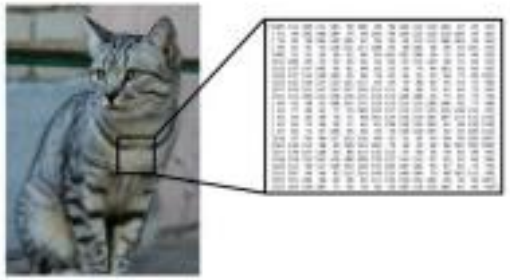
Part 1

Convolution, CNN, 그리고 Parametric 문제해결

컴퓨터를 이용한 문제해결의 어려움

Viewpoint



Illumination

This image is CC0 1.0 public domain

Deformation

This image by Umberto Salvagnin is licensed under CC-BY 2.0

Occlusion

This image by jonsson is licensed under CC-BY 2.0

Clutter

This image is CC0 1.0 public domain

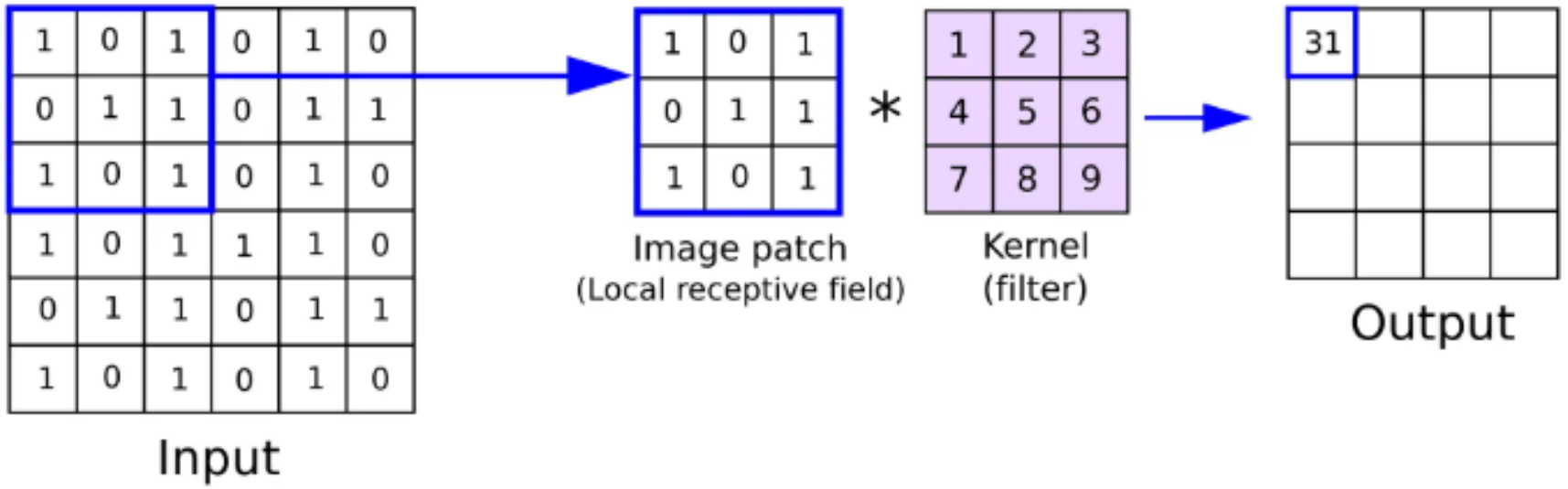
Intraclass Variation

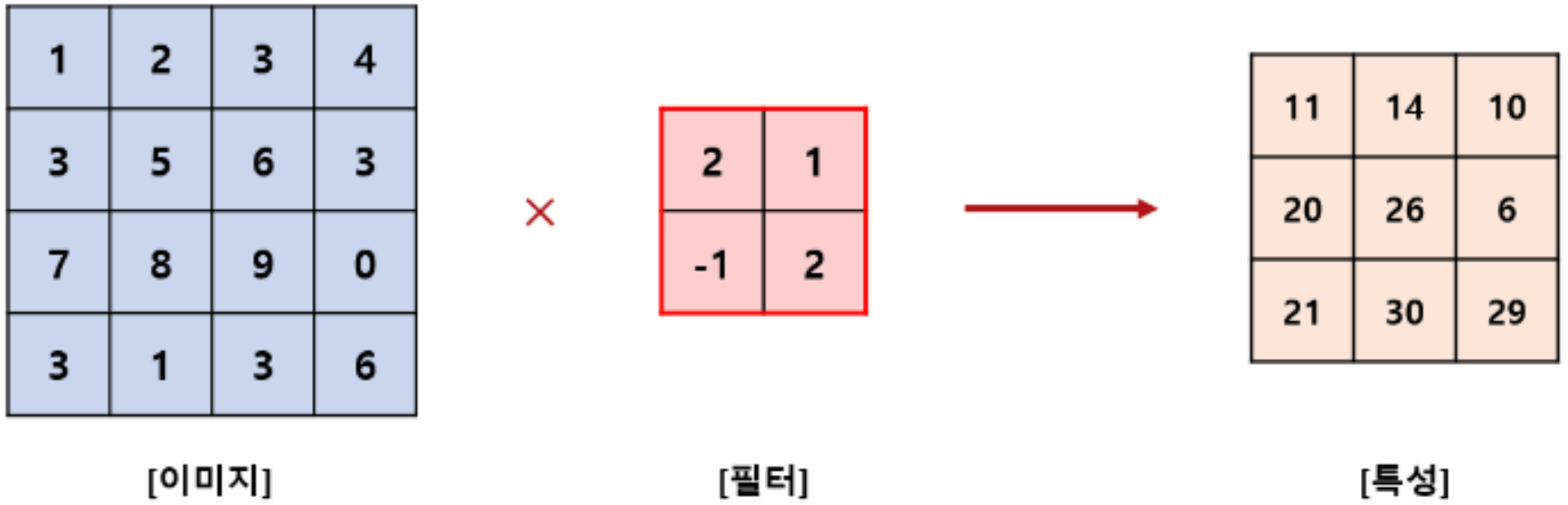
This image is CC0 1.0 public domain

컴퓨터를 이용한 문제해결의 4가지 방법

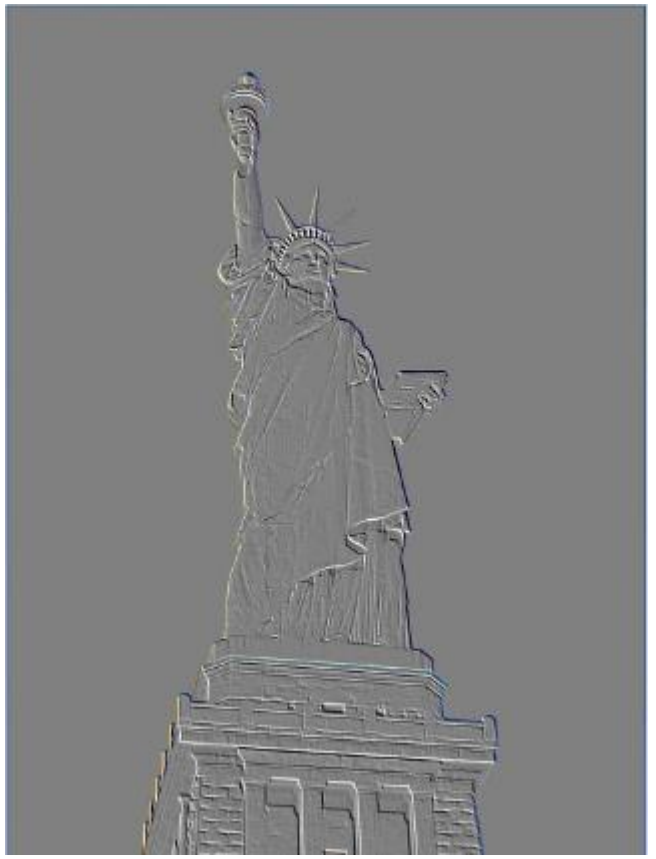
문제해결 방법	알고리즘	특징 및 지식표현	특징	단점
1. 고전적 프로그래밍	-사람이 작성	-사람이 작성	- 특징 찾기가 어려움 - 알고리즘 없으면 불가능	- 문제마다 작성 - -알고리즘을 모르는 경우가 너무 많음
2. Convolution (필터 기반)	-필터를 이용	- 알려진 필터 이용 또는 필터 개발	- 필터가 특징 찾는 역할	- 필터 개발이 어려움 - 단순한 기능만 가능
3. 데이터 기반 (머신 러닝)	- 데이터에 기반한 공통 알고리즘 사용	- 통계적 방법 사용	- 데이터 분포로 부터 특징 구함	- 복잡한 문제 해결이 어려움
4. 딥러닝 (Parametric Approach)	- 공통 학습알고리즘 사용	- 패러미터로 표현	- 알고리즘 개발이 불필요	- 많은 데이터와 학습이 필요

