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# Lung Disease Classification - Applied AI Progress Report

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## 1. Introduction and Problem Statement

Early diagnosis of respiratory diseases like pneumonia and COVID-19 leads to decreased mortality rate [7] and is a powerful way to manage a pandemic [39]. These diseases can be diagnosed using a variety of tests like pulse oximetry, chest x-ray, CT scan [29], PCR [1] however chest X-rays are by far the most accessible [9]. Furthermore, the scan is available in minutes making it one of the fastest ways of diagnosis [30]. However, the bottleneck with this method is the need for an expert radiologists to evaluate the scan [20]. Many researchers have tried to solve this problem using deep learning [35] but haven't been able to come up with models that can replace radiologists. Small [12] and highly imbalanced data [35], along with varying specifications to X-ray scanners are the biggest problems [26] that researchers have faced. Another issue with using deep neural networks in medical settings is its black-box nature [3]. Doctors and patients will not trust a model that cannot explain results [21].

This project is an attempt to alleviate these issues by using three backbone architectures and three lung disease datasets to identify the type of architecture that works best for lung disease classification. The small dataset problem and the issue of different radiographic contrast [22] is mitigated using data augmentation. Imbalanced data will be handled with a combination of using class weights, and a good backbone model. The novelty of this project will be the detailed comparison of the results across architectures and datasets along with the explanation of model results using Grad-CAM [11]. The final system will use the best model in terms of both efficiency and F1 score allowing rapid diagnosis of lung diseases leading to immediate initiation of treatment, reducing mortality rate.

## 2. Proposed Methodologies

In this project, 12 models will be trained, four models for each of the three datasets selected. The first three models will be trained from scratch and the



Figure 1. Effect of pre-processing on Chest X-ray images.

fourth model will be trained using transfer learning. The hyperparameters will be fixed across models to ensure results are comparable. Next, hyperparameters will be tuned to find the best model. Finally, the trained models will be visualized using t-SNE and Grad-CAM to explain model results. Before training the images were pre-processed using histogram equalization and Gaussian blur with a 5x5 filter as Giełczyk *et al.* [10] showed that this improved the F1 score by 4% for chest X-ray classification. Visually, these methods improved the contrast of the scan and allowed irregularities to stand out as shown in Fig. 1. Next, the scans were divided into train, validation and test sets using the 70:15:15 split. During training, images were augmented using RandomHorizontalFlip, RandomAdjustSharpness, and RandomAutocontrast in Pytorch [24] to increase the number of images the model gets to learn from. To train the model, cosine annealing with warm restarts [19] was used along with the Adam optimizer [18] and the cross entropy loss function.

**Datasets:** (Tab. 1) with varying disease types were chosen to ensure model robustness. Other criteria included number of images per class and image quality as noisy scans can lead to mis-diagnosis [28]. **COVID**, this dataset was developed in collaboration with researchers and medical doctors 43 [8] different publications. [5, 6, 25] X-rays with widespread, hazy, and irregular ground glass opacities are of the COVID-19



Figure 2. Sample images of Chest X-rays.

Dataset	No. of Images	Classes	Size
COVID [5, 6, 25]	10k:3.6k:1.3k	3	299 <sup>2</sup>
Pneumonia [17, 33]	3k:1.5k:1.5k	3	224 <sup>2</sup>
Chest X-Ray8 [36, 37]	25k:12k:6k:5k :3k:2.7k:2.6k	7	1024 <sup>2</sup>

Table 1. Shortlisted Datasets.

Arch.	Params (Mil.)	Layers	FLOPS (Bil.)	Imagenet Acc.
MobileNet	5.5	18	8.7	92.6
EfficientNet	7.8	25	25.8	94.9
Resnet	21.8	34	153.9	91.4

Table 2. Shortlisted Backbone Architectures.

