```
%tensorflow_version 1.x
import tensorflow
print(tensorflow.__version__)
```

```
TensorFlow 1.x selected.
1.15.2
```

모듈 임포팅

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

import tensorflow as tf
from tensorflow import keras

import time


from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense
```

디바이스

더블클릭 또는 Enter 키를 눌러 수정

리스트 보기

```
from tensorflow.python.client import device_lib
print(tf.test.gpu_device_name())
```

```
/device:GPU:0
```

더블클릭 또는 Enter 키를 눌러 수정

NVIDIA GPU 상태 보기

```
!nvidia-smi
```

```
Thu Oct 17 11:08:16 2019
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 430.40       Driver Version: 418.67       CUDA Version: 10.1     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|===============================+======================+======================|
|   0  Tesla K80           Off  | 00000000:00:04.0 Off |                    0 |
| N/A   33C    P0    57W / 149W |     69MiB / 11441MiB |      0%      Default |
+-------------------------------+----------------------+----------------------+

+-----------------------------------------------------------------------------+
| Processes:                                                       GPU Memory |
|  GPU       PID   Type   Process name                             Usage      |
|=============================================================================|
+-----------------------------------------------------------------------------+
```

Keras DNN 최소 코드

데이터 준비

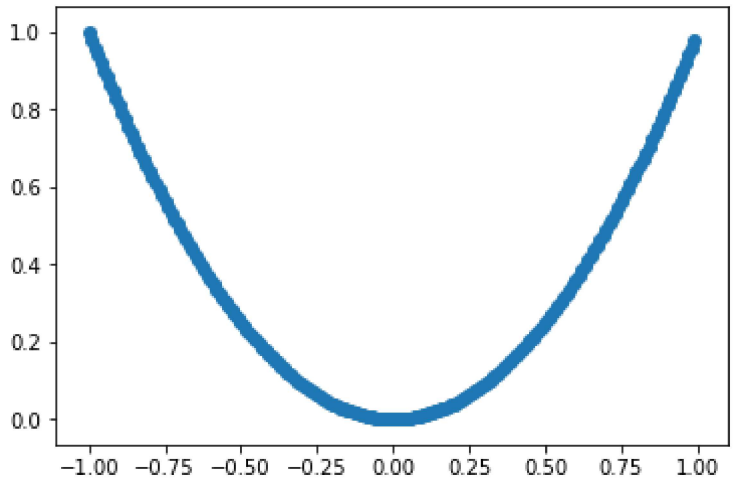
1차원 데이터 x와 x**2의 1차원 데이타 y

```
import numpy as np

x = np.arange(-1,1,0.01)
y = x**2

plt.scatter(x,y)
```

```
<matplotlib.collections.PathCollection at 0x7efc5007fb00>
```




```
print(x[:10])
print(y[:10])


print(len(x))
print(x.shape)
```

200
(200,)

최소 코드

아래의 코드는 최소 코드.

```
import numpy as np
import matplotlib.pyplot as plt

from tensorflow import keras
from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense, Input

import time


# 모델 정의
model = keras.Sequential()
model.add(Input(1))
model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


# 컴파일 : 모델 + optimizer + loss
model.compile(optimizer="SGD", loss="mse")


# 학습
model.fit(x, y, epochs=1000, verbose=0, batch_size=20)


# 예측
y_ = model.predict(x)


# 결과 그래프로 보기
plt.scatter(x,y) # 정답
plt.scatter(x,y_,color='r') # 결과
plt.show()
```

Keras DNN 최소 코드에 기본 정도만 추가

최소는 아니고, 이정도는 매번 사용하는 코드

model.evaluate() - 성능 평가하기

```
from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense


model = keras.Sequential()
#model.add(Input(1))
model.add(Dense(10, activation='tanh', input_shape=(1,) ))
model.add(Dense(10, activation='tanh' ))
model.add(Dense(1))


