EGBE601 Medical Signal Processing and Instrumentation **| Term Project Presentation**

Low-pass filter effect on *COVID-19* detection convolutional neural network model

MEMBERS

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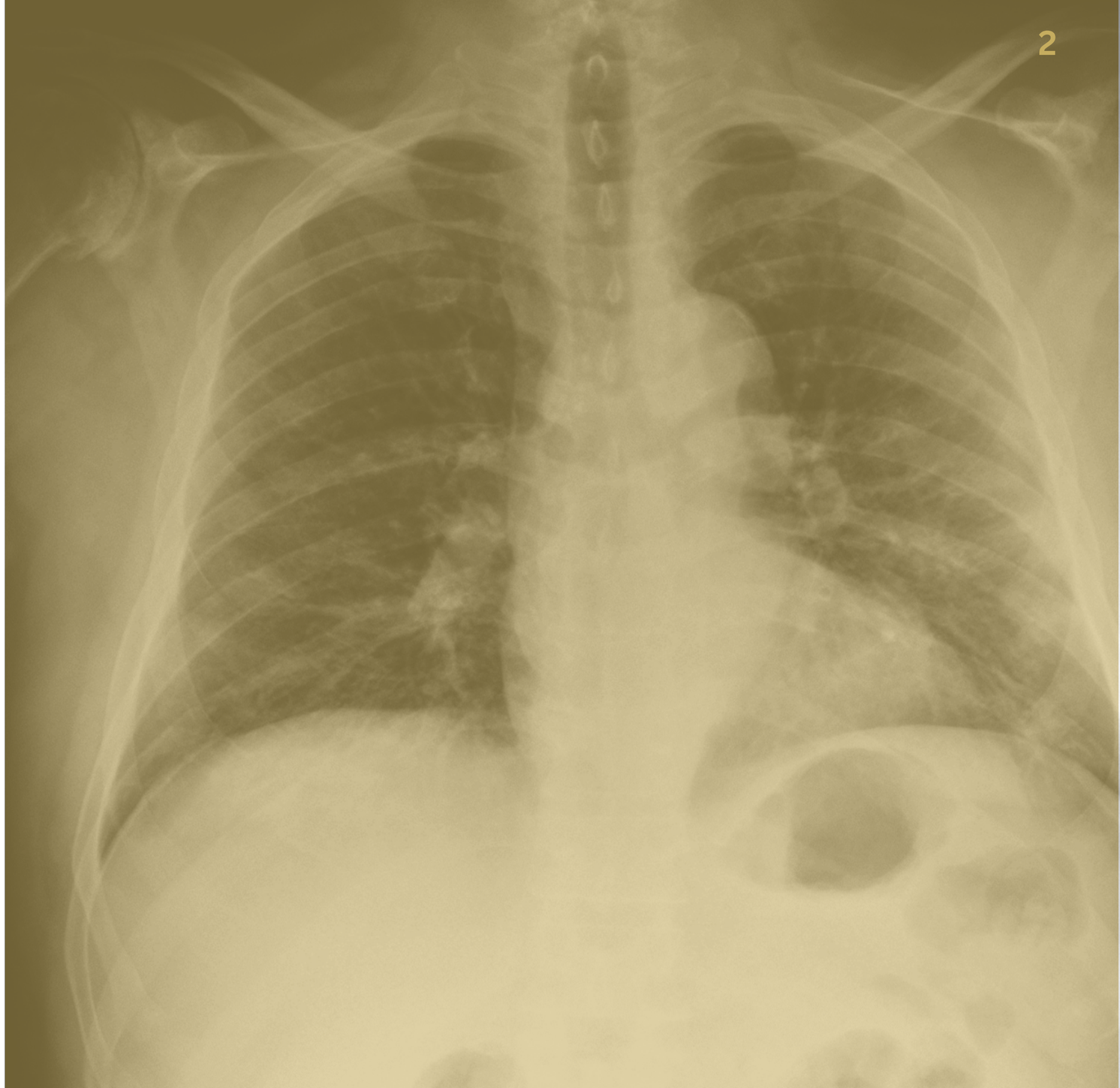
Agenda

- Introduction
- Objectives
- Methodology
- Results
- Discussion
- Conclusion

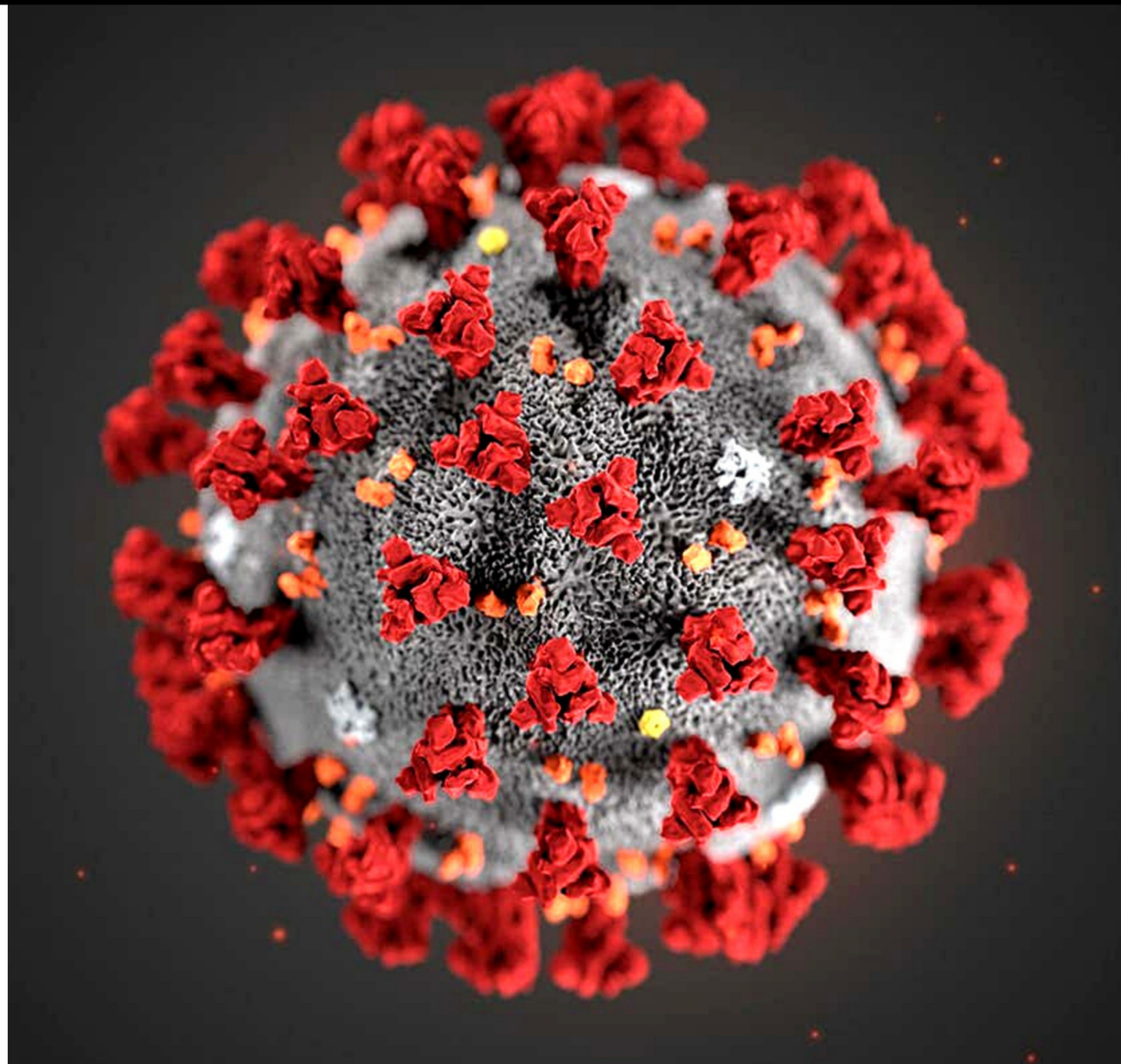


Introduction

- **Covid pandemic** began in **DEC 2019**
- **7 million deaths** reported, **774 million** confirmed cases
- **Chest X-ray** is **modality of choice** to evaluate pneumonia
- **Shortage of radiologist:** 1 to 1680 population, 6% in all doctor
- **Workload exacerbated** during pandemic
- **Longer time for diagnosis and late treatment**
- **Increase mortality rate** and **disease burden**

