A blue-toned background featuring several COVID-19 virus particles. On the left, a large cluster of virus particles is visible, appearing as bright blue and green spherical structures with prominent spikes. In the center, a single virus particle is shown in greater detail, revealing its characteristic crown-like shape. Another smaller cluster of particles is visible in the upper right corner.

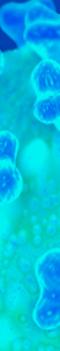
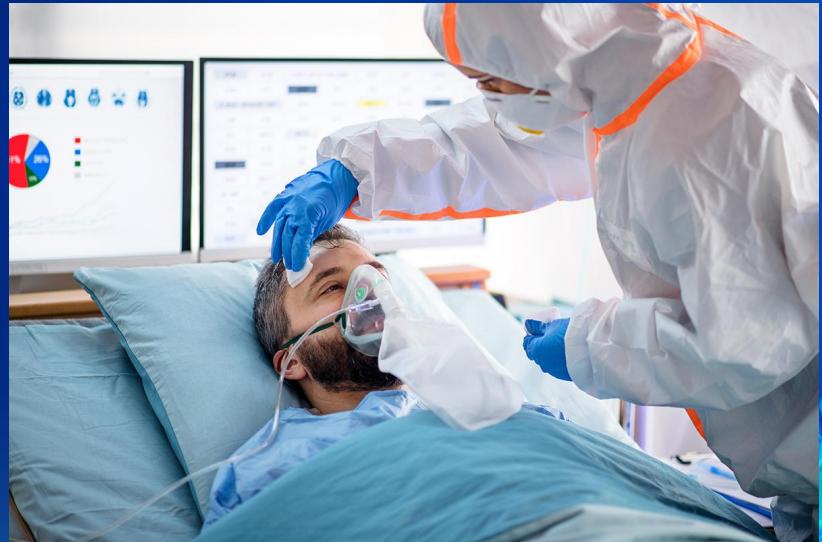
# COVID-19 Classification

