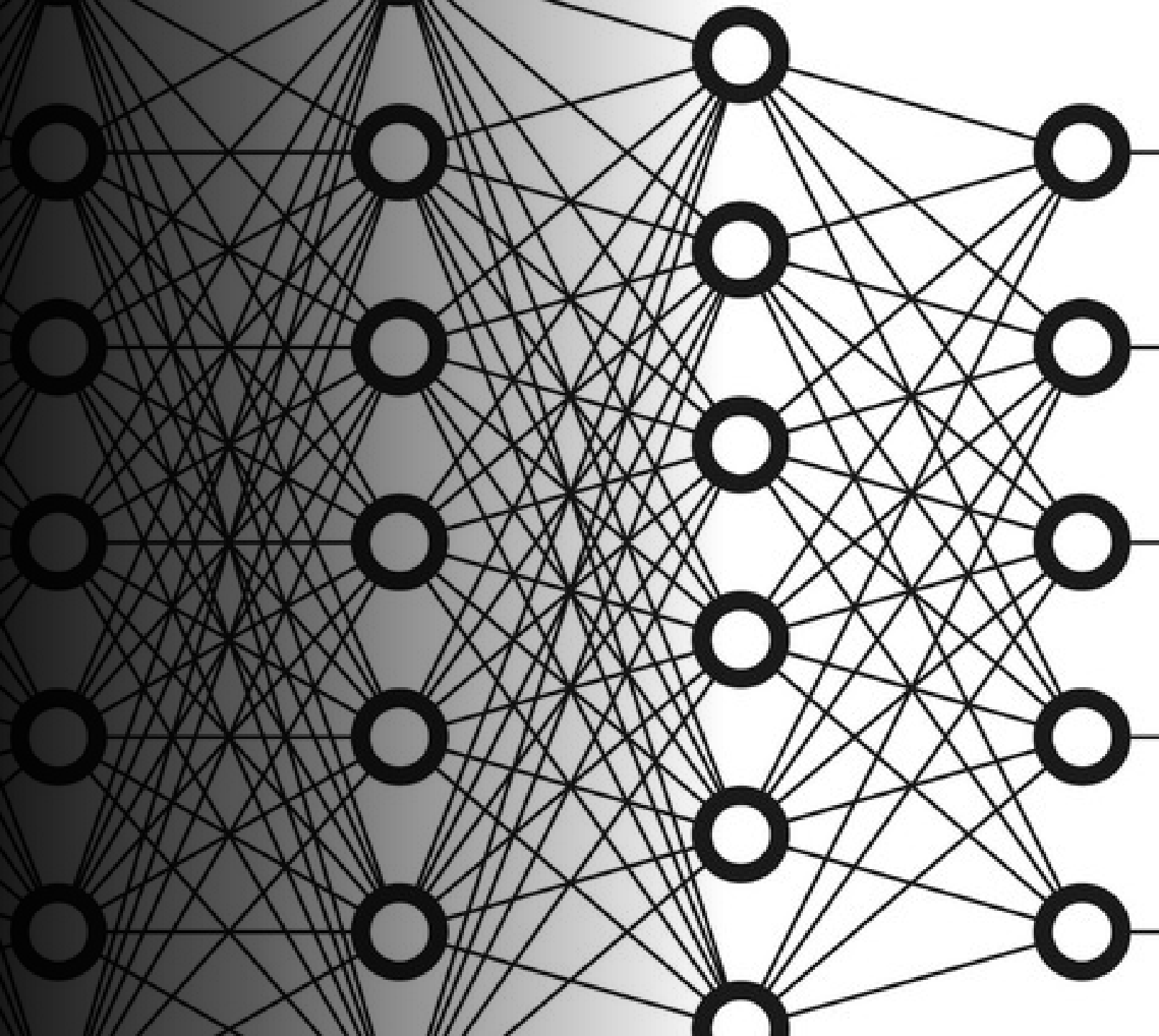
An Automated Interpretation of Smartphone-Captured Radiographs Utilizing Deep Learning-Based Approaches

https://bitbucket.org/la96bikal/xrayimageclassification



Team

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What We'll Cover Today

Information on Dataset

Data Preprocessing and Tools Used

State of the Art Models

Result

Challenges

Future Work

CheXPhoto Dataset Description

Overview

- Provided by Stanford ML group as a part of competition
- Parent Dataset: ChexPert, randomly sampled 3000 unique patient's data from ChexPert

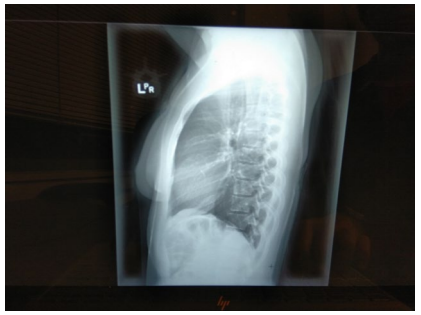
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Path	Sex	Age	Frontal/Lateral	AP/PA	No Finding	Enlarged Cardiomediastinum	Cardiomegaly	Lung Opacity	Lung Lesion	Edema	Consolidation	Pneumonia	Atelectasis	Pneumothorax	Pleural Effusion
2	CheXphoto-v1.0/train/synthetic/digital/patient00004/study1/view1_frontal.jpg	Female	20	Frontal	PA	1	0					0				0
3	CheXphoto-v1.0/train/synthetic/digital/patient00004/study1/view2_lateral.jpg	Female	20	Lateral		1	0					0				0
4	CheXphoto-v1.0/train/synthetic/digital/patient00019/study1/view1_frontal.jpg	Female	46	Frontal	PA					1					0	
5	CheXphoto-v1.0/train/synthetic/digital/patient00019/study1/view2_lateral.jpg	Female	46	Lateral						1					0	
6	CheXphoto-v1.0/train/synthetic/digital/patient00019/study4/view1_frontal.jpg	Female	50	Frontal	AP			1	1	1				1	1	1
7	CheXphoto-v1.0/train/synthetic/digital/patient00019/study3/view1_frontal.jpg	Female	46	Frontal	AP		1			1		1		1	0	1
8	CheXphoto-v1.0/train/synthetic/digital/patient00019/study2/view1_frontal.jpg	Female	46	Frontal	AP				1	1		-1		-1	0	
9	CheXphoto-v1.0/train/synthetic/digital/patient00029/study1/view1_frontal.jpg	Female	37	Frontal	AP				1					-1	0	
10	CheXphoto-v1.0/train/synthetic/digital/patient00090/study1/view1_frontal.jpg	Male	23	Frontal	PA									1		-1
11	CheXphoto-v1.0/train/synthetic/digital/patient00090/study1/view2_lateral.jpg	Male	23	Lateral										1		-1
12	CheXphoto-v1.0/train/synthetic/digital/patient00126/study1/view1_frontal.jpg	Female	58	Frontal	AP	1					0					
13	CheXphoto-v1.0/train/synthetic/digital/patient00135/study1/view1_frontal.jpg	Male	59	Frontal	PA						0	0				0
14	CheXphoto-v1.0/train/synthetic/digital/patient00135/study1/view2_lateral.jpg	Male	59	Lateral							0	0				0

Snippet of CheXPhoto Metadata

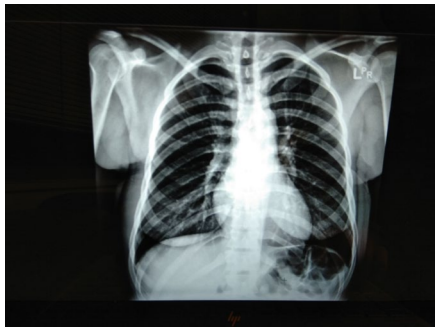
Phillips et al.