Introduction

- Machine learning helps **faster diagnosis**, reduces radiologist workload
- Convolutional neural networks (**CNN**) used variety in **image segmentation** and classification.
- **ResNet** is commonly used CNN
- **Low-pass filter**: reduce high-frequency (noise) component
- **speeding up** processing times and l**owering memory** requirements
- **PCA** : efficient method for analyzing and classifying images.



Introduction

ResNet50

A widely used deep convolutional neural network for image extraction

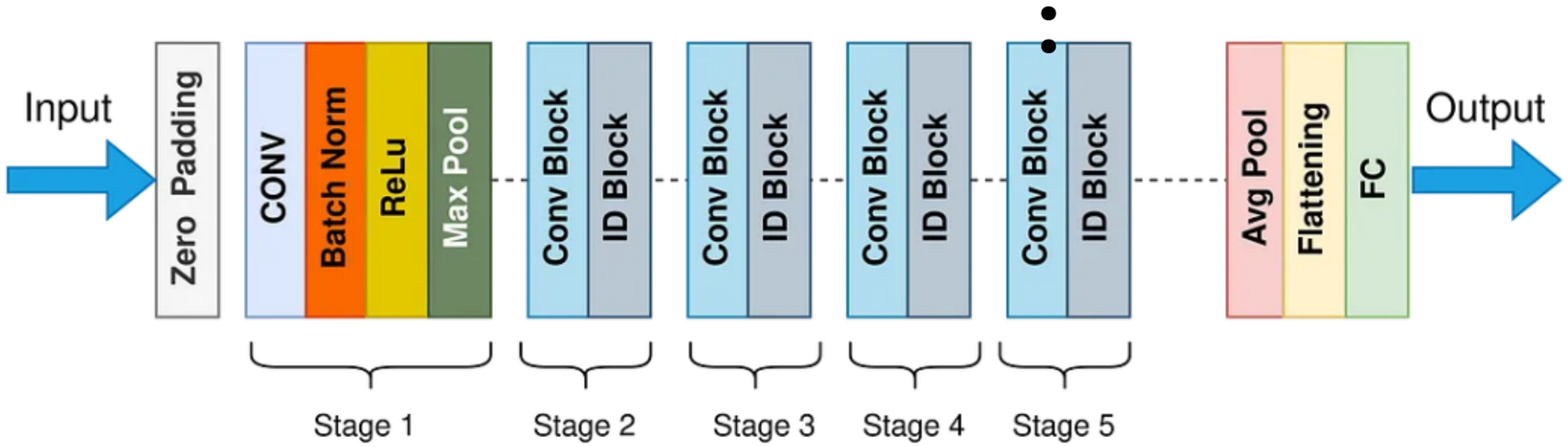


Figure ResNet50 Model Architecture

(Mukherjee & Praveen, 2022)

Advantage: enhance accuracy and efficiently in processing complex image data.

Disadvantage: High computational complexity requiring significant resources for training and inference.

Introduction

Low-pass filter

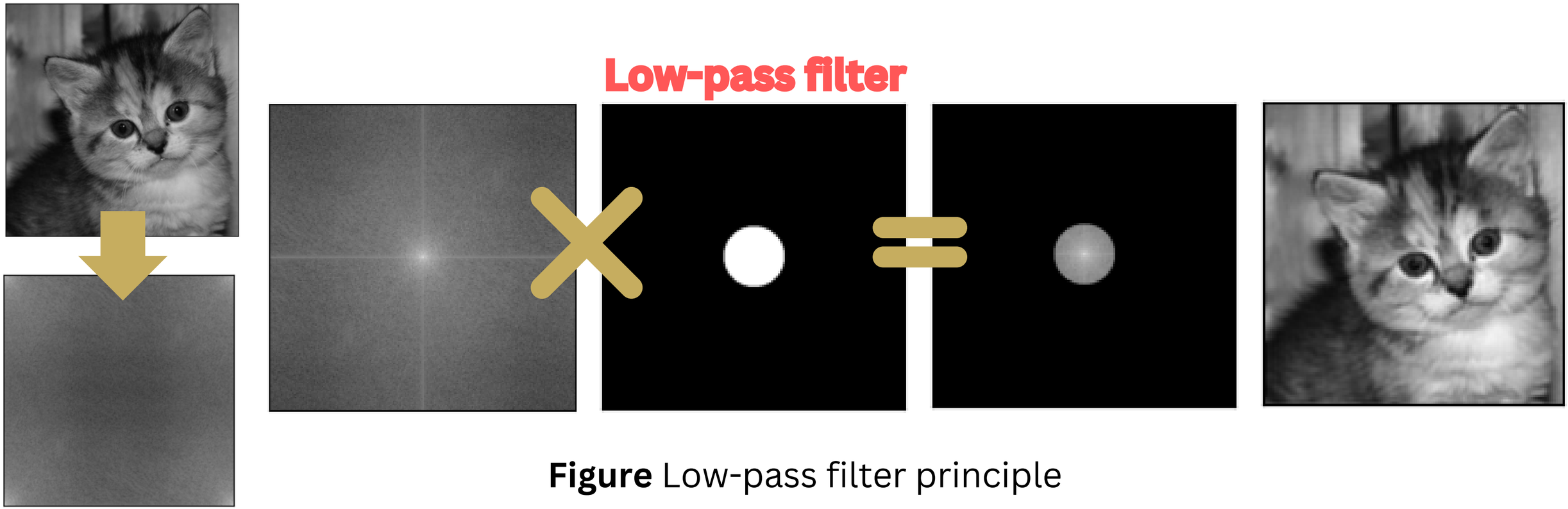


Figure Low-pass filter principle

Introduction

Principal component analysis (PCA)

