predict sin

In [1]:

```
import sys, os
sys.path.append(os.pardir)  # 親ディレクトリのファイルをインポートするための設定
import numpy as np
from common import functions
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

np.random.seed(0)

# sin曲線
round_num = 10#10πだと、5周。
div_num = 500#分割数　5周を500分割だと、1周100分割。1分割3.6度。
ts = np.linspace(0, round_num * np.pi, div_num)
f = np.sin(ts)

#tanhの導関数
def d_tanh(x):
    return 1/(np.cosh(x)**2 + 1e-4)

# ひとつの時系列データの長さ
maxlen = 2

# sin波予測の入力データ
test_head = [[f[k]] for k in range(0, maxlen)]#配列fのindexの０～k－1番目の値を抽出する。

#print(f)
print(test_head)
```

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In [2]:

```
data = []
target = []

for i in range(div_num - maxlen):#500-2
    data.append(f[i: i + maxlen])#0～1,1～2,2～3,
    target.append(f[i + maxlen])#    2,    3,    4,

X = np.array(data).reshape(len(data), maxlen, 1)
D = np.array(target).reshape(len(data), 1)
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In [3]:

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print(X)
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 [-1.25583075e-01]
 [-6.29161861e-02]
 [-1.22464680e-15]]
```

In [5]:

```
# データ設定
N_train = int(len(data) * 0.8)
N_validation = len(data) - N_train
print(N_train,N_validation,len(data))
```

```
398 100 498
```

In [6]:

```
x_train, x_test, d_train, d_test = train_test_split(X, D, test_size=N_validation)
```

In [7]:

```
x_train
```

Out[7]:

```
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        [-0.87429733]],

       [[-0.98907524],
        [-0.97784112]],

       [[-0.05034492],
        [ 0.01259122]],

       [[ 0.6529121 ],
        [ 0.60396372]],

       [[ 0.0691982 ],
        [ 0.00629574]],

       [[ 0.90843947],
        [ 0.88033969]],

       [[ 0.78351093],
        [ 0.74286391]],

       [[-0.16296018],
        [-0.10056216]],

       [[ 0.39789889],
        [ 0.33938943]],

       [[-0.80641875],
        [-0.84202625]],

       [[ 0.81744318],
        [ 0.85206398]],

       [[ 0.29761864],
        [ 0.35709413]],

       [[-0.82817601],
        [-0.86179776]],

       [[-0.98394564],
        [-0.99322482]],

       [[ 0.85534252],
        [ 0.82105338]],

       [[ 0.99999505],
        [ 0.99781582]],

       [[-0.82105338],
        [-0.85534252]],

       [[ 0.6992734 ],
        [ 0.6529121 ]],

       [[-0.90578975],
        [-0.8773359 ]],

       [[-0.99916279],
        [-0.99975723]],

       [[-0.81012572],
        [-0.77163571]],

       [[ 0.63363256],
        [ 0.5837031 ]],

       [[-0.4036669 ],
        [-0.34530476]],

       [[ 0.79510666],
        [ 0.83168816]],

       [[-0.20010478],
        [-0.13806466]],

       [[-0.67642786],
        [-0.6287494 ]],

       [[-0.99168287],
        [-0.99781582]],

       [[-0.95374324],
        [-0.97076771]],

       [[-0.72142606],
        [-0.67642786]],

       [[-0.44921588],
        [-0.39211512]],
       [[ 0.45483173],
        [ 0.39789889]],

       [[-0.98714074],
        [-0.97512765]],

       [[ 0.65766776],
        [ 0.70376007]],

       [[ 0.53678328],
        [ 0.58880346]],

       [[-0.57343317],
        [-0.62384133]],

       [[-0.2855744 ],
        [-0.22471249]],

       [[-0.09429635],
        [-0.15674537]],

       [[ 0.99639027],
        [ 0.99975723]],

       [[-0.46042956],
        [-0.4036669 ]],

       [[ 0.88330858],
        [ 0.91105319]],

       [[ 0.18156486],
        [ 0.11933469]],

       [[-0.98611478],
        [-0.99460929]]])
```

In [8]:

```
input_layer_size = 1#入力層サイズ
hidden_layer_size = 5#隠れ層サイズ
output_layer_size = 1#出力層サイズ

weight_init_std = 0.01
learning_rate = 0.1#学習率

iters_num = 500#反復回数
```

