COVID-19 Diagnosis

Through Images and Audio

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Some COVID Statistics

100,000,000+
Confirmed cases worldwide

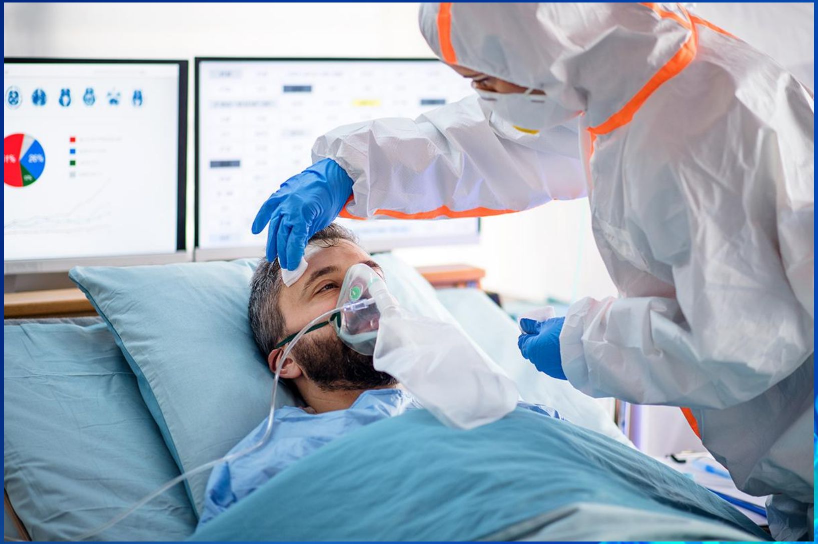
2,000,000+
Deaths worldwide

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

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



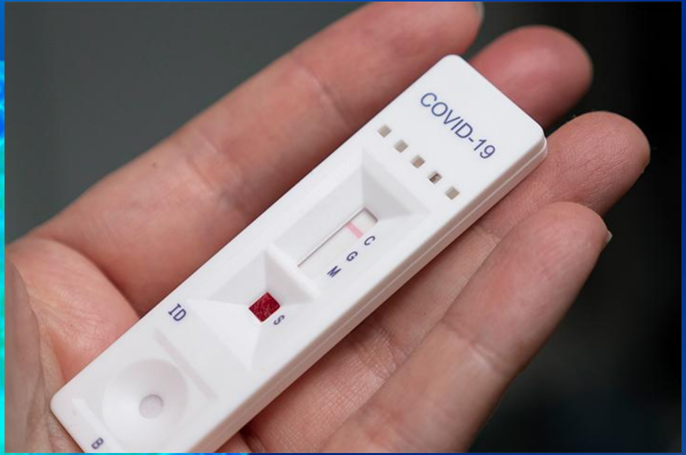
Modes of Transmission:

1. Contact (physical contact or contaminated surfaces)
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”
  - Distinctive Dry cough and shortness of breath

Types of Testing for COVID



Viral Testing:

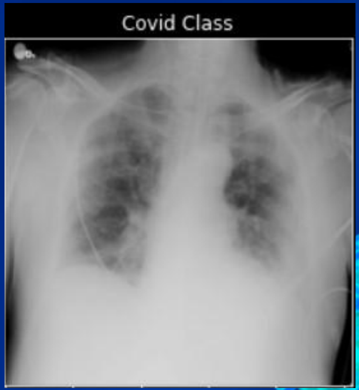
- Used if suspected of having a current COVID infection
- Two subtypes:
  - Molecular (PCR)
  - Antigen