Convolution : 필터를 이용한 문제 해결

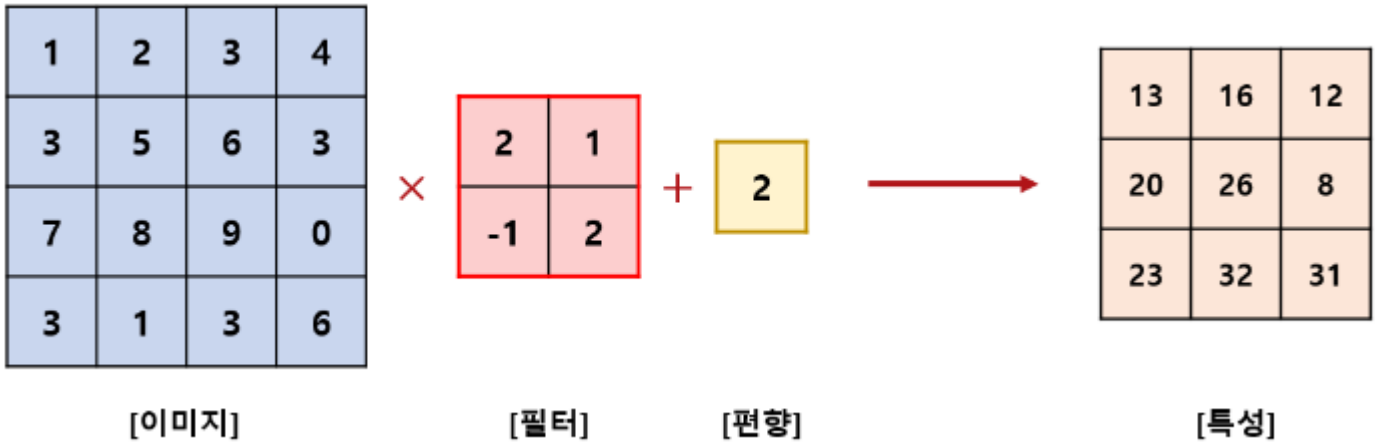




Embossing by Convolution



Convolution + Bias



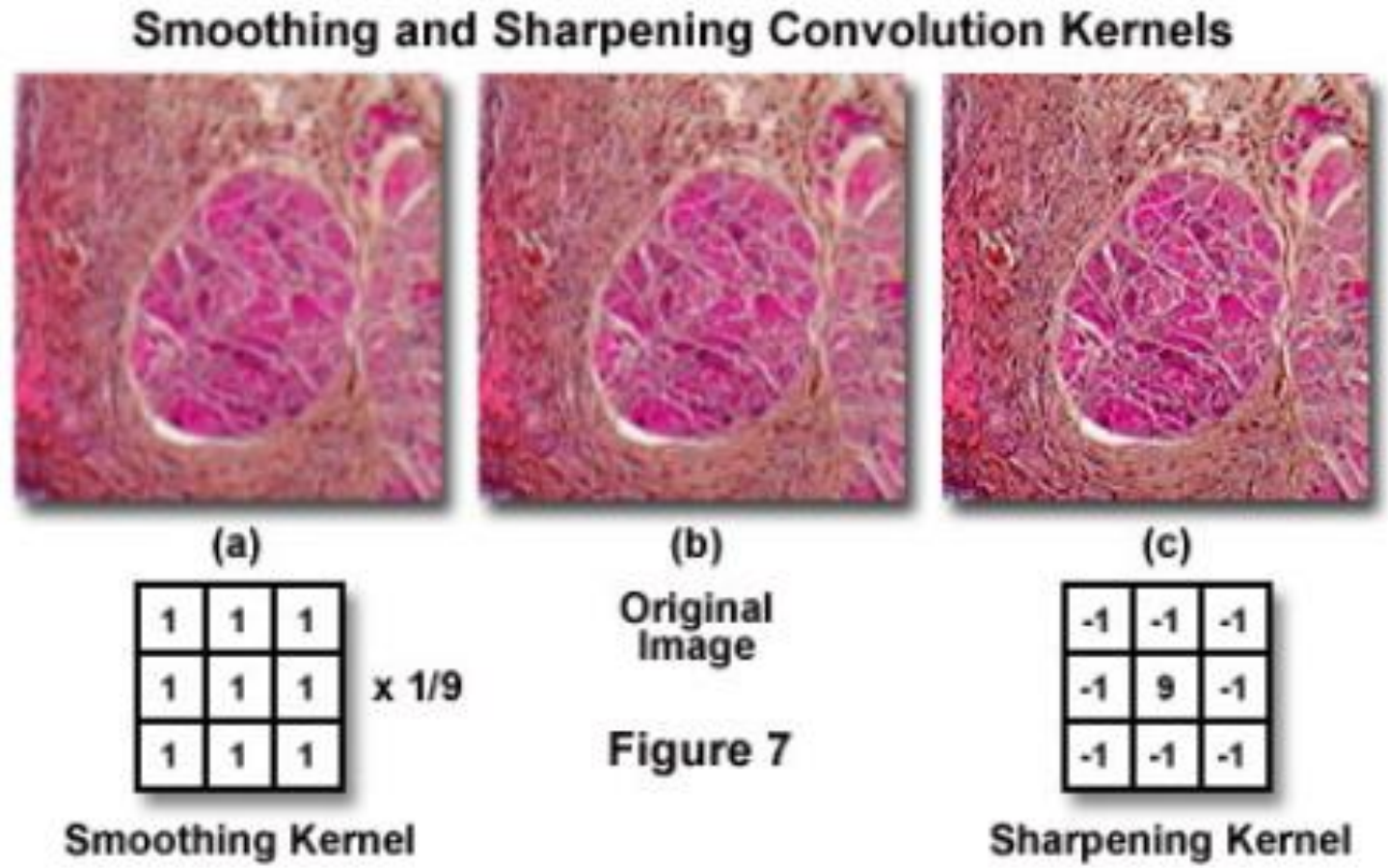
Convolution 을 이용한 문제 해결 - 엠보싱

Convolution 을 이용한 문제 해결 - 흐리게

Convolution 을 이용한 문제 해결

```python
import cv2
import numpy as np

# 이미지를 불러옵니다. 원하는 이미지 파일명으로 변경하세요.
image = cv2.imread('car0208.jpg', cv2.IMREAD_GRAYSCALE)
#imageColor = cv2.imread('car0208.jpg', cv2.IMREAD_COLOR)

# 커널 (필터)을 정의합니다. 예시로 간단한 평균 필터를 사용합니다.
kernel_embossing = np.array([[2, 0, 0],
                             [0, 0, 0],
                             [0, 0, -2]])
kernel_blurring = np.array([[1, 1, 1],
                            [1, 1, 1],
                            [1, 1, 1]]) / 9
kernel_blurring2 = np.array([[1, 1, 1, 1, 1],
                             [1, 1, 1, 1, 1],
                             [1, 1, 1, 1, 1],
                             [1, 1, 1, 1, 1],
                             [1, 1, 1, 1, 1]]) / 25

# 컨볼루션을 적용합니다.
embossedImg = cv2.filter2D(image, -1, kernel_embossing)
blurredImg = cv2.filter2D(image, -1, kernel_blurring)
blurredImg2 = cv2.filter2D(image, -1, kernel_blurring)

# 결과 이미지를 표시합니다.
cv2.imshow('Original Image', image)
cv2.imshow('embossing', embossedImg)
cv2.imshow('blurring', blurredImg)
cv2.imshow('more blurring', blurredImg2)

# 아무 키나 누를 때까지 대기합니다.
cv2.waitKey(0)
cv2.destroyAllWindows()
```

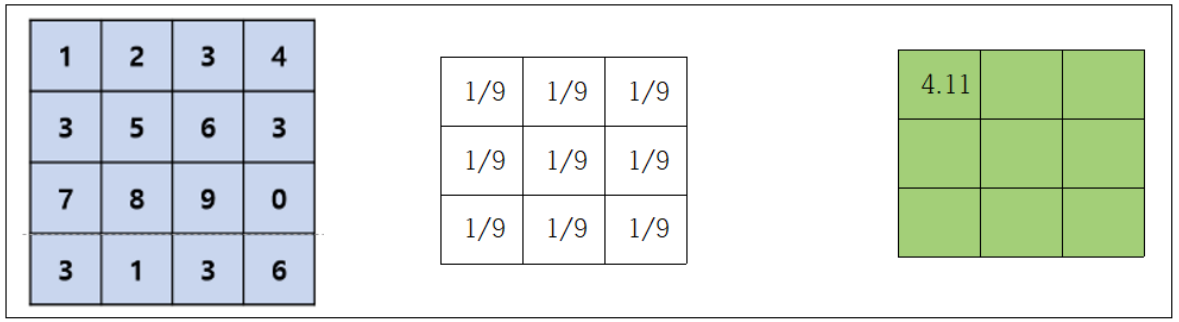
Convolution 예



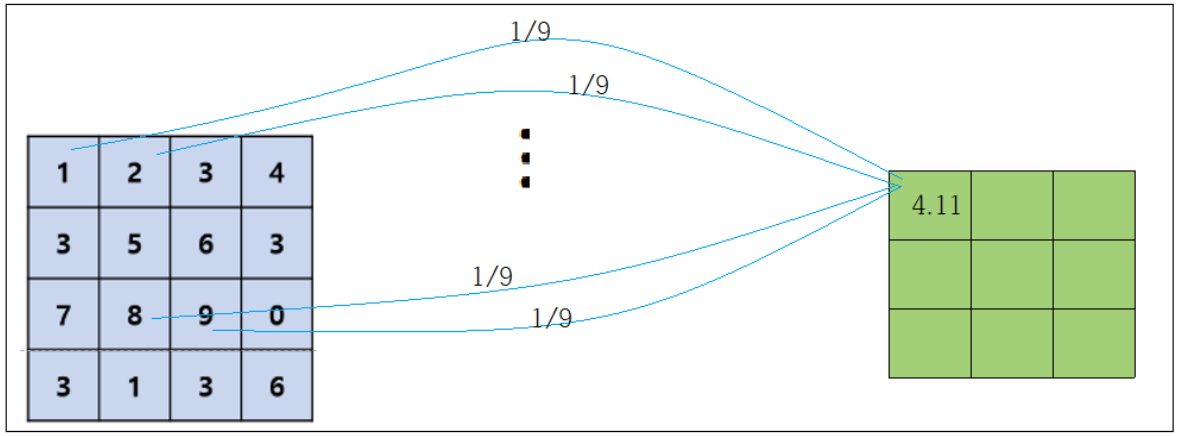
https://micro.magnet.fsu.edu/primer/digitalimaging/imageprocessingintro.html

Convolution, NN, CNN의 차이

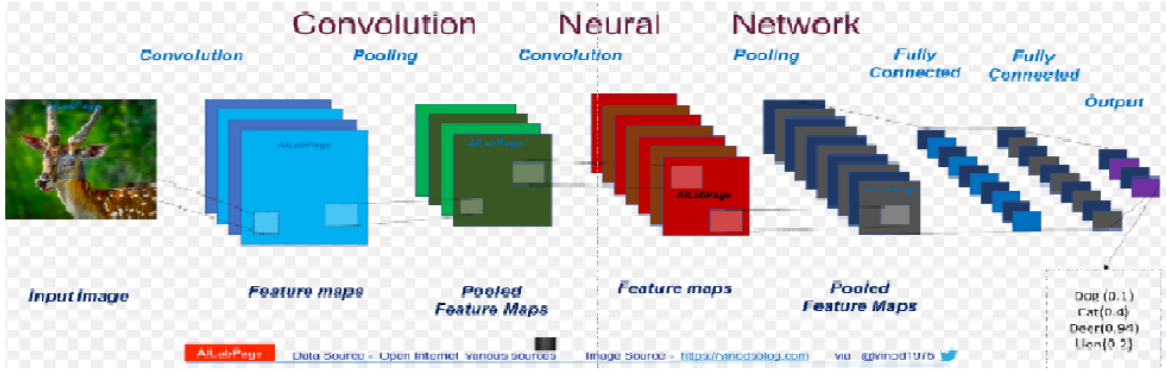
Convolution



NN

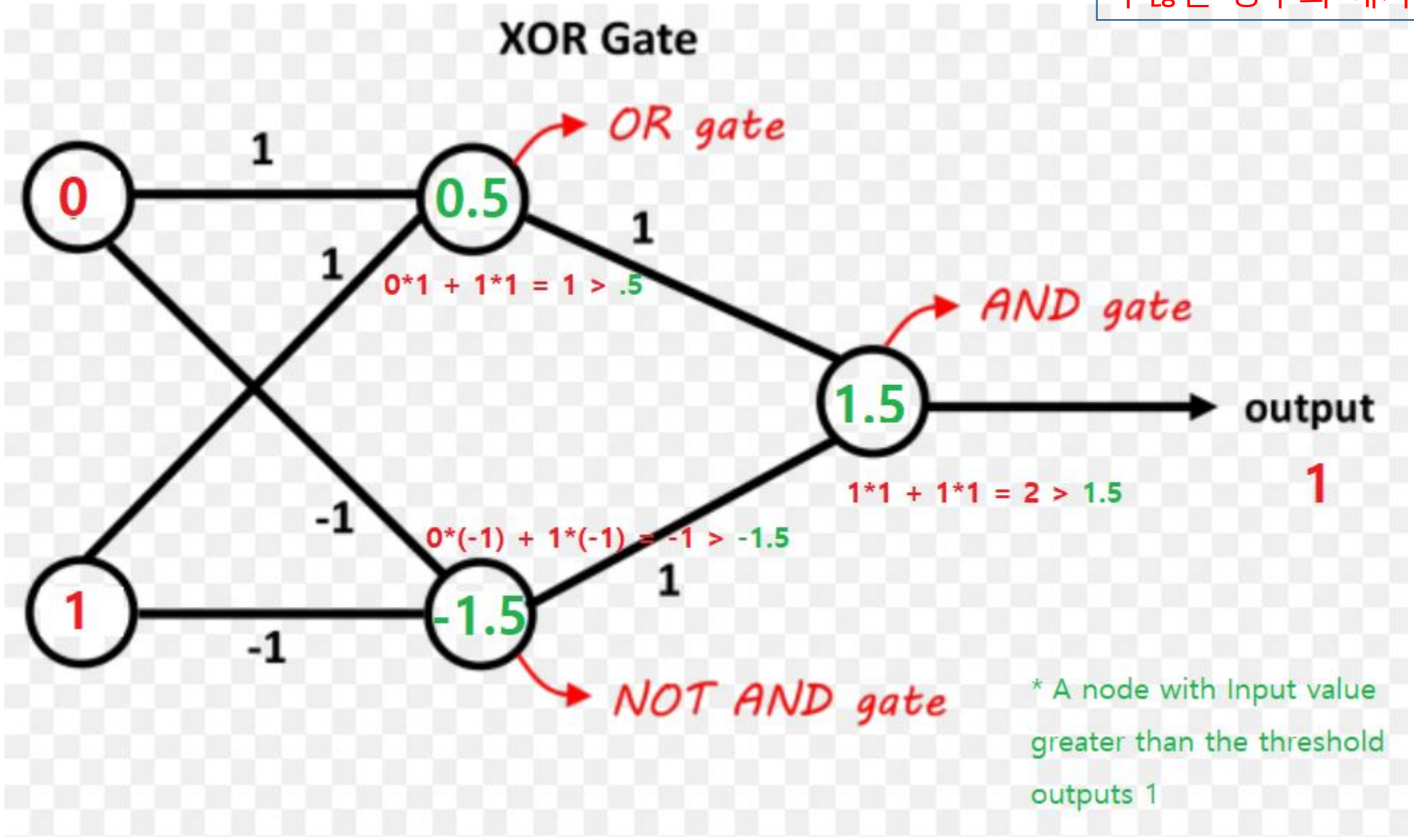


CNN



Parametric Approach의 개념

수많은 경우의 해가 존재!!!



