

The background of the entire slide is a reproduction of Vincent van Gogh's famous painting "Starry Night". It depicts a dark blue night sky filled with numerous swirling, luminous yellow and white stars of varying sizes. In the foreground, a large, dark, craggy pine tree trunk and branches extend from the left side. Below the tree, a small town with houses and a church steeple is nestled in a valley, with rolling hills and fields extending towards the horizon under the starry sky.

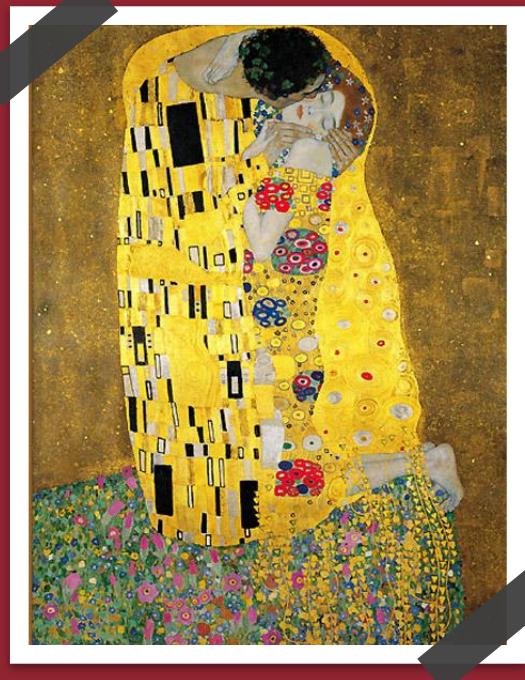
명화 화가 분류기 모델 개발

5조 권예준, 김경빈, 이아연, 전우근

이전 발표 요약



Content



01 과제 개요

02 탐색적 데이터 분석(EDA)

03 모델 생성 및 학습

04 결과

01 과제 개요





01 과제 개요

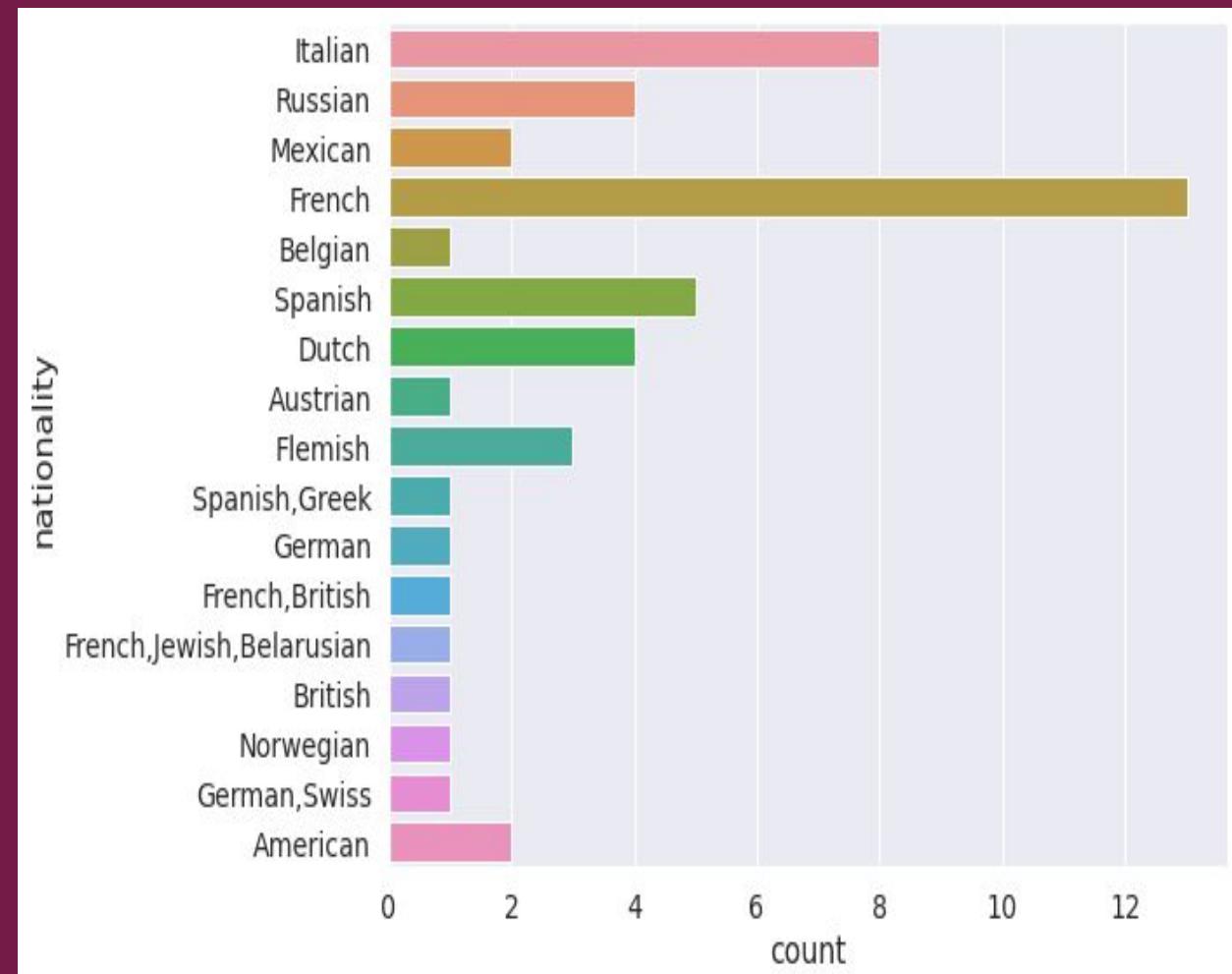
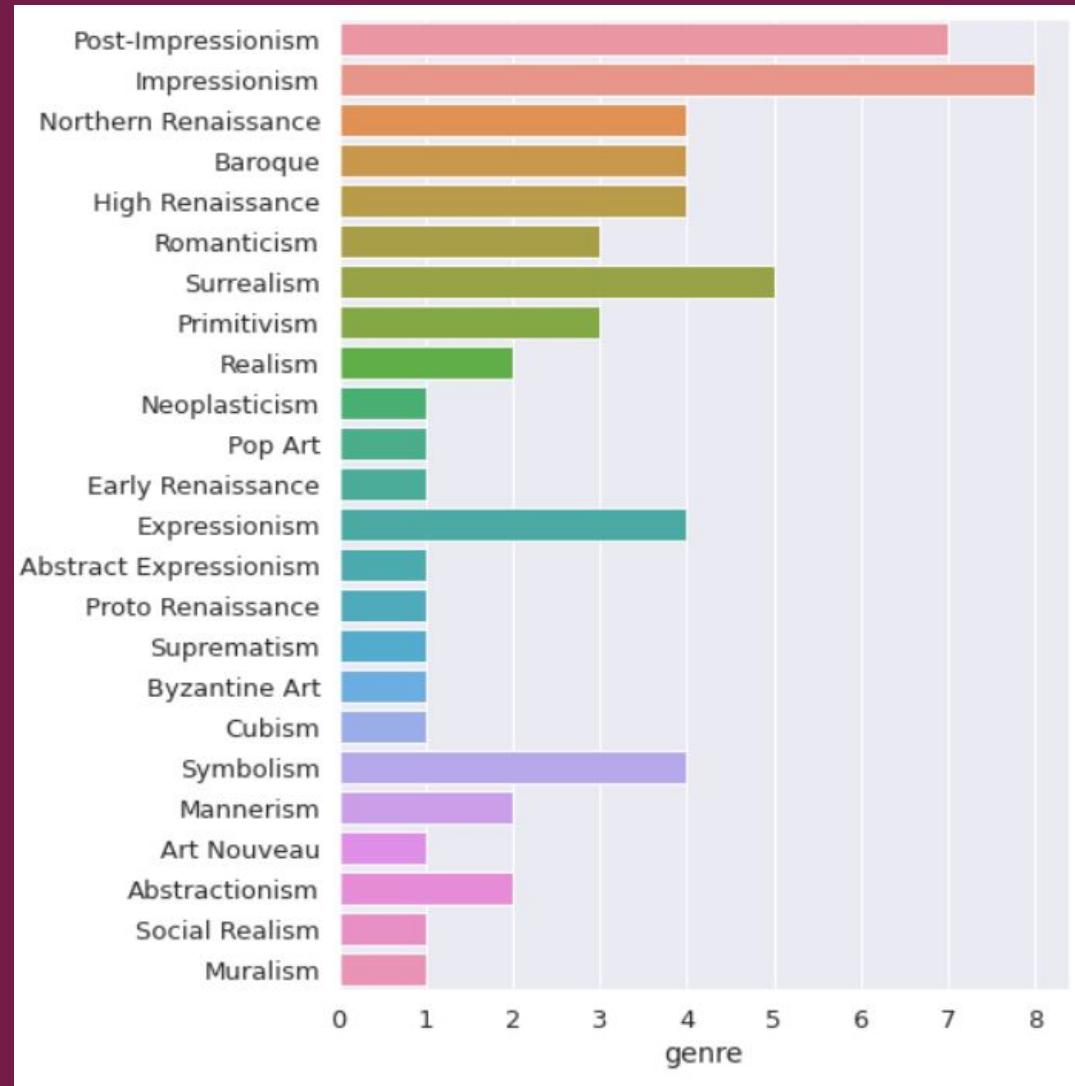
이 그림의 작가는
누구인가?

| 화풍에 대한 학습 모델을 통해
화가를 예측해주는 프로그램을 만든다면
그림에 대한 궁금증 해결에 도움을 줄 수 있을 것
같다.