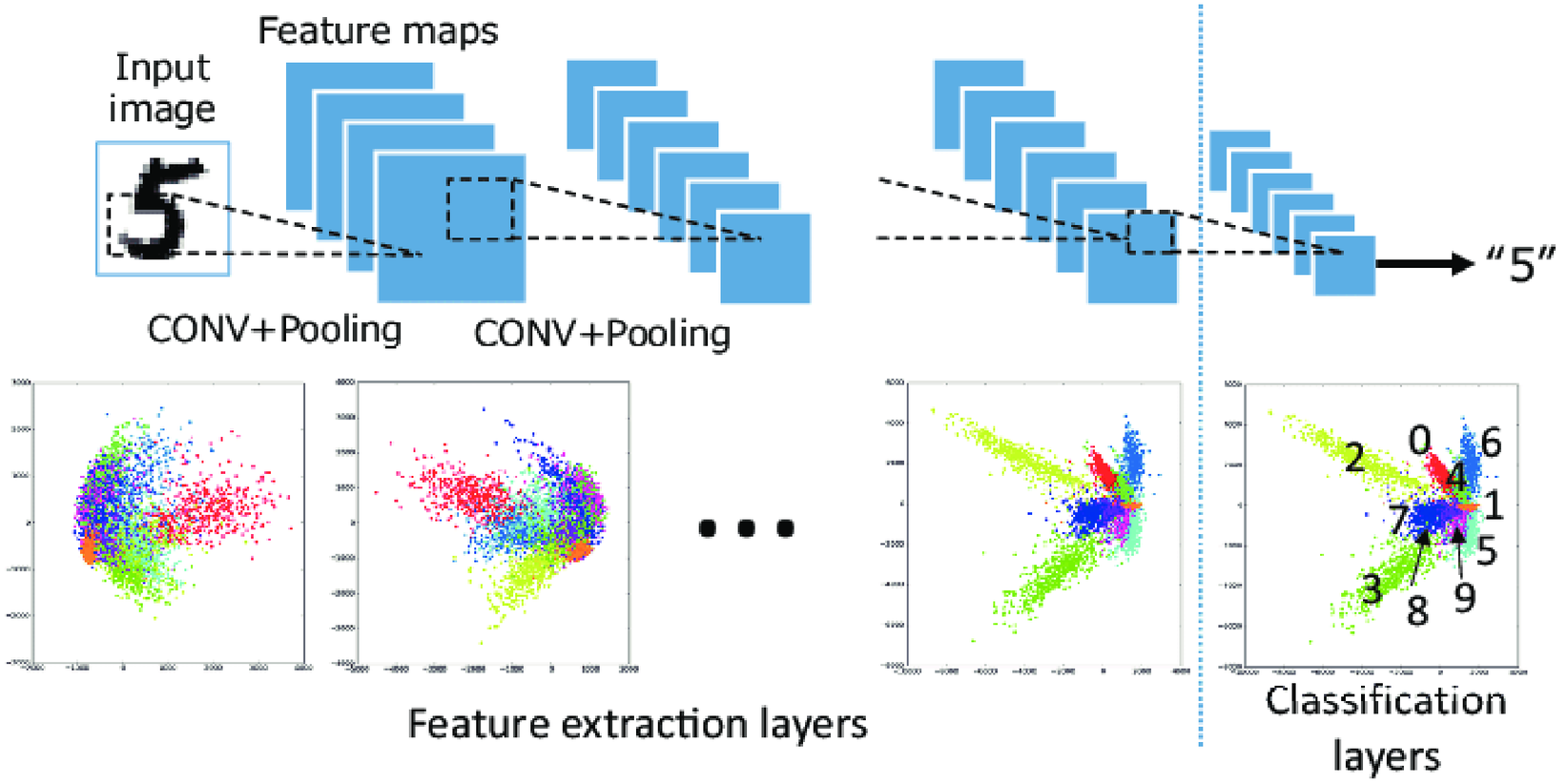


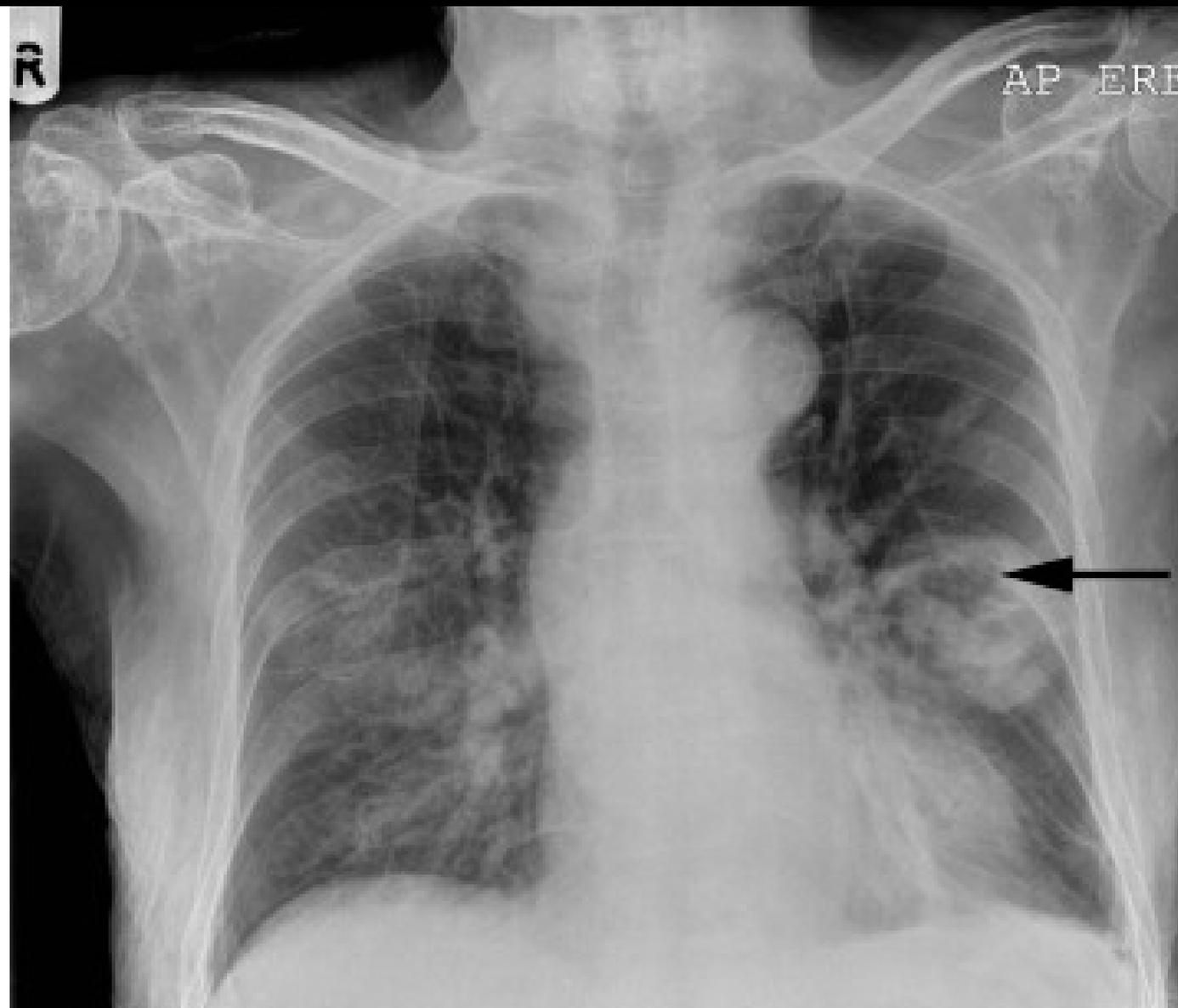
Figure ResNet50 Model Architecture (Nakahara et al., 2018)

- **Efficient method for analyzing and classifying the image**
- **Advantages: improves visualization and understanding of complex data**
- **Disadvantages: Loss of information due to dimensionality reduction.**

