주파수 분석함수 벤치마킹을 통한 폐렴과 코로나 구별 성능 향상

한성필
윤재영

목차

Usecase 정의

1. 코로나 또는 폐렴 의심 환자의 X-ray 사진을 받고,
2. X-ray 사진 분석을 통해, 코로나 또는 폐렴 환자인지 구별
   - 코로나 또는 폐렴, 두 class만 존재, 둘 다 아닌 경우는 없음

- 코로나 환자의 X-ray 사진

[1]

판별 과정…

결과: 코로나

- 폐렴 환자 X-ray 사진

출처 [1]: https://bmcpulmmed.biomedcentral.com/articles/10.1186/s12890-020-01286-5

Usecase Dataset

X-ray

- KAGGLE COVID-19 Radiography Database [2]
  Raw Data 추출

  1,345 COVID-19 (코로나)

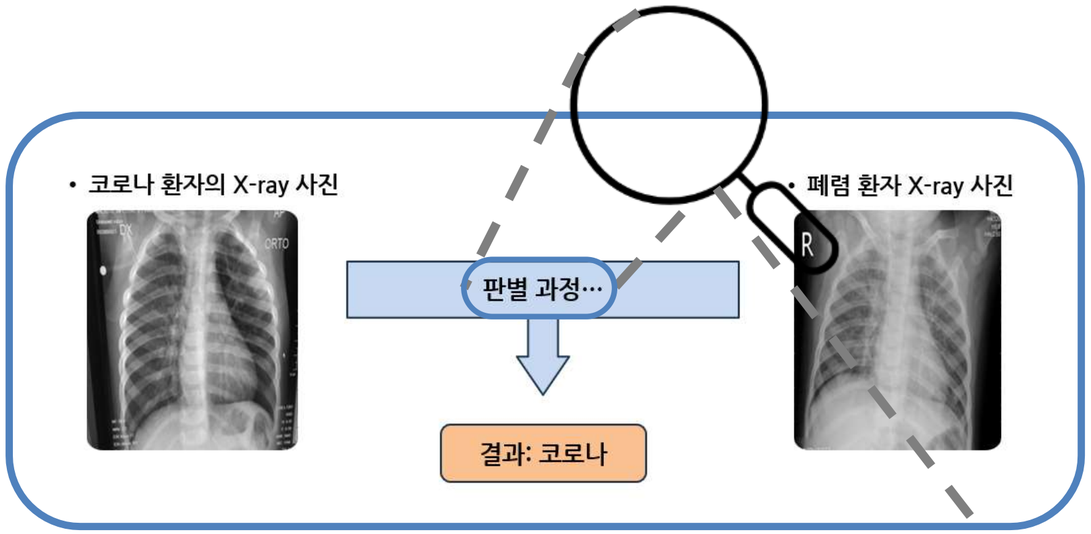
  1,345 Viral Pneumonia (폐렴)

- 코로나 환자의 X-ray 사진

- 폐렴 환자 X-ray 사진

출처 [2] : https://www.kaggle.com/datasets/tawsifurrahman/covid19-radiography-database/

기존 Solution



Raw Image Classification

[3] Pneumonia Classification Using Deep Learning from Chest X-ray Images During COVID-19

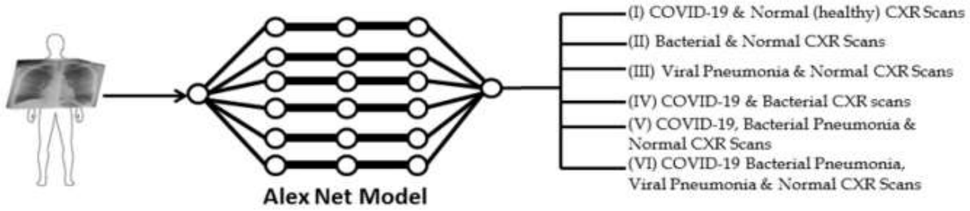
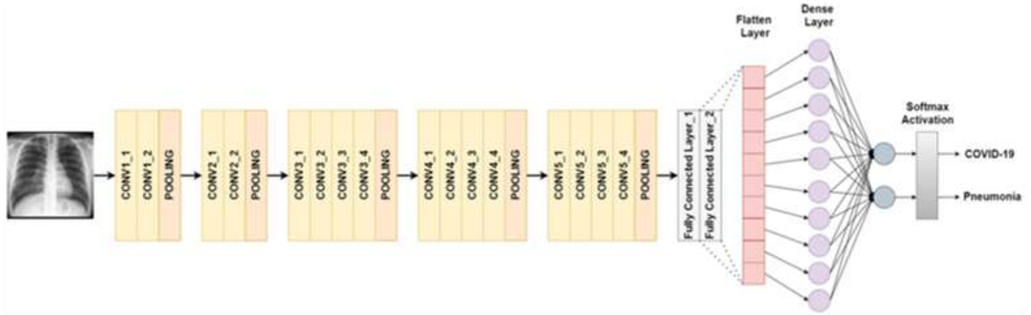