Examples

Frontal

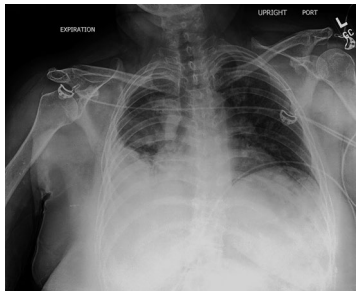


Lateral



Nokia

iPhone



Anterior-Posterior

Posterior-Anterior

Natural

Synthetic

Phillips et al.

Dataset Distribution

Pathology	Positive (%)	Uncertain (%)	Negative (%)
No Finding	972 (9.25)	0 (0.0)	9535 (90.75)
Enlarged Cardiomediastinum	518 (4.93)	600 (5.71)	9389 (89.36)
Cardiomegaly	1313 (12.5)	370 (3.52)	8824 (83.98)
Lung Opacity	5184 (49.34)	213 (2.03)	5110 (48.63)
Lung Lesion	415 (3.95)	78 (0.74)	10014 (95.31)
Edema	2553 (24.3)	634 (6.03)	7320 (69.67)
Consolidation	671 (6.39)	1315 (12.52)	8521 (81.1)
Pneumonia	263 (2.5)	885 (8.42)	9359 (89.07)
Atelectasis	1577 (15.01)	1595 (15.18)	7335 (69.81)
Pneumothorax	957 (9.11)	166 (1.58)	9384 (89.31)
Pleural Effusion	4115 (39.16)	607 (5.78)	5785 (55.06)
Pleural Other	170 (1.62)	127 (1.21)	10210 (97.17)
Fracture	391 (3.72)	31 (0.3)	10085 (95.98)
Support Devices	5591 (53.21)	48 (0.46)	4868 (46.33)

Phillips et al.

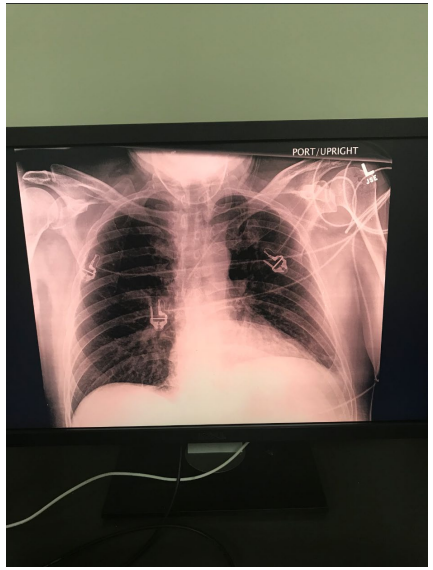
Data Preprocessing

Metadata Cleaning

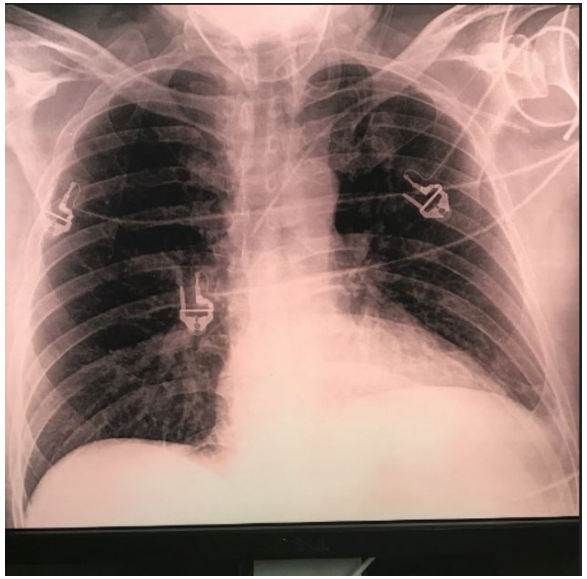
- Selected only five among 14 observations
- Age and sex included for passing into the network
- Images with NAN labels converted to 0
- Images with -1 labels ignored
- Only frontal images selected

Image Cropping

- Labelimg tool used to create 600 Hand Labeled training Images
- YOLOv3 (You Only Look Once) custom object detection with DarkNet
- Trained for 10 hours on Google Colab

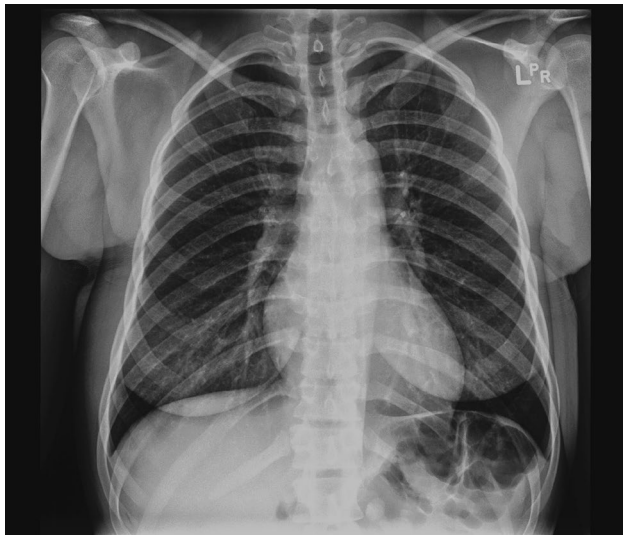


YOLO



Data Resize and Normalization

- Resized all the images to 224x224x3
- Min-Max Normalization

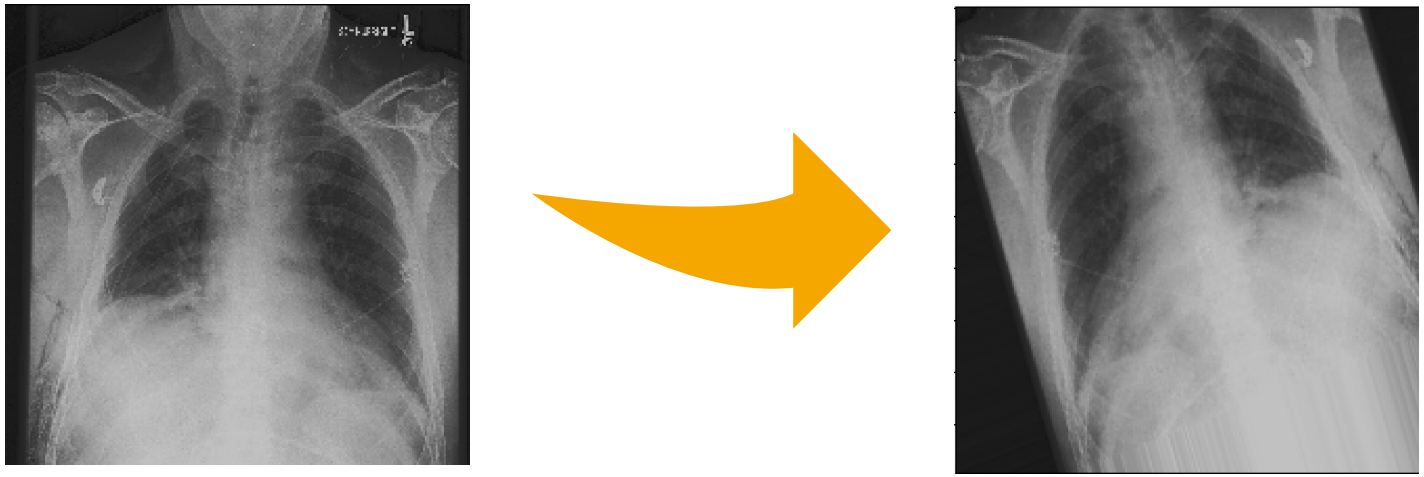


Data Augmentation

- Highly Imbalanced Classes
- Keras Image Generator Class
- Parameters adapted from Previous Paper

