# DIGITAL IMAGE PROCESSING

-APPLIED MATHEMATICS CAPSTONE DESIGN-

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# 목차

- 주제 ; cats and dogs binary classification
- (1) CNN(Convolutional Neural Network , 합성 곱 신경망)을 이용한 직접 모델링 후, cats 와 dogs 의 각각 data set 을 training 한 후 accuracy 측정 – Python
- (2)기존 data set의 image 들을 fourier transform의 한 종류인 DWT(Discrete Wavelet Transform)한 image 들로 training 한 후, accuracy 측정 – DWT : Matlab 으로 RGB 변환
- (3)검증된 알고리즘을 통해, 기존 data set과 DWT data set 의 accuracy 측정 ( Alex net, Google net)
- -Matlab R2017b의 toolbox

# CATS AND DOGS TRAINING , TEST , AUGMENTATION SET <FILE PATH>

```
TRAIN_CATS_DIR = 'input/train/cats/'
TRAIN_DOGS_DIR = 'input/train/dogs/'
TEST_DIR = 'input/test/'
VALD_CATS_DIR = 'input/validation/cats/'
VALD_DOGS_DIR = 'input/validation/dogs/'
AUG_DIR = 'input/train/aug/'
```

Image : 128 x 128 pixels

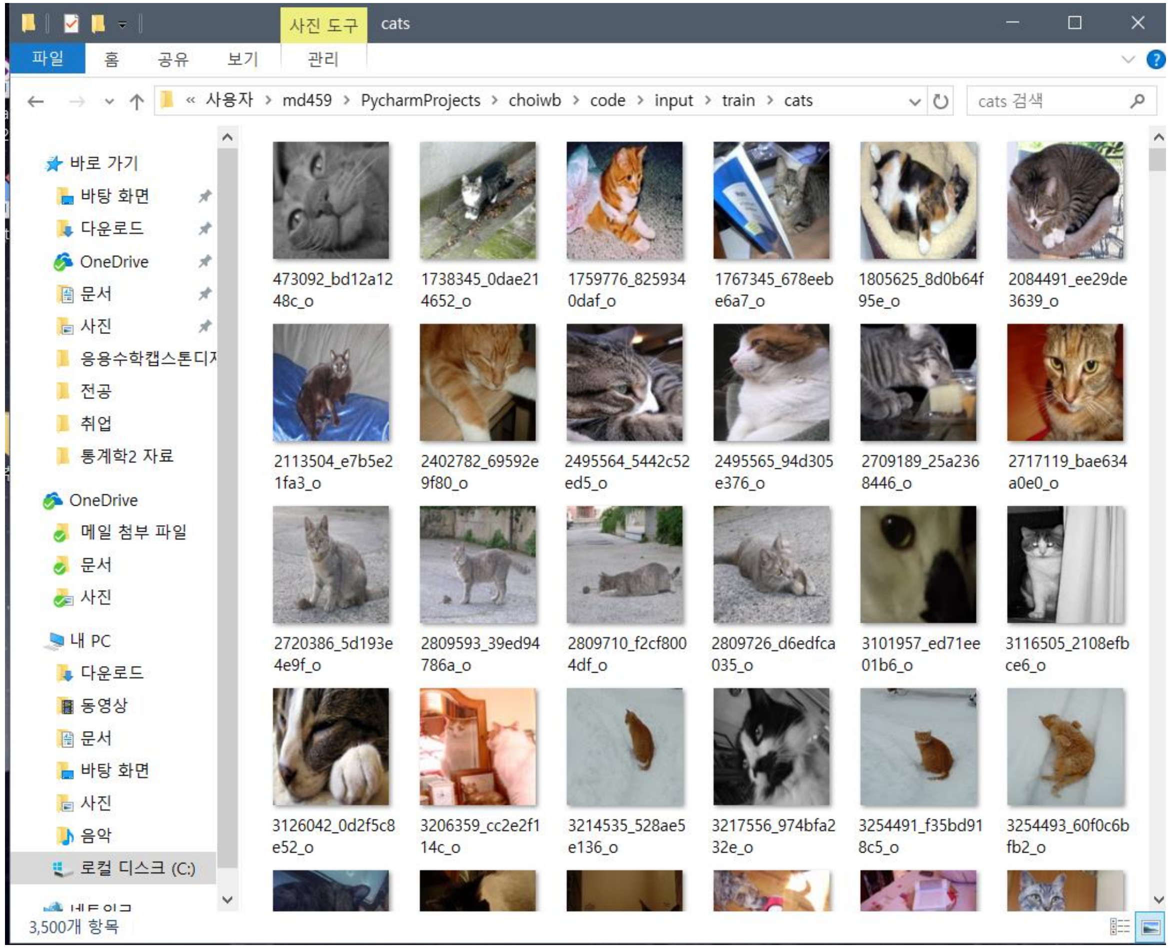
사진 도구
cats
파일
홈
공유
보기
관리
« 사용자 › md459 › PycharmProjects › choiwb › code › input › train › cats
cats 검색
바로 가기
바탕 화면
다운로드
OneDrive
문서
사진
응용수학캡스톤디자
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취업
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동영상
문서
바탕 화면
사진
음악
로컬 디스크 (C:)
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3116505_2108efbce6_o
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3,500개 항목

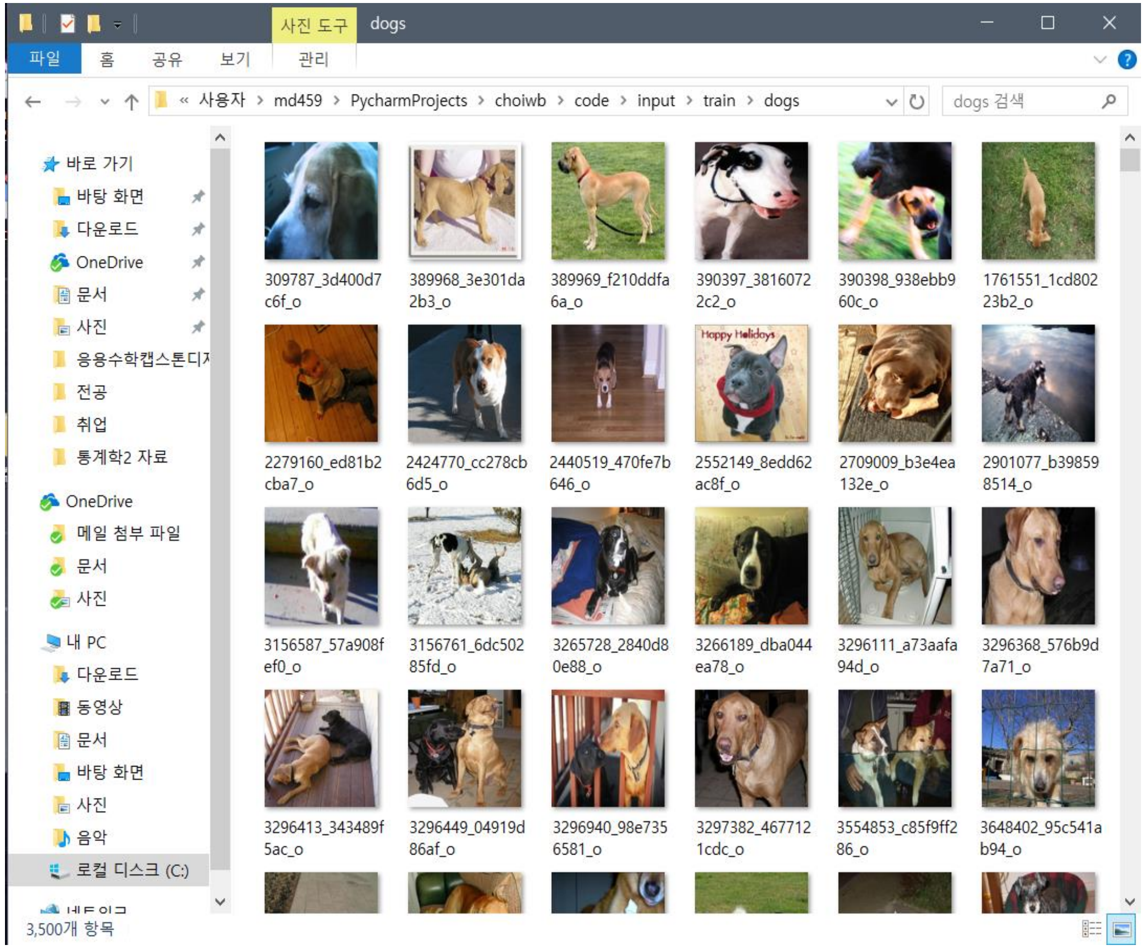
사진 도구
dogs
파일
홈
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바탕 화면
사진
음악
로컬 디스크 (C:)
Happy Holidays
309787_3d400d7c6f_o
389968_3e301da2b3_o
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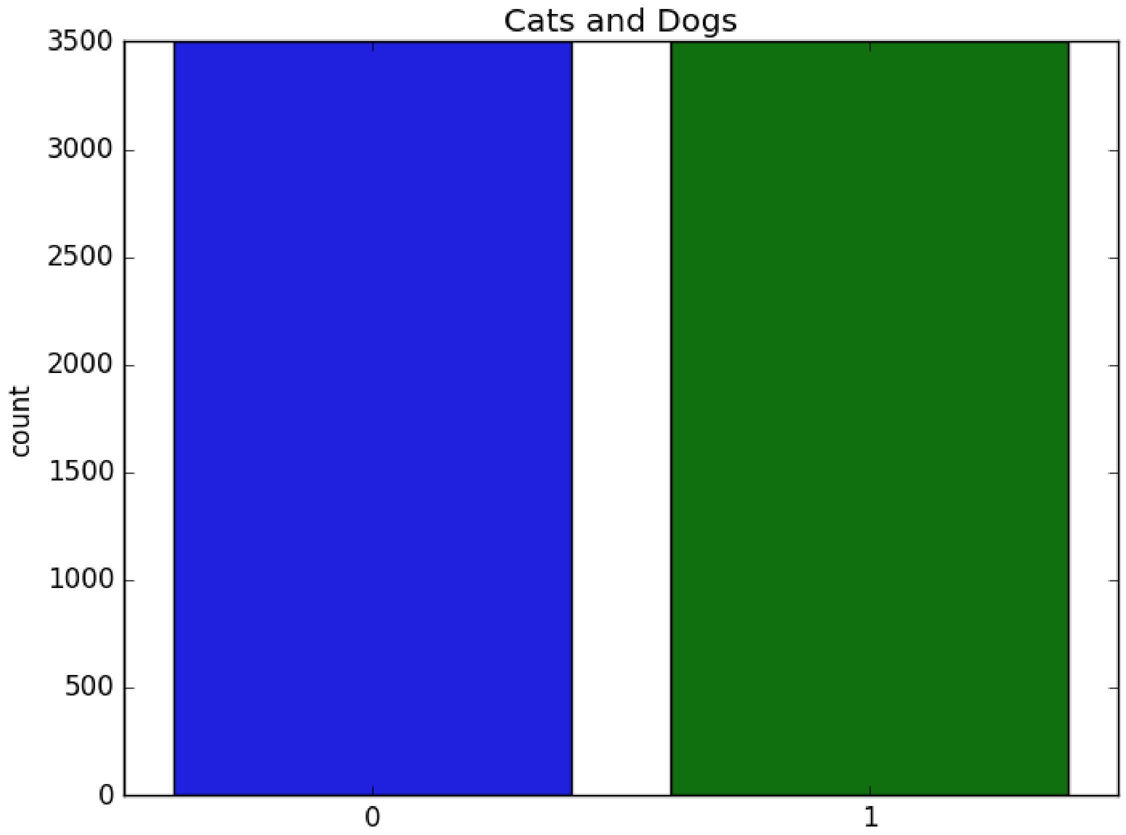
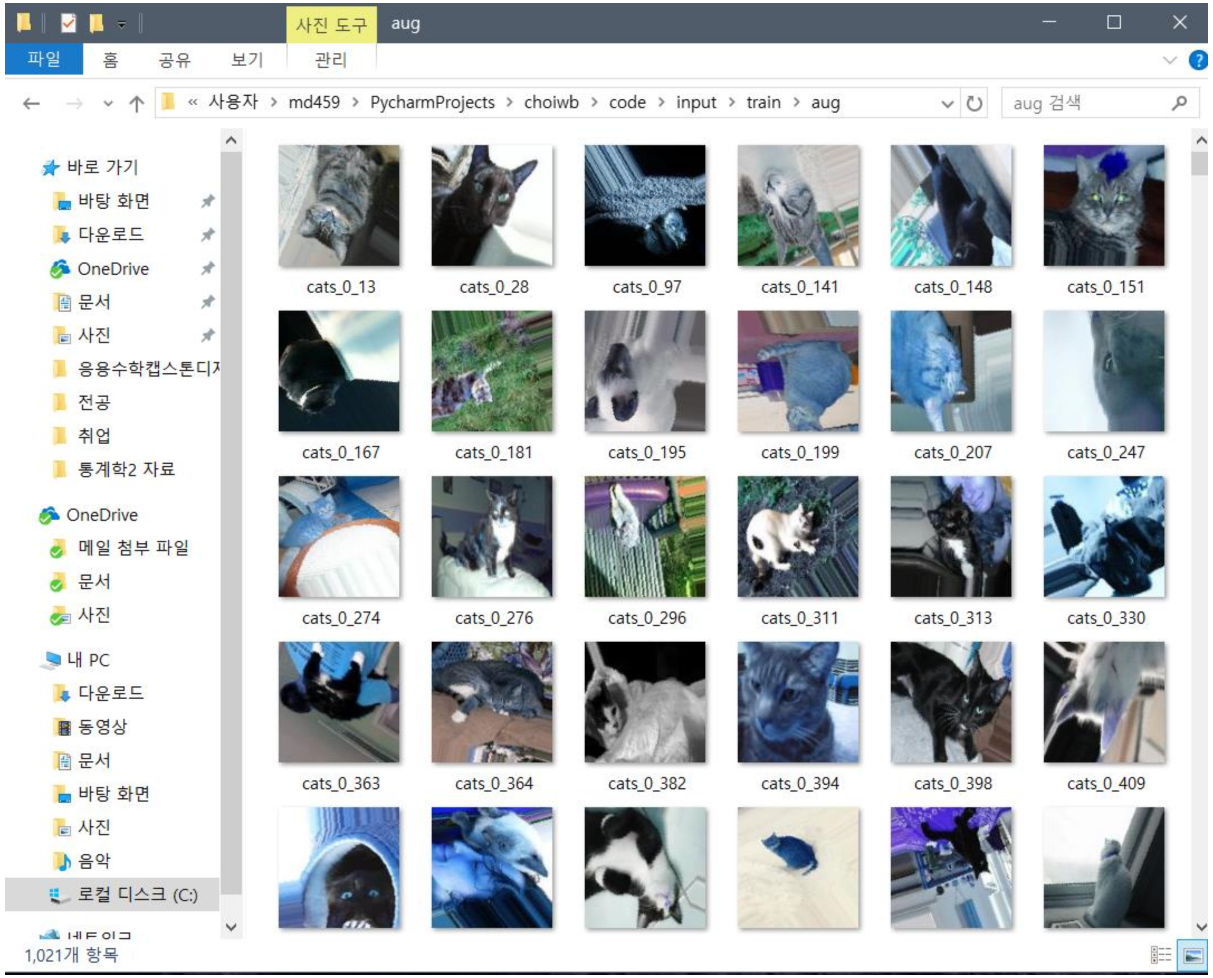
3,500개 항목