Fig. 2 The complete workflow of the proposed method

[4] A comparative study of multiple neural network for detection of COVID-19 on chest X-ray



VGG19 architecture designed for binary classification

출처 [3] : https://asp-eurasipjournals.springeropen.com/articles/10.1186/s13634-021-00755-1/figures/2
출처 [4] : https://link.springer.com/article/10.1007/s12559-020-09787-5

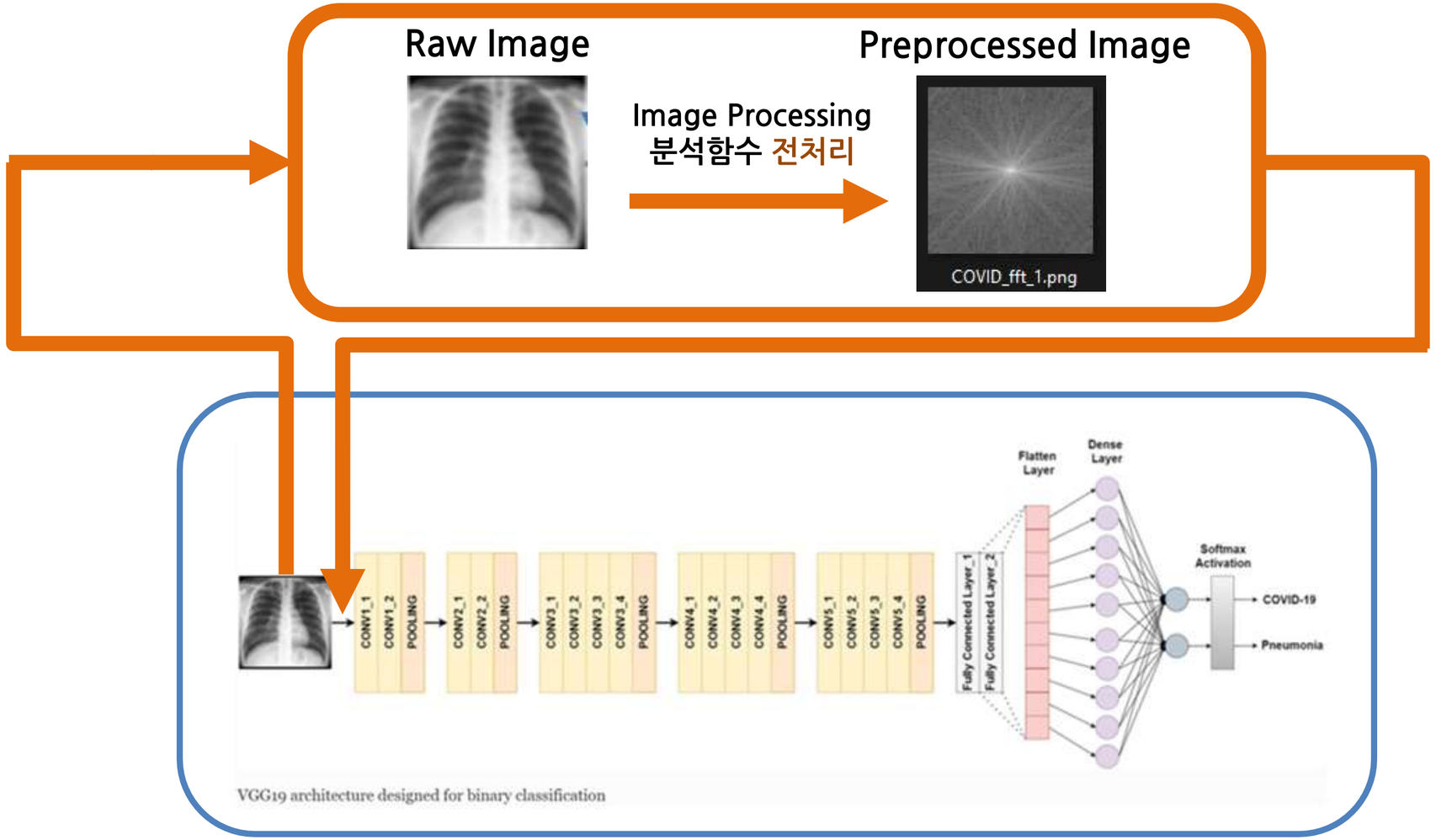
제시하는 Solution

Preprocessed Data in Frequency Domain

Image Processing 분석함수
(Raw image 변형 전처리 용도)

- FFT(Fast Fourier Transform)
- PSD(Power Spectral Density)
- DCT(Discrete Cosine Transform)
- DWT(Discrete Wavelet Transform)

제시하는 Solution



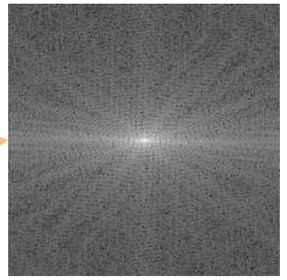
제시하는 Solution

Raw Image

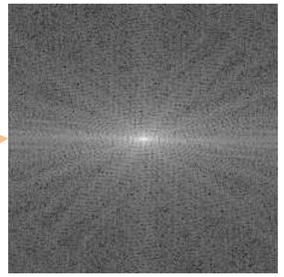
Cropping Mask

Cropped Image

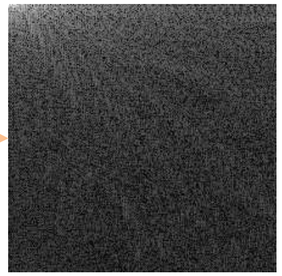
Image Processing 분석함수



FFT
(Fast Fourier Transform)



PSD
(Power Spectral Density)

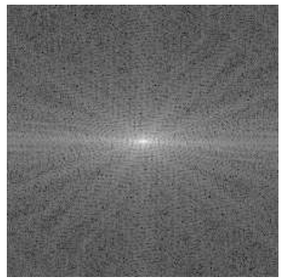


DCT
(Discrete Cosine Transform)

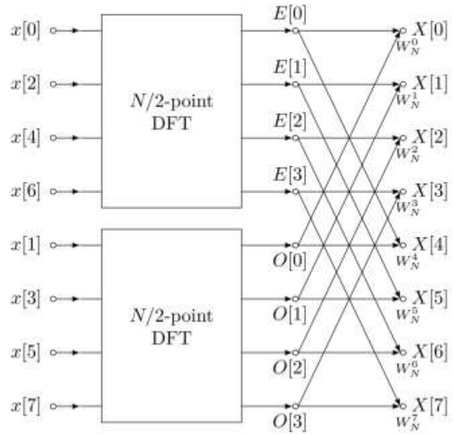
DWT
(Discrete Wavelet Transform)

