



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

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Agenda

Introduction

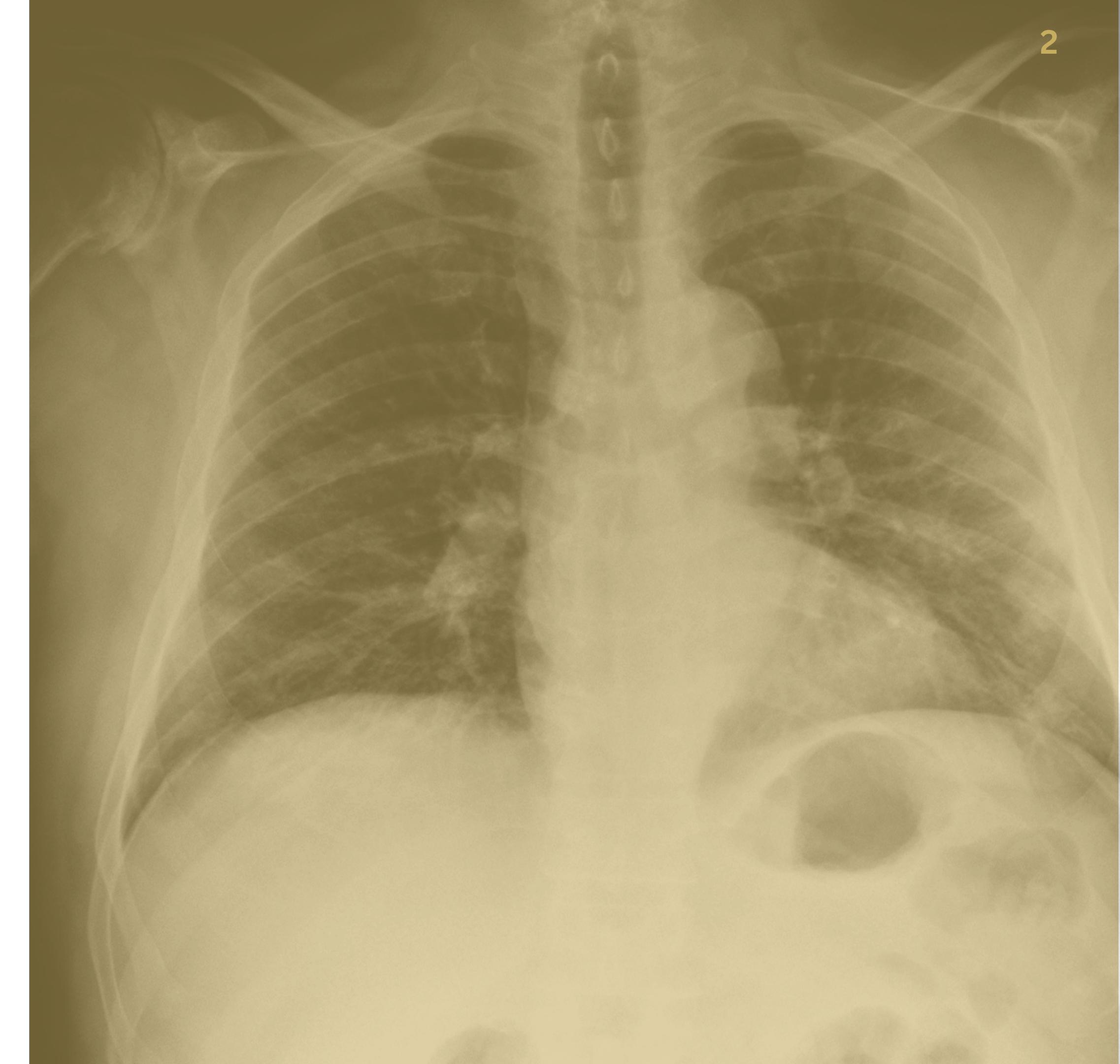
Objectives

Methodology

Results

Discussion

Conclusion



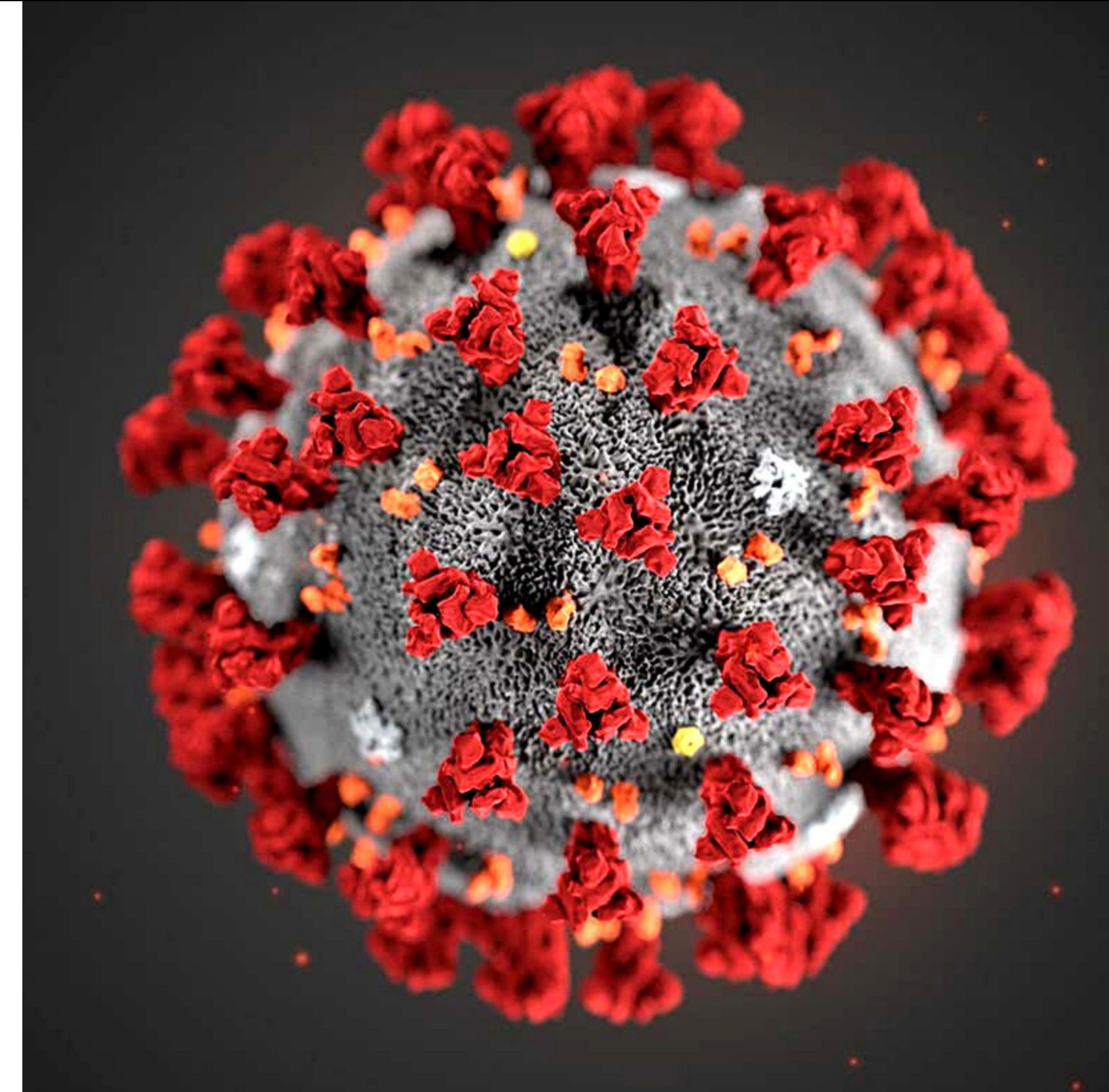
Introduction

- 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 **lowering memory** requirements
- **PCA** : efficient method for analyzing and classifying images.



Introduction

ResNet50

A widely used deep convolutional neural network for image extraction

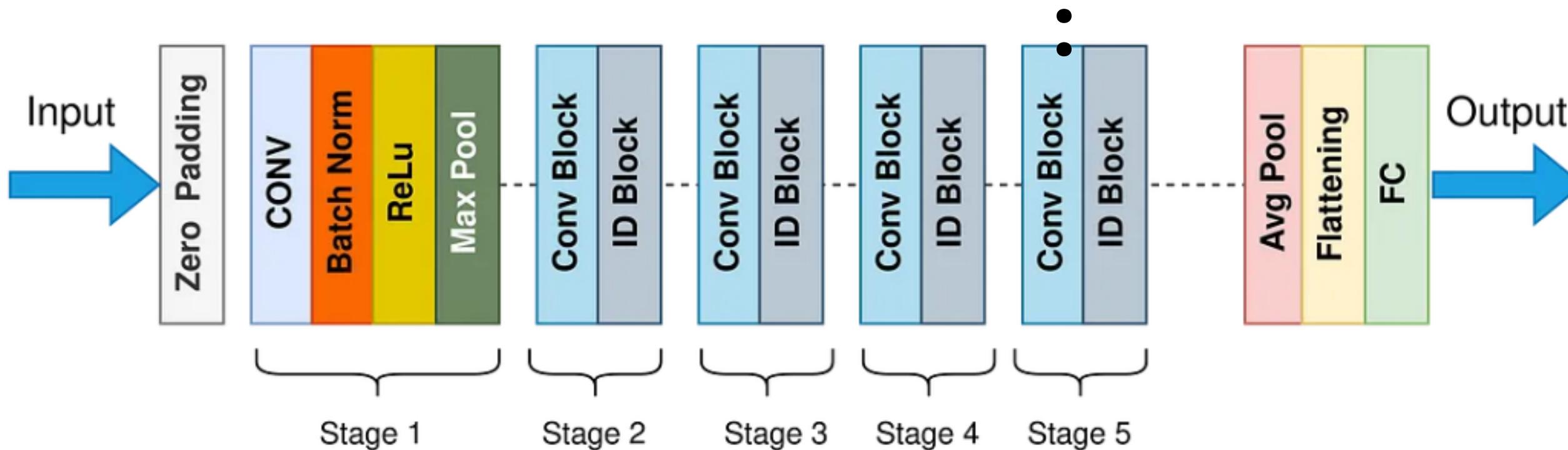


Figure ResNet50 Model Architecture
(Mukherjee & Praveen, 2022)