class [16]. Whereas, the ones with haziness on the lower regions [40] and clean upper regions are viral pneumonia cases as shown in Fig. 2. **Pneumonia**, chest X-ray scans from retrospective cohorts of pediatric patients, one to five years old were collected during routine clinical care. [17, 33] The scans with one white condensed area or with other areas appearing normal are tagged bacterial pneumonia as it affects only one side of the lungs [2]. X-rays which show bilateral patchy areas of consolidation are classified as viral pneumonia as viruses affect both sides of the lungs [13]. **Chest X-ray 8**, NIH [38] released over 100,000 chest x-ray images and their radiological reports which Wang *et al.* [36] used to create disease labels through NLP. [37] The dataset contains 15 classes but only 7 were chosen for this study. Furthermore, normal class images were undersampled to choose only one scan per patient. **Backbone Architecture:** (Tab. 2) were chosen according to the following criteria. *Number of trainable parameters*, important as total training time and hardware resources are limited for this project. *Top 5 classification accuracy* on the ImageNet 1K benchmark dataset *Varying architectures and blocks* to find the best type of model for X-ray classification. **ResNet 34**: residual learning network with 34 layers that are made possible

by skip connections. The 34 layer variant was chosen to decrease training time. [14] **MobileNet V3 Large**: uses depthwise separable convolution from MobileNet V2 [27] along with squeeze-excitation blocks in residual layers from MnasNet [31]. Howard *et al.* [15] also used network architecture search to find the most effective model. The large configuration was chosen to not compromise on the prediction accuracy. **EfficientNet B1**: uses compound scaling to scale the model by depth, width and resolution. The B1 version was chosen to have faster training without compromising on the accuracy. [32]

### 3. Attempts at Solving the Problem

Two datasets in this study had a very small number of samples which caused the models to overfit early. To mitigate this, random contrast and sharpness adjustment [23] data augmentation techniques were used. Some scans in the datasets were anterior-posterior while some others were posterior-anterior and using the horizontal flip data augmentation would make the model invariant to these differences [4]. ResNet was the first model trained and each epoch took over 1 hour. To reduce the training time, the X-ray images were resized, pre-processed and split into train, test and validation sets separately. Furthermore, EfficientNet and MobileNet were chosen as the other two models as they have a considerably low number of learnable parameters.

The 9 models to be trained from scratch were trained and the training F1 scores and loss can be seen in Fig. 3. From the plots it is clearly visible that going from a smaller architecture to a bigger architecture, makes the model starts to overfit earlier. Another interesting observation is that cosine annealing impacted the loss of MobileNet the most every 10 epochs due to warm restarts. All three datasets had similar performance across models, the X-ray 8 dataset performed the worst which could be due to the high number of classes as compared to the other datasets. Surprisingly, the pneumonia dataset performed worse than the COVID + pneumonia dataset which indicates that COVID cases are easier to distinguish from pneumonia cases.

### 4. Future Improvement

Going forward, the models will be trained for 50 epochs as all the models start to overfit after that point. One model for each dataset will be trained using transfer learning and its performance will be compared with models trained from scratch. Ablation study will be performed to see how different hyperparameters af-

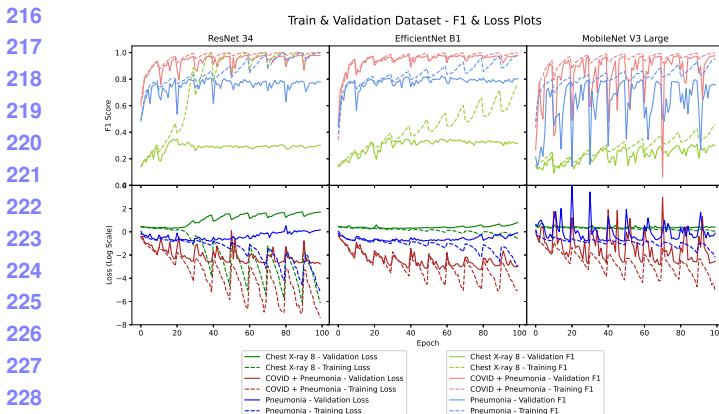


Figure 3. Train & Val F1 & Loss plots for the 9 models.

affect the F1 score of the models. Looking at the F1 score of the Chest X-ray 8 dataset, class weights will be explored to improve model performance. Further, t-SNE [34] and grad-CAM [11] will be used to visualize the trained models.

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