In [9]:

```
# ウェイト初期化（バイアスは簡単のため省略）
W_in = weight_init_std * np.random.randn(input_layer_size, hidden_layer_size)#係数×標準正規分布
W_out = weight_init_std * np.random.randn(hidden_layer_size, output_layer_size)
W = weight_init_std * np.random.randn(hidden_layer_size, hidden_layer_size)
```

In [10]:

```
print(W_in)
```

```
[[-0.00596314 -0.00052567 -0.0193628   0.00188779  0.00523891]]
```

In [11]:

```
# 勾配
W_in_grad = np.zeros_like(W_in)
W_out_grad = np.zeros_like(W_out)
W_grad = np.zeros_like(W)
```

In [12]:

```
print(W_in_grad)
```

```
[[0. 0. 0. 0. 0.]]
```

In [13]:

```
us = []
zs = []

u = np.zeros(hidden_layer_size)
z = np.zeros(hidden_layer_size)
y = np.zeros(output_layer_size)
```

In [14]:

```
print(u,z,y)
```

```
[0. 0. 0. 0. 0.] [0. 0. 0. 0. 0.] [0.]
```

In [15]:

```
delta_out = np.zeros(output_layer_size)
delta = np.zeros(hidden_layer_size)
```

In [16]:

```
print(delta_out,delta)
print(x_train.shape[0])
```

```
[0.] [0. 0. 0. 0. 0.]
398
```

In [17]:

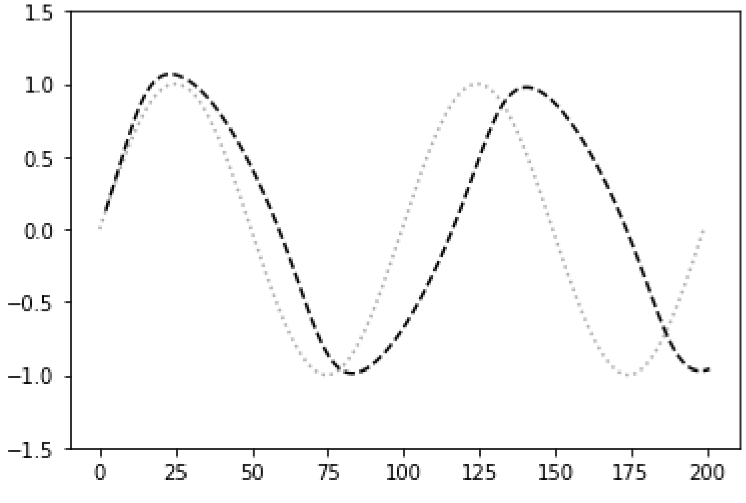
```
losses = []

# トレーニング
for i in range(iters_num):#500
    for s in range(x_train.shape[0]):##398行
        us.clear()
        zs.clear()
        z *= 0

        # sにおける正解データ
        d = d_train[s]

        xs = x_train[s]

        # 時系列ループ
        for t in range(maxlen):#t=0, t=1.

            # 入力値
            x = xs[t]
            u = np.dot(x, W_in) + np.dot(z, W)
            us.append(u)
            z = np.tanh(u)
            zs.append(z)

        y = np.dot(z, W_out)# z1 * W_out

        #誤差
        loss = functions.mean_squared_error(d, y)

        delta_out = functions.d_mean_squared_error(d, y)

        delta *= 0

        for t in range(maxlen)[::-1]:#range(1, -1, -1), t=1,t=0.

            #t=1の場合 delta = 0 + np.dot(delta_out, W_out.T) * d_tanh(us[t])
            #t=0の場合 delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])
            delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])

            # 勾配更新
            W_grad += np.dot(zs[t].reshape(-1,1), delta.reshape(1,-1))
            W_in_grad += np.dot(xs[t], delta.reshape(1,-1))
        W_out_grad = np.dot(z.reshape(-1,1), delta_out)


        # 勾配適用
        W -= learning_rate * W_grad
        W_in -= learning_rate * W_in_grad
        W_out -= learning_rate * W_out_grad.reshape(-1,1)

        #勾配初期化
        W_in_grad *= 0
        W_out_grad *= 0
        W_grad *= 0
```

