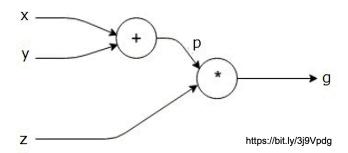
Intro

	Keras K	TensorFlow	PyTorch C
Level of API	high-level API ¹	Both high & low level APIs	Lower-level API ²
Speed	Slow	High	High
Architecture	Simple, more readable and concise	Not very easy to use	Complex ³
Debugging	No need to debug	Difficult to debugging	Good debugging capabilities
Dataset Compatibility	Slow & Small	Fast speed & large	Fast speed & large datasets
Popularity Rank	1	2	3
Uniqueness	Multiple back-end support	Object Detection Functionality	Flexibility & Short Training Duration
Created By	Not a library on its own	Created by Google	Created by Facebook ⁴
Ease of use	User-friendly	Incomprehensive API	Integrated with Python language
Computational graphs used	Static graphs	Static graphs	Dynamic computation graphs ⁵

• Computational Graph

$$g = (x + y) * z$$



o Define and Run - TensorFlow

그래프 먼저 정의 => 실행시점에 데이터 feed

o Define by Run (Dynamic Computational Graph, DCG) - PyTorch

실행을 하면서 그래프를 생성하는 방식

TensorFlow: Build graph once, then run many times (static)

```
N, D, H = 64, 1000, 100
x = tf.placeholder(tf.float32, shape=(N, D))
y = tf.placeholder(tf.float32, shape=(N, D))
wl = tf.Variable(tf.random_normal((D, H)))
w2 = tf.Variable(tf.random_normal((H, D)))
h = tf.maximum(tf.matmul(x, w1), 0)
y_pred = tf.matmul(h, w2)
diff = y_pred - y
loss = tf.reduce_mean(tf.reduce_sum(diff ** 2, axis=1))
grad_w1, grad_w2 = tf.gradients(loss, [w1, w2])
learning_rate = 1e-5
new_w1 = w1.assign(w1 - learning_rate * grad_w1)
new_w2 = w2.assign(w2 - learning_rate * grad_w2)
updates = tf.group(new_w1, new_w2)
with tf.Session() as sess:
     sess.run(tf.global_variables_initializer())
     values = {x: np.random.randn(N, D),
                 y: np.random.randn(N, D),}
     losses = []
     for t in range(50):
          loss_val, _ = sess.run([loss, updates],
                                       feed_dict=values)
```

N, D_in, H, D_out = 64, 1000, 100, 10

Build

graph

Run each

iteration

a new graph (dynamic)

```
import torch
from torch.autograd import Variable
x = Variable(torch.randn(N, D_in), requires_grad=False)
y = Variable(torch.randn(N, D_out), requires_grad=False)
w1 = Variable(torch.randn(D_in, H), requires_grad=True)
w2 = Variable(torch.randn(H, D_out), requires_grad=True)
for t in range(500):
    y_pred = x.mm(w1).clamp(min=0).mm(w2)
    loss = (y_pred - y).pow(2).sum()
    if w1.grad: w1.grad.data.zero_()
    if w2.grad: w2.grad.data.zero_()
    loss.backward()
    w1.data -= learning_rate * w1.grad.data
w2.data -= learning_rate * w2.grad.data
           New graph each iteration
```

PyTorch: Each forward pass defines

Degine by Run 장점

즉시 확인 가능 => pythonic code

사용 편함

GPU 잘 지원, good API and community

- TensorFlow: production, scalability 장점
- PyTorch: Numpy + AutoGrad + Function

Numpy 구조를 가지는 Tensor 객체로 array 표현

자동미분 지원, DL 연산 지원

다양한 형태의 DL 지원하는 함수와 모델 지원