[알고리즘]

(1)

```
If x1 == x2:
    result = 0
Else :
    result = 1
```

또는

(2)

```
If x1 != x2:
    result = 1
Else :
    result = 0
```

.....

학습의 원리

Backpropagation: a simple example

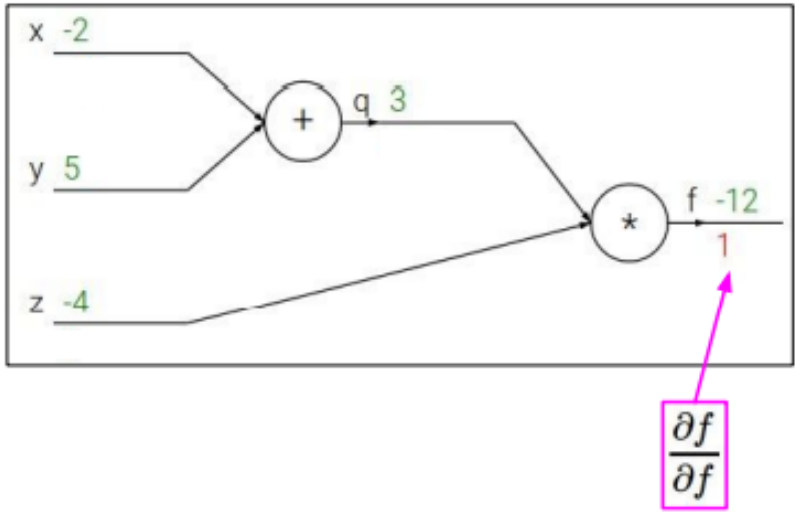
$$f(x,y,z) = (x+y)z$$

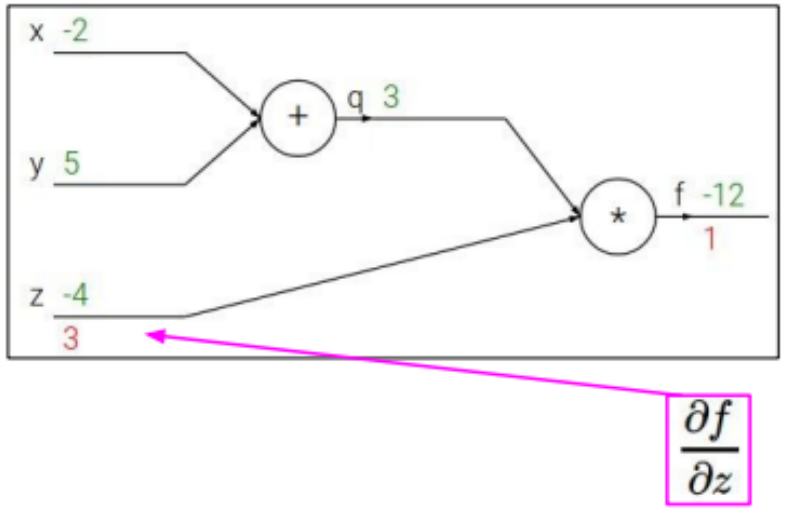
e.g. x = -2, y = 5, z = -4

$q = x + y \qquad \frac{\partial q}{\partial x} = 1, \frac{\partial q}{\partial y} = 1$

$f = qz \qquad \frac{\partial f}{\partial q} = z, \frac{\partial f}{\partial z} = q$

Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$





학습의 원리

Backpropagation: a simple example

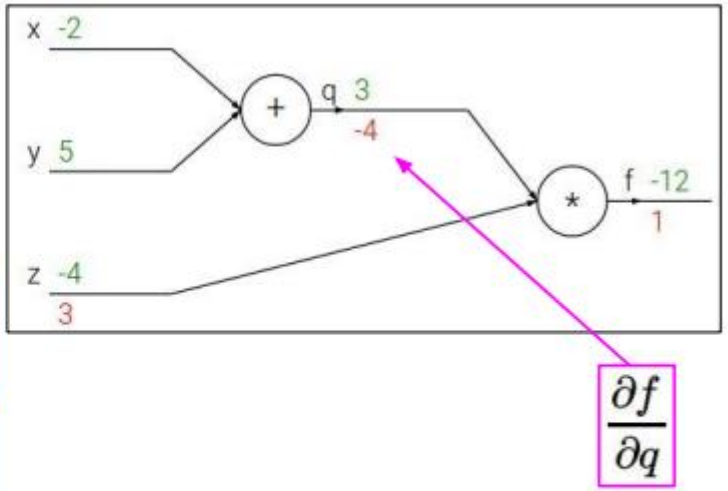
$$f(x,y,z) = (x+y)z$$

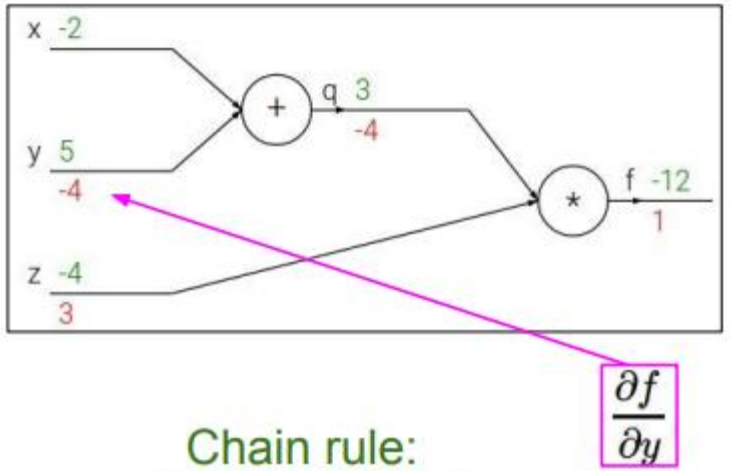
e.g. x = -2, y = 5, z = -4

$$q = x + y \qquad \frac{\partial q}{\partial x} = 1, \frac{\partial q}{\partial y} = 1$$

$$f = qz \qquad \frac{\partial f}{\partial q} = z, \frac{\partial f}{\partial z} = q$$

Want: $\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}$

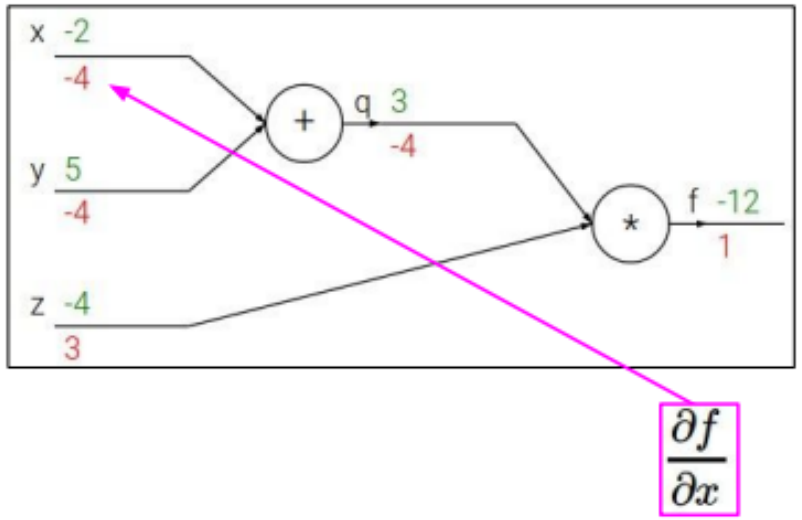


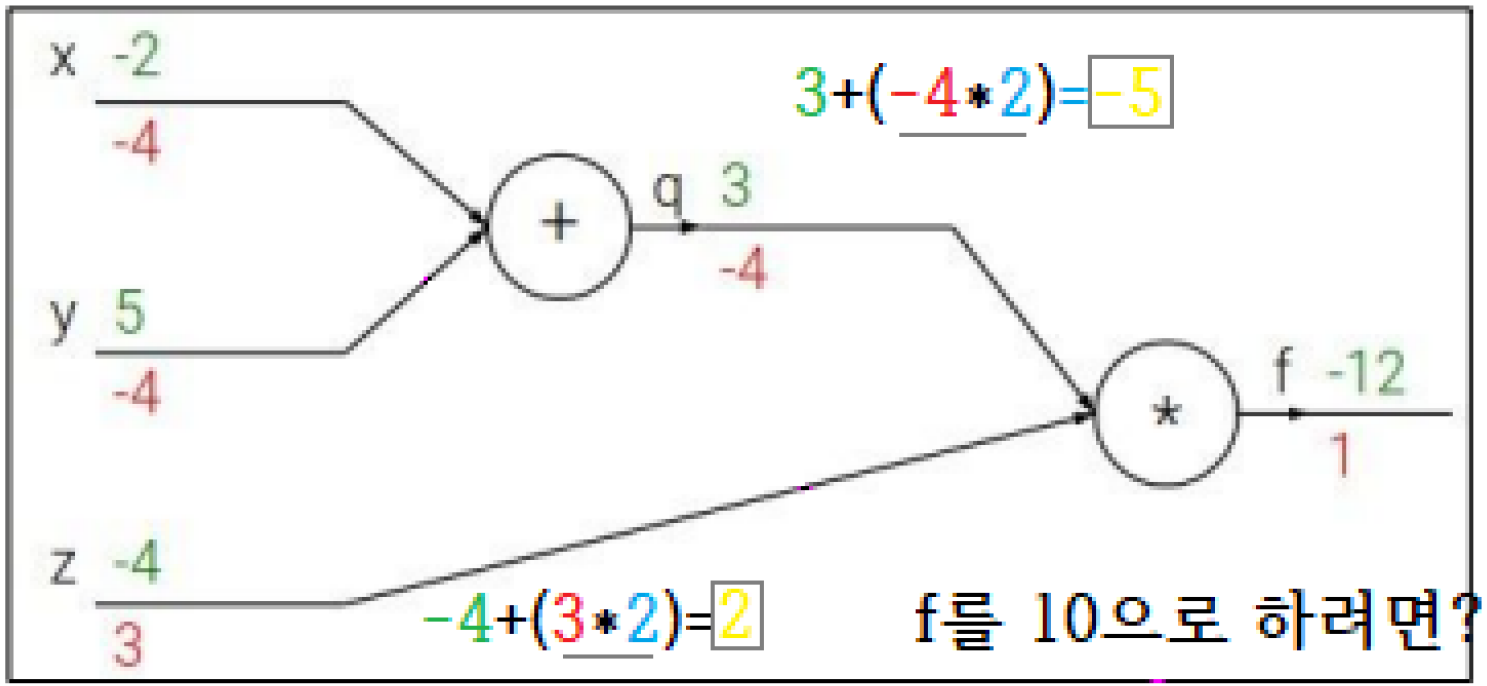


Chain rule:

