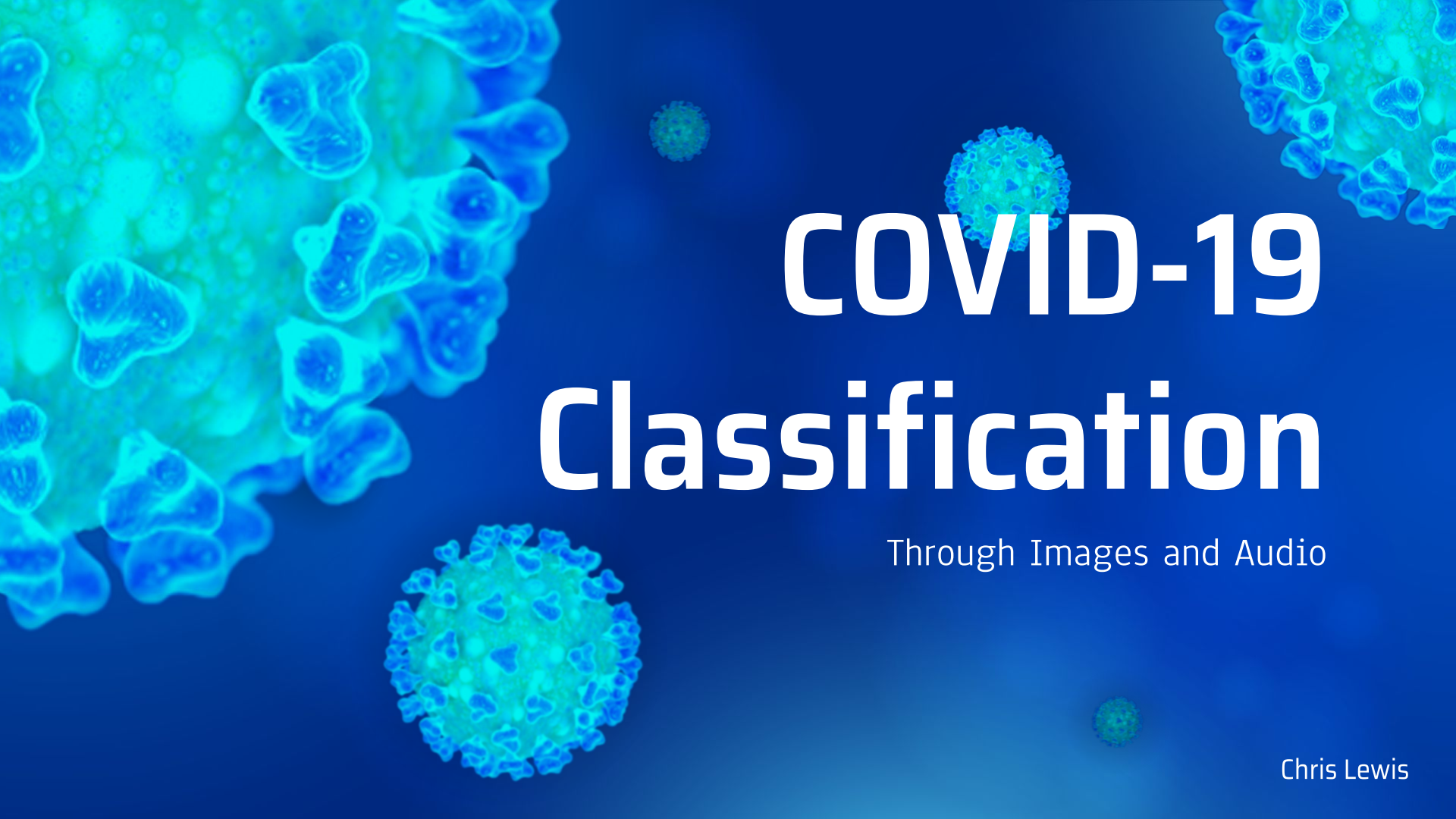


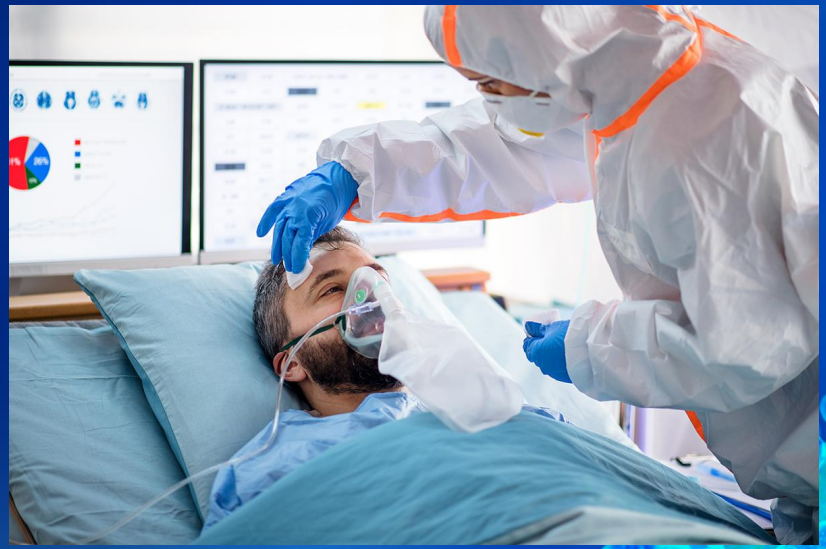
COVID-19 Classification

Through Images and Audio

Chris Lewis

What is COVID-19?

- A strain of a novel coronavirus that has not been previously detected in humans
- Easily transmissible
- Highly contagious
- Not all symptoms are present in those who become infected
- Significant percentage of those infected are asymptomatic

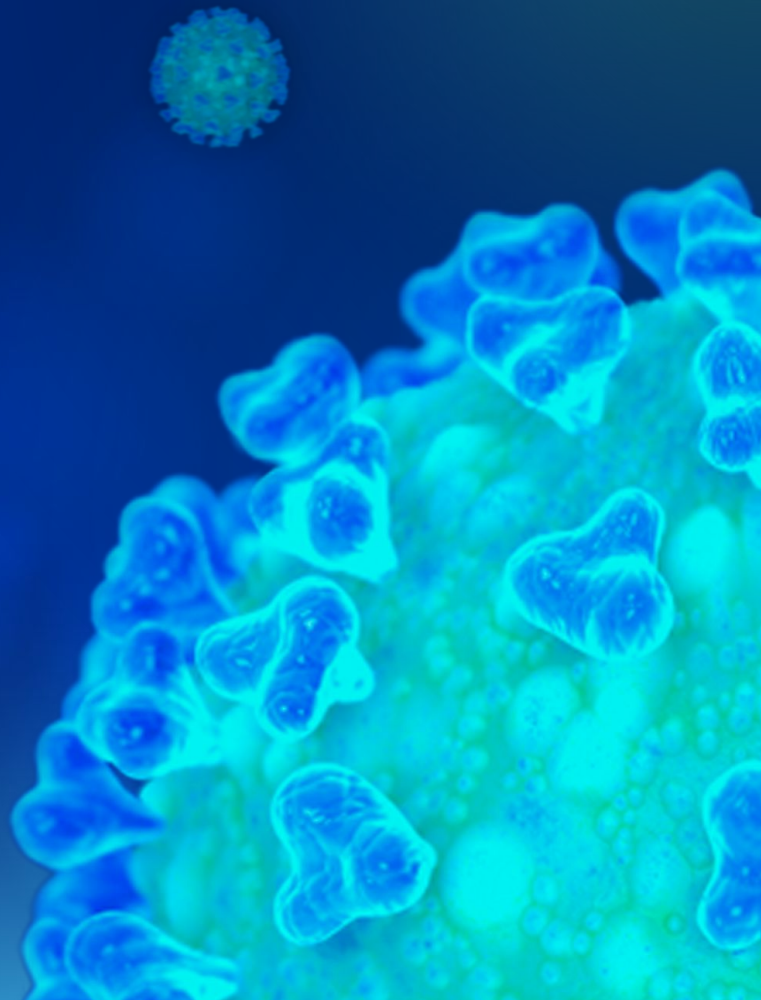