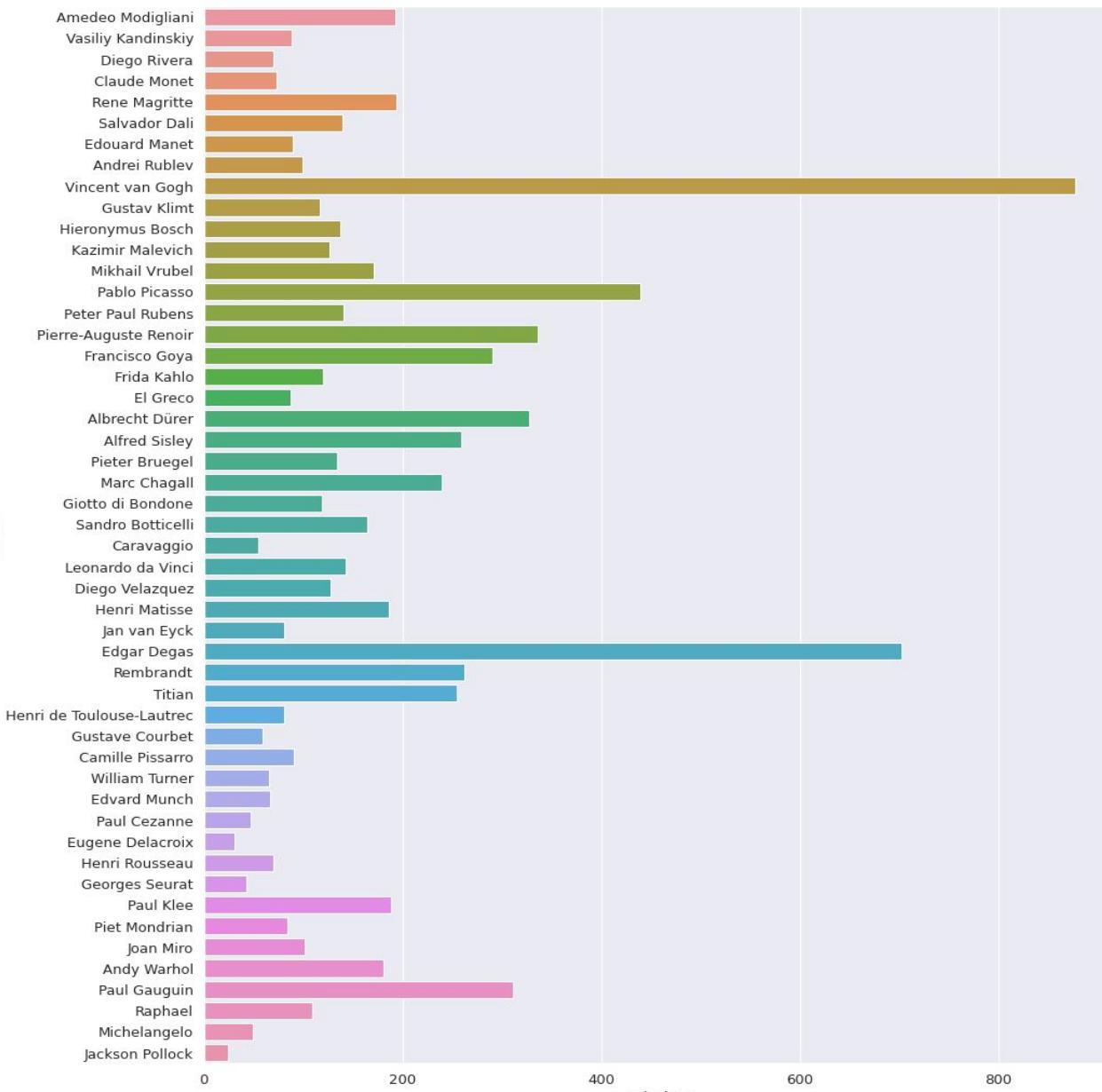
02 탐색적 자료 분석(EDA)



02 EDA



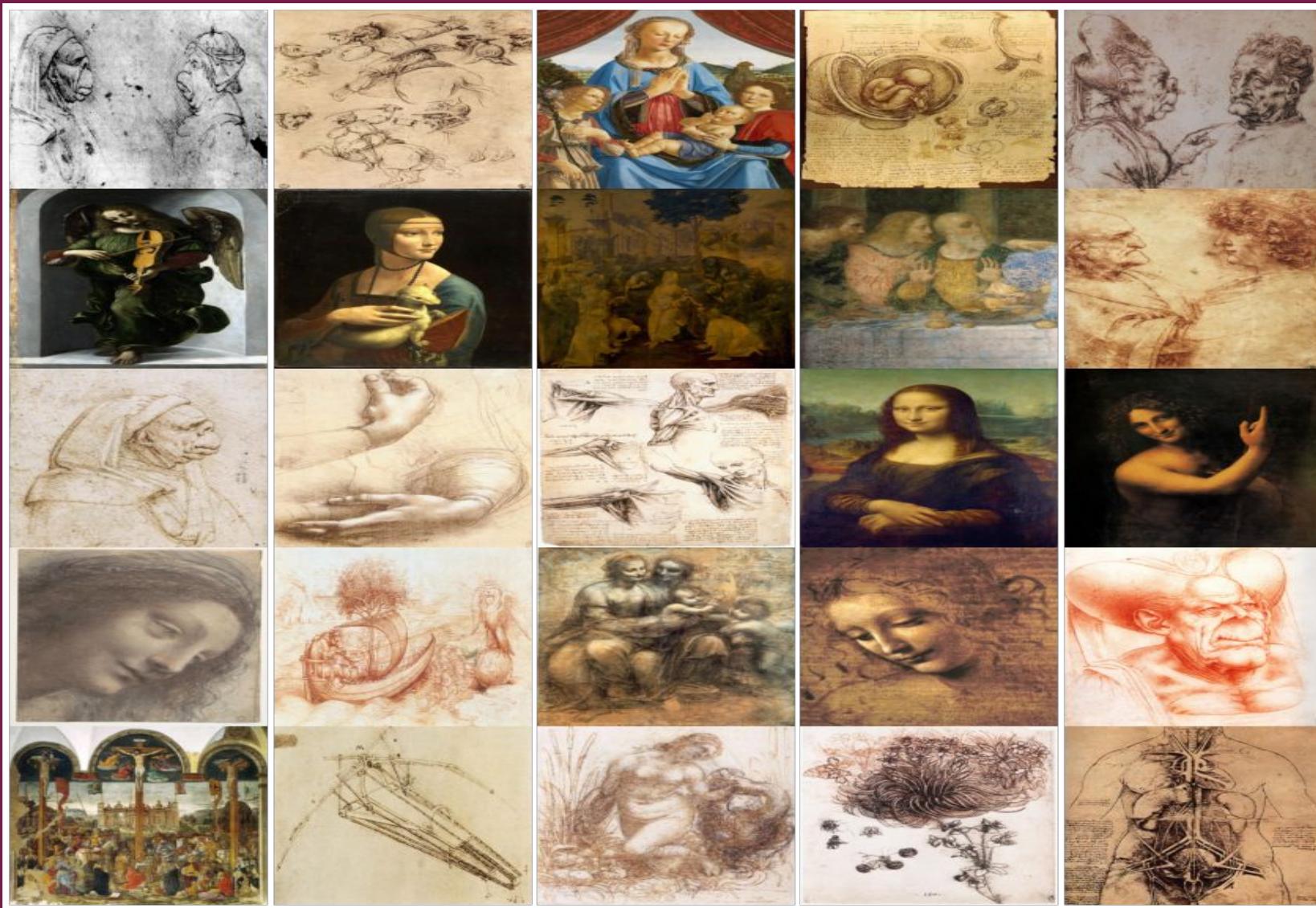
02 EDA



| | name | years | genre | nationality | paintings | class_weight |
|----|-----------------------|-------------|---|---------------------------|-----------|--------------|
| 0 | Joan Miro | 1893 – 1983 | Surrealism | Spanish | 102 | 2.317320 |
| 1 | Raphael | 1483 – 1520 | High Renaissance | Italian | 109 | 2.168502 |
| 2 | Gustav Klimt | 1862 – 1918 | Symbolism,Art Nouveau | Austrian | 117 | 2.020228 |
| 3 | Giotto di Bondone | 1266 - 1337 | Proto Renaissance | Italian | 119 | 1.986275 |
| 4 | Frida Kahlo | 1907 - 1954 | Primitivism,Surrealism | Mexican | 120 | 1.969722 |
| 5 | Kazimir Malevich | 1879 - 1935 | Suprematism | 126 | 1.875926 | |
| 6 | Diego Velazquez | 1599 - 1660 | Baroque | Spanish | 128 | 1.846615 |
| 7 | Pieter Bruegel | 1525 - 1569 | Northern Renaissance | Flemish | 134 | 1.763930 |
| 8 | Hieronymus Bosch | 1450 - 1516 | Northern Renaissance | Dutch | 137 | 1.725304 |
| 9 | Salvador Dali | 1904 - 1989 | Surrealism | Spanish | 139 | 1.700480 |
| 10 | Peter Paul Rubens | 1577 - 1640 | Baroque | Flemish | 141 | 1.676359 |
| 11 | Leonardo da Vinci | 1452 - 1519 | High Renaissance | Italian | 143 | 1.652914 |
| 12 | Sandro Botticelli | 1445 - 1510 | Early Renaissance | Italian | 164 | 1.441260 |
| 13 | Mikhail Vrubel | 1856 - 1910 | Symbolism | 171 | 1.382261 | |
| 14 | Andy Warhol | 1928 - 1987 | Pop Art | American | 181 | 1.305893 |
| 15 | Henri Matisse | 1869 - 1954 | Impressionism,Post-Impressionism | French | 186 | 1.270789 |
| 16 | Paul Klee | 1879 - 1940 | Expressionism,Abstractionism,Surrealism | German,Swiss | 188 | 1.257270 |
| 17 | Amedeo Modigliani | 1884 - 1920 | Expressionism | Italian | 193 | 1.224698 |
| 18 | Rene Magritte | 1898 - 1967 | Surrealism,Impressionism | Belgian | 194 | 1.218385 |
| 19 | Marc Chagall | 1887 - 1985 | Primitivism | French,Jewish,Belorussian | 239 | 0.988982 |
| 20 | Titian | 1488 - 1576 | High Renaissance,Mannerism | Italian | 255 | 0.926928 |
| 21 | Alfred Sisley | 1839 - 1899 | Impressionism | French,British | 259 | 0.912613 |
| 22 | Rembrandt | 1606 - 1669 | Baroque | Dutch | 262 | 0.902163 |
| 23 | Francisco Goya | 1746 - 1828 | Romanticism | Spanish | 291 | 0.812257 |
| 24 | Paul Gauguin | 1848 – 1903 | Symbolism,Post-Impressionism | French | 311 | 0.760021 |
| 25 | Albrecht Dürer | 1471 - 1528 | Northern Renaissance | German | 328 | 0.720630 |
| 26 | Pierre-Auguste Renoir | 1841 - 1919 | Impressionism | French | 336 | 0.703472 |
| 27 | Pablo Picasso | 1881 - 1973 | Cubism | Spanish | 439 | 0.538421 |
| 28 | Edgar Degas | 1834 - 1917 | Impressionism | French | 702 | 0.336705 |
| 29 | Vincent van Gogh | 1853 – 1890 | Post-Impressionism | Dutch | 877 | 0.269517 |