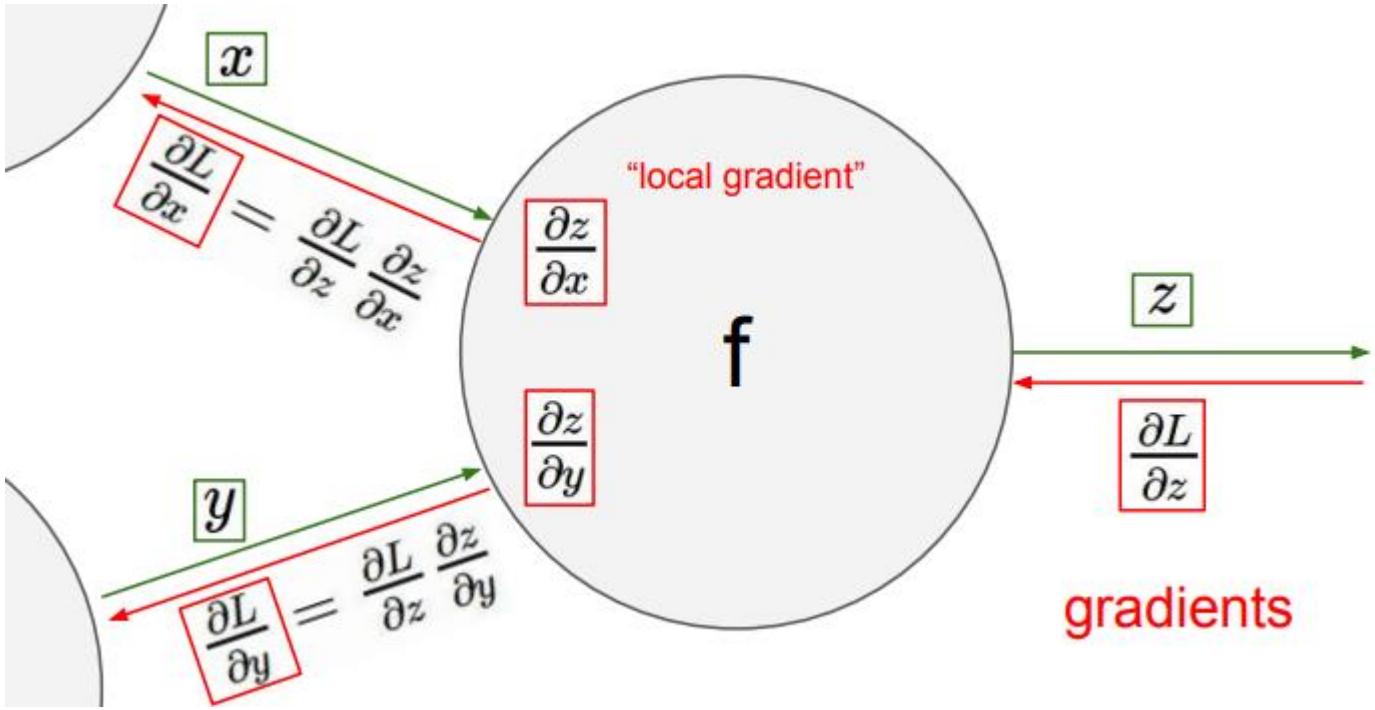
$$\frac{\partial f}{\partial y} = \frac{\partial f}{\partial q}\frac{\partial q}{\partial y}$$

학습의 원리


x -2
-4
y 5
-4
z -4
3
+
q 3
-4
*
f -12
1
$\frac{\partial f}{\partial x}$

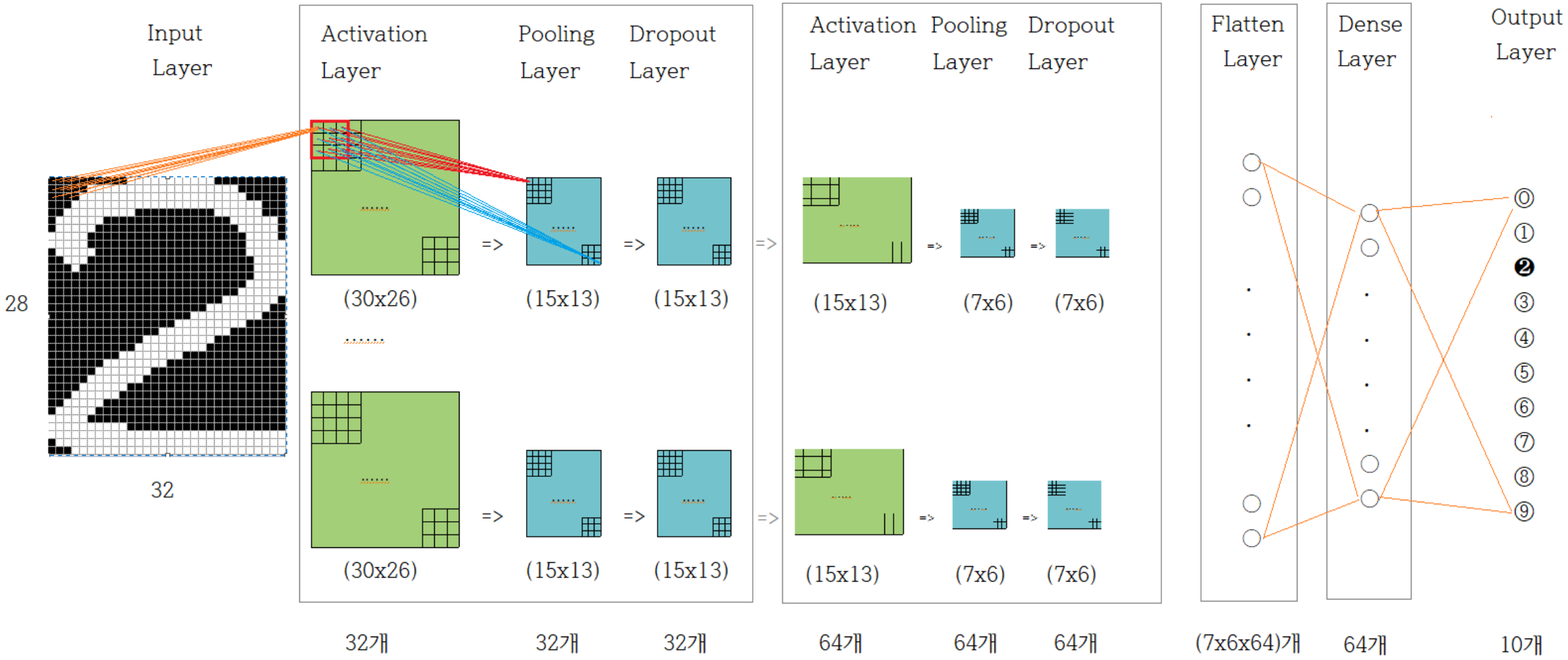

x -2
-4
y 5
-4
z -4
3
+
q 3
-4
*
f -12
1
3+(−4∗2)=−5
−4+(3∗2)=2
f를 10으로 하려면?

학습의 원리



- Chain Rule을 이용하여 기울기(미치는 영향)을 계산하고,
- 파라미터가 출력에 미치는 영향에 비례하여 값을 변화 시킨다

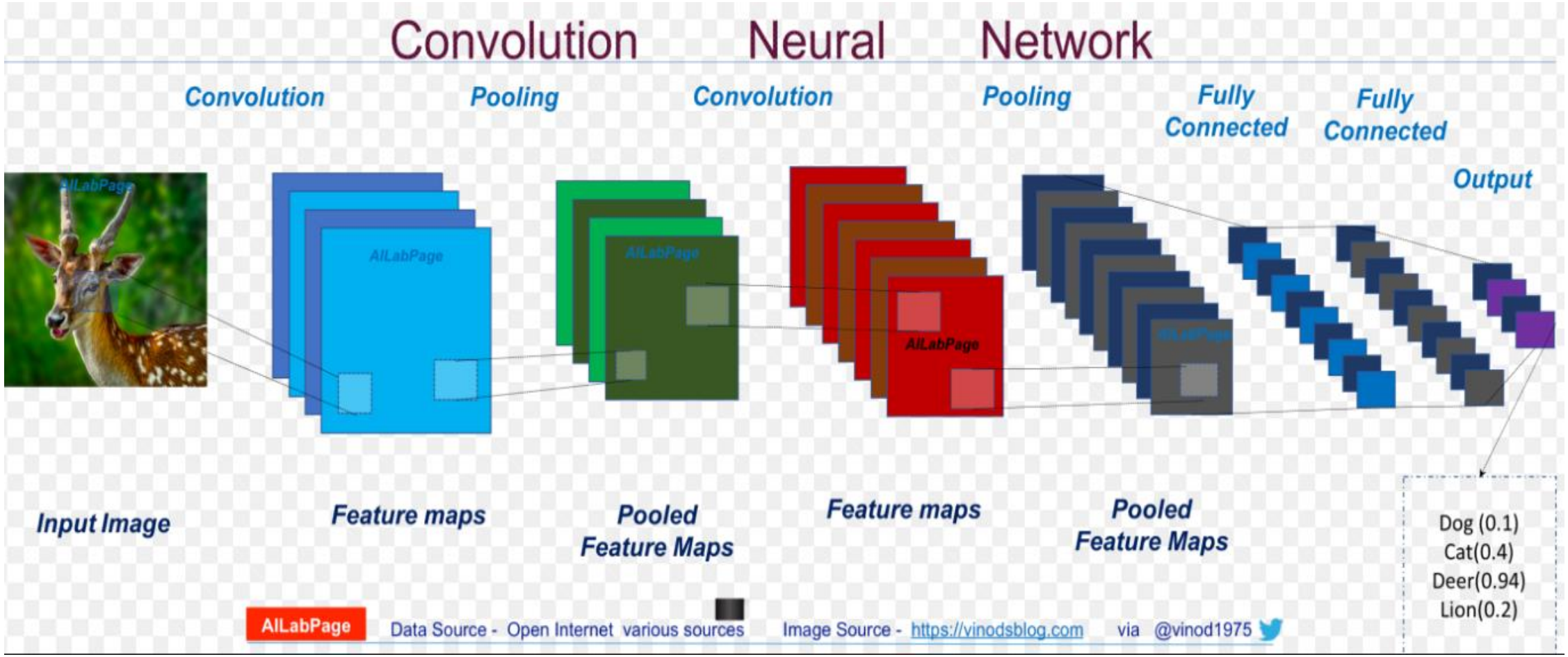
CNN의 구조


Input Layer
Activation Layer
Pooling Layer
Dropout Layer
Activation Layer
Pooling Layer
Dropout Layer
Flatten Layer
Dense Layer
Output Layer
28
32
(30x26)
(15x13)
(15x13)
(30x26)
(15x13)
(15x13)
(15x13)
(7x6)
(7x6)
(15x13)
(7x6)
(7x6)
32개
32개
32개
64개
64개
64개
(7x6x64)개
64개
10개
⓪
①
❷
③
④
⑤
⑥
⑦
⑧
⑨

