

**과목명 | 오픈소스 프로젝트**

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**(High Quality Image)**

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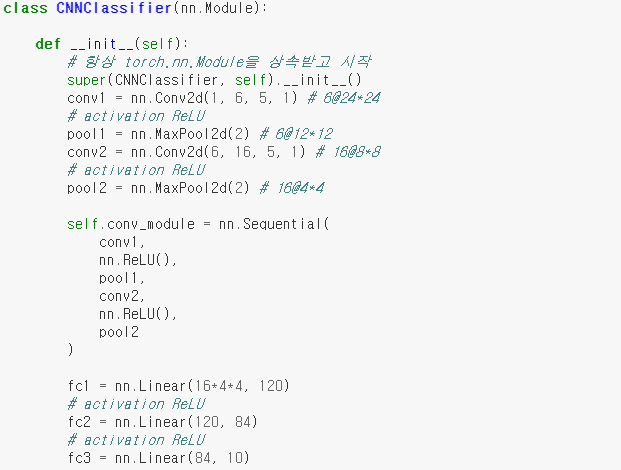
# 1. 프로 젝트 소개

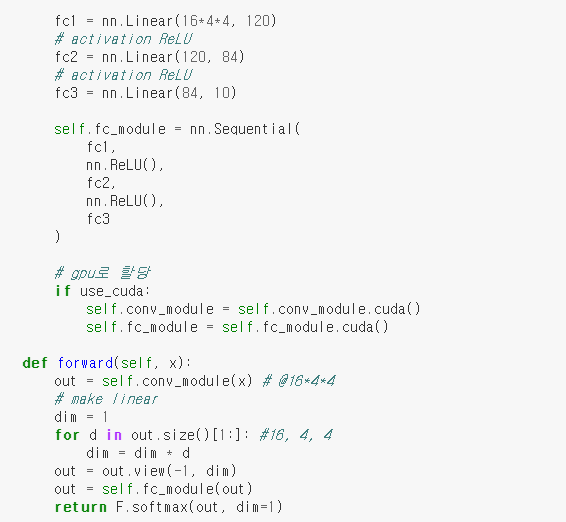
H.Q.I 는 저해상도 이미지를 입력데이터로 받아서 고해상도 이미지로 변환해주는 프로그램으로, 과거 휴대폰으로 찍은 저화질 사진들을 고화질로 개선하고 싶다는 생각에서 착안하였다. 신경망을 이용하여 이미지를 처리할 경우, 보통 convolution 신경망을 활용하는 경우가 많다. 이 때, convolution 신경망의 단점 중 하나가 보통 층을 통과함에 따라 하나의 output image 당 데이터 양이 증가하기 때문에 연산 속도가 떨어진다는 것이다. 이를 개선하기 위해 본 프로젝트에서는 output image의 크기를 고정시키는 convolution layer에 마지막으로 한 번 image의 크기를 확장시킨 후 shuffling 과정을 거치는 Subpixel layer를 추가해, 이미지 해상도를 개선하는 ESPCN(Efficiently Sub-pixel Convolutional Network)layer의 개념을 활용하여 본 프로젝트를 진행하였다.

# 2. 사용한 오픈소스 소프트웨어 소개 - keras

현재 많이 쓰이는 인공지능 오픈소스는 크게 3가지가 있다. Tensorflow, pytorch, keras를 뽑을 수 있다. Tensorflow와 keras는 구글에서 만든 라이브러리이고, pytorch는 페이스북에서 만들었다. 케라스는 텐서플로우와 티아노(Theano)를 한번더 랩핑해서 만든 라이브러리인데 기존의 텐서플로우는 사용법이 너무 어렵고 직관적이지 않았기 때문에 케라스를 통해 좀더 쉽고 간결하고 직관적인 어떻게 보면 파이썬의 특징을 따라가는 라이브러리이다. 케라스의 4가지의 주요 특징을 가지고 있다. 모듈화(Modularity), 최소주의(Minimalism), 쉬운 확장성, 파이썬 기반이다. 파이썬 기반은 위 3가지 라이브러리 모두 가지고 있는 특징이므로 나머지 3개에 대해 설명하겠다.

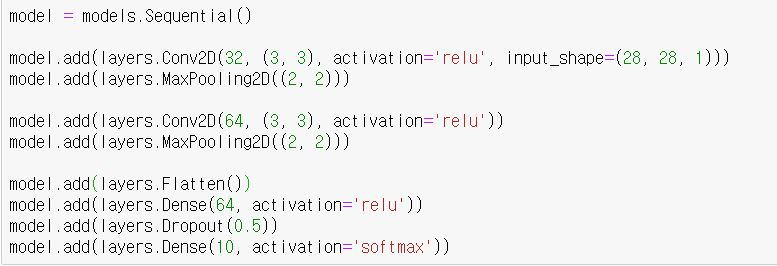
모듈화의 특징을 말하자면 케라스에서 제공하는 모듈은 독립적이고 설정 가능하며, 가능한 최소한의 제약사항으로 서로 연결될 수 있다. 모델은 시퀀스 또는 그래프로 이러한 모듈들을 구성한 것 이다. 특히 신경망 층, 비용함수, 최적화기, 초기화기법, 활성화함수, 정규화기법은 모두 독립적인 모듈이며, 새로운 모델을 만들기 위해 이러한 모듈을 조합할 수 있다. 다음으로는 최소주의 인데 케라스가 다른 오픈소스인 텐서플로우나, 파이토치와 비교했을 때 가지는 가장 큰 장점인 최소주의다. 각 모듈은 짧고 간결하다. 이 부분에 대해서 파이토치의 코드와 케라스의 코드를 비교하면 쉽게 알 수 있다.



파이토치의 신경망 구성

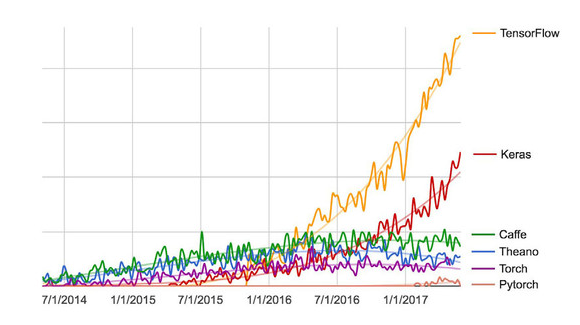
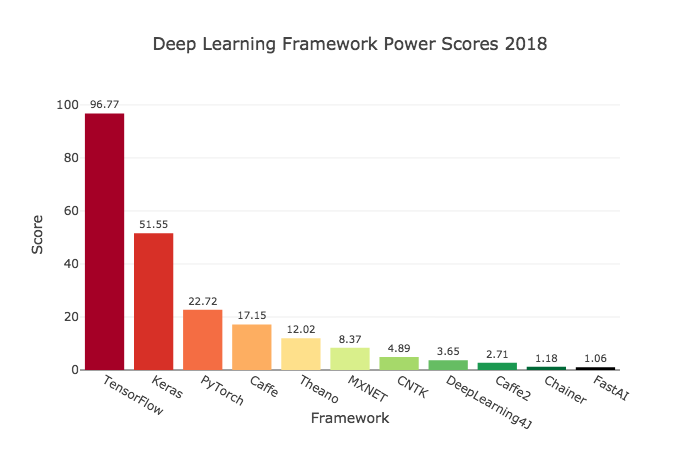
파이토치의 모델클레스를 만드는 방법이다. nn.Module이라는 클래스를 상속받아서 내부 함수들을 오버라이딩 하는 방식으로 구성된다. 파이토치는 텐서플로보단 쉽고 간결하다고 알려져 있는데도 이정도 이다.