Label	Positive (%)	Negative (%)	Uncertain (%)
Atelectasis	1577 (15.01)	7335 (69.81)	1595 (15.18)
Cardiomegaly	1313(12.5)	8824 (83.98)	370 (3.52)
Consolidation	671 (6.39)	8521 (81.1)	1315 (13.52)
Edema	2553 (24.3)	7320 (69.67)	634 (6.03)
Pleural Effusion	4115 (39.16)	607 (5.81)	607 (5.78)

```
aug = ImageDataGenerator(
    featurewise_center=False,
    featurewise_std_normalization=False,
    rotation_range=10,
    width_shift_range=0.1,
    height_shift_range=0.1,
    horizontal_flip=True,
    brightness_range=(0.9, 1.1),
    zoom_range=(0.85, 1.15),
    fill_mode='constant',
    cval=0.,
)
```



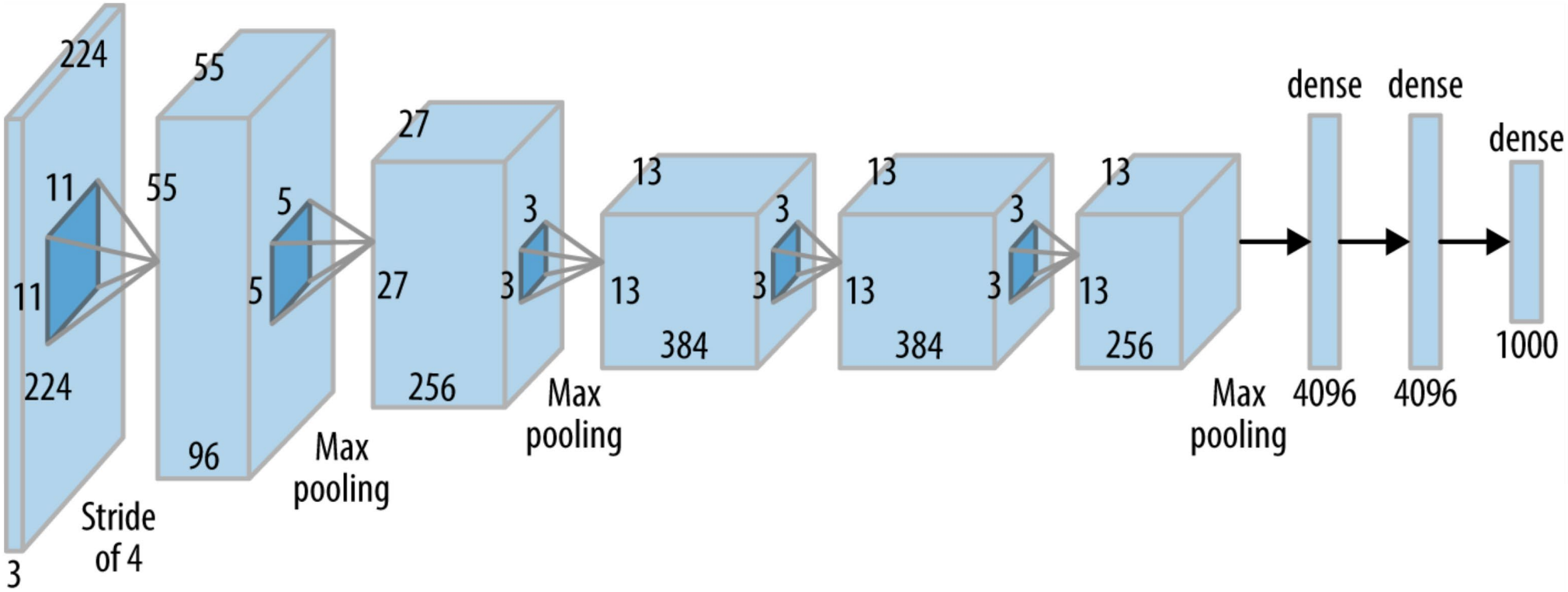
Wang et al.

