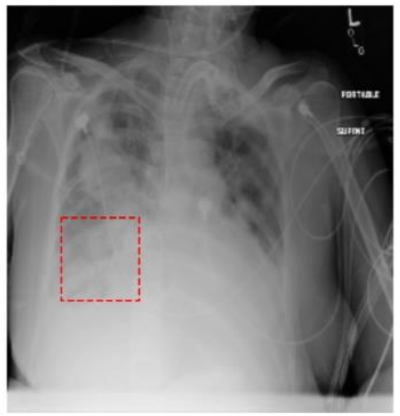


TP



Ground truth

CheXNet



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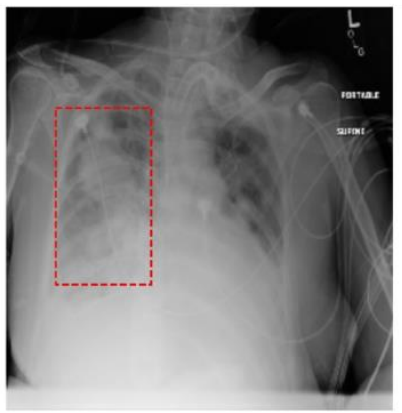
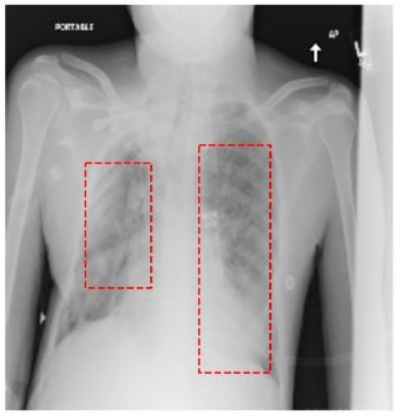
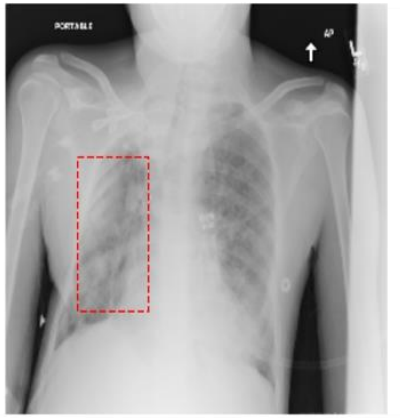