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

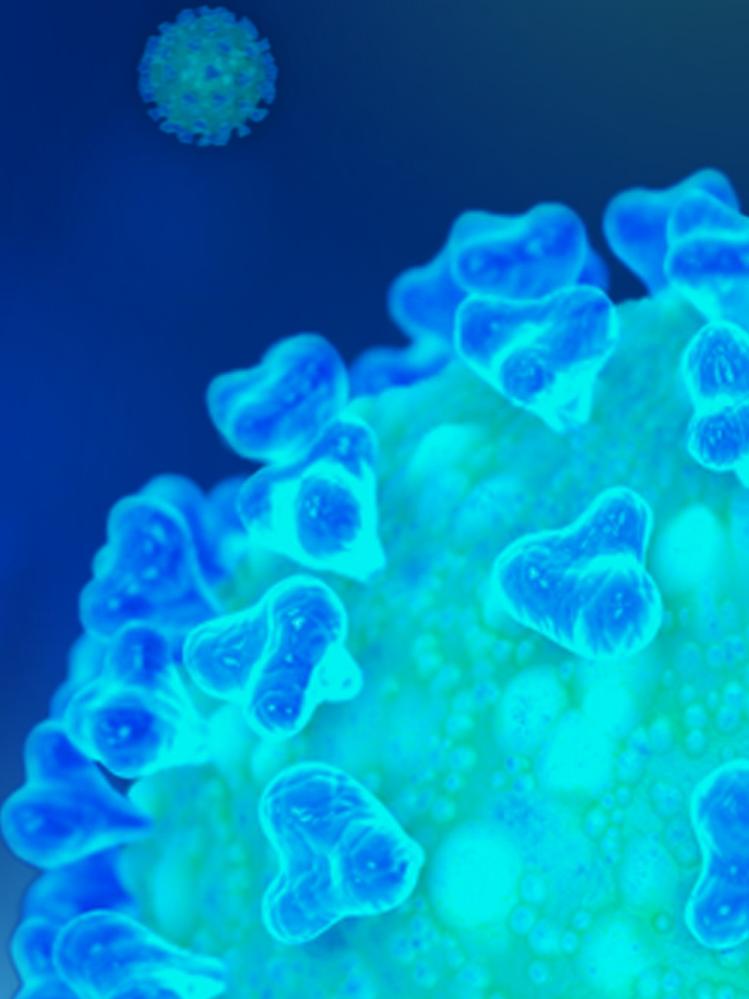


## Modes of Transmission:

1. Contact
  - Fomite
2. Droplet
3. 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



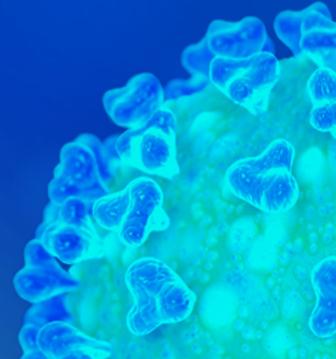
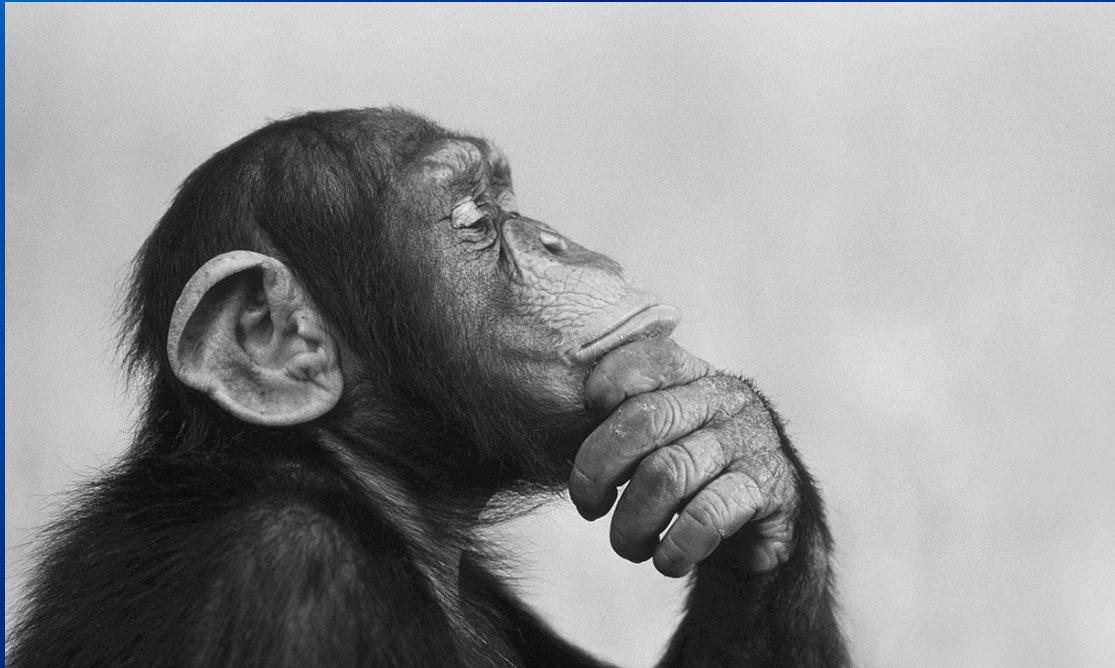
## Viral Testing:

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

## Antibody Testing:

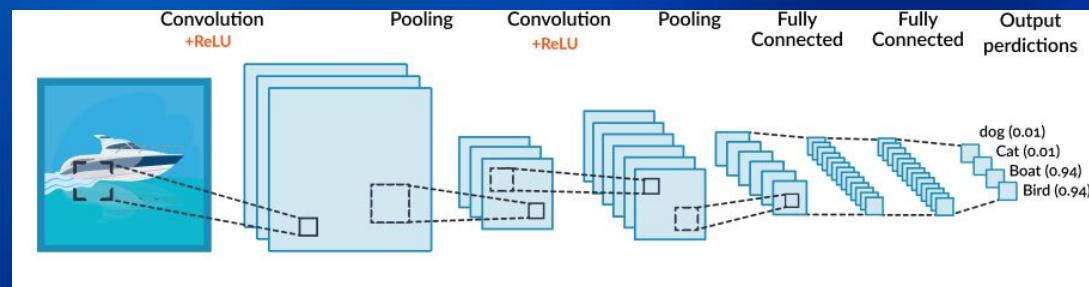
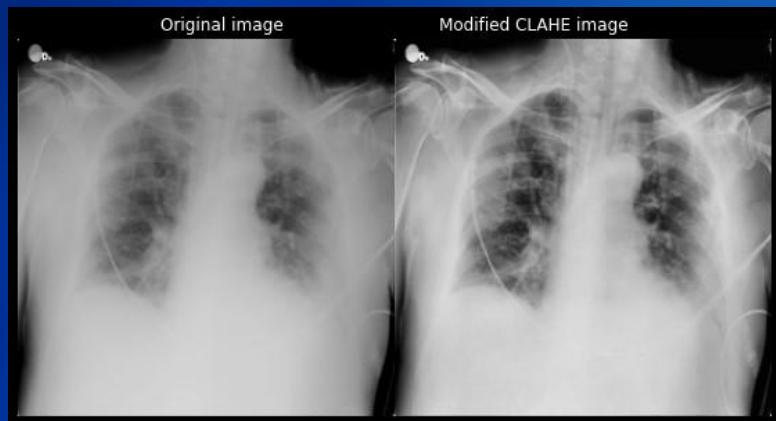
- Used to determine if a past COVID infection occurred