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

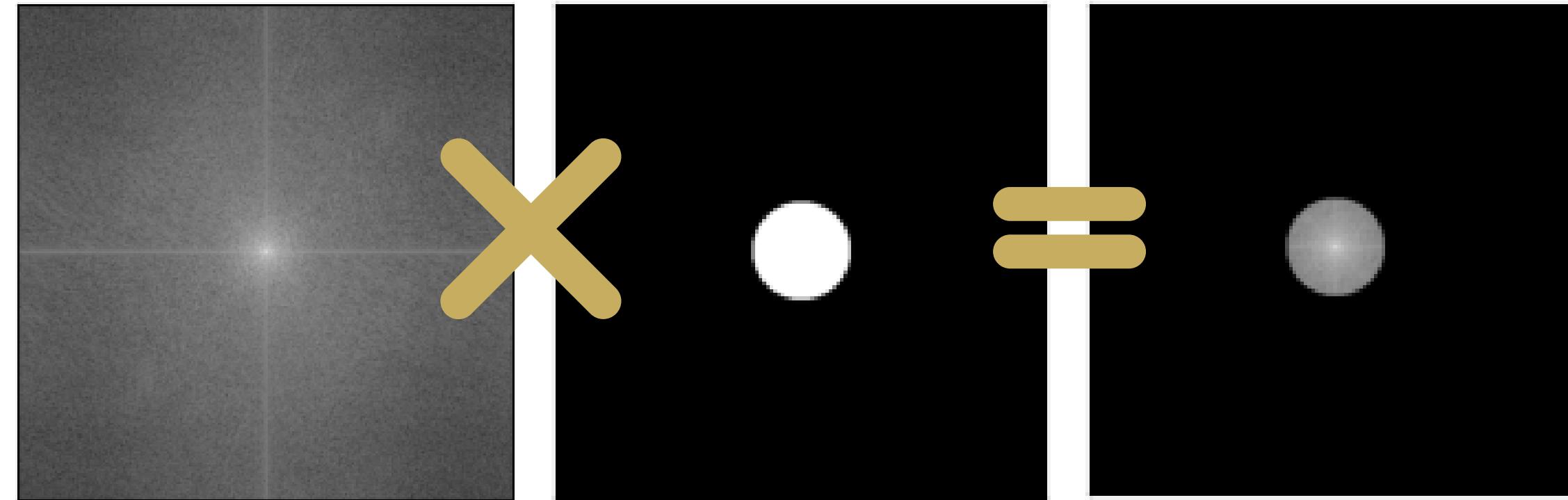
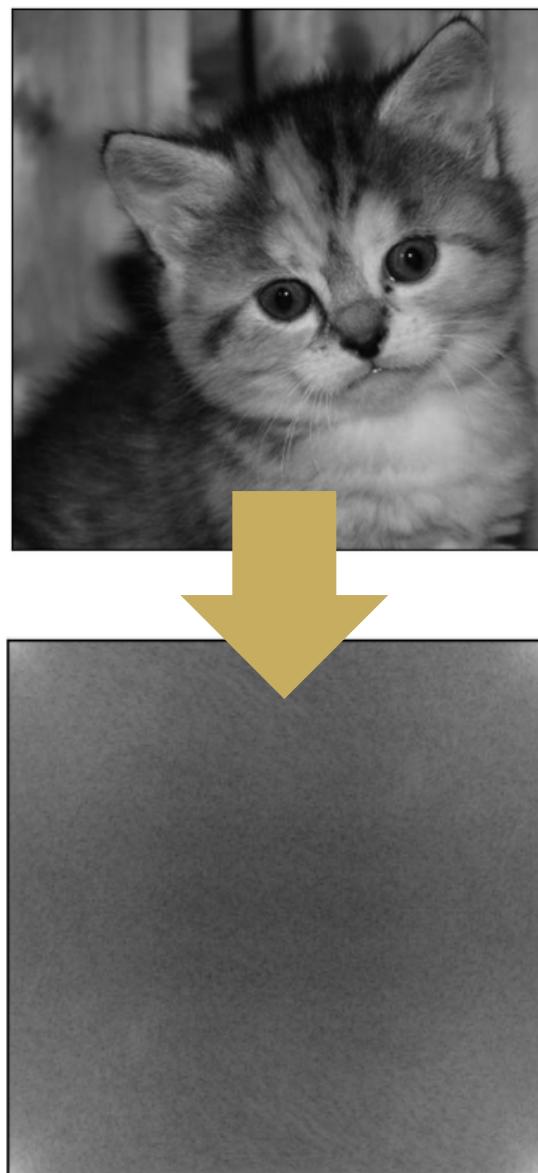
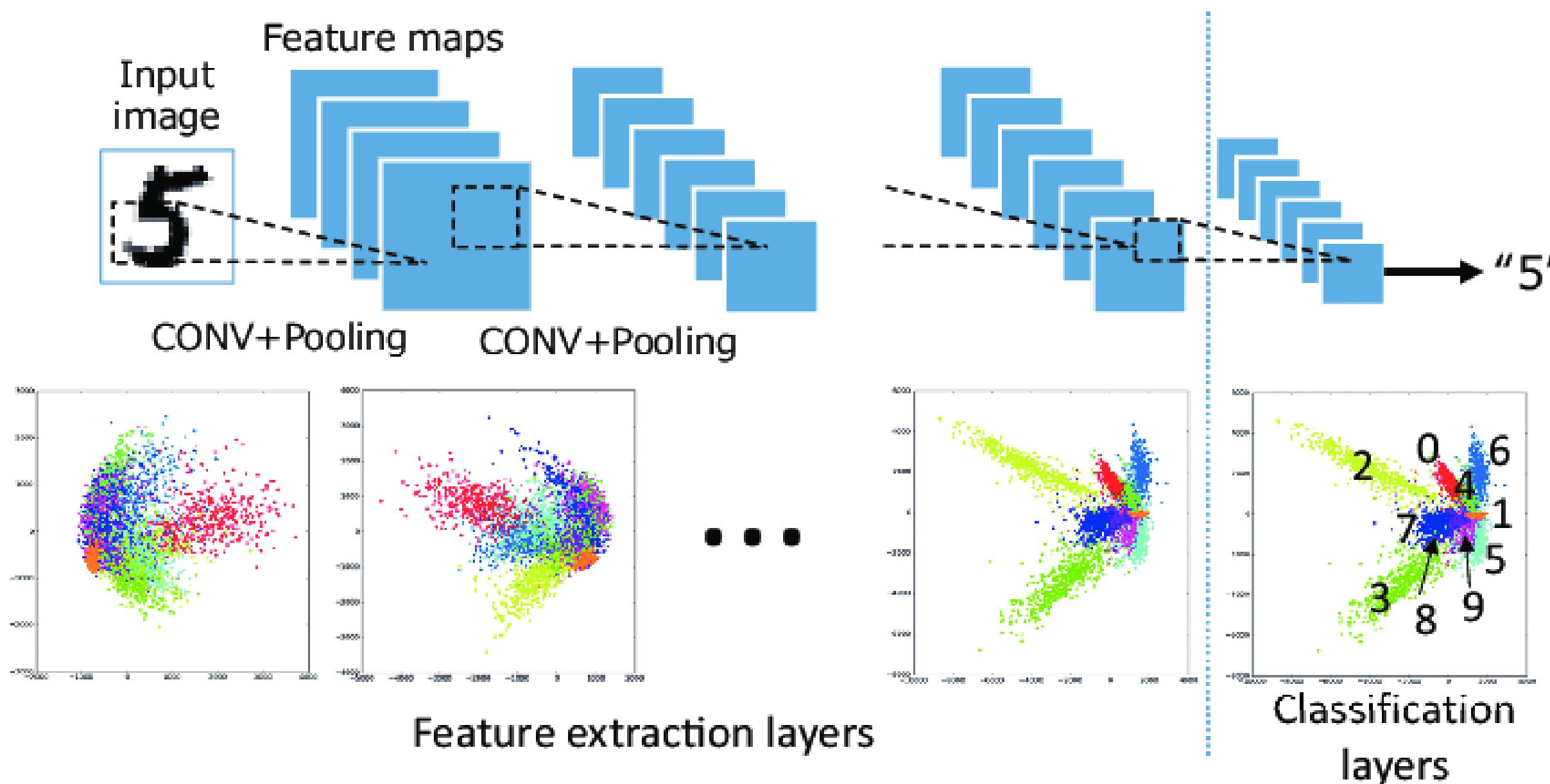


Figure Low-pass filter principle

Introduction

Principal component analysis (PCA)

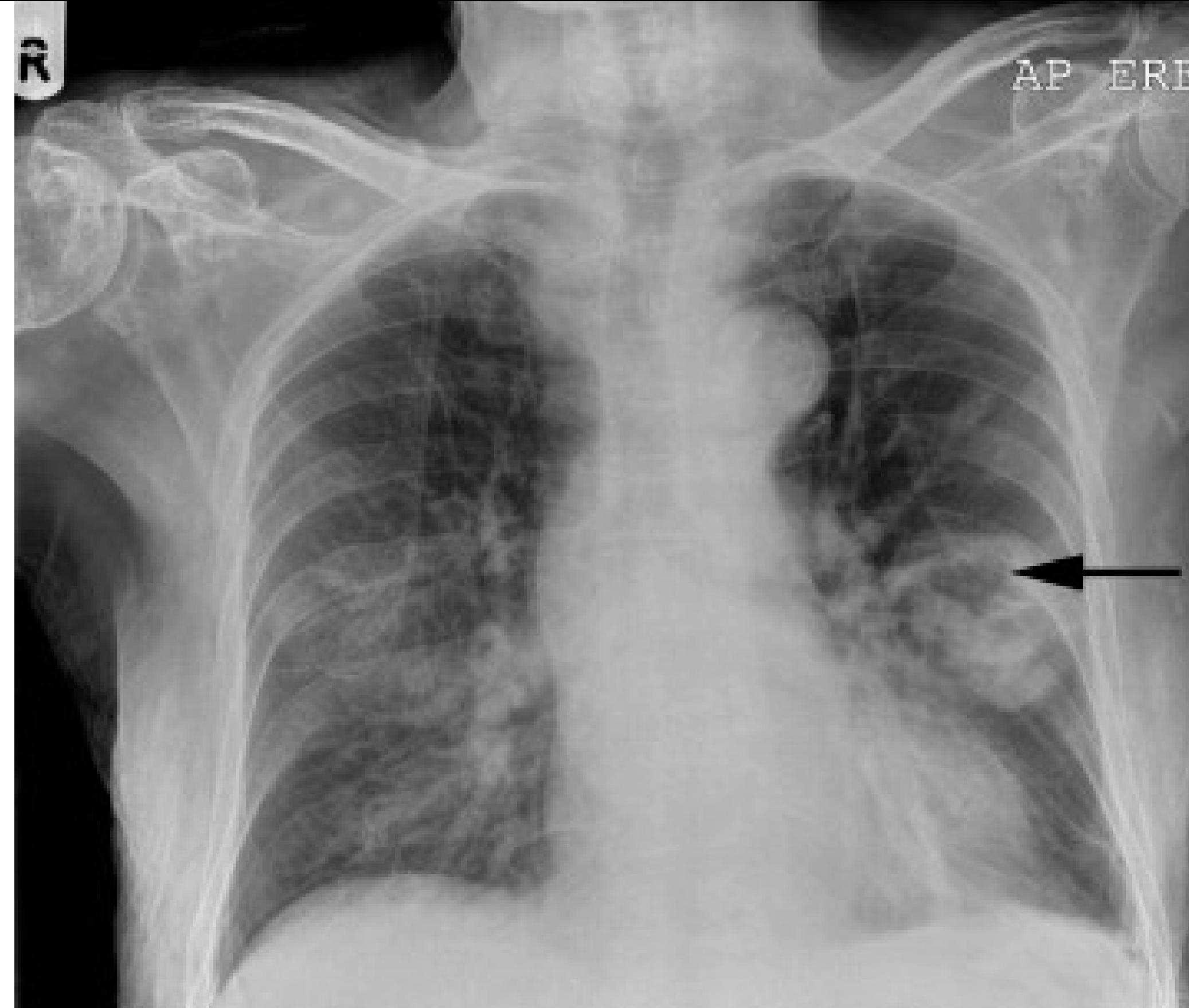


- Efficient method for analyzing and classifying the image
- Advantages: improves visualization and understanding of complex data
- Disadvantages: Loss of information due to dimensionality reduction.