In [18]:

```
# テスト
for s in range(x_test.shape[0]):
    z *= 0

    # sにおける正解データ
    d = d_test[s]

    xs = x_test[s]

    # 時系列ループ
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)

    #誤差
    loss = functions.mean_squared_error(d, y)
    print('loss:', loss, '   d:', d, '   y:', y)



original = np.full(maxlen, None)
pred_num = 200

xs = test_head

# sin波予測
for s in range(0, pred_num):
    z *= 0
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)
    original = np.append(original, y)
    xs = np.delete(xs, 0)
    xs = np.append(xs, y)

plt.figure()
plt.ylim([-1.5, 1.5])
plt.plot(np.sin(np.linspace(0, round_num* pred_num / div_num * np.pi, pred_num)), linestyle='dot
ted', color='#aaaaaa')
plt.plot(original, linestyle='dashed', color='black')
plt.show()
```

```
loss: 5.111112056304763e-07    d: [-0.47157024]    y: [-0.47258129]
loss: 1.4153640452728792e-06    d: [-0.39789889]    y: [-0.39958137]
loss: 2.559902991488718e-06    d: [-0.78740743]    y: [-0.78967013]
loss: 7.216263290783507e-09    d: [0.25526991]    y: [0.25514977]
loss: 1.692063852303632e-06    d: [0.6529121]    y: [0.6547517]
loss: 7.238070929589735e-07    d: [0.8773359]    y: [0.87613273]
loss: 6.94623672640184e-07    d: [0.92114593]    y: [0.91996727]
loss: 1.2284734878711618e-06    d: [-0.58880346]    y: [-0.59037093]
loss: 1.249746554038834e-08    d: [-0.6529121]    y: [-0.65307019]
loss: 1.747012227351786e-06    d: [-0.32751865]    y: [-0.32938788]
loss: 2.0214401036935557e-07    d: [0.39789889]    y: [0.39853473]
loss: 1.7248378220182004e-06    d: [-0.15674537]    y: [-0.1586027]
loss: 1.3462666565758106e-06    d: [0.97076771]    y: [0.97240861]
loss: 6.884294927342299e-07    d: [-0.50453668]    y: [-0.50571008]
loss: 8.964485145726196e-09    d: [-0.99460929]    y: [-0.99447539]
loss: 1.6819644091700236e-06    d: [0.95745284]    y: [0.95928694]
loss: 6.636708769141727e-07    d: [-0.92833248]    y: [-0.92718037]
loss: 1.6550737476982935e-06    d: [-0.35120641]    y: [-0.35302579]
loss: 1.4812813327813093e-06    d: [-0.3863158]    y: [-0.38803701]
loss: 1.5504762308512516e-06    d: [0.63363256]    y: [0.63539351]
loss: 1.0859688992783592e-06    d: [0.44921588]    y: [0.45068963]
loss: 7.024336524123257e-07    d: [-0.86811636]    y: [-0.86693109]
loss: 4.298419312275074e-07    d: [0.45483173]    y: [0.45575893]
loss: 1.5800953987150462e-07    d: [0.59893397]    y: [0.59949613]
loss: 1.305987382511987e-07    d: [0.18156486]    y: [0.18105379]
loss: 1.6215636803484033e-06    d: [0.64332332]    y: [0.64512419]
loss: 2.6565935995811714e-08    d: [0.99247351]    y: [0.99224301]
loss: 7.407414549659186e-07    d: [-0.89762559]    y: [-0.89640842]
loss: 3.7108253202912373e-07    d: [-0.11308158]    y: [-0.11222009]
loss: 2.5763917247784403e-06    d: [0.79127273]    y: [0.7935427]
loss: 1.656899449754742e-06    d: [-0.64813056]    y: [-0.64995094]
loss: 4.637650286011886e-07    d: [0.95561698]    y: [0.9546539]
loss: 3.6393779690636794e-07    d: [0.99690497]    y: [0.99775813]
loss: 2.2160406235611887e-07    d: [-0.4036669]    y: [-0.40433264]
loss: 5.740145938550149e-08    d: [-0.99987614]    y: [-1.00021496]
loss: 2.762903013775288e-07    d: [-0.57343317]    y: [-0.57417653]
loss: 1.855495428968903e-07    d: [0.75537465]    y: [0.75476547]
loss: 9.152860658438427e-07    d: [0.00629574]    y: [0.00494275]
loss: 1.8797284550728012e-06    d: [-0.23084276]    y: [-0.23278169]
loss: 1.0524302613338606e-06    d: [0.56307233]    y: [0.56452314]
loss: 4.631459840874837e-08    d: [0.99975723]    y: [1.00006158]
loss: 3.447189422141964e-07    d: [0.11933469]    y: [0.11850437]
loss: 1.883099480769221e-06    d: [0.23696388]    y: [0.23890455]
loss: 5.1214730714751955e-09    d: [0.99524241]    y: [0.9951412]
