A Two-Stage Deep Learning Approach to Chest X-Ray Analysis

Charles Anderson, PhD, Pattern Exploration LLC; David Anderson

Introduction

New approaches to the automated analysis of X-ray images based on deep learning algorithms have recently been studied. Rajpurkar, et al. [1] and Baltruschat, et al. [2] showed how 121-layer and 50-layer convolutional neural networks can be used to detect pneumonia and other findings from chest X-ray images.

Here we describe an approach, shown in Figure 1, consisting of two, five-layer networks. One, called the alignment network, is trained to align an X-ray image into a standard configuration, and a second classifies the aligned image. A key advantage of our approach is that our first network can be trained with unlabelled data.

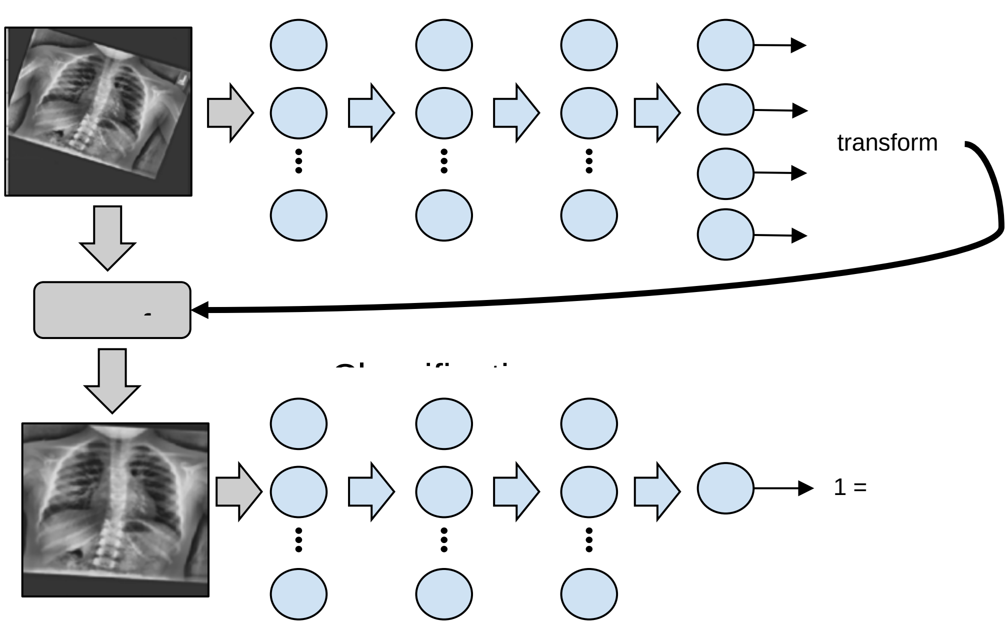

Figure 1: Alignment and

Hypothesis

We hypothesize that complex convolutional neural networks can be replaced by the above combination of two simple neural networks.

Methods

We randomly selected 570 images from the NIH Chest X-Ray dataset from which we generated randomized training data.

The alignment network consisted of four hidden layers, with 200, 100, 25, and 25 units, respectively. It was trained by creating batches of 400 images that were downscaled to ¼ of their original size, then had a series of random transformations applied---translate (x - y movement), rotation, and scale. The network was trained on 386 such batches, for a total of 1,930 training iterations. Figure 2 shows three examples of original images and the result of applying the predicted transformations as produced by the alignment network.

The trained alignment network was then given images from a second set of 407 image samples that would potentially benefit from realignment and some that were already ideally positioned. Of this set, 63 had a diagnosis label of pneumonia. This data was partitioned into random groupings of 75% training, 25% testing. The alignment network was then used to transform each image. These aligned images were then used as training data for the classification network, which consisted of four hidden layers of 200, 175, 75, and 50 units, respectively. The classification network was then trained on both the original images and the alignment network's modified images.