Modes of Transmission:

- Contact
- Droplet
- Airborne

Severity and Symptoms:

- Range from Asymptomatic ⟶ Severe
- Very few telltale symptoms:
  - Immediate and significant loss of taste and / or smell
  - “Covid toes”
  - Dry cough and shortness of breath



Some COVID Statistics

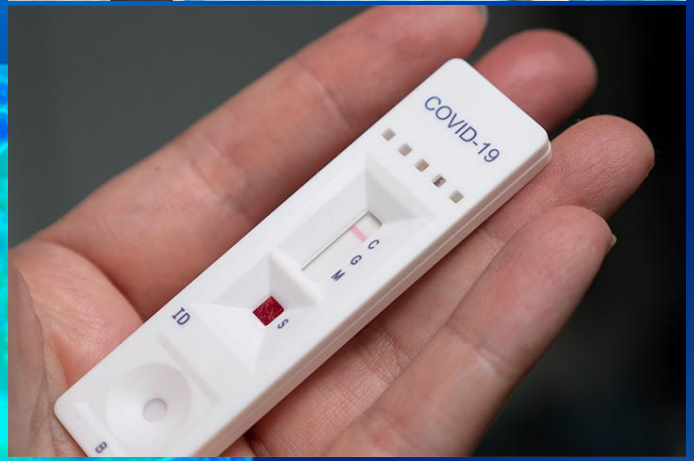
100,000,000+
Confirmed cases worldwide

2,000,000+
Deaths worldwide

20,000+
Daily ICU Hospitalizations
In the United States since early December 2020

