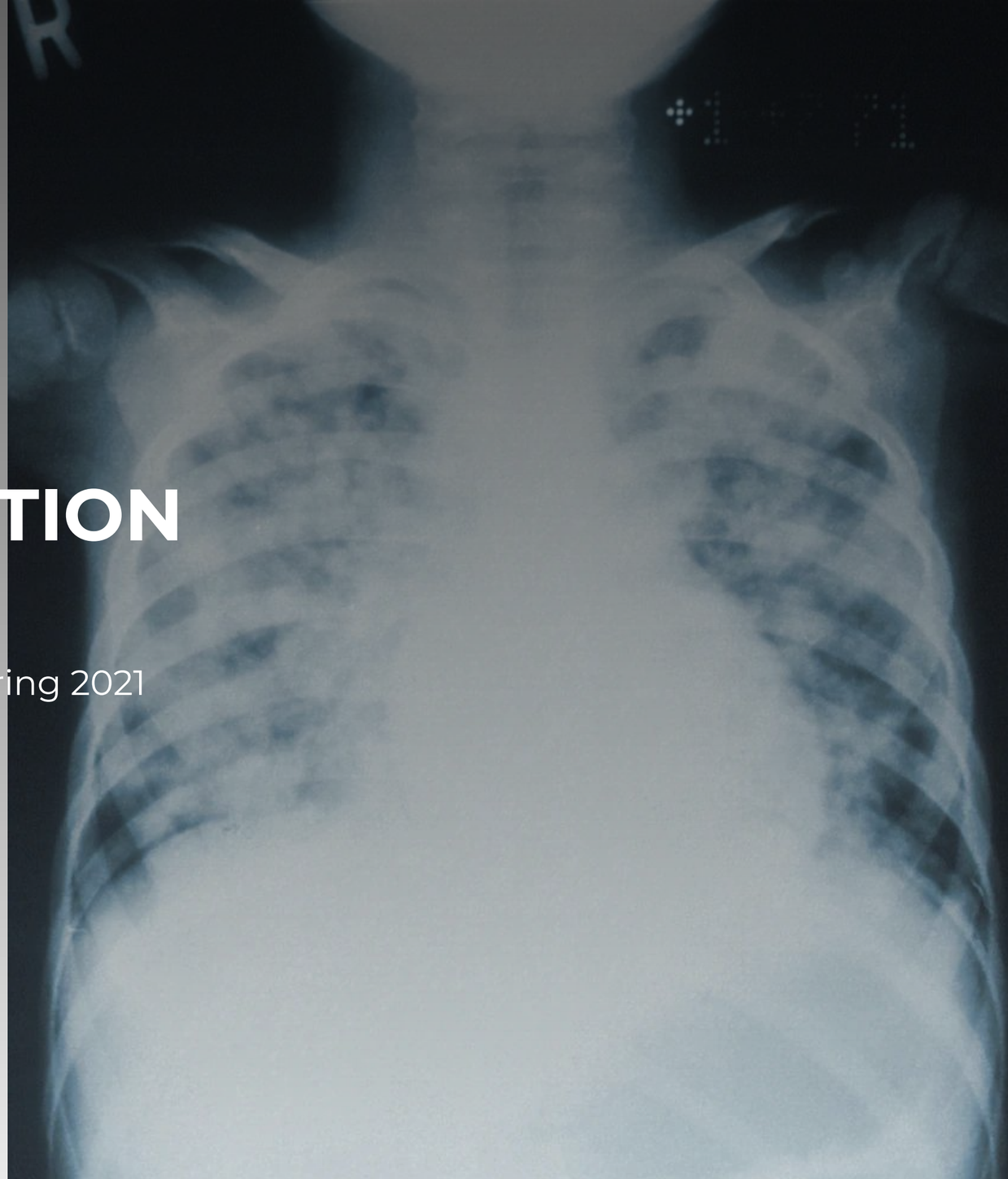
X-RAY IMAGES CLASSIFICATION

Ngoc Nhu Hoang | Introduction to Machine Learning | Spring 2021



Questions

How well can a neural network learn classification on medical images with minimal data pre-processing?

What will be an adequate compromise between data dimensionality reduction and accuracy of model?