# TRAINING SET (CATS:; 3500 , DOGS : 3500),



# AUGMENTATION 과정

- round(len(train) / 50)

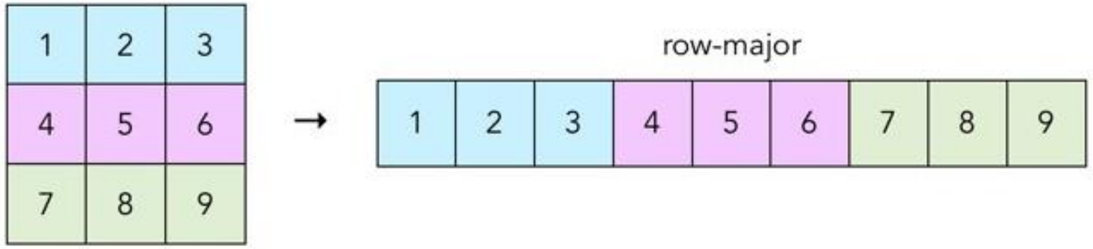


# TRANSPOSE(대각화) : [COUNT , ROW , COLUMN , CHANNEL] -> [COUNT , CHANNEL , ROW , COLUMN]

teosorflow : [count , row , column , channel] default(기본값) 시작 과정 (CPU)

row major order(행 우선 순위)

속도 때문 !




NVIDIA cuDNN : [count , channel , row , column] default(기본값) 모델링 과정 (GPU)

- gray scale : 1 channel
- RGB scale : 3 channel

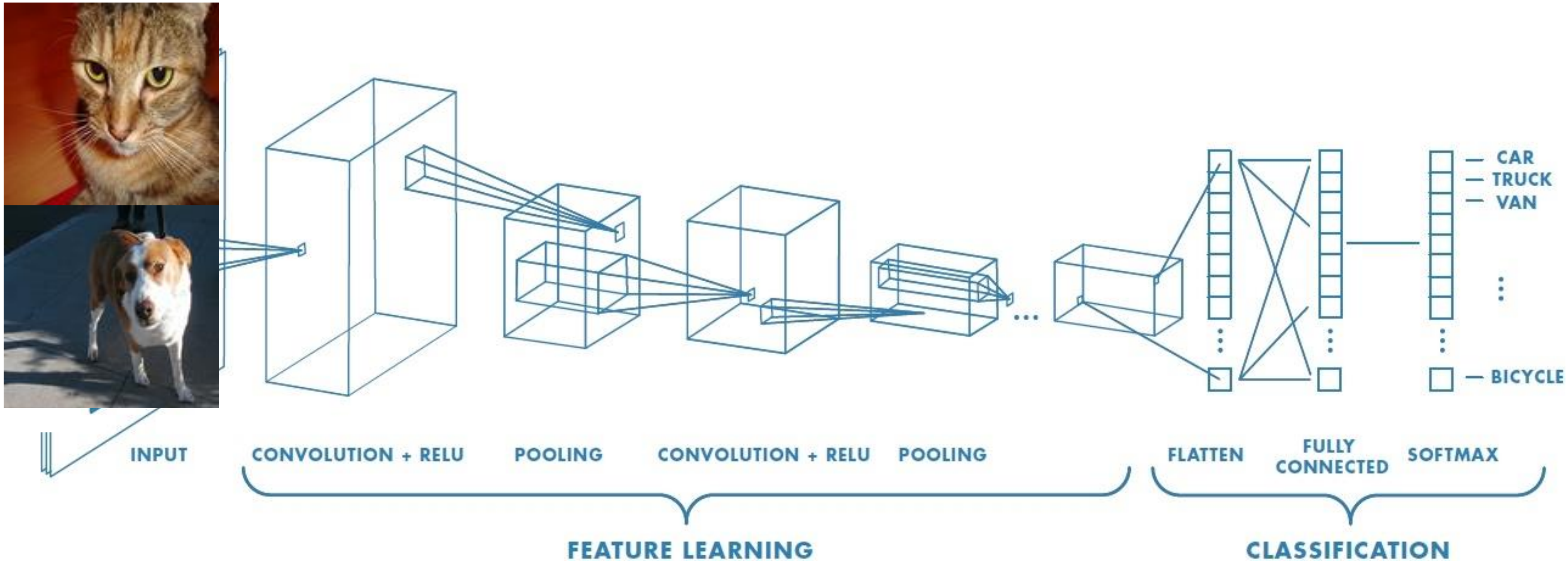
- Train set 형태 :  (7000, 3, 128, 128)

augmentation 적용

- Train set 형태 : (7890, 3, 128, 128)
- Validation set 형태 : (1964, 3, 128, 128)

Validation_split : 20% → Train on 6312 samples, validate on 1578 samples

# CNN(CONVOLUTIONAL NEURAL NETWORK) 모델링 과정



- CNN 모델링 과정

Input layer(128 X 128 픽셀) : 16 neurons, 4 x 4 , ReLU , max_norm = 2

Max pooling layer 3 x 3

Hidden layer : 32 neurons 4 x 4 , ReLU , max_norm = 2

Max pooling layer 3 x 3

Hidden layer 64 neurons 4 x 4 , ReLU , max_norm = 2

Max pooling layer 3 x 3

- Model flatten
- Output Layer 128 neurons , Sigmoid , Dropout : 0.3

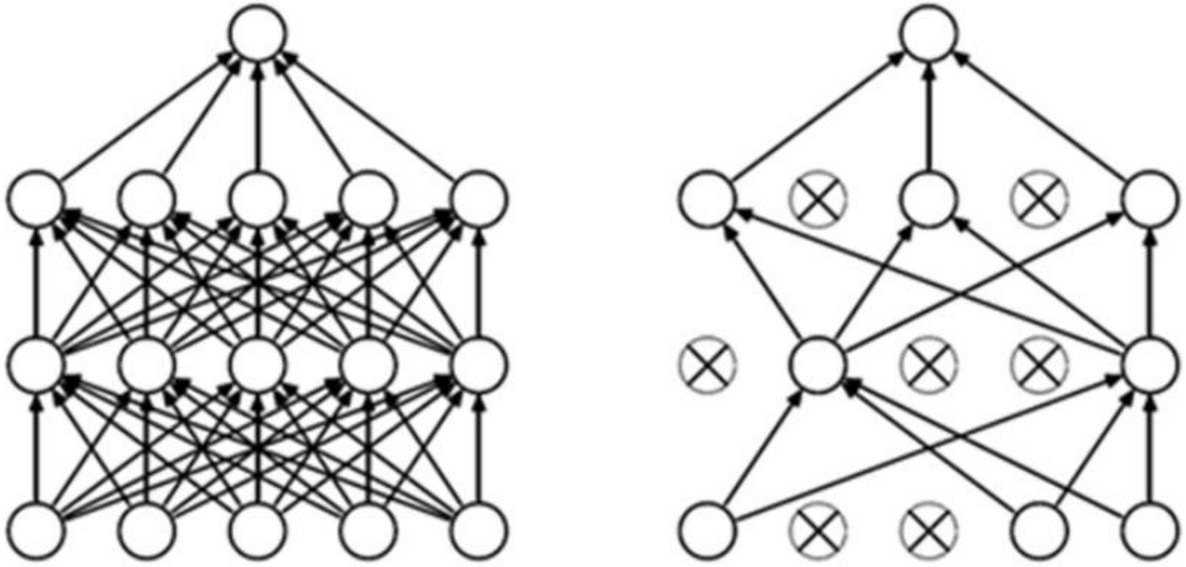
- max_norm : 정규화(normalization)의 형태, 모든 뉴런에 대한 weight vector의 크기에 upper bound를 적용하고 gradient descent를 사용

- flatten layer : 2차원 행렬 형태를

1차원 벡터 형태로 변환

- dropout :

overfitting 피하기 위함



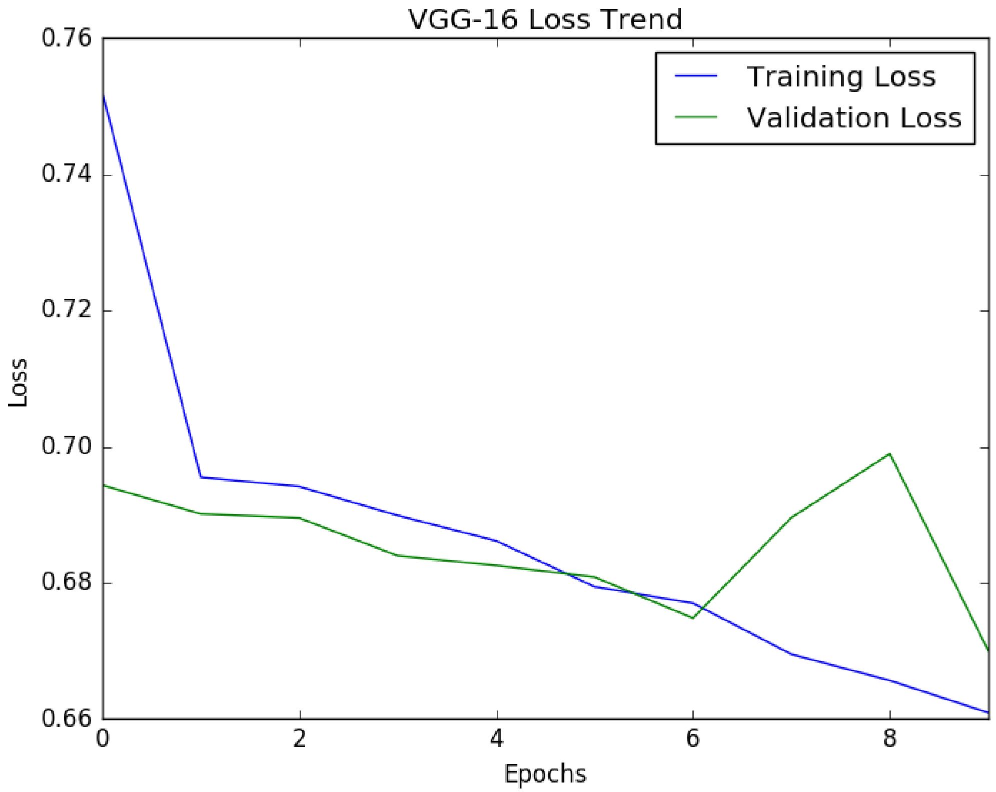
(a) Standard Neural Net (b) After applying dropout.