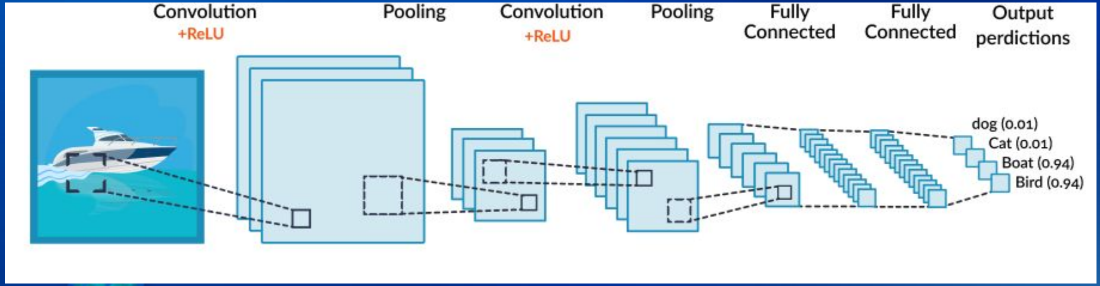
Antibody Testing:

- Used to determine if a past COVID infection occurred

X-Ray Image Classification via Computer Vision

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



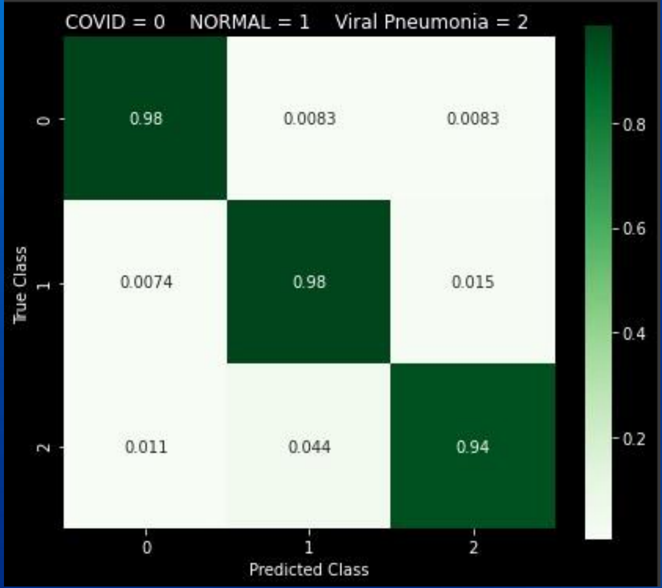


Ex. of CNN
architecture

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



- 97% Accuracy
- 98% Recall rate on COVID class
- Less than 2% False Negatives for COVID class

RECOMMENDATION:

- Using Computer Vision with x-rays images is a great way to diagnose patients for many diseases.
- Our model is able to achieve an accuracy equal to a professional when diagnosing chest x-rays for our three classes.

Things to Consider:

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

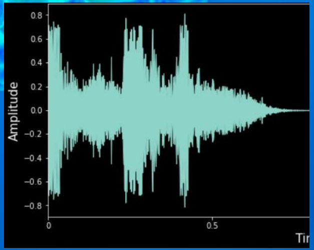
- Exposure to those in the building
- Getting an x-ray can be pricey
- If you are asymptomatic, you wouldn’t think to get an x-ray

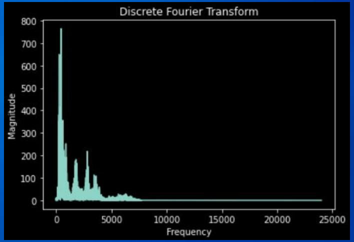
Conclusion:

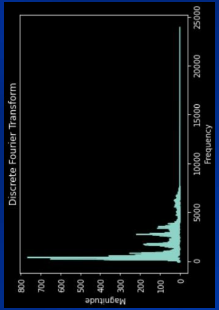
- Diagnosing infections and diseases with Computer Vision using chest x-rays work extremely well, but we need to consider the risks when giving X-rays to people who have an extremely contagious infection