다음은 케라스의 모델 코드이다.



케라스의 신경망 구성

누가 봐도 더욱 간결하다. 이러한 최소주의적인 특징 때문에 케라스는 자주 쓰인다.

딥러닝 프레임 워크 Power score

실제 연구실에서는 파이토치가 많이 쓰인다고 듣긴 했지만 파워스코어는 텐서플로와 케라스가 많이 쓰인다. 그래서 우리는 코드가 간결하고 직관적이고, 개발속도가 더욱 빠른 케라스를 이용했다.

# 3. 설계 및 개발 내용

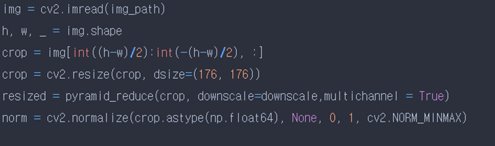
## 3.1. 사용한 데이터 및 전처리 과정

- 사용한 DataSet : Kaggle CelebFaces Attributes(CelebA) Dataset – Celebrity Image​(<https://www.kaggle.com/jessicali9530/celeba-dataset>)



총 202599 장의 인물 사진이 있으며, Train : 162770 / Validation : 19867 / Test : 19992 로 구성된다. 전처리 과정을 통해 각각의 이미지를 저해상도 이미지로 변환하여, Input 데이터로 사용하였고, 정답이미지 또한 생성하여 학습과정에 사용하였다.

- 데이터 전처리 :

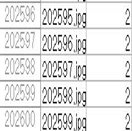
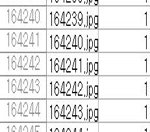
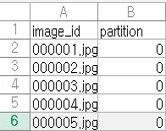


CelebA에 있는 원본 사진의 크기 즉, 배열 형상은 (218,178,3) 이다. 앞의 두 인자(218,178)는 pixel단위 크기를 나타내며, 마지막 인자는 RGB 채널 3가지를 가리킨다. 먼저 이것을 가로-세로 길이를 맞추어 176x176 크기로 resize 해주었으며(crop), 저해상도 이미지를 만들어주기 위해 44x44로 크기를 줄여줌과 동시에 각각의 pixel 값을 0~1 사이로 정규화를 해주었다(pyramid\_reduce). 그리고 crop 이미지에 대해 크기는 줄이지 않고, 0~1로 정규화하는 과정만을 통해 정답이미지를 생성하였다.

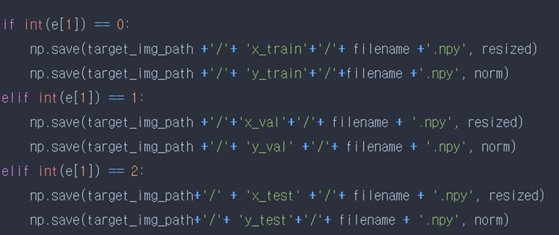


위의 사진 중 resized가 실제로 학습과정에서 사용되는 저해상도 이미지(44,44,3)이며, 고해상도로 변환되어 나오는 Output의 형상은 정답이미지(norm)처럼 (176,176,3)이다.

이후 Train, Validation, Test 이미지 파일들로 분류하기 위해 “list\_attr\_celeba.csv”파일(아래사진)을 이용하였다. 각 용도에 따라 0(Train), 1(Valid), 2(Test)로 partition 되어있다.



위 Excel의 내용들로 리스트로 변경한 이후, 아래의 과정을 통해 resized(저해상도 이미지)와 norm(정답 이미지)를 Train,Valid,Test로 분류하였다.

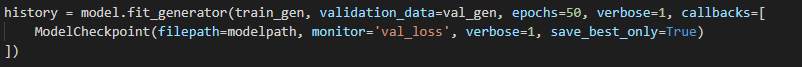


## 3.2. DataGenerator Class

Convolution 신경망 및 Subpixel 계층을 구성하고, 데이터를 검증 및 학습하는 과정에서 Call back 형식으로 호출되는 Custom-Generator class이다. DataGenerator class를 호출하는 코드 및 해당 class의 전체 코드는 아래와 같다.

**<DataGenerator class 호출 코드 – train.py>**





- DataGenerator 생성자 등록 시 parameter로 넘겨주는 list\_IDs는 train, validation 용도로 사용하는 사진의 절대 경로를 저장한 리스트임.

- 단일 데이터의 크기(dim)는 저해상도 이미지로서, 44 X 44의 pixel 값임.

- RGB 사진을 처리하므로 채널의 수(n\_channels)는 3임.

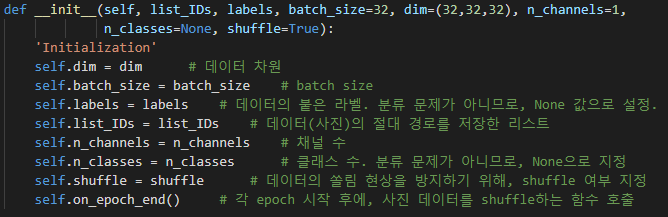
- keras package의 fit\_generator 함수를 통해, 지정한 optimizer(본 프로젝트에서는 Adam optimizer를 사용)와 Cost function을 적용하여 학습을 진행함. 이 때, 각 epoch마다 DataGenerator class를 호출하여 새로운 train data를 불러오게 됨.

- callback method로 ModelCheckpoint method를 사용하여, 학습된 모델의 아키텍쳐를 저장함.

**<DataGenerator class 코드 – DataGenerator.py>**

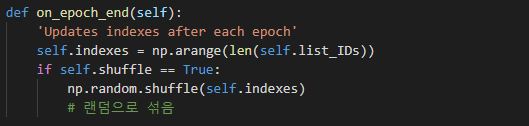
1. 생성자 \_\_init\_\_()

fit\_generator() 함수를 매 epoch마다 호출할 때마다, 자동으로 호출되는 callback 생성자 함수이다. 각 epoch 당 Train 용도의 data와 validation 용도의 data가 별도로 불린다. 코드는 지면 관계 상 다음 페이지에 표시하였다.



- on\_epoch\_end() 함수는 생성자 호출 시, 자동으로 호출되는 함수로서, 각 epoch이 진행될 때 마다 특정 구역의 데이터만 호출되지 않도록(지역성 제거) 데이터의 index를 shuffling해주는 함수임.

2. on\_epoch\_end()



각 epoch 당 생성되는 DataGenerator class 객체는 data shuffling을 통해, 고유의 데이터(test, validation) 순서를 가지게 됨.