loss: 1.051230447773728e-06    d: [-0.98039956]    y: [-0.98184954]
loss: 1.813882872732977e-06    d: [0.18775236]    y: [0.18965703]
loss: 5.27036239975623e-07    d: [0.82463104]    y: [0.82360436]
loss: 5.169924703573374e-07    d: [-0.94988243]    y: [-0.94886558]
loss: 6.747741177793689e-07    d: [0.92597363]    y: [0.92481193]
loss: 1.8809353374298544e-06    d: [0.26135201]    y: [0.26329156]
loss: 2.0325852791579403e-07    d: [-0.75948523]    y: [-0.75884764]
loss: 9.92544090722427e-08    d: [-0.98611478]    y: [-0.98566924]
loss: 3.54176004989751e-07    d: [-0.43793098]    y: [-0.43877262]
loss: 3.137779621326153e-08    d: [0.23084276]    y: [0.23059225]
loss: 2.6937112046164813e-06    d: [0.83516734]    y: [0.83748842]
loss: 2.588227073819169e-07    d: [0.77163571]    y: [0.77091623]
loss: 1.2613599482853231e-06    d: [0.97371292]    y: [0.97530122]
loss: 1.4907373517710847e-07    d: [-0.99975723]    y: [-1.00030326]
loss: 4.232044587656063e-07    d: [0.99583607]    y: [0.99675608]
loss: 3.787447800805401e-07    d: [0.44358222]    y: [0.44445256]
loss: 1.8816335271670955e-06    d: [-0.94789551]    y: [-0.94983543]
```

```
loss: 1.2190012629922352e-06    d: [-0.97512765]    y: [-0.97668906]
loss: 1.996710038100712e-06    d: [-0.694759]    y: [-0.69675736]
loss: 1.8849134192596554e-06    d: [-0.2430756]    y: [-0.24501721]
loss: 1.8748123442560268e-06    d: [0.22471249]    y: [0.22664888]
loss: 4.2620357543512357e-07    d: [-0.10056216]    y: [-0.0996389]
loss: 4.325800120889982e-09    d: [0.68564779]    y: [0.68555477]
loss: 1.8306176723615103e-06    d: [0.29761864]    y: [0.29953208]
loss: 2.332044298284346e-09    d: [-0.99583607]    y: [-0.99576778]
loss: 6.585761031379055e-07    d: [-0.99085292]    y: [-0.99200059]
loss: 7.651581590766538e-08    d: [0.35120641]    y: [0.3515976]
loss: 7.290859282135365e-07    d: [-0.88033969]    y: [-0.87913214]
loss: 1.6685814037161896e-09    d: [-0.68105132]    y: [-0.68099355]
loss: 2.691838713149061e-06    d: [0.85534252]    y: [0.85766279]
loss: 7.327100876992387e-07    d: [-0.98907524]    y: [-0.99028578]
loss: 5.4908929482703205e-08    d: [-0.71705202]    y: [-0.71672063]
loss: 6.837326417292688e-07    d: [-0.86179776]    y: [-0.86062837]
loss: 1.6566551435475068e-06    d: [0.13806466]    y: [0.13988491]
loss: 5.681550927763364e-07    d: [-0.48263615]    y: [-0.48370213]
loss: 2.2589028031750398e-07    d: [-0.15052435]    y: [-0.1498522]
loss: 1.7452123204601994e-06    d: [0.16296018]    y: [0.16482845]
loss: 2.09155034432836e-06    d: [0.70821885]    y: [0.71026411]
loss: 1.7631822152185102e-06    d: [0.95374324]    y: [0.9556211]
loss: 2.4114224765198005e-07    d: [0.97512765]    y: [0.97443319]
loss: 2.067490890143368e-06    d: [0.93739898]    y: [0.93943244]
loss: 8.485394806789291e-07    d: [0.98611478]    y: [0.9874175]
loss: 1.72986325908338e-07    d: [0.98039956]    y: [0.97981136]
loss: 3.9139136578767244e-07    d: [-0.55262221]    y: [-0.55350696]
loss: 5.144245939051554e-07    d: [0.08175375]    y: [0.08073943]
loss: 1.5434925122990647e-06    d: [-0.37467145]    y: [-0.37642843]
loss: 8.64601116962286e-08    d: [0.98714074]    y: [0.9867249]
loss: 1.7821870821634795e-06    d: [0.17537017]    y: [0.17725812]
loss: 1.7227716039716527e-06    d: [-0.95561698]    y: [-0.9574732]
loss: 1.7032584357931716e-06    d: [0.15052435]    y: [0.15237003]
loss: 2.2961399277292755e-06    d: [-0.92114593]    y: [-0.92328889]
loss: 1.4861572178323642e-07    d: [-0.38050117]    y: [-0.38104635]
loss: 8.149646046184465e-07    d: [-0.48814053]    y: [-0.48941721]
loss: 9.154701847834834e-07    d: [0.54208448]    y: [0.5434376]
loss: 8.19187220025201e-09    d: [-0.69021707]    y: [-0.69008907]
loss: 1.1946819048400479e-07    d: [0.60896952]    y: [0.60945833]
```