#model.compile(optimizer="SGD", loss="mse")
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])


model.fit(x, y, epochs=1000, verbose=0, batch_size=20)

loss, mse = model.evaluate(x, y) # ADD
print("loss=",loss) # ADD
print("mse=",mse) # ADD


y_ = model.predict(x)


plt.scatter(x,y)
plt.scatter(x,y_,color='r')
plt.show()
```

```
200/200 [==============================] - 0s 203us/sample - loss: 6.3815e-04 - mean_squared_
loss= 0.0006381518929265439
mse= 0.0006381519
```

출력에 loss와 mse가 추가되었다.

테스트셋으로 평가하기

데이터를 train과 test으로 나누어 준비한다.

```
x = np.arange(-1,1,0.01)
np.random.shuffle(x)
y = x**2

split_index = int(x.shape[0]*0.6)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]

plt.scatter(train_x,train_y)
plt.scatter(test_x,test_y)
plt.show()
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])


# model.fit(x, y, epochs=1000, verbose=0, batch_size=20)
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
```

```
# loss, mse = model.evaluate(x, y)
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


# y_ = model.predict(x)
y_ = model.predict(test_x)

# plt.scatter(x,y)
plt.scatter(test_x,test_y)
# plt.scatter(x,y_,color='r')
plt.scatter(test_x,y_,color='r')
plt.show()
```

train_x, train_y로 학습하였고, evaluate()와 predict()에는 test_x, test_y를 사용하였다.

그려진 그림을 보면 test_x의 점사이에 빈 간격이 보인다. 그 간격이 train_x에 해당한다.

Base Model 결과 저장

이후 비교를 위해 그래프를 저장해 둔다.

```
plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.savefig("base_result.png")

from IPython.display import Image
display(Image("base_result.png"))
```

학습 시간을 출력

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])

start_time = time.time() # ADD
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time)) # ADD


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

elapsed로 경과된 시간이 초 단위로 보인다.

model.summary() 네트웍 모양 보기

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary() # ADD

start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

네트웤의 모양이 보인다.

노드 10개, 10개를 갖는 은닉층 2개가 있다.

모든 레이어는 activation(w*x+b) 의 형태로,

첫 번 째 은닉층은 20개(= ((1+1)*10) = (입력수+1)*10)의 웨이트를,

두 번 째 은닉층은 110개(= ((10+1)*10))의 웨이트가 있다..

Keras DNN Template

본 실습에 사용되는 코든 코드의 템플릿.

```
import numpy as np
import matplotlib.pyplot as plt

from tensorflow import keras
from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense

import time


# 모델 정의
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


# 모델 컴파일
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


# 학습
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
# 평가
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


# 예측
y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

layer 수

히든 레이어를 1개 만

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)
```

```
# base 모델의 결과
display(Image("base_result.png")) # ADD

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

히든레이어 없을 때

```
from tensorflow.keras.layers import Input

model = keras.Sequential()
model.add(Input((1,)))
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


# base 모델의 결과
display(Image("base_result.png")) # ADD

y_ = model.predict(test_x)
```

```
plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

히든 레이어가 없을 경우 학습되지 않는다.

히든 레이어를 3개로

```
model = keras.Sequential()
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


display(Image("base_result.png"))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

3개로 증가해도 별 차이 없다.

히든 레이어를 5개로

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


display(Image("base_result.png"))

y_ = model.predict(test_x)
```

```
plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

5개로 증가했을 때 살짝 좋은 듯 하다.

히든 레이어를 10개로

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(10, activation='tanh')) # ADD
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


display(Image("base_result.png"))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

10개로 했을 때 좋아진 차이가 보인다.

node 수

node 수를 작게

```
model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(5, activation='tanh', input_shape=(1,)))
model.add(Dense(5, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


display(Image("base_result.png"))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

5개 노드의 경우 살짝 차이가 난다.

노드 수를 아주 작게

```
model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(2, activation='tanh', input_shape=(1,)))
model.add(Dense(2, activation='tanh'))
model.add(Dense(1))
```

```
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()
```

```
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)
```

```
display(Image("base_result.png"))
```

```
y_ = model.predict(test_x)
```

```
plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

2개의 경우 차이가 커 보인다.