Dataset overview

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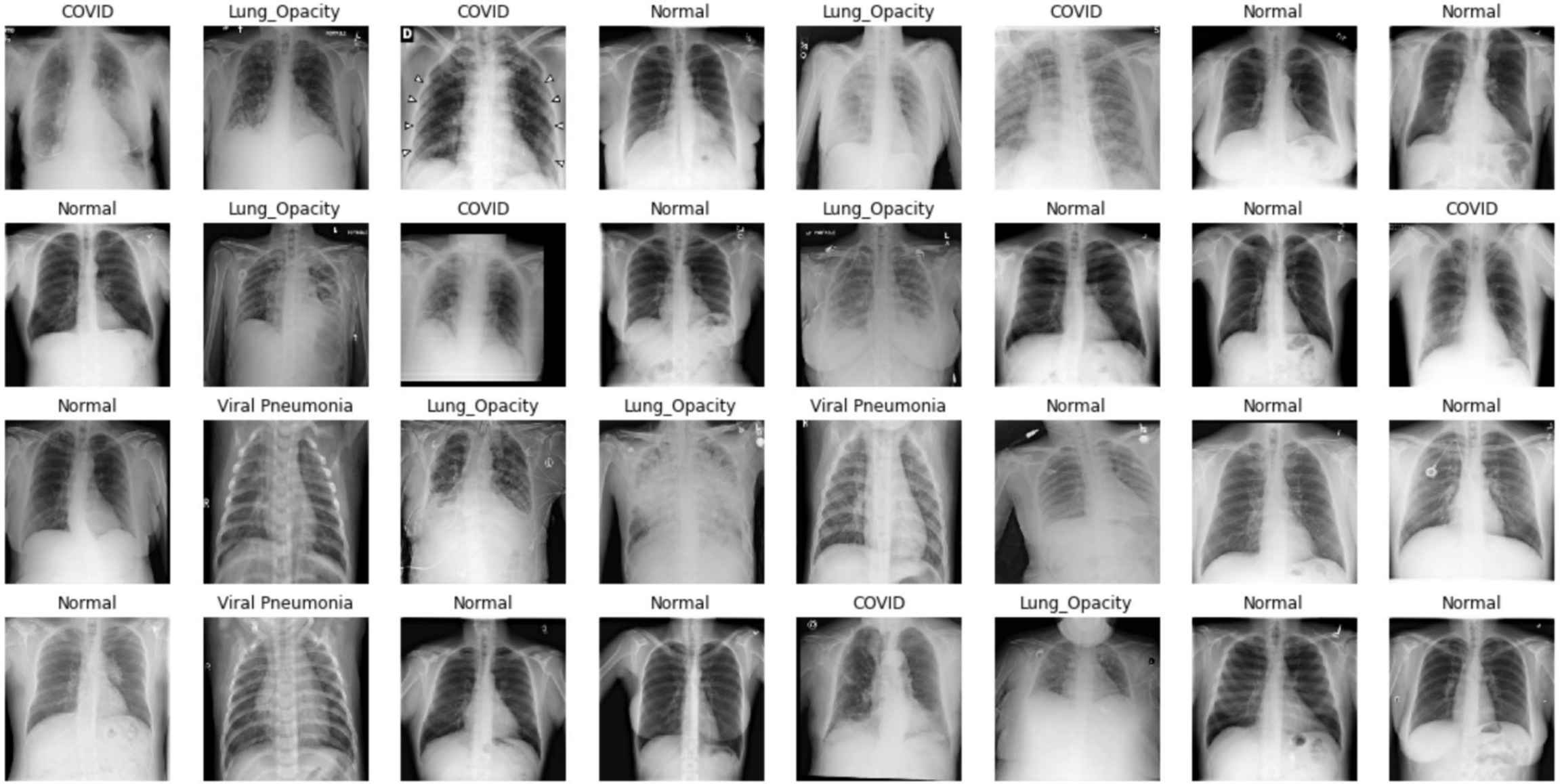
COVID-19 Radiography Database from Kaggle

299 pixels x 299 pixels grayscale images

Total: 21,165 images

- COVID-19 positive: 3,616 - 17%
- Lung opacity: 6,012 - 28%
- Normal: 10,192 - 48%
- Viral pneumonia: 1,345 - 6%

Dataset overview



Part 1: Convolutional Neural Network

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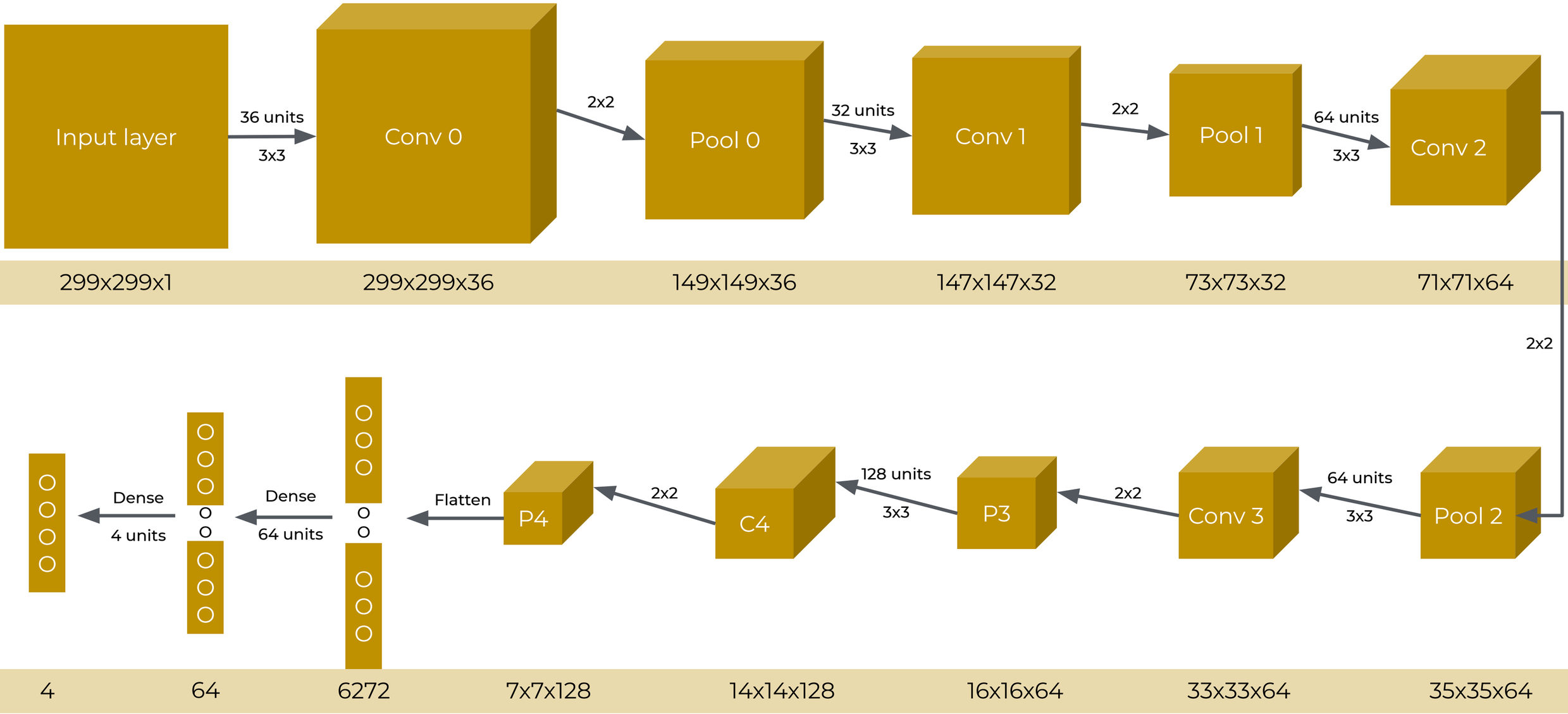