3. \_\_len\_\_()

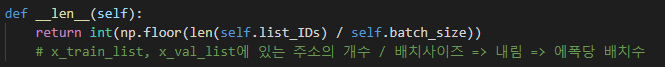
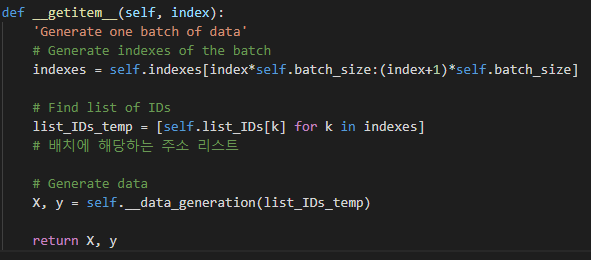


사진 파일의 절대 경로 리스트의 길이를 배치 size로 나눈 값을 반환해주는 내장 시퀀스. Keras의Sequence class method를 overriding 함. 예를 들어, 리스트의 길이가 1600이고, 배치 size가 16인 경우, 결과 값은 100이며, 각 epoch 당 100개의 batch를 처리하게 됨.

4. \_\_getitem\_\_()

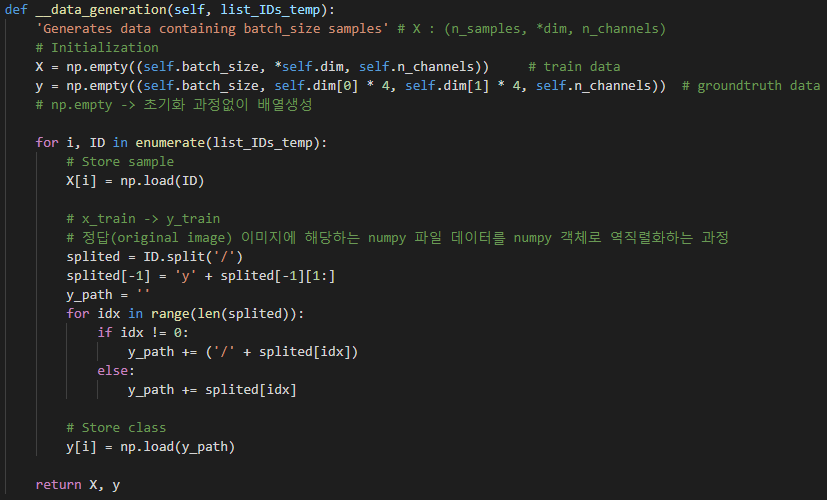
\_\_len\_\_()과 마찬가지로 Keras의 Sequence class method를 overriding한 내장 시퀀스.

self.list\_IDs(사진 파일 절대경로 리스트)에서 지정된 인덱스에 해당하는 곳부터 생성자 호출 시 지정한 배치 size만큼 사진 파일을 불러들이게 된다 (self.\_\_data\_generation() 함수 호출). 파라미터로 들어가는 index의 최댓값은 \_\_len\_\_() 시퀀스에서 반환한 값이 됨. 예를 들어, index가 10이고, 배치 size가 16인 경우, 해당 시퀀스는 self.list\_IDs의 160~175번 째 인덱스에 해당하는 사진 파일을 불러들임.

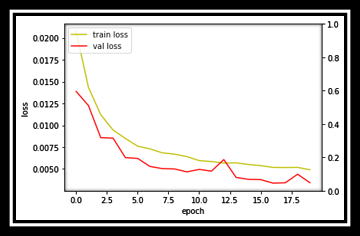
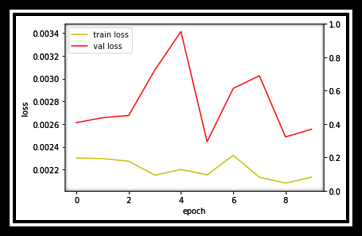


5. \_\_data\_generation()

\_\_getitem\_\_() 내장 시퀀스에 의해 호출되는 함수이며, parameter로 넘어온 사진 파일의 절대 경로 리스트 값을 참조하여, 해당 파일을 numpy 배열로 역직렬화(load)하여 하나의 리스트로 저장하고 반환하여 주는 역할을 수행함. Train data와 그와 동일한 index에 대응하는 groundtruth data를 불러들인다.

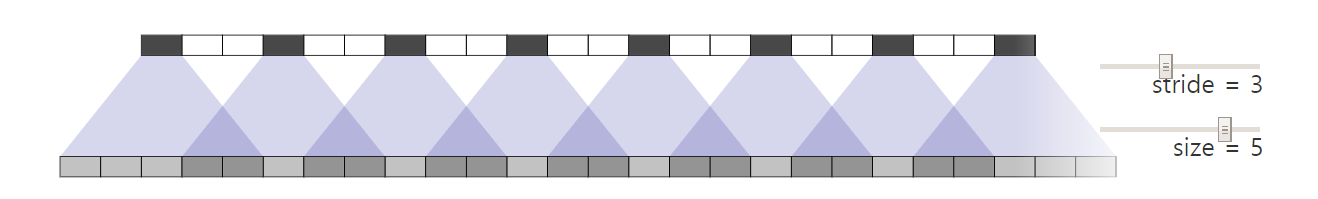


## 3.3. Train(학습)



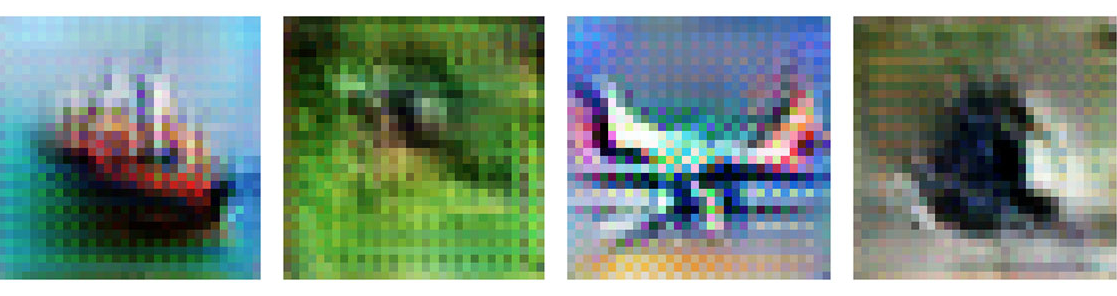
## 3.4. Subpixel Class

기존에 해상도 개선을 위해 사용하던 방법은 SRCNN 혹은 조금 개선된 FRCNN의 deconvolution 방식이었다. 하지만 위와 같은 방식을 사용하게 되면 몇가지 문제점들이 발생하게 되었다. 크게 2가지 문제점을 들 수 있다. 첫 번째 CheckerBoard aritracts problem이다.



<그림 1>

다음의 <그림 1>과 같이 커널(출력 창)의 크기가 Strides에 의해서 분할되지 않을 경우 고르지 않은 중첩이 발생하게 된다. 따라서 <그림 2>와 같이 바둑판 형상의 잔상이 이미지에 남게 되는 문제가 발생하게 된다.



<그림 2>

두 번째 연산량에서의 문제점이다. 과도한 양의 연산량으로 인해 연산 시간이 오래걸렸다.

이를 개선한 방안이 바로 이 ESPCN(Efficient Sub-Pixel Convolution Neural network) 모델의 방식이다. 이는 이전 LR(Low Resolution) 공간의 image가 HR(High resolution) 공간으로 interpolation(fixed filter)에 의해서 resizing 된 이후, network의 input으로 들어가 computational cost 와 complexity가 컸었던 기존의 방식에 비하여 계산량 측면에서도 단축되고, network의 끝단에서 Super Resolution을 진행함에 따라 정확도 또한 좋아졌다.