노드 수가 1개

```
model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(1, activation='tanh', input_shape=(1,)))
model.add(Dense(1, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


display(Image("base_result.png"))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

1개의 경우 거의 학습이 되지 않는다.

학습 추가 진행

모델은 그대로 두고 데이터만 sin 데이터로 변경한다.

```
def get_sin_data(start=0, end=10, step=0.1):
  x = np.arange(start,end,step)
  np.random.shuffle(x)
  y = np.sin(x)

  split_index = int(x.shape[0]*0.6)

  train_x, test_x = x[:split_index], x[split_index:]
  train_y, test_y = y[:split_index], y[split_index:]

  return (train_x, train_y), (test_x, test_y)


(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

plt.scatter(train_x,train_y)
plt.show()
```

```
plt.scatter(test_x,test_y,color="r")
plt.show()
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))
```

```
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()
```

```
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)
```

```
y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
```

```
plt.show()
```

학습이 충분히 되지 않은 듯 하다.

추가 학습

```
def fit_one_more(model, train_x, train_y, test_x, test_y, batch_size=20):

  start_time = time.time()
  model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=batch_size)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()

def fit_n_times(model, train_x, train_y, test_x, test_y, n):
```

```
  for i in range(n):
    print("{} times fitting".format(i))
    fit_one_more(model, train_x, train_y, test_x, test_y)


fit_n_times(model, train_x, train_y, test_x, test_y, 10)
```

학습이 더 진행되면서 거의 완벽하게 학습된 것을 볼 수 있다.

model.fit()의 batch_size

batch_size는 GPU와 관련된 옵션이다.

한번에 GPU에 보내는 데이터의 수이다.

batch_size가 1일 경우 1개를 보내고, 1개의 결과를 받고, 1번 웨이트를 업데이트 한다.

batch_size가 10일 경우 10개를 보내고, 10개의 결과를 한 번에 받고, 1번 웨이트를 업데이트 한다.

GPU는 보통 수천개의 코어를 가지고 있다. 동시에 꽤 많은 연산을 처리할 수 있다. 그런데 데이터가 적으면 대부분은 사용하지 못하고 일부만 연산에 사용된다.

복수의 데이터를 한번에 보내어 한번에 연산을 할수 있고, 그 결과를 반환할 수 있다. 이런 방법으로 연산 시간을 줄일 수 있다.

하지만, 복수의 데이터를 한번에 보내는 경우 한번에 보낸 결과가 한번에 오고 1번 업데이트 되면서 업데이트 되는 사항이 뭉개지는 단점이 있다.

```
def build_model():

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))

  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])

  return model

def fit_with_batch_sizes(train_x, train_y, test_x, test_y, batch_sizes):

  for batch_size in batch_sizes:
    model = build_model()
    print("batch_size={}".format(batch_size))
    fit_one_more(model, train_x, train_y, test_x, test_y, batch_size)


(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)
```

batch_size 적용 : [1,2,5,10,20,50,100,200,500]

```
fit_with_batch_sizes(train_x, train_y, test_x, test_y, batch_sizes=[1,2,5,10,20,50,100,200,500])
```

맨 앞의 결과가 batch_size 1인 경우이다. 100개의 데이터를 매번 1개 씩 보냈고, 매번 업데이트 했다.

batch_size를 키우면, 시간은 줄어들지만 학습이 빠르게 진행되지 않는다.

학습 진행된 내역 보기

model.fit()의 반환값 history

반환된 history의 loss로 진행 상황을 확인.

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
# model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
plt.plot(history.history['loss'])
```

model.fit() verbose

- 0 : X
- 1: progress bar
- 2 : 1 line per epoch

```
# (train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.01)
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.0001)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

print(train_x.shape)

start_time = time.time()
# history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=5, verbose=1, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

학습 시에 validation

model.fit()의 validation_data

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
# history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=1000, verbose=1, batch_size=20, validation_data=(test_
print("elapsed : {}".format(time.time() - start_time))
```

```
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['val_loss'], label='val_loss')
plt.legend()
```

model.fit()의 validation_split

따로 validation 데이터를 주지 않고, test 데이터로 준 것의 일부를 validation에 사용.