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



# X-Ray Image Classification

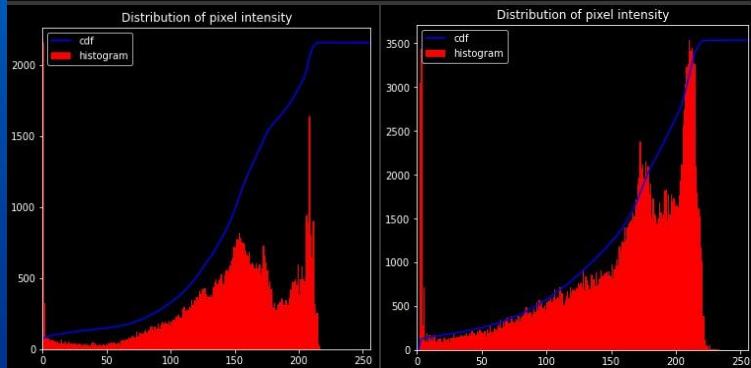
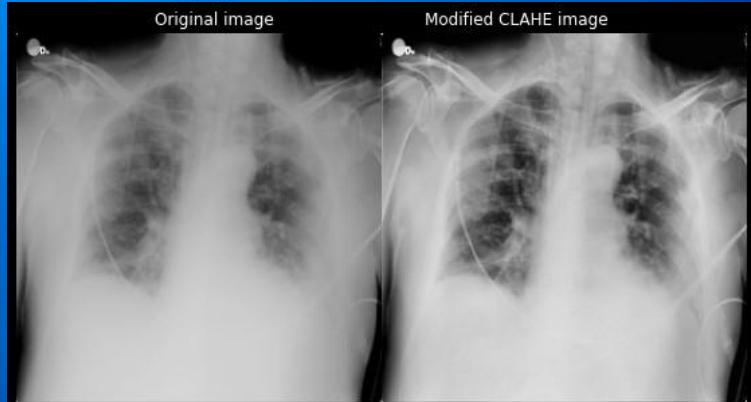
1. Gathered dataset via Kaggle's API
2. Contained 3800+ high quality chest x-ray images
3. Multiple classes: Healthy, Viral Pneumonia, COVID
4. Used CLAHE as a preprocessing technique
5. Created a Sequential Convolutional Neural Network



Ex. of CNN  
architecture

Comparison of original CXR image to modified CLAHE CXR image

# 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 contrast of the image
- helps with the pixel intensity distribution

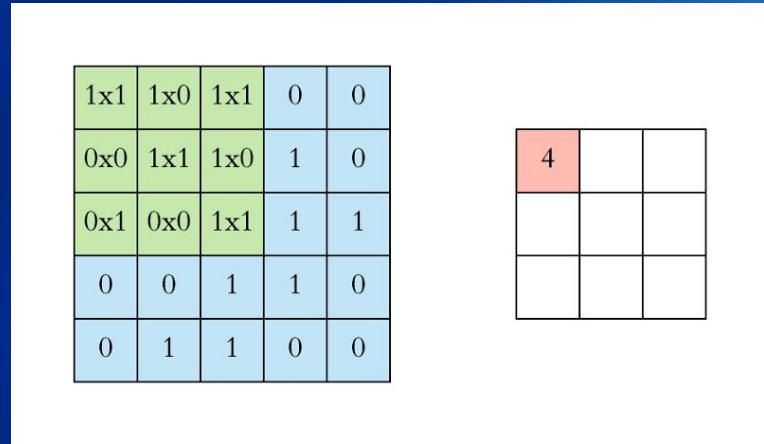
## RECOMMENDATION:

Use CLAHE as a preprocessing technique if working with x-ray or MRI scans. CLAHE is able to provide enough contrast to the image without over-amplifying the intensity of the pixels, providing more 'depth' within each image. It is a great tool if the goal of your project involves detection and/or recognition between classes.