<class weight>

02 EDA - Leonardo da Vinci



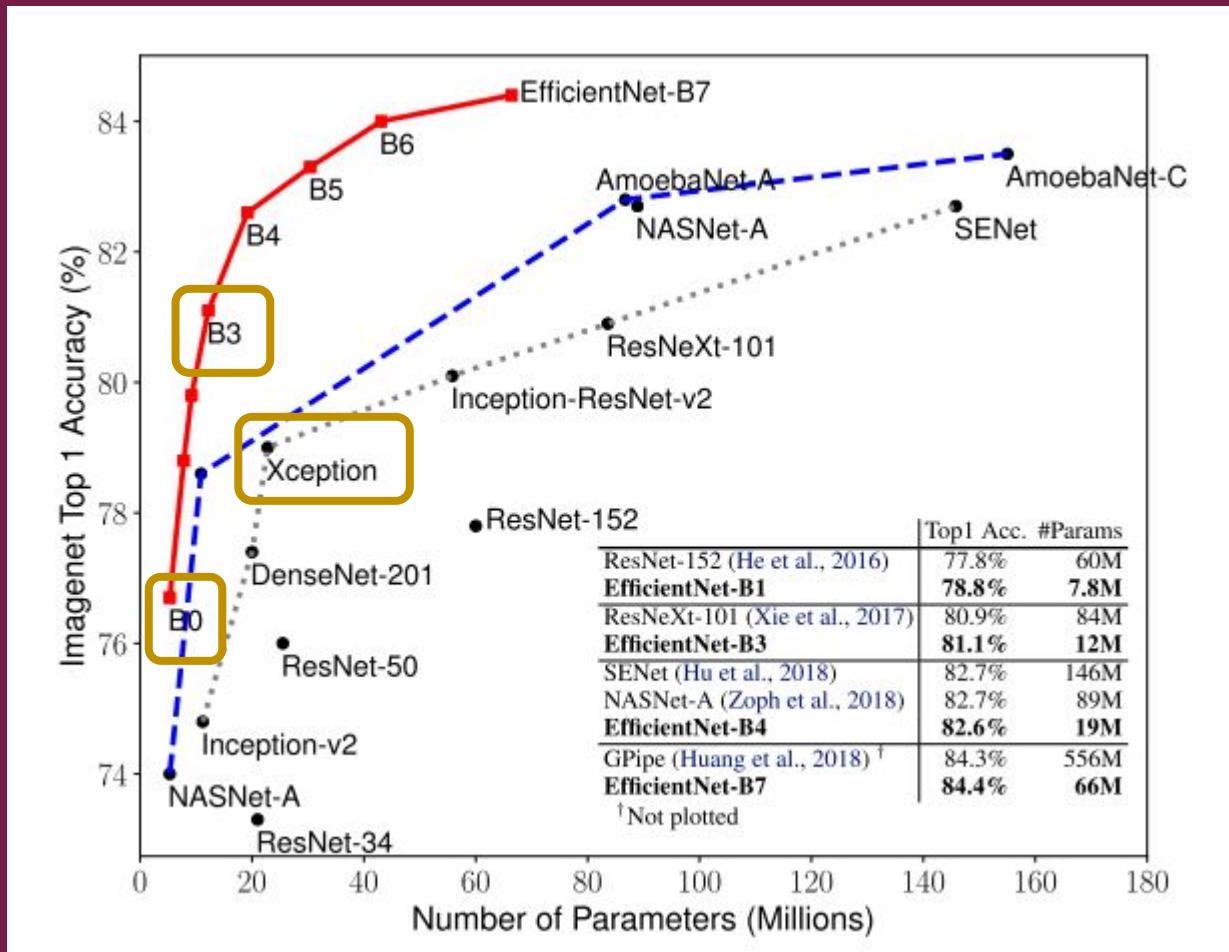
02 EDA - Camille Pissarro



03 모델 생성 및 학습



03 모델 선정



1. EfficientNet-B0
2. EfficientNet-B3
3. Xception

03 EfficientNet

| Stage i | Operator $\hat{\mathcal{F}}_i$ | Resolution $\hat{H}_i \times \hat{W}_i$ | #Channels \hat{C}_i | #Layers \hat{L}_i |
|--------------|-----------------------------------|--|--------------------------|------------------------|
| 1 | Conv3x3 | 224×224 | 32 | 1 |
| 2 | MBConv1, k3x3 | 112×112 | 16 | 1 |
| 3 | MBConv6, k3x3 | 112×112 | 24 | 2 |
| 4 | MBConv6, k5x5 | 56×56 | 40 | 2 |
| 5 | MBConv6, k3x3 | 28×28 | 80 | 3 |
| 6 | MBConv6, k5x5 | 14×14 | 112 | 3 |
| 7 | MBConv6, k5x5 | 14×14 | 192 | 4 |
| 8 | MBConv6, k3x3 | 7×7 | 320 | 1 |
| 9 | Conv1x1 & Pooling & FC | 7×7 | 1280 | 1 |

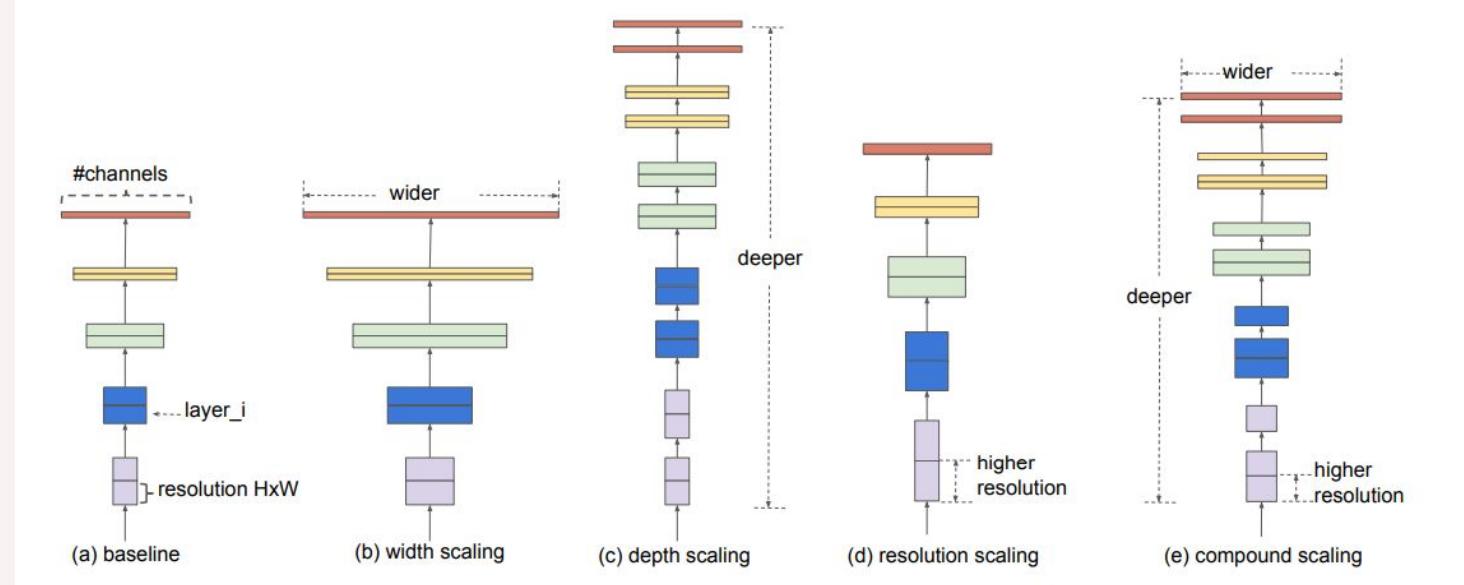


그림 EfficientNet architecture

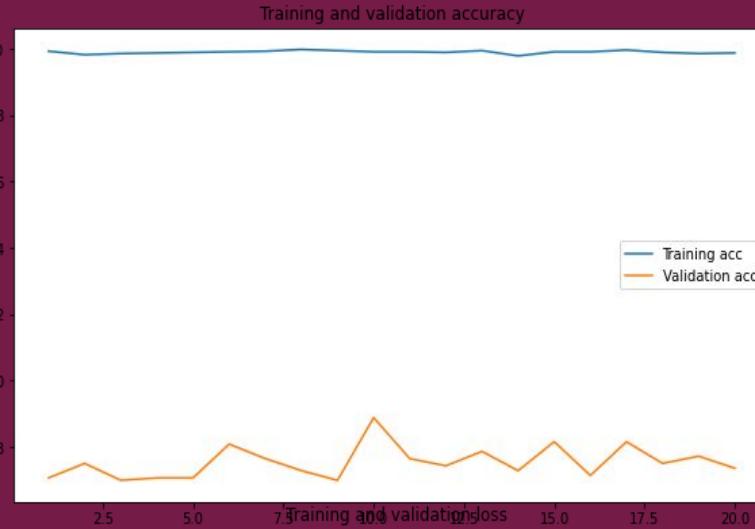
03 EfficientNet

batch_size =32, seed = 123, epoch=30, activation = relu

| | version1 | version2 | version3 | version4 | version5 | version6 | version7 | version8 | version9 |
|------------------|---|---|--|---|--|---|--|--|--|
| 설명 | B0 Untrained GlobalAvgPool Dense(512) BatchNorm Dense(128) BatchNorm Softmax | B0 All trained GlobalAvgPool Dense(512) BatchNorm Dense(128) BatchNorm Softmax | B0 except BatchNorm GlobalAvgPool Dense(512) BatchNorm Dense(128) BatchNorm Softmax | B0 all trained 64 batch GlobalAvgPool Dense(1024) BatchNorm Dense(256) BatchNorm Dense(128) BatchNorm Softmax | B0 64 batch GlobalAvgPool Dense(1024) BatchNorm Dense(256) BatchNorm Dense(128) BatchNorm Softmax | B0 32batch GlobalAvgPool Dense(512) Dense(128) Softmax | B0 except BatchNorm 32batch GlobalAvgPool Dense(512) Dense(128) Softmax | B0 32batch GlobalAverage Pool Dense(512) Dense(128) Softmax resoultion 350*350 epoch+20 | B0 32batch GlobalAverage Pool Dense(512) Dense(128) Softmax resoultion 350*350 epoch+20 |
| Optimizer | Adam (0.0005) | Adam (0.0005) | Adam | Adam | Adam | Adam | Adam | Adam | Adam |
| val_acc | 0.7078 | 0.8728 | 0.8387 | 0.8624 | 0.8504 | 0.8626 | 0.8416 | 0.8888 | 0.8917 |
| val_loss | 1.0732 | 0.4966 | 0.6524 | 0.5114 | 0.5428 | 0.5431 | 0.6632 | 0.4073 | 0.4085 |