Objectives

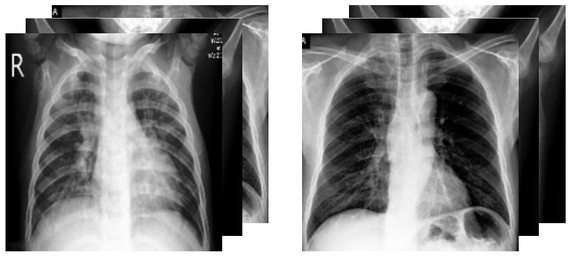
- To study the impact of low pass filtering on the performance of CNN models during training

- To visualize the ResNet50-based CNN model features in COVID-19 Detection



Experimental Design

Training *(n=251)* Testing *(n=66)*

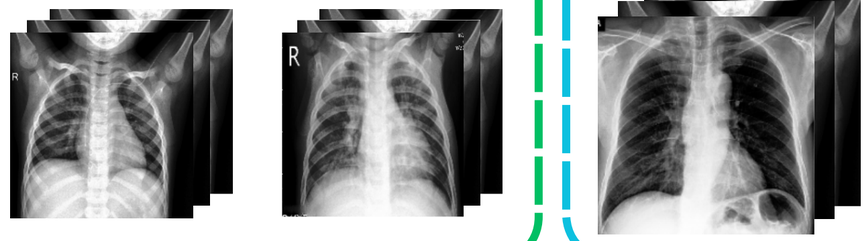


from *Kaggle*
(pranavraikokte/covid19-image-dataset/)

Chest X-ray Dataset

Data resample

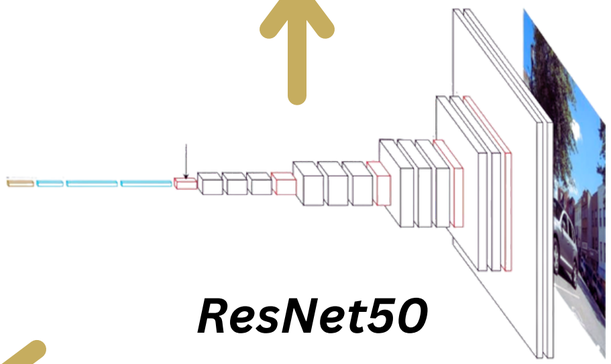
Training *(n=200)* *Validation (n=51)* Testing *(n=66)*



Data Preprocessing

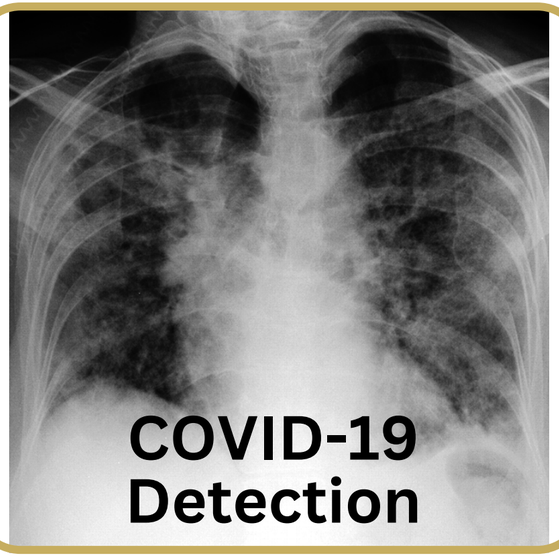
LOW-PASS FILTERS

CNN Model



ResNet50

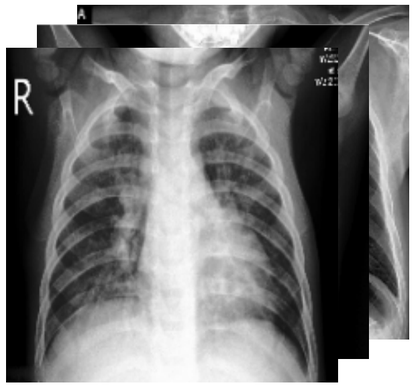
PCA



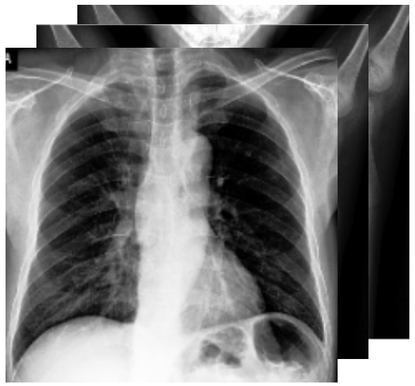
Methodology

1. Dataset preparation

Training *(n=251)*



Testing *(n=66)*



from *Kaggle*

(pranavraikokte/covid19-image-dataset/)

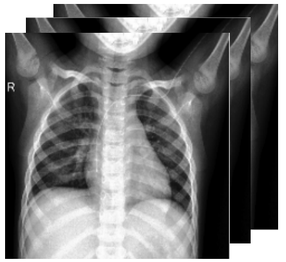
Chest X-ray Dataset

3 classes:

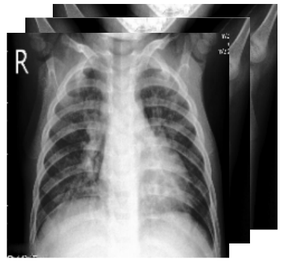
- *COVID-19 pneumonia (+)*
- *Viral pneumonia (-)*
- *Normal (-)*

Data resample

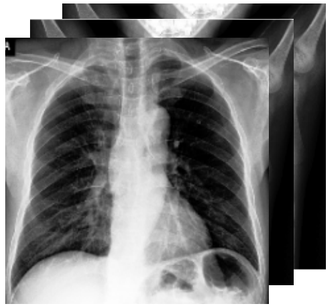
Training *(n=200)*



Validation (n=51)