Deep Learning Modeling

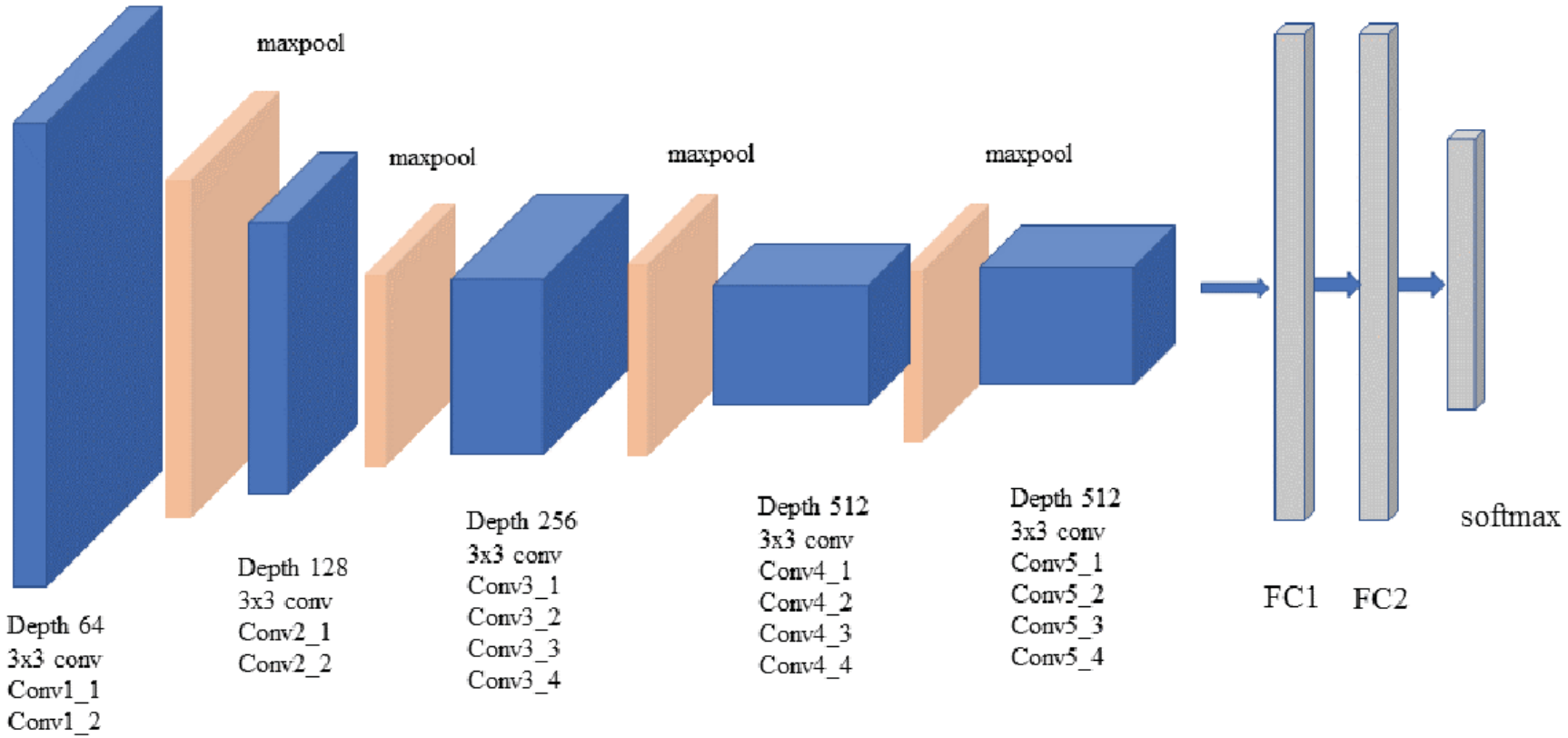
State-of-the-art Models

- AlexNet
- Resnet50
- VGG19
- SqueezeNet

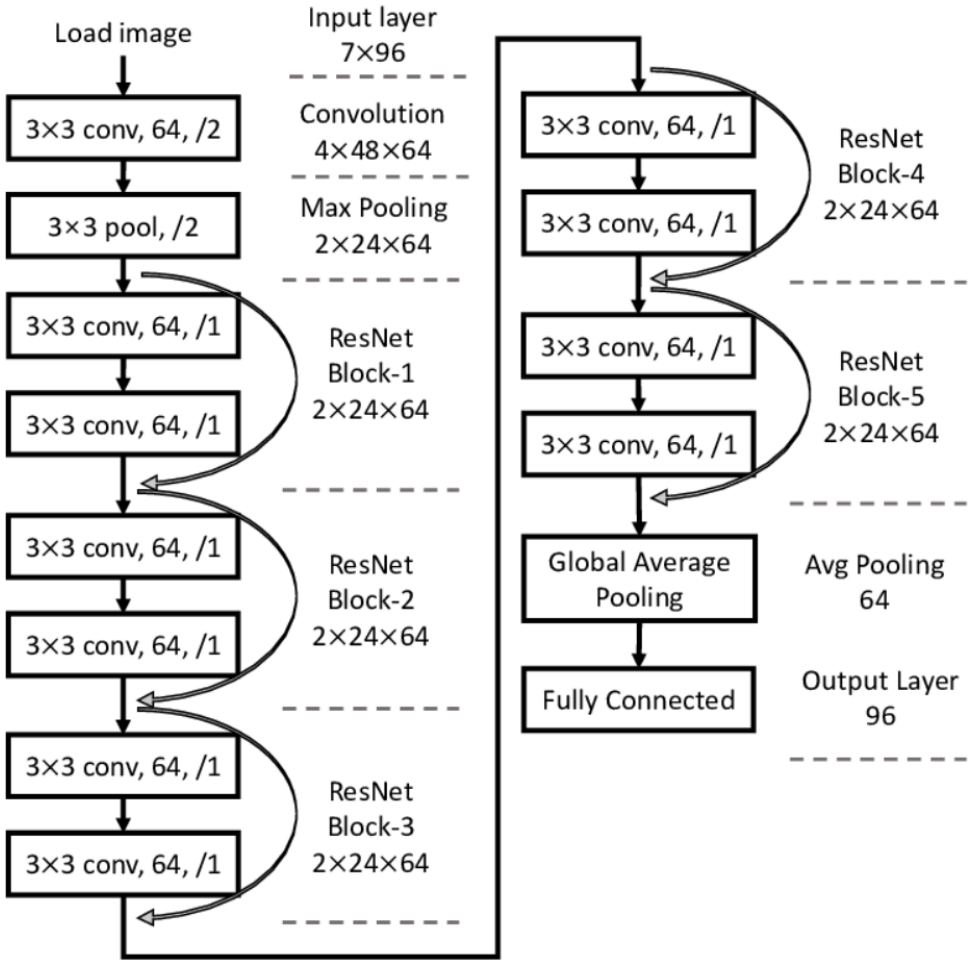
Architecture: AlexNet (60 million params.)



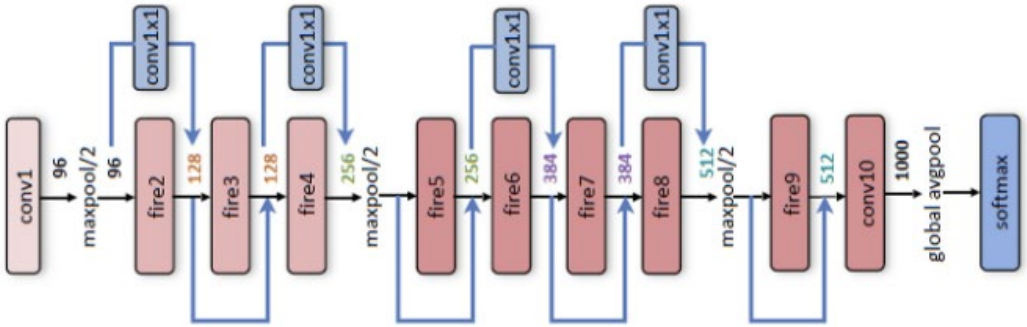
Architecture: VGG19 (143 Mil. Parameters)

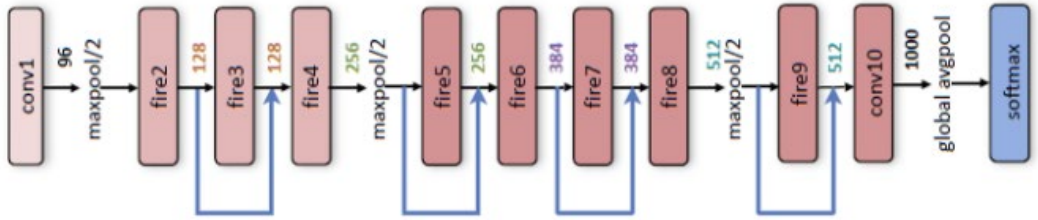


Architecture: ResNet – 12 (10 million params.)