# 모델 연산과정

- Epoch 1/10
- 80s - loss: 0.7521 - acc: 0.5021 - val_loss: 0.6943 - val_acc: 0.5006
- Epoch 2/10
- 89s - loss: 0.6955 - acc: 0.5120 - val_loss: 0.6901 - val_acc: 0.5406
- Epoch 3/10
- 84s - loss: 0.6941 - acc: 0.5119 - val_loss: 0.6895 - val_acc: 0.5393
- Epoch 4/10
- 82s - loss: 0.6899 - acc: 0.5368 - val_loss: 0.6840 - val_acc: 0.5507
- Epoch 5/10
- 74s - loss: 0.6862 - acc: 0.5433 - val_loss: 0.6825 - val_acc: 0.5634

- Epoch 6/10
- 80s - loss: 0.6794 - acc: 0.5700 - val_loss: 0.6808 - val_acc: 0.5653
- Epoch 7/10
- 74s - loss: 0.6770 - acc: 0.5762 - val_loss: 0.6748 - val_acc: 0.5659
- Epoch 8/10
- 78s - loss: 0.6695 - acc: 0.5848 - val_loss: 0.6896 - val_acc: 0.5406
- Epoch 9/10
- 74s - loss: 0.6656 - acc: 0.6008 - val_loss: 0.6990 - val_acc: 0.5640
- Epoch 10/10
- 79s - loss: 0.6609 - acc: 0.6006 - val_loss: 0.6700 - val_acc: 0.5875
- Baseline Accuracy: 60.08% , 연산시간: 987.7676200866699 , 약16분 28초

# LOSS TREND



VGG-16 Loss Trend
Training Loss
Validation Loss
Loss
Epochs
0.76
0.74
0.72
0.70
0.68
0.66
0
2
4
6
8

# <개선방향>

1. Train set과 augmentation set 데이터 증가
2. Googlenet 알고리즘 적용
3. Model parameter / hyper parameter 조정

*Hyperparameter : Bayesian statistics에서 prior distribution의 parameter이다. → Posterior distribution만으로 추정을 하는 것 보다 prior distribution을 알 때, 훨씬 더 잘 추정

*Neural Network에서 hyperparameter
신경망 학습을 통해서 tuning 또는 optimization 해야 하는 주 변수가 아니라 사람들이 prior 설정을 하거나,
외부 모델 메커니즘을 통해 자동으로 설정이 되는 변수

Neural Network 에서 Hyperparameter이란 ( = free parameter)

Ex) learning rate , cost function(cross entropy , least square) ,

mini batch size , training 회수, hidden layer 개수,

weights initialization

-cross entropy

p , m : 확률 분포

$$H(p, m) = -\sum_i p(xi)\log(m(xi))$$

기대 값과 예측 값의 차이가 클수록 결과가 크게 나온다.

결과는 항상 양수 이다.

-cross entropy cost function

y : 기대 값

a : 신경망에서 출력된 값

n : 훈련 데이터의 개수

$$C = -\frac{1}{n}\sum_x [y \ln a + (1-y)\ln(1-a)]$$

# 중간결과에서 개선점

- Training set 증가 (7000 → 15724)
- Batch Normalization 적용
- neuron 개수 증가 (GPU 연산)

[input – hidden1 – hidden2 – output]

[16 – 32 – 64 - 128] → [64 – 128 – 256 – 512]

# BATCH NORMALIZATION

Gradient Vanishing / Gradient Exploding 이 일어나지 않도록 하는 아이디어 중의 하나. 지금까지는 이 문제를 Activation 함수의 변화 (ReLU 등), Careful Initialization, small learning rate 등으로 해결하였지만, 이런 간접적인 방법보다는 training 하는 과정 자체를 전체적으로 안정화 하여

학습 속도를 가속시킬 수 있는 근본적인 방법.

➡ Layer Normalization !

*** Internal Covariate Shift : Network의 각 층이나 Activation 마다 input의 distribution이 달라지는 현상.

⬇

각 층의 input의 distribution을 평균 0, 표준편차 1인 input으로 normalize 시키는 방법 고안.

# LAYER NORMALIZATION

- State of the art한 DNN 학습시간 단축.
- 중간 층의 출력을 정규화 함으로써 실현.

***Covariate Shift(공 변량 변화)

: 입출력 규칙(주어진 입력에 대하여 출력의 생성규칙)은 training할 때와, test 할 때 다르지 않지만, 입력(공 변량)의 분포가 training 할 때와, test 할 때 다른 상황.

# INTERNAL COVARIATE SHIFT

<CNN에서의 각 층 마다 입력분포>

(1)입력 층 으로의 입력분포

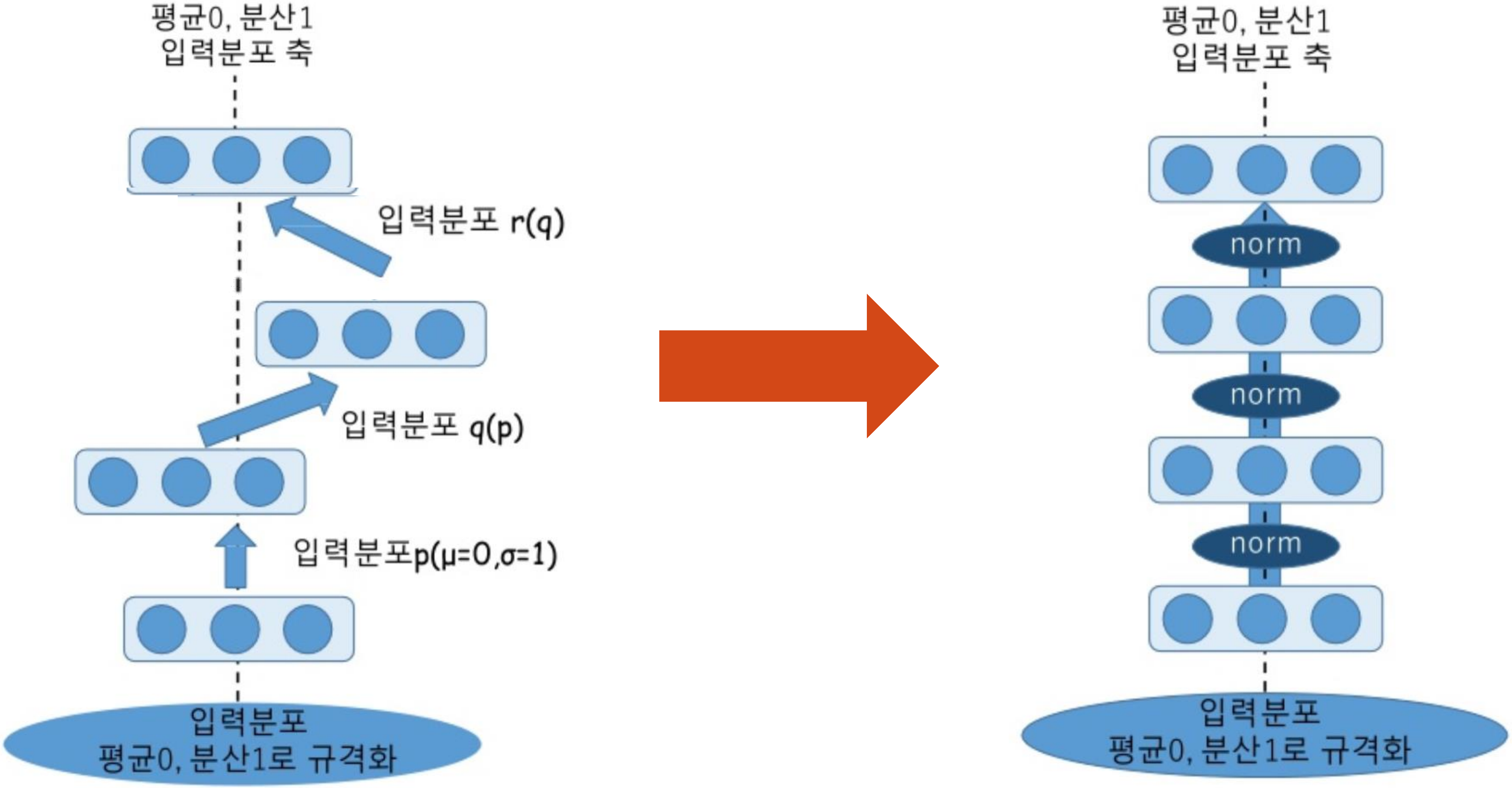
평균 0 , 분산 1로 선형변환

(2)중간 층 으로의 입력분포

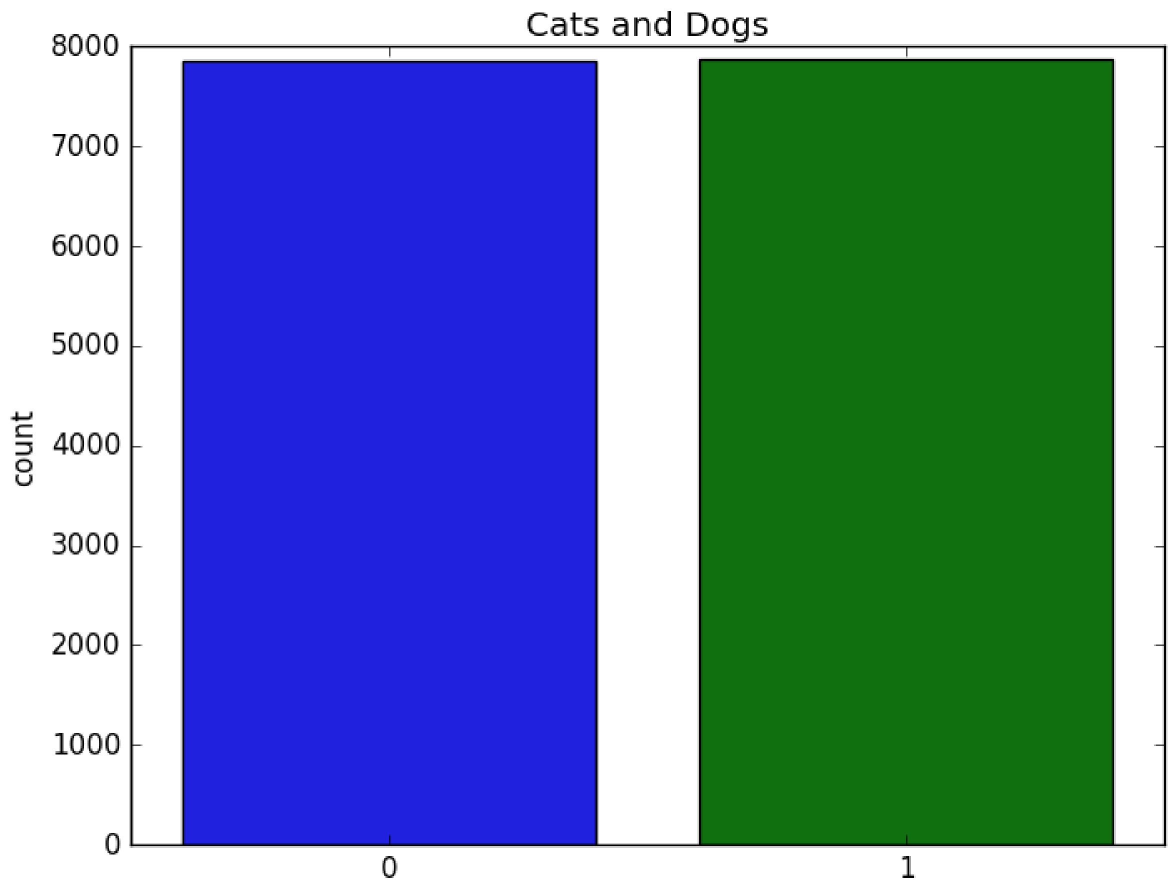
-정해진 입력분포를 유지하지 못함!

학습할 때 마다, 중간층으로의 입력분포가 변화 (Internal Covariate Shift)