Testing *(n=66)*



batch size = 32

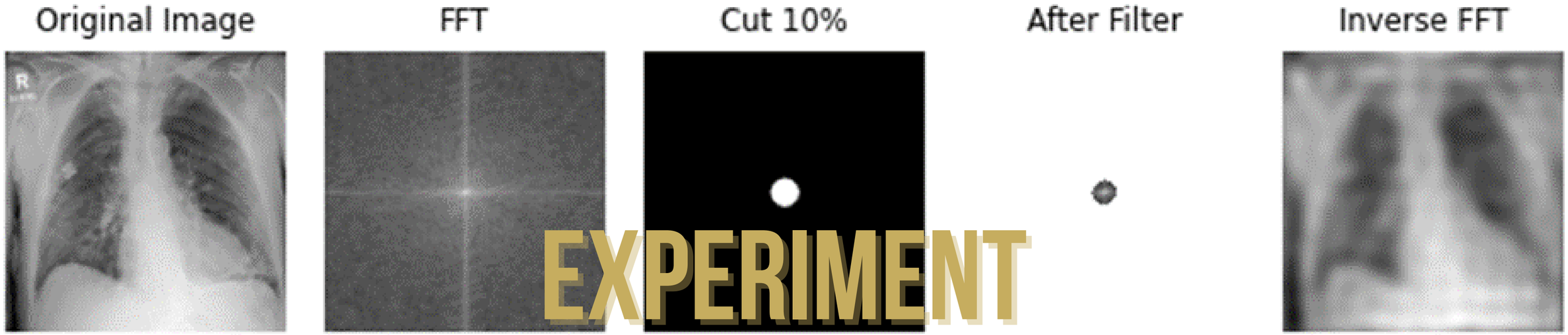
Covid

Viral Pneumonia

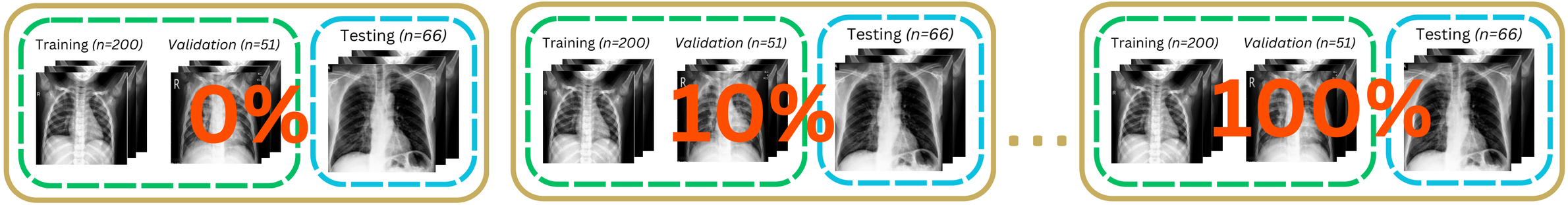
Normal

Methodology

2. Low-pass filter application on the dataset

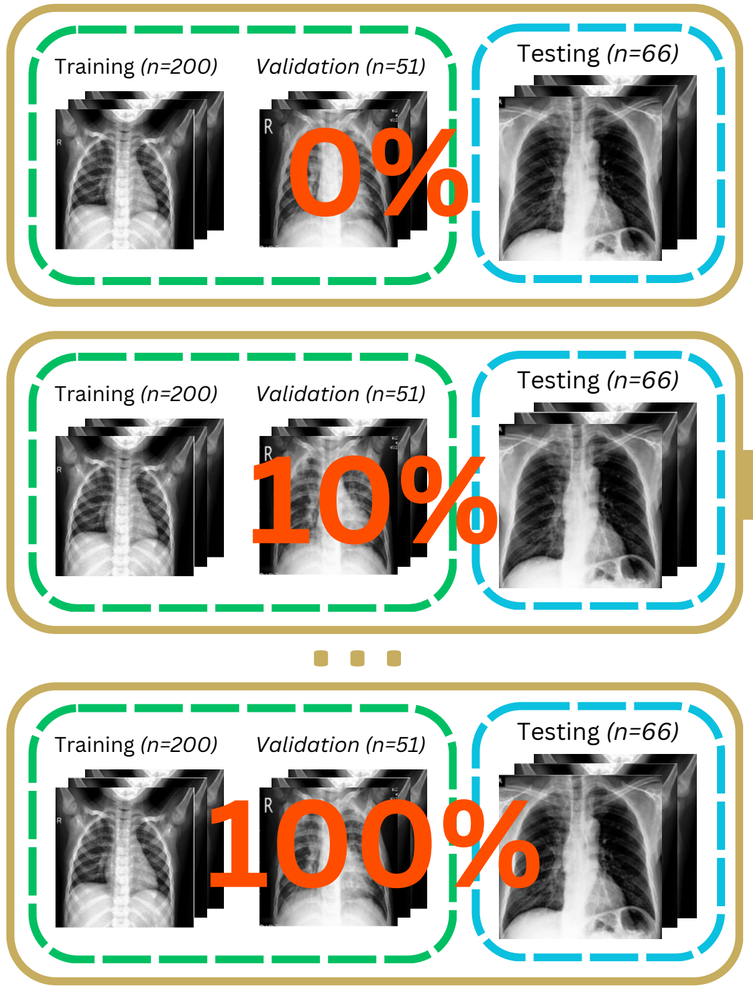



```
for cut_percentage in range(0, 101, 10):
```