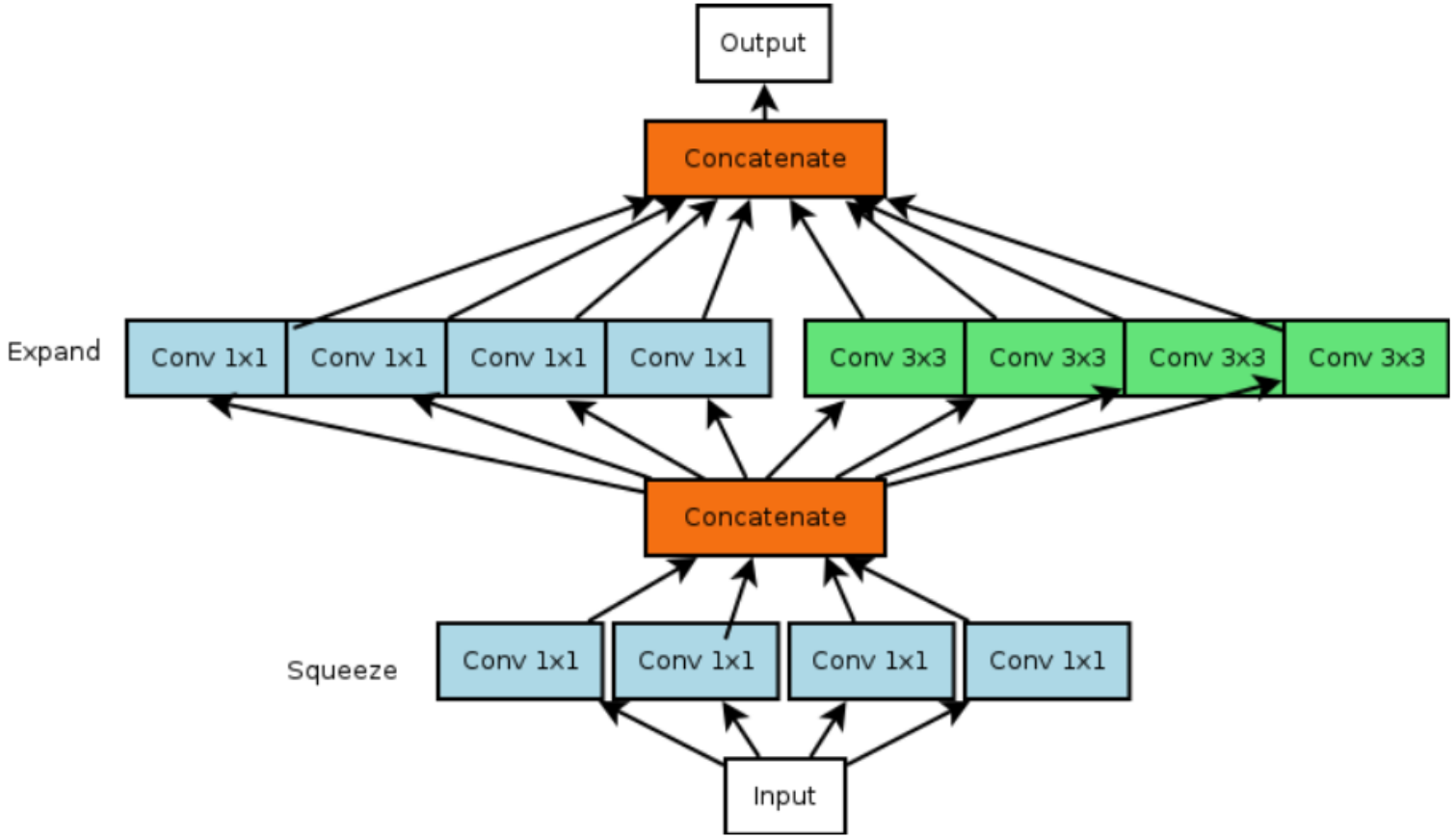


SqueezeNet (1.2 Million params.)

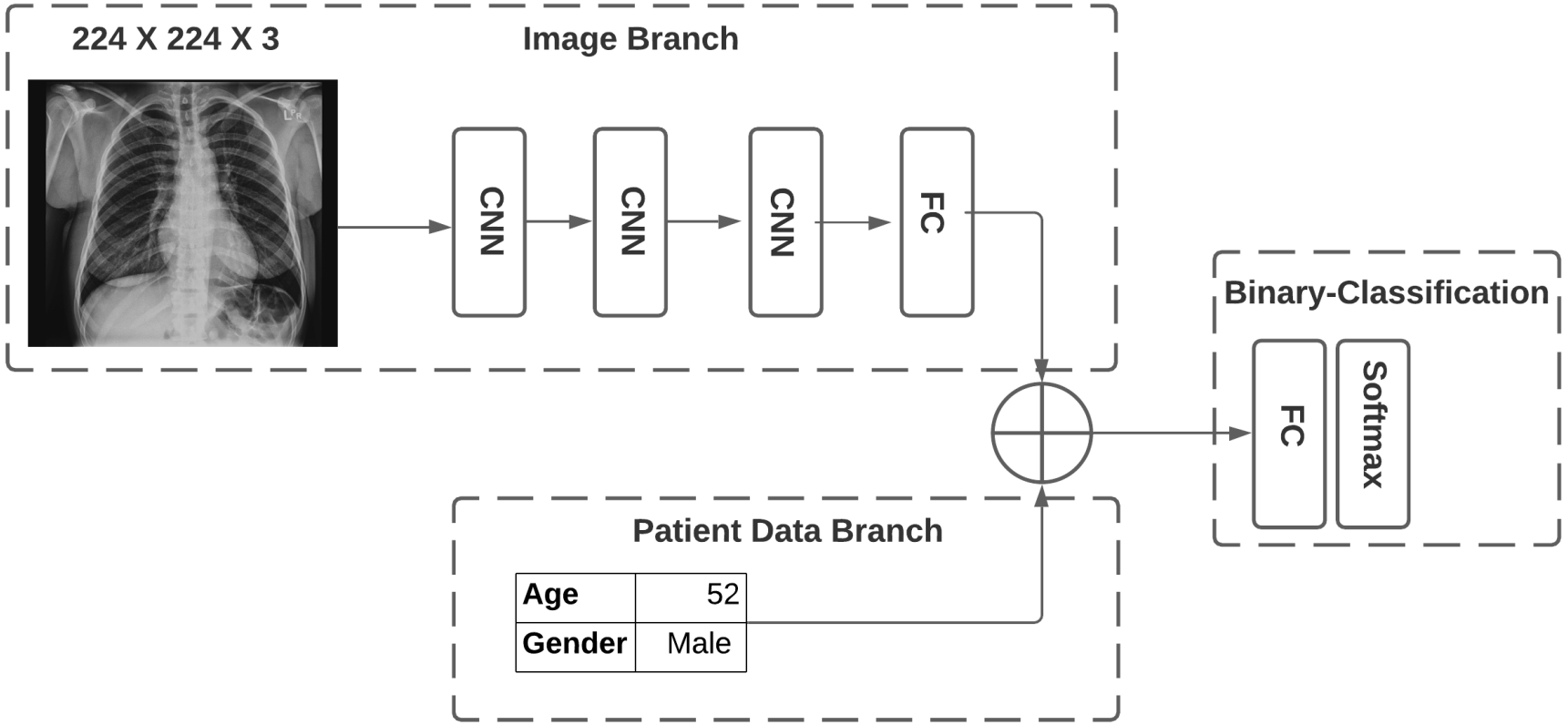




Fire Modules in Squeeze Net



Hybrid Arch. with Added Features



Results

Results for AlexNet without Age and Sex

Target	Data (Synthetic and Natural Combined)	Training	Validation	Epochs	Optimizer
Pleural Effusion	Augmented and Balanced(30K Images)	85.23 (Overfitting)	76	25	(Adam(0.001)
Edema	Augmented and Balanced(36K Images)	83	79	25	(Adam(0.001)
CardioMegaly	Augmented and Balanced(47K Images)	89	88	25	(Adam(0.001)
Atelectasis	Augmented and Balanced(35 K Images)	82	84	25	(Adam(0.001)
Consolidation	Augmented and Balanced(41K Images)	89	91	25	(Adam(0.001)