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

Classifying COVID cough audio via Mel-Spectrograms







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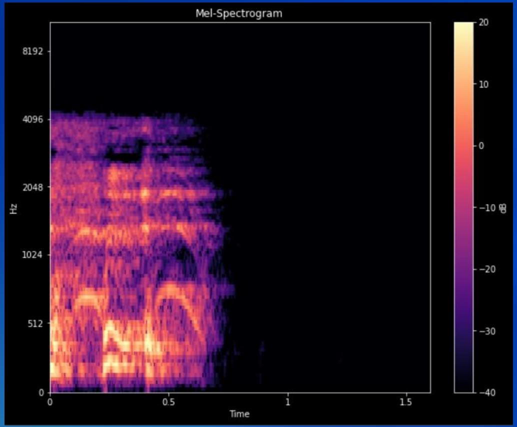
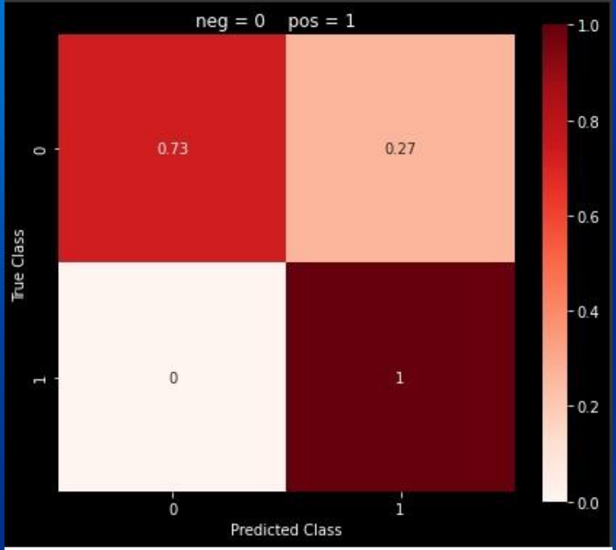


1. Gathered cough audio from University of Stanford's Virufy dataset via Github
2. Two Classes: healthy and COVID
3. Created mel-spectrogram images for each segmented mp3 audio file
4. Trained Sequential Convolutional Neural Network model off the images

Virufy Model Evaluation Results

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



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

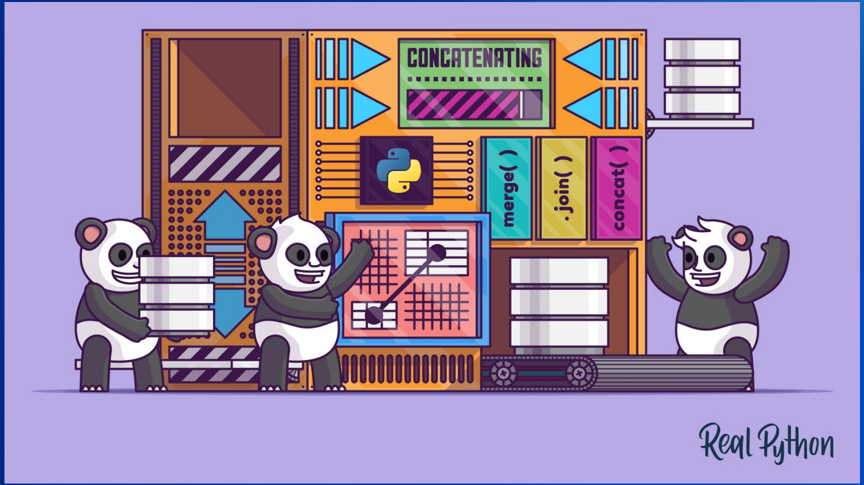
Things to note:

- 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:
Using cough audio to diagnose COVID-19 in infected individuals would be extremely safe, efficient, cheap, and provide virtually no risk

Combined Audio Datasets

1. Gathered CoughVid cough audio via Zenodo
2. Combined with Virufy audio dataset
3. Created mel-spectrograms for each audio file
4. Trained Sequential Neural Network model off the images



Did not achieve the accuracy and COVID class recall rate we were aiming for

Things to consider:

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

Recommendation:
Gathering high quality coughing audio from current COVID-19 patients through Hospitals and Institutions could significantly boost the model's recall rate for the COVID class