# Convolution and Pooling

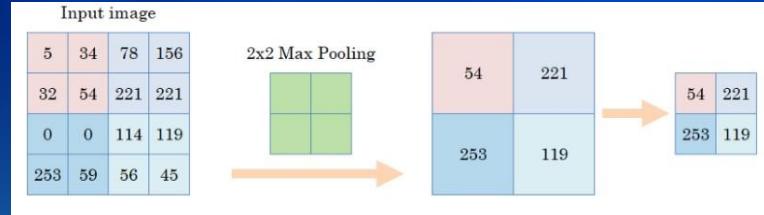
## Convolutional Layers:

- Applying a filter (green) to an image (blue)
- Creating a new image (red)
- Allows us to retain the important features of the image while ignoring the rest



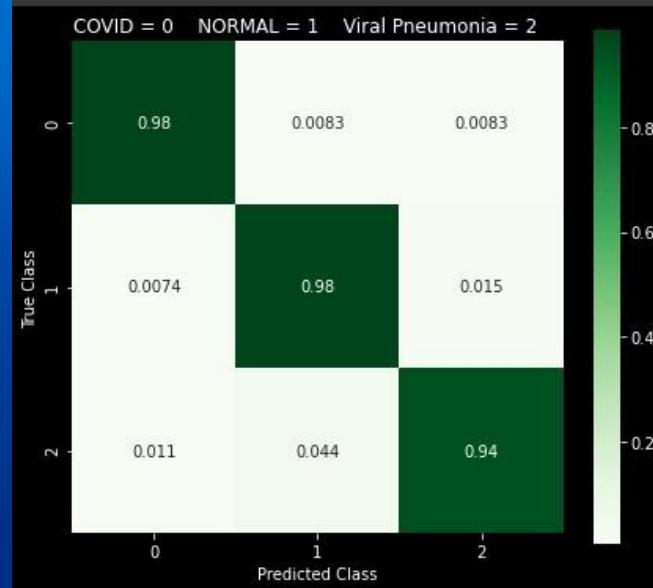
## Max Pooling Layers:

- Reduces the information in the image
- Keeps (and intensifies) the important features
- These important features are kept throughout the model



# 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



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

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

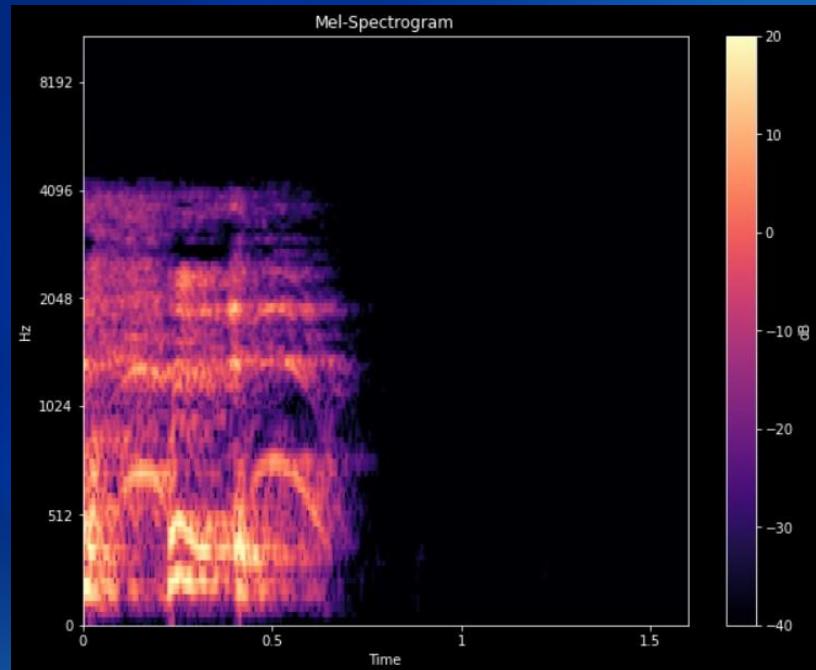
- Exposure to those in the building
- Getting an x-ray can be pricey
- If you are asymptomatic, you wouldn't think to get an x-ray

## RECOMMENDATION:

-Do not implement the use of x-rays to diagnose patients for easily transmittable diseases; the risk of infecting others around the contagious individual and cost of an x-ray are too high.