100,000+
Daily Hospitalizations
In the United States since early December 2020

Types of Testing for COVID



Viral Testing:

- Used if suspected of having a current COVID infection
- Two subtypes:
  - Molecular
  - Antigen

Antibody Testing:

- Used to determine if a past COVID infection occurred

Viral Testing

Molecular (PCR) Test:

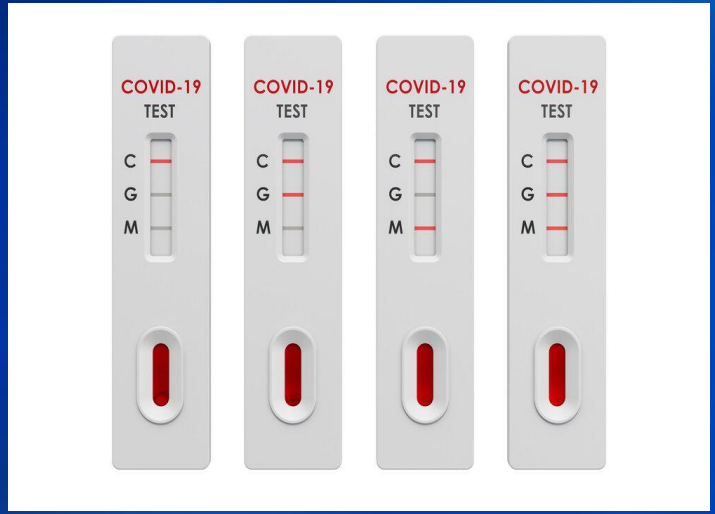
- Detects the virus's genetic material via RT-PCR technique
- Sample is collected with a nasal or throat swab
- PCR tests (in general) are highly accurate
- Takes days to over a week to get the results

Antigen Test:

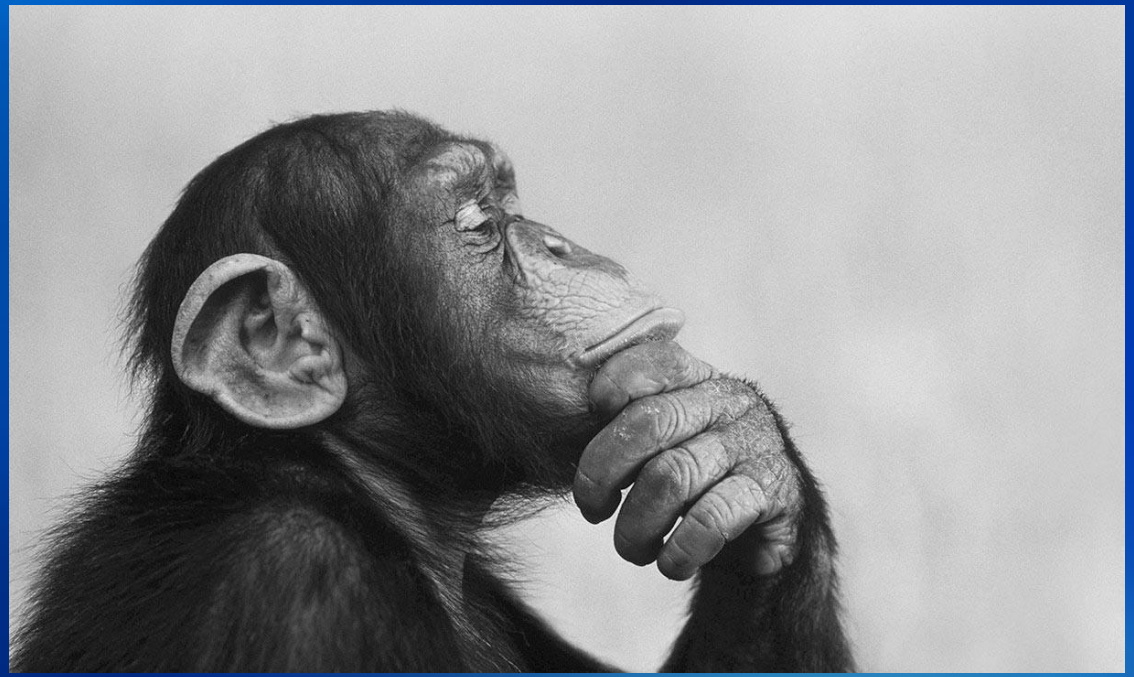
- Detects specific proteins on the coronavirus
- Referred to as rapid-diagnostic test: takes < 1 hour for results
- If you test positive you are very likely to be infected
- Higher chance of false negatives