validation에 사용된 데이터는 학습에 사용되지 않는다.

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
# history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20, validation_split=0.1)
print("elapsed : {}".format(time.time() - start_time))
```

```
plt.plot(history.history['loss'], label='loss')
plt.plot(history.history['val_loss'], label='val_loss')
plt.legend()
```

데이터 크기와 epoch 수

```
# (train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.01)
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.0001)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start_time = time.time()
# history = model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=5, verbose=2, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
y_ = model.predict(test_x)
```

```
plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

train_x의 데이터 수가 6000개. epoch는 5. 총 30,000번 업데이트 되었다.

epoch가 적어도 데이터 수가 많으면 학습 잘된다.

model.fit()의 shuffle - 학습 시의 데이터 섞기

학습 시에 데이터를 섞어 주지 않으면 특정 데이터 순서로 학습이 일어나 편향이 생길 수있다.

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.01)
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))
```

```
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start_time = time.time()
history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start_time = time.time()
# history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20, shuffle=True)
print("elapsed : {}".format(time.time() - start_time))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

학습된 결과가 살짝 향상된 것을 볼 수 있다.

편향을 방지하기 위해서라도 항상 shuffle하는 것이 좋다.

데이터 준비

Shuffle

```
x = np.arange(0,10,0.1)
# np.random.shuffle(x) # COMMENTED
y = np.sin(x)

split_index = int(x.shape[0]*0.6)
print(split_index)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]

plt.scatter(train_x, train_y)
plt.scatter(test_x, test_y, color="r")
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start_time = time.time()
history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))

y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

train 데이터와 test 데이터가 서로 떨어져 있다.

train 영역의 데이터로 학습된 모델은 test 영역의 데이터에 적용하지 못한다.

전체데이터를 잘 섞어 주고, 이를 train, test로 나누어야 한다.

```
x = np.arange(0,10,0.1)
np.random.shuffle(x) # UNCOMMENT
y = np.sin(x)

split_index = int(x.shape[0]*0.6)
print(split_index)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]

plt.scatter(train_x, train_y)
plt.scatter(test_x, test_y, color="r")
```

Normalization/Standardization

입력이 여러 차원일 때 각 차원의 입력을 동일한 스케일로 맞추어주면, 학습이 빠르게 진행된다고 한다.

- Normalization : 전체 데이터를 0~1로 변환해준다.
- Standardization : 평균을 0, 표준편차를 1이되도록 변환해 준다.

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=-10, end=10, step=0.1)

print("min=",np.min(train_x))
print("max=",np.max(train_x))
```

```
plt.scatter(train_x, train_y)
plt.scatter(test_x, test_y, color="r")
```

```
min = -10 # ADDED
max = 10 # ADDED

train_x = (train_x-min)/(max-min) # ADDED
test_x = (test_x-min)/(max-min) # ADDED

print("min=",np.min(train_x))
print("max=",np.max(train_x))

plt.scatter(train_x, train_y)
plt.scatter(test_x, test_y, color="r")
```

```
model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))
```

```
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()
```

```
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)
```

```
y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

모델 저장과 로딩

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

모델 저장

```
model.save('my_model.h5')