# Classifying COVID cough audio via Mel-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



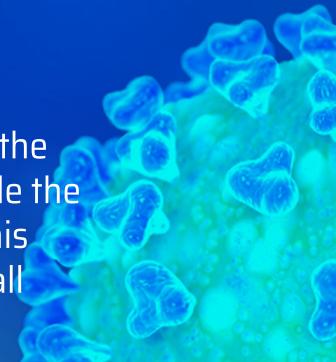
- 85% Accuracy
- 100% Recall for COVID class
- 0% False Negative rate

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

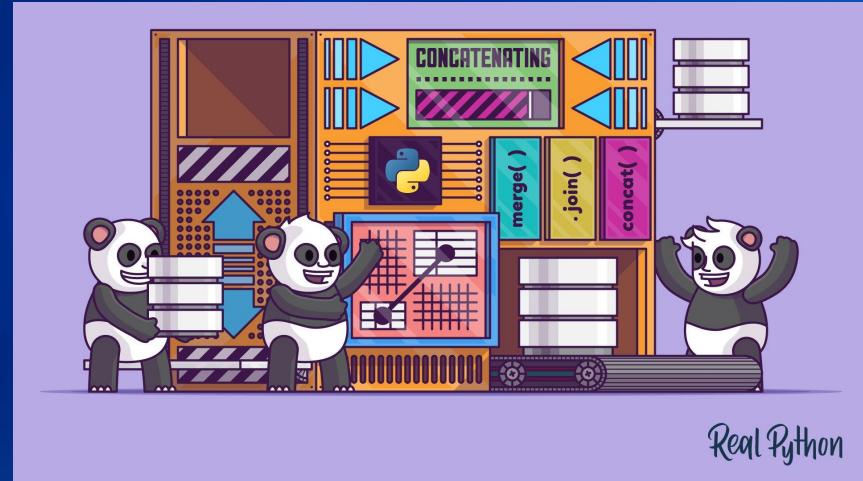
## RECOMMENDATION:

Gather more data to avoid any chance of the model overfitting on the training set. While the results may look good, we cannot trust this model because it is trained on such a small dataset



# Combined Audio Datasets

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



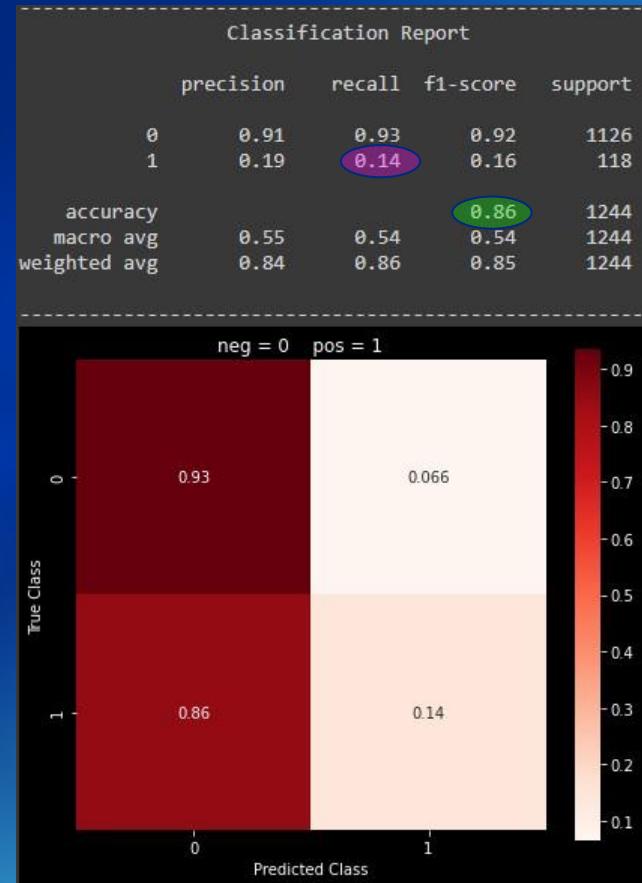
Real Python

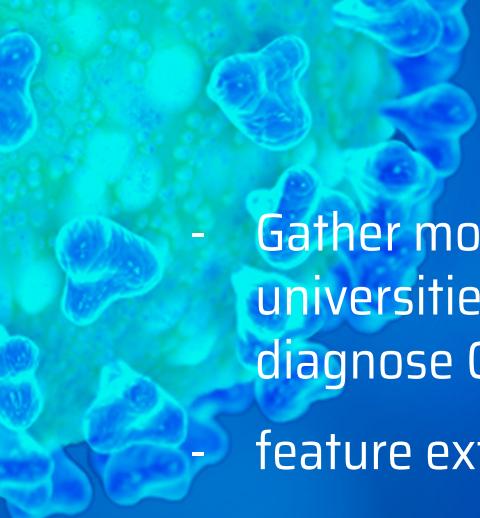
# Combined Audio Model Evaluation Results