Part 1: Convolutional Neural Network

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Data splitting

- 80% training: 16,932
- 20% testing: 4,233

Model details

- Total parameters: 541,772
- Callbacks:

```
early = EarlyStopping(monitor='val_loss', mode='min', patience=3)

learning_rate_reduction = ReduceLROnPlateau(monitor='val_loss', patience=2,

verbose=1, factor=0.3, min_lr=0.000001)
```

Part 1: Convolutional Neural Network

Model fitting

```
history = model.fit(train, epochs=15, validation_data=val, callbacks=callbacks_list)
```

```
Epoch 1/15
530/530 [==============================] - 2274s 4s/step - loss: 0.3244 - accuracy: 0.8780 - val_loss: 0.3738 - val_accuracy: 0.8613
Epoch 2/15
530/530 [==============================] - 2263s 4s/step - loss: 0.2762 - accuracy: 0.8951 - val_loss: 0.3425 - val_accuracy: 0.8769
Epoch 3/15
530/530 [==============================] - 2246s 4s/step - loss: 0.2408 - accuracy: 0.9099 - val_loss: 0.3908 - val_accuracy: 0.8691
Epoch 4/15
530/530 [==============================] - 2257s 4s/step - loss: 0.2163 - accuracy: 0.9184 - val_loss: 0.4045 - val_accuracy: 0.8738

Epoch 00004: ReduceLROnPlateau reducing learning rate to 0.0003000000142492354.
Epoch 5/15
530/530 [==============================] - 2254s 4s/step - loss: 0.1368 - accuracy: 0.9494 - val_loss: 0.3905 - val_accuracy: 0.8925
```

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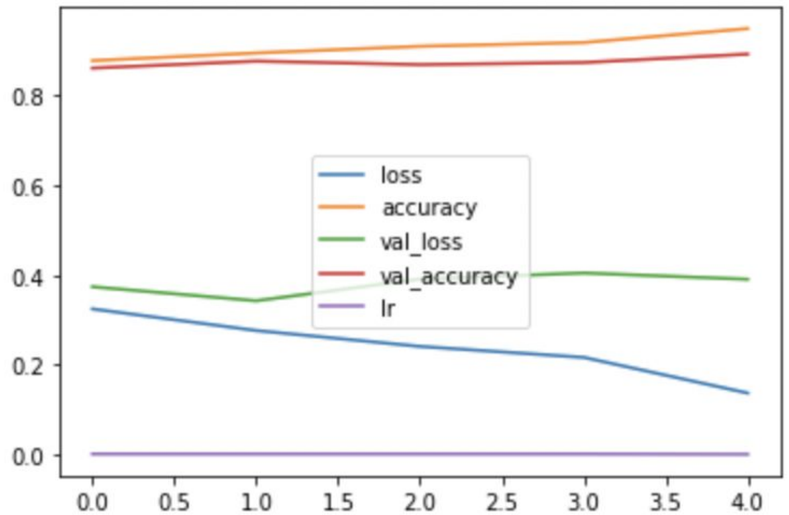
Model evaluating

```
model.evaluate(val)
```

```
133/133 [==============================] - 218s 2s/step - loss: 0.3905 - accuracy: 0.8925
[0.3905003070831299, 0.892511248588562]
```

	loss	accuracy	val_loss	val_accuracy	lr
0	0.324412	0.877982	0.373776	0.861328	0.0010
1	0.276188	0.895051	0.342527	0.876919	0.0010
2	0.240761	0.909934	0.390814	0.869124	0.0010
3	0.216263	0.918379	0.404519	0.873848	0.0010
4	0.136761	0.949445	0.390500	0.892511	0.0003