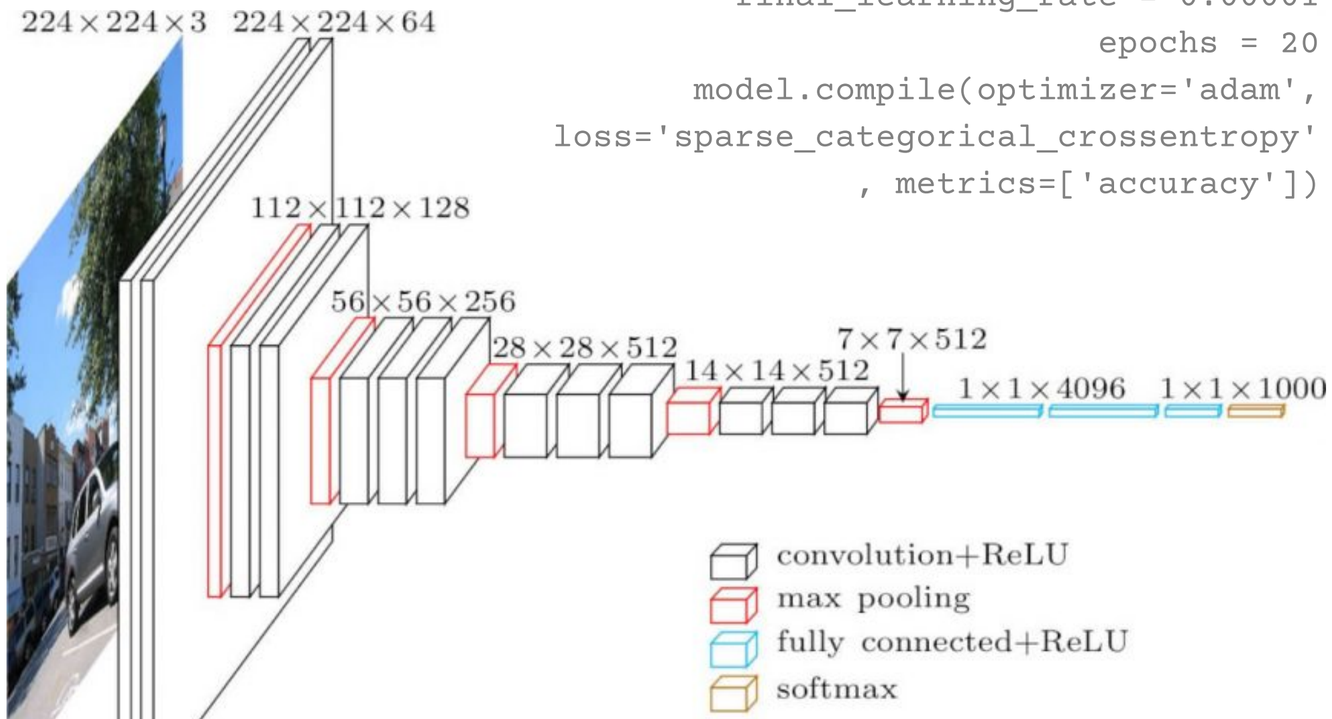


Methodology

3. CNN model development



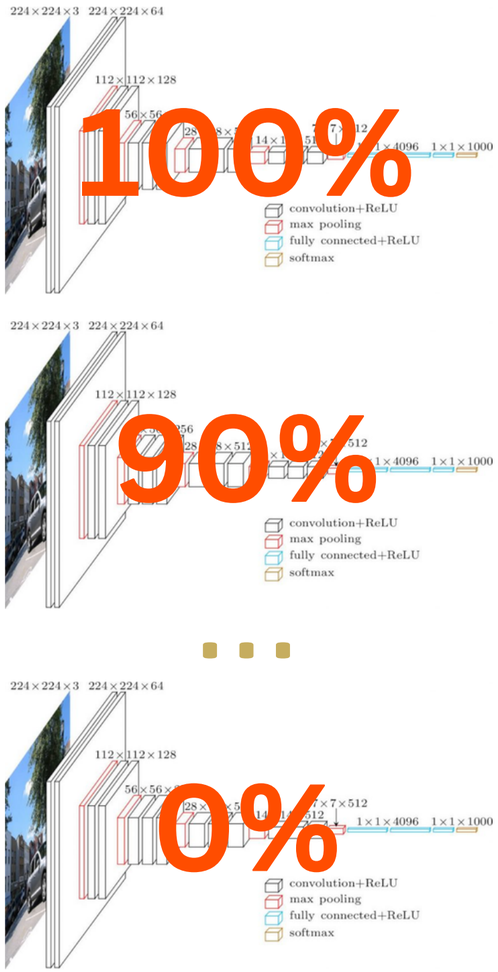

```
initial_learning_rate = 0.0001
final_learning_rate = 0.00001
epochs = 20
model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy'
, metrics=['accuracy'])
```

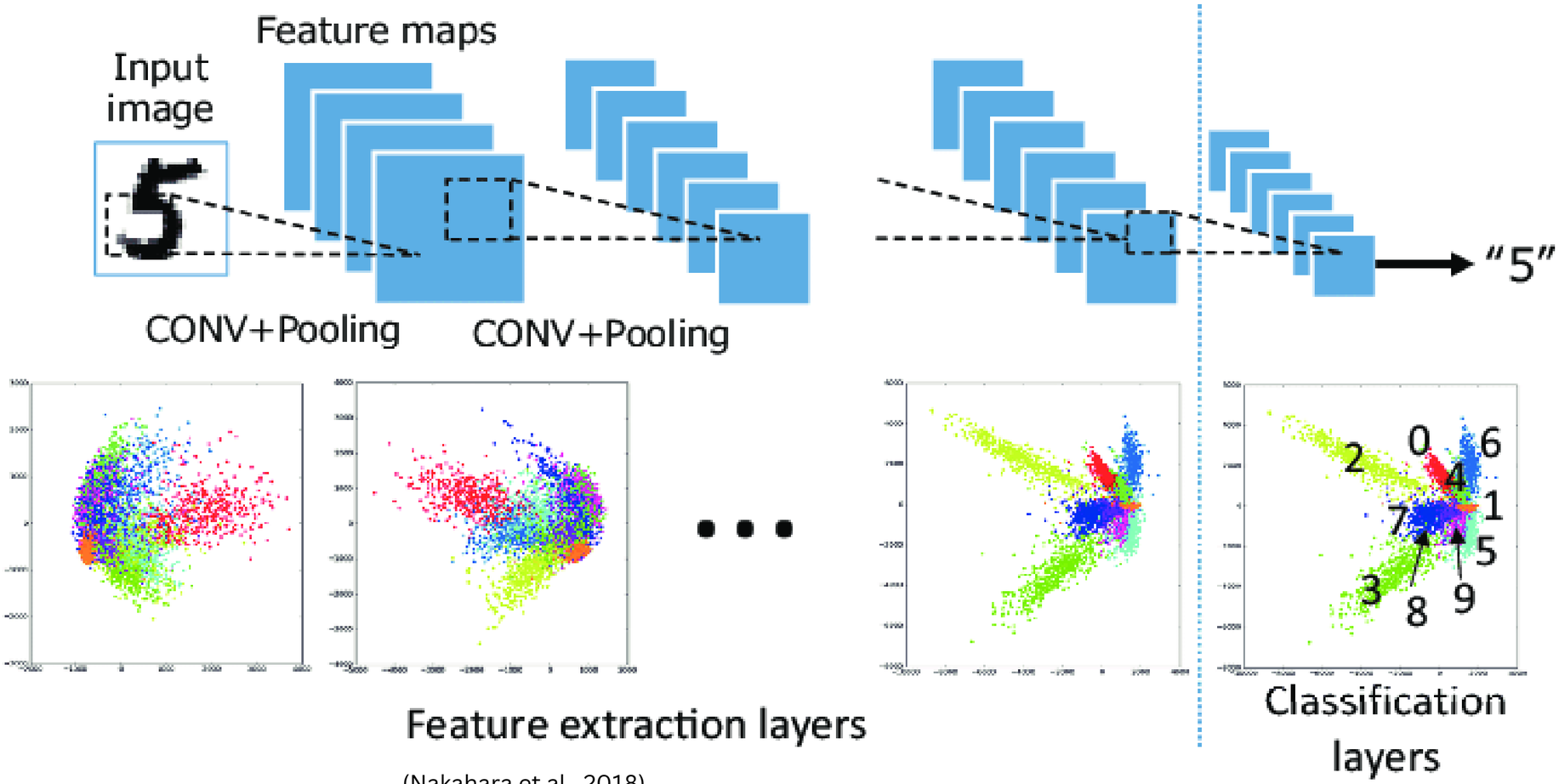


ResNet50

Methodology

4. PCA-Based Visualization of CNN Features

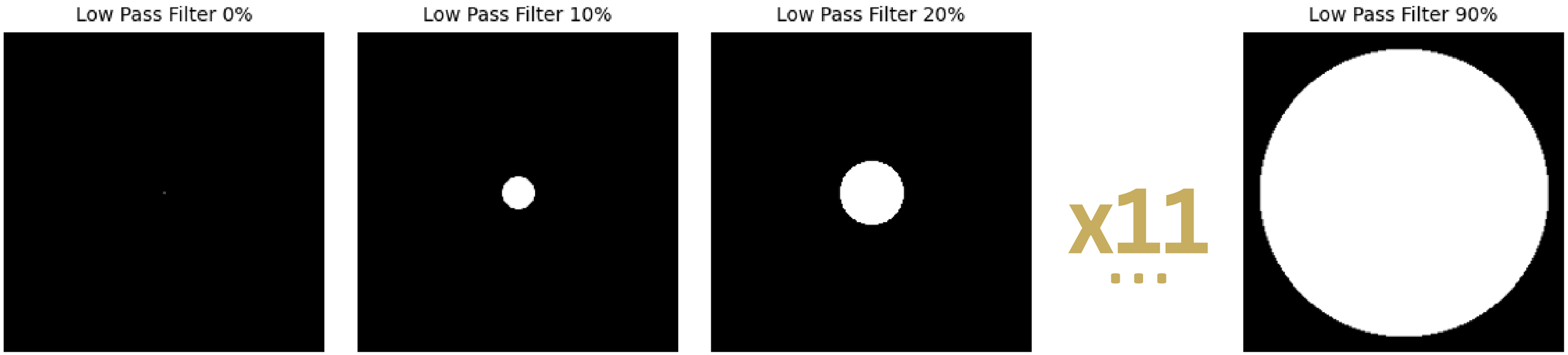


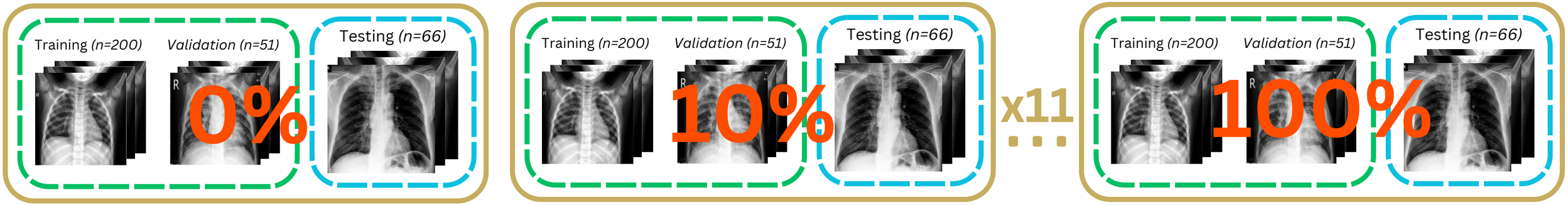


(Nakahara et al., 2018)

Results: 1) Dataset preparation and Low-pass filter preprocessing

Low-pass filters with 11 cut percentages was applied.