# NORMALIZATION PROCESS



# TRAINING SET (CATS:; 7853 , DOGS : 7871),



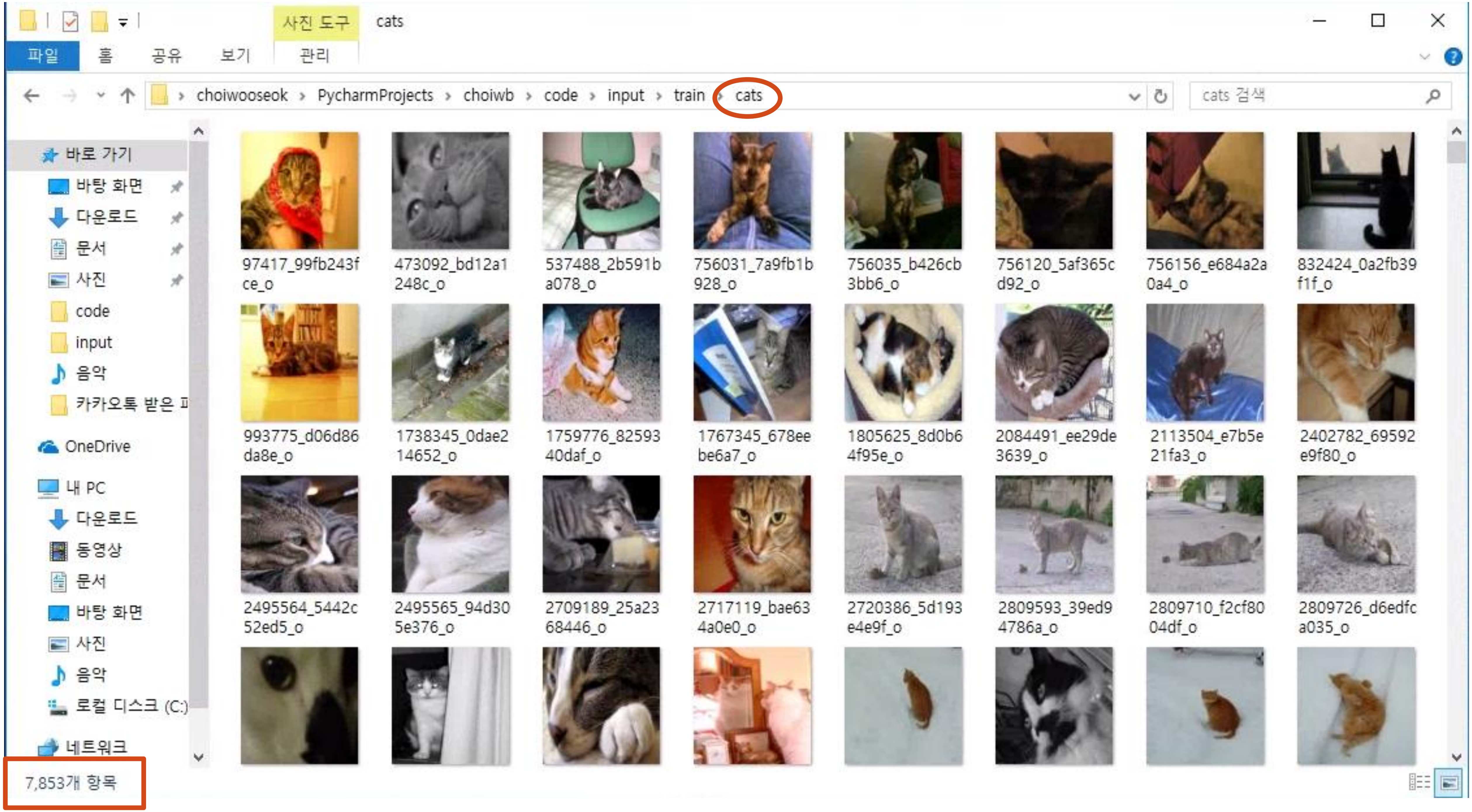


사진 도구
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2720386_5d193e4e9f_o
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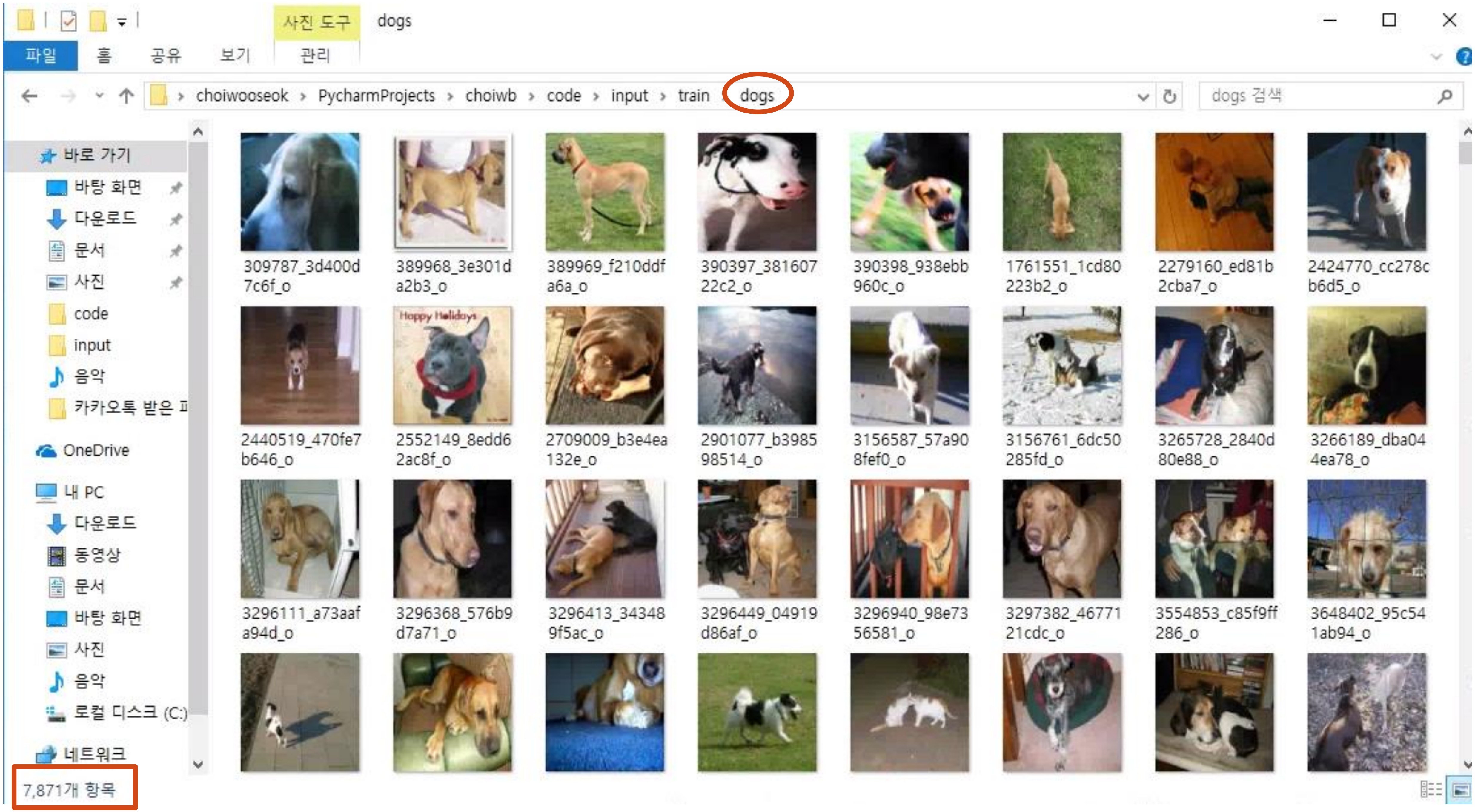
7,853개 항목



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1761551_1cd80223b2_o
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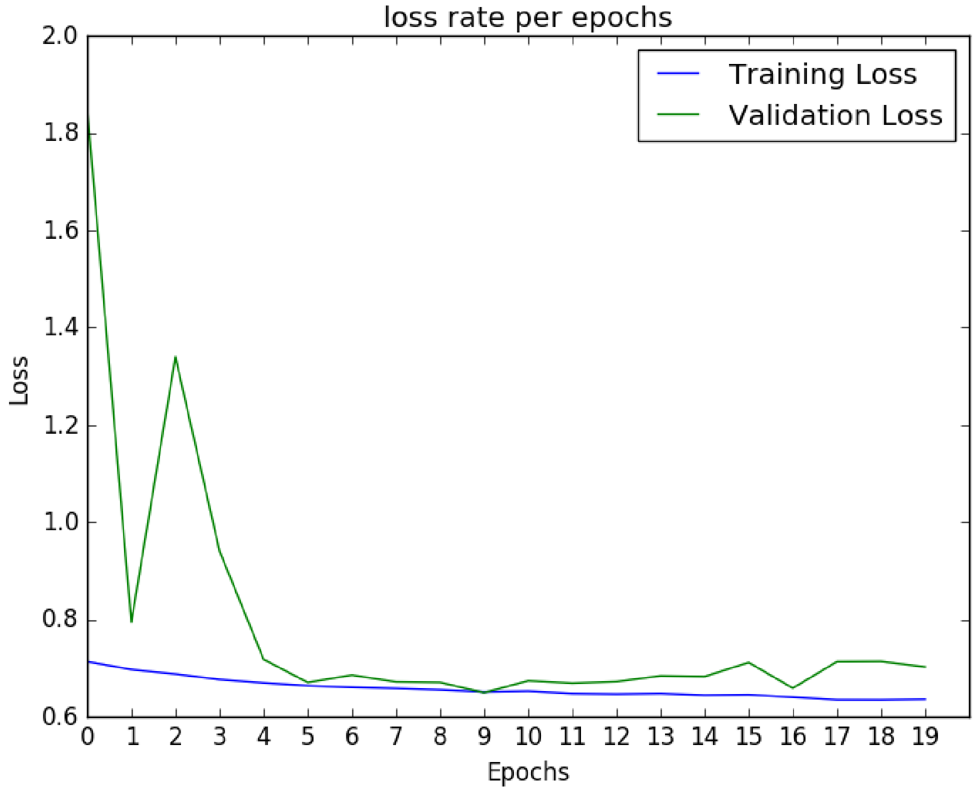
3296413_343489f5ac_o
3296449_04919d86af_o
3296940_98e7356581_o
3297382_4677121cdc_o
3554853_c85f9ff286_o
3648402_95c541ab94_o
Happy Holidays

# MODELING

| Layer (type) | Output Shape | Param # |
|---|---|---|
| conv2d_1 (Conv2D) | (None, 3, 128, 64) | 131136 |
| batch_normalization_1 (Batch | (None, 3, 128, 64) | 256 |
| activation_1 (Activation) | (None, 3, 128, 64) | 0 |
| conv2d_2 (Conv2D) | (None, 3, 128, 64) | 65600 |
| batch_normalization_2 (Batch | (None, 3, 128, 64) | 256 |
| activation_2 (Activation) | (None, 3, 128, 64) | 0 |
| max_pooling2d_1 (MaxPooling2 | (None, 3, 42, 21) | 0 |
| conv2d_3 (Conv2D) | (None, 3, 42, 128) | 43136 |
| batch_normalization_3 (Batch | (None, 3, 42, 128) | 512 |
| activation_3 (Activation) | (None, 3, 42, 128) | 0 |
| conv2d_4 (Conv2D) | (None, 3, 42, 128) | 262272 |
| batch_normalization_4 (Batch | (None, 3, 42, 128) | 512 |
| activation_4 (Activation) | (None, 3, 42, 128) | 0 |
| max_pooling2d_2 (MaxPooling2 | (None, 3, 14, 42) | 0 |
| conv2d_5 (Conv2D) | (None, 3, 14, 256) | 172288 |
| batch_normalization_5 (Batch | (None, 3, 14, 256) | 1024 |
| activation_5 (Activation) | (None, 3, 14, 256) | 0 |
| conv2d_6 (Conv2D) | (None, 3, 14, 256) | 1048832 |
| batch_normalization_6 (Batch | (None, 3, 14, 256) | 1024 |
| activation_6 (Activation) | (None, 3, 14, 256) | 0 |
| max_pooling2d_3 (MaxPooling2 | (None, 3, 4, 85) | 0 |
| conv2d_7 (Conv2D) | (None, 3, 4, 512) | 696832 |
| batch_normalization_7 (Batch | (None, 3, 4, 512) | 2048 |
| activation_7 (Activation) | (None, 3, 4, 512) | 0 |
| conv2d_8 (Conv2D) | (None, 3, 4, 512) | 4194816 |
| batch_normalization_8 (Batch | (None, 3, 4, 512) | 2048 |
| activation_8 (Activation) | (None, 3, 4, 512) | 0 |
| max_pooling2d_4 (MaxPooling2 | (None, 3, 1, 170) | 0 |
| flatten_1 (Flatten) | (None, 510) | 0 |
| dense_1 (Dense) | (None, 512) | 261632 |
| batch_normalization_9 (Batch | (None, 512) | 2048 |
| activation_9 (Activation) | (None, 512) | 0 |

```
_________________________________________________________________
dropout_2 (Dropout)          (None, 512)               0
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 513
_________________________________________________________________
batch_normalization_11 (Batc (None, 1)                 4
_________________________________________________________________
activation_11 (Activation)   (None, 1)                 0
=================================================================
Total params: 7,151,493
Trainable params: 7,145,603
Non-trainable params: 5,890
_________________________________________________________________
```



# 하드웨어 사양 , 연산시간 , ACCURACY

- 프로세서 : Intel(R) core TM i5 – 6500 CPU @ 3.20GHz
- RAM : 8.00 GB
- GPU : NVIDIA GeForce GTX 1060 3 GB

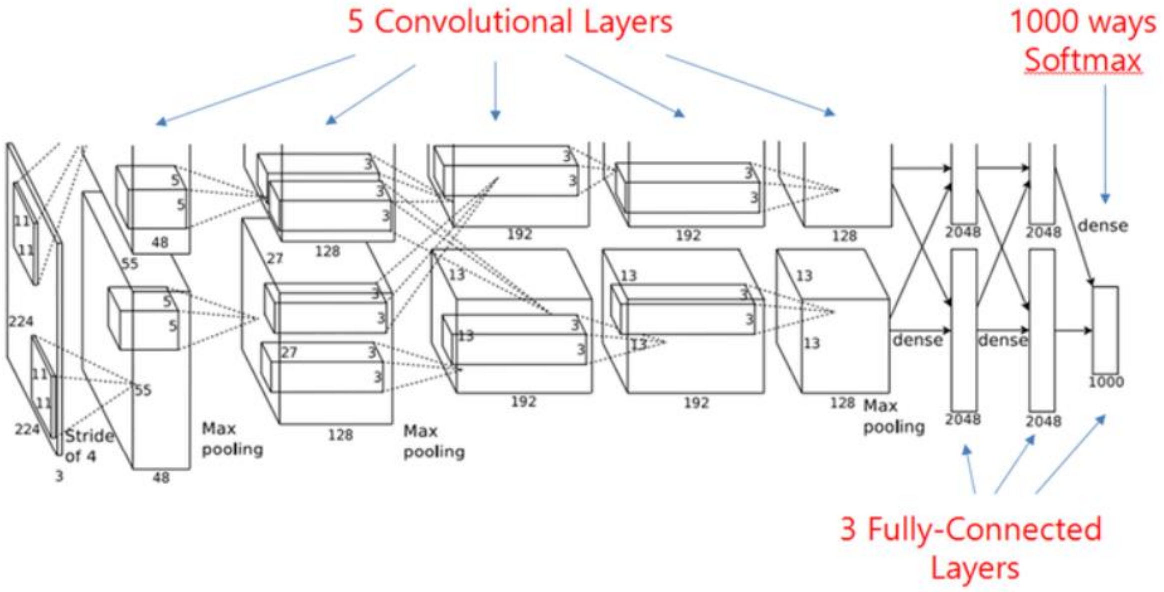
- 연산시간 : 약 28분 4초
- Accuracy : 70.67%

```
Accuracy: 70.67%
[INFO] Saving the model and weights...
Saved model to disk
연산시간: 1684.4383420944214
```