![모니터, 화면, 텔레비전, 자주색이(가) 표시된 사진

매우 높은 신뢰도로 생성된 설명](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDaRXhpZgAATU0AKgAAAAgABAE7AAIAAAAFAAAISodpAAQAAAABAAAIUJydAAEAAAAKAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHVzZXIAAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM0MgAAkpIAAgAAAAM0MgAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Hoe9NJJWRMacacuZeX4Cx7po/Ib/WpzGfUelMK/M6eqfrTBIQq44ZeVbvVidhNsukGCflkHof8A69MesX5MqIfU4oBMcgYdjSMCrHI7808DKnuRSNjYgOYpveI1MetUrB91tJk8iNgaunrXBivjXoeHiFaq0JXQeEZGjv5yuf8AV84+tc/XWeAIppdUult3VD5IzuxzzXn1pqFNyex5mOi5YeSX9anRxuszFWY57g1etbaeKQGBvLk7Y6Gpbi3ujIrSwRS7Rg4HX8qVkEkQ+yrtdfvRk4dfoe9eRUrqcUo2s/mv6+R8pGnyv0+THXys8YGoRYLAFZl6qaqazJ5t3FMf44lz744zV+Cd57HyL8rIHLJG/cMOmRVPXIGt2tVfgiIAiufCS5a8actGr7bW8vu1NqybpuS209b+ZnxHb0PNZ+uabdX01rcadKqXVq2ULDIwavYJx2zUysAw57V7fM4S547nJRrSoz54mRF4dv3N9Lqd0A98q7zGMZxXSeF7C1sNOfTvMd4pj8u452t7UXBZ7AP6VRt5mDcHGDkexrjrOrjKEoN216dGtv0O2WNq8/vbdum1vyLk9vNDe5jO2eI5Ge9dHp0y31qXUYIUhl9GFUQRqFtHP/y1HGR61Ba3Y0vVBcHiGX5J1Hb/AGq8HFKWLouKX7yP59vn08zfDuNCqm37kv6/4c2LmHzLFSR8y1iyDC4zlh2PpXSMMxNtIKHkH2rn76PZJkdev4Vw5XW5m4PudOPp8tpI8l8Wab/Z+vzIBhJP3i49DzWJp/8Ax7v/ANdWr0P4hWYl0y0vUTmJzG7ex5H9a88sP9Q//XVv51+iU67r4SEnvs/lp/wT3sPV9rhIv5Fmkb7h+lLSN90/SoKW5ijzD90mmjf1+YkdjUnnsq/6vafoalhl7q3zdxn+Ve2e820r2IVaJz82VPqKHbKDOCQCM+oqWRo5GxOhB/vqOR9RUDja23cSwyCaAWpH6f5zTon8qVX5+U5ptBpGm+hrPfacIi0MconZSCw6PkdDz/KoJNTM0JQwRqzKFZ/b2HaqJ4A9qKLHPHDwWur9WOKknGcsvcHqKc2JU3j7y8MD/OmH5kBPVeM+1OSUo25fTDDsRTNtRhA29ec0uc9OKWVNjfJyjDKmm9/rSHuiWAb0liXnI3DPtUmnf8fQ/GoIn8qdJOgB5x6Vas02X5XoATj6VlW/hs5sR/DkadFFFeUeMZmpDNwv+7VbZjBUZFXNRJEqkH+GqcbheGB65z6V61H+Gj26F/ZIcPmIBO5O59DT7X93cqAM7gVdfUdKYMxsSCCD0I6GrEUSreRypwFcbh6A9DWpU3oyoV25XrtJH60jHd/OjO92x3JNAHH0pGpbtJXFjPaSTLHbylXbK5OR0xVu61O1eXT2RJHNrFsLE7S5ByPwrLj5IHXtTHGJCKXKtzCVCEpXf9aW/Iu6jcm+na6ESow4dV/nVeFgnyP/AKqT9D2NLG2GG45VxhvemMDFvjYZGearYqMFGPItkPaMwyrv6hucdxUBGJSOnNWQ32m12H/WwjKn+8v/ANaq75JB9RQXFvZiOMkEdxToOLmPP98fzpF/nTov+PmP/fH86RT2aNuL/Up9KdTIf9Sn0p9eKfOlbUOLF8eo/nWR5j/3jx71s3gZrUhOGJGM/Ws6SOdiFaNW9CBXfhfhZ6eDaUXcW2DO+funsamui/lDz4946bh2qBUBXC/u5M/dbvUsFxKgaO4XKDrnqBXadMr3uivK5a0jB5CkgH2qvVy7h8mAAfdLkr9Kp1LNoNNXQ+JgkoLdO9TSpCsRMTbjnvVanjZ5Zznd2oG1rcckirKCFwCMGmyRmKTB+oplPJaQDOSV/lQFrMv2Z+0DaT+8Xr71YmgIVh6GqtuBAyy4O+tVSsq7l5DjpVo4qsnGV1sYDYEjAnGOlSWr/KR6U+/tyh3gcdDVe3J8zA7ip2Z1JqULmnZnM8n+4v8AM1bqlYnM8v8Aur/M1dryq/8AEZ4tf+IwrEuVJvJjtJG81t1lzPtmlAl2/OeM1phfjNsG7TfoVl4PB2+oxS7ASTu2nHHvU2X7MCSOCaaVVyM5z3OMEV6J6dxvPzJJhjjIYUw/eOBxmpAhEcmGyuzI46+1Q/eoKQh5rdtDYz21tJfXRhe24CAZJx3rDP3aUc5/nSMq1L2sbXt6G4+q6XHc3LR2jXAlfILnbkY74rFkKtIxRNiMcqAc7fao/pTgM5X8qSVhUqEKXw3+8cD/AA/xDpRjOcdCtJuOPfqDSn5v3ijGeGA7GqNhg5HSpbaQw3ccnvgj1FRHqfrR9KQNXVmb+Nm9SOQpoqKCXzbVH5z5ZVs+oqWuLF/EjxKqalqFUtSGUi4z8x/lV2qt8xXyiG28n+Vc9L+Igo/xEZ2MDpj3x1oIz1OTUrOxYksHakdt4w/JHtXrHs3ZHyOh47U5h3Axnmk24A2nJ9MdKdJnzME9hmgOow+npV7SpUSV0llWFJF2l26CqODmigmpBTi4s3ZL3SrSGKG2Mk5ik3FiuF6ds/4VQ1C9jvmQxWohwOTvLMx9aotwfSjt71KjbqZU8NCD5tW/UXPfp60hPFL05/nTc549ao6BTjP4c0EZFN6YyKUH16+1AzZsJN9ouf4eKkb/AFjfhVDTpdsrRnPzDirx/wBY34Vz4r+H8zyMRHlkFFFFeYcpDdRtJblUG45HFUfsc7Z3Rr7CtSitqdaVNWRvTrypq0TI+wz94/1p4s7heQM4GBWpRV/WZmv1uoZ4tpVsvKCfNnNQCwuBxs4+ta9FP61MSxdRGP8AYJ/7n606KyuElBZOB71rUUvrMx/XKnkZDWE5JwnHbmhbK4Vgdn1+la9FH1mYfXKnkZYspg5+X5c8c0hsZ/M4TjrnPetWin9ZmH1uoZv2OYhsj736VJp8M1nqMc5U7Qfm57VeopfWZkSxM5RcXsyCGLy7q4KqRGzfJnuKnoorCUnJ3ZhKTk7sWsuS2uDOzCPvla06KqnUdN3RdOrKm7ozBbSuP3tuc56qRTGs7gDCKWUcgE9K1qK1+szN/rdQzHt7hrNIhGc7ix5FRLZ3IXHlHH1FbFFH1mYLF1F0Rj/Y7j/nkevqKkjtp1PMZ49xWpRR9ZmDxlR9jGFlchifKP5ipFtrpWDCM7hz1FatFH1mYfXKj6IzJbSV5GIiO1ueo4Pei2t543ZZYiY3GG5H51p0UfWZi+tTasZElncFsiM5xg8jmhLS5VhmI46HkdK16KPrMx/XKlraFCzhmgeYNGQrqQDkVoUlFZTqObuznqTdSXMwrZ8OavHo95NLIXG9NoKjPesaispRUlZnPVpqrBwlszvR46ghw0E05buDHVuP4g6VOMXttKH7SRrg15vRXJPA0J7rXutH+BxRy+lHRN2PRJPGeitcRtuuWTeGb93zxRrnjjStRuxJCJyqqAMpivO6KUcDSjUjU1vFNL5jeX0XBw1s9Ts/+EssNoBWU4/2aB4r0/P3Zf8AvmuMorq5ImP9kYfz+878eNNK+xNEVn3H/YqgnimwVs4l/wC+a4+iohRhC9uo3lWHe9z0Gw8dadbCRHE+x14wvRu1On8baPPD8yz78f3OteeUVi8FR5/adTT+zaPLy3dj1PSfiTpUFl5N6LjcvygiPOVqG88eaHKv7kXBPvHivMqK5Y5Tho1nWjdN676G8sLCVNU5XsjttV8VaVqGhXNkwnLPgx5ToRXBWcbRQuHGCZGI+hqeivTpwVOLhHZu5pQoxoQ5IvQKG5U/SiirNjOEFwBjyRjHQGg2TSfei8s+qmtGiur61M6vrVQzGtLj0Dds96a1jPnhc8Y4PStWij6zMf1uoZH2G4/ufrR9huP7v61r0UvrMx/XKnkZH2G52/d/Wj7DcH+D9a16KPrMw+uVPIylsZweU+vNDWM5wQOR3z1rVoo+szD63UMsWUxjKsmO4+tNNhOPurx6ZrWoo+szF9bqGR9gnOf3f61bt4ZFljkkVgwBD5/Q1coqZV5yVmTPEzmrMKKKKwOYo30Es0y7FJUDnFVxbXOSGiLDGByK1qK6I4icVZHVHEzjFRRkmznGdkbAHgjIqSKC4jimBibc6hQcjpWlRT+szG8XNqzsYy2Vyv8AyyP5ij7Fcf8API/mK2aKPrMyvrlTyMhbO4HWI8j1FElpcPJuERx9RWvRR9ZmL65U8jIFpcd4j+Yp7207rGTEdwG1uRyO1alFH1mYfW6nkZCWt1FKrxxnKnI5FOns5WcmOJsZyBkce1atFH1mYfW6l76GMLK6/wCeR/MVJ9kn8+N/KOAQTyK1aKPrMweMqPsNiBWJQeCBzTqKK5jjIbxHktWWIZfIxWesF8hDKGBHuK1qK1p1ZU1ZG9OvKmrJFJPPk4urYH/aBGabPbPJjAf05xV+itfrVQr6zNO6Kl3E0lmkUUbEr61n/YLn/nkfzFbdFJ4mbKhiqkFZGJ9guf8AnkfzFKLC47xkfiK2qKPrMyvrtTyMT7Bc/wDPI/mKfFaXMcgbyjjvyK2KKPrMw+uVH2KIjm24MR9jxS2n2mJissZ2ZyCMcVdop/Wqhm8TJq1kVb9JLhAsUbe+aopZ3KPkRH8xWxRR9aqDjipxjyoqWUUqSSNKm3KgDn61boornlJyd2YTk5y5mFZs0FwZ5CqMVLEjDVpUVUJuDuiqdR03dGP9kugciNvzFPEF0fvwE+h3DitWitfrMzf65U7IyTbTmHYIDndktkUz7Hc4x5J/MVs0UfWZh9cqLojG+x3P/PI/mKVbS5B5hJ/EVsUUfWZj+uVOyMb7Fc/88T+Ypfsl1nPlHP1FbFFH1mYfXKnZGObO5yf3JH4ihbW6BOYTgjB5FbFFH1mYfXKnZGP9juc58kk45yRSfY7n/nifzFbNFH1mYfXKnZFSxSWKKVJkZR1TvyetW6KKyqVJVNzlnNzlzMKrXscjrH5QJwTnBqzRUxk4u6FGTjJSRltbXB6Rtj0zTfs1z/zyJ/EVrUVv9ZmdX1up2RlrbzrIpMBIHbIpv2W4ySYjknPUVrUUfWZh9bqeRk/Zbj/nkfzFKLW47xH8xWrRR9ZmH1up5GUbWc4/cnj3FJ9luOnlHH1Fa1FP6zMPrdTsjK+zTnrCfzFJ9kuP+eR/MVrUUvrMw+t1PIyWtLhhzGc/UUC0nGf3J/MVrUUfWZh9cqeRmQwXEUiuImyD6jpWnnLE4x0ooqJ1pTVmY1K0qm4UUUViYn//2Q==) Sub pixel 방식에 대해 좀 더 자세히 살펴보겠다. 예를 들어 <그림 3>의 이미지를 각기 다른

