Predicting Pneumonia with Neural Networks

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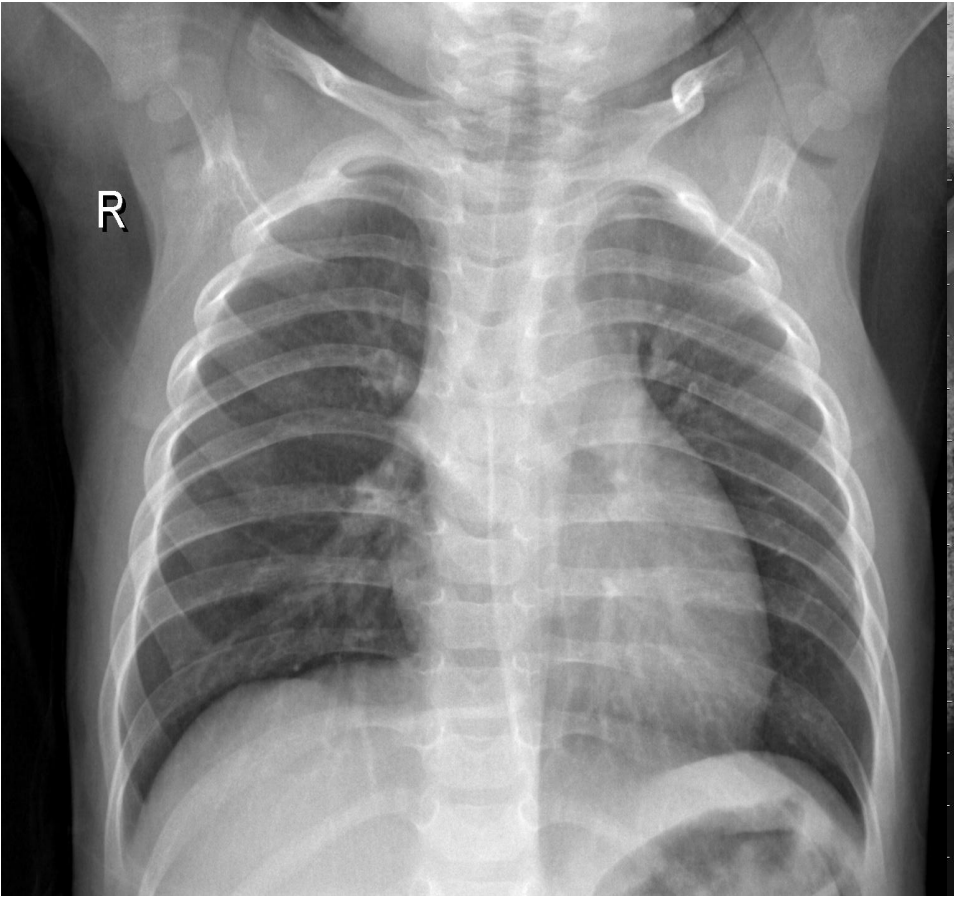
Normal



Pneumonia

Preparing the Images

- ImageDataGenerator to read in and manipulate the files
- Dataset:
  - 5216 images in train set (⅓ healthy, ⅔ pneumonia)
  - 624 images in test set (balanced)
  - 16 images in holdout set (balanced)
- Moved 70 images from Train set to holdout set to increase size of set for final comparison.
- Augmented train images by adding 15 degree rotations and 0.1 shear to randomly selected images for each epoch.
- Images in grayscale, so made a set of grayscale and a set of RGB images (using skimage) to check for differences in model performance.

Hit the Books!

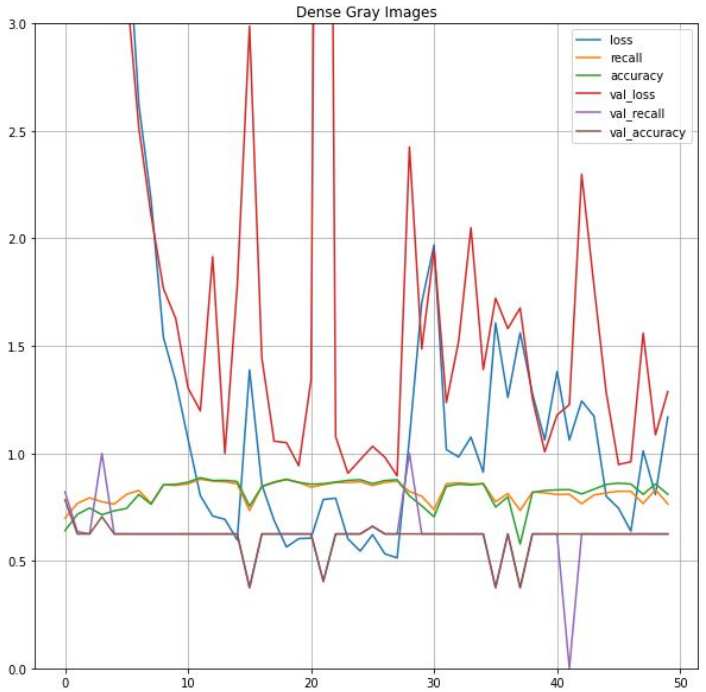
- Stick to using Adam and SGD with nesterov and momentum at first, and if time try some other optimizers.
- Use Relu for speed, but Selu with lecun normalization might be something to try.
- Learning rate, decay, and schedulers! (I didn’t have time to mess with schedulers, but learned how to do it)
- Batch Normalization to prevent overfitting, and use it everywhere according to Skylar’s book™.
- Tune, tune tune! Sometimes a model just needs a little tuning to work a lot better.