# ALEX NET , GOOGLE NET

- Alex net 이란?
- ImageNet 영상 데이터 베이스를 기반으로 한, ILSVRC(ImageNet Large Scale Visual Recognition Challenge) – 2012 우승 한 CNN 알고리즘

2개의 GPU를 기반으로 한 병렬 구조



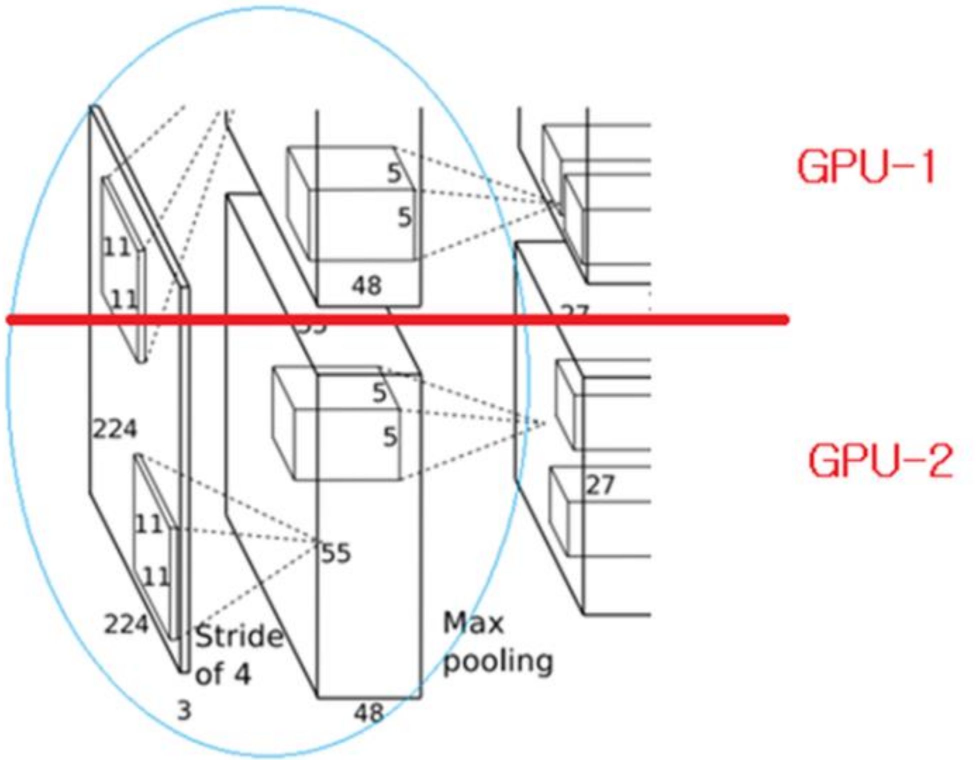
Alex net 구조

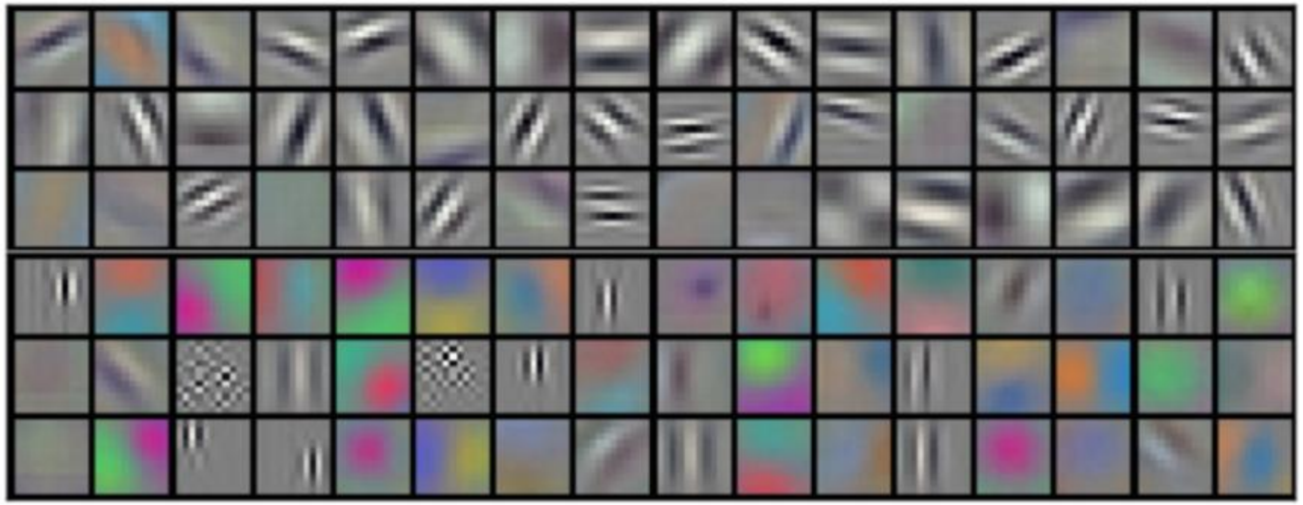
- GPU-1 : color과 상관 없는 정보를 추출 하기 위

Kernel 이 학습

- GPU-2 : 주로 color과 관련된 정보를 추출하기

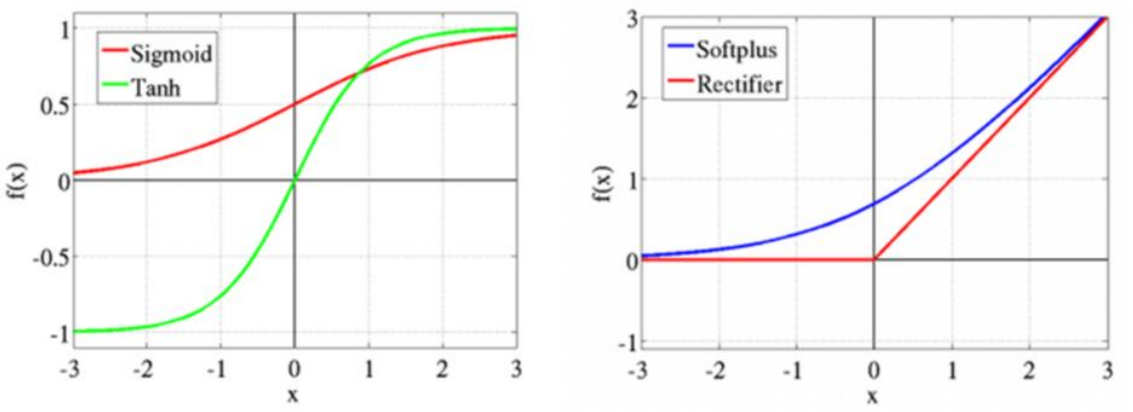
Kernel이 학습



- Alex net 성능 향상

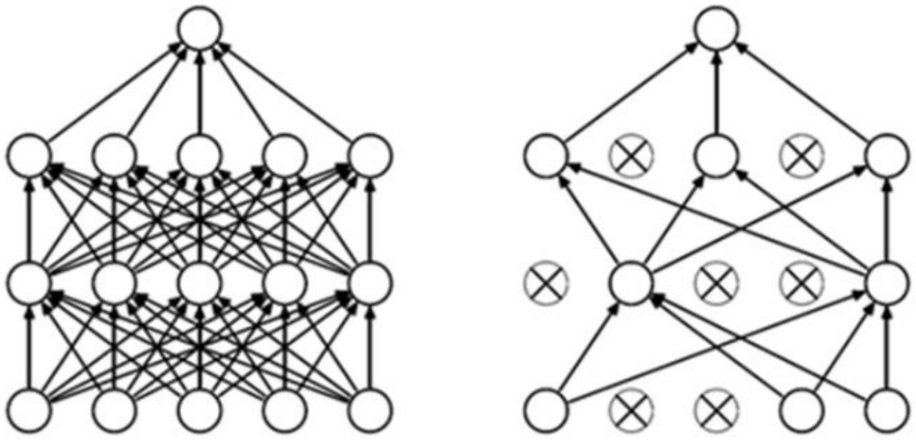
(1) ReLU : x = 0에서 미분이 안되지만, Sigmoid나 Tanh보다 학습 속도 탁월, back propagation 결과도 단순




(2) Max pooling : pooling란 convolution에서 Feature map 영상의 크기를 줄이기 위한 용도이며, max pooling는 Window에서 최대값을 갖는 픽셀을 선택 ( Alex net에서

(3) Dropout : overfitting 해결

일정한 mini batch 구간 동안 생략된 망에 대한 학습을 끝내면 다시 무작위로 다른 뉴런들을 생략하면서 반복적인 학습 수행



(a) Standard Neural Net

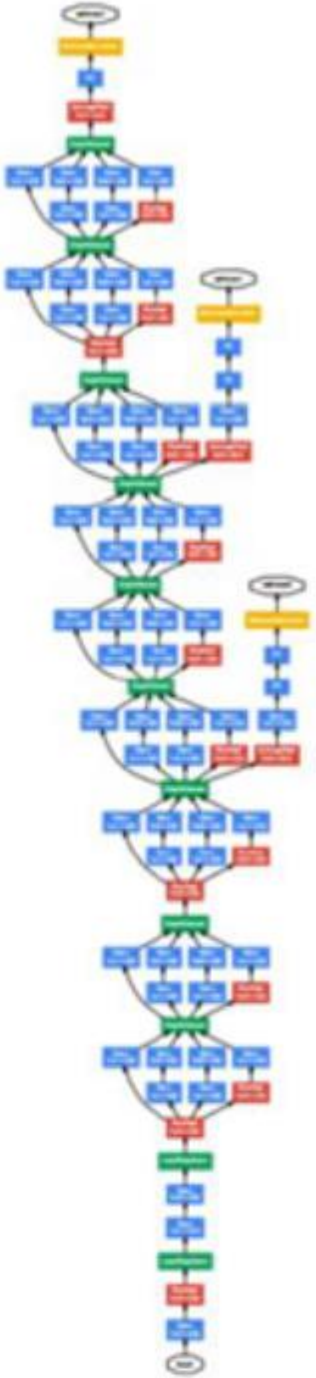
(b) After applying dropout.

- Google net 이란?
- ILSVRC 2014 우승한 CNN 알고리즘

- 핵심 : Networks are deeper and deeper !!!
- 2013년도 까지는 10 layers 미만 이었지만, Google net은 22 layers

- ** 망 증가 시 free parameter의 수 , 연산 량 증가 → overfitting 문제 발생
- 따라서, 문제 해결을 위한 Inception model 적용

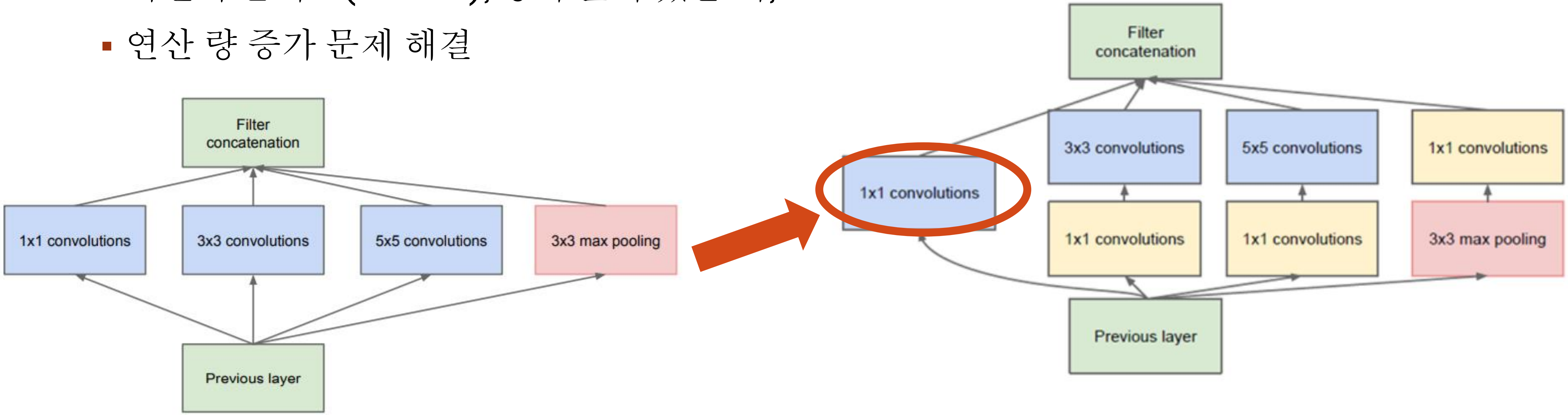

C. Szegedy et al, “Going Deeper with Convolutions” (CVPR 2015)



# INCEPTION MODEL

- 같은 layer에 서로 다른 크기를 갖는 convolution filter을 적용하여, 다른 scale의 feature을 획득

- 1 x 1 convolution을 사용하여 차원(dimension)을
- 적절히 줄이고(reduce), 많이 깊어 졌을 때,
- 연산 량 증가 문제 해결