03 EfficientNet

version 1 - B3



batch_size = 32

all layers trained

Epoch: 60

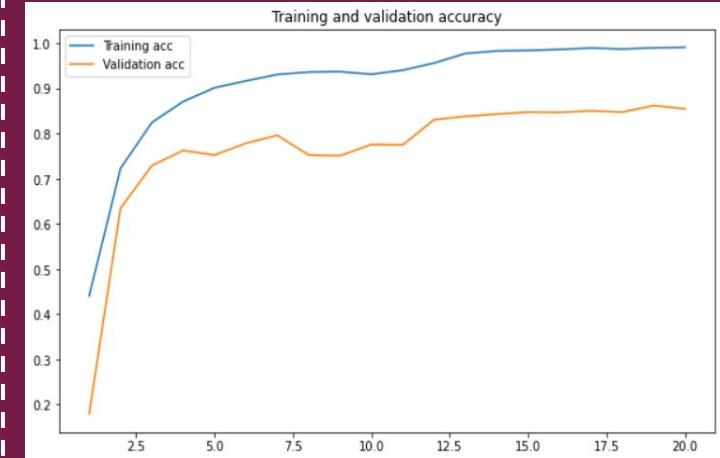
lr = 0.00003

optimizer = Adam

val_acc : 0.8888

val_loss : 0.5523

version 2 - B0



batch_size = 32

batch norm
제외한 후 trained

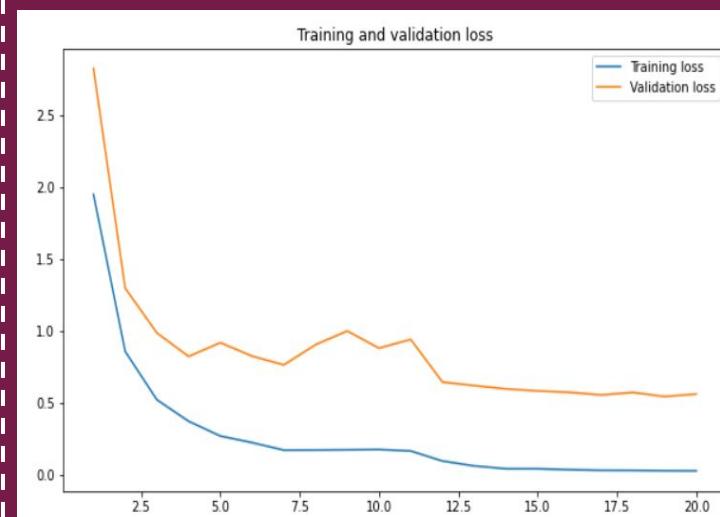
Epoch: 20

lr = 0.0005

optimizer = Adam

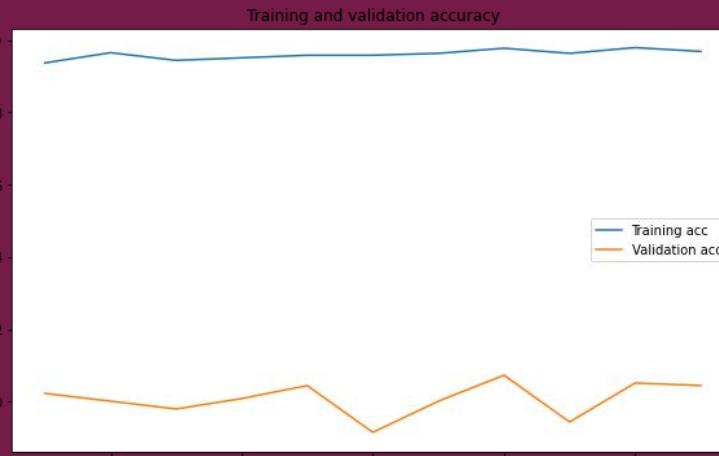
val_acc : 0.8626

val_loss : 0.5431



03 EfficientNet

version 3 – B3



resolution : 350

all layers trained

batch_size = 32

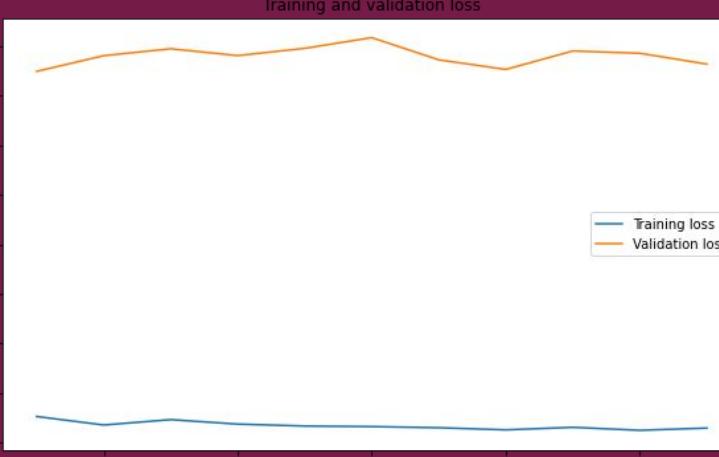
Epoch: 60

lr = 0.0005

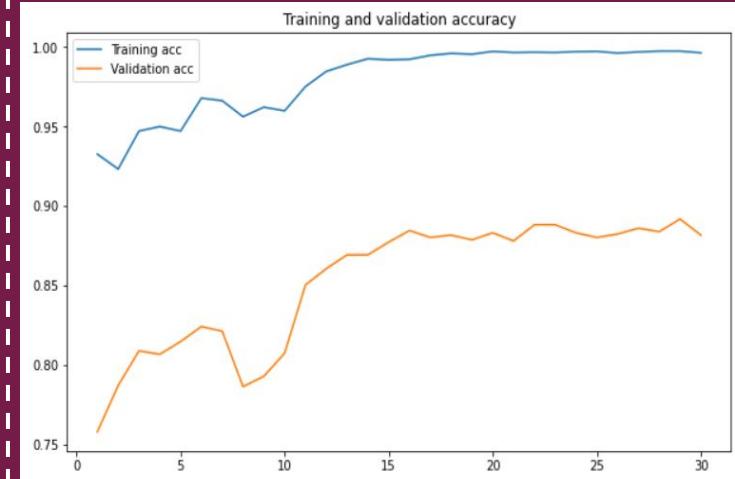
optimizer = Adam

val_acc : 0.9073

val_loss : 0.3744



version 4 – B0



resolution : 350

batch_size = 32

Epoch: 30

lr = 0.0005

optimizer = Adam

val_acc : 0.8917

val_loss : 0.4085



03 Xception

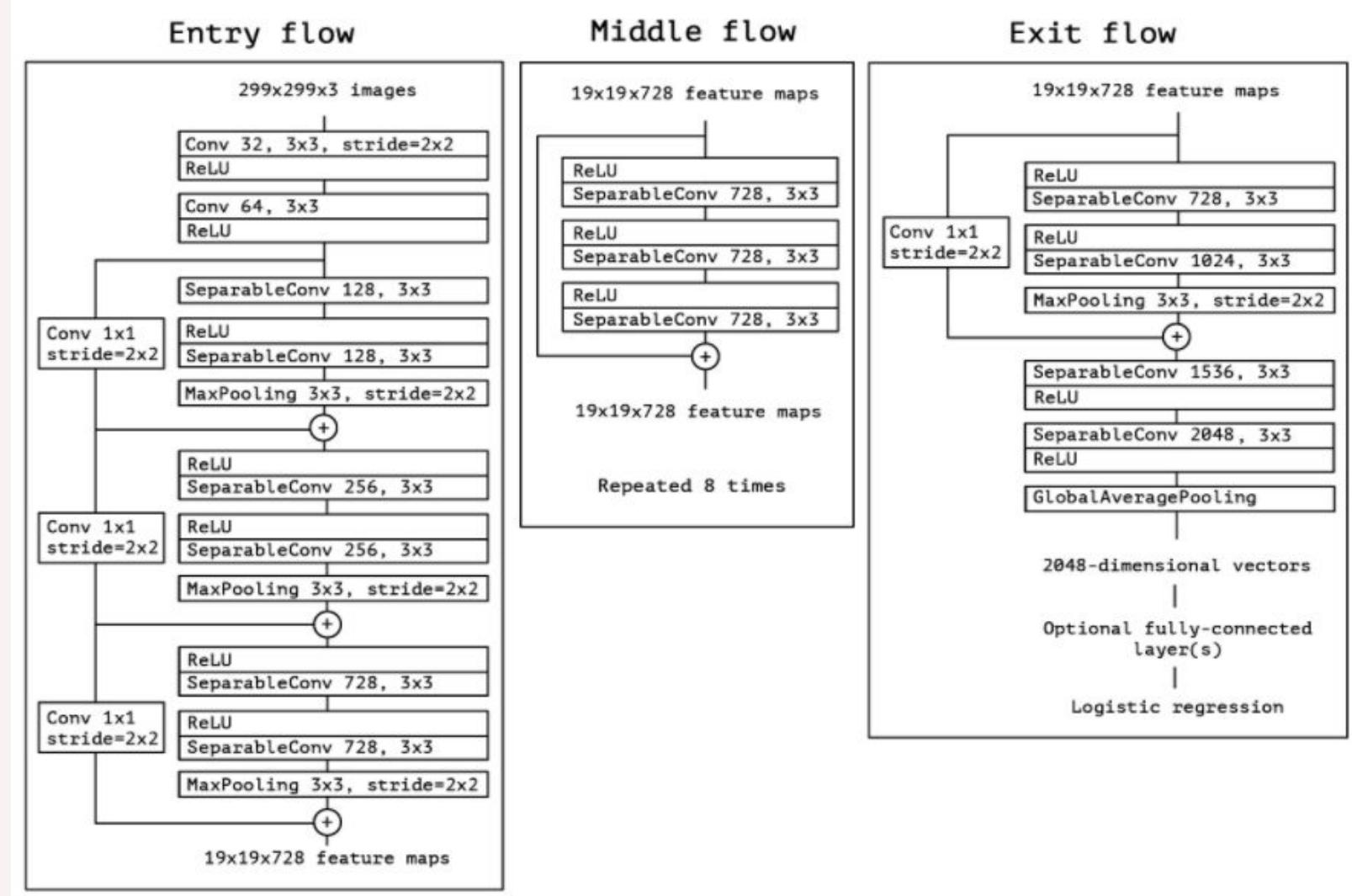


그림 Xception architecture

03 Xception

batch_size = 32, seed = 123, epoch=30, activation = selu, loss = 'categorical_crossentropy'

| | version1 | version2 | version3 | version4 | version5 | version6 | version7 | version8 | version9 | version10 | version11 |
|-----------|--|--|--|---|---|---|---|---|---|---|--|
| 설명 | * 전체 학습 Flatten() Dense(512) BatchNorm Dense(128) BatchNorm | * 전체 학습 Flatten() Dense(512) BatchNorm Dense(256) Dropout(0.5) BatchNorm | * batchnorm 제외 학습 GAP2D() Dense(1024) Dropout(0.5) BatchNorm Dense(256) Dropout(0.5) BatchNorm | * batchnorm 제외 학습 GAP2D() Dense(1024) Dropout(0.5) BatchNorm Dense(512) Dropout(0.3) Dense(128) Dense(64) BatchNorm | * batchnorm 제외 학습 * 'block14' 이후로 학습 | * batchnorm 제외 학습 * 'block14' 이후로 학습 | * batchnorm 제외 학습 * 'block13' 이후로 학습 | * batchnorm 제외 학습 GAP2D() Dense(512) Dropout(0.3) BatchNorm Dense(128) BatchNorm | * batchnorm 제외 학습 GAP2D() Dense(1024) Dropout(0.5) BatchNorm Dense(512) Dropout(0.3) Dense(128) Dense(64) BatchNorm | * 전체 학습 GAP2D() Dense(512) Dropout(0.5) Dense(512) Dropout(0.3) Dense(128) BatchNorm | * 전체 학습 GAP2D() Dense(512) Dropout(0.5) Dense(512) Dropout(0.5) |
| Optimizer | Adam (0.0001) | Adam (0.001) | Adam (0.001) | RMSprop (0.0001) | RMSprop (0.001) | RMSprop (0.001) | RMSprop (0.001) | Adadelta (0.001) | Adam (0.0001) | Adam (0.0001) | Adam (0.0001) |
| val_acc | 0.8481 | 0.8350 | 0.8387 | 0.8481 | 0.8517 | 0.7035 | 0.7638 | 0.7638 | 0.8423 | 0.8387 | 0.8350 |
| val_loss | 0.6499 | 0.6008 | 0.6524 | 0.6210 | 0.6321 | 1.1363 | 0.8924 | 0.8924 | 0.6447 | 0.6192 | 0.6449 |