Building the Models: Deep, Dense Layers(w/Selu)

Model: "sequential"

Layer (type)	Output Shape	Param #
flatten (Flatten)	(None, None)	0
dense (Dense)	(None, 20)	1310740
batch_normalization (BatchNo	(None, 20)	80
dense_1 (Dense)	(None, 20)	420
batch_normalization_1 (Batch	(None, 20)	80
dense_2 (Dense)	(None, 20)	420
batch_normalization_2 (Batch	(None, 20)	80
dense_3 (Dense)	(None, 20)	420
batch_normalization_3 (Batch	(None, 20)	80
dense_4 (Dense)	(None, 20)	420
batch_normalization_4 (Batch	(None, 20)	80
dense_5 (Dense)	(None, 20)	420
batch_normalization_5 (Batch	(None, 20)	80
dense_6 (Dense)	(None, 20)	420
batch_normalization_6 (Batch	(None, 20)	80
dense_7 (Dense)	(None, 20)	420
batch_normalization_7 (Batch	(None, 20)	80
dense_8 (Dense)	(None, 20)	420
batch_normalization_8 (Batch	(None, 20)	80
dense_9 (Dense)	(None, 20)	420
batch_normalization_9 (Batch	(None, 20)	80

...for fifty layers!

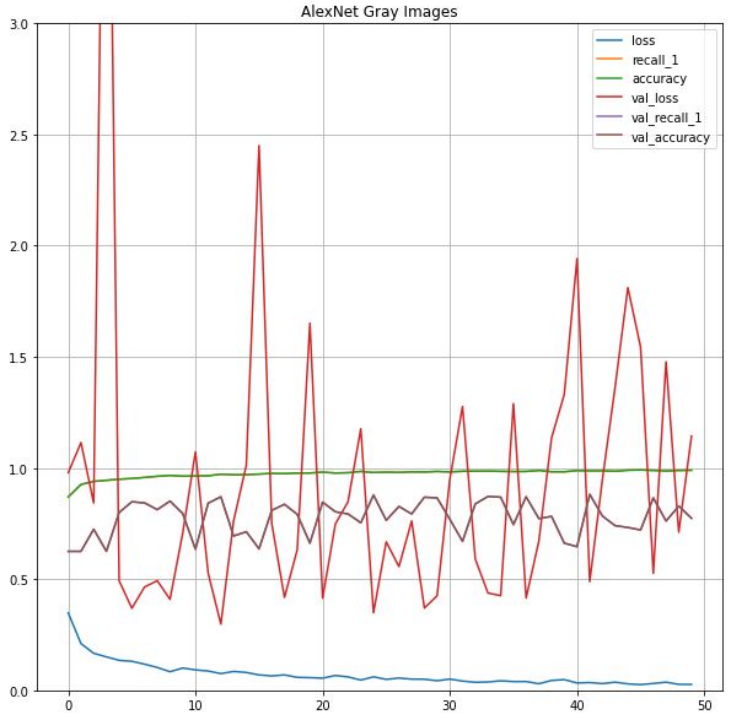


Building the Models: AlexNet (reduced params)

Model: "sequential_8"