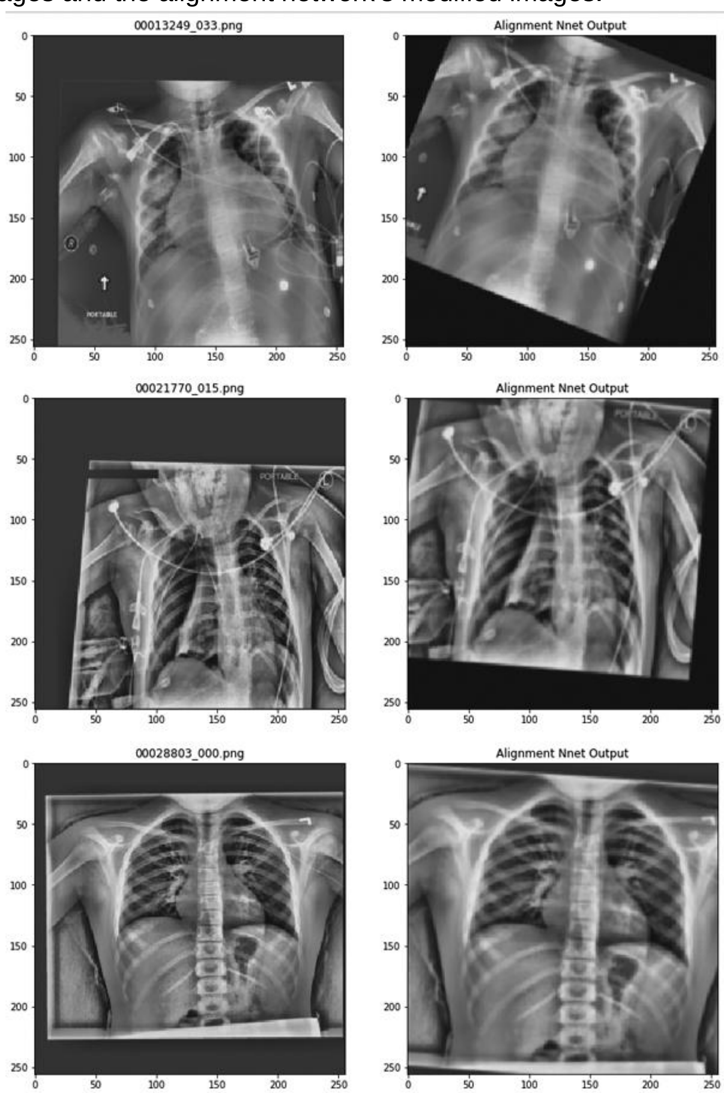

Figure 2: original images (left) and the alignment network's modified images (right)

Results

The results in Table 1 show a marked improvement in classification accuracy when utilizing the alignment neural network on images.

Without Alignment Network **With Alignment Network**

F1 = 0.232 Accuracy 67 %

		Predicted	
		Negative	Positive
Actual	Negative	63	23
	Positive	10	5

F1 = 0.258 Accuracy 77 %

		Predicted	
		Negative	Positive
Actual	Negative	74	12
	Positive	11	4

Table 1: Counts of actual and predicted findings (positive indicates pneumonia). Table on left is without use of alignment network and table on right is with use of alignment network.

Conclusion

The combination of the alignment network with the classification network was found to be capable of classifying chest X-ray images that were not initially in a standard alignment. This is counter to the current deep learning approaches that rely on large convolutional networks. Our approach based on small networks results in models whose decisions are much easier to interpret than are results from large convolutional networks.

Statement of Impact

The neural network approach demonstrated here will lead to faster, more accurate, and more interpretable classification methods for X-rays and other imaging modalities. On-going work with additional X-ray images is expected to increase the significance of these results.

References

[1] P. Rajpurkar, et al. (2017) *CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning*. https://arxiv.org/abs/1711.05225v3

[2] I. M. Baltruschat, et al. (2018) *Comparison of Deep Learning Approaches for Multi-Label Chest X-Ray Classification*. https://arxiv.org/abs/1803.02315v1

Keywords

chest X-ray, deep learning, image classification, pneumonia