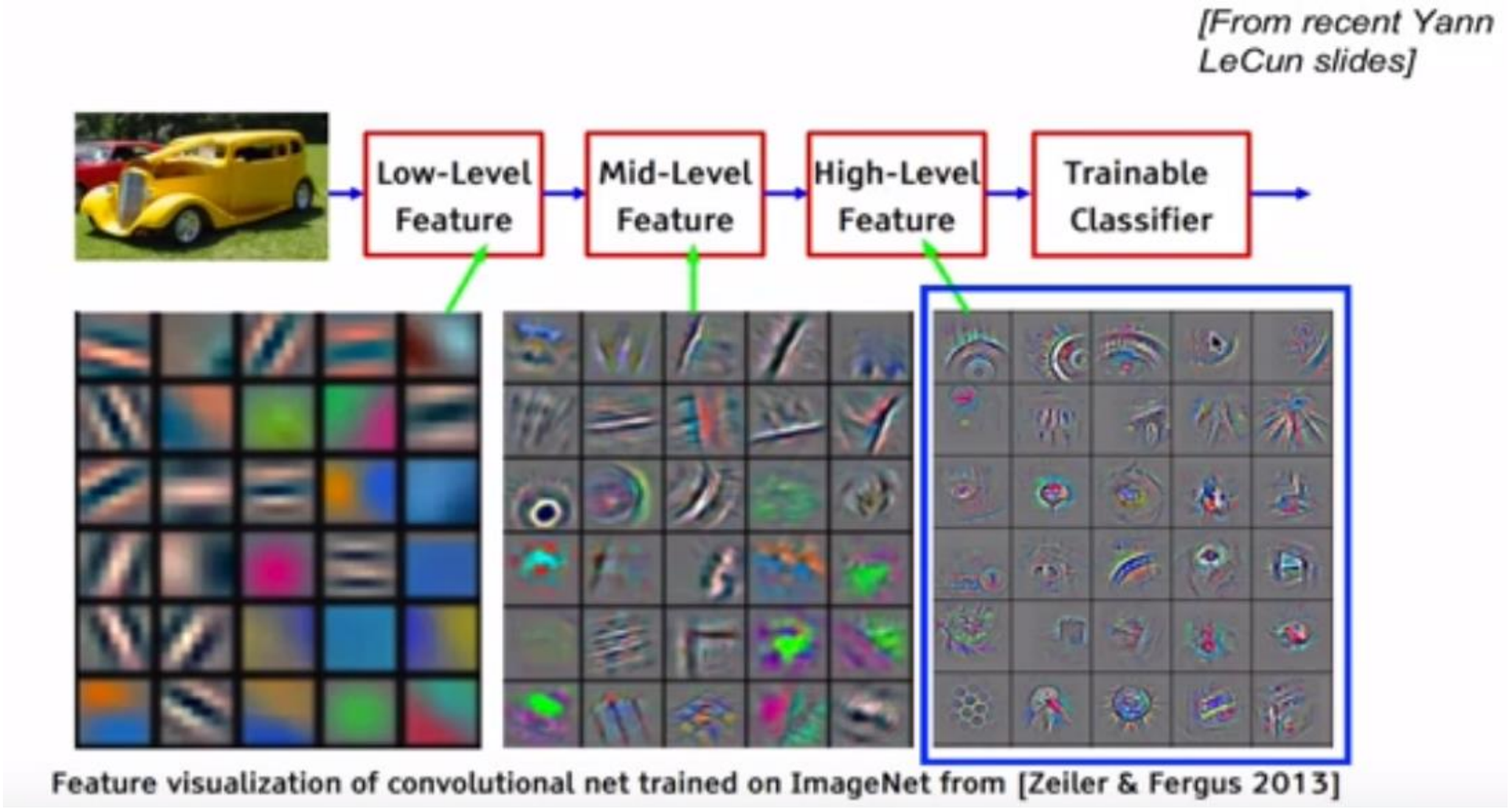
CNN을 이용한 숫자 인식

Classify_num.py 실행 데모

연결과 학습: 오늘날 AI 성능의 이유



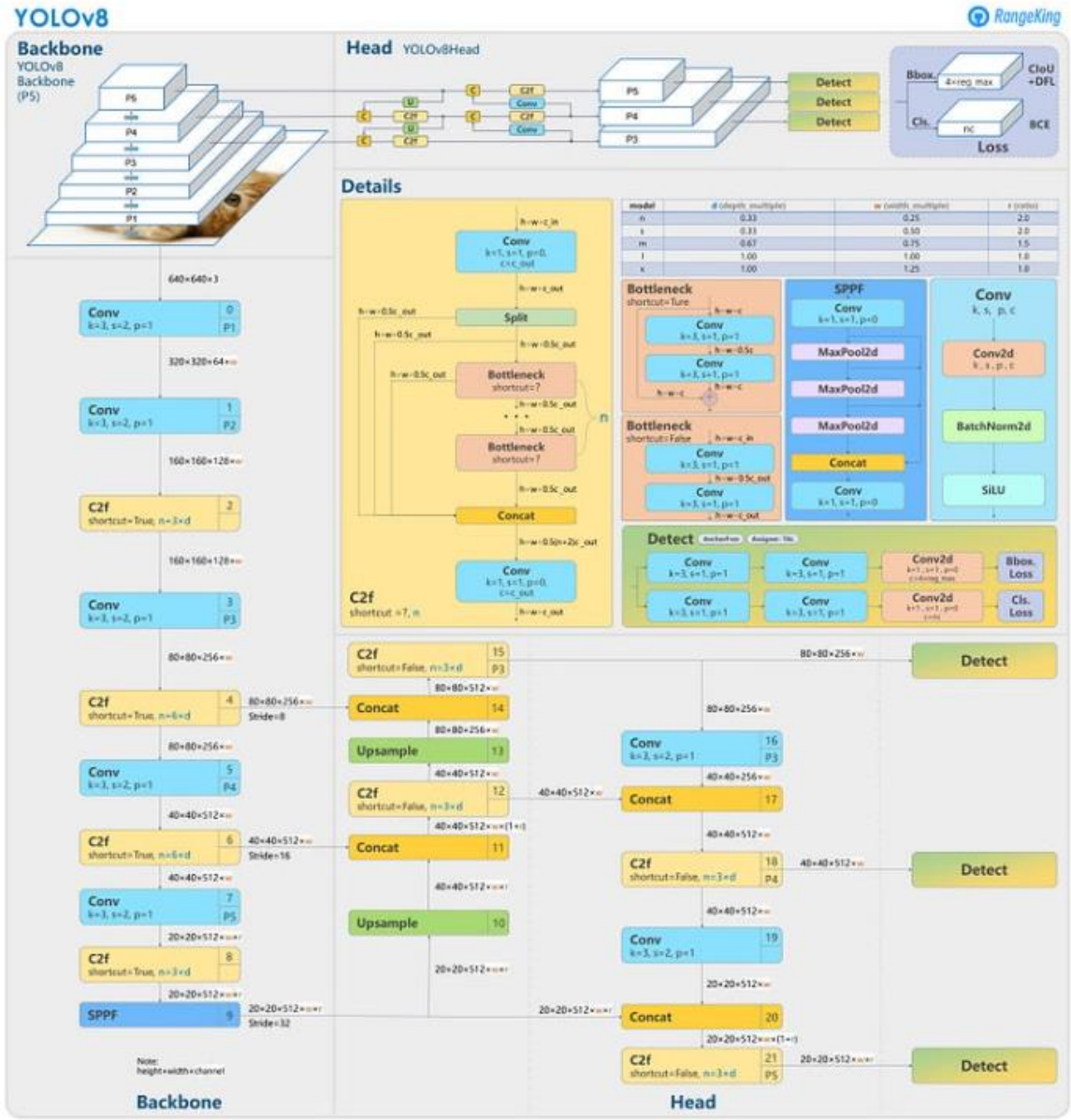
연결의 힘


[From recent Yann LeCun slides]
Low-Level Feature
Mid-Level Feature
High-Level Feature
Trainable Classifier
Feature visualization of convolutional net trained on ImageNet from [Zeiler & Fergus 2013]