- 86% Accuracy
- 14% Recall rate 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



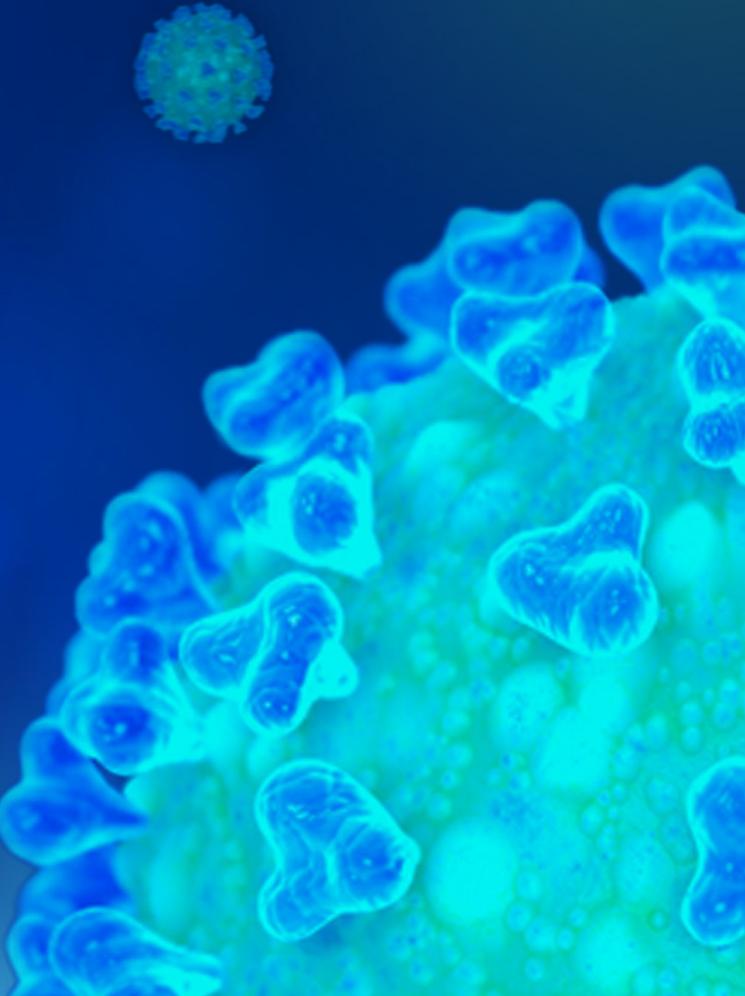
A decorative background image on the left side of the slide shows a microscopic view of COVID-19 virus particles. The particles are spherical and appear to be budding from a surface, with a color gradient from light blue to dark purple.

# 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
- Tweaking spectrograms / create new images to model off of
- Create more complex custom models / use of transfer models

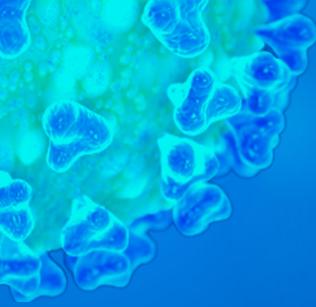
# Thanks for your time!

Are there any questions?



# References

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4. Smyth, Tamara. "The Mel Scale." *University of California, San Diego*, Tamara Smyth, 4 June 2019, musicweb.ucsd.edu/~trsmyth/pitch2/Mel\_Scale.html.
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9. Zafra, Miguel Fernández. "Understanding Convolutions and Pooling in Neural Networks: A Simple Explanation." *Medium*, 25 May 2020, towardsdatascience.com/understanding-convolutions-and-pooling-in-neural-networks-a-simple-explanation-885a2d78f211.