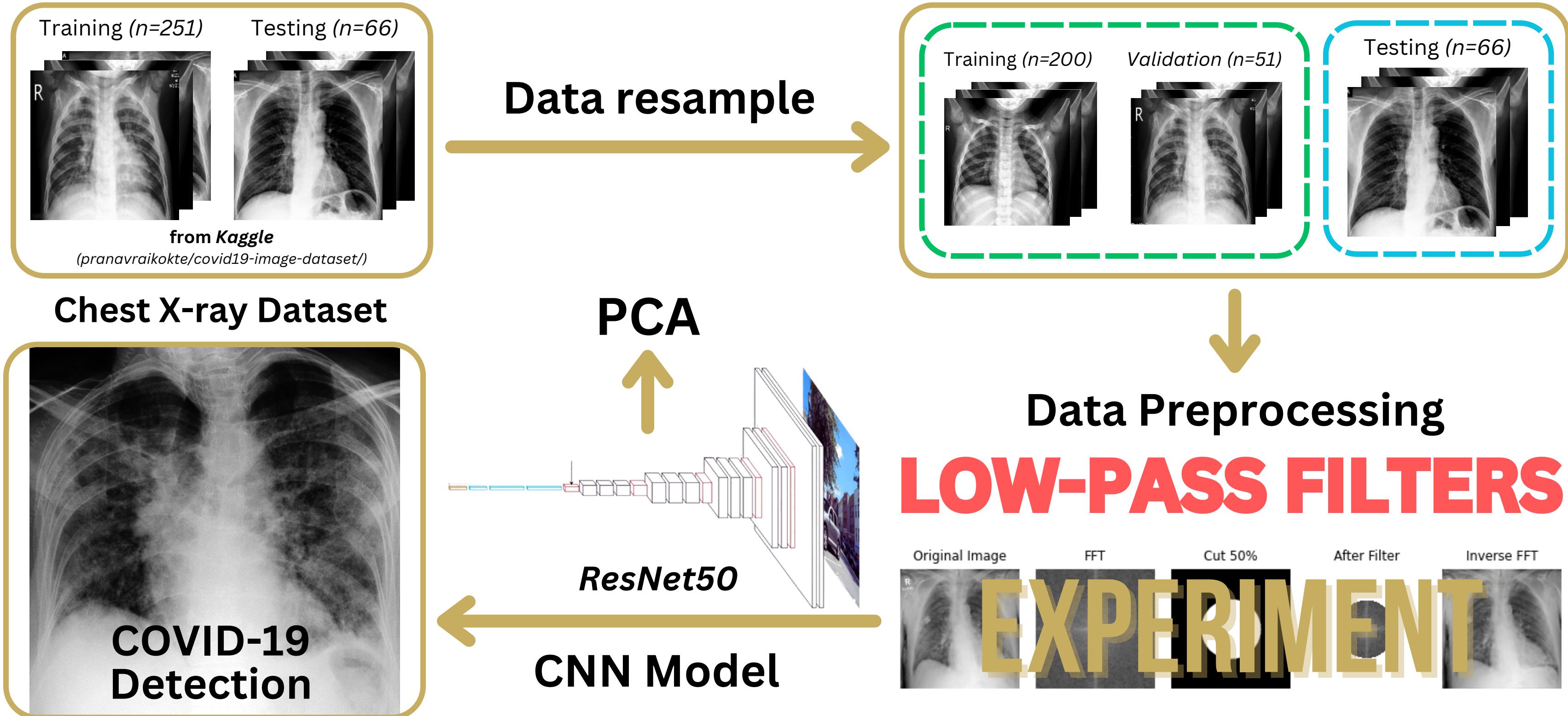
Figure Principal Component Analysis (Nakahara et al., 2018)