[try]

- iters_numを100にしよう

In [19]:

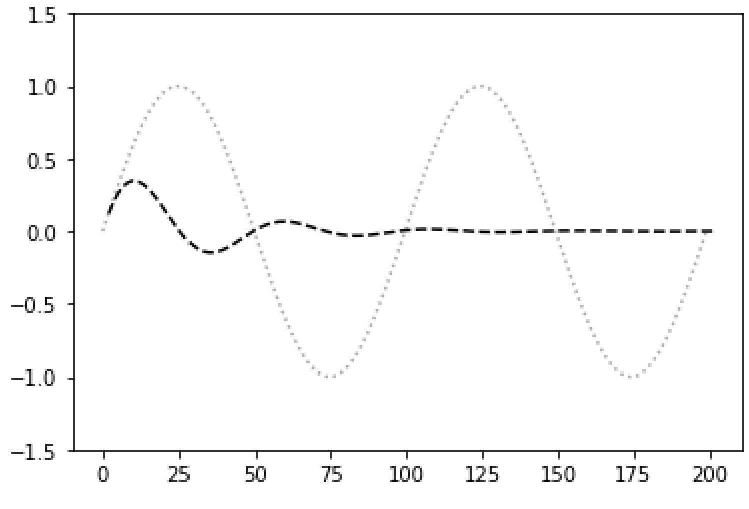
```
import sys, os
sys.path.append(os.pardir)  # 親ディレクトリのファイルをインポートするための設定
import numpy as np
from common import functions
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

np.random.seed(0)

# sin曲線
round_num = 10
div_num = 500
ts = np.linspace(0, round_num * np.pi, div_num)
f = np.sin(ts)

def d_tanh(x):
    return 1/(np.cosh(x)**2 + 1e-4)

# ひとつの時系列データの長さ
maxlen = 2

# sin波予測の入力データ
test_head = [[f[k]] for k in range(0, maxlen)]

data = []
target = []

for i in range(div_num - maxlen):
    data.append(f[i: i + maxlen])
    target.append(f[i + maxlen])

X = np.array(data).reshape(len(data), maxlen, 1)
D = np.array(target).reshape(len(data), 1)

# データ設定
N_train = int(len(data) * 0.8)
N_validation = len(data) - N_train

x_train, x_test, d_train, d_test = train_test_split(X, D, test_size=N_validation)

input_layer_size = 1
hidden_layer_size = 5
output_layer_size = 1

weight_init_std = 0.01
learning_rate = 0.1

iters_num = 100

# ウェイト初期化 (バイアスは簡単のため省略)
W_in = weight_init_std * np.random.randn(input_layer_size, hidden_layer_size)
W_out = weight_init_std * np.random.randn(hidden_layer_size, output_layer_size)
W = weight_init_std * np.random.randn(hidden_layer_size, hidden_layer_size)

# 勾配
W_in_grad = np.zeros_like(W_in)
W_out_grad = np.zeros_like(W_out)
W_grad = np.zeros_like(W)
```

```
us = []
zs = []

u = np.zeros(hidden_layer_size)
z = np.zeros(hidden_layer_size)
y = np.zeros(output_layer_size)

delta_out = np.zeros(output_layer_size)
delta = np.zeros(hidden_layer_size)

losses = []

# トレーニング
for i in range(iters_num):
    for s in range(x_train.shape[0]):
        us.clear()
        zs.clear()
        z *= 0

        # sにおける正解データ
        d = d_train[s]

        xs = x_train[s]

        # 時系列ループ
        for t in range(maxlen):

            # 入力値
            x = xs[t]
            u = np.dot(x, W_in) + np.dot(z, W)
            us.append(u)
            z = np.tanh(u)
            zs.append(z)

        y = np.dot(z, W_out)

        #誤差
        loss = functions.mean_squared_error(d, y)

        delta_out = functions.d_mean_squared_error(d, y)

        delta *= 0
        for t in range(maxlen)[::-1]:

            delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])

            # 勾配更新
            W_grad += np.dot(zs[t].reshape(-1,1), delta.reshape(1,-1))
            W_in_grad += np.dot(xs[t], delta.reshape(1,-1))
        W_out_grad = np.dot(z.reshape(-1,1), delta_out)

        # 勾配適用
        W -= learning_rate * W_grad
        W_in -= learning_rate * W_in_grad
        W_out -= learning_rate * W_out_grad.reshape(-1,1)

        W_in_grad *= 0
        W_out_grad *= 0
        W_grad *= 0

# テスト
```

```
for s in range(x_test.shape[0]):
    z *= 0

    # sにおける正解データ
    d = d_test[s]

    xs = x_test[s]

    # 時系列ループ
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)

    #誤差
    loss = functions.mean_squared_error(d, y)
    print('loss:', loss, '    d:', d, '    y:', y)



original = np.full(maxlen, None)
pred_num = 200

xs = test_head

# sin波予測
for s in range(0, pred_num):
    z *= 0
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)
    original = np.append(original, y)
    xs = np.delete(xs, 0)
    xs = np.append(xs, y)

plt.figure()
plt.ylim([-1.5, 1.5])
plt.plot(np.sin(np.linspace(0, round_num* pred_num / div_num * np.pi, pred_num)), linestyle='dotted', color='#aaaaaa')