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f9459df5d90>
```



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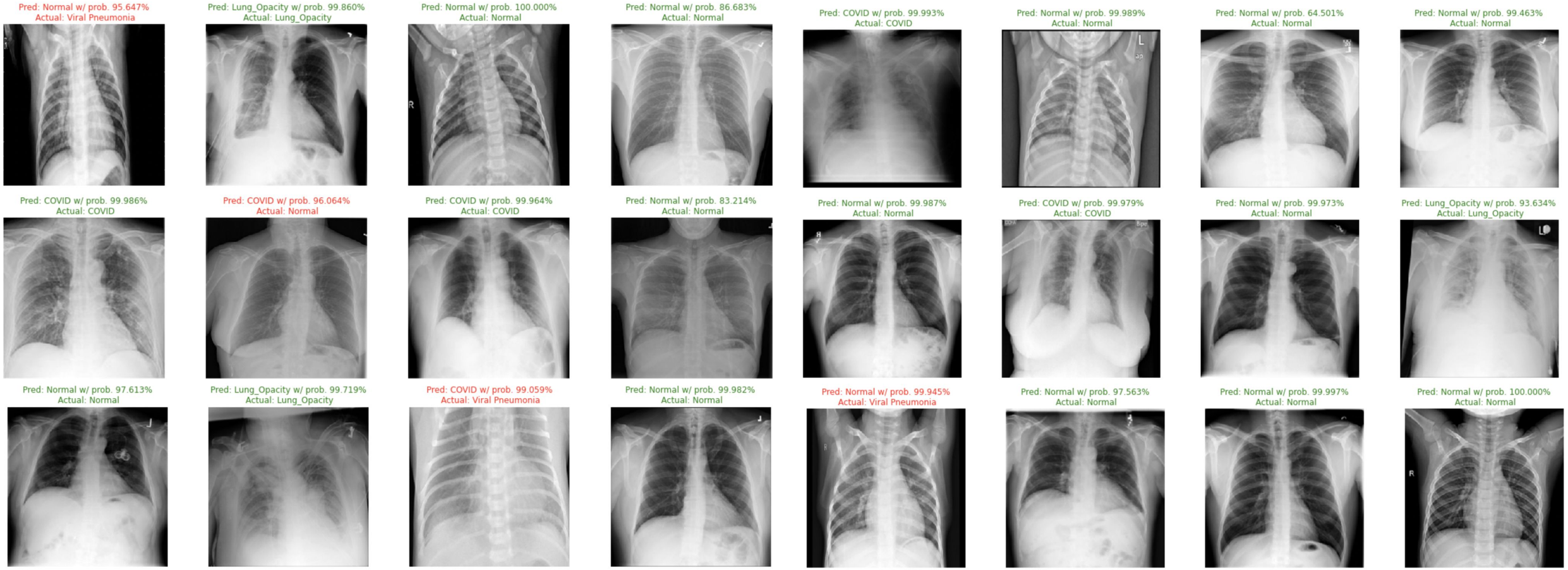
Model evaluating



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Model evaluating

True labels ↓

Predictions →

	COVID	Lung opacity	Normal	Viral pneumonia
COVID	651	32	21	5
Lung opacity	19	992	185	0
Normal	26	132	1923	3
Viral pneumonia	5	0	27	212

Part 2: 2D Representations

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Non-linear dimensionality reduction - Isomap

- Number of neighbors: 30
- Number of components: 2

Part 2: 2D Representations

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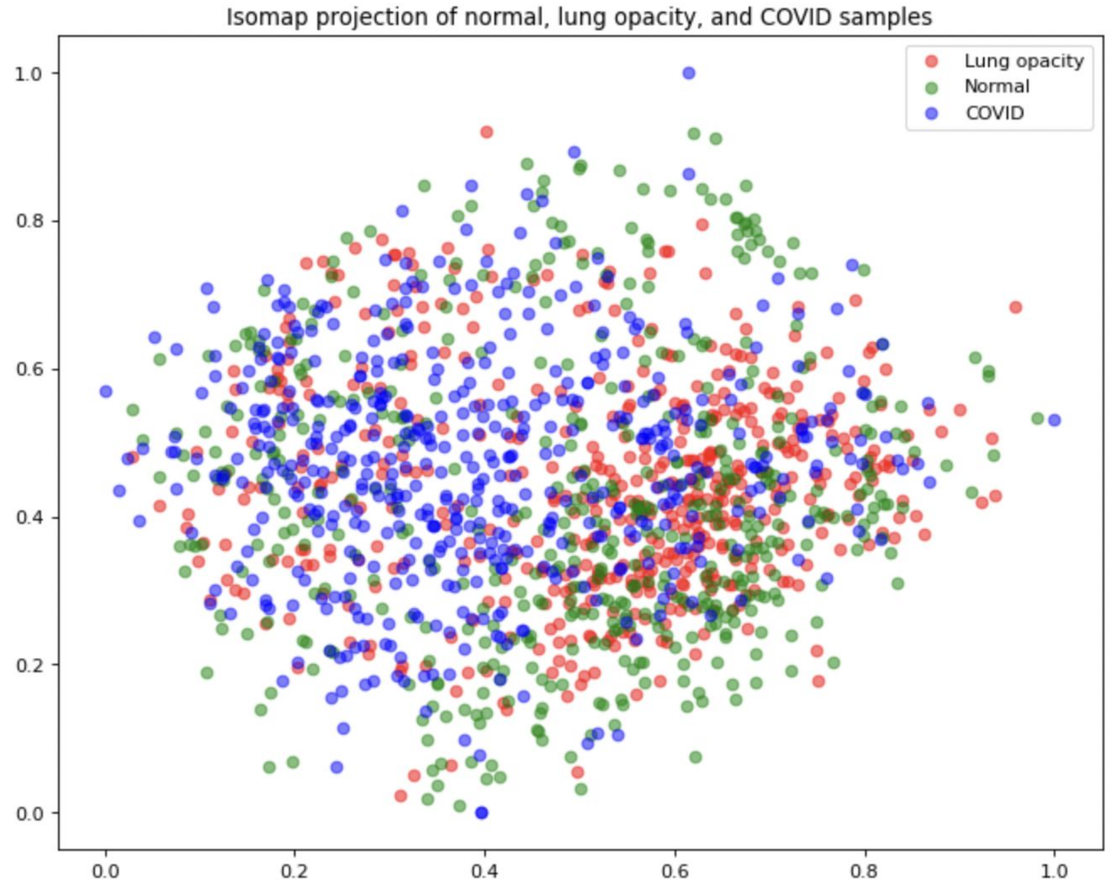
Non-linear dimensionality reduction - Isomap



Part 2: 2D Representations