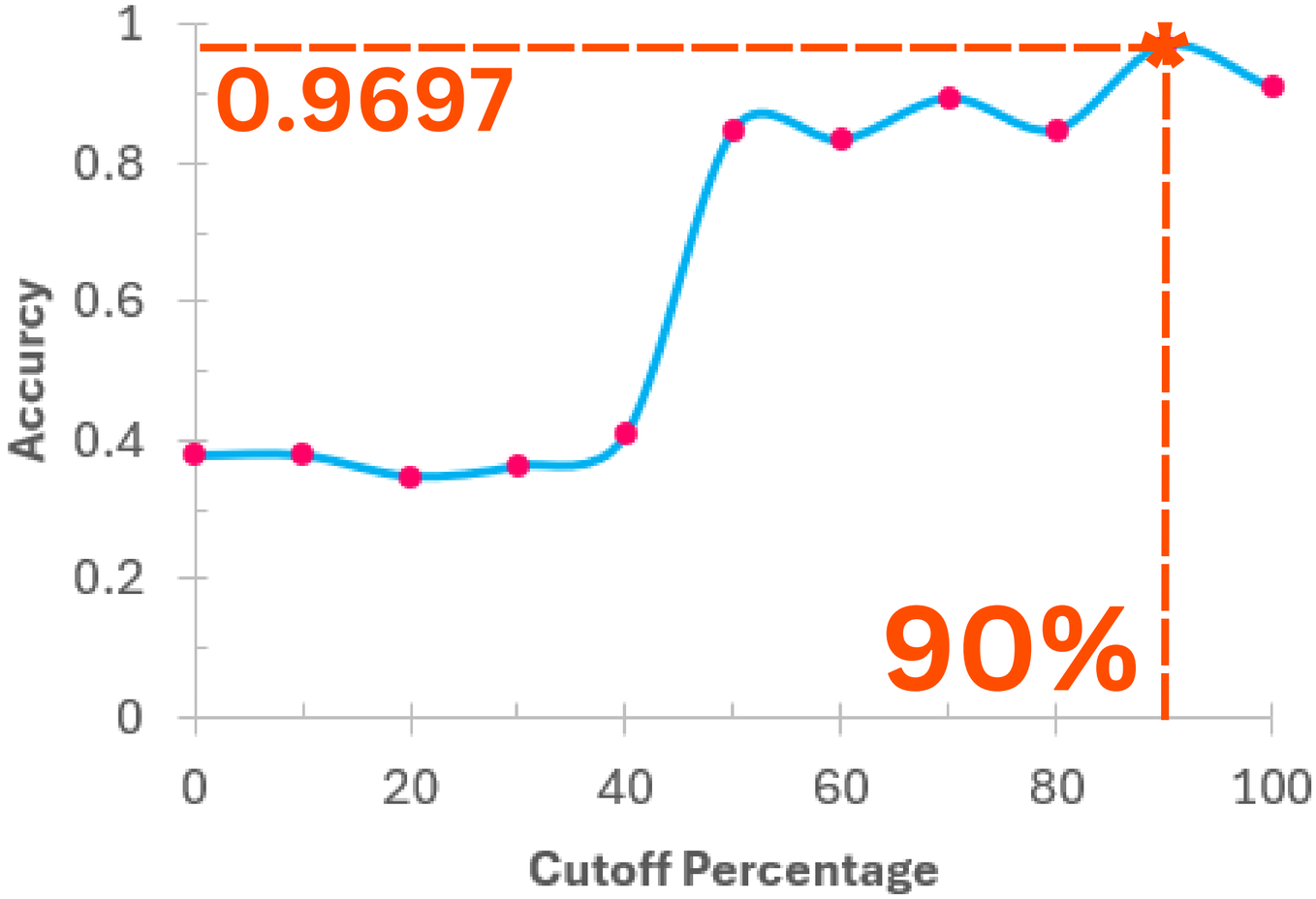




Results: 2) Effects of the low-pass filters on the CNN model training

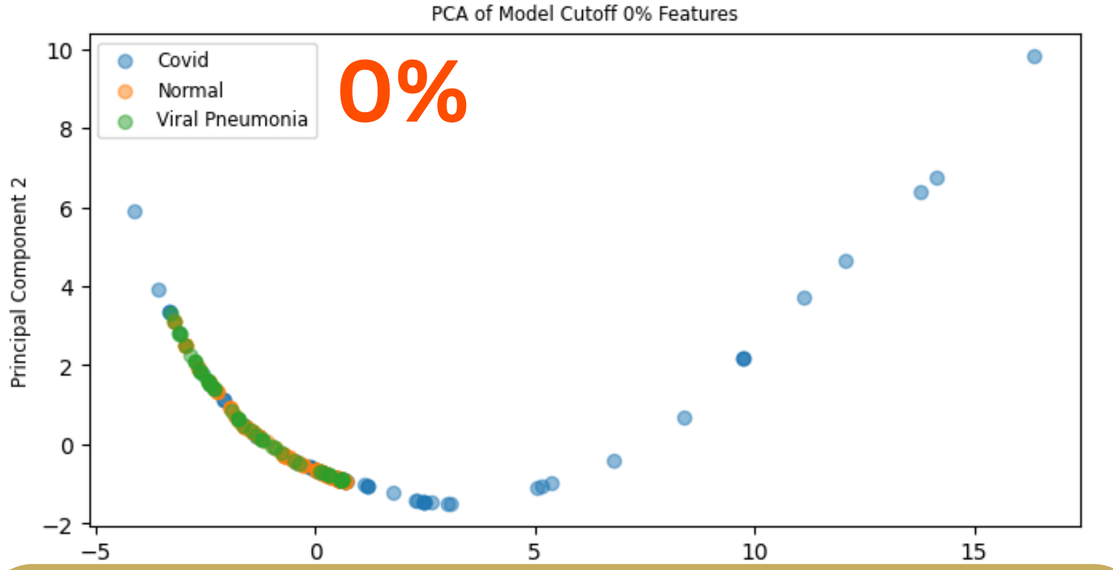
- **Highest model accuracy (0.9697) at a 90% low-pass filter cutoff.**
- **No Filtering Still Effective (100% cutoff), accuracy remains high at ≈0.9090.**
- **Accuracy Declines with Strong Filtering**