plt.plot(original, linestyle='dashed', color='black')
plt.show()
```

```
loss: 1.0018211688363152e-06    d: [-0.47157024]    y: [-0.47298574]
loss: 3.831628581739869e-05    d: [-0.39789889]    y: [-0.38914489]
loss: 1.1955502192448862e-05    d: [-0.78740743]    y: [-0.79229732]
loss: 5.688169957032234e-07    d: [0.25526991]    y: [0.25633651]
loss: 5.042766131766361e-06    d: [0.6529121]    y: [0.65608787]
loss: 2.323535484703895e-05    d: [0.8773359]    y: [0.87051895]
loss: 1.2851597420607724e-05    d: [0.92114593]    y: [0.9160761]
loss: 2.9577805540623868e-06    d: [-0.58880346]    y: [-0.59123566]
loss: 5.3033087017894245e-05    d: [-0.6529121]    y: [-0.64261325]
loss: 3.068291439526736e-05    d: [-0.32751865]    y: [-0.31968501]
loss: 5.638683232237903e-07    d: [0.39789889]    y: [0.39896084]
loss: 1.4135523848939483e-05    d: [-0.15674537]    y: [-0.15142832]
loss: 1.3233060812018978e-05    d: [0.97076771]    y: [0.97591224]
loss: 1.3588146407522809e-06    d: [-0.50453668]    y: [-0.50618521]
loss: 1.352410323795142e-07    d: [-0.99460929]    y: [-0.99512937]
loss: 1.4962796333390856e-05    d: [0.95745284]    y: [0.96292327]
loss: 1.1148085202439717e-05    d: [-0.92833248]    y: [-0.92361059]
loss: 3.3266626628950615e-05    d: [-0.35120641]    y: [-0.34304962]
loss: 3.707863108292281e-05    d: [-0.3863158]    y: [-0.37770434]
loss: 4.326570868918968e-06    d: [0.63363256]    y: [0.63657418]
loss: 4.3539234693184196e-05    d: [0.44921588]    y: [0.4398843]
loss: 2.533672093849227e-05    d: [-0.86811636]    y: [-0.86099783]
loss: 8.639496897928521e-07    d: [0.45483173]    y: [0.45614623]
loss: 5.311920595825067e-05    d: [0.59893397]    y: [0.58862677]
loss: 1.0055949688712286e-06    d: [0.18156486]    y: [0.18298303]
loss: 4.676740710063253e-06    d: [0.64332332]    y: [0.64638167]
loss: 1.59930658073789e-08    d: [0.99247351]    y: [0.99265236]
loss: 1.8474236177344764e-05    d: [-0.89762559]    y: [-0.89154706]
loss: 1.8802261802955873e-06    d: [-0.11308158]    y: [-0.11502077]
loss: 1.2182950786145393e-05    d: [0.79127273]    y: [0.79620891]
loss: 4.857808115858404e-06    d: [-0.64813056]    y: [-0.65124754]
loss: 5.0259896375981215e-06    d: [0.95561698]    y: [0.95244649]
loss: 5.84751441954738e-06    d: [0.99690497]    y: [1.00032477]
loss: 5.842918948781338e-07    d: [-0.4036669]    y: [-0.40474791]
loss: 2.0465335767793966e-06    d: [-0.99987614]    y: [-1.00189927]
loss: 5.237713037590953e-05    d: [-0.57343317]    y: [-0.56319822]
loss: 4.550293795779566e-05    d: [0.75537465]    y: [0.74583495]
loss: 4.716398434628641e-06    d: [0.00629574]    y: [0.00936702]
loss: 2.065453201950312e-05    d: [-0.23084276]    y: [-0.22441554]
loss: 2.3468307818580476e-06    d: [0.56307233]    y: [0.56523881]
loss: 1.8459664559315096e-06    d: [0.99975723]    y: [1.00167867]
loss: 1.7754700800083484e-06    d: [0.11933469]    y: [0.12121909]
loss: 2.1247195911347073e-05    d: [0.23696388]    y: [0.2304451]
loss: 2.0004302281892026e-07    d: [0.99524241]    y: [0.99587493]
loss: 1.1411501423016343e-05    d: [-0.98039956]    y: [-0.9851769]
loss: 1.6706877736517124e-05    d: [0.18775236]    y: [0.18197189]
loss: 3.446312694027539e-05    d: [0.82463104]    y: [0.81632886]
loss: 6.2409520302279e-06    d: [-0.94988243]    y: [-0.94634946]
loss: 1.1705129757380487e-05    d: [0.92597363]    y: [0.92113522]