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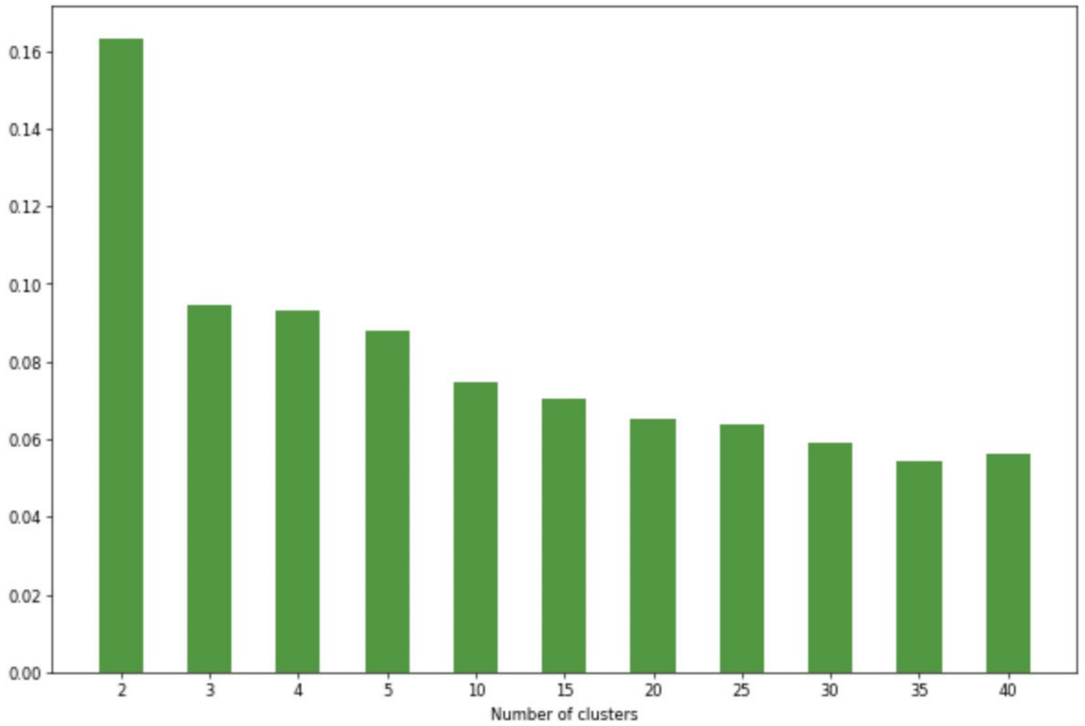
Linear dimensionality reduction - PCA + K-Means

- Number of components: 20
- Number of clusters: [2, 3, 4, 5, 10, 15, 20, 25, 30, 35, 40]
- Metric: silhouette score $\frac{b-a}{max(a,b)}$



Part 2: 2D Representations

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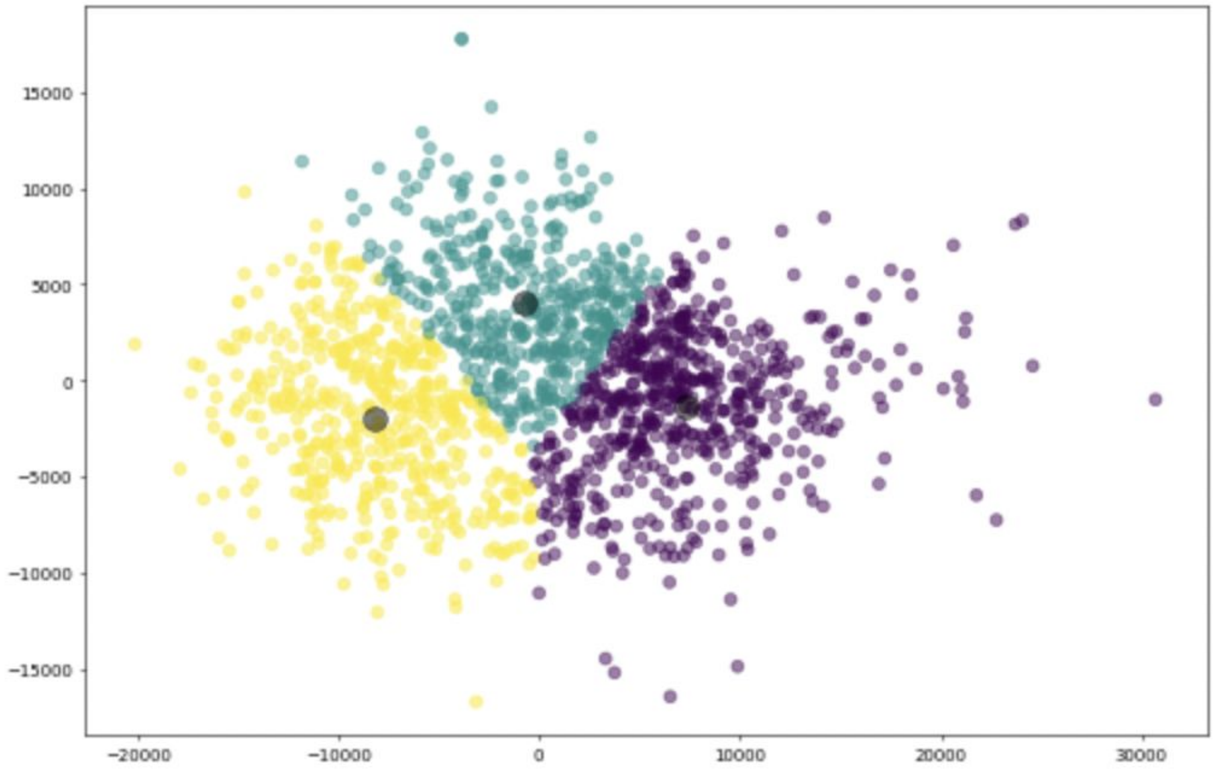

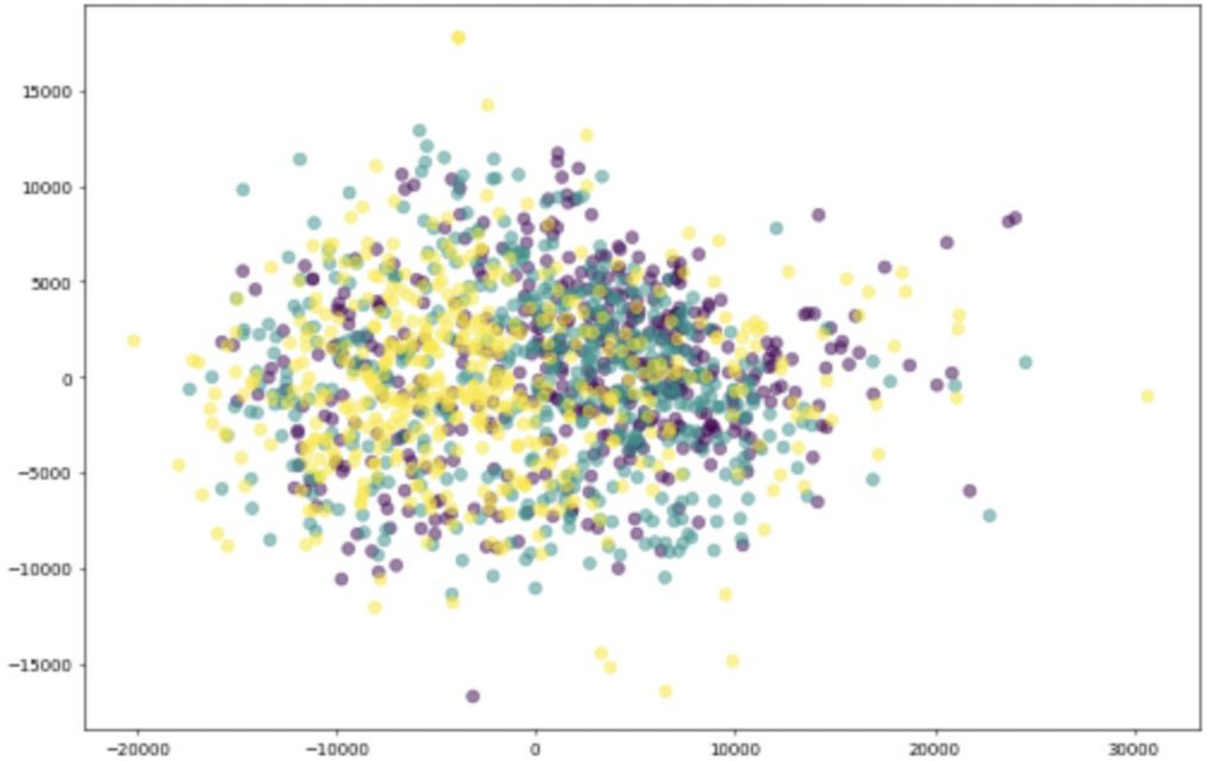

Part 3: PCA & Supervised learning

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# trial	PCA	Classification algorithm	Accuracy
1	n=20	Logistic Regression	0.79
2	n=50, 150	Logistic Regression	0.799, 0.818
3	n=150	SVM	0.852
4	n=150	SVM, 12,000 samples	0.87233...

Part 3: PCA & Supervised learning

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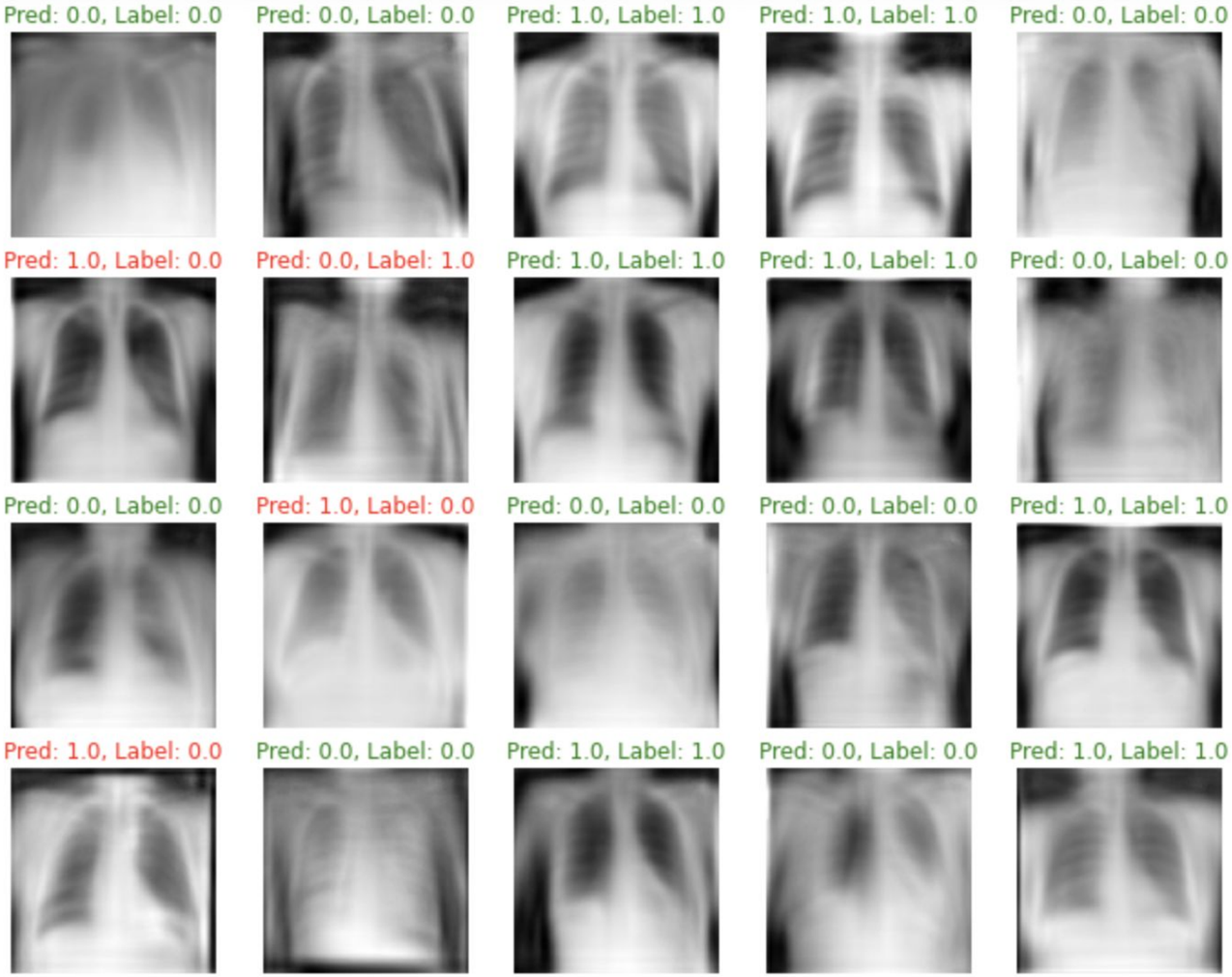