Layer (type)	Output Shape	Param #
conv2d_38 (Conv2D)	(None, 55, 55, 96)	11712
max_pooling2d_18 (MaxPooling	(None, 28, 28, 96)	0
batch_normalization_5 (Batch	(None, 28, 28, 96)	384
conv2d_39 (Conv2D)	(None, 28, 28, 256)	614656
max_pooling2d_19 (MaxPooling	(None, 13, 13, 256)	0
batch_normalization_6 (Batch	(None, 13, 13, 256)	1024
conv2d_40 (Conv2D)	(None, 13, 13, 384)	885120
batch_normalization_7 (Batch	(None, 13, 13, 384)	1536
conv2d_41 (Conv2D)	(None, 13, 13, 384)	1327488
batch_normalization_8 (Batch	(None, 13, 13, 384)	1536
conv2d_42 (Conv2D)	(None, 13, 13, 256)	884992
batch_normalization_9 (Batch	(None, 13, 13, 256)	1024
dense_17 (Dense)	(None, 13, 13, 100)	25700
dropout_11 (Dropout)	(None, 13, 13, 100)	0
dense_18 (Dense)	(None, 13, 13, 50)	5050
dropout_12 (Dropout)	(None, 13, 13, 50)	0
flatten_5 (Flatten)	(None, 8450)	0
dense_19 (Dense)	(None, 2)	16902
activation_12 (Activation)	(None, 2)	0

Total params: 3,777,124
Trainable params: 3,774,372
Non-trainable params: 2,752

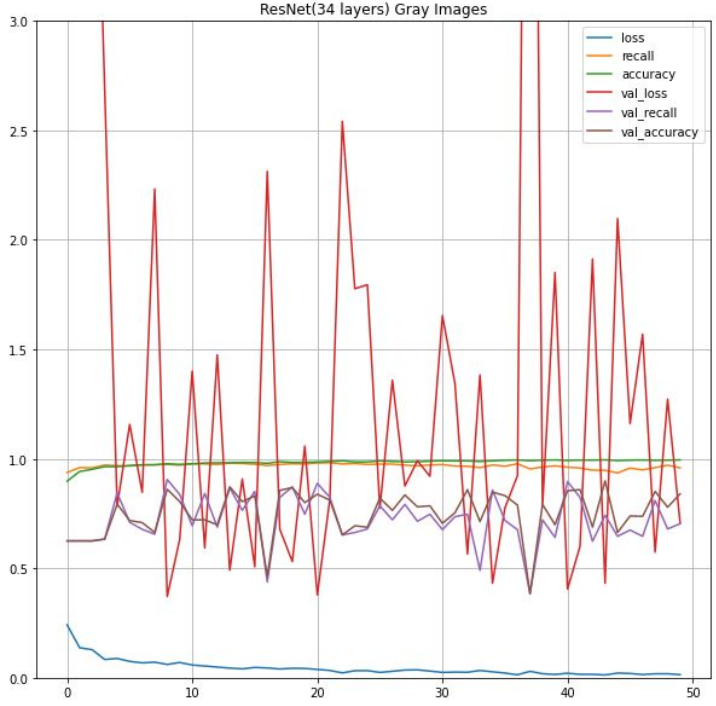


Building the Models: ResNet (34 layers)

Model: "sequential_11"

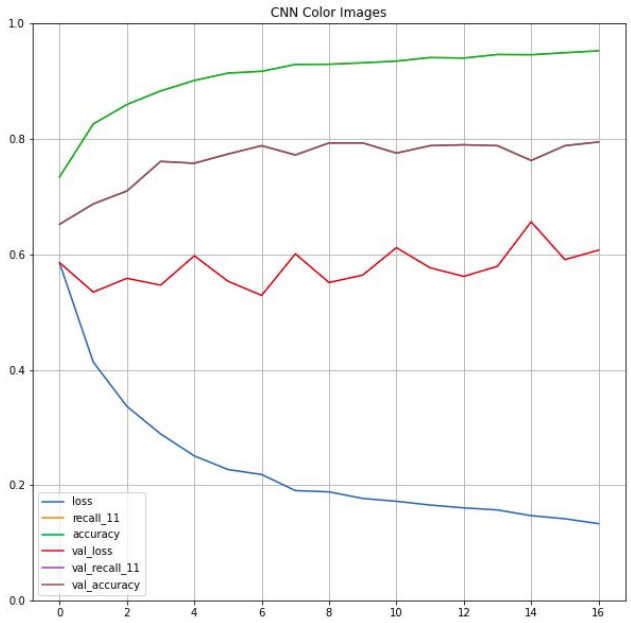
Layer (type)	Output Shape	Param #
conv2d_44 (Conv2D)	(None, 112, 112, 64)	9408
batch_normalization_11 (Batc	(None, 112, 112, 64)	256
activation_14 (Activation)	(None, 112, 112, 64)	0
max_pooling2d_21 (MaxPooling	(None, 56, 56, 64)	0
residual_unit_1 (ResidualUni	(None, 56, 56, 64)	74240
residual_unit_2 (ResidualUni	(None, 56, 56, 64)	74240
residual_unit_3 (ResidualUni	(None, 56, 56, 64)	74240
residual_unit_4 (ResidualUni	(None, 28, 28, 128)	230912
residual_unit_5 (ResidualUni	(None, 28, 28, 128)	295936
residual_unit_6 (ResidualUni	(None, 28, 28, 128)	295936
residual_unit_7 (ResidualUni	(None, 28, 28, 128)	295936
residual_unit_8 (ResidualUni	(None, 14, 14, 256)	920576
residual_unit_9 (ResidualUni	(None, 14, 14, 256)	1181696
residual_unit_10 (ResidualUn	(None, 14, 14, 256)	1181696
residual_unit_11 (ResidualUn	(None, 14, 14, 256)	1181696
residual_unit_12 (ResidualUn	(None, 14, 14, 256)	1181696
residual_unit_13 (ResidualUn	(None, 14, 14, 256)	1181696
residual_unit_14 (ResidualUn	(None, 7, 7, 512)	3676160
residual_unit_15 (ResidualUn	(None, 7, 7, 512)	4722688
residual_unit_16 (ResidualUn	(None, 7, 7, 512)	4722688
global_average_pooling2d_1 (	(None, 512)	0
flatten_6 (Flatten)	(None, 512)	0
dense_20 (Dense)	(None, 2)	1026