!ls -al
```

모델 로딩

```
new_model = keras.models.load_model('my_model.h5')

y_ = new_model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

TensorFlow 포멧의 저장과 로딩

```
keras.experimental.export_saved_model(model, 'model_path')

!ls -al
!ls -al model_path

new_model = keras.experimental.load_from_saved_model('model_path')


y_ = new_model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

GPU 사용

따로 명시하지 않아도 default로 GPU를 사용한다.

명시적으로 설정할 수도 있다.

디바이스 리스트 보기

```
from tensorflow.python.client import device_lib
print(tf.test.gpu_device_name())
```

디바이스 설정

다음의 디바이스 이름이 가능

- /device:GPU:0
- /GPU:0
- /gpu:0
- /gpu
- /cpu:0
- /cpu

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.01)
```

```
with tf.device('/device:GPU:0'): # ADDED

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device('/device:GPU:0'):
with tf.device('/GPU:0'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device('/device:GPU:0'):
with tf.device('/gpu:0'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device('/GPU:0'):
with tf.device('/gpu:0'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device('/GPU:0'):
with tf.device('/gpu'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device('/GPU:0'):
with tf.device('/CPU:0'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

```
# with tf.device( /GPU:0 ):
with tf.device('/CPU'):

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()

  start_time = time.time()
  history = model.fit(train_x, train_y, epochs=50, verbose=0, batch_size=20)
  print("elapsed : {}".format(time.time() - start_time))

  y_ = model.predict(test_x)

  plt.scatter(test_x,test_y)
  plt.scatter(test_x,y_,color='r')
  plt.show()
```

Overfitting 처리

- DropOut

- BatchNormalization
- Regularization

DropOut 레이어

```
from tensorflow.keras.layers import Dropout


(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dropout(0.1)) # ADDED
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

BatchNormalization 레이어

```
from tensorflow.keras.layers import BatchNormalization


(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(BatchNormalization()) # ADDED
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

Regularization

Dense() 생성시에 kernel_regularization, bias_regularization으로 설정한다.

- l1()
- l1_l2()
- l2()

```
from tensorflow.keras.regularizers import l1, l2

(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh', input_shape=(1,), kernel_regularizer=l2(0.001)))
model.add(Dense(10, activation='tanh', kernel_regularizer=l2(0.001)))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
```

```
model.summary()
```

```
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))
```

```
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)
```

```
y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

웨이트 초기값

Dense() 생성시에 kernel_initializer, bias_initializer로 설정한다.

- 'he_normal'
- 'lecun_normal'

```
(train_x, train_y), (test_x, test_y) = get_sin_data(start=0, end=10, step=0.1)

model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
# model.add(Dense(10, activation='tanh'))
model.add(Dense(10, activation='tanh', input_shape=(1,), kernel_initializer='he_normal'))
model.add(Dense(10, activation='tanh', kernel_initializer='he_normal'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x,test_y)
plt.scatter(test_x,y_,color='r')
plt.show()
```

노이즈

```
def train_sin_with_noise(noise_size):

  # x = np.arange(0,10,0.1)
  x = np.arange(0,10,0.001)
  np.random.shuffle(x)
  y = np.sin(x)

  noiseless_y = np.copy(y) # ADD
  y = y + np.random.rand(y.shape[0])*noise_size - noise_size/2.0 # ADD

  split_index = int(x.shape[0]*0.6)

  train_x, test_x = x[:split_index], x[split_index:]
  train_y, test_y = y[:split_index], y[split_index:]
  test_noiseless_y = noiseless_y[split_index:] # ADD

  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
  model.summary()


  start_time = time.time()
  model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=100)
  print("elapsed : {}".format(time.time() - start_time))
```

```
loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

# plt.scatter(test_x,test_y)
plt.scatter(test_x,test_y, s=1)
plt.scatter(test_x,y_, s=1)
plt.show()
```

노이즈 없을 때

```
train_sin_with_noise(0.0)
```

노이즈 크기 0.1

```
train_sin_with_noise(0.1)
```

노이즈 크기 0.5

```
train_sin_with_noise(0.5)
```

노이즈 크기 1.0

train_sin_with_noise(1.0)