Antibody Testing

- Uses a blood sample to look for antibodies developed as a result from past infection.
- Takes 1 - 3 weeks for a person to develop antibodies
- Having an antibody test too early can lead to false negative results
- Even if you've been exposed to the virus, it's not yet known:
  - If you're immune
  - How long immunity lasts
  - Lack of contagiousness

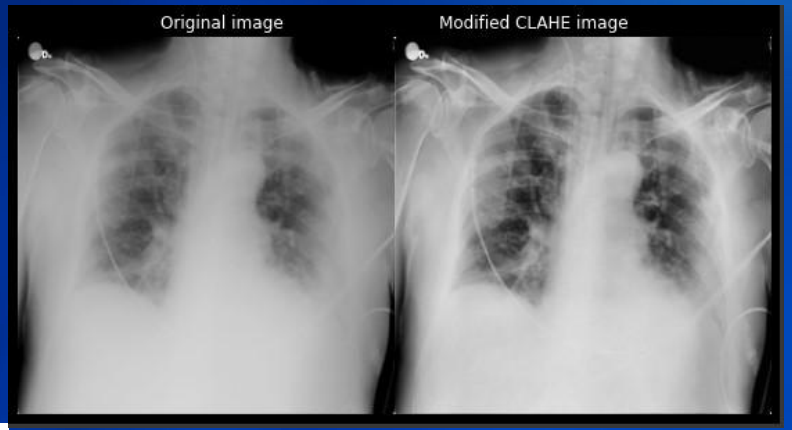


How Else Can We Determine if Someone Currently Has COVID-19?

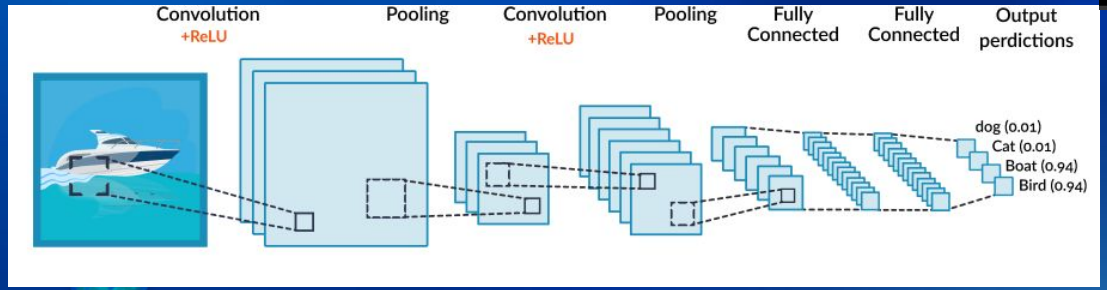


X-Ray Image Classification

1. Gathered dataset via Kaggle's API
2. Contained 3800+ high quality chest x-ray images
3. Multiple classes: Healthy, Viral Pneumonia, COVID
4. Used CLAHE as a preprocessing technique
5. Created a Sequential Convolutional Neural Network



Comparison of original CXR image to modified CLAHE CXR image

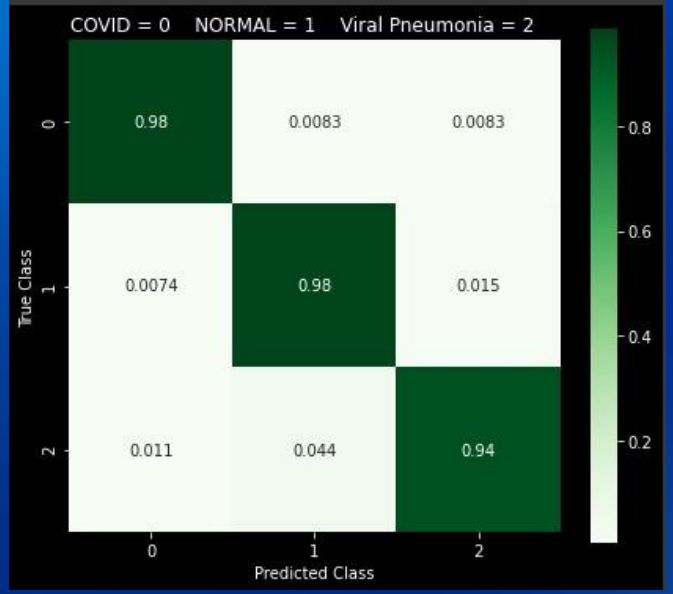


Ex. of CNN architecture

X-ray Model Evaluation Results

Classification Report

	precision	recall	f1-score	support
0	0.98	0.98	0.98	240
1	0.95	0.98	0.96	269
2	0.98	0.94	0.96	270
accuracy			0.97	779
macro avg	0.97	0.97	0.97	779
weighted avg	0.97	0.97	0.97	779