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

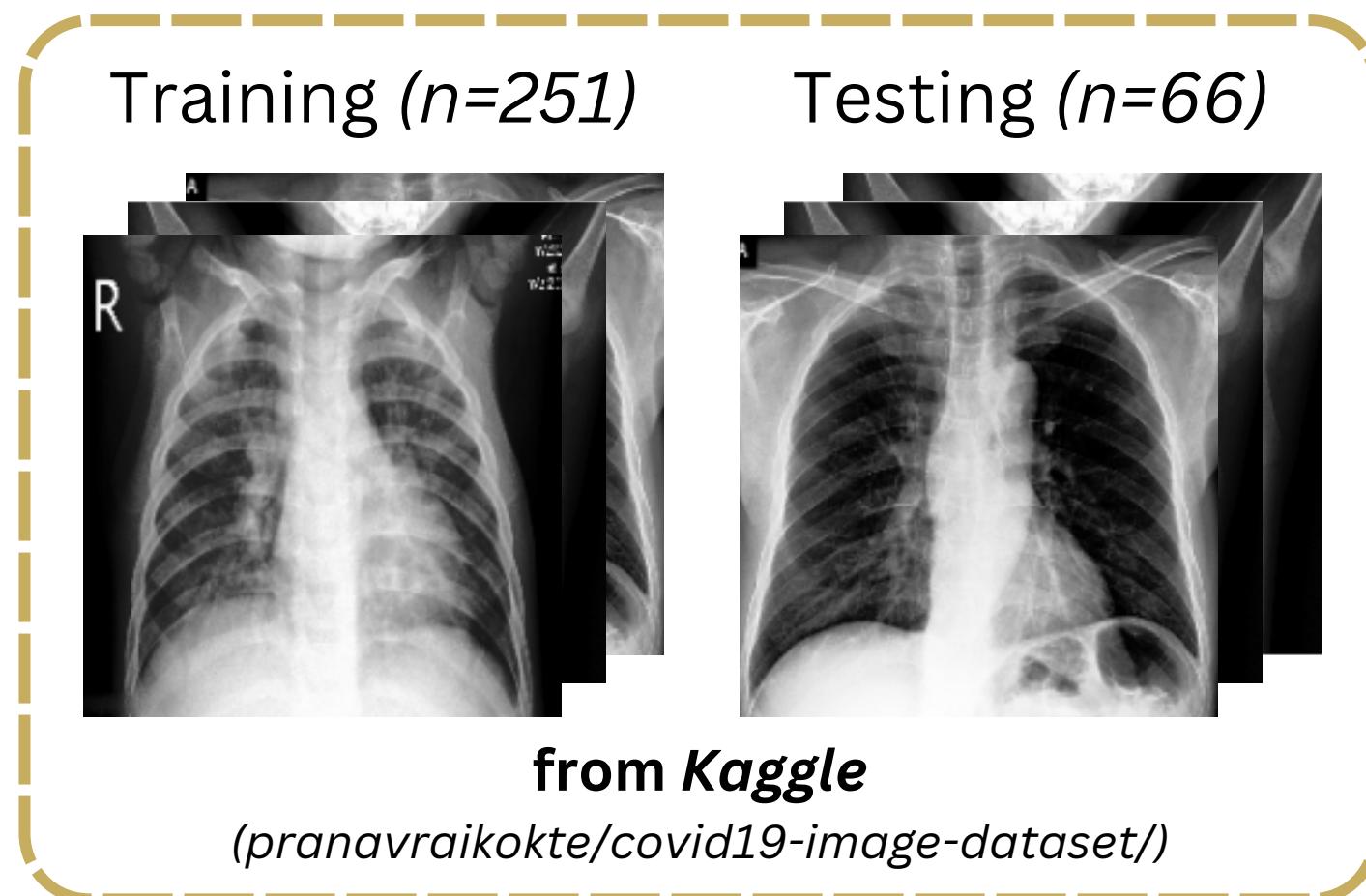


Experimental Design



Methodology

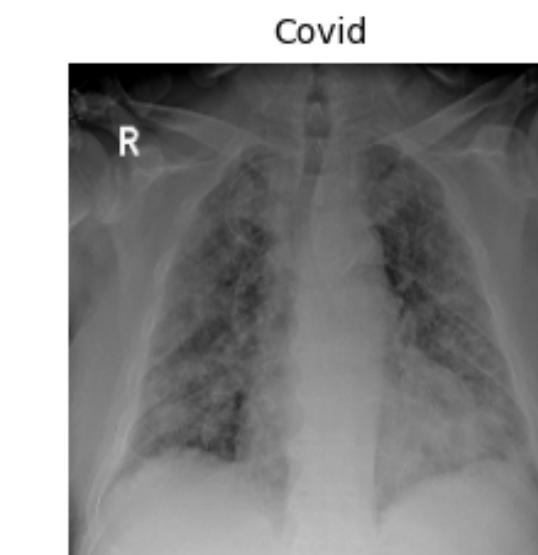
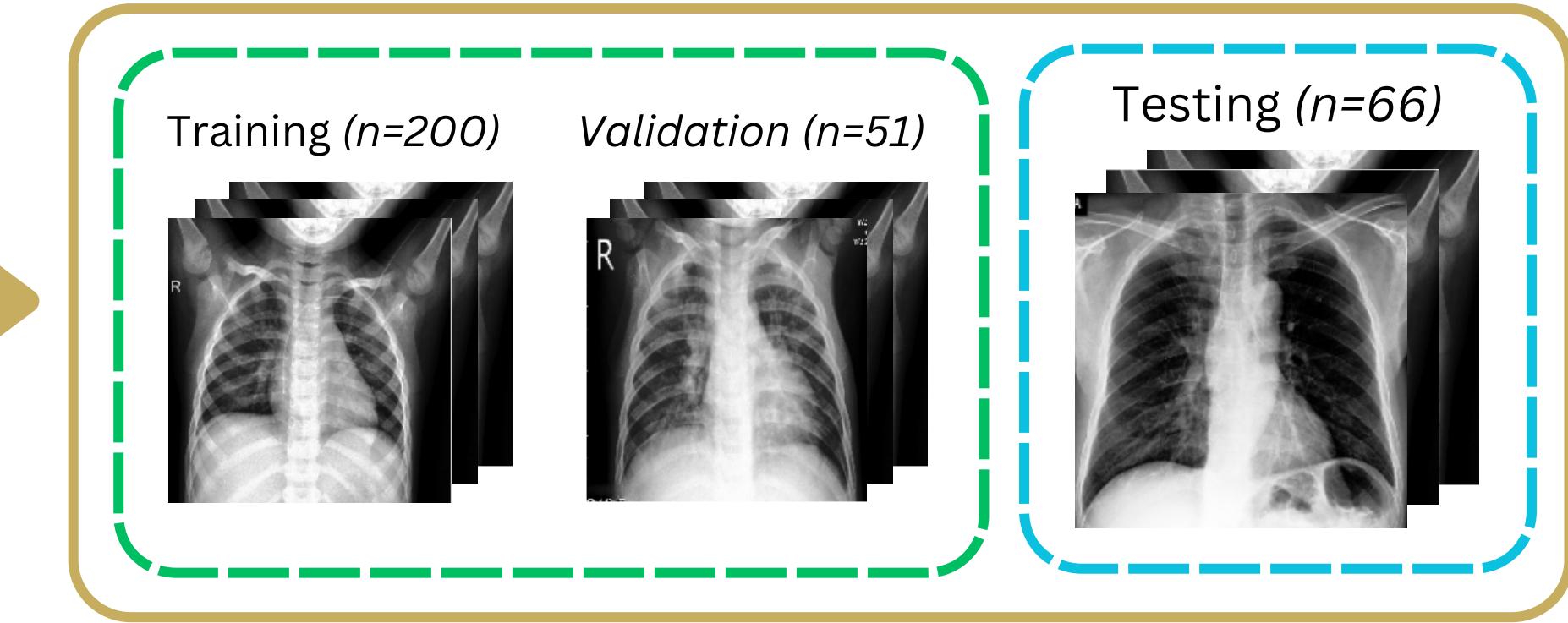
1. Dataset preparation



Chest X-ray Dataset

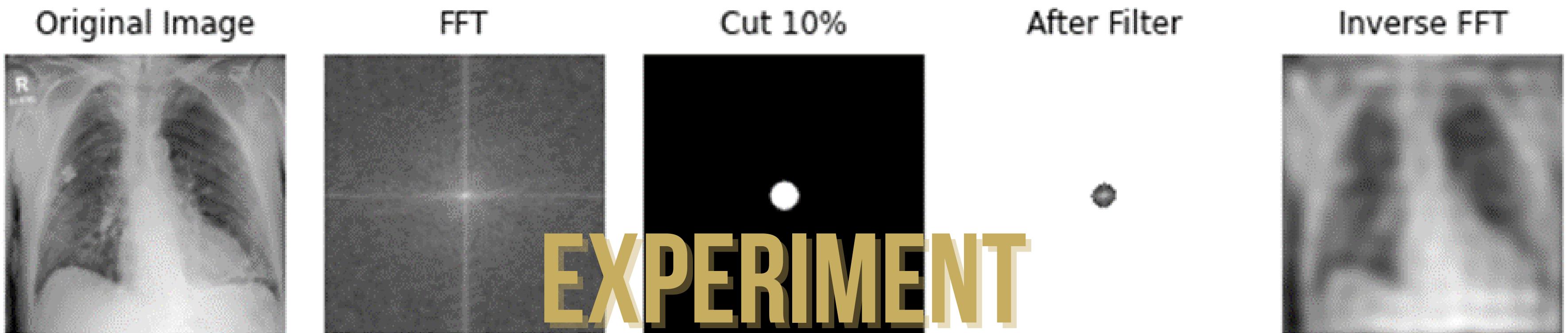
- 3 classes:**
- COVID-19 pneumonia (+)
 - Viral pneumonia (-)
 - Normal (-)

Data resample

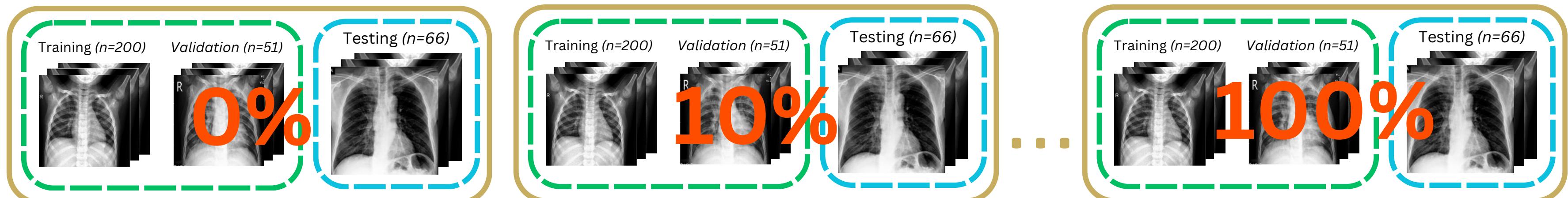


Methodology

2. Low-pass filter application on the dataset

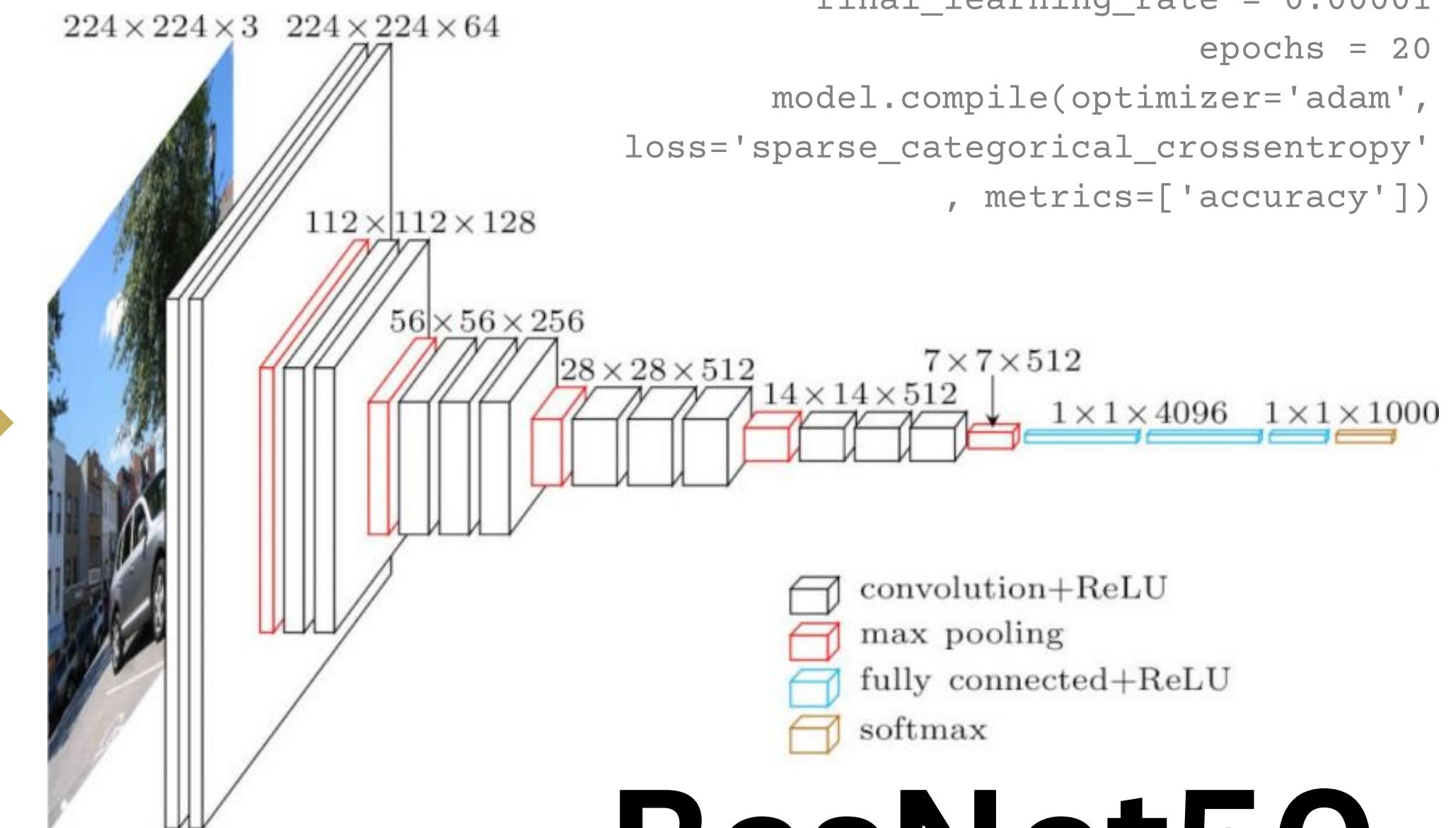
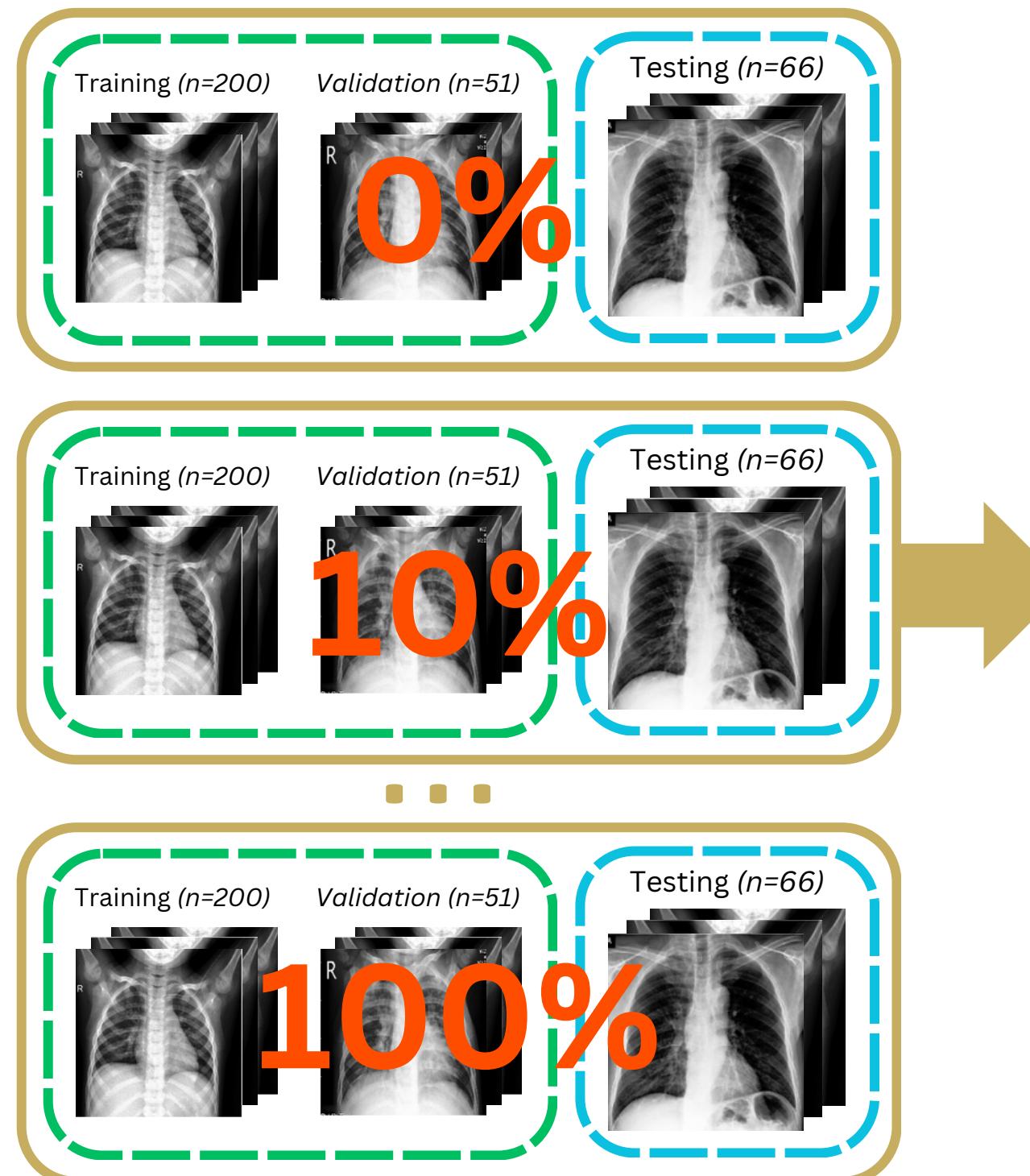