Final Conclusions

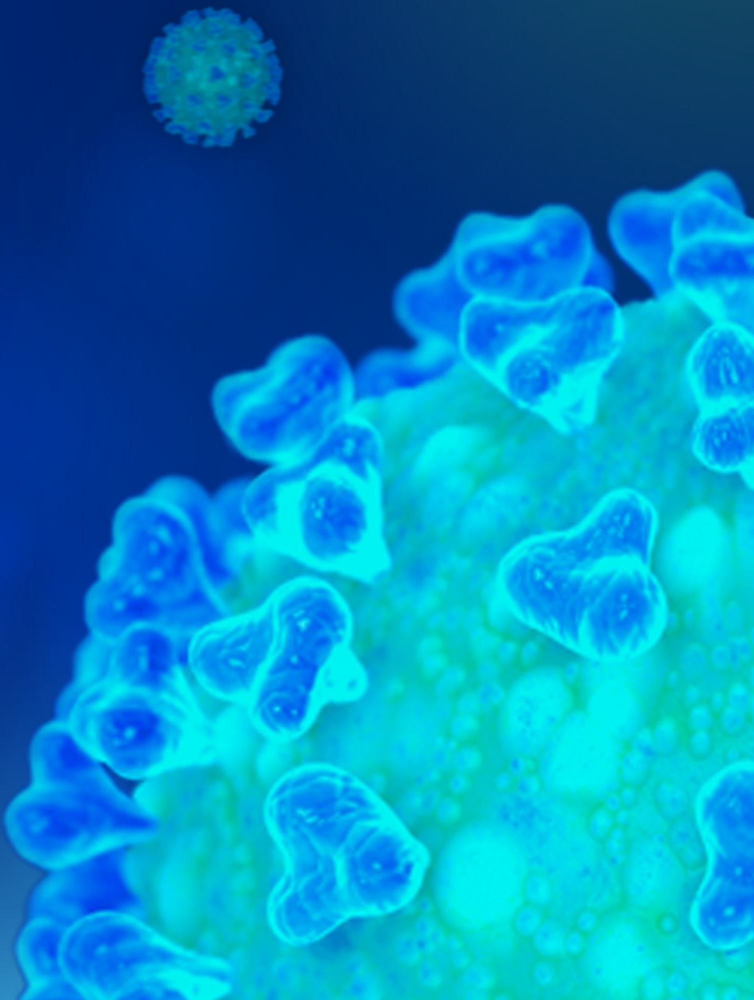
- Using Computer Vision for diagnosing diseases and infections through x-rays and spectrograms can be extremely beneficial for patients and staff (depending on the disease/infection)
- Gathering high quality COVID positive cough audio data and storing in a database would help further improve our models accuracy and recall rate, allowing us to move quicker towards the end goal of creating an app to quickly diagnose people who have COVID-19
- Setting up a national database of cough audio data collected from various sources could help protect against future variants or strains of COVID-19 or similar diseases

Further Research:

1. Gather more higher quality data - request access from other universities or institutions that are also gathering coughing audio to diagnose COVID-19
2. feature extraction of audio files
   a. Segmenting audio files (2 second segments)
   b. Tweaking spectrogram parameters (sample rate, vmin, vmax, etc.)
3. Apply use of transfer models (e.g. VGG-16, ImageNet, etc.)

Thanks for your time!

Are there any questions?



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Appendix

Viral Testing

Molecular (PCR) Test:

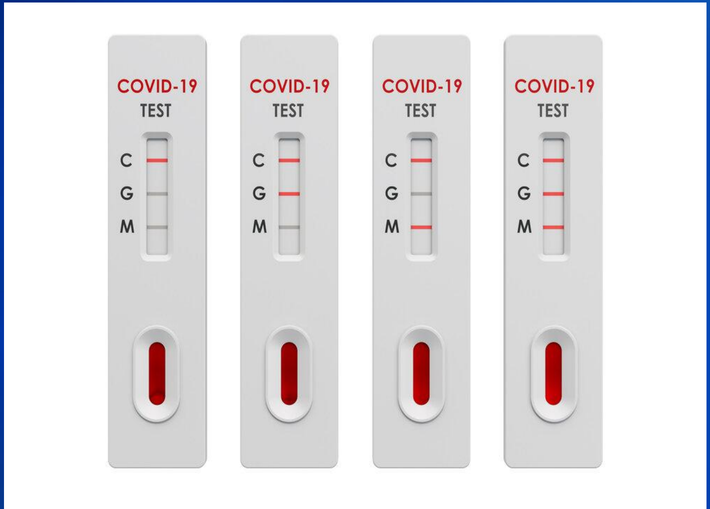
- Detects the virus's genetic material via RT-PCR technique
- Sample is collected with a nasal or throat swab
- PCR tests (in general) are highly accurate
- Takes days to over a week to get the results