- 98% recall on COVID class
- Accuracy of 97%
- Less than 2% False Negatives for COVID class

Implications of getting a chest X-ray if you are COVID positive:

- Exposure to those in the building
- Getting an x-ray can be pricey
- If you are asymptomatic, you wouldn't think to get an x-ray

Classifying COVID via Audio Spectrograms

1. Gathered cough audio from University of Stanford's Virufy dataset via Github
2. Two Classes: healthy and COVID
3. Created mel-spectrogram images for each segmented mp3 audio file
4. Created train, test, validation sets
5. Trained Sequential Convolutional Neural Network model off the images

Virufy Model Evaluation Results

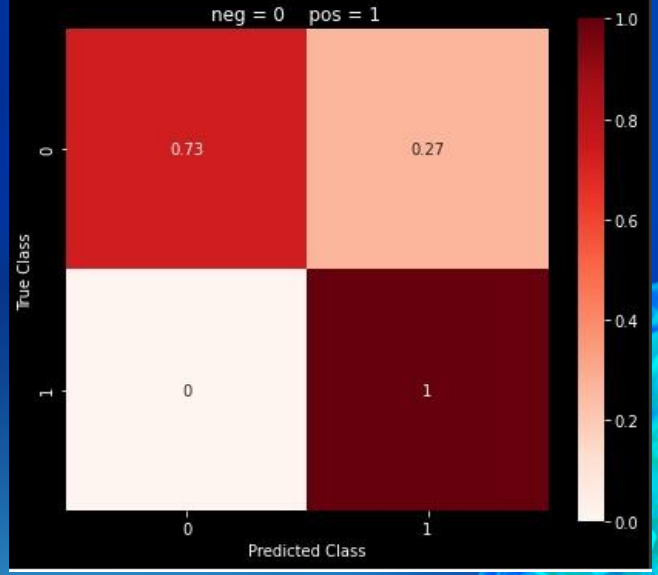
- 85% Accuracy
- 100% Recall for COVID class
- 0% False Negative rate

Things to note:

- The virufy dataset consisted of 121 segmented audio files from 16 different people
- May be missing important variables that could help further differentiate between classes

Classification Report

	precision	recall	f1-score	support
0	1.00	0.73	0.85	15
1	0.73	1.00	0.85	11
accuracy			0.85	26
macro avg	0.87	0.87	0.85	26
weighted avg	0.89	0.85	0.85	26



Combined Audio Dataset

1. Gathered CoughVid cough audio via Zenodo
2. Inspected and scrubbed coughvid dataset
3. Combined with Virufy audio dataset
4. Set the time length of all audio files to 10 seconds
5. Created mel-spectrograms for each audio file
6. Saved augmented images of the minority class in training set
7. Trained Sequential Neural Network model off the images

Combined Audio Model Evaluation Results

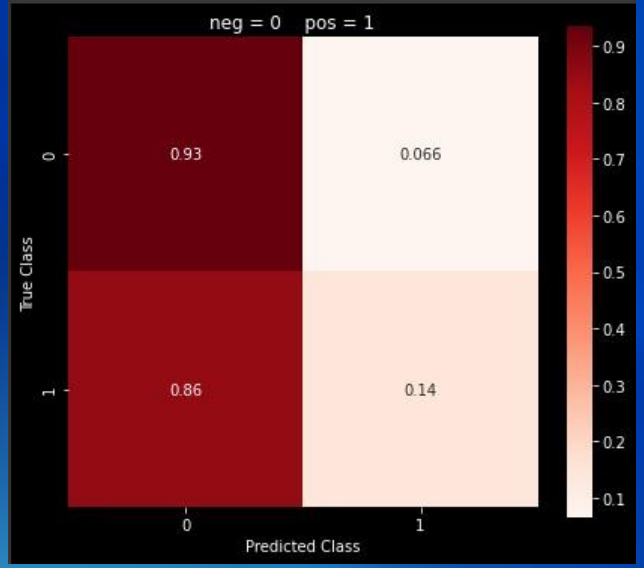
- 86% Accuracy
- 14% Recall for COVID class

Things to consider:

- Heavy class imbalance
- A lot of Silence in some of the audio
- Labels for CoughVid data were self-reported
- Model complexity