노이즈 크기 10.0

```
train_sin_with_noise(10.0)
```

노이즈 피쳐

노이즈 입력을 하나 더 준다.

```
x = np.arange(0,10,1.0)
np.random.shuffle(x)

y = np.zeros((x.shape[0],2))
y[:,0] = np.sin(x)
y[:,1] = np.random.rand(x.shape[0])
```

```
# x = np.arange(0,10,0.001)
x = np.zeros((10000,2))
x[:,0] = np.arange(0,10,0.001) # ADD
x[:,1] = np.random.rand(x.shape[0]) # ADD
np.random.shuffle(x)

# y = np.sin(x)
```

```
# y = np.sin(x)
y = np.sin(x[:,0])

split_index = int(x.shape[0]*0.6)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]

model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh', input_shape=(2,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))


model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


start_time = time.time()
# model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20)
model.fit(train_x, train_y, epochs=100, verbose=1, batch_size=20)
print("elapsed : {}".format(time.time() - start_time))


loss, mse = model.evaluate(test_x, test_y)
print("loss=",loss)
print("mse=",mse)


y_ = model.predict(test_x)

plt.scatter(test_x[:,0],test_y)
plt.scatter(test_x[:,0],y_,color='r')
plt.show()
```

학습 되지 않는 랜덤 함수

랜덤 한수의 경우 x와 y의 간에 관계가 없다.

입출력 간에 관계가 없는 함수로 학습되지 않는다.

```
x = np.arange(0,10,0.1)
np.random.shuffle(x)
# y = np.sin(x)
y = np.random.random_sample(x.shape[0])

split_index = int(x.shape[0]*0.6)
print(split_index)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]


plt.scatter(train_x, train_y)
plt.scatter(test_x, test_y, color="r")
```

```
plt.scatter(test_x, test_y, color='r')
```

CallBack

학습 도중 로그 출력이나 모델저장 등 다양한 액션을 취할 수 있다.

```
import numpy as np
import matplotlib.pyplot as plt

from tensorflow import keras
from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense
from tensorflow.keras.callbacks import Callback

import time


x = np.arange(-1,1,0.01)
np.random.shuffle(x)
y = x**2

split_index = int(x.shape[0]*0.6)

train_x, test_x = x[:split_index], x[split_index:]
train_y, test_y = y[:split_index], y[split_index:]


def train_with_callbacks(callbacks):


  # 모델 정의
  model = keras.Sequential()
  model.add(Dense(10, activation='tanh', input_shape=(1,)))
  model.add(Dense(10, activation='tanh'))
  model.add(Dense(1))


  # 모델 컴파일
```

```
# 모델 컴파일
model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()


# 학습
start_time = time.time()
model.fit(train_x, train_y, epochs=1000, verbose=0, batch_size=20, validation_split=0.1, callback
print("elapsed : {}".format(time.time() - start_time))
```

모델 저장

```
from tensorflow.keras.callbacks import ModelCheckpoint

model_check_point = ModelCheckpoint('best_model.h5', monitor='val_loss', mode='min', save_best_only

train_with_callbacks([model_check_point])
```

로스 출력

```
# copy from https://gist.github.com/stared/dfb4dfaf6d9a8501cd1cc8b8cb806d2e

from IPython.display import clear_output

class PlotLosses(Callback):

  def on_train_begin(self, logs={}):

    self.i = 0
    self.x = []
    self.losses = []
```

```
        self.losses = []
        self.val_losses = []

        self.fig = plt.figure()

        self.logs = []


    def on_epoch_end(self, epoch, logs={}):

        self.logs.append(logs)
        self.x.append(self.i)
        self.losses.append(logs.get('loss'))
        self.val_losses.append(logs.get('val_loss'))
        self.i += 1

        clear_output(wait=True)
        plt.plot(self.x, self.losses, label="loss")
        plt.plot(self.x, self.val_losses, label="val_loss")
        plt.legend()
        plt.show();
        print("loss = ", self.losses[-1], ", val_loss = ", self.val_losses[-1])



plot_losses = PlotLosses()

train_with_callbacks([plot_losses])
```

early stopping

```
from tensorflow.keras.callbacks import EarlyStopping

early_stopping = EarlyStopping(monitor='val_loss',  # 모니터링 대상
                               mode='auto',         # 학습 방향을 자동으로 탐지
                               patience=50)         # 중지까지의 여유분
```

```
train_with_callbacks([early_stopping])
```