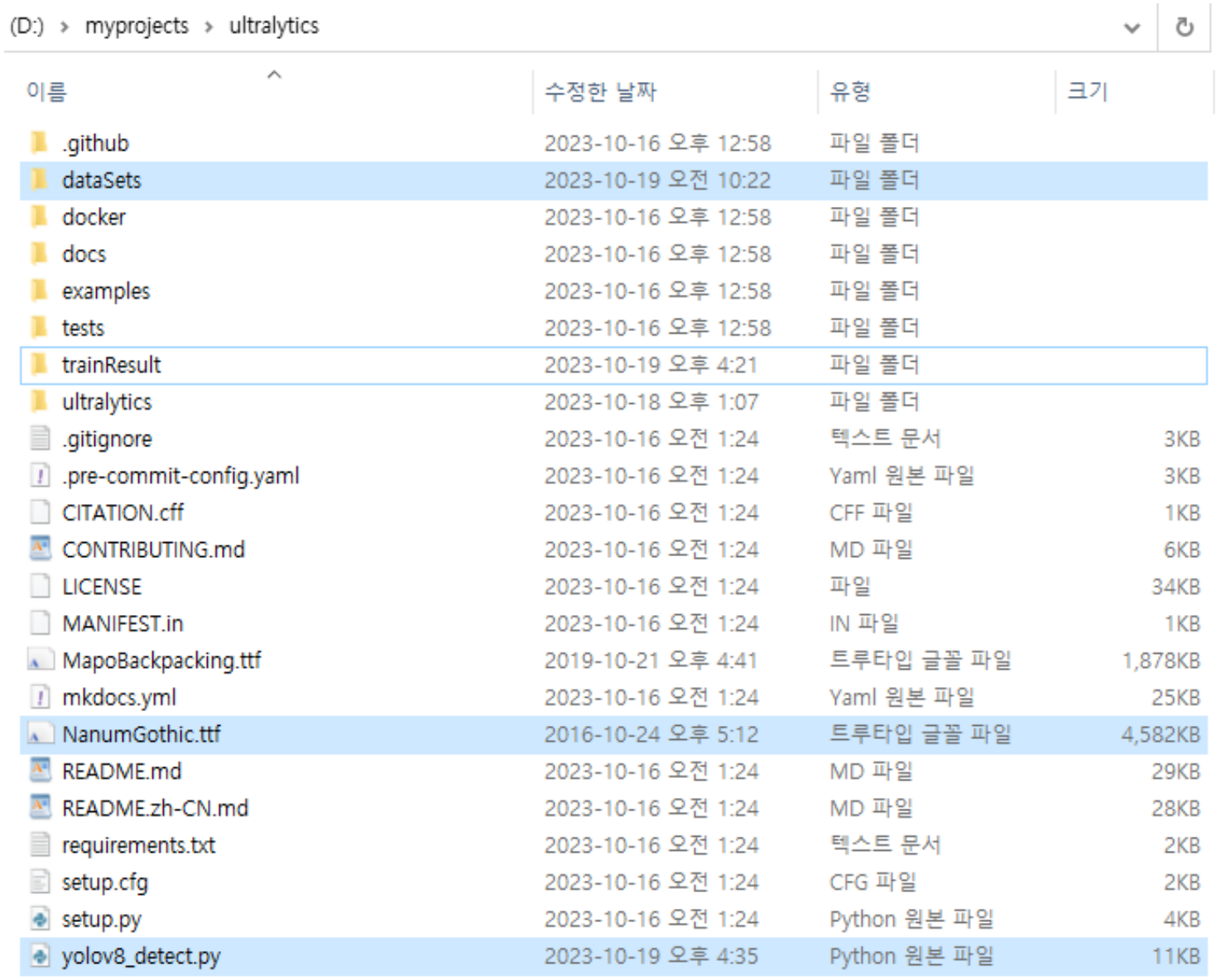
Part 2

YOLO8을 이용한 객체 인식

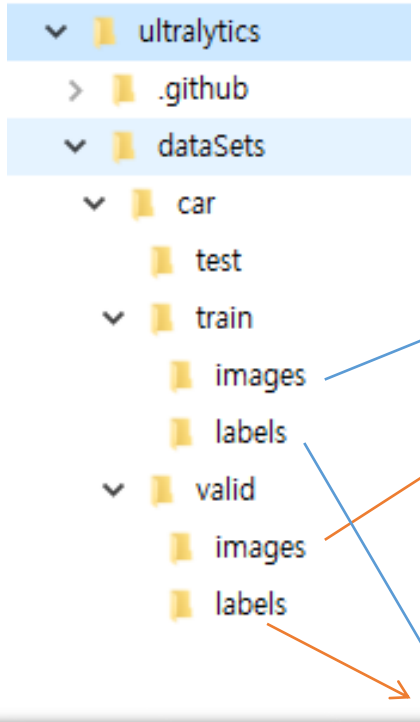
Yolov8 구조

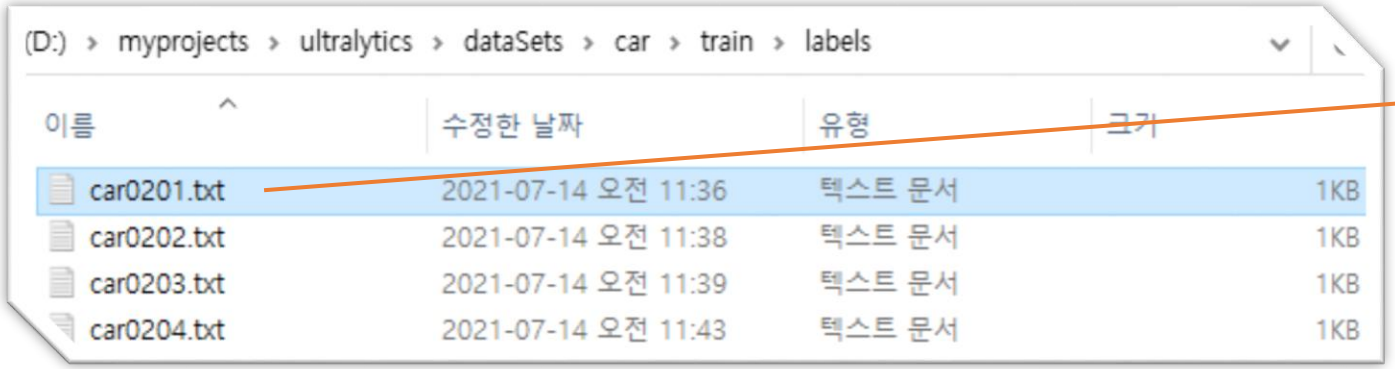

YOLOv8
RangeKing
Backbone
YOLOv8
Backbone
(P5)
Head
YOLOv8Head
Detect
Detect
Detect
Bbox.
4×reg_max
CIoU
+DFL
Cls.
nc
BCE
Loss
Details
Conv
Split
Bottleneck
shortcut=?
Bottleneck
shortcut=?
Concat
Conv
C2f
shortcut =?, n
Bottleneck
shortcut=Ture
Conv
Conv
Bottleneck
shortcut=False
Conv
Conv
SPPF
Conv
MaxPool2d
MaxPool2d
MaxPool2d
Concat
Conv
Conv
k, s, p, c
Conv2d
BatchNorm2d
SiLU
Detect
Conv
Conv
Conv2d
Bbox. Loss
Conv
Conv
Conv2d
Cls. Loss
640×640×3
Conv
0
P1
320×320×64
Conv
1
P2
160×160×128
C2f
2
160×160×128
Conv
3
P3
80×80×256
C2f
4
80×80×256
Stride=8
80×80×256
Conv
5
P4
40×40×512
C2f
6
40×40×512
Stride=16
40×40×512
Conv
7
P5
20×20×512
C2f
8
20×20×512
SPPF
9
20×20×512
Stride=32
Note:
height×width×channel
Backbone
C2f
15
P3
Detect
80×80×512
Concat
14
80×80×256
Upsample
13
40×40×512
C2f
12
40×40×512×(1+n)
Concat
11
40×40×512
Upsample
10
20×20×512
Conv
16
P3
40×40×256
Concat
17
40×40×512
C2f
18
P4
40×40×512
Detect
Conv
19
20×20×512
Concat
20
20×20×512×(1+n)
C2f
21
P5
20×20×512
Detect
Head

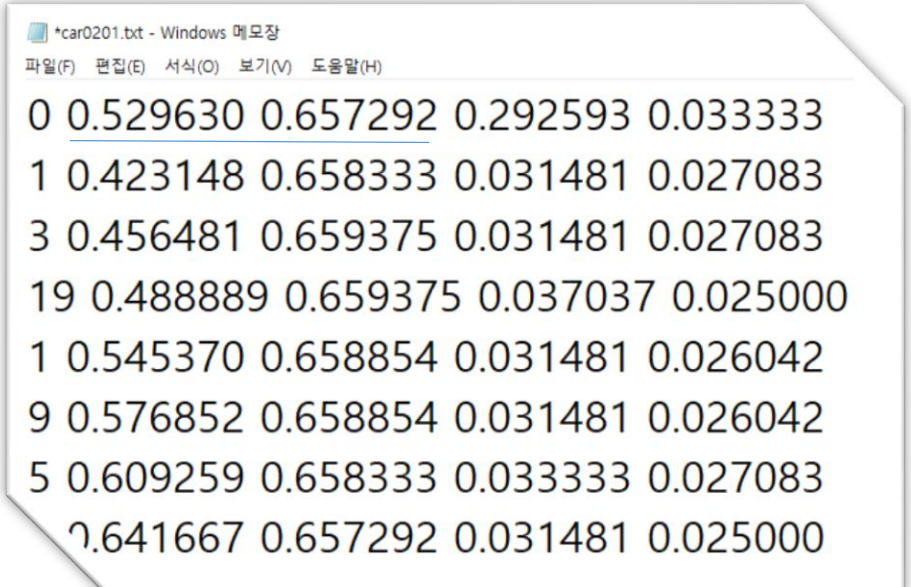
Ultralytics Yolov8 폴더 구조



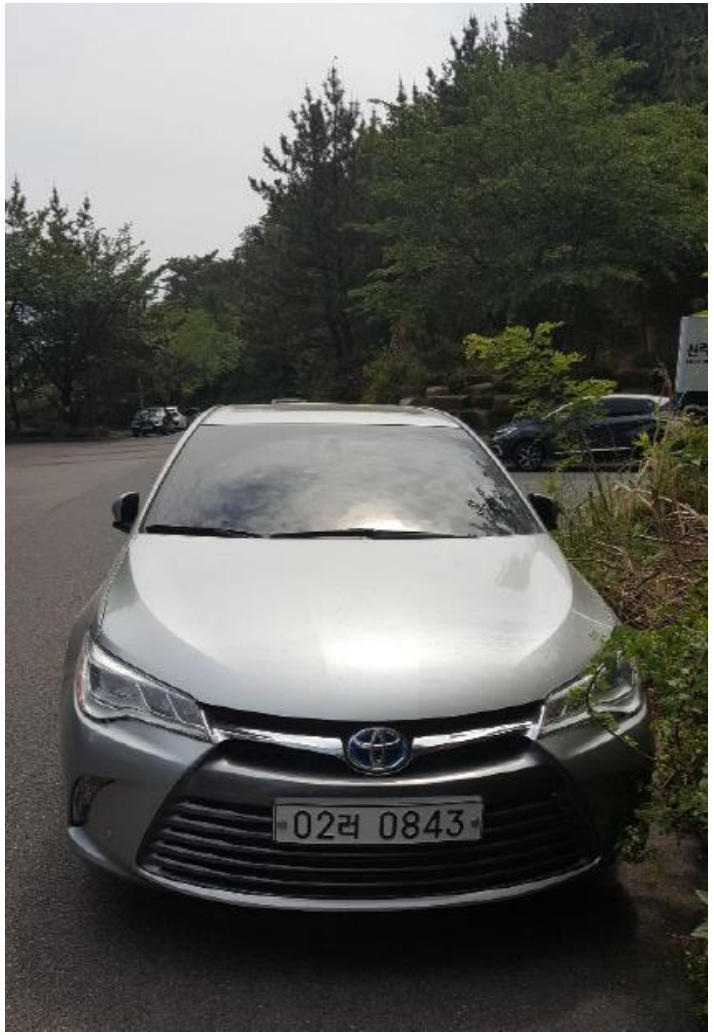
Ultralytics Yolov8 폴더 구조 - dataset







객체 라벨링



*car0201.txt - Windows 메모장

파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)

```
0 0.529630 0.657292 0.292593 0.033333
1 0.423148 0.658333 0.031481 0.027083
3 0.456481 0.659375 0.031481 0.027083
19 0.488889 0.659375 0.037037 0.025000
1 0.545370 0.658854 0.031481 0.026042
9 0.576852 0.658854 0.031481 0.026042
5 0.609259 0.658333 0.033333 0.027083
 0.641667 0.657292 0.031481 0.025000
```

학습의 시작 - 기본 YOLOv8m 모델의 구조

관리자: Anaconda Prompt (Anaconda30) - "D:₩program₩Anaconda30₩condabin₩conda.bat" activate yolov8_detect - "D:₩program₩Anaconda30₩condabin₩c

```
(yolov8_detect) D:₩myprojects₩ultralytics>python yolov8_detect.py  train  data-car.yaml  conf-car.yaml 100

                   from  n    params  module                                       arguments
  0                  -1  1      1392  ultralytics.nn.modules.conv.Conv             [3, 48, 3, 2]
  1                  -1  1     41664  ultralytics.nn.modules.conv.Conv             [48, 96, 3, 2]
  2                  -1  2    111360  ultralytics.nn.modules.block.C2f             [96, 96, 2, True]
  3                  -1  1    166272  ultralytics.nn.modules.conv.Conv             [96, 192, 3, 2]
  4                  -1  4    813312  ultralytics.nn.modules.block.C2f             [192, 192, 4, True]
  5                  -1  1    664320  ultralytics.nn.modules.conv.Conv             [192, 384, 3, 2]
  6                  -1  4   3248640  ultralytics.nn.modules.block.C2f             [384, 384, 4, True]
  7                  -1  1   1991808  ultralytics.nn.modules.conv.Conv             [384, 576, 3, 2]
  8                  -1  2   3985920  ultralytics.nn.modules.block.C2f             [576, 576, 2, True]
  9                  -1  1    831168  ultralytics.nn.modules.block.SPPF            [576, 576, 5]
 10                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 11             [-1, 6]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 12                  -1  2   1993728  ultralytics.nn.modules.block.C2f             [960, 384, 2]
 13                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 14             [-1, 4]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 15                  -1  2    517632  ultralytics.nn.modules.block.C2f             [576, 192, 2]
 16                  -1  1    332160  ultralytics.nn.modules.conv.Conv             [192, 192, 3, 2]
 17            [-1, 12]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 18                  -1  2   1846272  ultralytics.nn.modules.block.C2f             [576, 384, 2]
 19                  -1  1   1327872  ultralytics.nn.modules.conv.Conv             [384, 384, 3, 2]
 20             [-1, 9]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 21                  -1  2   4207104  ultralytics.nn.modules.block.C2f             [960, 576, 2]
 22        [15, 18, 21]  1   3822016  ultralytics.nn.modules.head.Detect           [80, [192, 384, 576]]
YOLOv8m summary: 295 layers, 25902640 parameters, 25902624 gradients, 79.3 GFLOPs
```

Custom 학습 모델의 구조 확인

```
New https://pypi.org/project/ultralytics/8.0.200 available  Update with 'pip install -U ultralytics'
Ultralytics YOLOv8.0.199  Python-3.10.13 torch-2.1.0 CPU (Intel Core(TM) i7-8700K 3.70GHz)
engine₩trainer: task=detect, mode=train, model=None, data=data-car.yaml, epochs=100, patience=20, batch=16, imgsz=640, save=True, save_period=-1, cache=
False, device=None, workers=8, project=trainResult, name=car, exist_ok=True, pretrained=True, optimizer=auto, verbose=False, seed=0, deterministic=True,
 single_cls=False, rect=False, cos_lr=False, close_mosaic=10, resume=False, amp=True, fraction=1.0, profile=False, freeze=None, overlap_mask=True, mask_
ratio=4, dropout=0.0, val=True, split=val, save_json=False, save_hybrid=False, conf=None, iou=0.5, max_det=300, half=False, dnn=False, plots=True, sourc
e=None, show=False, save_txt=False, save_conf=False, save_crop=False, show_labels=True, show_conf=True, vid_stride=1, stream_buffer=False, line_width=No
ne, visualize=True, augment=False, agnostic_nms=False, classes=None, retina_masks=False, boxes=True, format=torchscript, keras=False, optimize=False, in
t8=False, dynamic=False, simplify=False, opset=None, workspace=4, nms=False, lr0=0.01, lrf=0.01, momentum=0.937, weight_decay=0.0005, warmup_epochs=3.0,
 warmup_momentum=0.8, warmup_bias_lr=0.1, box=7.5, cls=0.5, dfl=1.5, pose=12.0, kobj=1.0, label_smoothing=0.0, nbs=64, hsv_h=0.1, hsv_s=0.7, hsv_v=0.4,
degrees=10.0, translate=0.1, scale=0.5, shear=0.0, perspective=0.0005, flipud=0.0, fliplr=0.0, mosaic=1.0, mixup=0.0, copy_paste=0.0, cfg=conf-car.yaml,
 tracker=botsort.yaml, save_dir=trainResult₩car
Overriding model.yaml nc=80 with nc=75

                   from  n    params  module                                       arguments
  0                  -1  1       928  ultralytics.nn.modules.conv.Conv             [3, 32, 3, 2]
  1                  -1  1     18560  ultralytics.nn.modules.conv.Conv             [32, 64, 3, 2]
  2                  -1  1     29056  ultralytics.nn.modules.block.C2f             [64, 64, 1, True]
  3                  -1  1     73984  ultralytics.nn.modules.conv.Conv             [64, 128, 3, 2]
  4                  -1  2    197632  ultralytics.nn.modules.block.C2f             [128, 128, 2, True]
  5                  -1  1    295424  ultralytics.nn.modules.conv.Conv             [128, 256, 3, 2]
  6                  -1  2    788480  ultralytics.nn.modules.block.C2f             [256, 256, 2, True]
  7                  -1  1   1180672  ultralytics.nn.modules.conv.Conv             [256, 512, 3, 2]
  8                  -1  1   1838080  ultralytics.nn.modules.block.C2f             [512, 512, 1, True]
  9                  -1  1    656896  ultralytics.nn.modules.block.SPPF            [512, 512, 5]
 10                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 11             [-1, 6]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 12                  -1  1    591360  ultralytics.nn.modules.block.C2f             [768, 256, 1]
 13                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 14             [-1, 4]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 15                  -1  1    148224  ultralytics.nn.modules.block.C2f             [384, 128, 1]
 16                  -1  1    147712  ultralytics.nn.modules.conv.Conv             [128, 128, 3, 2]
 17            [-1, 12]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 18                  -1  1    493056  ultralytics.nn.modules.block.C2f             [384, 256, 1]
 19                  -1  1    590336  ultralytics.nn.modules.conv.Conv             [256, 256, 3, 2]
 20             [-1, 9]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 21                  -1  1   1969152  ultralytics.nn.modules.block.C2f             [768, 512, 1]
 22        [15, 18, 21]  1   2145073  ultralytics.nn.modules.head.Detect           [75, [128, 256, 512]]
Model summary: 225 layers, 11164625 parameters, 11164609 gradients, 28.8 GFLOPs
```