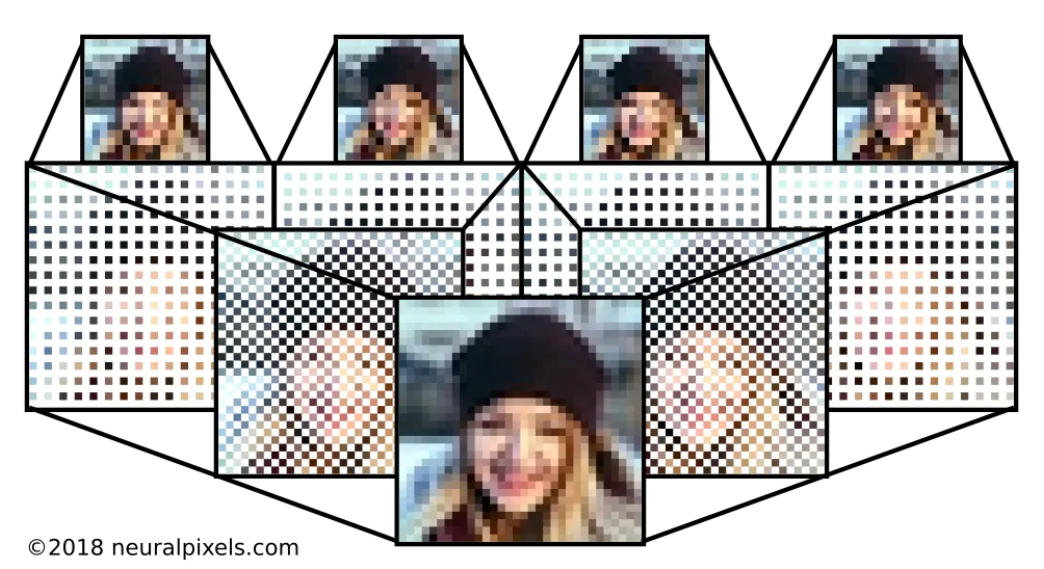
사람, 실내, 의류, 젊은이(가) 표시된 사진

매우 높은 신뢰도로 생성된 설명

<그림 3>

<그림 4>

Filter를 갖고 feature map을 추출하게 되면 같은 이미지이더라도 서로 다른 filter에 의해 다음과 같이 각기 다른 이미지 결과값들이 나오게 된다. 이렇게 4개의 convolution Layer를 거쳐서 16개의 channel을 형성한다. 각 채널의 이미지를 pixel 단위로 쪼갠 다음 shuffling 과정을 통해서 HR Image를 형성한다. 이해를 돕기 위하여 예시를 들어본다.