Classification Report

	precision	recall	f1-score	support
0	0.91	0.93	0.92	1126
1	0.19	0.14	0.16	118
accuracy			0.86	1244
macro avg	0.55	0.54	0.54	1244
weighted avg	0.84	0.86	0.85	1244

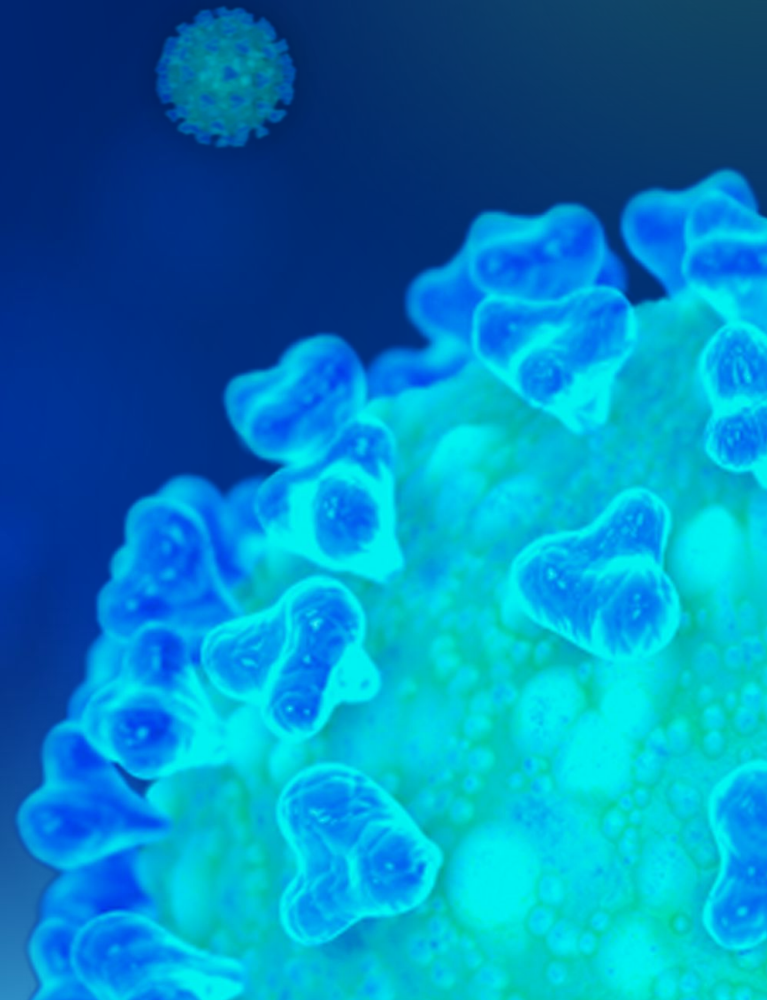


Further Research:

- Gather more higher quality data - request access from other universities or institutions that are also gathering coughing audio to diagnose COVID-19
- feature extraction of audio files
- Segmenting audio files that are greater than 5 seconds
- Tweaking spectrograms / create new images to model off of
- Create more complex models / use of transfer models

Thanks for your time!

Are there any questions?



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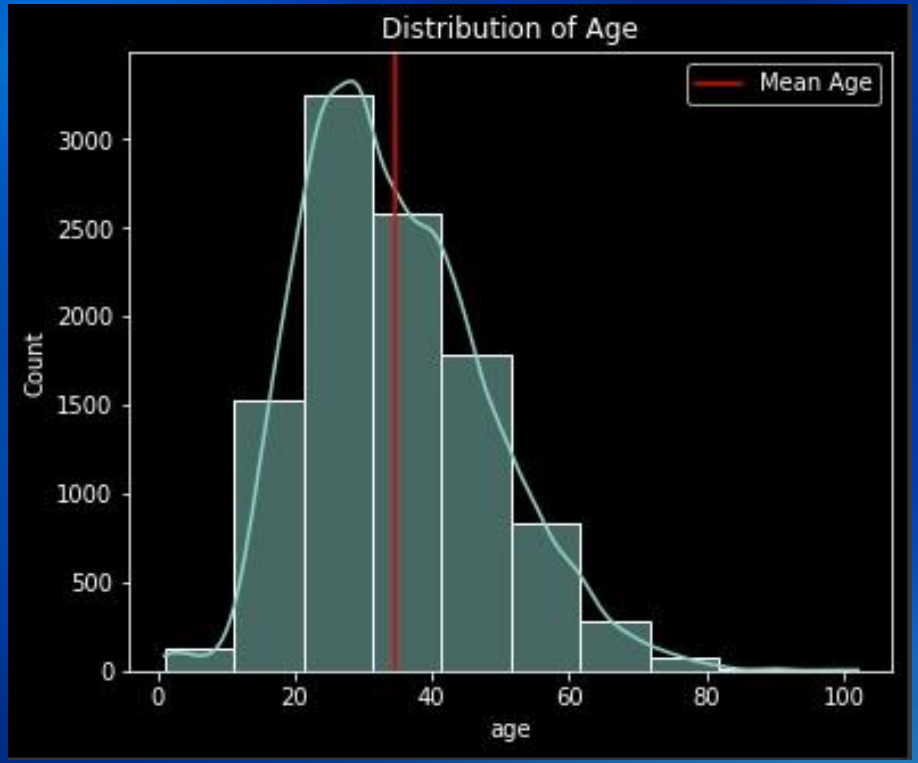
Appendix