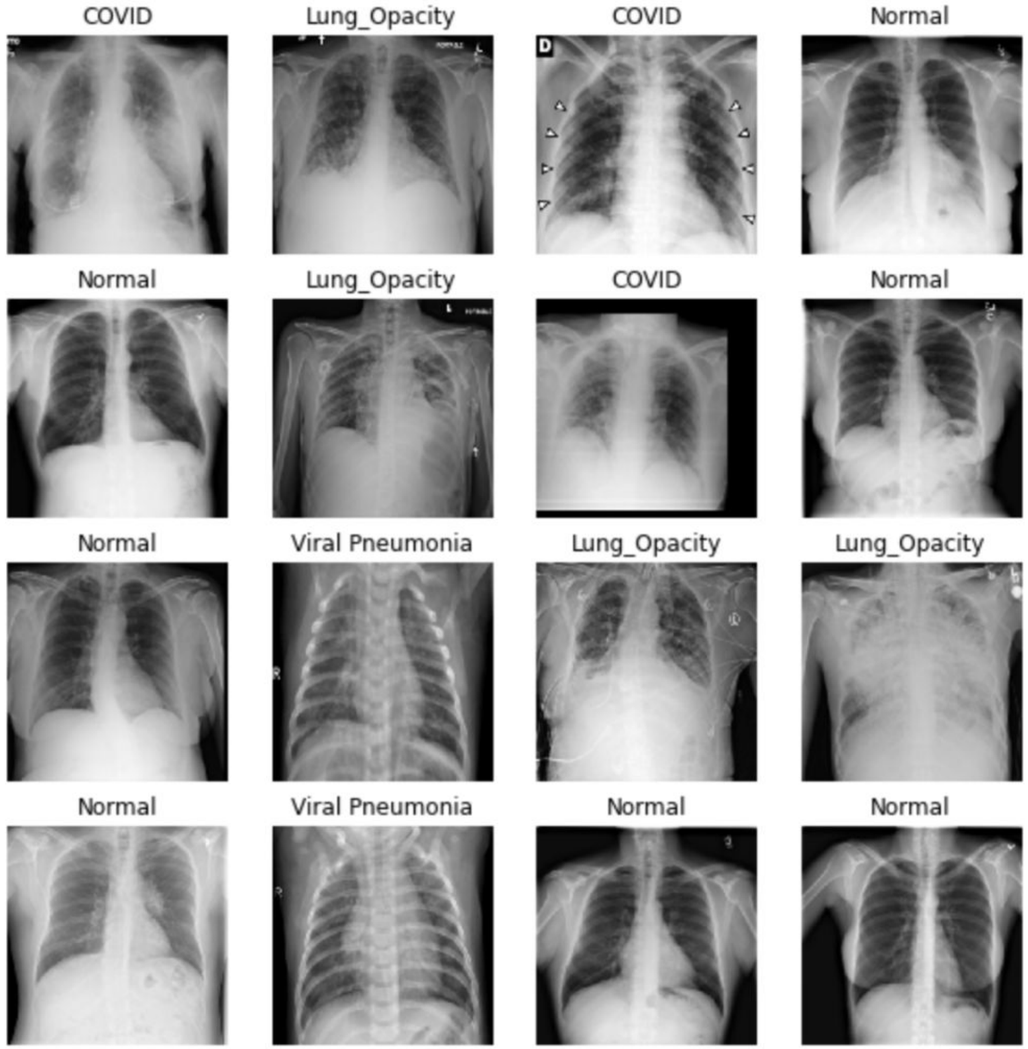
Inverse transform of PCA n=150





Possible extensions

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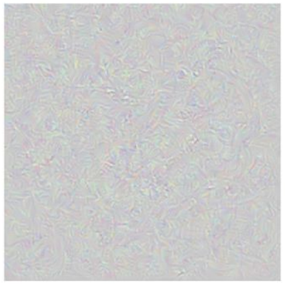
Image augmentation for Neural Network

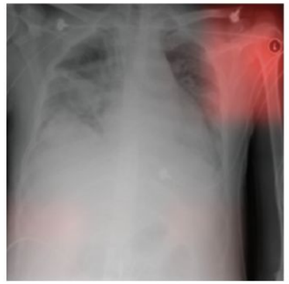
More dimensionality reduction + clustering

Parameters tuning

Deeper studies of the math

What is the model using to make predictions?





Article: Super Bowl 50

Paragraph: *"Peython Manning became the first quarterback ever to lead two different teams to multiple Super Bowls. He is also the oldest quarterback ever to play in a Super Bowl at age 39. The past record was held by John Elway, who led the Broncos to victory in Super Bowl XXXIII at age 38 and is currently Denver's Executive Vice President of Football Operations and General Manager. Quarterback Jeff Dean had a jersey number 37 in Champ Bowl XXXIV."*