for cut_percentage in range(0, 101, 10):



Methodology

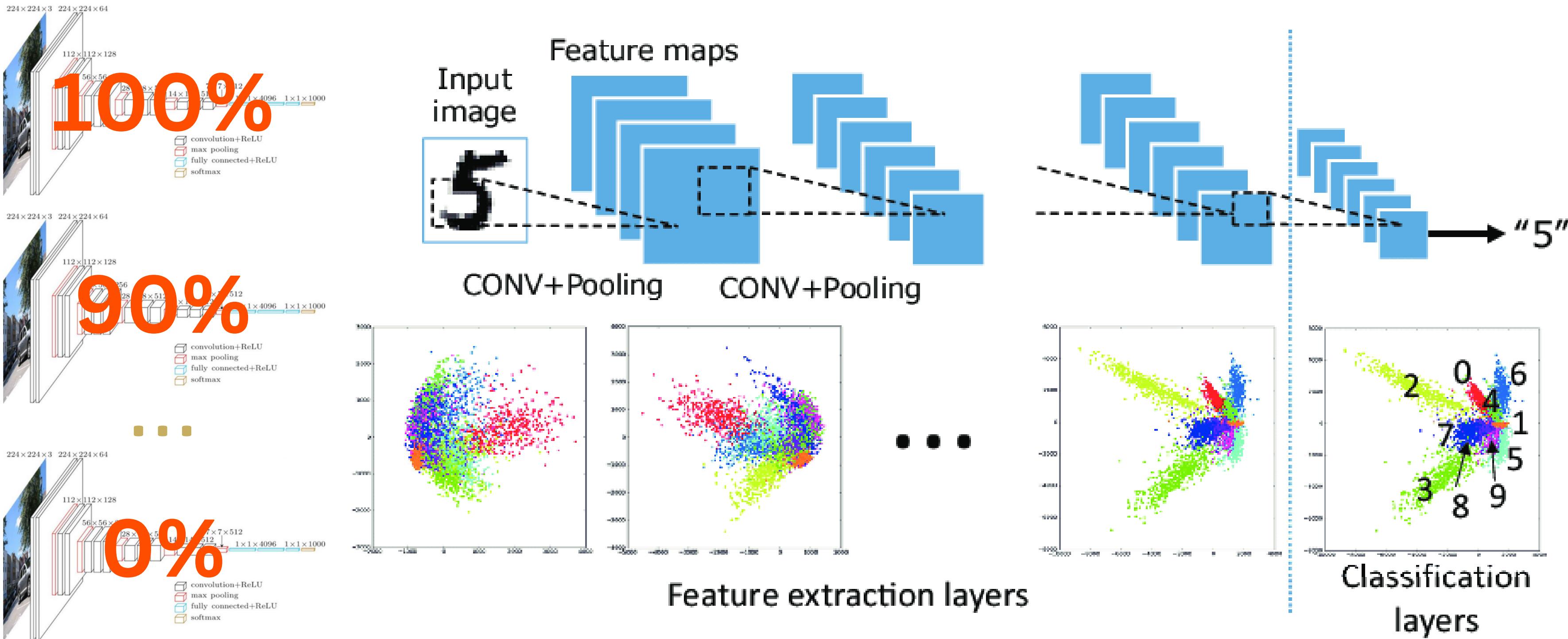
3. CNN model development



ResNet50

Methodology

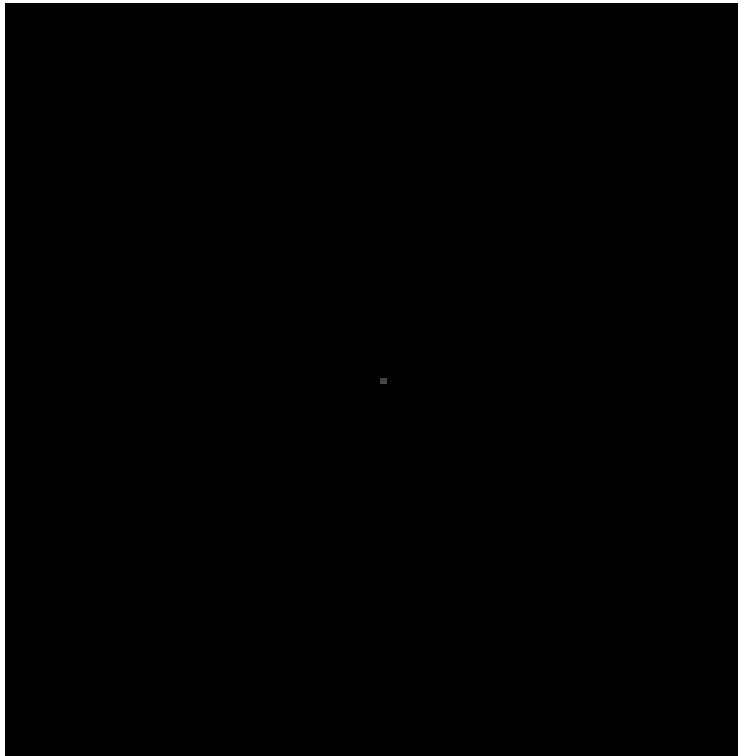
4. PCA-Based Visualization of CNN Features



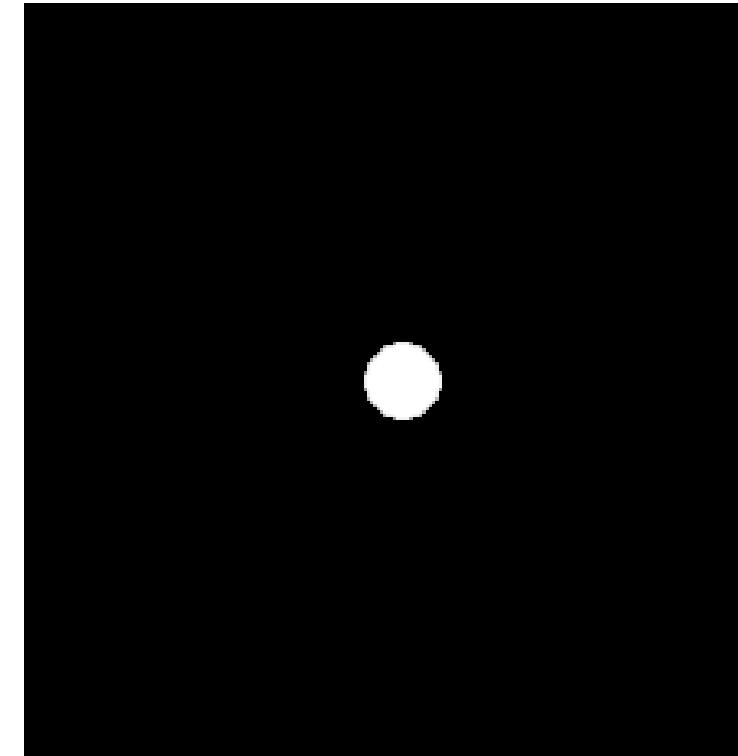
Results: 1) Dataset preparation and Low-pass filter preprocessing

Low-pass filters with 11 cut percentages was applied.