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

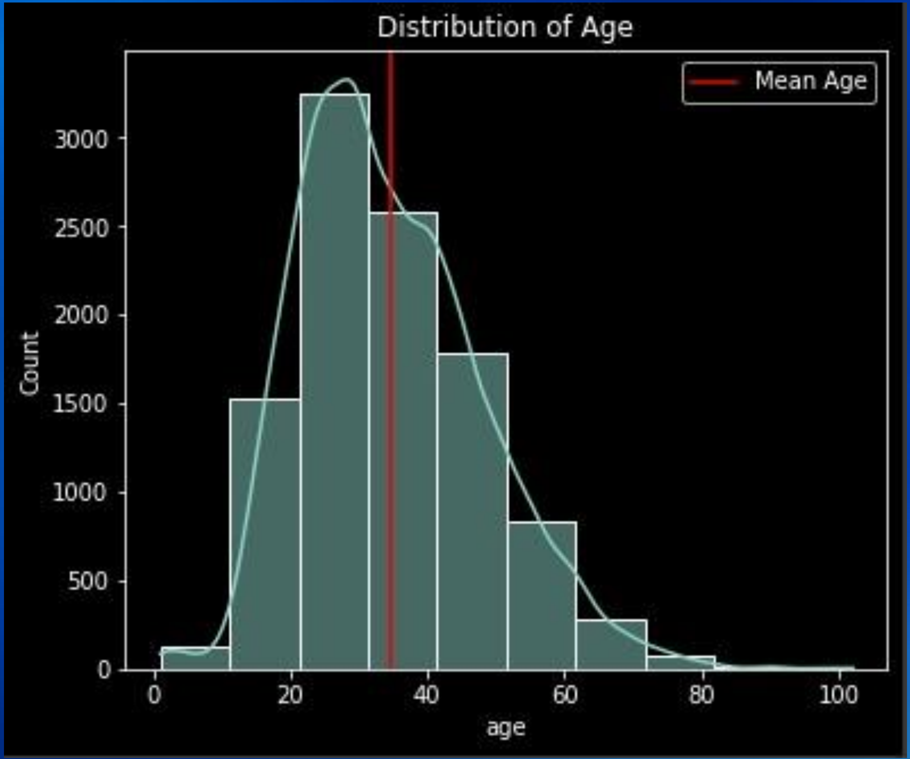
- Uses a blood sample to look for antibodies developed as a result from past infection.
- Takes 1 - 3 weeks for a person to develop antibodies
- Having an antibody test too early can lead to false negative results
- Even if you've been exposed to the virus, it's not yet known:
  - If you're immune
 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