<그림 5>

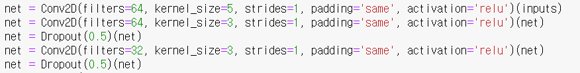
시계이(가) 표시된 사진

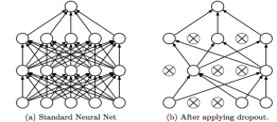
자동 생성된 설명

<그림 6>

<그림 5>의 이미지를 보게 되면 뒤의 4개의 이미지가 각 채널의 이미지를 의미한다. (여기서는 효율적인 설명을 위하여 4개의 채널의 shuffling 과정을 이미지를 통해 나타내었다. 실제 구현한 코드는 16개의 채널에 대하여 shuffling과정을 거치게 된다.) 이렇게 각 채널의 이미지를 pixel 단위로 쪼개어 <그림 6>과 같이 해상도가 개선된 HR Image의 결과 값을 얻게 된다.

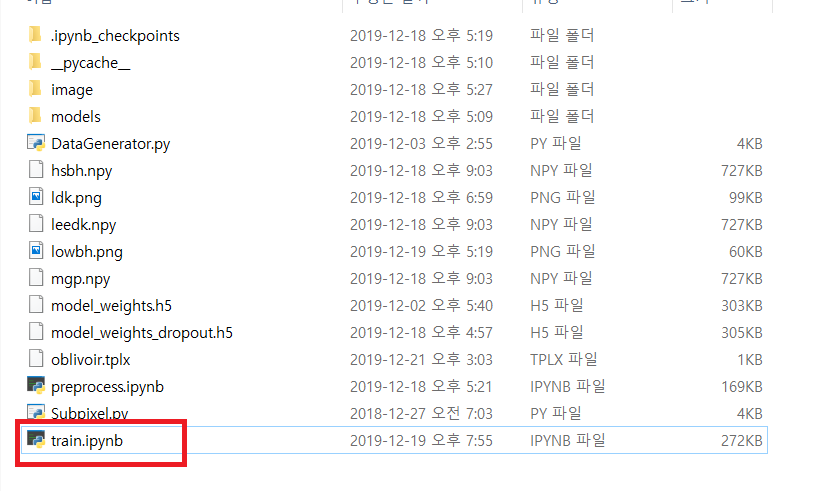
## 3.5. Drop out

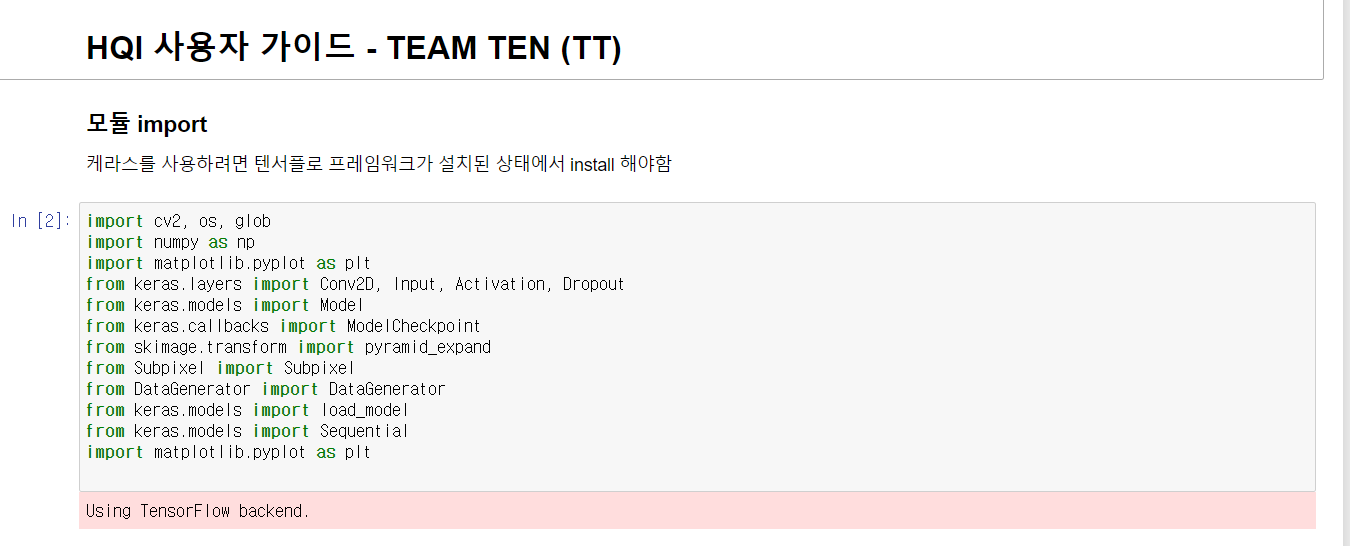




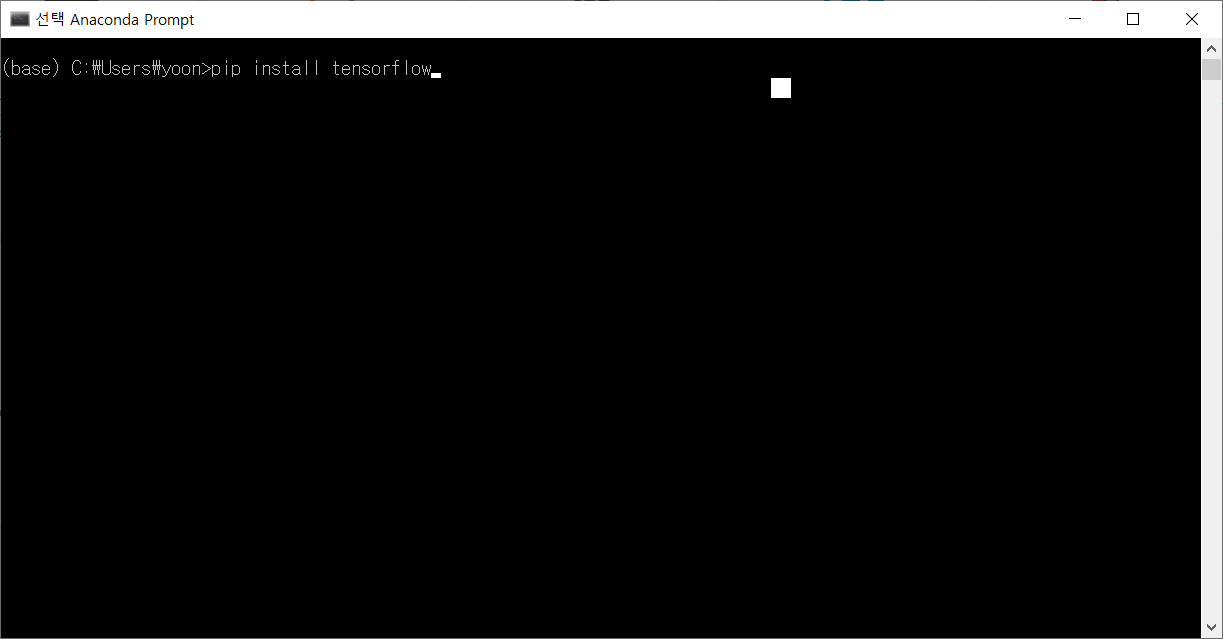
# 4. 시스템 셋팅 및 사용자 가이드( 사용 방법에 대한 설명 )