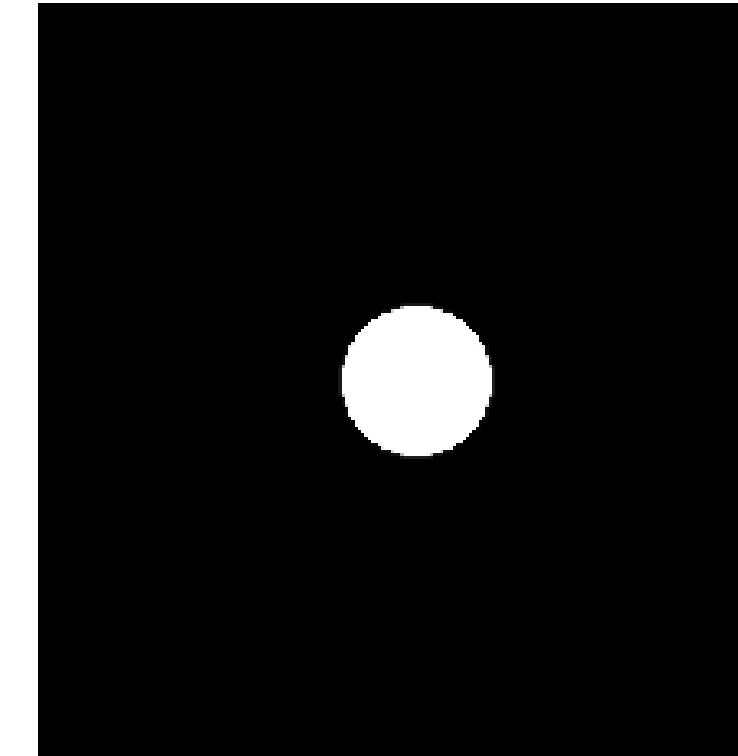
Low Pass Filter 0%



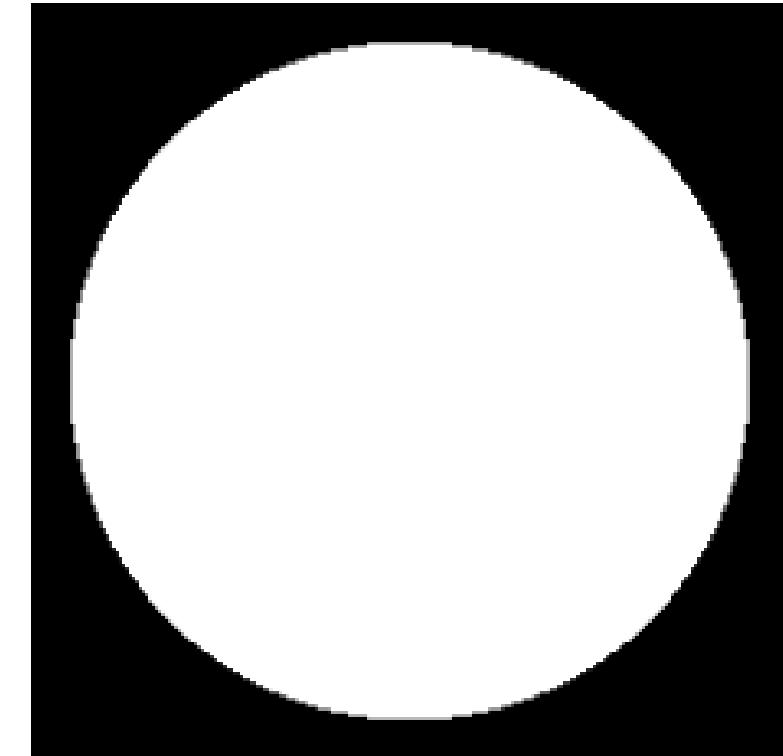
Low Pass Filter 10%



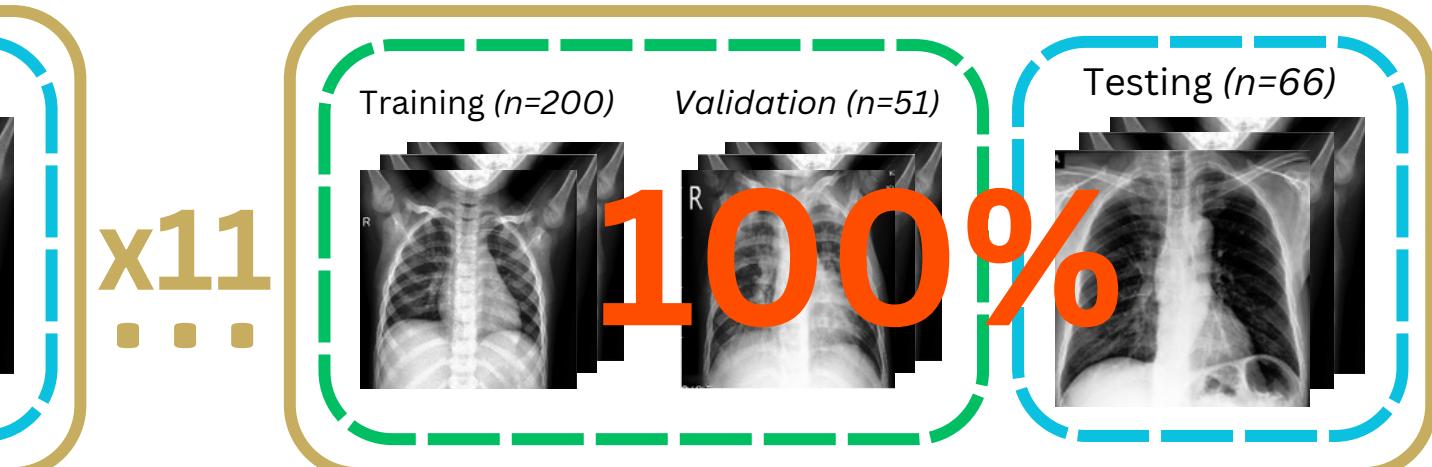
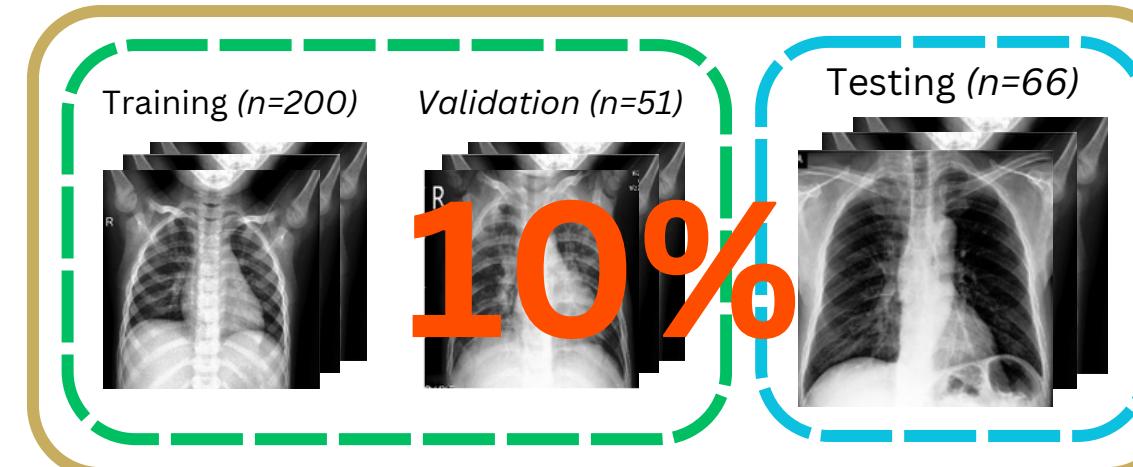
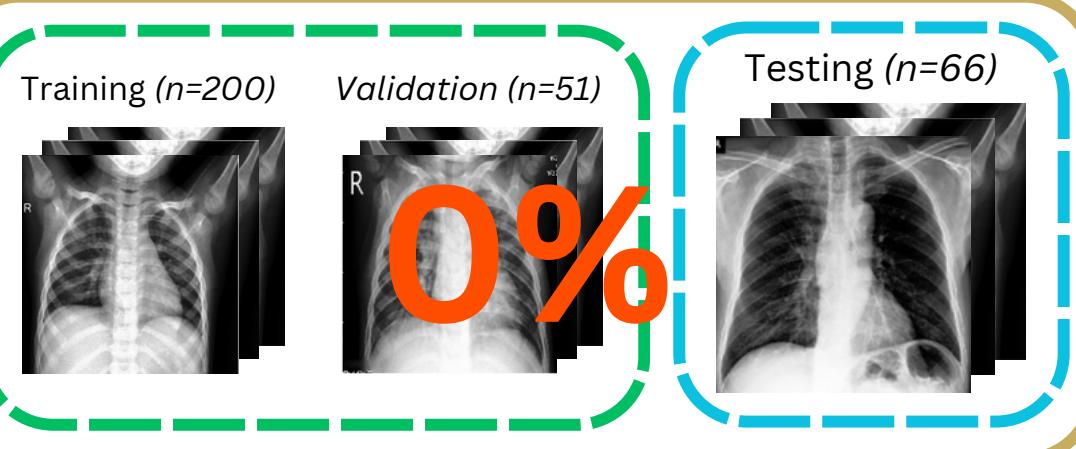
Low Pass Filter 20%



Low Pass Filter 90%



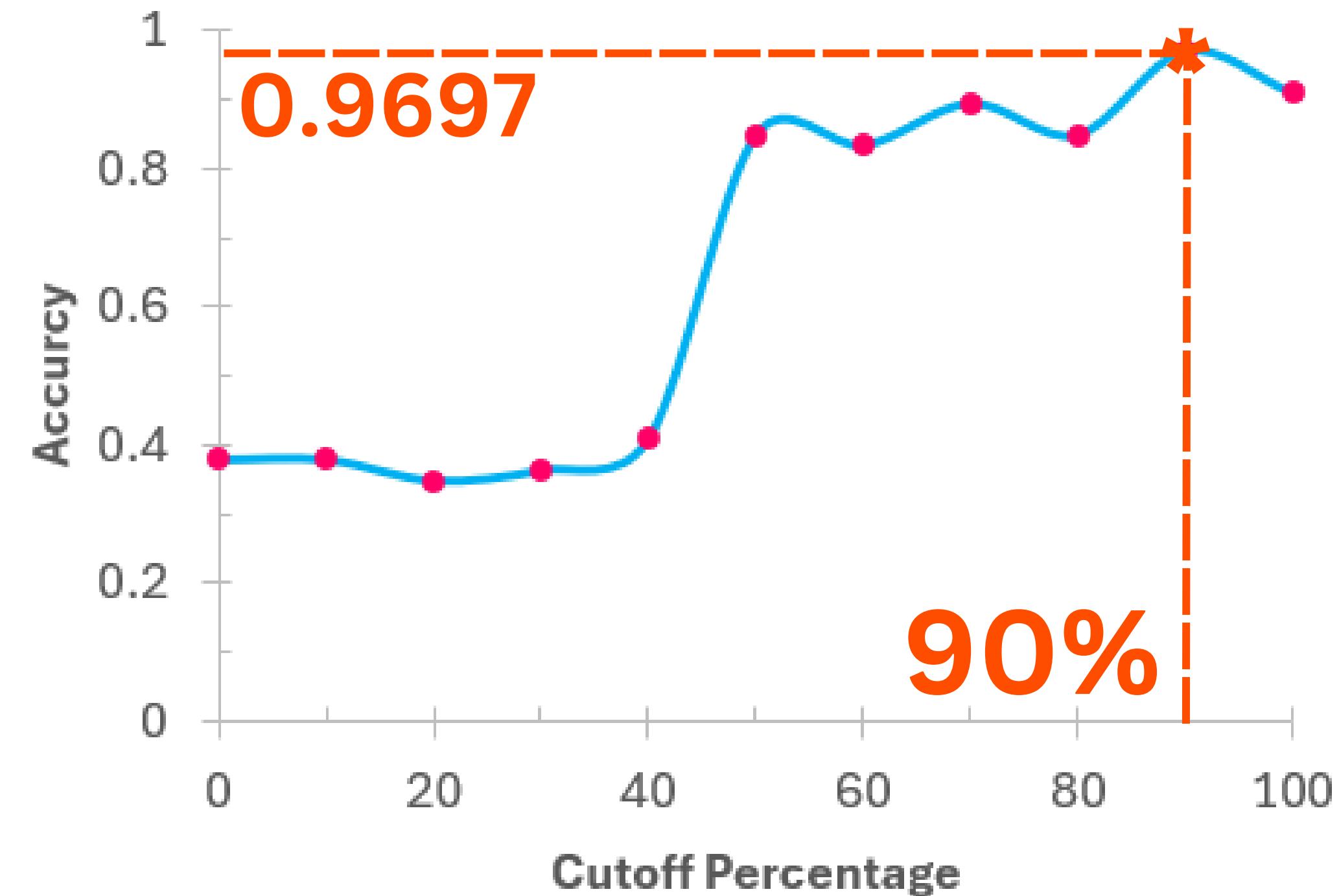
x11
...