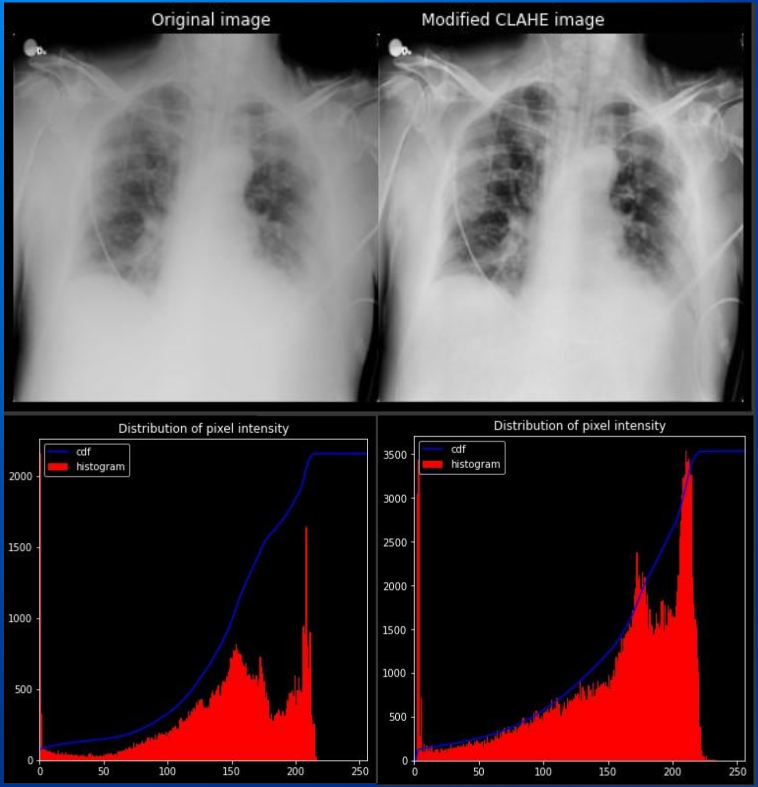
Our Social Defense

- 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



CLAHE



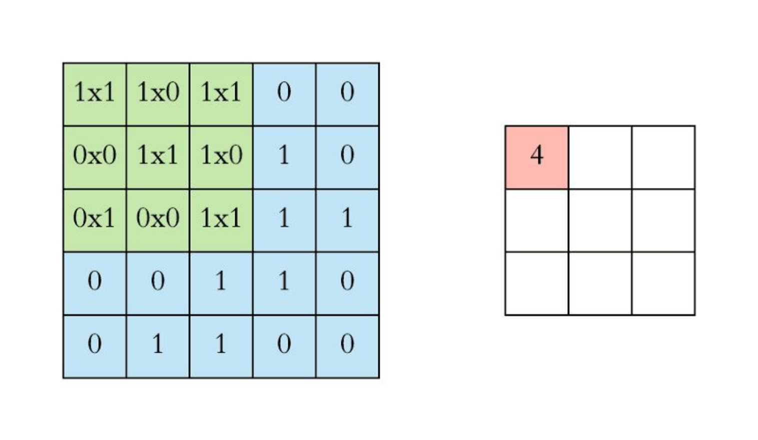
- Contrast Limited Adaptive Histogram Equalization
- focuses on small portions of the image
- **Bilinear interpolation** - a resampling method that uses the distance-weighted average of the X nearest pixel values to estimate a new pixel value.
- enhances the contrast of the image
- helps with the pixel 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

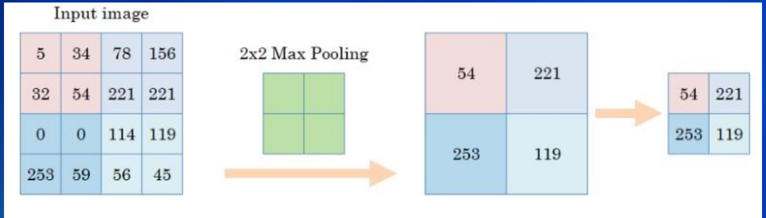
Convolutional Layers:

- 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

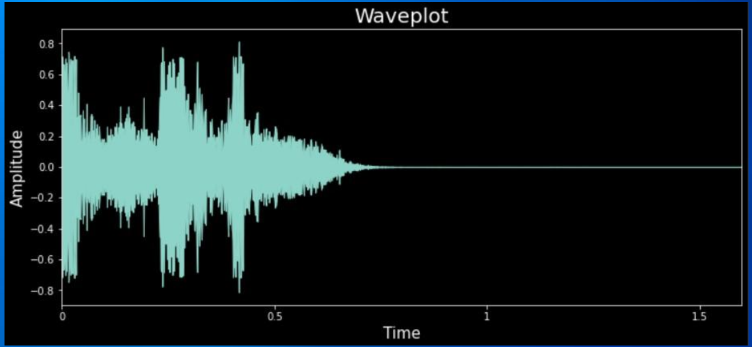


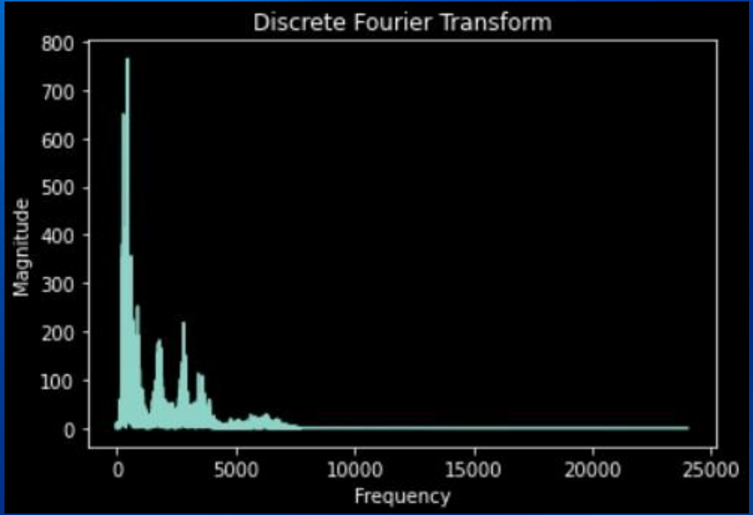
Max Pooling Layers:

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



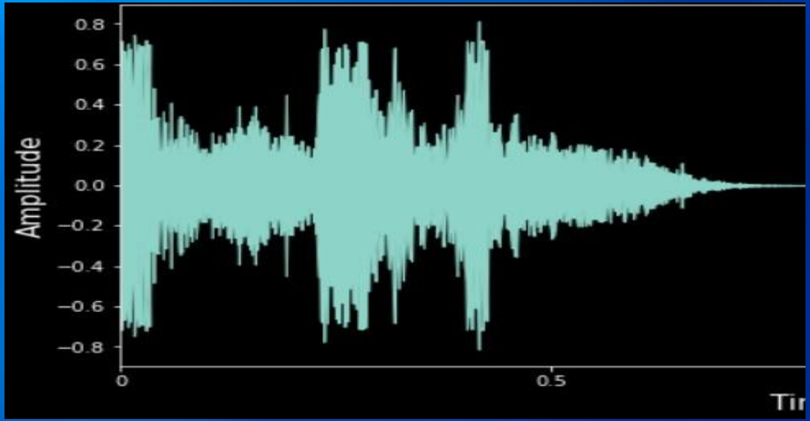
Fast Fourier Transformation

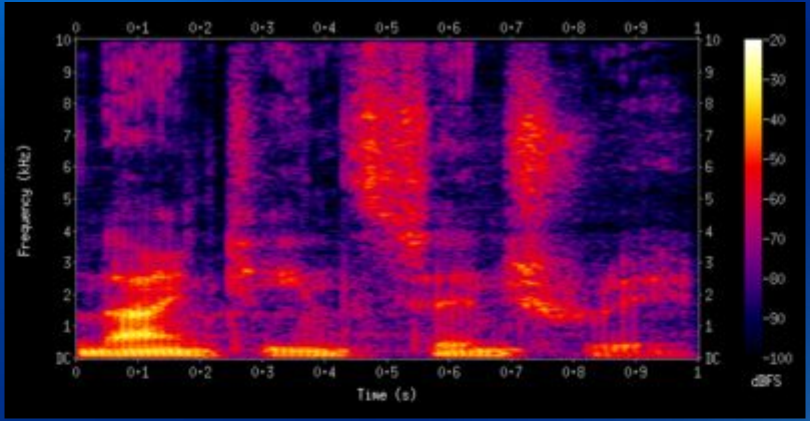




- Our waveplot (top figure) is our "signal"
- The FFT is an efficient algorithm for computing the Discrete Fourier Transform.
- The DFT (bottom figure) allows us to decompose a signal into individual frequencies and the magnitude of each frequency
- The DFT represents a histogram of the magnitude of 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