학습율 조정

학습 과정을 모니터링 하면서 진척되지 않으면 학습율을 조정한다.

```
from tensorflow.keras.callbacks import ReduceLROnPlateau

reduce_lr = ReduceLROnPlateau(monitor='val_loss', # 모니터링 대상
                              factor=0.2,         # 줄이는 양
                              patience=5,         # 대상 기간동안 유지
                              min_lr=0.001)       # 최소 학습율

train_with_callbacks([reduce_lr])
```

모두 한번에

```
from sklearn.datasets import make_moons
from tensorflow.keras.layers import Dense
from tensorflow.keras.models import Sequential
from matplotlib import pyplot
from pandas import DataFrame

x, y = make_moons(n_samples=100, noise=0.2, random_state=1)

df = DataFrame(dict(x=x[:,0], y=x[:,1], label=y))
colors = {0:'red', 1:'blue'}
fig, ax = pyplot.subplots()
grouped = df.groupby('label')
for key, group in grouped:
    group.plot(ax=ax, kind='scatter', x='x', y='y', label=key, color=colors[key])
pyplot.show()

split_index = 30
train_x, test_x = x[:split_index], x[split_index:]
```

```
train_y, test_y = y[:split_index], y[split_index:]
```

```
# copy from https://machinelearningmastery.com/how-to-stop-training-deep-neural-networks-at-the-rig

model = Sequential()
model.add(Dense(500, input_shape=(2,), activation='relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])

history = model.fit(train_x, train_y, validation_data=(test_x, test_y), epochs=4000, verbose=0)

pyplot.plot(history.history['loss'], label='train_loss')
pyplot.plot(history.history['val_loss'], label='test_loss')
pyplot.legend()
pyplot.show()
```

```
from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau

model = Sequential()
model.add(Dense(500, input_shape=(2,), activation='relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam', metrics=['accuracy'])
```

```
model_check_point = ModelCheckpoint('best_model.h5', monitor='val_loss', mode='min', save_best_only
plot_losses = PlotLosses()
early_stopping = EarlyStopping(monitor='val_loss', mode='min', verbose=1, patience=50)
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=0.2, patience=5, min_lr=0.001)

callbacks = [model_check_point, plot_losses, early_stopping, reduce_lr]


# history = model.fit(train_x, train_y, validation_data=(test_x, test_y), epochs=4000, verbose=0)
history = model.fit(train_x, train_y, validation_data=(test_x, test_y), epochs=4000, verbose=0, cal


pyplot.plot(history.history['loss'], label='train_loss')
pyplot.plot(history.history['val_loss'], label='test_loss')
pyplot.legend()
pyplot.show()
```