학습과정 분석

```
Transferred 349/355 items from pretrained weights
Freezing layer 'model.22.dfl.conv.weight'
train: Scanning D:₩myprojects₩ultralytics₩datasets₩car₩train₩labels.cache... 227 images, 0 backgrounds, 0 corrupt: 100%|██████████| 227/227 [00:00<?, '
val: Scanning D:₩myprojects₩ultralytics₩datasets₩car₩valid₩labels.cache... 10 images, 0 backgrounds, 0 corrupt: 100%|██████████| 10/10 [00:00<?, ?it/s]
Plotting labels to trainResult₩car₩labels.jpg...
optimizer: 'optimizer=auto' found, ignoring 'lr0=0.01' and 'momentum=0.937' and determining best 'optimizer', 'lr0' and 'momentum' automatically...
optimizer: AdamW(lr=0.000127, momentum=0.9) with parameter groups 57 weight(decay=0.0), 64 weight(decay=0.0005), 63 bias(decay=0.0)
Image sizes 640 train, 640 val
Using 0 dataloader workers
Logging results to trainResult₩car
Starting training for 100 epochs...

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
      1/100         0G      2.197      8.459      1.499         29        640: 100%|██████████| 15/15 [03:18<00:00, 13.22s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.89s/it]
                   all         10         81     0.0136       0.03      0.012    0.00689

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
      2/100         0G          2      5.028      1.179         49        640: 100%|██████████| 15/15 [03:10<00:00, 12.69s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:03<00:00,  3.84s/it]
                   all         10         81      0.934      0.045     0.0573     0.0298

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
      3/100         0G      1.676      3.897      1.034         29        640: 100%|██████████| 15/15 [03:07<00:00, 12.49s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:03<00:00,  3.35s/it]
                   all         10         81      0.411      0.253      0.115     0.0602

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
      4/100         0G      1.518      2.924     0.9699         58        640: 100%|██████████| 15/15 [03:07<00:00, 12.47s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.66s/it]
                   all         10         81      0.389      0.401      0.187      0.109

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
      5/100         0G      1.382      2.566     0.9384         12        640: 100%|██████████| 15/15 [03:07<00:00, 12.50s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.65s/it]
                   all         10         81      0.484      0.279      0.191      0.104
```

학습과정 분석

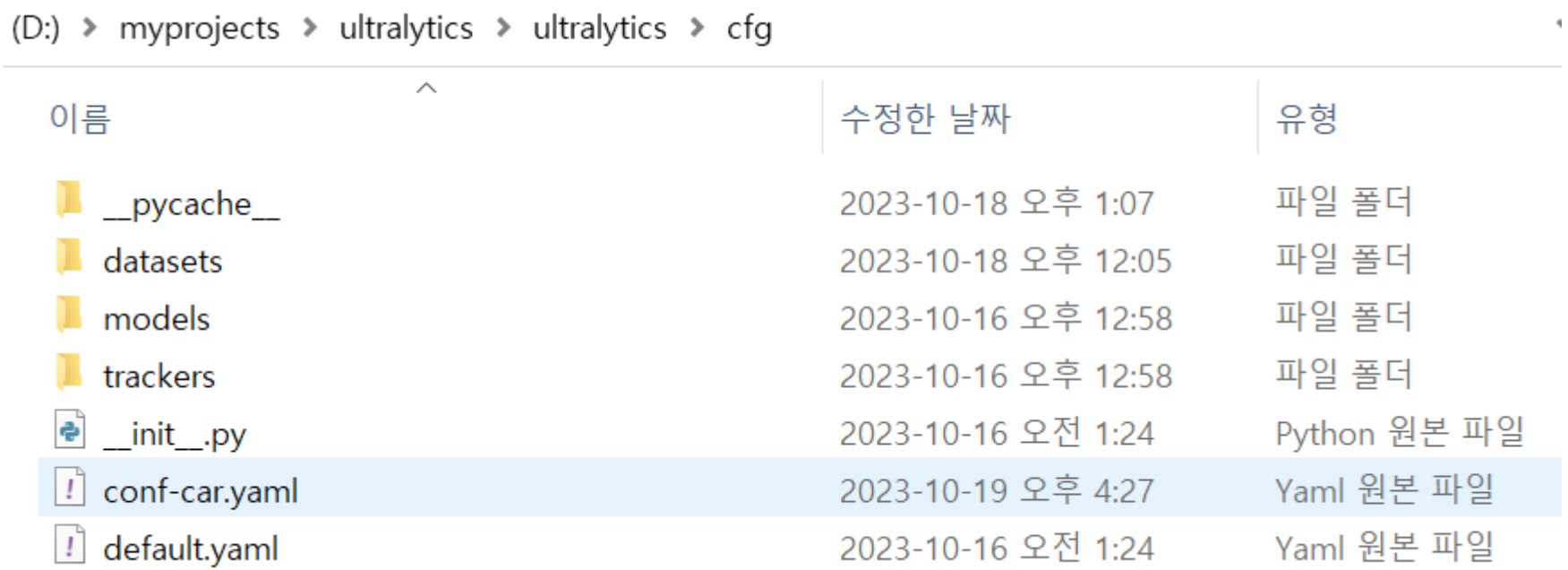
```
      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     1/100         0G      2.197      8.459      1.499         29        640: 100%|██████████| 15/15 [03:18<00:00, 13.22s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.89s/it]
                   all         10         81     0.0136       0.03      0.012    0.00689

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     2/100         0G          2      5.028      1.179         49        640: 100%|██████████| 15/15 [03:10<00:00, 12.69s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:03<00:00,  3.84s/it]
                   all         10         81      0.934      0.045     0.0573    0.0298

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     3/100         0G      1.676      3.897      1.034         29        640: 100%|██████████| 15/15 [03:07<00:00, 12.49s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:03<00:00,  3.35s/it]
                   all         10         81      0.411      0.253      0.115    0.0602

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     4/100         0G      1.518      2.924     0.9699         58        640: 100%|██████████| 15/15 [03:07<00:00, 12.47s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.66s/it]
                   all         10         81      0.389      0.401      0.187     0.109

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     5/100         0G      1.382      2.566     0.9384         12        640: 100%|██████████| 15/15 [03:07<00:00, 12.50s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.65s/it]
                   all         10         81      0.484      0.279      0.191     0.104

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     6/100         0G       1.29      2.195     0.9239         32        640: 100%|██████████| 15/15 [03:09<00:00, 12.66s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.49s/it]
                   all         10         81      0.527      0.333      0.242     0.151

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     7/100         0G      1.221      2.032     0.8917         44        640: 100%|██████████| 15/15 [03:10<00:00, 12.69s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.51s/it]
                   all         10         81      0.516      0.383      0.303     0.199

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     8/100         0G      1.164       1.93     0.9017         28        640: 100%|██████████| 15/15 [03:11<00:00, 12.75s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.60s/it]
                   all         10         81      0.609      0.365      0.396     0.269

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
     9/100         0G      1.186        1.8     0.8946         40        640: 100%|██████████| 15/15 [03:19<00:00, 13.29s/it]
                 Class     Images  Instances      Box(P          R      mAP50  mAP50-95): 100%|██████████| 1/1 [00:02<00:00,  2.48s/it]
                   all         10         81      0.665      0.444      0.449     0.307

      Epoch    GPU_mem   box_loss   cls_loss   dfl_loss  Instances       Size
    10/100         0G      1.174      1.727     0.8804        206        640:  33%|███       | 5/15 [01:06<02:13, 13.35s/it]
```

인식대상의 부류 라벨링

D: > myprojects > ultralytics > ultralytics > cfg > datasets > ! data-car.yaml

```yaml
# Train/val/test sets as 1) dir: path/to/imgs, 2) file: path/to/imgs.txt, or 3) list: [path/to/imgs1, path/to/imgs2, ..]
path: ../dataSets/car/  # dataset root dir
train: train/images  # train images (relative to 'path')
val: valid/images  # val images (relative to 'path')
test: test  # optional

# Classes
nc: 75

# label names
names: [
'plate', '0', '1', '2', '3', '4', '5', '6', '7', '8', '9',
'가', '나', '다', '라', '마', '거', '너', '더', '러', '머', '버', '서', '어', '저',
'고', '노', '도', '로', '모', '보', '소', '오', '조',
'구', '누', '두', '루', '무', '부', '수', '우', '주',
'바', '사', '아', '자', '기타', '허', '하', '호', '기타', '기타', '기타', '기타', '기타', '기타',
'합참', '육', '해', '공',
'강원', '전남', '전북', '충남', '충북', '서울', '부산', '대구', '인천', '광주', '경기', '제주', '경북', '경남' ]
```

연결과 학습: 오늘날 AI 성능의 이유



학습과 인식을 위한 환경 설정

D: > myprojects > ultralytics > ultralytics > cfg > ! conf-car.yaml

```yaml

task: detect  # (str) YOLO task, i.e. detect, segment, classify, pose
mode: train  # (str) YOLO mode, i.e. train, val, predict, export, track, benchmark

# Train settings -------------------------------------------------------------------------------------
project: trainResult # (str, optional) project name
name: car # (str, optional) experiment name, results saved to 'project/name' directory
exist_ok: True  # (bool) whether to overwrite existing experiment
patience: 20  # (int) epochs to wait for no observable improvement for early stopping of training
batch: 16  # (int) number of images per batch (-1 for AutoBatch)

epochs: 100  # (int) number of epochs to train for
imgsz: 640  # (int | list) input images size as int for train and val modes, or list[w,h] for predict and export modes

model:  # (str, optional) path to model file, i.e. yolov8n.pt, yolov8n.yaml
data:  # (str, optional) path to data file, i.e. coco128.yaml
save: True  # (bool) save train checkpoints and predict results
save_period: -1 # (int) Save checkpoint every x epochs (disabled if < 1)
cache: False  # (bool) True/ram, disk or False. Use cache for data loading
device:  # (int | str | list, optional) device to run on, i.e. cuda device=0 or device=0,1,2,3 or device=cpu
workers: 8  # (int) number of worker threads for data loading (per RANK if DDP)
pretrained: True  # (bool | str) whether to use a pretrained model (bool) or a model to load weights from (str)
optimizer: auto  # (str) optimizer to use, choices=[SGD, Adam, Adamax, AdamW, NAdam, RAdam, RMSProp, auto]
verbose: True  # (bool) whether to print verbose output
```

학습과 인식을 위한 환경설정(계속)