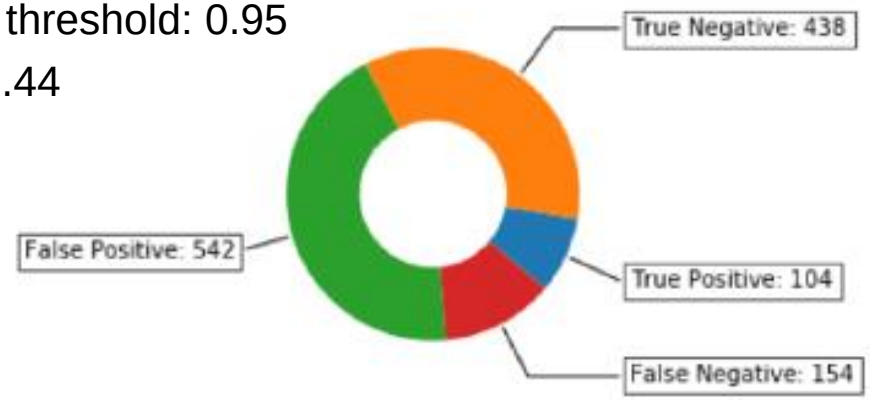


TP+FN

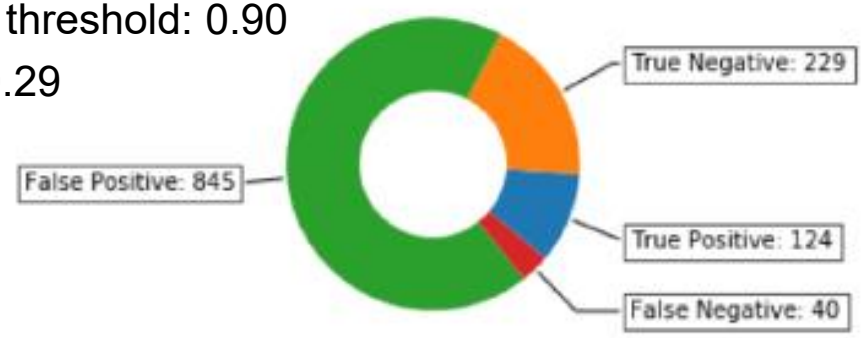


Pneumonia Detection Using Mask R-CNN and ChexNet - Results

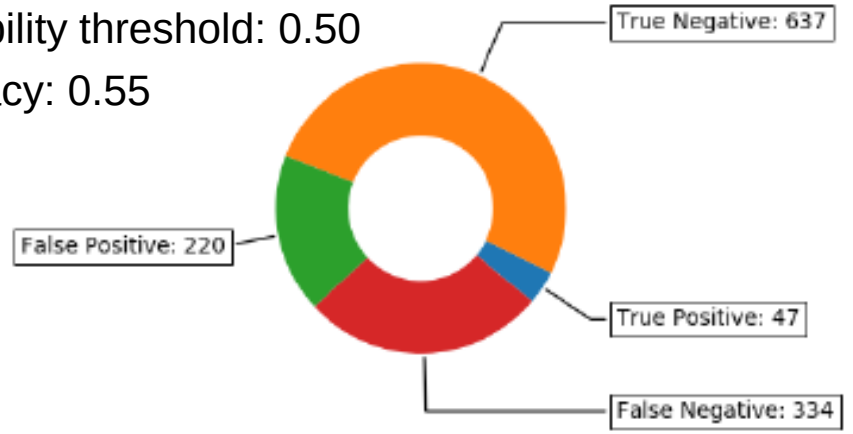
Confidence threshold: 0.95
Accuracy: 0.44



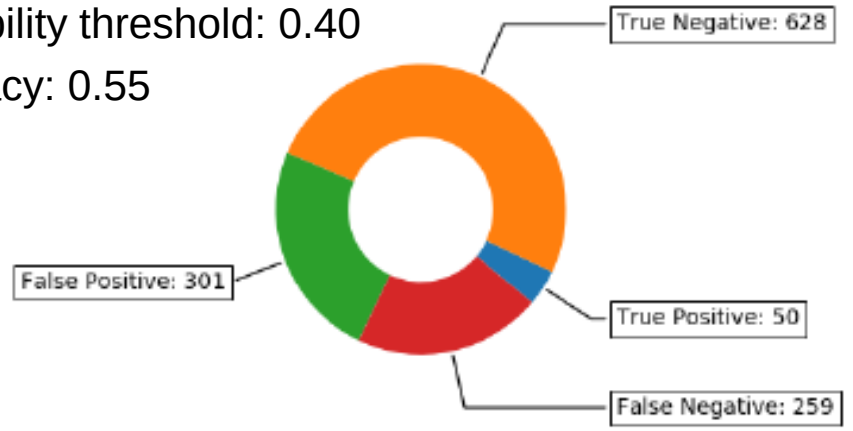
Confidence threshold: 0.90
Accuracy: 0.29