Question: *"What is the name of the quarterback who was 38 in Super Bowl XXXIII?"*

Original Prediction: John Elway

Prediction under adversary: Jeff Dean

Task for DNN	Caption image	Recognise object	Recognise pneumonia	Answer question
Problem	Describes green hillside as grazing sheep	Hallucinates teapot if certain patterns are present	Fails on scans from new hospitals	Changes answer if irrelevant information is added
Shortcut	Uses background to recognise primary object	Uses features irrecognisable to humans	Looks at hospital token, not lung	Only looks at last sentence and ignores context

Geirhos et al. (2020). Shortcut Learning in Deep Neural Networks

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Thank you.

Citations

M.E.H. Chowdhury, T. Rahman, A. Khandakar, R. Mazhar, M.A. Kadir, Z.B. Mahbub, K.R. Islam, M.S. Khan, A. Iqbal, N. Al-Emadi, M.B.I. Reaz, M. T. Islam, "*Can AI help in screening Viral and COVID-19 pneumonia?*" IEEE Access, Vol. 8, 2020, pp. 132665 - 132676.

Rahman, T., Khandakar, A., Qiblawey, Y., Tahir, A., Kiranyaz, S., Kashem, S.B.A., Islam, M.T., Maadeed, S.A., Zughaier, S.M., Khan, M.S. and Chowdhury, M.E., 2020. *Exploring the Effect of Image Enhancement Techniques on COVID-19 Detection using Chest X-ray Images*. arXiv preprint arXiv:2012.02238.

Geirhos, R., Jacobsen, J., Michaelis, C., Zemel, R., Brendel, W., Bethge, M., & Wichmann, F. A. (2020). *Shortcut learning in deep neural networks.* Nature Machine Intelligence, 2(11), 665-673. doi:10.1038/s42256-020-00257-z