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

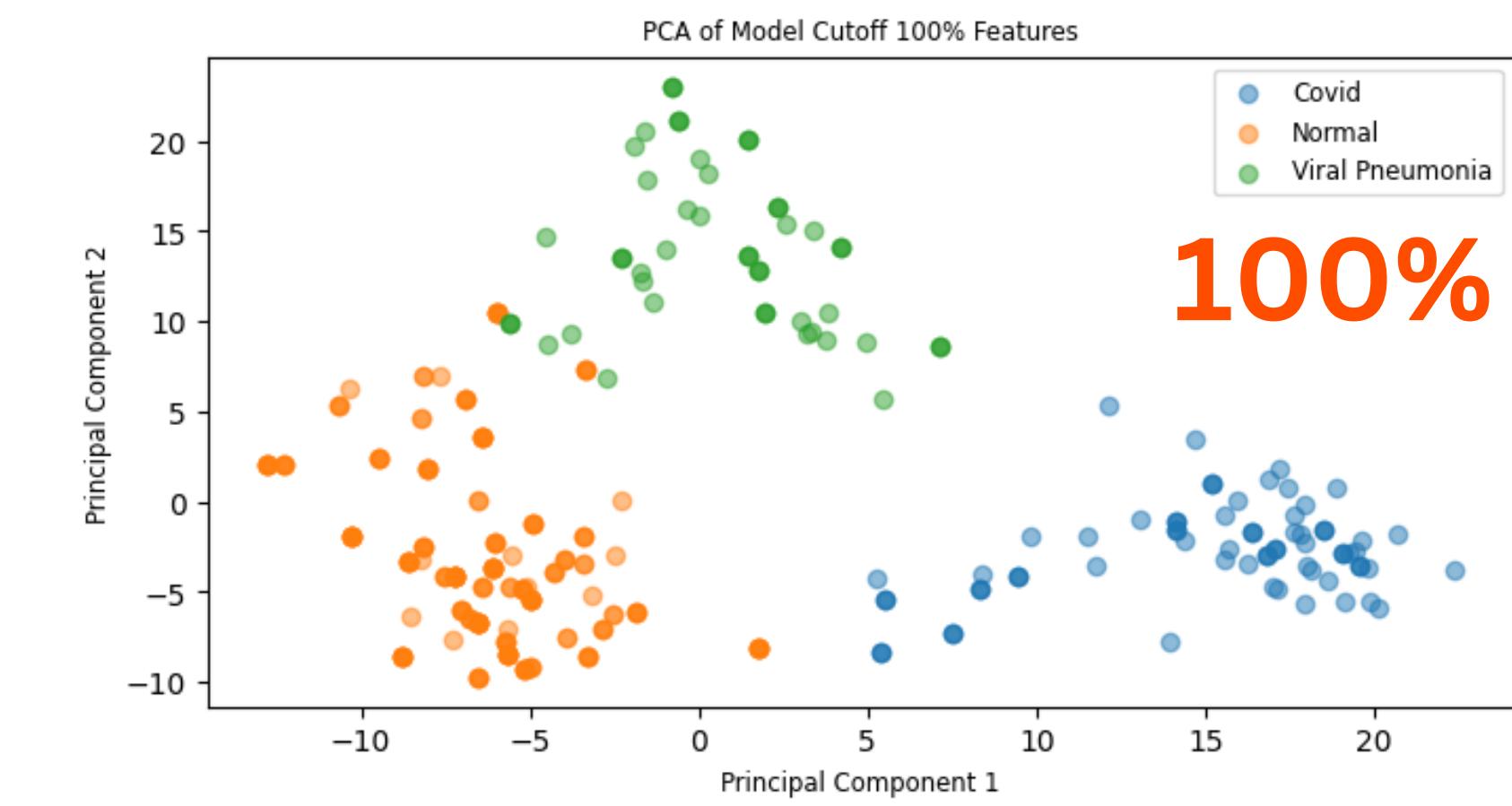
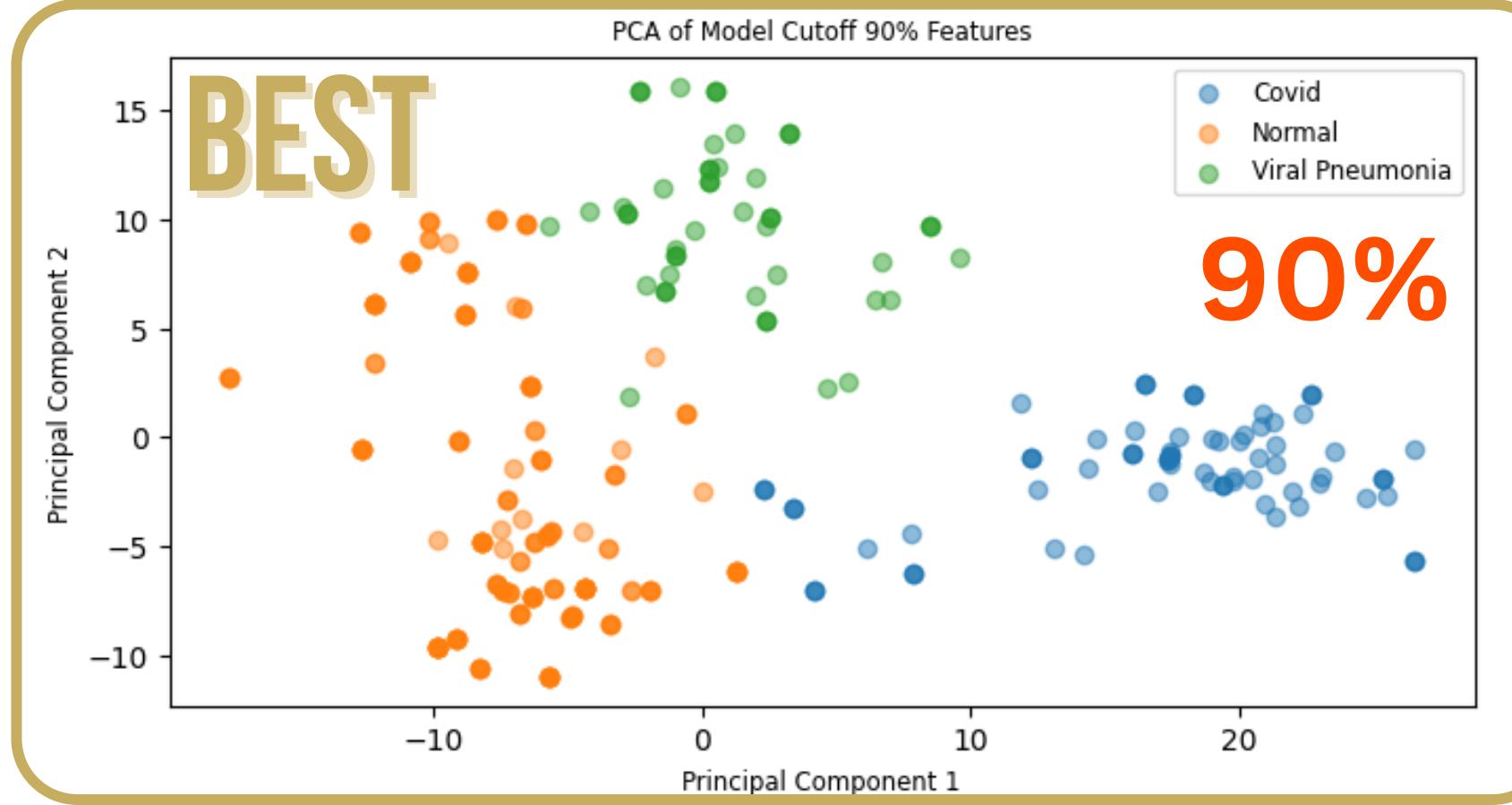
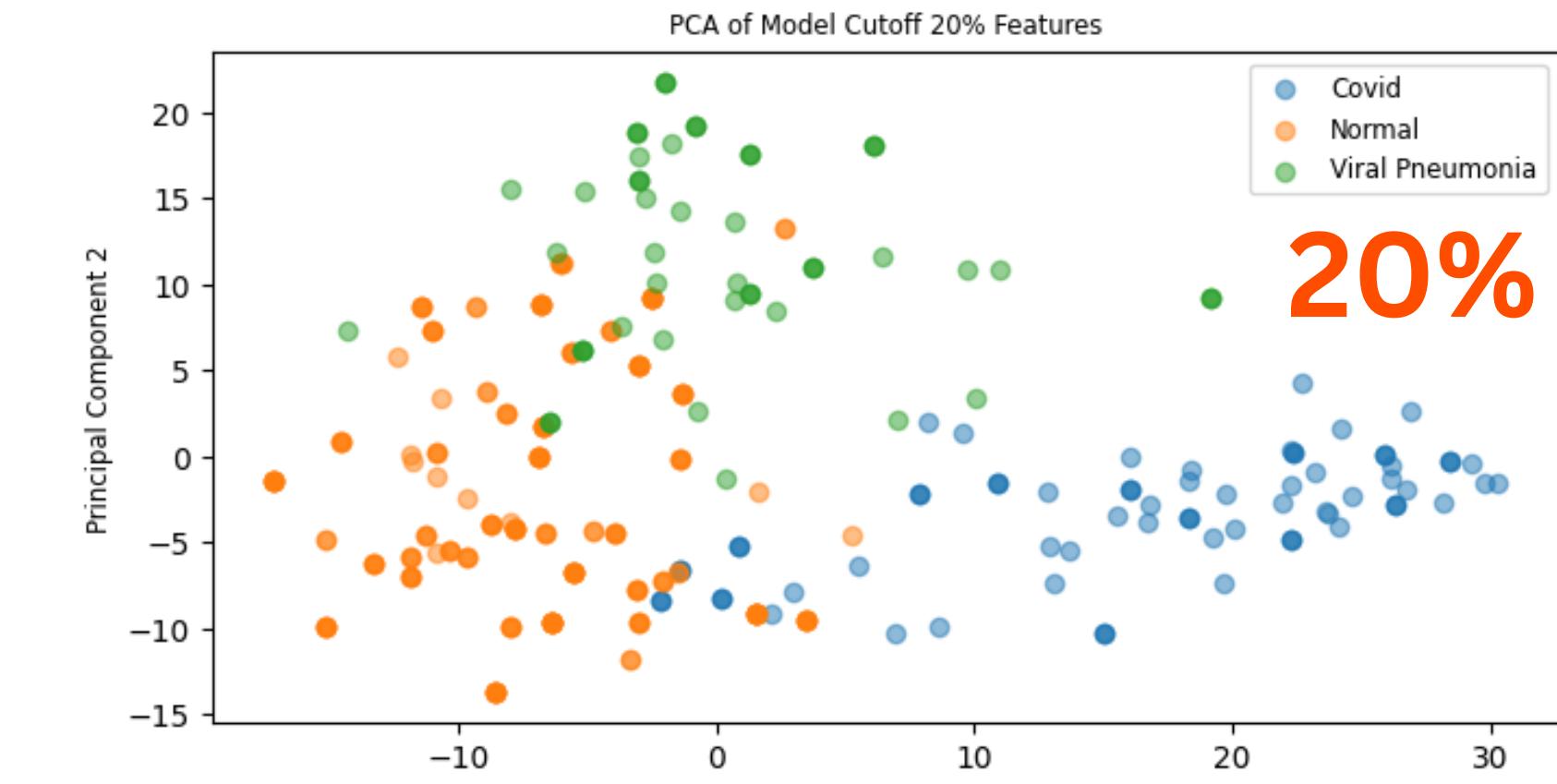
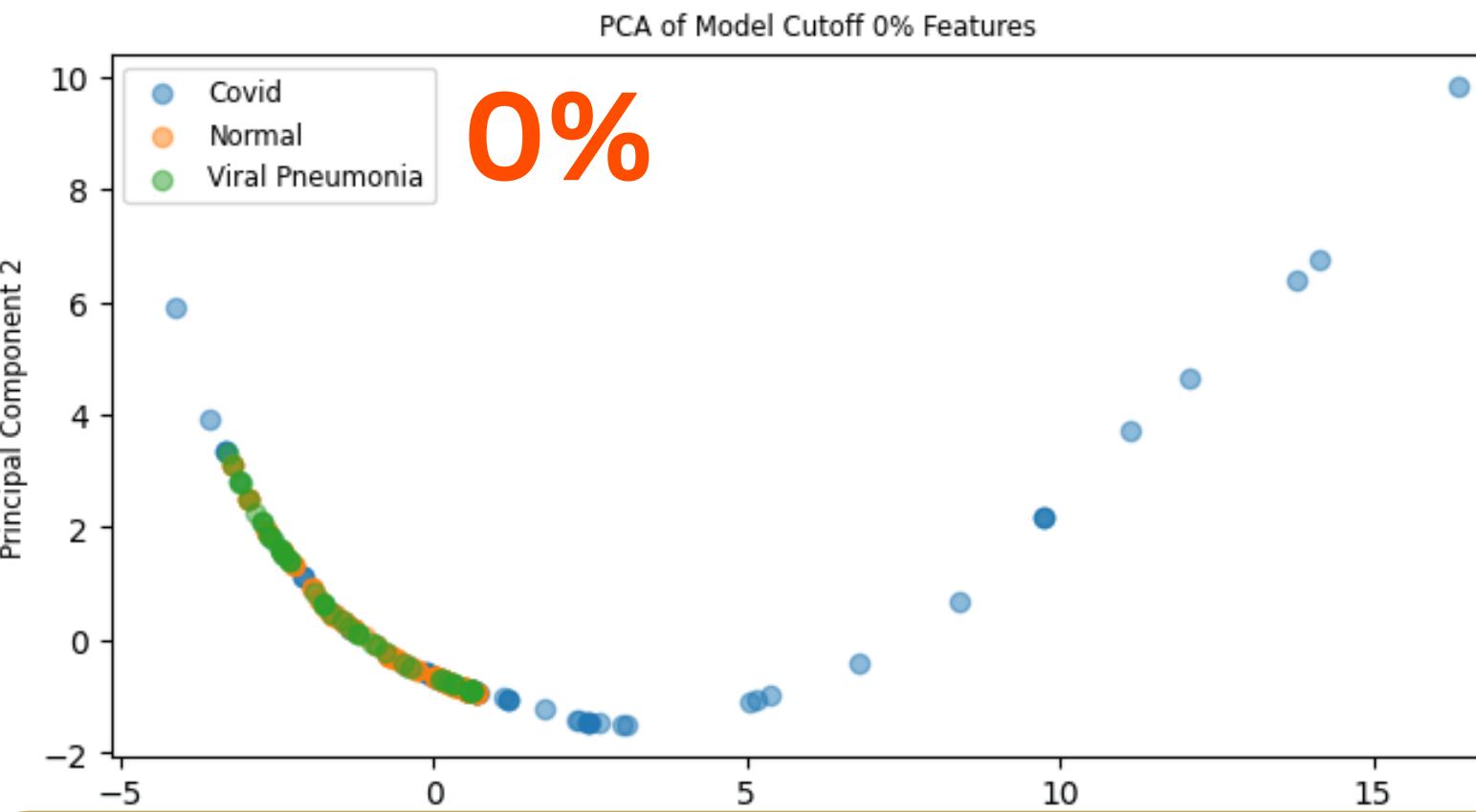
- **Highest model accuracy (0.9697) at a 90% low-pass filter cutoff.**
- No Filtering Still Effective (100% cutoff), accuracy remains high at ≈ 0.9090 .
- **Accuracy Declines with Strong Filtering**