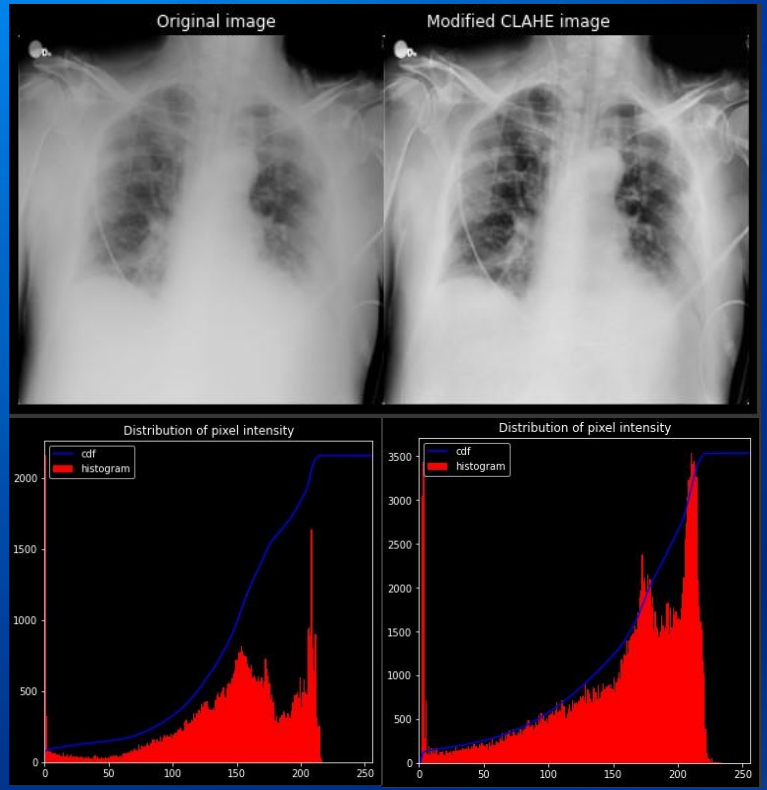
Our Social Defense

- Social distancing
- Use of masks in the community
- Hand hygiene
- Surface cleaning and disinfection
- Ventilation
- Avoidance of crowded indoor spaces