제시하는 Solution

FFT
(Fast Fourier Transform)

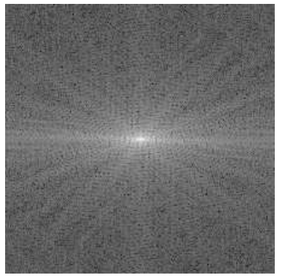


$$X(k) = \sum_{n=0}^{N-1} x(n) W_N^{kn}, \qquad k = 0,1,\ldots,N-1$$
$$= \sum_{n \text{ even}} x(n) W_N^{kn} + \sum_{n \text{ odd}} x(n) W_N^{kn}$$
$$= \sum_{m=0}^{(N/2)-1} x(2m) W_N^{2mk} + \sum_{m=0}^{(N/2)-1} x(2m+1) W_N^{k(2m+1)}$$



[5]

PSD
(Power Spectral Density)



6.5.3 The power spectrum

The **power spectral density** (PSD) or **power spectrum** provides a way of representing the distribution of signal frequency components which is easier to interpret visually than the complex DFT. As the term suggests, it represents the proportion of the total signal power contributed by each frequency component of a voltage signal ($P = V^2/R$). It is computed from the DFT as the mean squared amplitude of each frequency component, averaged over the n samples in the digitised record. However, since only $n/2$ frequency components are unique, the two halves of the DFT are combined (doubling the power of each component) and plotted as the lower $k = 1 \ldots n/2+1$ components,