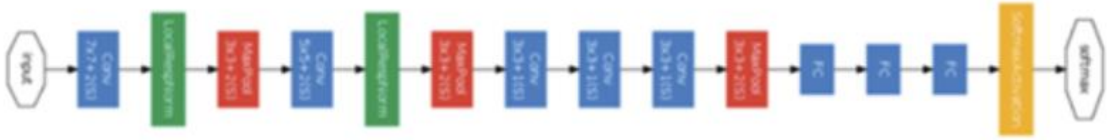
# 22 LAYERS

| type | patch size/ stride | output size | depth | #1×1 | #3×3 reduce | #3×3 | #5×5 reduce | #5×5 | pool proj | params | ops |
|---|---|---|---|---|---|---|---|---|---|---|---|
| convolution | 7×7/2 | 112×112×64 | 1 | | | | | | | 2.7K | 34M |
| max pool | 3×3/2 | 56×56×64 | 0 | | | | | | | | |
| convolution | 3×3/1 | 56×56×192 | 2 | | 64 | 192 | | | | 112K | 360M |
| max pool | 3×3/2 | 28×28×192 | 0 | | | | | | | | |
| inception (3a) | | 28×28×256 | 2 | 64 | 96 | 128 | 16 | 32 | 32 | 159K | 128M |
| inception (3b) | | 28×28×480 | 2 | 128 | 128 | 192 | 32 | 96 | 64 | 380K | 304M |
| max pool | 3×3/2 | 14×14×480 | 0 | | | | | | | | |
| inception (4a) | | 14×14×512 | 2 | 192 | 96 | 208 | 16 | 48 | 64 | 364K | 73M |
| inception (4b) | | 14×14×512 | 2 | 160 | 112 | 224 | 24 | 64 | 64 | 437K | 88M |
| inception (4c) | | 14×14×512 | 2 | 128 | 128 | 256 | 24 | 64 | 64 | 463K | 100M |
| inception (4d) | | 14×14×528 | 2 | 112 | 144 | 288 | 32 | 64 | 64 | 580K | 119M |
| inception (4e) | | 14×14×832 | 2 | 256 | 160 | 320 | 32 | 128 | 128 | 840K | 170M |
| max pool | 3×3/2 | 7×7×832 | 0 | | | | | | | | |
| inception (5a) | | 7×7×832 | 2 | 256 | 160 | 320 | 32 | 128 | 128 | 1072K | 54M |
| inception (5b) | | 7×7×1024 | 2 | 384 | 192 | 384 | 48 | 128 | 128 | 1388K | 71M |
| avg pool | 7×7/1 | 1×1×1024 | 0 | | | | | | | | |
| dropout (40%) | | 1×1×1024 | 0 | | | | | | | | |
| linear | | 1×1×1000 | 1 | | | | | | | 1000K | 1M |
| softmax | | 1×1×1000 | 0 | | | | | | | | |

Table 1: GoogLeNet incarnation of the Inception architecture.

# ALEX NET 과 GOOGLE NET의 파라미터(PARAMS)의 수와 연산량(FLOP'S) 비교

| | params | FLOPs |
|---|---|---|
| Krizhevsky, Suskever and Hinton (2012) | 60M | 2B |
| Szegedy et al (2014) | 5M | 1.5B |



# ALEX NET , GOOGLE NET APPLICATION

- Alex net 검증 (validation set : cats 976 images , dogs 976 images)

```
23x1 Layer array with layers:

 1   'input'             Image Input                 227x227x3 images with 'zerocenter' normalization
 2   'conv1'             Convolution                 96 11x11x3 convolutions with stride [4  4] and padding [0  0  0  0]
 3   'relu1'             ReLU                        ReLU
 4   'norm1'             Cross Channel Normalization cross channel normalization with 5 channels per element
 5   'pool1'             Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
 6   'conv2'             Convolution                 256 5x5x48 convolutions with stride [1  1] and padding [2  2  2  2]
 7   'relu2'             ReLU                        ReLU
 8   'norm2'             Cross Channel Normalization cross channel normalization with 5 channels per element
 9   'pool2'             Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
10   'conv3'             Convolution                 384 3x3x256 convolutions with stride [1  1] and padding [1  1  1  1]
11   'relu3'             ReLU                        ReLU
12   'conv4'             Convolution                 384 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
13   'relu4'             ReLU                        ReLU
14   'conv5'             Convolution                 256 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
15   'relu5'             ReLU                        ReLU
16   'pool5'             Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
17   'fc6'               Fully Connected             4096 fully connected layer
18   'relu6'             ReLU                        ReLU
19   'fc7'               Fully Connected             4096 fully connected layer
20   'relu7'             ReLU                        ReLU
21   'fc8'               Fully Connected             1000 fully connected layer
22   'prob'              Softmax                     softmax
23   'classificationLayer'  Classification Output    crossentropyex with 'n01440764', 'n01443537', and 998 other classes
```

```
ans =

  2×2 table

    Label    Count
    _____    _____

    cats      976
    dogs      976

confMat =

    0.9268    0.0732
    0.1098    0.8902
```

| % | cats | dogs |
|---|---|---|
| cats | 92.68 | 7.32 |
| dogs | 10.98 | 89.02 |

## ▪ Google net 검증 (validation set : cats 77 images , dogs 77 images)

mini batch size : 10
cross validation : 3
validation split : 0.7 , 0.3

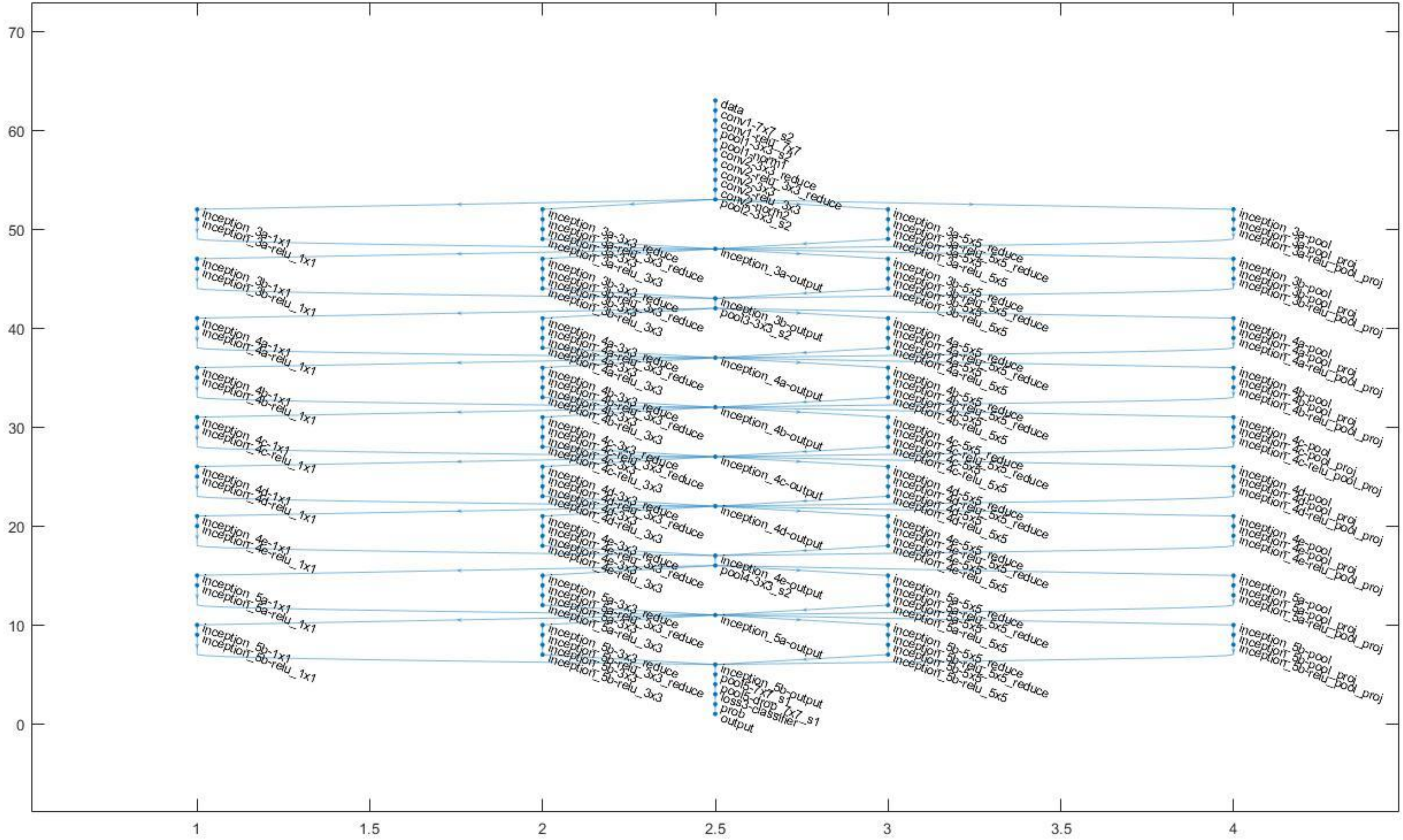
Layers: [144×1 nnet.cnn.layer.Layer]
Connections: [170×2 table]

Training on single GPU.
Initializing image normalization.

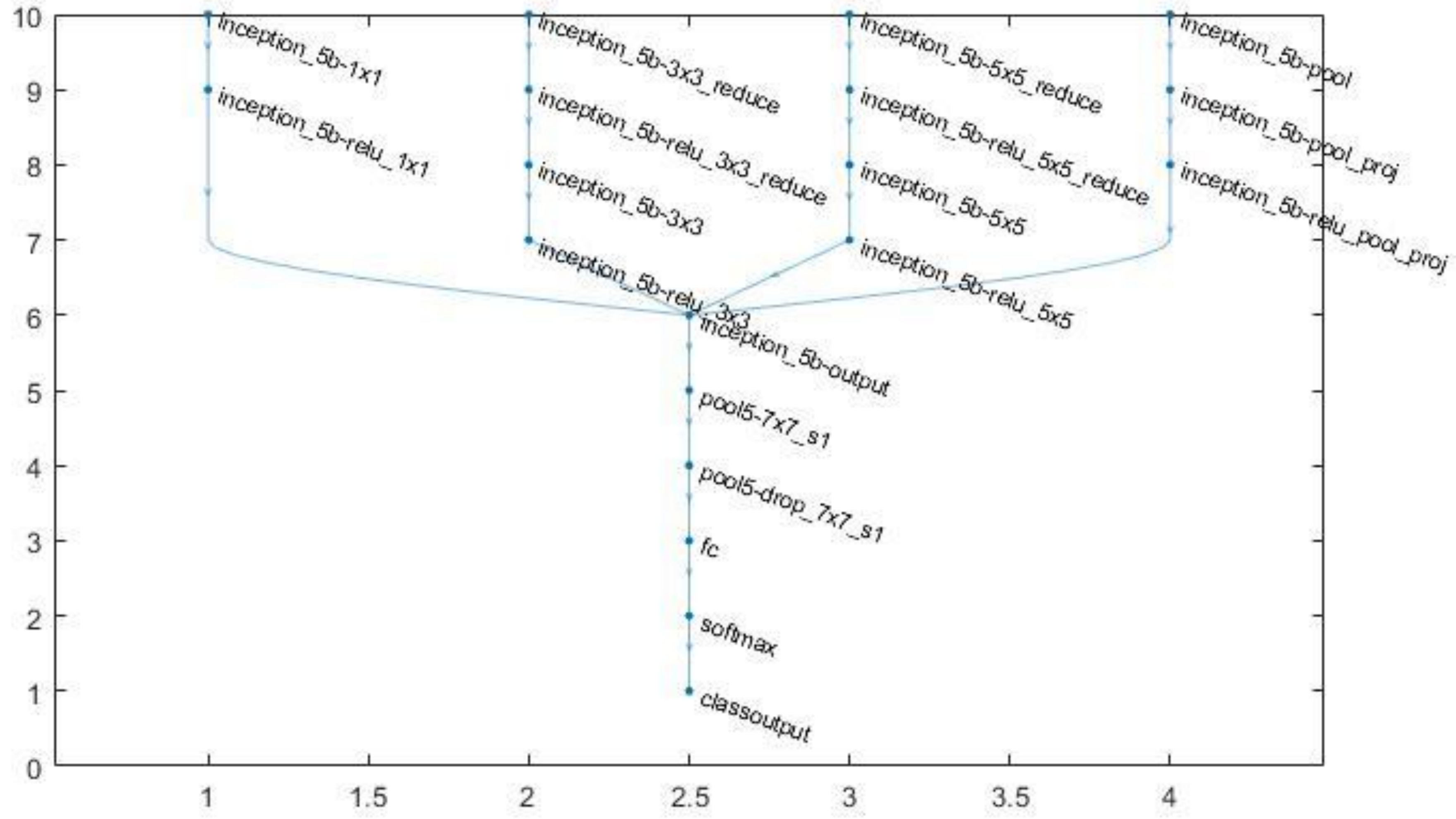
| Epoch | Iteration | Time Elapsed (seconds) | Mini-batch Loss | Validation Loss | Mini-batch Accuracy | Validation Accuracy | Base Learning Rate |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.43 | 0.6682 | 0.5906 | 60.00% | 65.22% | 1.00e-04 |
| 1 | 2 | 2.39 | 0.7177 | | 40.00% | | 1.00e-04 |
| 1 | 3 | 3.08 | 0.4452 | 0.5106 | 80.00% | 78.26% | 1.00e-04 |
| 1 | 4 | 5.68 | 0.6661 | | 60.00% | | 1.00e-04 |
| 1 | 5 | 6.00 | 0.9095 | | 60.00% | | 1.00e-04 |
| 1 | 6 | 6.29 | 0.5651 | 0.2347 | 60.00% | 93.48% | 1.00e-04 |
| 1 | 7 | 8.09 | 0.2109 | | 90.00% | | 1.00e-04 |
| 1 | 8 | 8.42 | 0.3843 | | 80.00% | | 1.00e-04 |
| 1 | 9 | 8.75 | 0.1850 | 0.2542 | 100.00% | 93.48% | 1.00e-04 |
| 1 | 10 | 10.13 | 0.0413 | | 100.00% | | 1.00e-04 |
| 2 | 11 | 10.43 | 0.3277 | | 90.00% | | 1.00e-04 |
| 2 | 12 | 10.72 | 0.2489 | 0.1380 | 90.00% | 93.48% | 1.00e-04 |
| 2 | 13 | 11.82 | 0.1378 | | 90.00% | | 1.00e-04 |
| 2 | 14 | 12.11 | 0.0070 | | 100.00% | | 1.00e-04 |
| 2 | 15 | 12.39 | 0.1494 | 0.1026 | 90.00% | 93.48% | 1.00e-04 |
| 2 | 16 | 13.58 | 0.0633 | | 100.00% | | 1.00e-04 |
| 2 | 17 | 13.88 | 0.0345 | | 100.00% | | 1.00e-04 |
| 2 | 18 | 14.17 | 0.0098 | 0.0956 | 100.00% | 93.48% | 1.00e-04 |
| 2 | 19 | 15.08 | 0.0344 | | 100.00% | | 1.00e-04 |
| 2 | 20 | 15.41 | 0.0010 | | 100.00% | | 1.00e-04 |
| 3 | 21 | 15.71 | 0.0760 | 0.0925 | 100.00% | 93.48% | 1.00e-04 |
| 3 | 22 | 16.89 | 0.0149 | | 100.00% | | 1.00e-04 |
| 3 | 23 | 17.16 | 0.0557 | | 100.00% | | 1.00e-04 |
| 3 | 24 | 17.46 | 0.0047 | 0.0905 | 100.00% | 93.48% | 1.00e-04 |
| 3 | 25 | 18.46 | 0.1053 | | 90.00% | | 1.00e-04 |
| 3 | 26 | 18.74 | 0.0140 | | 100.00% | | 1.00e-04 |
| 3 | 27 | 19.03 | 0.0090 | 0.0889 | 100.00% | 93.48% | 1.00e-04 |
| 3 | 28 | 19.89 | 0.0048 | | 100.00% | | 1.00e-04 |
| 3 | 29 | 20.18 | 0.0342 | | 100.00% | | 1.00e-04 |
| 3 | 30 | 20.47 | 0.0009 | 0.0904 | 100.00% | 93.48% | 1.00e-04 |