03

Xception

batch_size = 32, seed = 123, epoch=30, activation = selu, loss = 'categorical_crossentropy'

| | version12 | version14 | version15 | version16 | version17 | version18 | version19 | version20 | version21 |
|-----------|---|--|---|---|---|--|--|--|--|
| 설명 | * 전체 학습 GAP2D Flatten Dropout(0.5) Dense(512) Dropout(0.5) | * 전체 학습 GAP2D Flatten Dropout(0.5) Dense(1024) Dropout(0.5) Dense(256) | * 전체 학습 GAP2D Dropout(0.5) Dense(1024) Dropout(0.5) Dense(512) Dropout(0.5) Dense(256) | * 전체 학습 GAP2D Dropout(0.5) Dense(1024) Dropout(0.5) Dense(128) | * 전체 학습 GAP2D Dense(1024) Dropout(0.5) Dense(128) Dropout(0.5) | * 전체 학습 GAP2D Dense(1024) Dropout(0.5) BatchNorm Dense(128) Dropout(0.5) | * 전체 학습 GAP2D Dense(1024) Dropout(0.5) BatchNorm Dense(512) Dropout(0.5) | * 전체 학습 GAP2D Dense(1024) Dropout(0.5) BatchNorm Dense(512) Dropout(0.5) | * 전체 학습 GAP2D Dense(1024) Dropout(0.5) BatchNorm Dense(512) Dropout(0.5) |
| Optimizer | Adam (0.0001) | Adam (0.0001) | Nadam (0.001) | Nadam (0.0001) | Nadam (0.0001) | Adam (0.0001) | Adam (0.0001) | RMSprop (0.0001) | RMSprop (0.0001) |
| val_acc | 0.806 | 0.8292 | 0.7885 | 0.8045 | 0.8132 | 0.811 | 0.8372 | 0.8503 | 0.8481 |
| val_loss | 0.9524 | 0.9307 | 0.9511 | 0.8440 | 0.8767 | 0.9657 | 0.8636 | 0.9271 | 0.9538 |

03 Xception

version 5



lr = 0.001

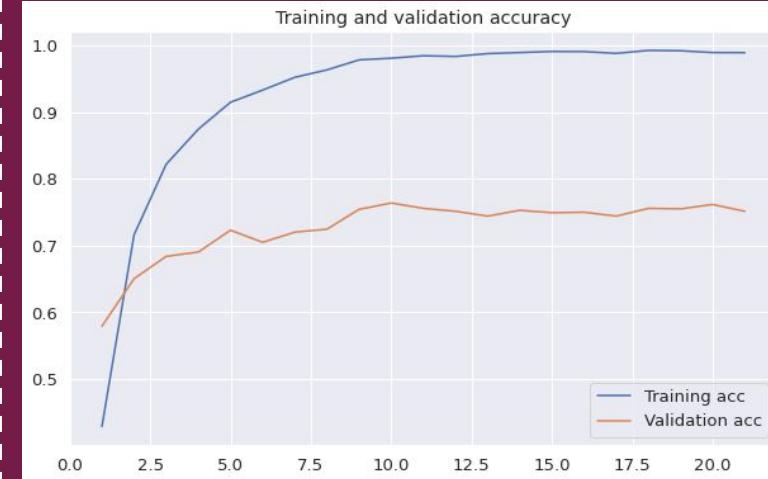
RMSprop

val_acc : 0.8517



val_loss : 0.6321

version 8



lr = 0.0001

Adadelta

val_acc : 0.7638



val_loss : 0.8924

03 Xception

version 15



Nadam(0.001)

GAP2D

1024 > 512 > 128

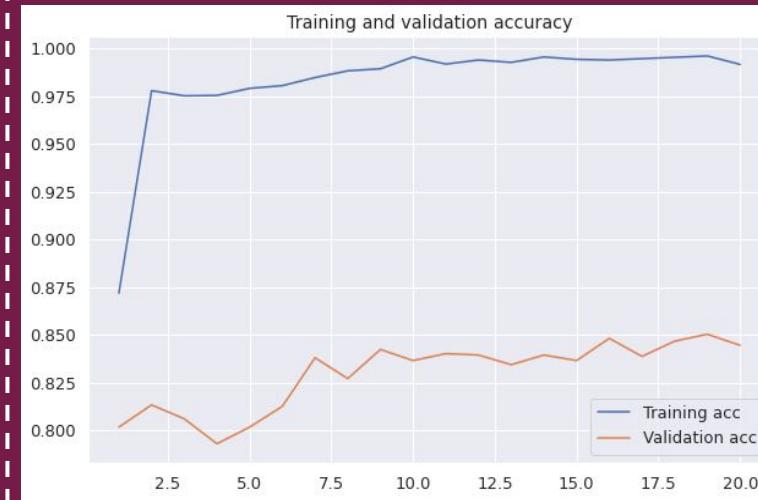
Dropout(0.5) * 2

val_acc : 0.7885

val_loss : 0.9511



version 21



RMSprop(0.0001)

GAP2D + Batchnorm

1024 > 512

Dropout (0.5)

val_acc : 0.8503

val_loss : 0.9271

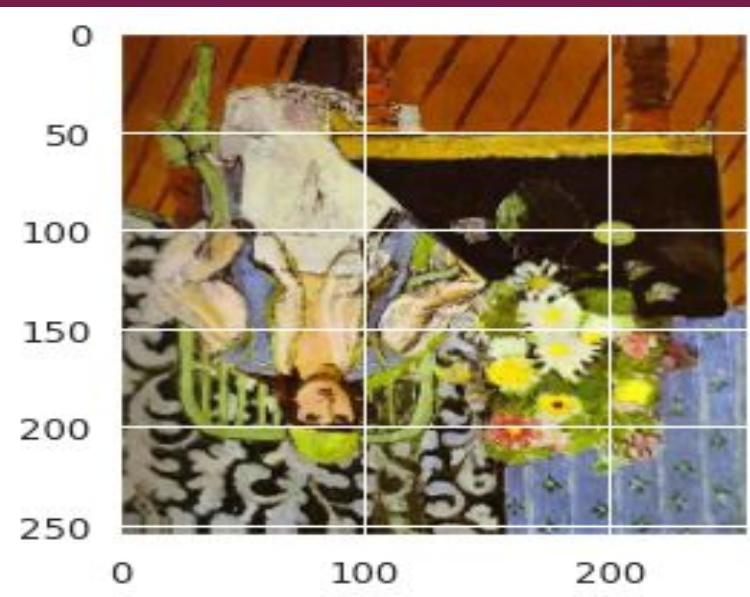


04 결과

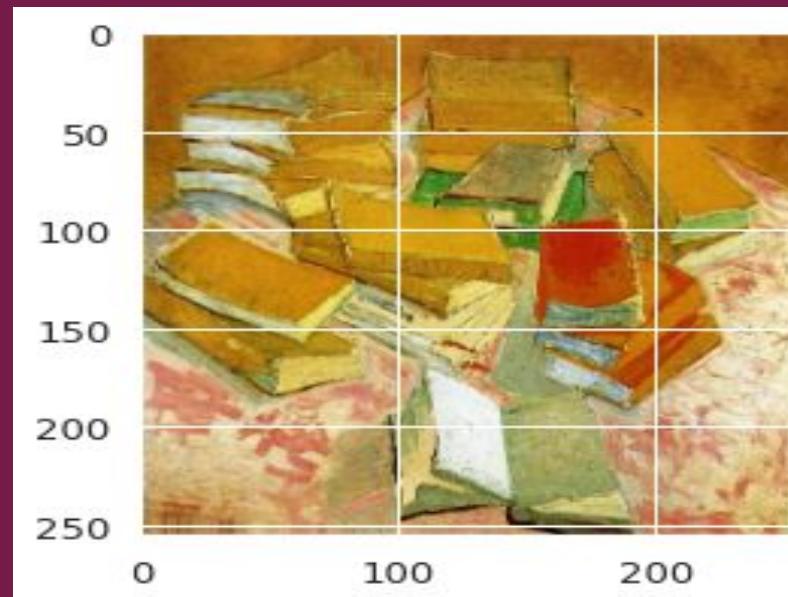


04 Validation 검증

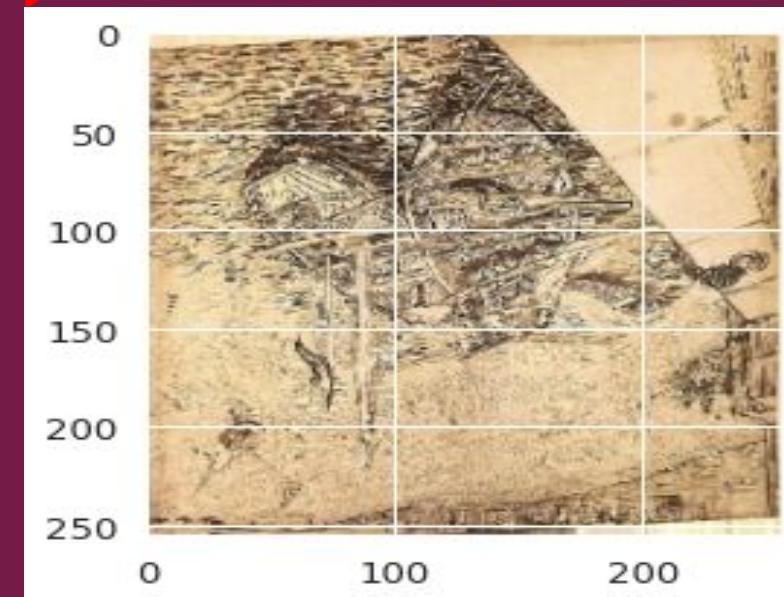
- 가장 val_acc가 높았던 EfficientNet B3 이용
- 100개 이상의 작품을 가진 화가들 예측



Prediction Probability : 99.97%
Pred Artist : Henri Matisse
Actual Artist : Henri Matisse