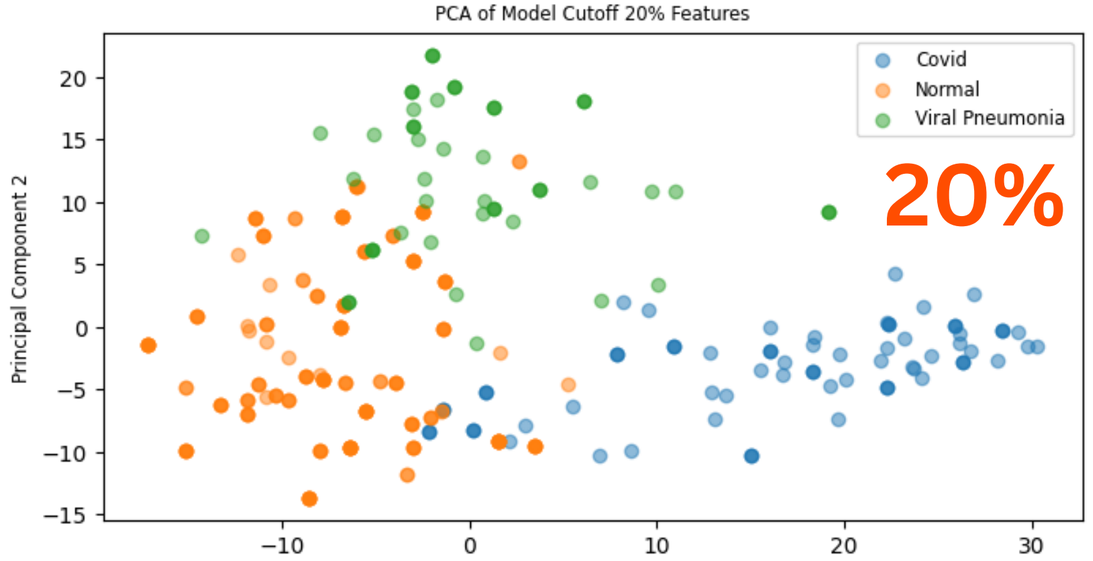
Figure Cutoff percentage of the low-pass filter effect on the model accuracy

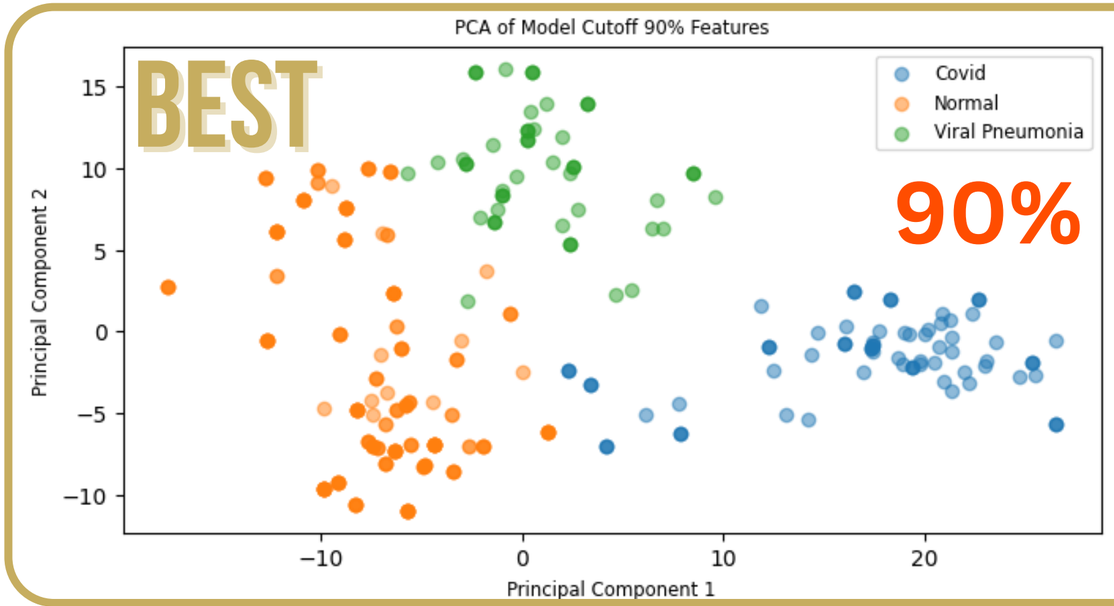


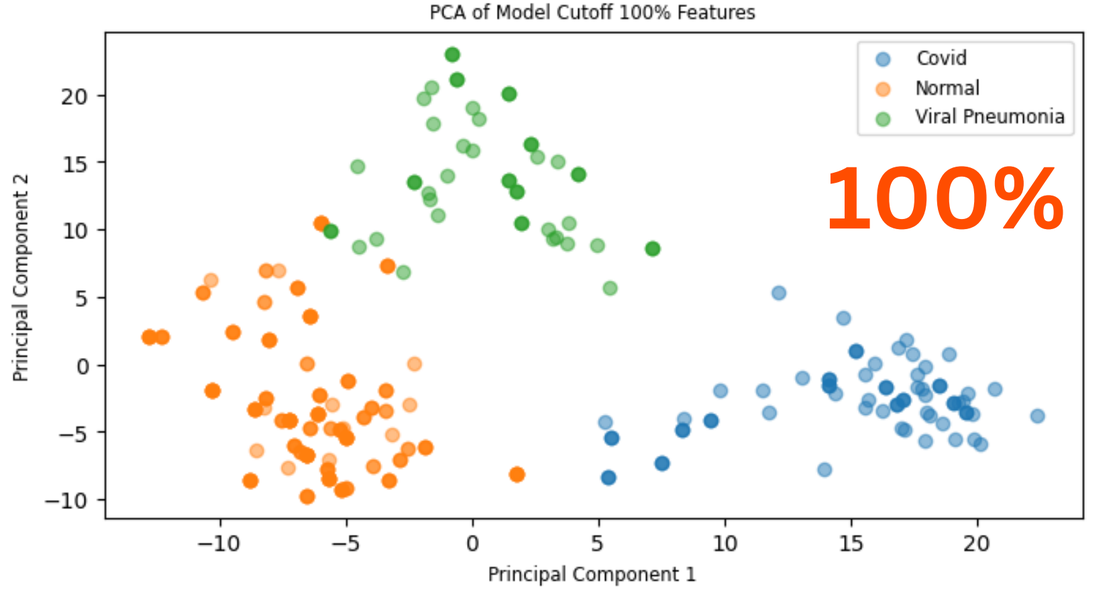
Results

3) The visualization of the CNN model features









Discussion

1) Impact of Low Pass Filtering on Image Quality and Model Performance

- Applying an optimal filtering enhances performance (90% cutoff), surpassing unfiltered images, by reducing noise without losing critical information.
- Accuracy drops significantly below the 90% cutoff, with the lowest at a 20% cutoff (0.3485), underscoring the importance of high-frequency details for image recognition.

2) Further Analysis with Principal Component Analysis (PCA)

- Optimal low-pass filtering (90% cutoff) via PCA analysis shows improved class distinction, aligning with its higher accuracy.
- At each optimal filtering level, PCA key features distinguishing different classes become more evident, supporting the observed increase in model accuracy.

Discussion

Limitations

- **Limited data resource**
- **Impact** of **low-pass filter vary across different cut percentages.**
- **Low-pass filter needs task-specific optimization** before processing data.
- Not much research on the combination of low-pass filter and data augmentation or preprocessing technique is not widely study

Conclusion

“ Our analysis shows the significance of optimal low pass filtering in enhancing CNN model performance for medical imaging tasks. By balancing the removal of noise with the preservation of critical high-frequency details, models can improved accuracy and feature discrimination. ”

References

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