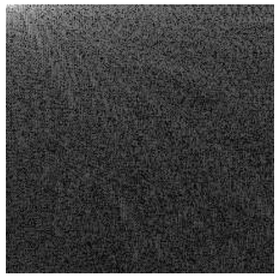
$$\text{PSD}(k) = \frac{2\,di}{n^2}\left((Y_{\text{real}}(k))^2 + (Y_{\text{imag}}(k))^2 \right) \qquad [6.32]$$

[6]

출처 [5] : https://en.wikipedia.org/wiki/Cooley%E2%80%93Tukey_FFT_algorithm
출처 [6] : https://www.sciencedirect.com/topics/computer-science/power-spectral-density

제시하는 Solution

DCT
(Discrete Cosine Transform)



Discrete Cosine Transform [7]

The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension. The definition of the two-dimensional DCT for an input image A and output image B is

$$B_{pq} = \alpha_p \alpha_q \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} A_{mn} \cos \frac{\pi(2m+1)p}{2M} \cos \frac{\pi(2n+1)q}{2N}, \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix}$$

where

$$\alpha_p = \begin{cases} \frac{1}{\sqrt{M}}, & p = 0 \\ \sqrt{\frac{2}{M}}, & 1 \le p \le M-1 \end{cases}$$

and

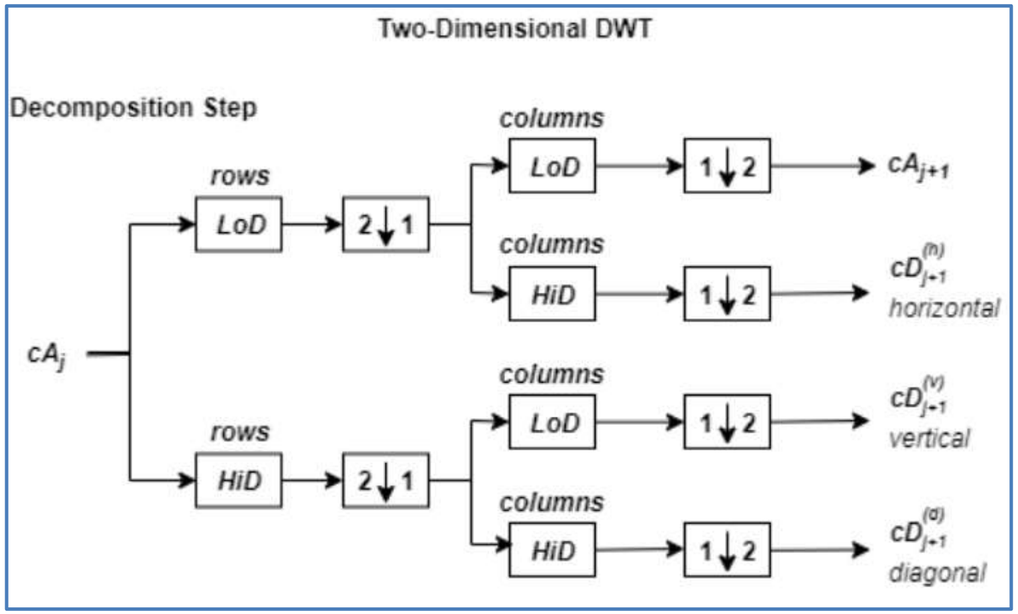
$$\alpha_q = \begin{cases} \frac{1}{\sqrt{N}}, & q = 0 \\ \sqrt{\frac{2}{N}}, & 1 \le q \le N\text{-}1 \end{cases}$$

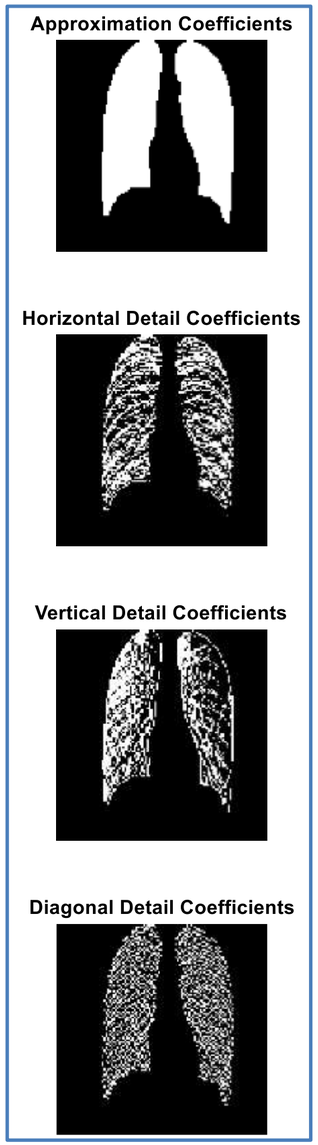
M and *N* are the row and column size of A, respectively.