우리는 가이드를 주피터 노트북의 마크업(mark up)기능을 이용하여 작성하였다. 주피터 노트북은 파이썬의 편집기중 문서편집과 코드실행을 함께 할 수 있는 편집기이다.

1) 코드집을 압축해제한 후 train.ipynb를 실행

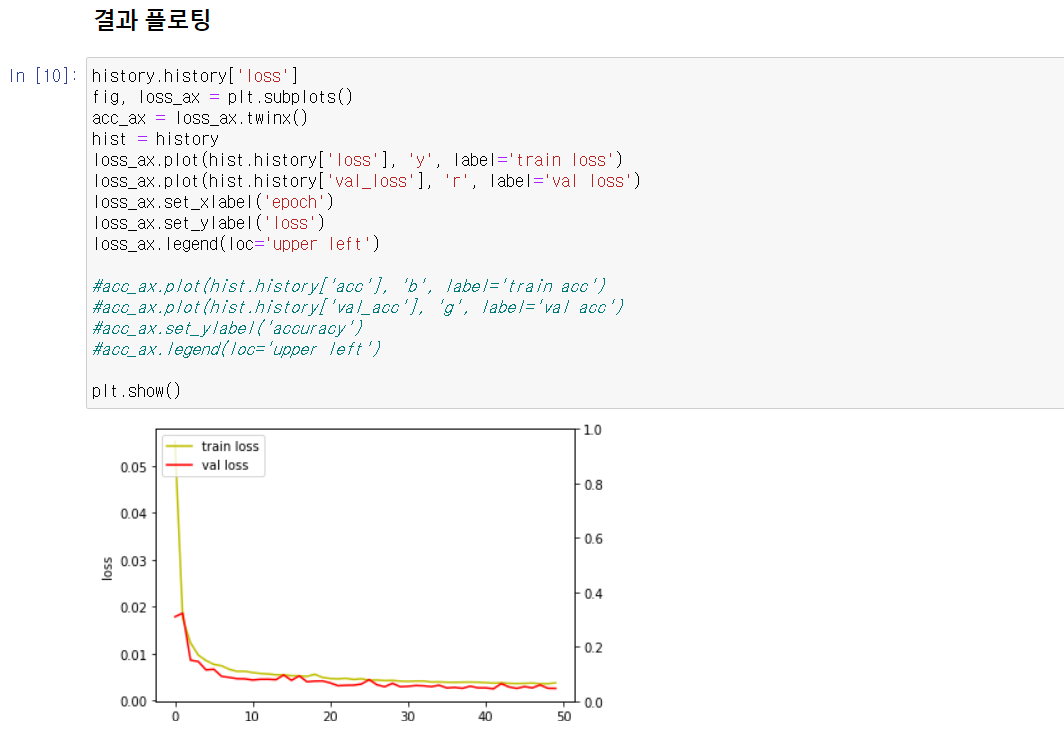
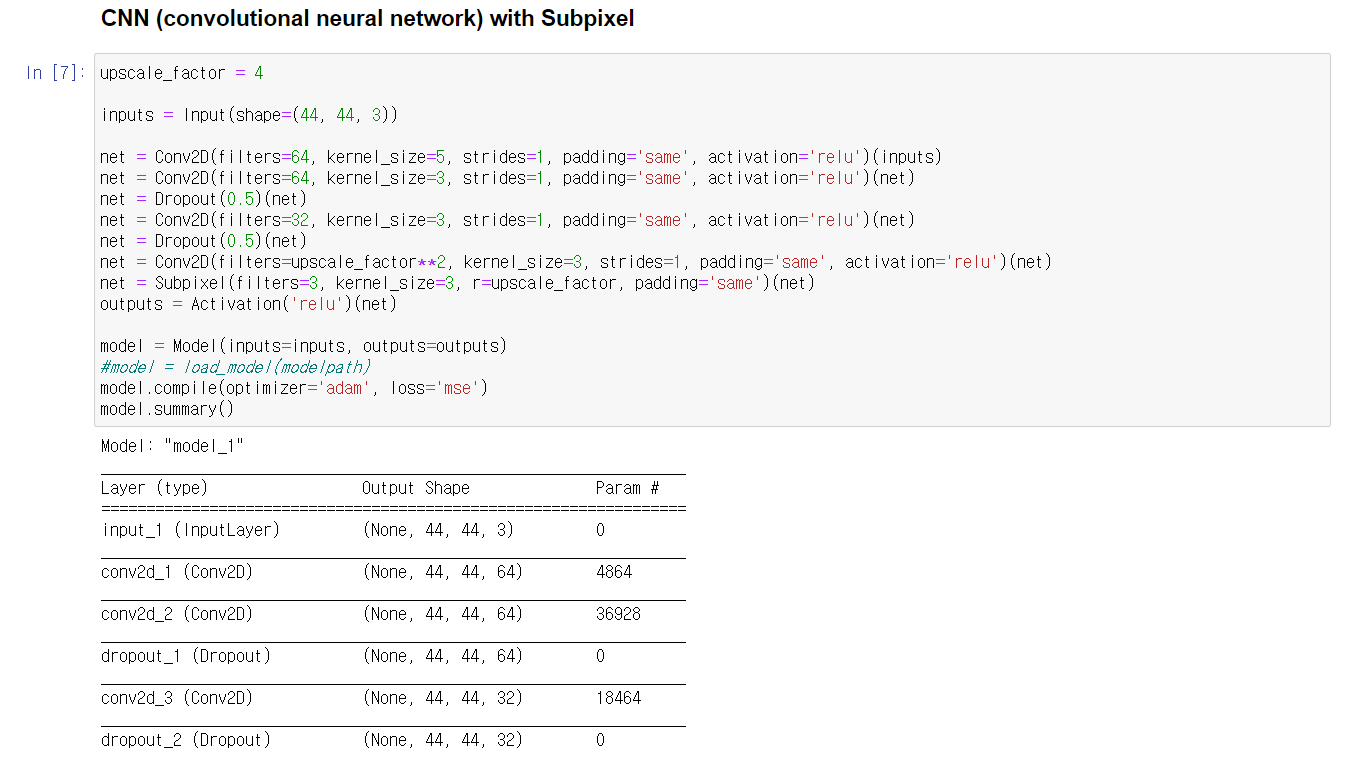
2) 마크업된 설명대로 실행

기본적으로 keras를 이용하고 있기 때문에 사용하려면 케라스와 텐서플로가 설치되어있어야 한다.