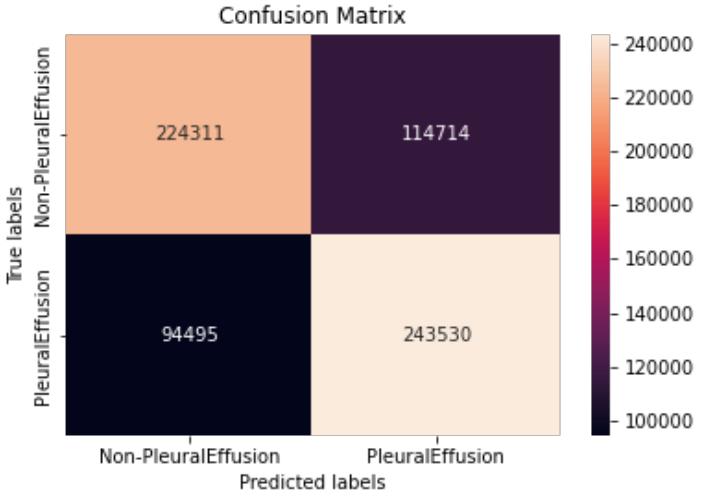
Results for ResNet without Age and Sex

Target	Data (Synthetic and Natural Combined)	Training	Validation	Epochs	Optimizer
Pleural Effusion	Augmented and Balanced(28K)	86	80	15	Adam(0.001)
Pleural Effusion	Augmented and Balanced(28K)	**96(Grossly Overfitting)**	**78(Grossly Overfitting)**	20	Adam(0.001)
Edema	Augmented and Balanced(36K)	79	78	5	Adam(0.001)
CardioMegaly	Augmented and Balanced(47K)	**89 (Overfitting)**	81	10	Adam(0.001)
Atelectasis	Augmented and Balanced(35K)	**88(Overfitting)**	80	15	Adam(0.001)
Consolidation	Augmented and Balanced(41 K)	95	96	15	Adam(0.001)

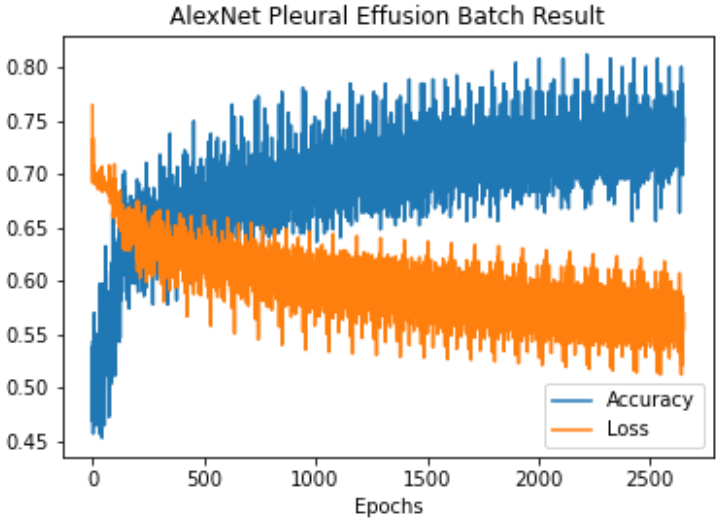
Results for AlexNet with Age and Sex

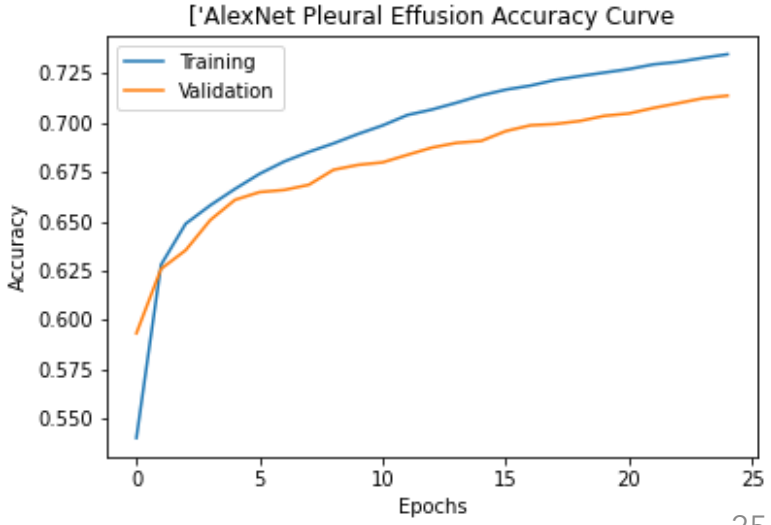
Target	Data (Synthetic and Natural Combined)	Training	Validation	Epochs	Optimizer
Pleural Effusion	Augmented and Balanced(30K)	80 **(-5)**	76 **(+ 0)**	25	(Adam(0.0001)
Edema	Augmented and Balanced(36K)	84 **(+1)**	82 **(+ 3)**	25	(Adam(0.0002)
CardioMegaly	Augmented and Balanced(47K)	91 **(+2)**	87 **(- 1)**	25	(Adam(0.0001)
Atelectasis	Augmented and Balanced(35 K)	86 **(+4)**	85 **(+ 1)**	40	(Adam(0.0001)
Consolidation	Augmented and Balanced(41K)	93 **(+4)**	92 **(+ 1)**	35	(Adam(0.0001)