출처 [7] : https://www.mathworks.com/help/images/ref/dct2.html

제시하는 Solution

DWT
(Discrete Wavelet Transform)



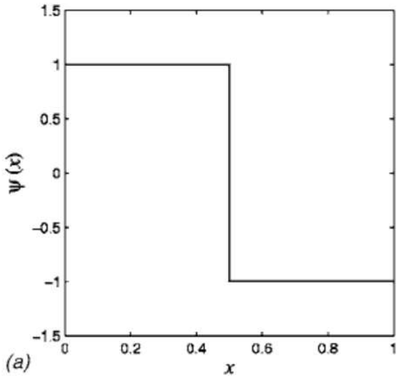


제시하는 Solution

DWT
(Discrete Wavelet Transform)

Daubechies wavelet functions with p vanishing moments
p=1, D1, or Haar wavelet

[8]



Approximation Coefficients

Vertical Detail Coefficients

Horizontal Detail Coefficients

Diagonal Detail Coefficients

출처[8] :https://www.researchgate.net/publication/242185849_Adaptive_Control_of_Rotor_Vibration_Using_Compact_Wavelets_This_paper_investigates_the_use_of_dyadic_wavelets_for_the_control_of_multifrequency_rotor

제시하는 Solution

Approximation Coefficients

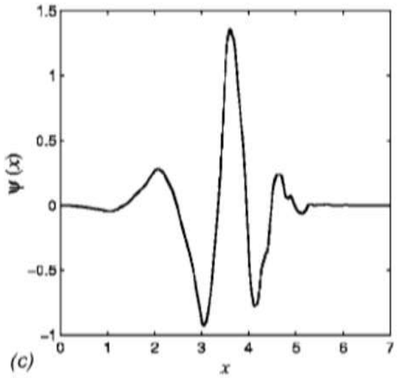
Vertical Detail Coefficients

Horizontal Detail Coefficients

Diagonal Detail Coefficients

IDWT
(Inverse Discrete Wavelet Transform)

Daubechies wavelet functions with p vanishing moments
p=4, D4 wavelet



Preprocessed Data 분석

Dimensionality Reduction

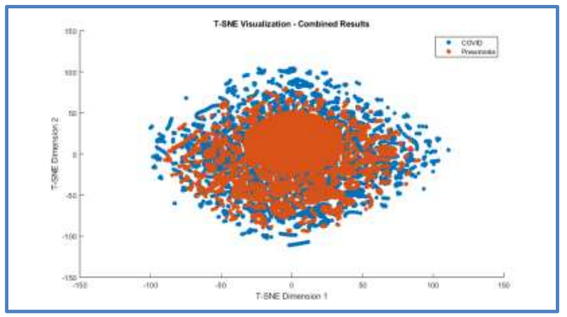
차원 축소 함수
(전처리 데이터 분석용)

- T-SNE (t-distributed Stochastic Neighbor Embedding)
- UMAP (Uniform Manifold Approximation and Projection)
- Wasserstein Distance