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.

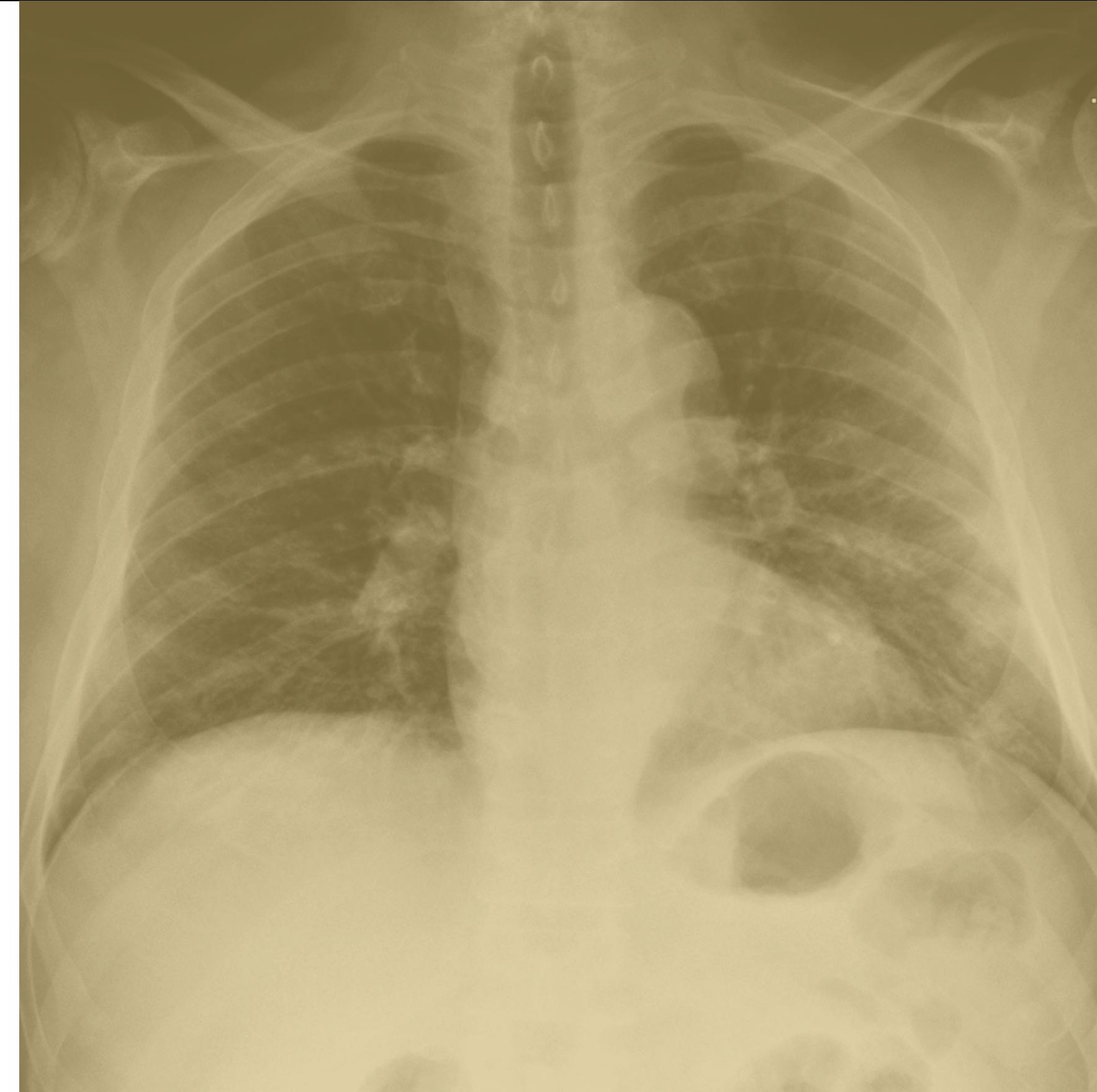
2) Further Analysis with Principal Component Analysis (PCA)

- 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. ”



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