Age of Persons in CoughVid Dataset

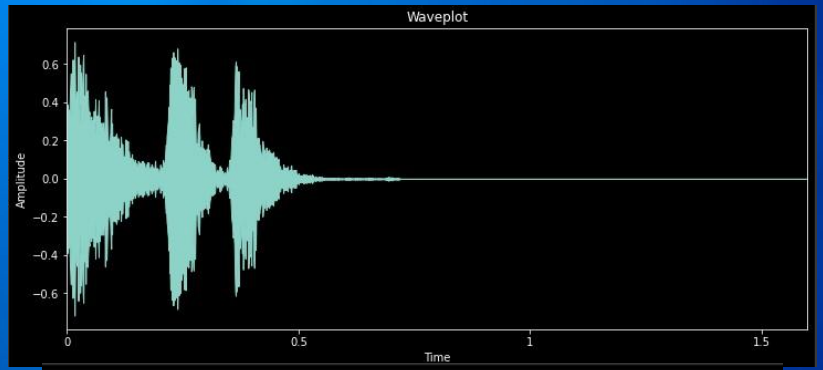


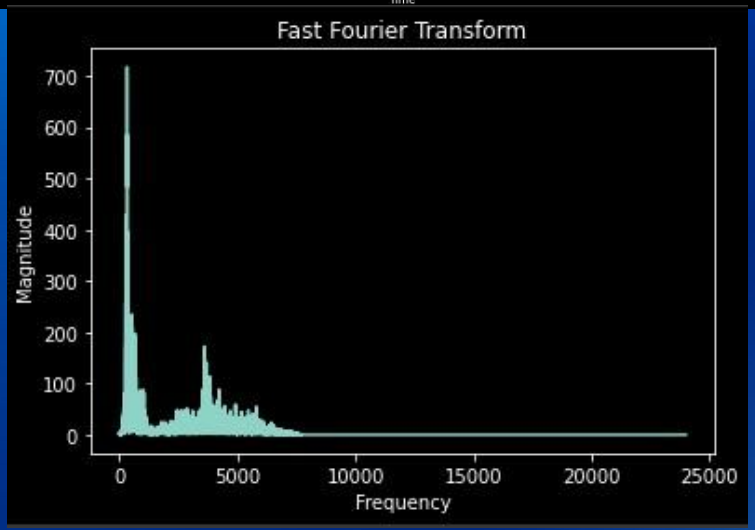
CLAHE



- Contrast Limited Adaptive Histogram Equalization
- focuses on small portions of the image
- Bilinear interpolation - a resampling method that uses the distance-weighted average of the X nearest pixel values to estimate a new pixel value.
- enhances the local contrast of the total image
- helps with the pixel intensity distribution
- Allows us to see more "depth" in an image

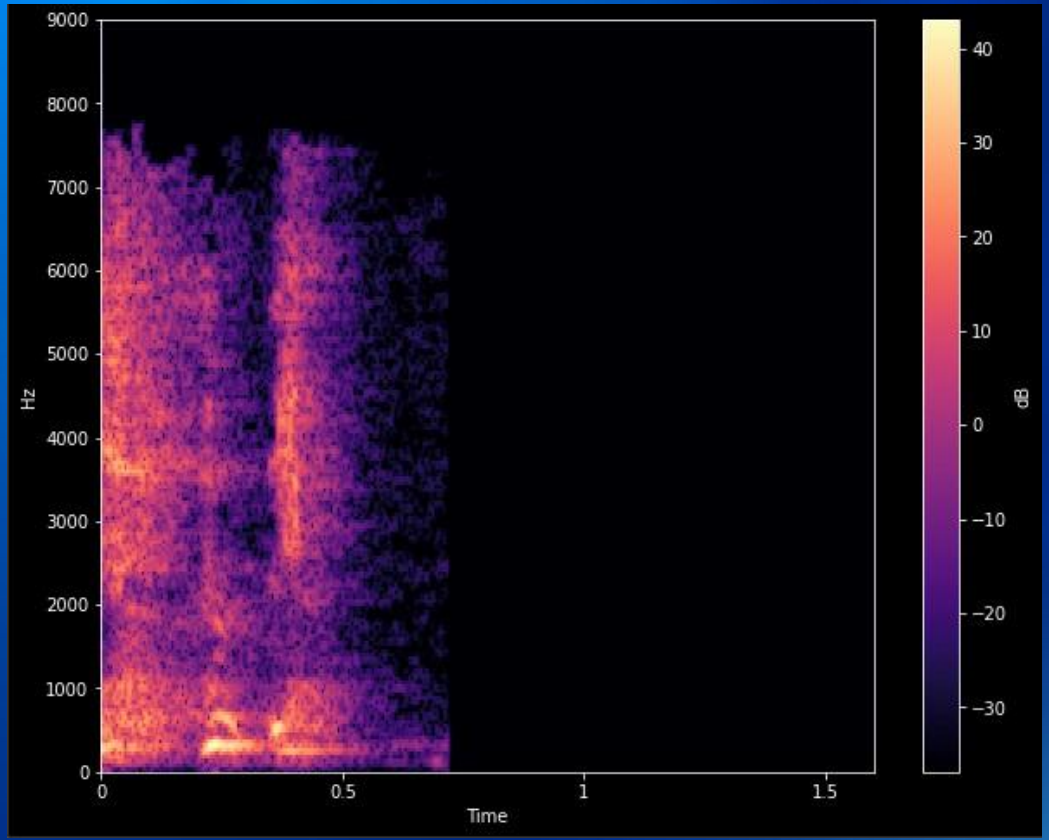
Fast Fourier Transform





- Our waveplot (top figure) is our “signal”
- The Fast Fourier transform (bottom figure) allows us to decompose a signal into individual frequencies and each frequency’s magnitude
- Fast-Fourier Transforms are a histogram of the magnitude of frequencies of a sound
- No time is associated with a FFT

Spectrograms



- Each FFT is calculated on overlapping windowed portions of the signal
- A spectrogram is basically composed of multiple Fast Fourier Transforms
- In order for us to visualize “loudness” in our signal, we must convert from amplitude to decibels
- Allows us to view the loudness of frequencies over time

Mel-Spectrograms

- A spectrogram where the frequencies are converted to the mel-scale
- According to the University of California, the mel-scale is “a perceptual scale of pitches judged by listeners to be equal in distance from one another”
- Perceptually relevant amplitude and frequency representation