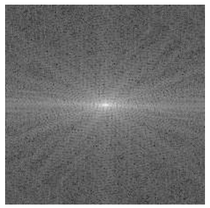
Preprocessed Data 분석

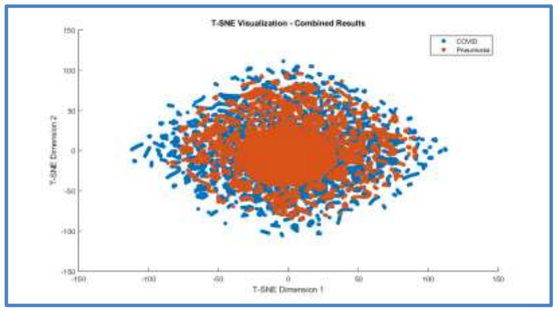
차원 축소 함수 (전처리 데이터 분석용)
TSNE

RAW Image

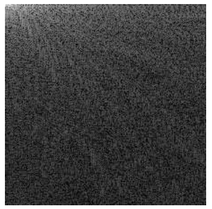


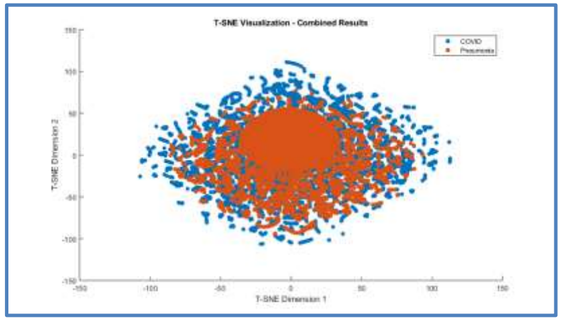
FFT



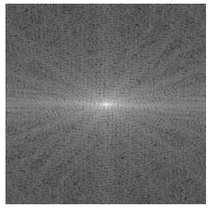


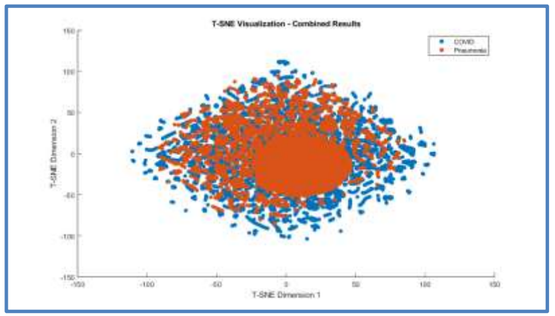
DCT



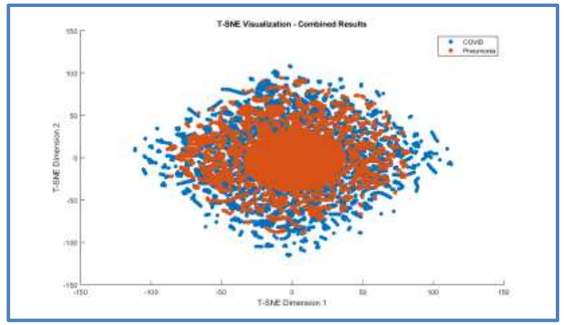


PSD





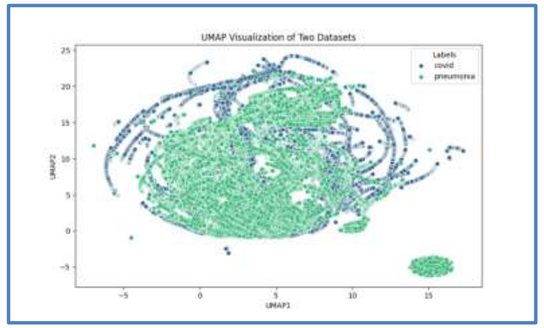
DWT



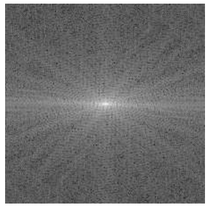
Preprocessed Data 분석

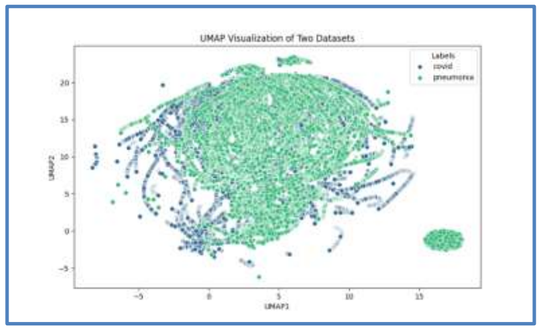
차원 축소 함수 (전처리 데이터 분석용)
UMAP

RAW Image

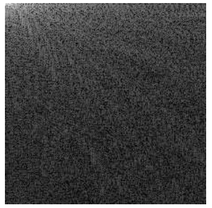


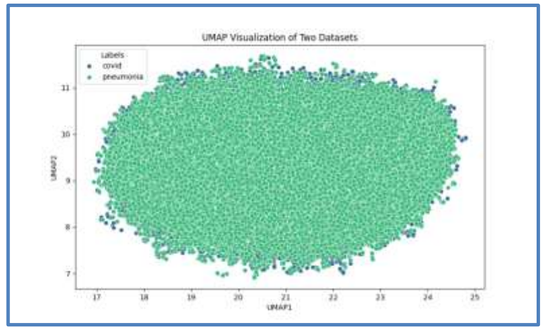