※ 설치 방법

이런식으로 아나콘다 프롬프트에서 명령어를 치면 자동으로 설치된다.

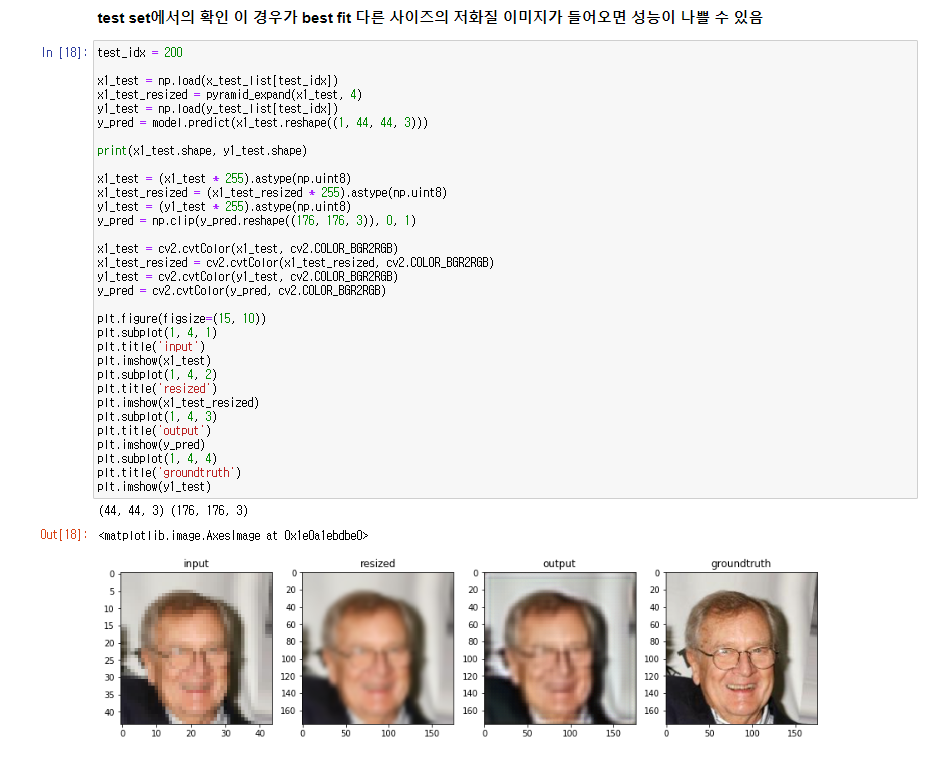
처음엔 트레이닝 방법부터 설명되어 있음

**모델 선언부**

**트레이닝 결과 플로팅**

**학습모델을 저장하고 불러오는 단계**

**모델학습을 건너뛰고 싶다면 모델선언부를 실행후 바로 이단계로 와서 학습된 weight을 불러와서 실행시켜볼 수 있음**

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**test set에서의 결과 확인**

**본인이 원하는 사진에서의 결과 확인**

**원하는 사진의 경로를 입력해주면 화질을 바꿔준다.**

※**시연 동영상에서는 트레이닝을 제외하고 실행했다.**

# 5. 개발 후 소감

가장 아쉬웠던 점은 데이터 수집, 학습 및 test 과정을 거쳐서 사용한 사진 파일의 크기를 44 x 44와 176 x 176 크기로 제한시켰다는 점이다. 사용자에 입장에서 실제로 이 프로그램을 이용한다고 하였을 때, 개인이 가지고 있는 사진 크기의 종류는 매우 다양하며 176 x 176 크기보다는 클 가능성이 매우 높다. 따라서 사진의 크기를 사전에 별도로 조절하지 않는 이상, 프로그램은 제 기능을 수행하지 못한 채로 오류를 뱉어내게 될 것이다. 이 문제를 해결하기 위해 생각한 방법으로 **1)본 프로그램에 적용할 수 있는 사진 크기의 종류를 추가시키는 것**과, **2)사용자가 어떠한 사진을 입력하더라도, 프로그램에 적용될 수 있는 가장 비슷한 크기로 자동 조절하여 process를 진행하는 기능을 추가**시키는 것을 생각해봤다. 시간적 여유가 될 때 한번 개선을 해보고 싶다는 마음이 든다.

또 하나의 아쉬운 점은, Subpixel layer를 탑재한 모델과 기존의 convolution 모델 간의 성능 비교를 못해봤다는 점이다. 이번 프로젝트 주제와 관련하여 논문을 읽었을 때, 보통 deconvolution model의 단점 중에 하나가, 층을 통과할 때마다 데이터의 차원이 확장되어 연산의 양이 많아 진다는 것이었다. 이를 개선하기 위해, input data와 output data의 차원을 유지시켜주는 convolution 층을 통과시킨 다음, 최종 관문인 Subpixel 층에서 처음이자 마지막으로 차원을 확장시켜 convolution 연산과 pixel shuffling을 통해 연산 속도를 향상시킨다는 것이 주요 topic이였다. 이 부분과 관련하여 본 프로젝트 수행 당시, 기존 convolution model에 비해 연산 속도가 얼마나 향상되었는지 비교 및 분석을 수행하였으면 어땠을까 하는 아쉬움이 든다.

## 5.1. 잘한 점

딥러닝을 구현해보는 것을 처음해보는 것이라 어떠한 주제를 갖고 어떻게 시작하고, 구현해야될 지 정말 막막했었다. 하지만 이와 관련한 여러가지의 논문들도 읽어보고 keras, pytorch, tensorflow와 같은 라이브러리를 사용해봄에 따라 실력향상에 많은 도움을 얻었던 것 같다. 또한 논문 내용을 실제 코드화하여 구현해봄으로써 논문에 대한 이해도를 높인 것 같다.

## 5.2. 부족한 점

기존의 의도는 좀 더 convolution layer층을 늘려서 특징을 좀 더 정확히 뽑아낸 다음 채널 개수를 늘려 176\*176보다 고해상도의 이미지 화질 개선을 하고 싶었으나 시간 관계상 거기까지 밖에 구현을 못한 것에 대한 아쉬움이 무엇보다도 가장 큰 것 같다.

## 5.3. 개선 점

지금 구현되어 있는 코드는 44\*44 image에만 국한되어 176\*176 image로 HR(High Resolution) Image를 만들 수 밖에 없는 구조이다. 이를 개선 하여 어떠한 이미지를 넣더라도 이미지의 크기와 해상도 구분없이 원하는 해상도를 선택하게 되면 해당 해상도에 맞게 이미지의 해상도를 향상시켜주는 방식이면 사용함에 있어 좀 더 실용적으로 사용할 수 있을 것 같다.

또한 해상도 개선을 4배 향상 밖에는 아직 못하지만 해상도를 8배 16배 32배 64배 이상으로 개선이 가능한 구현을 하게 된다면 현재 많이 사용하고 있는 1440\*1080의 해상도 까지도 이미지 해상도 개선을 할 수 있을 것이다.

이어서 이러한 개선이 이루어진다면 각 프레임별 개선을 통하여 비디오의 화질 개선에도 접목시킬 수 있을 것이다. 그러면 이미지를 넘어서서 동영상의 화질 개선도 가능해질 것이다.