accuracy =

0.9348

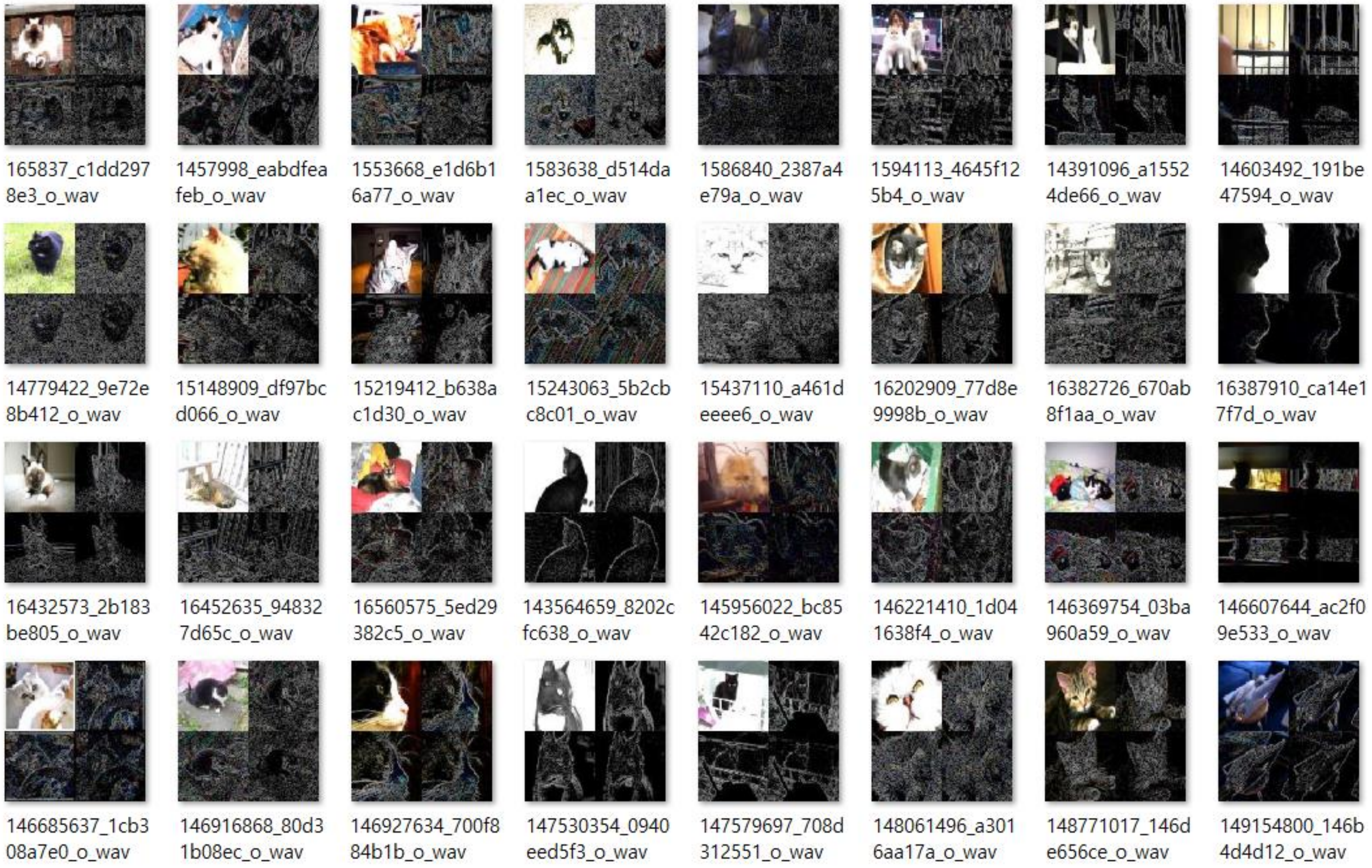


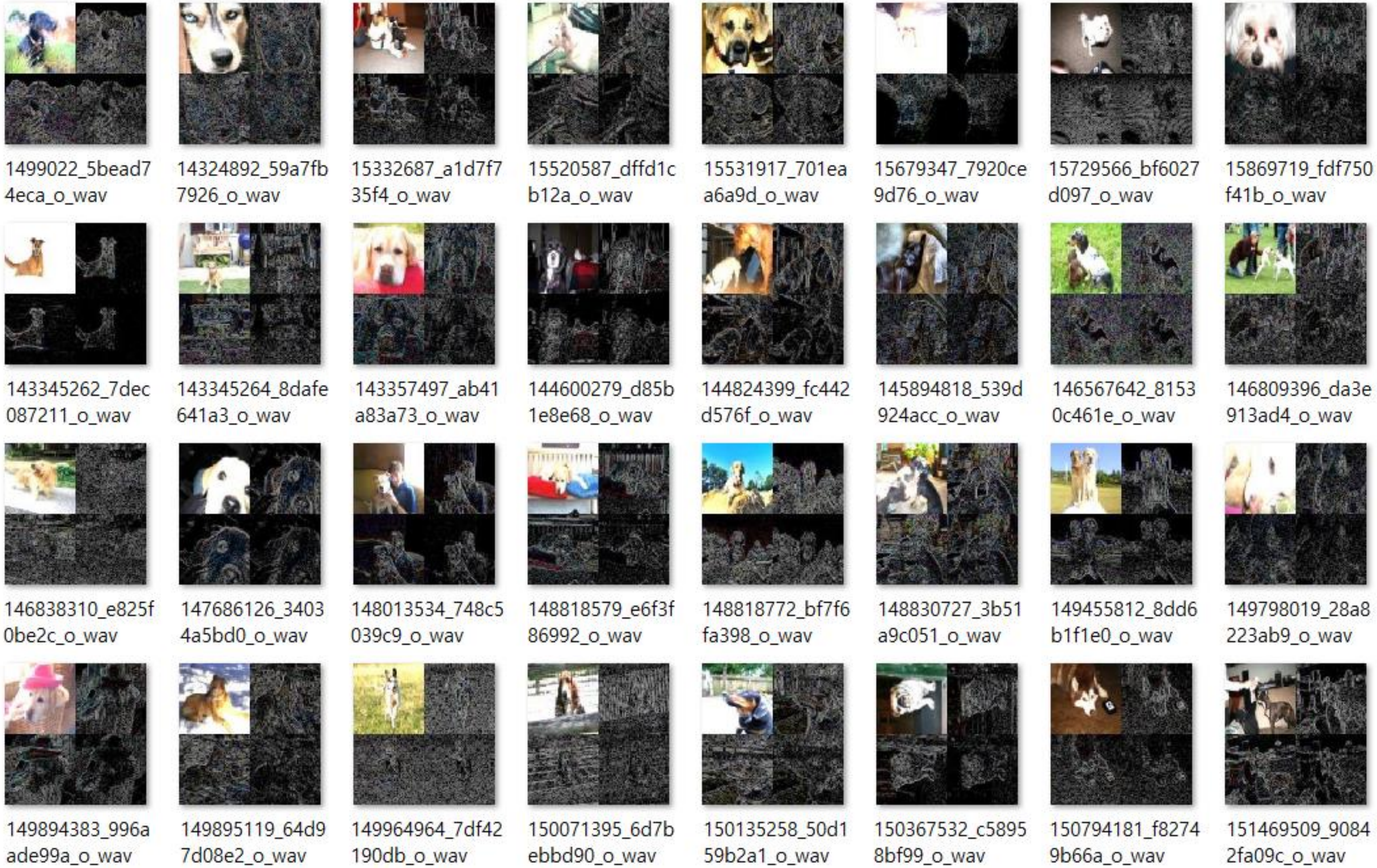
70
60
50
40
30
20
10
0
1
1.5
2
2.5
3
3.5
4
data
conv1-7x7_s2
conv1-relu_7x7
pool1-3x3_s2
pool1-norm1
conv2-3x3_reduce
conv2-relu_3x3_reduce
conv2-3x3
conv2-relu_3x3
conv2-norm2
pool2-3x3_s2
inception_3a-1x1
inception_3a-relu_1x1
inception_3a-3x3_reduce
inception_3a-relu_3x3_reduce
inception_3a-3x3
inception_3a-relu_3x3
inception_3a-5x5_reduce
inception_3a-relu_5x5_reduce
inception_3a-5x5
inception_3a-relu_5x5
inception_3a-pool
inception_3a-pool_proj
inception_3a-relu_pool_proj
inception_3a-output
inception_3b-1x1
inception_3b-relu_1x1
inception_3b-3x3_reduce
inception_3b-relu_3x3_reduce
inception_3b-3x3
inception_3b-relu_3x3
inception_3b-5x5_reduce
inception_3b-relu_5x5_reduce
inception_3b-5x5
inception_3b-relu_5x5
inception_3b-pool
inception_3b-pool_proj
inception_3b-relu_pool_proj
inception_3b-output
pool3-3x3_s2
inception_4a-1x1
inception_4a-relu_1x1
inception_4a-3x3_reduce
inception_4a-relu_3x3_reduce
inception_4a-3x3
inception_4a-relu_3x3
inception_4a-5x5_reduce
inception_4a-relu_5x5_reduce
inception_4a-5x5
inception_4a-relu_5x5
inception_4a-pool
inception_4a-pool_proj
inception_4a-relu_pool_proj
inception_4a-output
inception_4b-1x1
inception_4b-relu_1x1
inception_4b-3x3_reduce
inception_4b-relu_3x3_reduce
inception_4b-3x3
inception_4b-relu_3x3
inception_4b-5x5_reduce
inception_4b-relu_5x5_reduce
inception_4b-5x5
inception_4b-relu_5x5
inception_4b-pool
inception_4b-pool_proj
inception_4b-relu_pool_proj
inception_4b-output
inception_4c-1x1
inception_4c-relu_1x1
inception_4c-3x3_reduce
inception_4c-relu_3x3_reduce
inception_4c-3x3
inception_4c-relu_3x3
inception_4c-5x5_reduce
inception_4c-relu_5x5_reduce
inception_4c-5x5
inception_4c-relu_5x5
inception_4c-pool
inception_4c-pool_proj
inception_4c-relu_pool_proj
inception_4c-output
inception_4d-1x1
inception_4d-relu_1x1
inception_4d-3x3_reduce
inception_4d-relu_3x3_reduce
inception_4d-3x3
inception_4d-relu_3x3
inception_4d-5x5_reduce
inception_4d-relu_5x5_reduce
inception_4d-5x5
inception_4d-relu_5x5
inception_4d-pool
inception_4d-pool_proj
inception_4d-relu_pool_proj
inception_4d-output
inception_4e-1x1
inception_4e-relu_1x1
inception_4e-3x3_reduce
inception_4e-relu_3x3_reduce
inception_4e-3x3
inception_4e-relu_3x3
inception_4e-5x5_reduce
inception_4e-relu_5x5_reduce
inception_4e-5x5
inception_4e-relu_5x5
inception_4e-pool
inception_4e-pool_proj
inception_4e-relu_pool_proj
inception_4e-output
pool4-3x3_s2
inception_5a-1x1
inception_5a-relu_1x1
inception_5a-3x3_reduce
inception_5a-relu_3x3_reduce
inception_5a-3x3
inception_5a-relu_3x3
inception_5a-5x5_reduce
inception_5a-relu_5x5_reduce
inception_5a-5x5
inception_5a-relu_5x5
inception_5a-pool
inception_5a-pool_proj
inception_5a-relu_pool_proj
inception_5a-output
inception_5b-1x1
inception_5b-relu_1x1
inception_5b-3x3_reduce
inception_5b-relu_3x3_reduce
inception_5b-3x3
inception_5b-relu_3x3
inception_5b-5x5_reduce
inception_5b-relu_5x5_reduce
inception_5b-5x5
inception_5b-relu_5x5
inception_5b-pool
inception_5b-pool_proj
inception_5b-relu_pool_proj
inception_5b-output
pool5-7x7_s1
pool5-drop_7x7_s1
loss3-classifier
prob
output