FFT



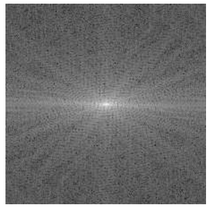


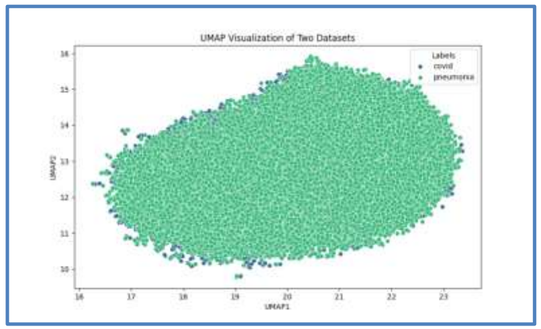
DCT



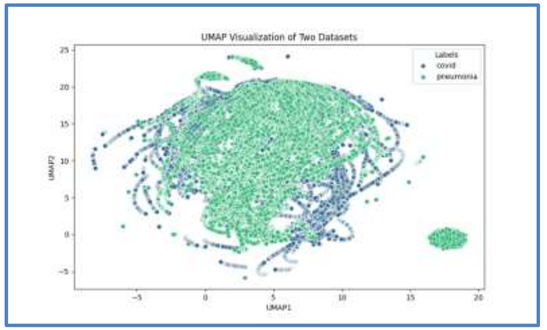


PSD





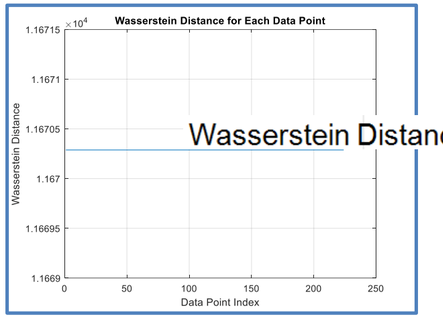
DWT



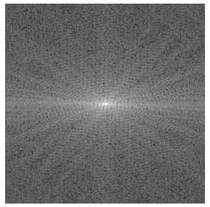
Preprocessed Data 분석

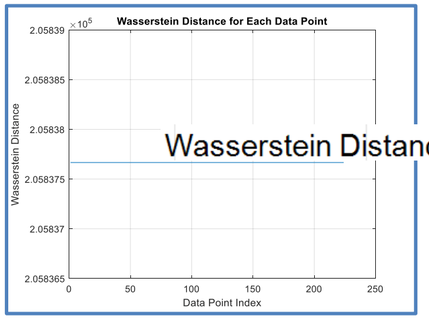
차원 축소 함수 (전처리 데이터 분석용)
Wasserstein Distance

RAW Image

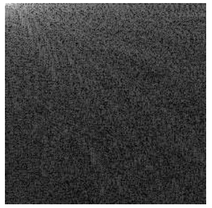


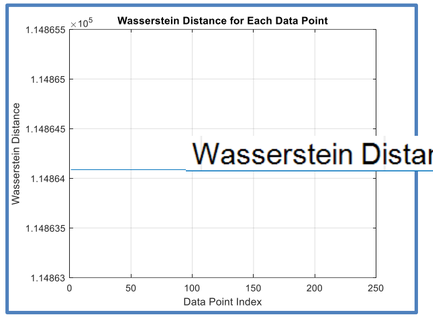
FFT



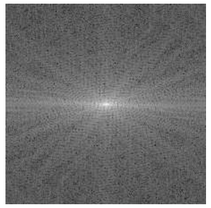


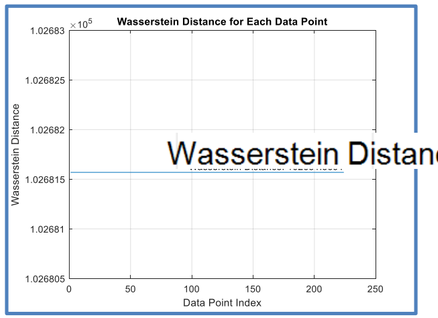
DCT



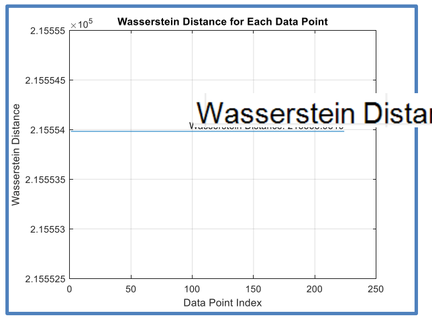


PSD





DWT



Performance Test

AI Model의 accuracy를 비교한 성능 평가 지표

[9]