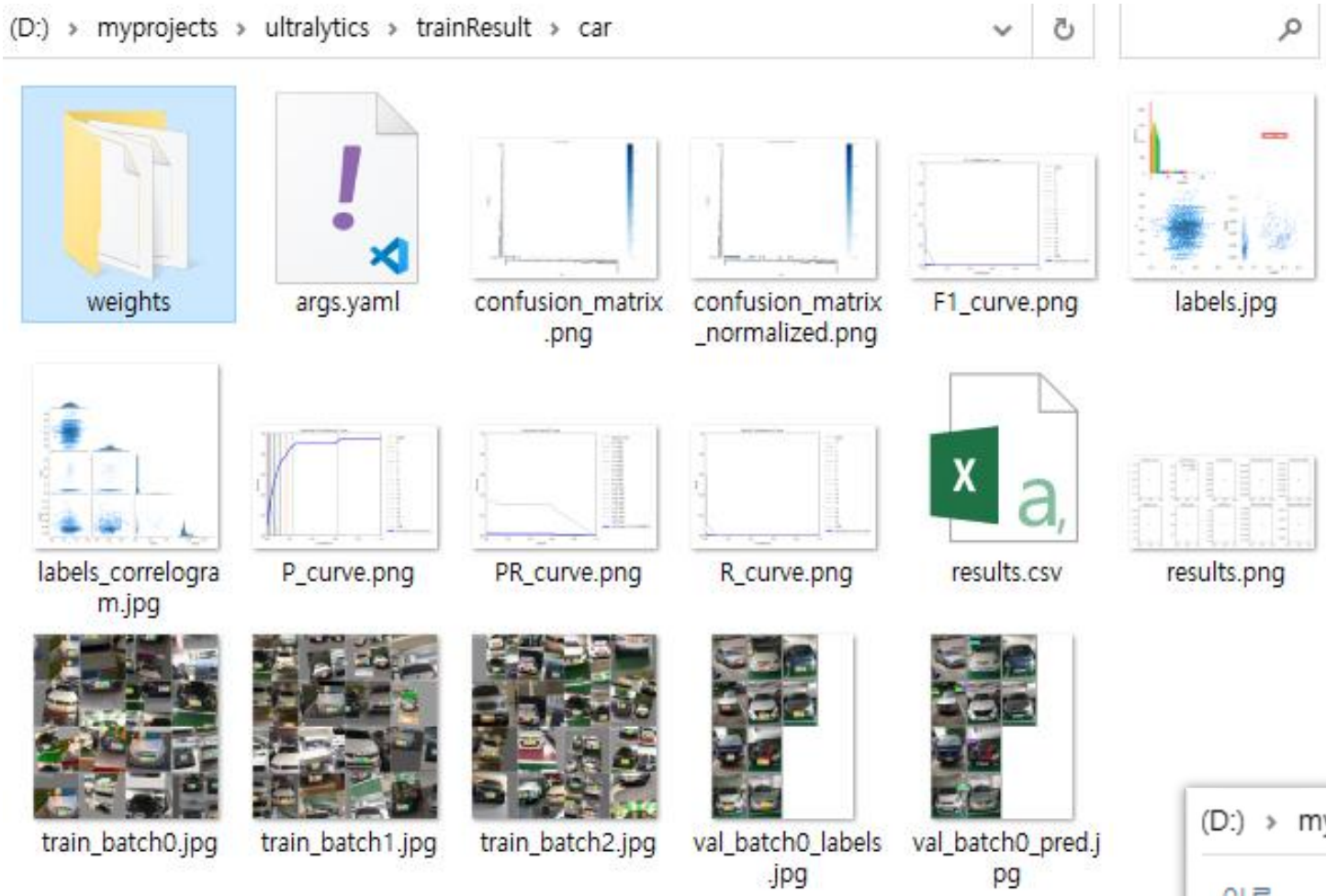
```
44  # Val/Test settings ----------------------------------------------------------------------
45  conf:  # (float, optional) object confidence threshold for detection (default 0.25 predict, 0.001
46  iou: 0.5 # 0.7  # (float) intersection over union (IoU) threshold for NMS
47  half: False  # (bool) use half precision (FP16)
```

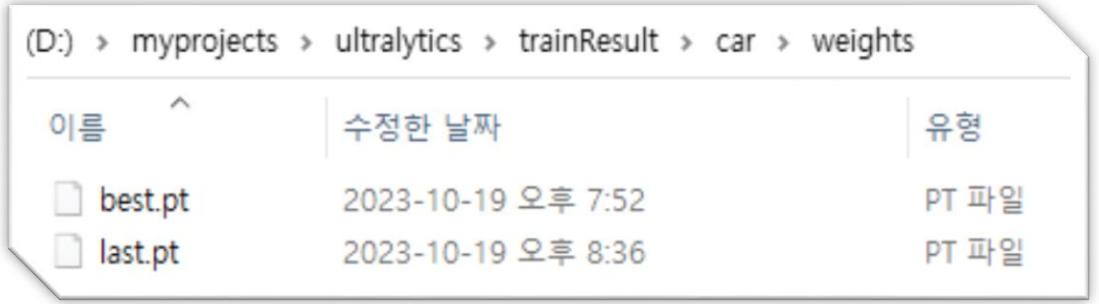
```
87  # Hyperparameters ------------------------------------------------------------------------
88  hsv_h: 0.1 #0.015  # (float) image HSV-Hue augmentation (fraction)
89  hsv_s: 0.7  # (float) image HSV-Saturation augmentation (fraction)
90  hsv_v: 0.4  # (float) image HSV-Value augmentation (fraction)
91  degrees: 10.0  # (float) image rotation (+/- deg)
92  translate: 0.1  # (float) image translation (+/- fraction)
93  scale: 0.5  # (float) image scale (+/- gain)
94  shear: 0.0  # (float) image shear (+/- deg)
95  perspective: 0.0005 #0.0  # (float) image perspective (+/- fraction), range 0-0.001
96  flipud: 0.0  # (float) image flip up-down (probability)
97  fliplr: 0.0  # (float) image flip left-right (probability)
98  mosaic: 1.0  # (float) image mosaic (probability)
99  mixup: 0.0  # (float) image mixup (probability)
100 copy_paste: 0.0  # (float) segment copy-paste (probability)
```

Prediction

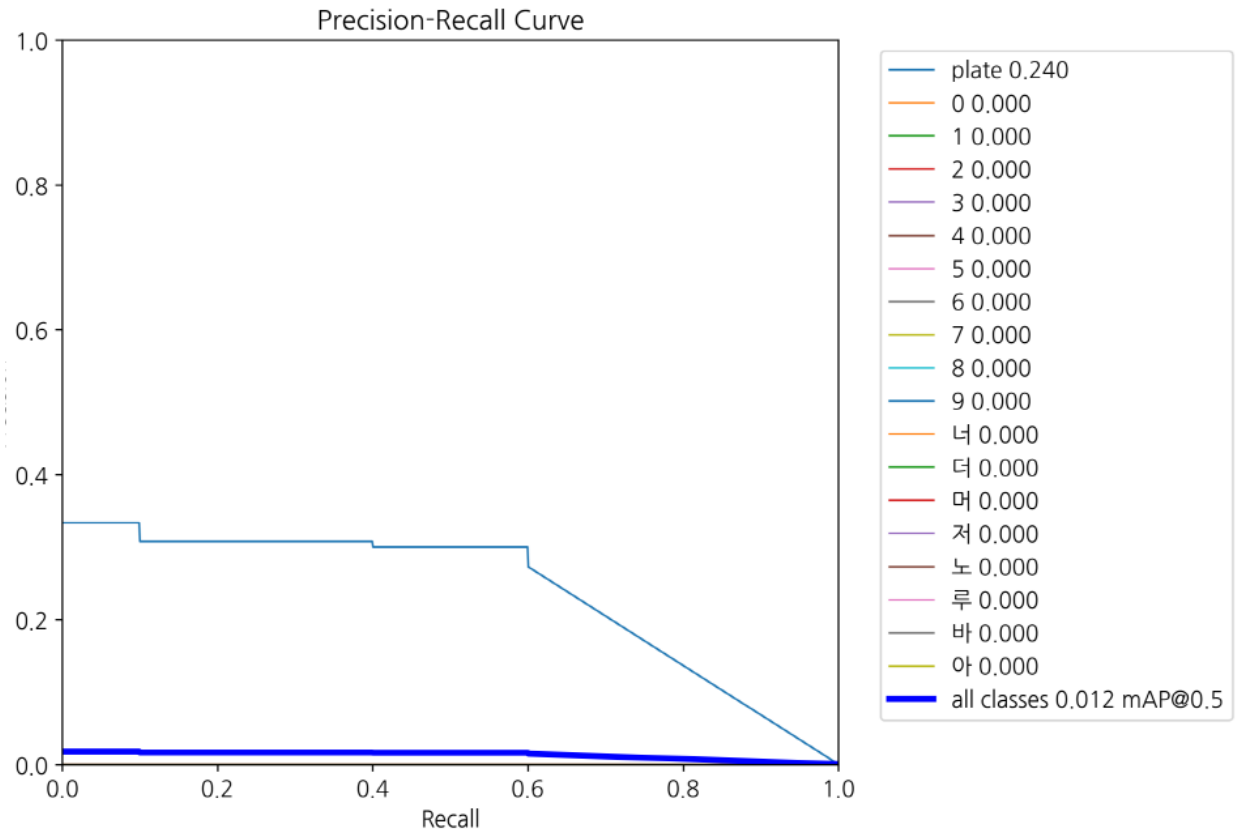
```
(yolov8_detect) D:₩myprojects₩ultralytics>python yolov8_detect.py  predict  trainResult/car/weights/best.pt  datasets/car/valid/images  auto  save
data_path:  D:₩myprojects₩ultralytics₩datasets/car/valid/images

                   from  n    params  module                                       arguments
  0                  -1  1      1392  ultralytics.nn.modules.conv.Conv             [3, 48, 3, 2]
  1                  -1  1     41664  ultralytics.nn.modules.conv.Conv             [48, 96, 3, 2]
  2                  -1  2    111360  ultralytics.nn.modules.block.C2f             [96, 96, 2, True]
  3                  -1  1    166272  ultralytics.nn.modules.conv.Conv             [96, 192, 3, 2]
  4                  -1  4    813312  ultralytics.nn.modules.block.C2f             [192, 192, 4, True]
  5                  -1  1    664320  ultralytics.nn.modules.conv.Conv             [192, 384, 3, 2]
  6                  -1  4   3248640  ultralytics.nn.modules.block.C2f             [384, 384, 4, True]
  7                  -1  1   1991808  ultralytics.nn.modules.conv.Conv             [384, 576, 3, 2]
  8                  -1  2   3985920  ultralytics.nn.modules.block.C2f             [576, 576, 2, True]
  9                  -1  1    831168  ultralytics.nn.modules.block.SPPF            [576, 576, 5]
 10                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 11             [-1, 6]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 12                  -1  2   1993728  ultralytics.nn.modules.block.C2f             [960, 384, 2]
 13                  -1  1         0  torch.nn.modules.upsampling.Upsample         [None, 2, 'nearest']
 14             [-1, 4]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 15                  -1  2    517632  ultralytics.nn.modules.block.C2f             [576, 192, 2]
 16                  -1  1    332160  ultralytics.nn.modules.conv.Conv             [192, 192, 3, 2]
 17            [-1, 12]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 18                  -1  2   1846272  ultralytics.nn.modules.block.C2f             [576, 384, 2]
 19                  -1  1   1327872  ultralytics.nn.modules.conv.Conv             [384, 384, 3, 2]
 20             [-1, 9]  1         0  ultralytics.nn.modules.conv.Concat           [1]
 21                  -1  2   4207104  ultralytics.nn.modules.block.C2f             [960, 576, 2]
 22        [15, 18, 21]  1   3822016  ultralytics.nn.modules.head.Detect           [80, [192, 384, 576]]
YOLOv8m summary: 295 layers, 25902640 parameters, 25902624 gradients, 79.3 GFLOPs

...... [19] of 20 predicted.
Recognized-images are saved at datasets/car/valid/images folder

 *** Prediction Ended(Stopped) !!! ***

(yolov8_detect) D:₩myprojects₩ultralytics>
```

학습과정 및 결과 저장, 확인





학습과정 및 결과 저장,확인(계속)



인식결과 저장

(D:) › myprojects › ultralytics › dataSets › car › valid › images

이름	날짜	유형
car1811.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1812.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1813.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1814.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1815.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1816.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1817.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1818.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1819.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1820.jpg	2021-06-25 오후 8:03	알씨 JPG 파일
car1811_result.png	2023-10-19 오후 10:10	알씨 PNG 파일

YOLOV8을 이용한 번호판 인식 데모