loss: 2.3677213141816805e-05    d: [0.26135201]    y: [0.25447055]
loss: 4.49811295488685e-05    d: [-0.75948523]    y: [-0.75000038]
loss: 2.028533646768841e-07    d: [-0.98611478]    y: [-0.98547783]
loss: 7.499350947699529e-07    d: [-0.43793098]    y: [-0.43915567]
loss: 6.702616914592727e-07    d: [0.23084276]    y: [0.23200057]
loss: 1.4664769817573572e-05    d: [0.83516734]    y: [0.84058301]
loss: 4.333798205022689e-05    d: [0.77163571]    y: [0.76232571]
loss: 1.2737717225792436e-05    d: [0.97371292]    y: [0.97876023]
loss: 3.4112375431131424e-06    d: [-0.99975723]    y: [-1.00236922]
loss: 6.429288289821193e-06    d: [0.99583607]    y: [0.99942196]
loss: 7.85436168297347e-07    d: [0.44358222]    y: [0.44483557]
loss: 1.5805387662329316e-05    d: [-0.94789551]    y: [-0.95351786]
```

```
loss: 1.2481961197274553e-05    d: [-0.97512765]    y: [-0.98012404]
loss: 6.866202285129303e-06    d: [-0.694759]    y: [-0.69846473]
loss: 2.1846135041325457e-05    d: [-0.2430756]    y: [-0.23646559]
loss: 2.00684638533191e-05    d: [0.22471249]    y: [0.21837712]
loss: 2.1074553733212728e-06    d: [-0.10056216]    y: [-0.10261519]
loss: 5.174173943527327e-05    d: [0.68564779]    y: [0.6754751]
loss: 2.74601418124138e-05    d: [0.29761864]    y: [0.29020782]
loss: 2.7697525031755335e-07    d: [-0.99583607]    y: [-0.99658035]
loss: 8.510577037380914e-06    d: [-0.99085292]    y: [-0.99497859]
loss: 4.6342324398754784e-07    d: [0.35120641]    y: [0.35216914]
loss: 2.2541089852561257e-05    d: [-0.88033969]    y: [-0.87362536]
loss: 5.198366295972673e-05    d: [-0.68105132]    y: [-0.67085488]
loss: 1.5650869216024103e-05    d: [0.85534252]    y: [0.86093731]
loss: 9.106005186775855e-06    d: [-0.98907524]    y: [-0.99334279]
loss: 4.9537135434721655e-05    d: [-0.71705202]    y: [-0.70709842]
loss: 2.674810502869443e-05    d: [-0.86179776]    y: [-0.85448365]
loss: 1.2704010990953187e-05    d: [0.13806466]    y: [0.13302402]
loss: 1.108184027478091e-06    d: [-0.48263615]    y: [-0.4841249]
loss: 1.3322624649906846e-06    d: [-0.15052435]    y: [-0.15215669]
loss: 1.4631672720098082e-05    d: [0.16296018]    y: [0.15755062]
loss: 7.5277718530109865e-06    d: [0.70821885]    y: [0.712099]
loss: 1.532365497732746e-05    d: [0.95374324]    y: [0.95927924]
loss: 1.4698452123511701e-06    d: [0.97512765]    y: [0.9734131]
loss: 1.6440458209345824e-05    d: [0.93739898]    y: [0.94313317]
loss: 9.989092604746525e-06    d: [0.98611478]    y: [0.99058448]
loss: 7.597360561243469e-07    d: [0.98039956]    y: [0.97916689]
loss: 5.144766400804239e-05    d: [-0.55262221]    y: [-0.54247848]
loss: 2.49562656838687e-06    d: [0.08175375]    y: [0.08398787]
loss: 3.582176538836955e-05    d: [-0.37467145]    y: [-0.3662072]
loss: 1.3465686259774947e-07    d: [0.98714074]    y: [0.98662178]
loss: 1.5651516544468314e-05    d: [0.17537017]    y: [0.16977526]
loss: 1.5147090412232574e-05    d: [-0.95561698]    y: [-0.96112099]
loss: 1.3648771002149447e-05    d: [0.15052435]    y: [0.14529965]
loss: 1.695825274903518e-05    d: [-0.92114593]    y: [-0.92696972]
loss: 5.135842537369791e-07    d: [-0.38050117]    y: [-0.38151466]
loss: 4.704410899615774e-05    d: [-0.48814053]    y: [-0.47844062]
loss: 1.933106793590669e-06    d: [0.54208448]    y: [0.54405075]
loss: 5.148111233523464e-05    d: [-0.69021707]    y: [-0.68007004]
loss: 5.3281078139314694e-05    d: [0.60896952]    y: [0.59864663]
```