Classification Accuracy

Classification Accuracy is what we usually mean, when we use the term accuracy. It is the ratio of number of correct predictions to the total number of input samples.

$$Accuracy = \frac{Number\ of\ Correct\ predictions}{Total\ number\ of\ predictions\ made}$$

[10]

Google Colaboratory

T4 GPU

[11]

Inception Resnet v2

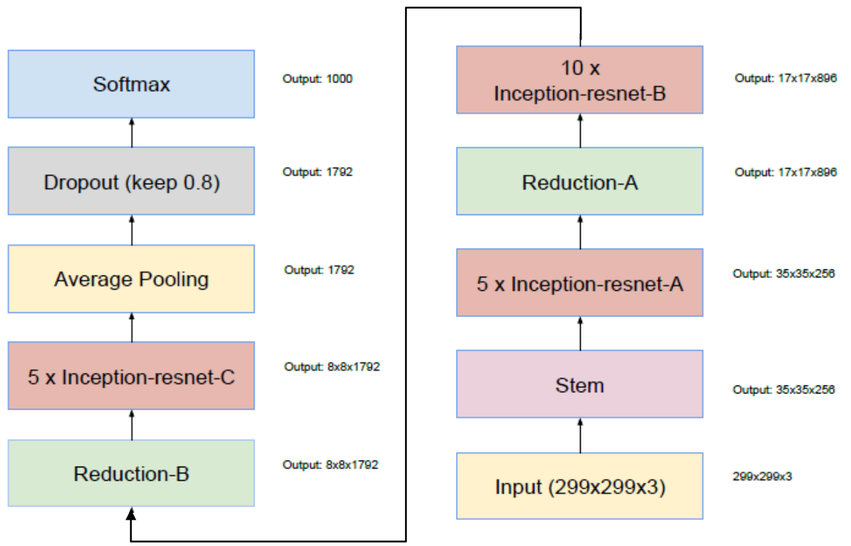


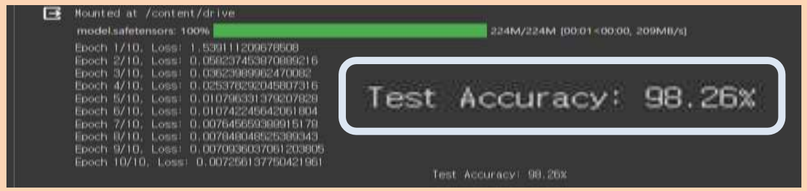
Figure 15. Schema for Inception-ResNet-v2 networks.

출처 [9] : https://towardsdatascience.com/metrics-to-evaluate-your-machine-learning-algorithm-f10ba6e38234
출처 [10] : https://www.hwlibre.com/en/google-collaboratory/
출처 [11] : https://arxiv.org/abs/1602.07261v2

Performance Test - Inception ResNet v2

기존 Solution

RAW



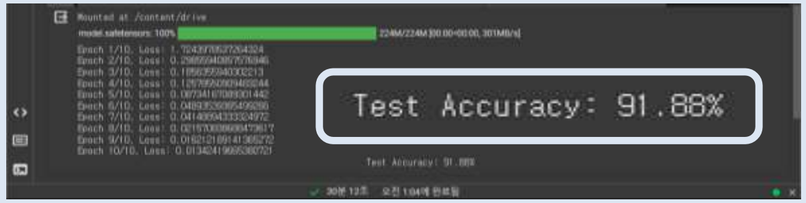
Inception Resnet v2 에 쓰인 Hyperparameter

Train data 1000개
Test data 345개
Batch size 32
Epoch 10
Loss 0.01이하

제시하는 Solution

FFT

PSD



DCT

DWT

Conclusion

1. 기존 solution (RAW image classification)에 대비하여,
   최종으로 제시된 solution (DWT image classification - Preprocessed image)은
   약 1.16%의 accuracy가 증가

2. 차원 축소 함수 (전처리 데이터 분석용)를 통해 예측한
   Solution별 성능 기대값 또한 만족

감사합니다

QnA