inception_5b-1x1
inception_5b-relu_1x1
inception_5b-3x3_reduce
inception_5b-relu_3x3_reduce
inception_5b-3x3
inception_5b-relu_3x3
inception_5b-5x5_reduce
inception_5b-relu_5x5_reduce
inception_5b-5x5
inception_5b-relu_5x5
inception_5b-pool
inception_5b-pool_proj
inception_5b-relu_pool_proj
inception_5b-output
pool5-7x7_s1
pool5-drop_7x7_s1
fc
softmax
classoutput
0
1
2
3
4
5
6
7
8
9
10
1
1.5
2
2.5
3
3.5
4

# DWT(DISCRETE WAVELET TRANSFORM) CATS ,DOGS)

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15332687_a1d7f735f4_o_wav
15520587_dffd1cb12a_o_wav
15531917_701eaa6a9d_o_wav
15679347_7920ce9d76_o_wav
15729566_bf6027d097_o_wav
15869719_fdf750f41b_o_wav
143345262_7dec087211_o_wav
143345264_8dafe641a3_o_wav
143357497_ab41a83a73_o_wav
144600279_d85b1e8e68_o_wav
144824399_fc442d576f_o_wav
145894818_539d924acc_o_wav
146567642_81530c461e_o_wav
146809396_da3e913ad4_o_wav
146838310_e825f0be2c_o_wav
147686126_34034a5bd0_o_wav
148013534_748c5039c9_o_wav
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148818772_bf7f6fa398_o_wav
148830727_3b51a9c051_o_wav
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149895119_64d97d08e2_o_wav
149964964_7df42190db_o_wav
150071395_6d7bebbd90_o_wav
150135258_50d159b2a1_o_wav
150367532_c58958bf99_o_wav
150794181_f82749b66a_o_wav
151469509_90842fa09c_o_wav

- DWT(Discrete Wavelet Transform) validation set( cats : 77 images , dogs : 77 images)

| Epoch | Iteration | Time Elapsed (seconds) | Mini-batch Loss | Validation Loss | Mini-batch Accuracy | Validation Accuracy | Base Learning Rate |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 3.75 | 0.6794 | 0.7729 | 60.00% | 52.17% | 1.00e-04 |
| 1 | 2 | 6.18 | 0.7394 | | 60.00% | | 1.00e-04 |
| 1 | 3 | 6.88 | 0.8574 | 0.7031 | 30.00% | 56.52% | 1.00e-04 |
| 1 | 4 | 9.55 | 0.8722 | | 40.00% | | 1.00e-04 |
| 1 | 5 | 9.92 | 0.9498 | | 50.00% | | 1.00e-04 |
| 1 | 6 | 10.22 | 0.4789 | 0.5751 | 70.00% | 65.22% | 1.00e-04 |
| 1 | 7 | 11.79 | 0.4361 | | 80.00% | | 1.00e-04 |
| 1 | 8 | 12.10 | 0.8257 | | 60.00% | | 1.00e-04 |
| 1 | 9 | 12.41 | 0.5685 | 0.5274 | 80.00% | 71.74% | 1.00e-04 |
| 1 | 10 | 13.66 | 0.5026 | | 60.00% | | 1.00e-04 |
| 2 | 11 | 13.96 | 0.1524 | | 100.00% | | 1.00e-04 |
| 2 | 12 | 14.25 | 0.3132 | 0.5333 | 80.00% | 73.91% | 1.00e-04 |
| 2 | 13 | 15.41 | 0.3985 | | 80.00% | | 1.00e-04 |
| 2 | 14 | 15.70 | 0.4820 | | 70.00% | | 1.00e-04 |
| 2 | 15 | 16.01 | 0.4234 | 0.5384 | 80.00% | 73.91% | 1.00e-04 |
| 2 | 16 | 17.25 | 0.5126 | | 80.00% | | 1.00e-04 |
| 2 | 17 | 17.55 | 0.0912 | | 100.00% | | 1.00e-04 |
| 2 | 18 | 17.88 | 0.7960 | 0.5496 | 80.00% | 78.26% | 1.00e-04 |
| 2 | 19 | 19.06 | 0.4647 | | 90.00% | | 1.00e-04 |
| 2 | 20 | 19.37 | 0.2492 | | 80.00% | | 1.00e-04 |
| 3 | 21 | 19.66 | 0.0324 | 0.5252 | 100.00% | 80.43% | 1.00e-04 |
| 3 | 22 | 20.49 | 0.2599 | | 90.00% | | 1.00e-04 |
| 3 | 23 | 20.79 | 0.2644 | | 90.00% | | 1.00e-04 |
| 3 | 24 | 21.09 | 0.2600 | 0.5385 | 90.00% | 80.43% | 1.00e-04 |
| 3 | 25 | 22.19 | 0.2810 | | 90.00% | | 1.00e-04 |
| 3 | 26 | 22.48 | 0.2412 | | 90.00% | | 1.00e-04 |
| 3 | 27 | 22.76 | 0.1104 | 0.5378 | 100.00% | 76.09% | 1.00e-04 |
| 3 | 28 | 23.84 | 0.2868 | | 90.00% | | 1.00e-04 |
| 3 | 29 | 24.12 | 0.4389 | | 80.00% | | 1.00e-04 |
| 3 | 30 | 24.41 | 0.1122 | 0.5462 | 100.00% | 76.09% | 1.00e-04 |

accuracy =

0.7609

# GOOGLE NET 성능 향상을 위한 파라미터 조정

mini batch size : 32
cross validation : 5
validation split : 0.8 , 0.2

| Epoch | Iteration | Time Elapsed (seconds) | Mini-batch Loss | Validation Loss | Mini-batch Accuracy | Validation Accuracy | Base Learning Rate |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.90 | 0.8037 | 0.5993 | 53.13% | 70.00% | 1.00e-04 |
| 1 | 2 | 2.30 | 0.6441 | | 62.50% | | 1.00e-04 |
| 1 | 3 | 3.28 | 0.5509 | | 84.38% | | 1.00e-04 |
| 2 | 4 | 4.24 | 0.3990 | | 81.25% | | 1.00e-04 |
| 2 | 5 | 5.23 | 0.3082 | 0.2285 | 93.75% | 90.00% | 1.00e-04 |
| 2 | 6 | 6.86 | 0.2100 | | 96.88% | | 1.00e-04 |
| 3 | 7 | 7.93 | 0.2087 | | 90.63% | | 1.00e-04 |
| 3 | 8 | 9.08 | 0.1065 | | 100.00% | | 1.00e-04 |
| 3 | 9 | 10.11 | 0.1262 | | 96.88% | | 1.00e-04 |

accuracy =

0.9333

mini batch size : 32
cross validation : 4
validation split : 0.75 , 0.25

| Epoch | Iteration | Time Elapsed (seconds) | Mini-batch Loss | Validation Loss | Mini-batch Accuracy | Validation Accuracy | Base Learning Rate |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.08 | 0.7959 | 0.6687 | 43.75% | 57.89% | 1.00e-04 |
| 1 | 2 | 4.63 | 0.7294 | | 56.25% | | 1.00e-04 |
| 1 | 3 | 5.63 | 0.5745 | | 71.88% | | 1.00e-04 |
| 2 | 4 | 6.63 | 0.3609 | 0.2693 | 90.63% | 94.74% | 1.00e-04 |
| 2 | 5 | 8.26 | 0.2540 | | 96.88% | | 1.00e-04 |
| 2 | 6 | 9.16 | 0.2788 | | 90.63% | | 1.00e-04 |
| 3 | 7 | 10.09 | 0.1105 | | 96.88% | | 1.00e-04 |
| 3 | 8 | 11.13 | 0.1820 | 0.1063 | 90.63% | 94.74% | 1.00e-04 |
| 3 | 9 | 12.62 | 0.2245 | | 87.50% | | 1.00e-04 |

accuracy =

0.9474

# Applied_Mathematics_Capstone_Design

-Matlab : 응용수학캡스톤디자인 전공수업 (Alexnet , Googlenet) : cats vs dogs binary classification

- CNN(Convolutional Neural Network) 사용

<프로젝트 진행 과정>

- (1) Python 으로 직접 모델링 (Contests 폴더 kaggle_cats_dogs 참조)
- (2) image augmentation , training image wavelet transform 하였으나 accuracy 가 평균 65%
- DWT_RGB.m : discrete wavelet transform code
- training set의 부족임을 알게되어 googlenet , alexnet 적용 ,
- At least, Matlab r2017b version, Using Computer Vision System Toolbox, Image Processing Toolbox, Neural Network Toolbox. Parallel Computing Toolbox, Statistics and Machine Learning Toolbox
- (3) Alexnet accuracy : cats : 87.04% , dogs : 83.33% , validation set : cats(77 images) , dogs(77 images)
- accuracy : cats : 92.68%, dogs : 89.02% , validation set : cats(976 images) , dogs(976 images)
- (4) Googlenet (I recommend using GPU better than CPU, because of time spending.)
- accuracy : 93.33% , validation set : cats(77 images) , dogs(77 images) -cross validation : 5, minibatch size : 32, validation : 0.2
- accuracy : 93.48% , validation set : cats(77 images) , dogs(77 images) -cross validation : 3, minibatch size : 10, validation : 0.3
- accuracy : 94.74% , validation set : cats(77 images) , dogs(77 images) -cross validation : 4, minibatch size : 32, validation : 0.25
- mini batch size : 64 -> GPU out of memory
- accuracy : 76.09% , DWT(Discrete Wavelet Transform) validation set : cats(77 images) , dogs(77 images)

# RESULT

- (1) Python 과 Matlab 의 사용을 통한 Deep Learning 에서 알고리즘의 한 종류인 CNN 직접 모델링.
- (2) 검증된 알고리즘인 Alex net , Google net 을 이용한 적용.

- <추가적인 진행 방향>
- Google net 의 내부 알고리즘 구조를 완벽히 이해 한 후, binary classification 뿐만 아니라, 실생활에 더욱더
- 밀접한 문제 해결 능력 향상.

- < Github portfolio URL (MATLAB , PYTHON related code) >
- https://github.com/choiwb

# 참고 문헌


- Batch Normalization: Accelerating Deep Network Training by

 Reducing Internal Covariate Shift : ICML 2015
https://pdfs.semanticscholar.org/c1ba/ed41e4bc9401b1b2ec8ef55ba45543f7a1a3.pdf

- Classifying cats and dogs from images using deep learning

: university of Alberta

https://github.com/shrobon/Classifying-Dogs-and-Cats-using-CNN/blob/master/MM803_Project_Reportf.pdf

- https://www.slideshare.net/ssuser06e0c5/normalization-72539464

- Mathematical Analysis of Convolutional Neural Networks

https://github.com/ahmedmazariML/Mathematical-analysis-of-Convolutional-Neural-Networks/blob/master/Mathematical-analysis-of-Convolutional-Neural-Networks.pdf

- -Google net
- https://www.cs.unc.edu/~wliu/papers/GoogLeNet.pdf
- -Alex net
- https://www.nvidia.cn/content/tesla/pdf/machine-learning/imagenet-classification-with-deep-convolutional-nn.pdf
- -Alex net vs Google net
- On the Performance of GoogLeNet and AlexNet Applied to Sketches.pdf