# Appendix

# Viral Testing

## Molecular (PCR) Test:

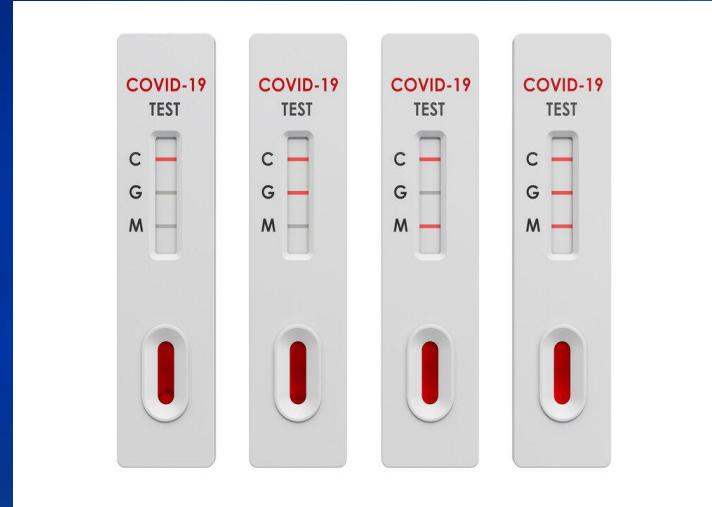
- Detects the virus's genetic material via RT-PCR technique
- Sample is collected with a nasal or throat swab
- PCR tests (in general) are highly accurate
- Takes days to over a week to get the results

## 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

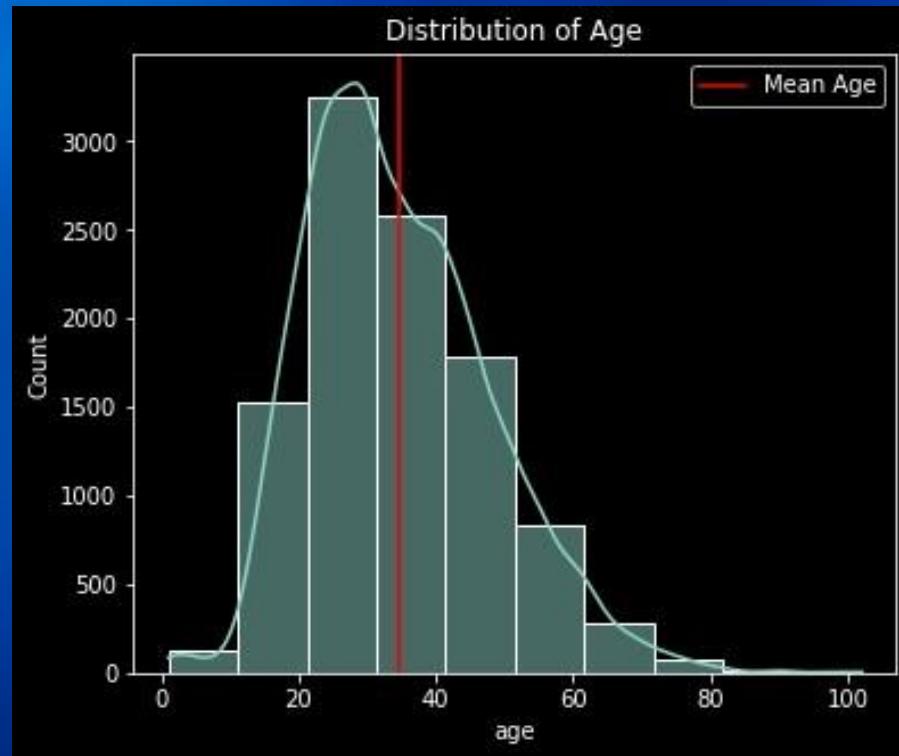


# Our Social Defense

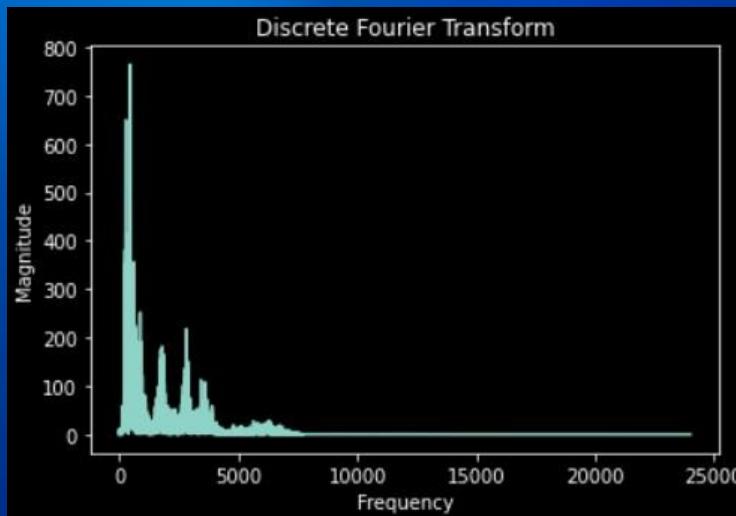
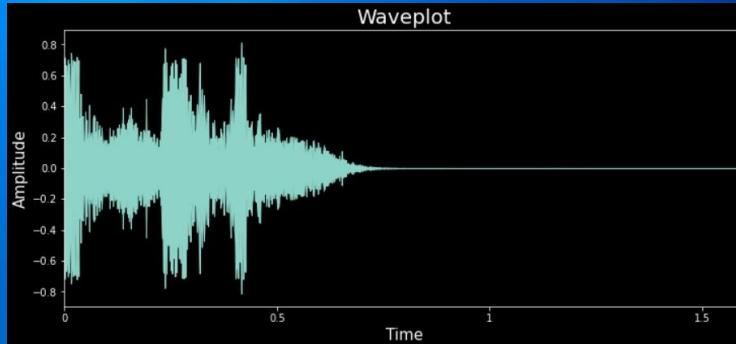
- Social distancing
- Use of masks in the community
- Hand hygiene
- Surface cleaning and disinfection
- Ventilation
- Avoidance of crowded indoor spaces