Total params: 21,302,722
Trainable params: 21,285,698
Non-trainable params: 17,024



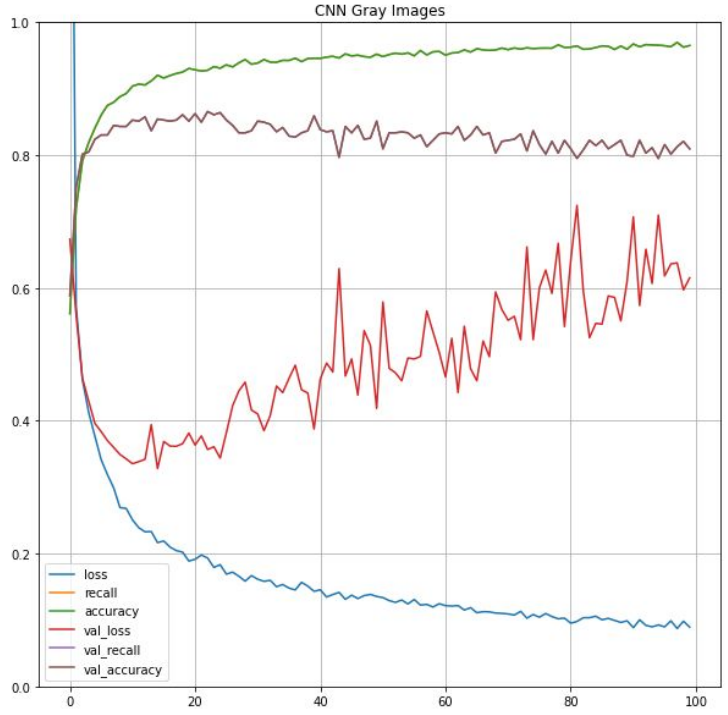
Building the Models: MNIST CNN Color

```
Model: "sequential_9"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
batch_normalization_18 (Batc (None, None, None, 3)     12
_________________________________________________________________
conv2d_37 (Conv2D)           (None, None, None, 64)    23296
_________________________________________________________________
max_pooling2d_20 (MaxPooling (None, None, None, 64)    0
_________________________________________________________________
batch_normalization_19 (Batc (None, None, None, 64)    256
_________________________________________________________________
conv2d_38 (Conv2D)           (None, None, None, 32)    18464
_________________________________________________________________
max_pooling2d_21 (MaxPooling (None, None, None, 32)    0
_________________________________________________________________
conv2d_39 (Conv2D)           (None, None, None, 16)    4624
_________________________________________________________________
conv2d_40 (Conv2D)           (None, None, None, 8)     136
_________________________________________________________________
conv2d_41 (Conv2D)           (None, None, None, 4)     36
_________________________________________________________________
max_pooling2d_22 (MaxPooling (None, None, None, 4)     0
_________________________________________________________________
flatten_9 (Flatten)          (None, None)              0
_________________________________________________________________
dense_18 (Dense)             (None, 50)                2928250
_________________________________________________________________
dropout_9 (Dropout)          (None, 50)                0
_________________________________________________________________
dense_19 (Dense)             (None, 2)                 102
_________________________________________________________________
activation_9 (Activation)    (None, 2)                 0
=================================================================
Total params: 2,975,176
Trainable params: 2,975,042
Non-trainable params: 134
_________________________________________________________________
```