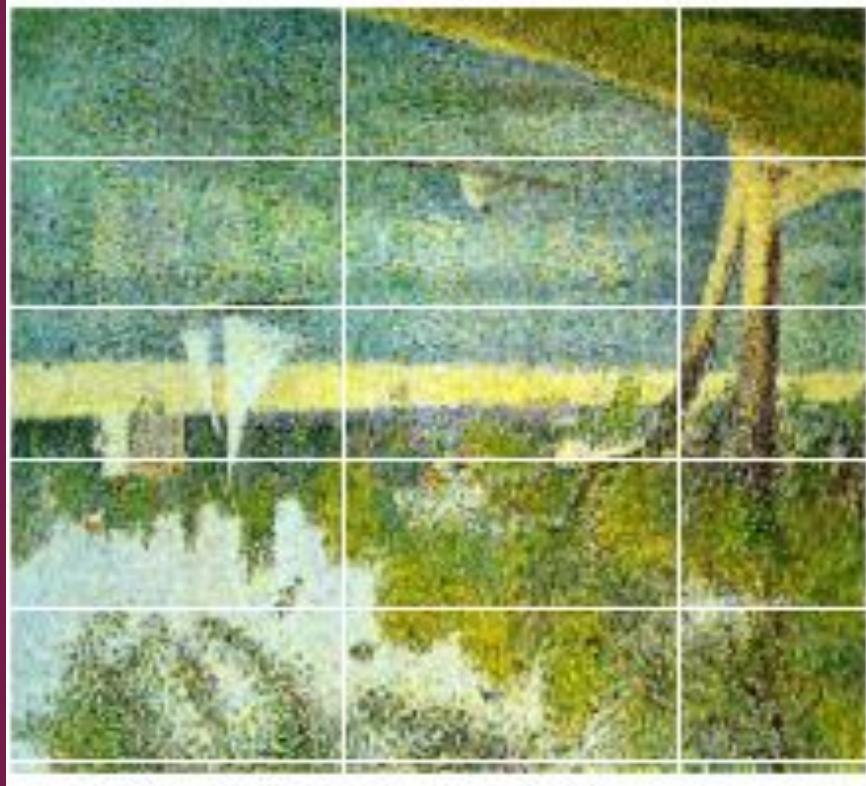
Prediction Probability : 93.70%
Pred Artist : Vincent van Gogh
Actual Artist : Vincent van Gogh



Prediction Probability : 99.86%
Pred Artist : Leonardo da Vinci
Actual Artist : Vincent van Gogh

04 Out-of-Sample 예측

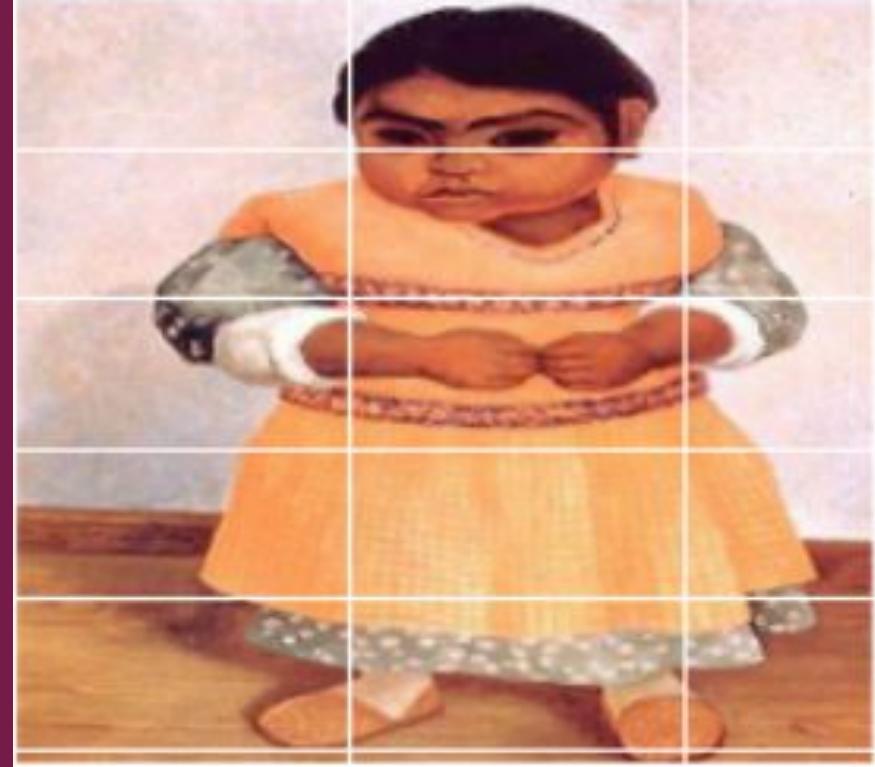
- 학습에 사용하지 않은 100개 이하의 작품 화가들 예측
- 장르, 시기, 국적 비교



Probability : 97.57%

예측 : Vincent van Gogh / Post-Impressionism / 1853 – 1890 / Dutch

실제 : Georges Seurat / Post-Impressionism / 1859 – 1891 / French



Probability : 32.85%

예측 : Rene Magritte / Surrealism, Impressionism / 1898-1967 / Belgium

실제 : Diego Rivera / social Realism, Muralism/ 1886 - 1957 / Mexican

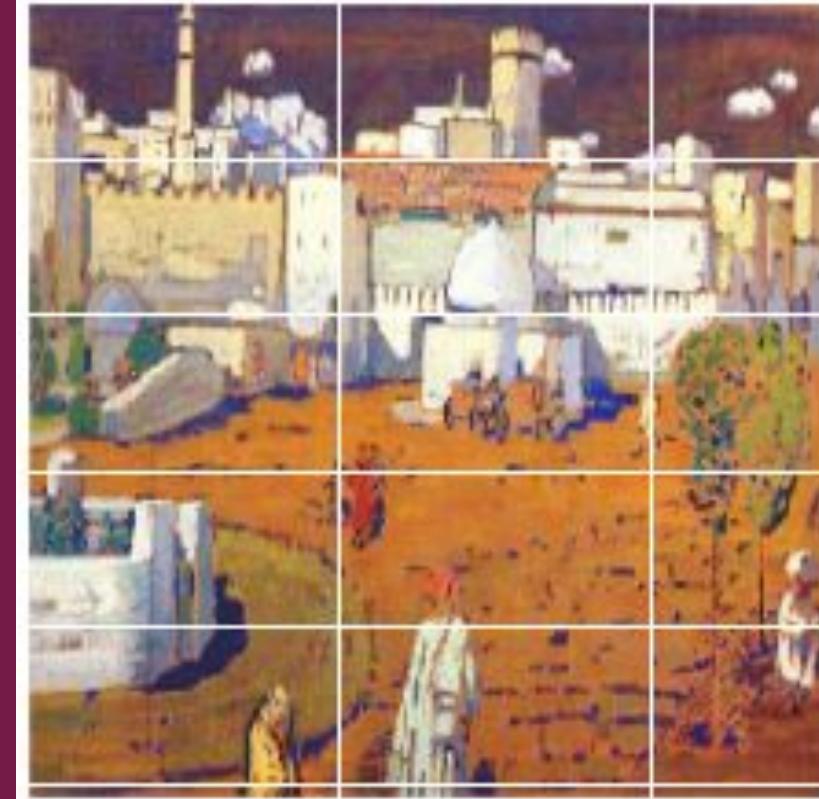
04 Out-of-Sample 예측



Probability : 99.6%

예측 : Edgar Degas / Impressionism / 1834 - 1917 / French

실제 : Andrei Rublev / Byzantine Art / 1360 - 1430 / Russian



Probability : 29.56%

예측: Vincent van Gogh / Post-Impressionism / 1853-1890 / Dutch

실제: Vasiliy Kandinskiy / Expressionism, Abstractionism /1866-1944/ Russian

05 Feedback 반영



05 피드백

- **Visualize**
 - 해당 이미지를 왜 그렇게 예측했는지, 그림의 어느 부분에 주목해 모델이 예측했는지에 대한 시각화 필요
- **Style Transfer**
 - ex) 드가의 그림을 고흐풍으로 style transfer를 시행했을 때 모델은 어떻게 예측할 것인가?