# Age of Persons in CoughVid Dataset

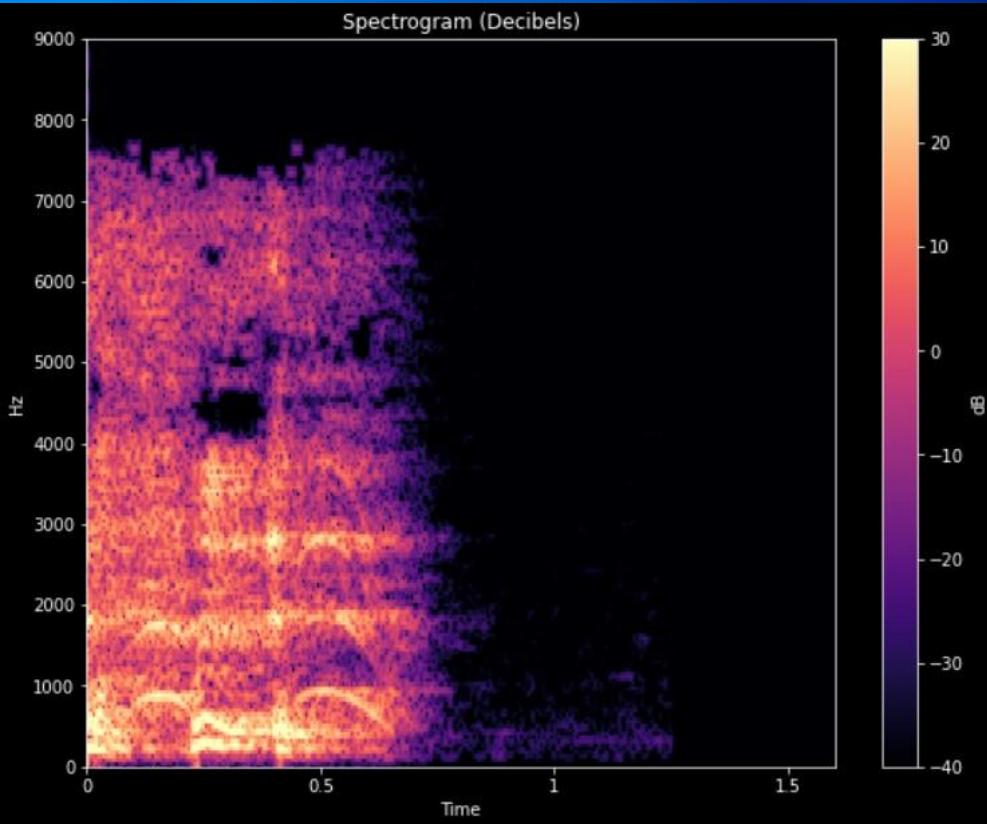


# Fast Fourier Transformation



- Our waveplot (top figure) is our “signal”
- The FFT is an efficient algorithm for computing the Discrete Fourier Transform.
- The FFT (bottom figure) allows us to decompose a signal into individual frequencies and the magnitude of each frequency
- The DFT represents a histogram of the magnitude of frequencies in a sound
- No time associated with a DFT; it is static

# Spectrograms



- Each DFT is calculated on overlapping windowed portions of the signal
- A spectrogram is basically composed of multiple Discrete 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
- The **mel-scale** = “a perceptual scale of pitches judged by listeners to be equal in distance from one another”
- Perceptually relevant amplitude and frequency representation