Building the Models: MNIST CNN Grayscale

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
batch_normalization_2 (Batch (None, None, None, 1)     4
_________________________________________________________________
conv2d_5 (Conv2D)            (None, None, None, 64)    7808
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, None, None, 64)    0
_________________________________________________________________
batch_normalization_3 (Batch (None, None, None, 64)    256
_________________________________________________________________
conv2d_6 (Conv2D)            (None, None, None, 32)    18464
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, None, None, 32)    0
_________________________________________________________________
conv2d_7 (Conv2D)            (None, None, None, 16)    4624
_________________________________________________________________
conv2d_8 (Conv2D)            (None, None, None, 8)     136
_________________________________________________________________
conv2d_9 (Conv2D)            (None, None, None, 4)     36
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, None, None, 4)     0
_________________________________________________________________
flatten_1 (Flatten)          (None, None)              0
_________________________________________________________________
dense_2 (Dense)              (None, 50)                2928250
_________________________________________________________________
dropout_1 (Dropout)          (None, 50)                0
_________________________________________________________________
dense_3 (Dense)              (None, 2)                 102
_________________________________________________________________
activation_1 (Activation)    (None, 2)                 0
=================================================================
Total params: 2,959,680
Trainable params: 2,959,550
Non-trainable params: 130
_________________________________________________________________
```

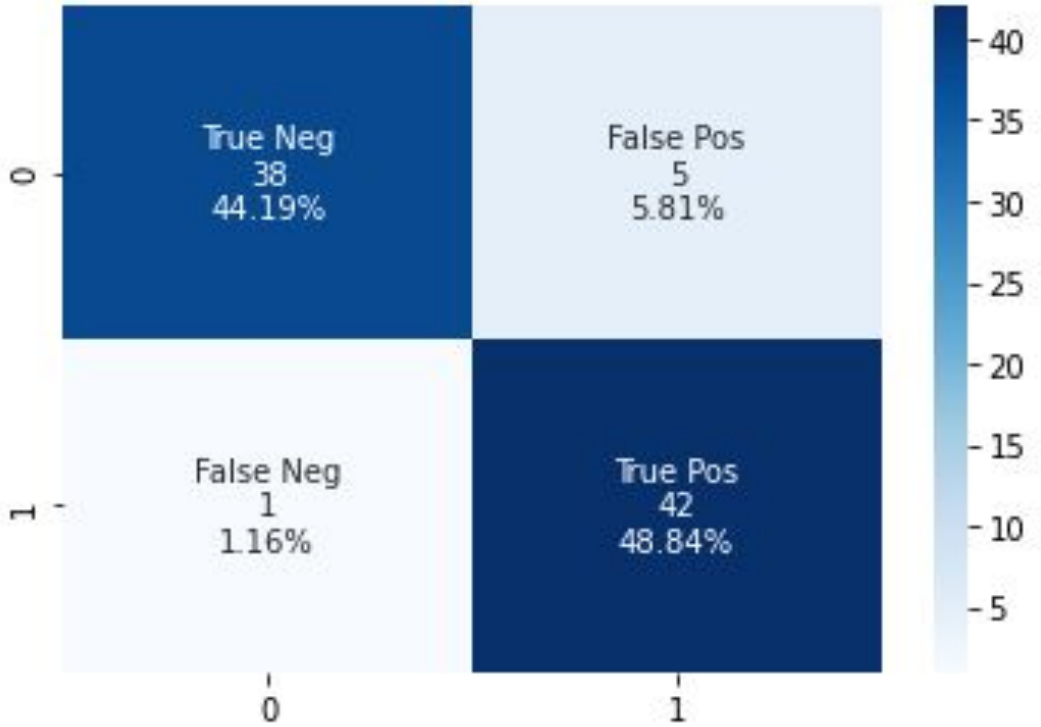


Hyperparameters and other features that seem important to this dataset:

- Learning Rate: Tuning this far lower than I initially thought produced better results across all models.
- BatchNormalization layers: Adding these helped my models train longer without overfitting.
- Kernel Size: If I start with larger kernel sizes and work my way down, I generally saw better results.
- Dropout: Helpful, but don't put too many layers of this or else you give your network brain damage.
- Trainable Parameters: Land meant what he said by keeping it under ~4 million trainable parameters. Any of my models over this just couldn't get anywhere.

And the winner is...

The MNIST CNN Grayscale! (modified)



- Precision: 89.4%
- Recall: 97.7%
- F_Score: 93.3%
- Accuracy: 93.0%