Probability threshold: 0.50
Accuracy: 0.55



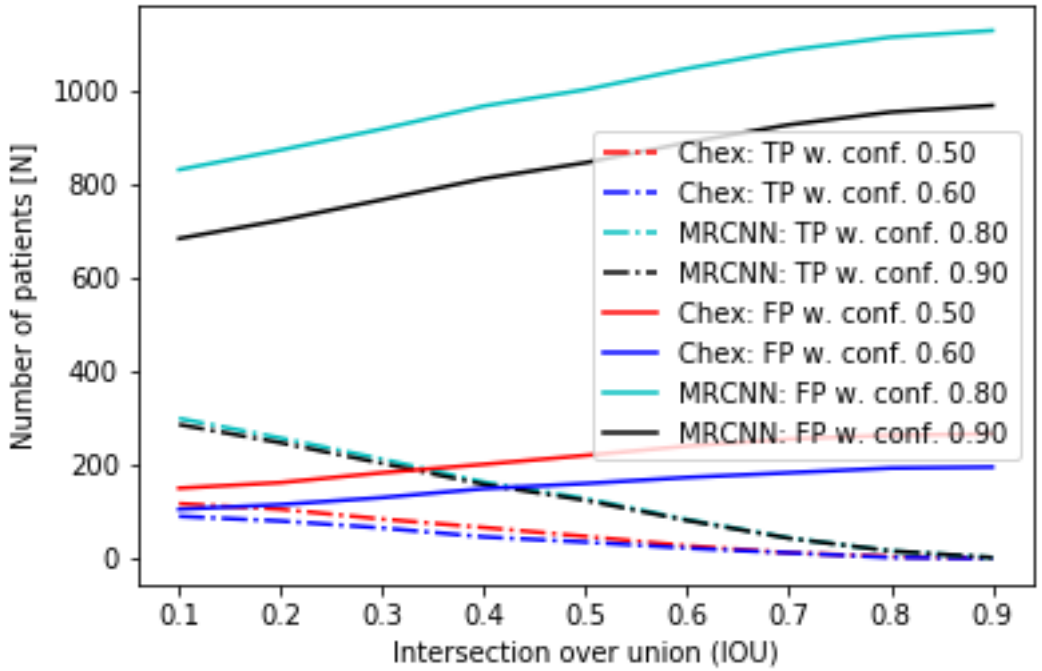
Probability threshold: 0.40
Accuracy: 0.55



Pneumonia Detection Using Mask R-CNN and ChexNet - Discussion

- As previously mentioned, this project is an exploration of models, not a comparison. Effort needs to be made to make experiment setups the same.
- Mask R-CNN is much faster than ChexNet, but seemingly less accurate.
- We argue that accuracies are high compared to the difficulty of the problem.

- Points of critique:
  - We only evaluate 2 thresholds for both models
  - We give results only for one single IoU-threshold (figure)
  - We only look at two (now outdated) models
  - We did not tweak hyperparameters
  - We did not include much data augmentation
  - We did not look at data quality



Thank you

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References

[1] World Health Organization, "*Pneumonia*," 2016

[2] Sumit Saha, "*A comprehensive guide to convolutional neural networks*", 2018

[3] Rajpurkar, Irvin et al., "*Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning*", 2017

[4] He et al., "*Deep residual learning for image recognition*", 2015

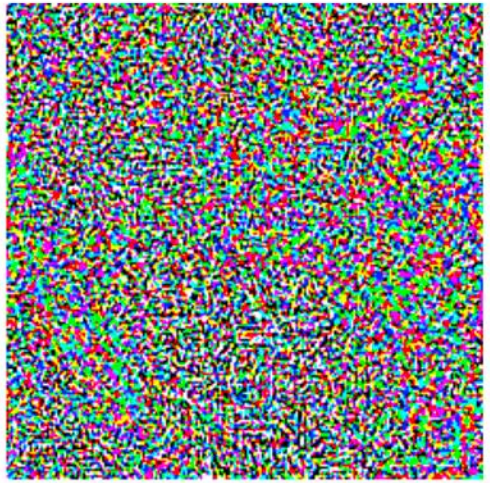
[5] Huang et al., "*Densely connected convolutional networks*", 2016

[6] He et al., "*Mask R-CNN*", 2017

[7] Liu et al., "*SSD: Single shot multibox detector*", 2016

[8] Redmon et al., " *Yolo v3: An incremental improvement*", 2018

$+ .007 \times$



$=$

“panda”

57.7% confidence

noise

“gibbon”

99.3% confidence