AlexNet Result: Pleural Effusion

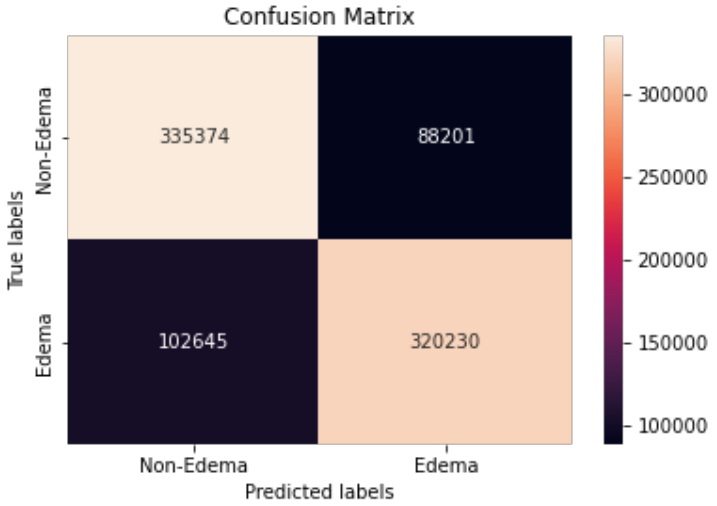


Precision: 0.66
Recall: 0.7035

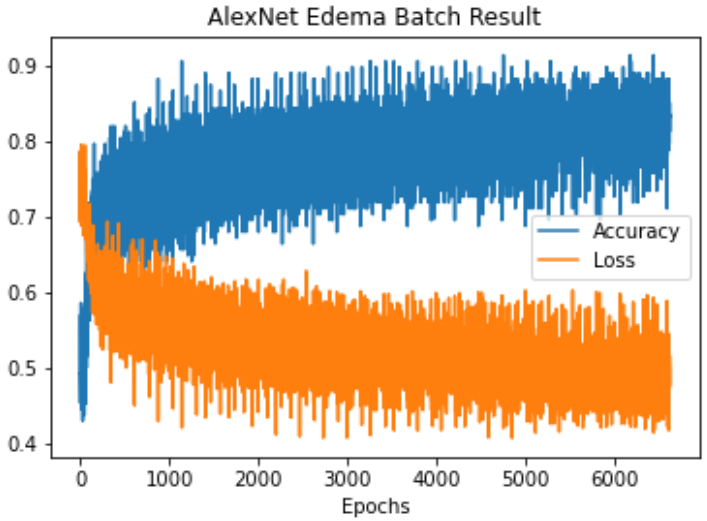


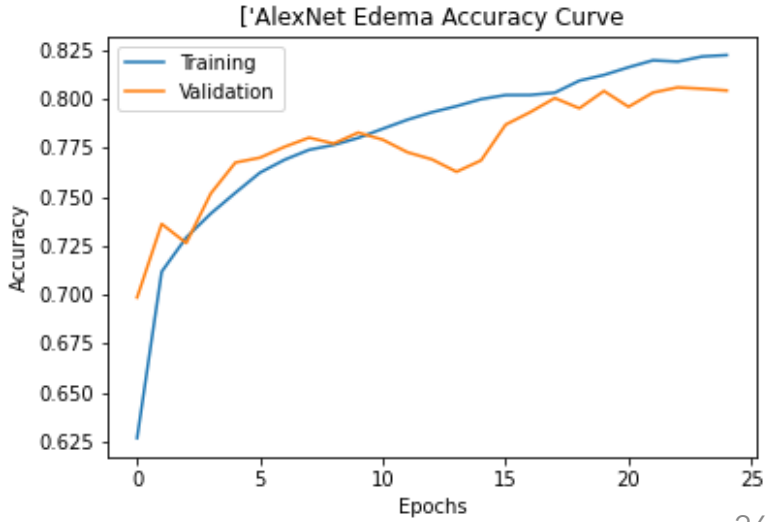


AlexNet Result: Edema

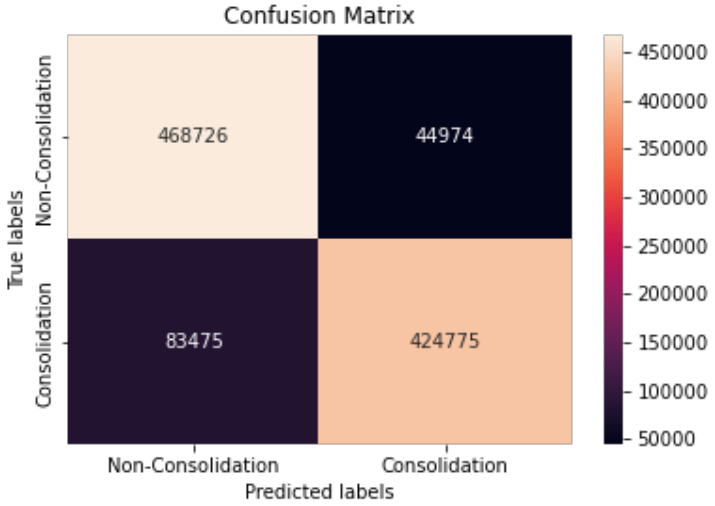


Precision: 0.79
Recall: 0.765

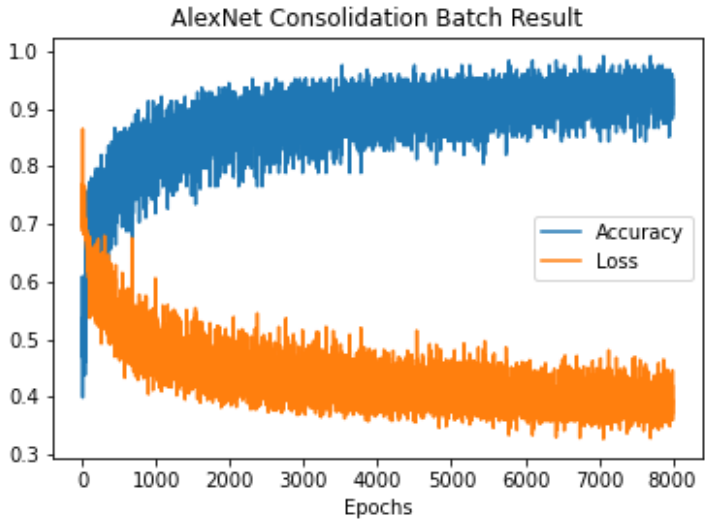


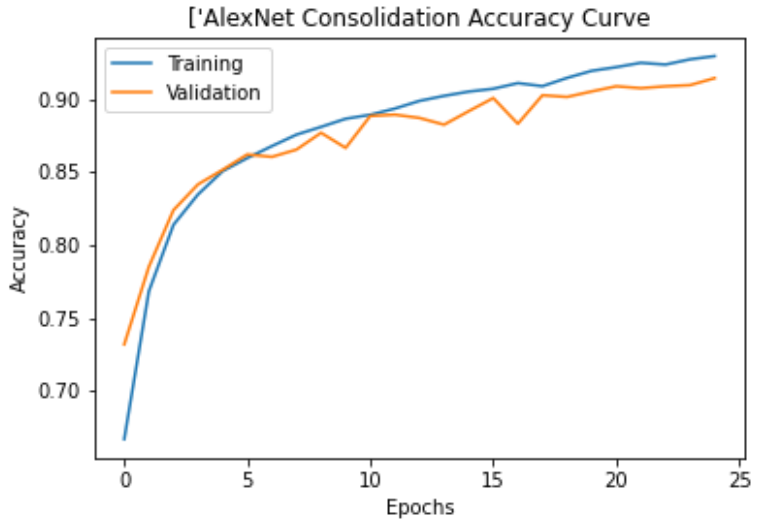


AlexNet Result: Consolidation

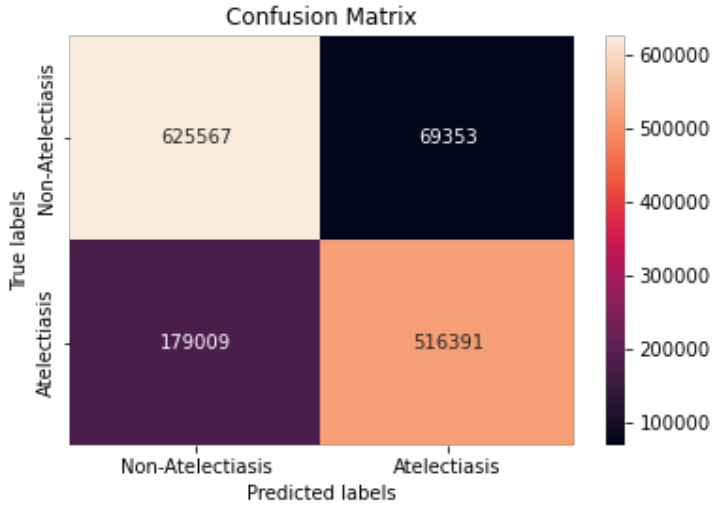


Precision: 0.91245
Recall: 0.8488

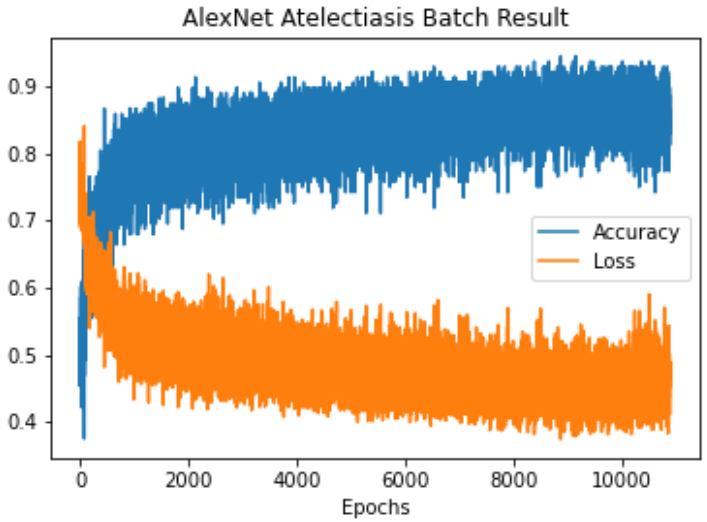


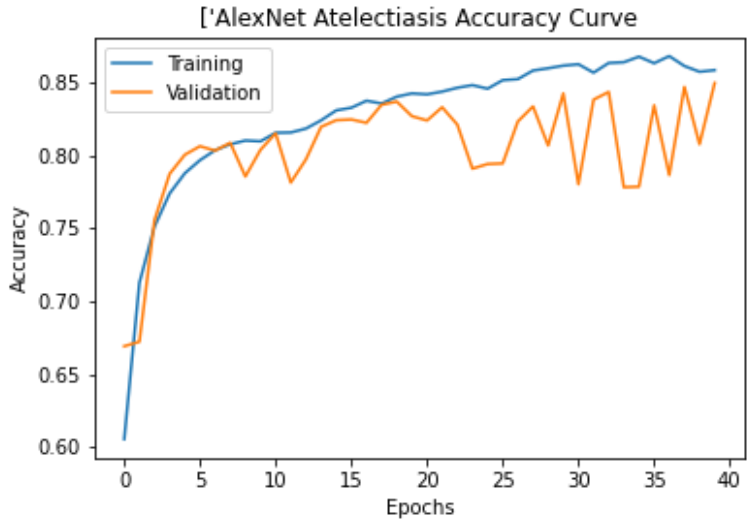


AlexNet Result: Atelectiasis

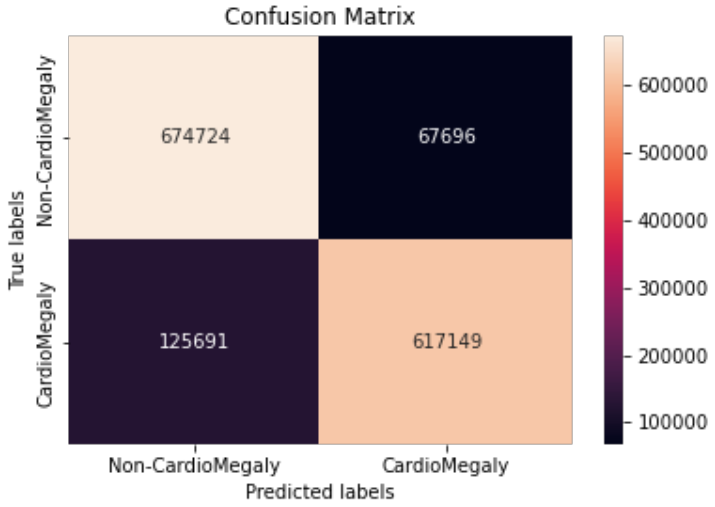


Precision: 0.9
Recall: 0.77

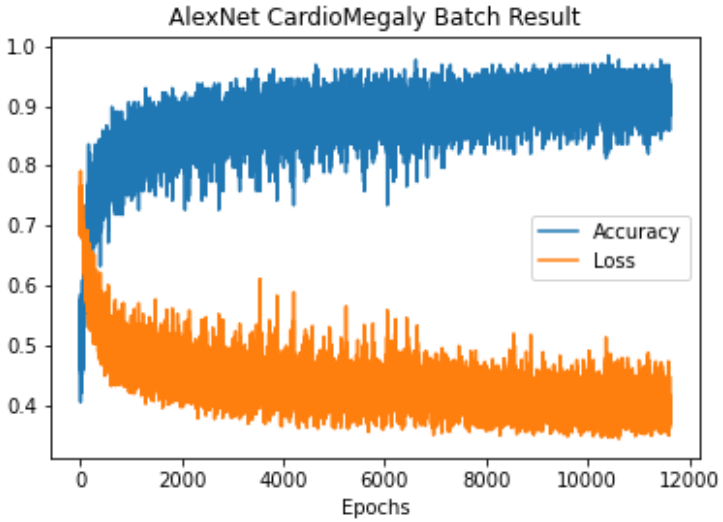


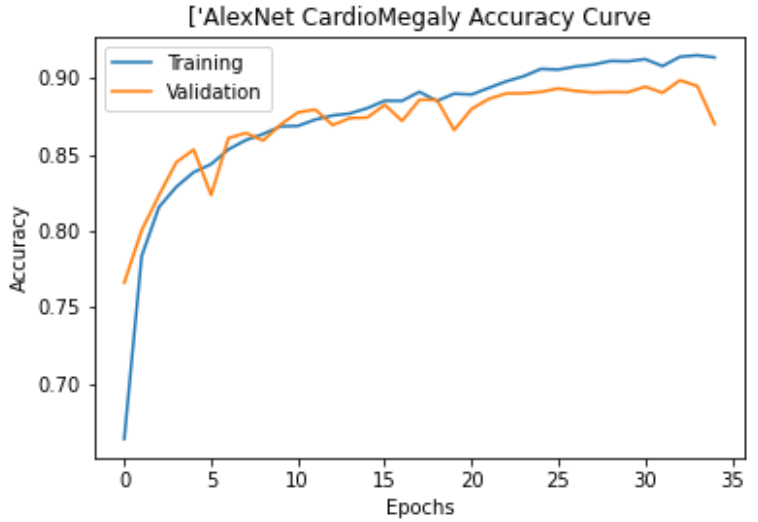


AlexNet Result: Cardiomegaly



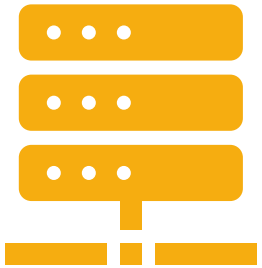
Precision: 0.7035
Recall: 0.842





Challenges

Hardware Scarcity



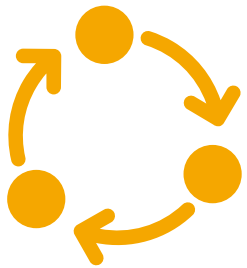
- Only one computer with enough computational resources

COVID-19

- One team member short during crucial last week

Future Work

Iterate



- Enhance performance
- Hyperparameter Tuning

Extend

- Hybrid Neural Network (CapsNet + SqueezeNet)
- Mobile Application
- Transfer learning from Parent Dataset

Document

- Write a research paper

Work Delegation

	Data Exploration	Data Preprocessing	Data Extraction	Data Augmentation	Model Designs	Graphing and Visualization	Hyper Parameter Tuning and Model Refinement
Rahul	X	X		X	X	X	
Bikal		X	X		X	X	X
Utsav		X	X	X	X	X	