05 Visualize- 라임

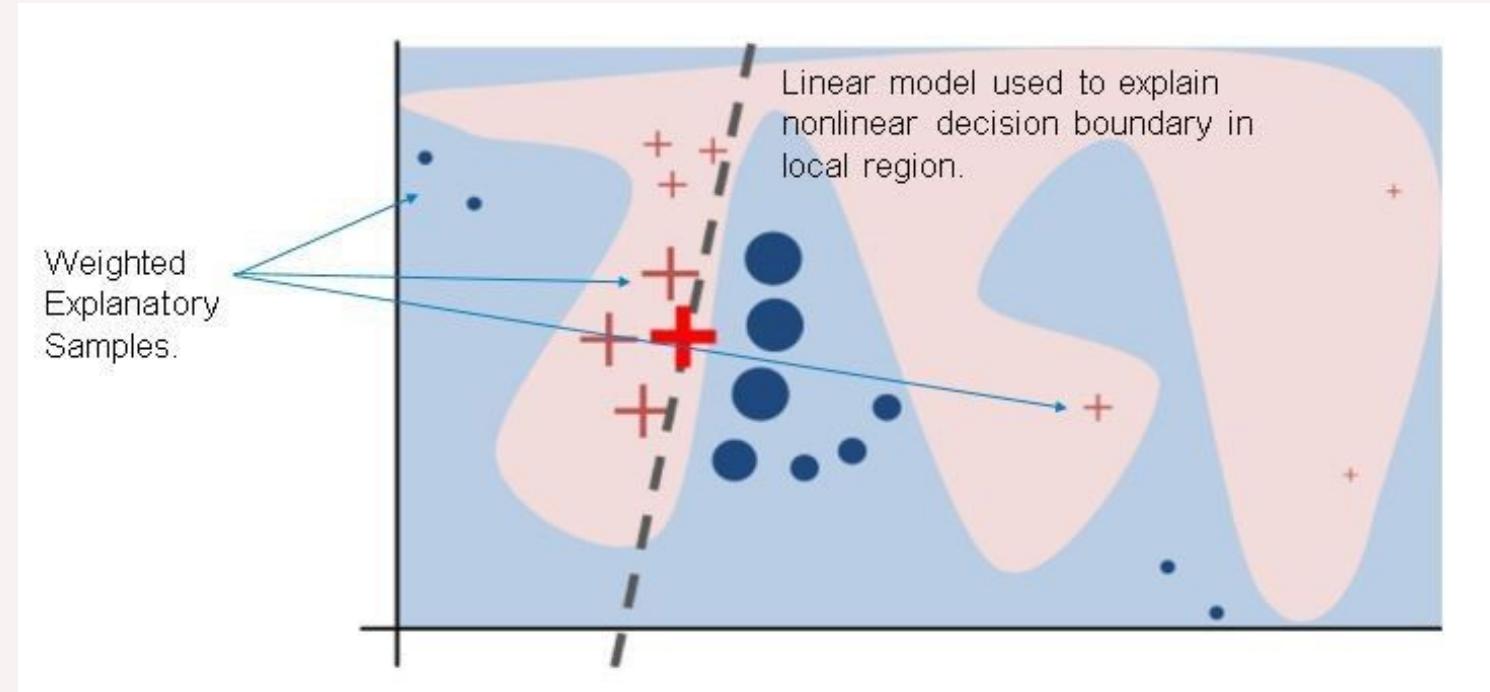
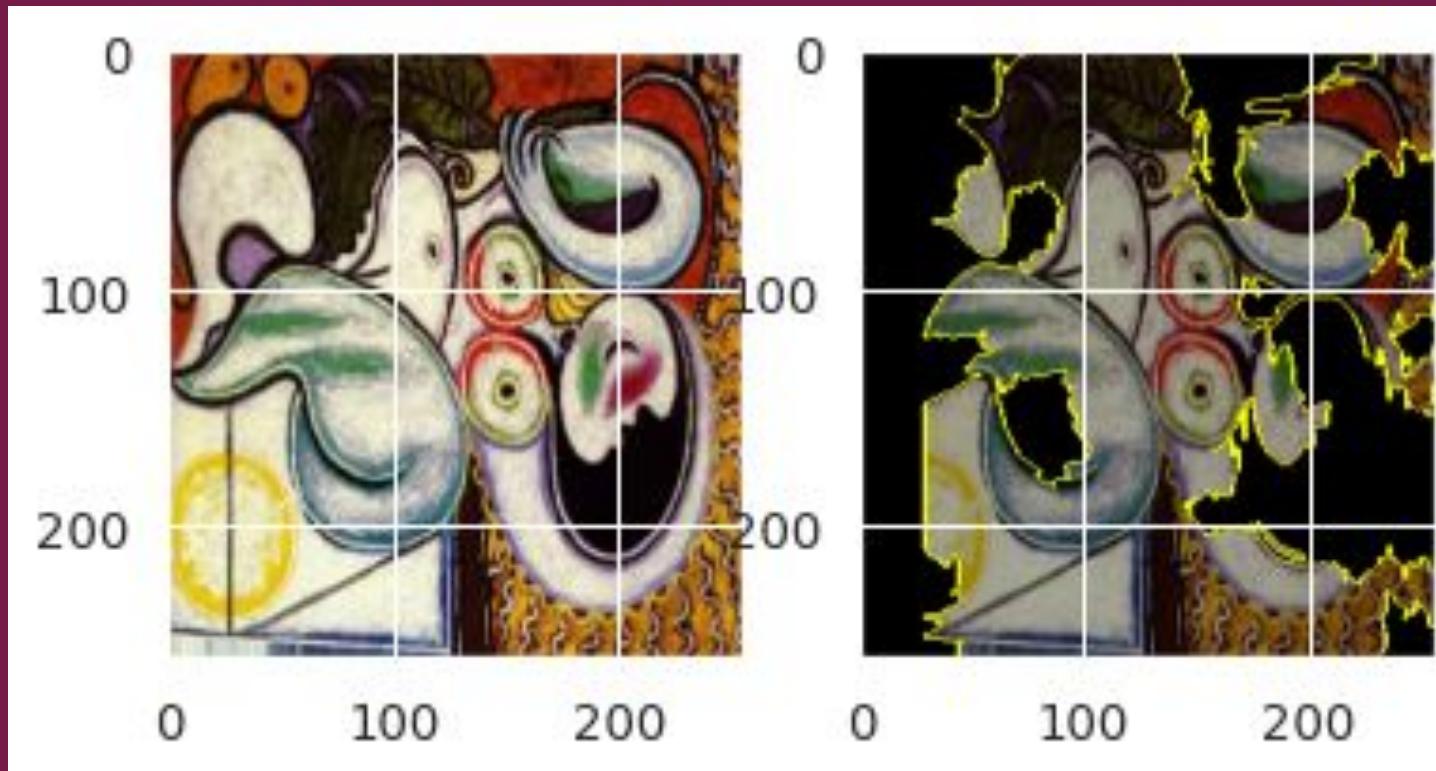


그림 lime 직관력

- 라임은 모델에 영향을 받지 않기 때문에 모델 행동에 대한 어떤 가정도 하지 않는다. 라임은 어떤 예측 모델이든지 적용할 수 있다.
- 따라서 우리는 모델이 작품의 어떤 부분을 보고 어떤 화가를 예측했는지 라임을 통해 visualize하였다.