다양한 입출력

2개의 입력, 1개의 출력

x1 + x2 -> y의 함수를 학습

x1과 x2는 0~10의 범위를 갖는다.

```
x1 = np.arange(0, 10, 0.1)
np.random.shuffle(x1)
x2 = np.arange(0, 10, 0.1)
np.random.shuffle(x2)

x = np.ones((x1.shape[0],2))
x[:,0] = x1
x[:,1] = x2
np.random.shuffle(x)

y = np.sum(x, axis=1)


s = int(x.shape[0]*0.6)
train_x, test_x = x[:s], x[s:]
train_y, test_y = y[:s], y[s:]



from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense

model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh', input_shape=(2,)))
model.add(Dense(10, activation='tanh'))
model.add(Dense(1))

model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start = time.time()
model.fit(train_x, train_y, epochs=1000*5, verbose=0, batch_size=20)
print("elapsed :", (time.time() - start))

loss, mse = model.evaluate(test_x, test_y)
print("loss=", loss)
print("mse=", mse)

y_ = model.predict(test_x)

# plt.scatter(test_x,test_y)
# plt.scatter(test_x,y_, color="r")
plt.scatter(test_x.T[0],test_y)
plt.scatter(test_x.T[0],y_, color="r")
plt.show()
```

```
print(x.shape)
print(x[:5])
print(y[:5])
```

1개의 입력, 2개의 출력

다음과 같이 y는 2개의 값을 갖고, y1 = x%2, y2=x%3인 함수를 학습

```
x = np.arange(0,10,0.1)
y1 = x%2
y2 = x%3
```

```
x = np.arange(0, 10, 0.1)
np.random.shuffle(x)
```

```
y1 = x%2
y2 = x%3

y = np.zeros((y.shape[0],2))
y[:,0] = y1
y[:,1] = y2


s = int(x.shape[0]*0.6)
train_x, test_x = x[:s], x[s:]
train_y, test_y = y[:s], y[s:]


from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense

model = keras.Sequential()
model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh'))
# model.add(Dense(1))
model.add(Dense(2))

model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start = time.time()
model.fit(train_x, train_y, epochs=1000*10, verbose=0, batch_size=20)
print("elapsed :", (time.time() - start))

loss, mse = model.evaluate(test_x, test_y)
print("loss=", loss)
print("mse=", mse)

y_ = model.predict(test_x)

# plt.scatter(test_x,test_y)
# plt.scatter(test_x,y_, color="r")
plt.scatter(test_x,test_y[:,0])
plt.scatter(test_x,y_[:,0], color="r")
plt.show()

plt.scatter(test_x,test_y[:,1])
plt.scatter(test_x,y_[:,1], color="r")
plt.show()
```

2개의 입력, 2개의 출력

x1 + x2 -> z,

y1 = z%2, y2=z%3인 함수를 학습

x1과 x2는 0~10의 범위를 갖는다.

```
x1 = np.arange(0, 10, 0.1)
np.random.shuffle(x1)
x2 = np.arange(0, 10, 0.1)
np.random.shuffle(x2)

x = np.ones((x1.shape[0],2))
x[:,0] = x1
x[:,1] = x2

z = x1 + x2
```

```
y1 = z%2
y2 = z%3

y = np.zeros((y.shape[0],2))
y[:,0] = y1
y[:,1] = y2


s = int(x.shape[0]*0.6)
train_x, test_x = x[:s], x[s:]
train_y, test_y = y[:s], y[s:]


from tensorflow.keras import optimizers
from tensorflow.keras.layers import Dense

model = keras.Sequential()
# model.add(Dense(10, activation='tanh', input_shape=(1,)))
model.add(Dense(10, activation='tanh', input_shape=(2,)))
model.add(Dense(10, activation='tanh'))
# model.add(Dense(1))
model.add(Dense(2))

model.compile(optimizer="SGD", loss="mse", metrics=["mse"])
model.summary()

start = time.time()
model.fit(train_x, train_y, epochs=1000*10, verbose=0, batch_size=20)
print("elapsed :", (time.time() - start))

loss, mse = model.evaluate(test_x, test_y)
print("loss=", loss)
print("mse=", mse)

y_ = model.predict(test_x)

# plt.scatter(test_x,test_y)
# plt.scatter(test_x,y_, color="r")
plt.scatter(test_x.T[0],test_y[:,0])
plt.scatter(test_x.T[0],y_[:,0], color="r")
plt.show()

plt.scatter(test_x.T[1],test_y[:,1])
plt.scatter(test_x.T[1],y_[:,1], color="r")
plt.show()
```