05 피드백

- Visualize



Prediction Probability : 0.9994000196456909

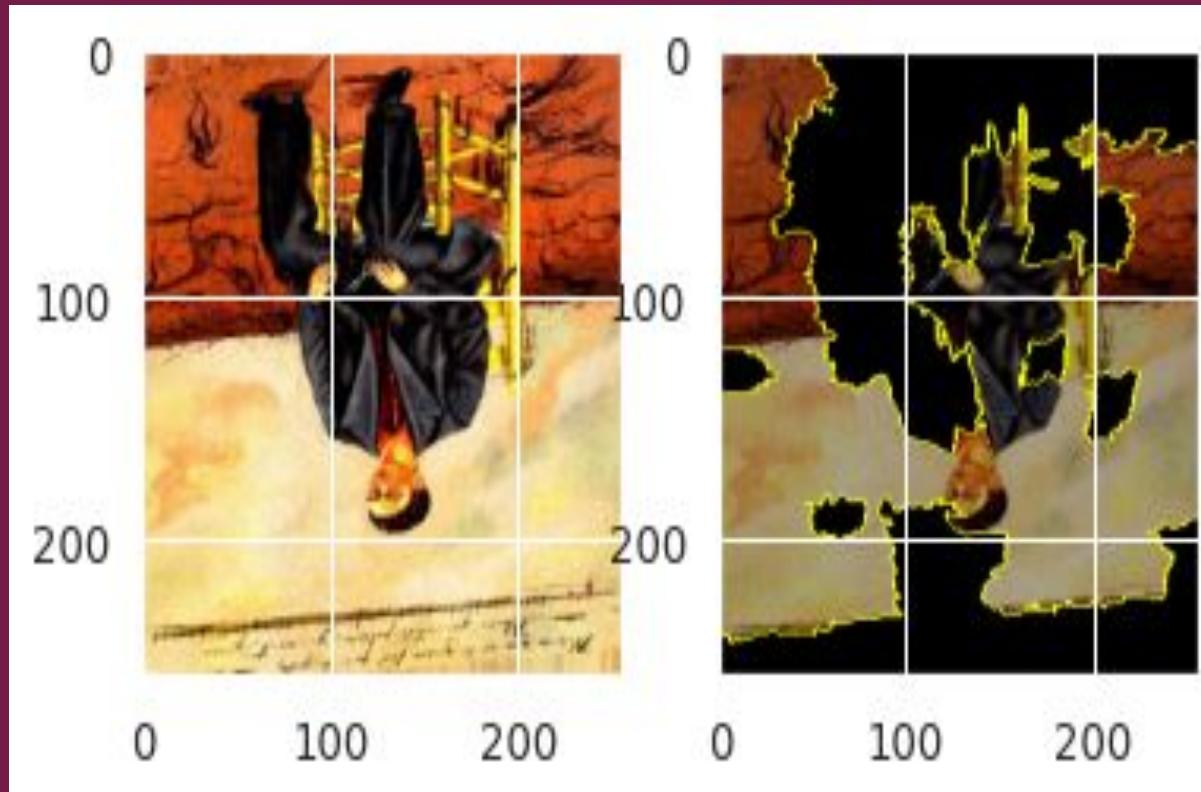
Pred Artist : Pablo Picasso

Actual Artist : Pablo Picasso

- 그림의 주요한 부분들이 대부분 학습에 쓰였음을 확인 가능

05 피드백

- Visualize



Prediction Probability : 0.996

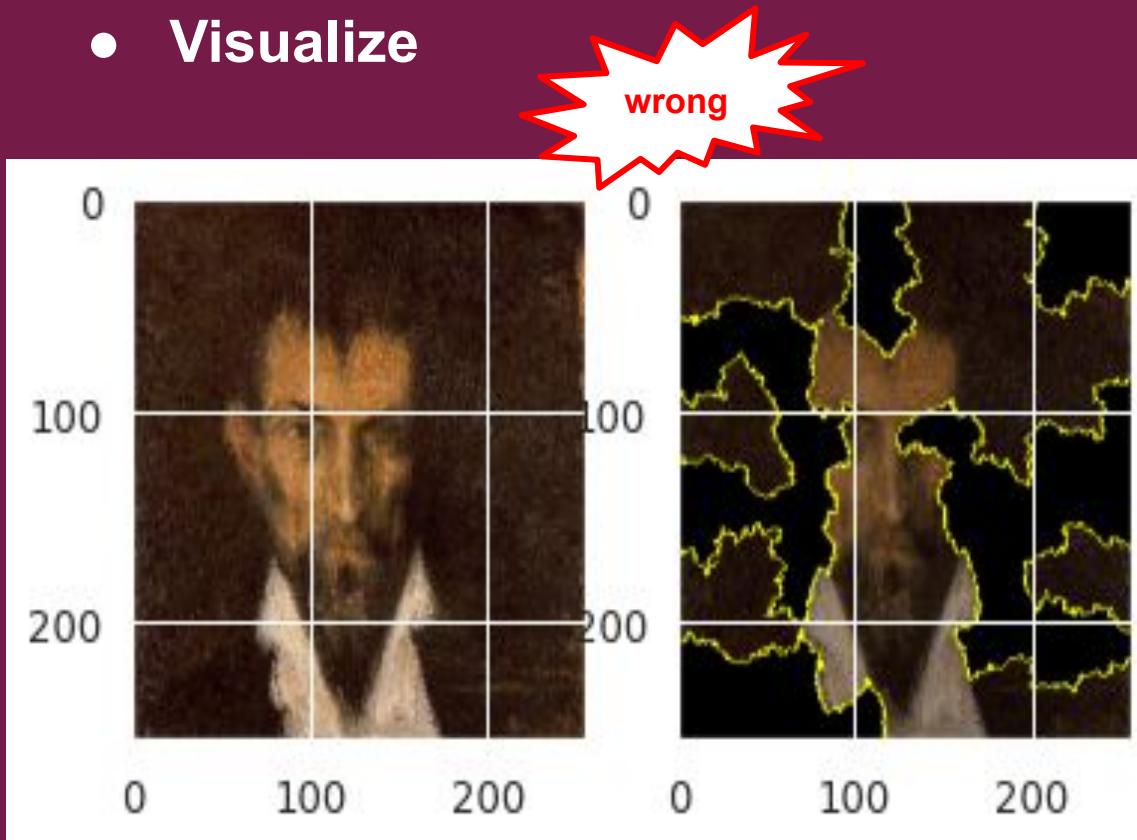
Pred Artist : Frida Kahlo

Actual Artist : Frida Kahlo

- 사람의 형태에 대해서도 얼굴과 몸통일부를
비롯한 특징들을 예측에 활용하는 것을 알
수 있음

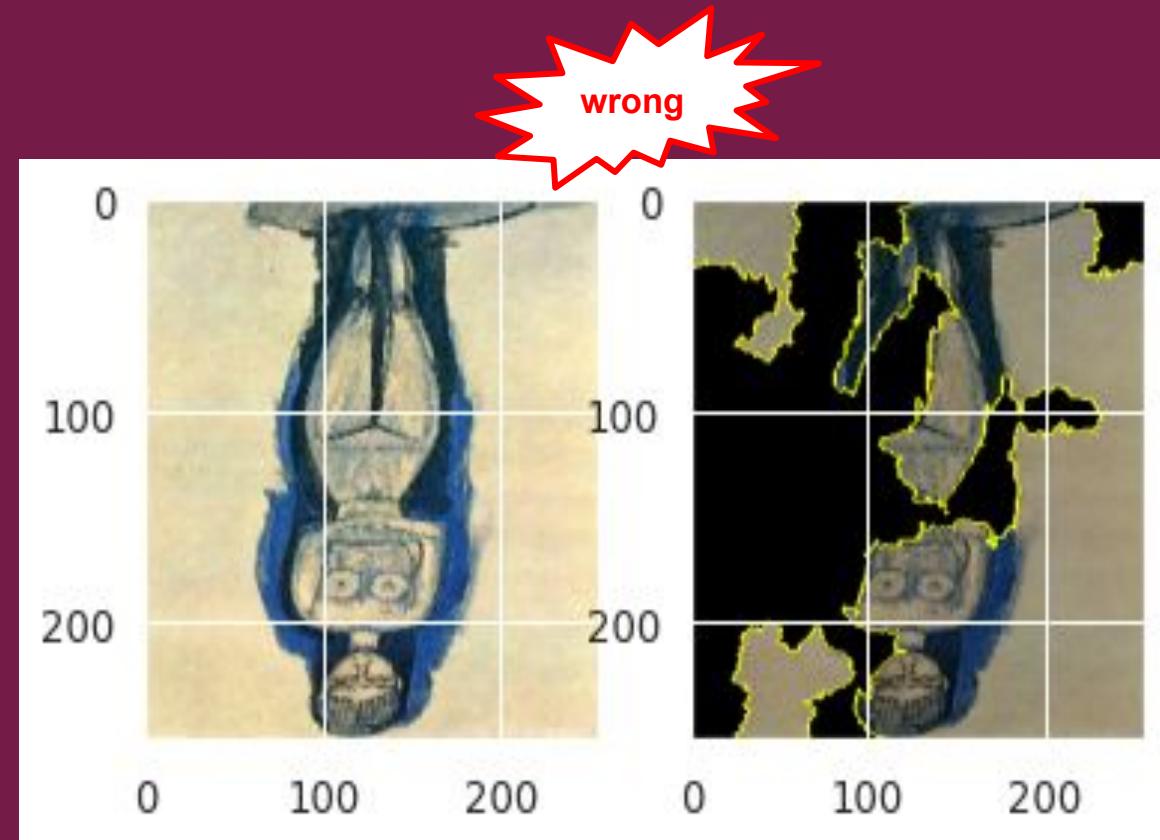
05 피드백

- Visualize



Pred Artist : Edgar Degas

Actual Artist : Pablo Picasso



Pred Artist : Pablo Picasso

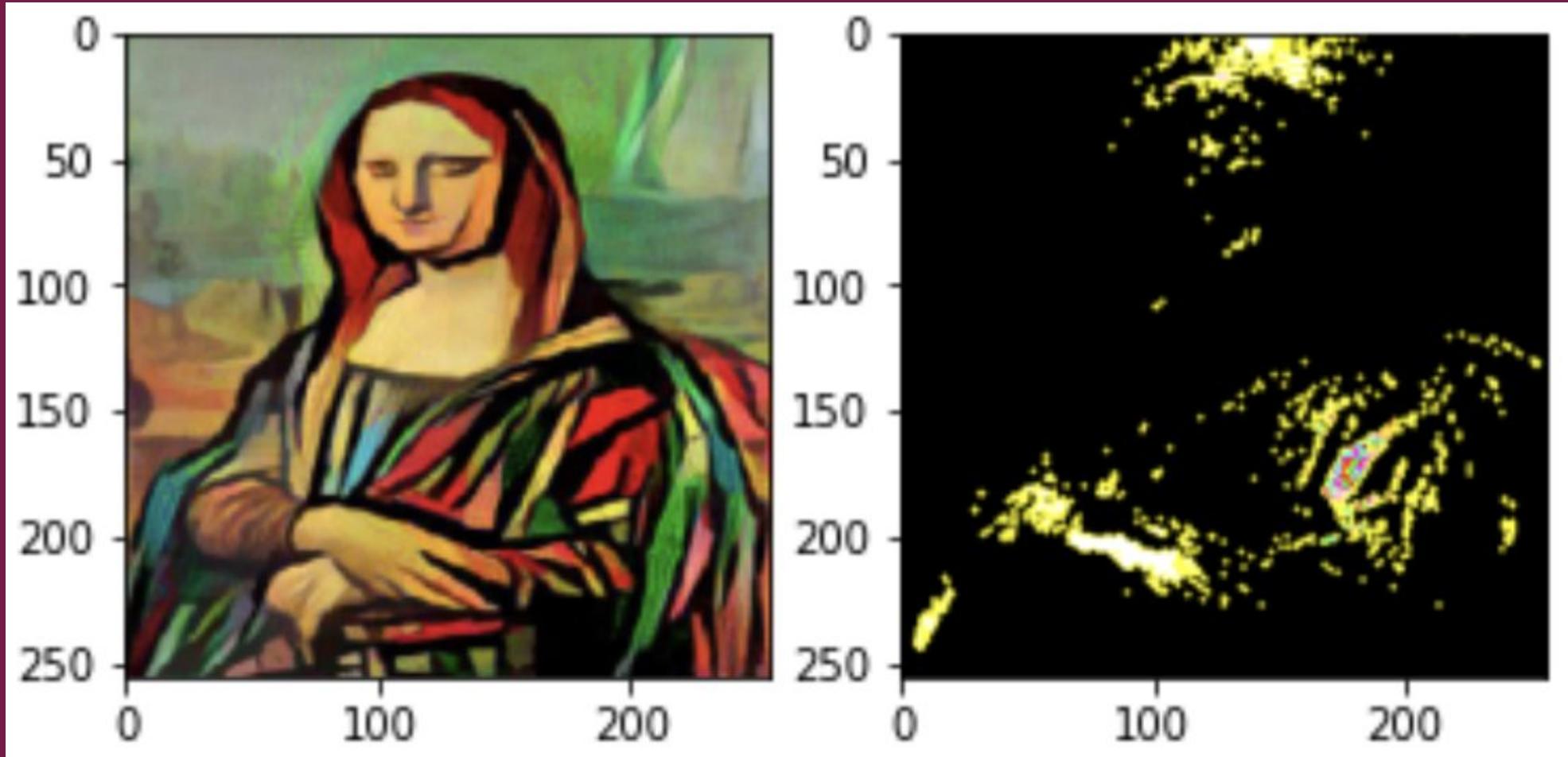
Actual Artist : Amedeo Modigliani

05 피드백

- Style transfer : 모나리자(feat.피카소 style) >> (예측) Salvador Dali 100%



05 피드백



05 피드백

< Style Transfer >

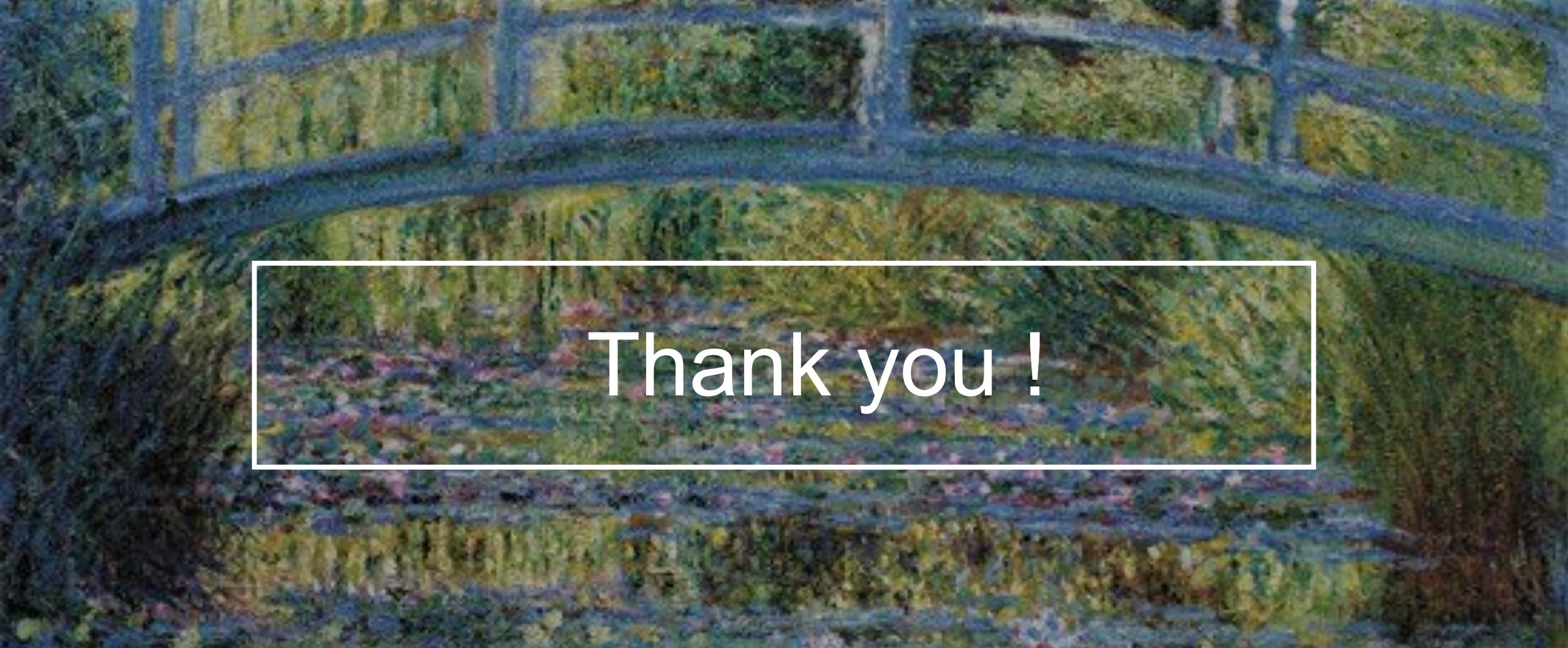
- 원작가 : ‘레오나르도 다빈치’
화풍은 ‘파블로 피카소’
- 예측 작가 ‘살바도르 달리’

> 최종 모델은 그림의 윤곽뿐만 아니라 색감까지
종합적으로 판단함을 알 수 있음.

> 일반적인 물체의 형태에 피카소의 색감이 더해져
동환적인 살바도르 화풍의 그림이 되었다고 생각할 수
있음.



살바도르 달리 <꿈>, 1944



Thank you !

**“Great things are done by a series
of small things brought together.”**

- Vincent Van
Gogh