[try]

- iters_numを3000(※時間がかかる)にしよう

In [20]:

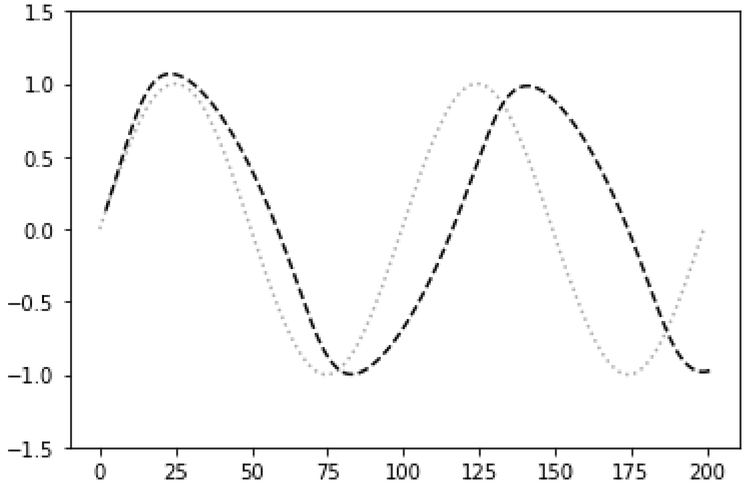
```
import sys, os
sys.path.append(os.pardir)  # 親ディレクトリのファイルをインポートするための設定
import numpy as np
from common import functions
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

np.random.seed(0)

# sin曲線
round_num = 10
div_num = 500
ts = np.linspace(0, round_num * np.pi, div_num)
f = np.sin(ts)

def d_tanh(x):
    return 1/(np.cosh(x)**2 + 1e-4)

# ひとつの時系列データの長さ
maxlen = 2

# sin波予測の入力データ
test_head = [[f[k]] for k in range(0, maxlen)]

data = []
target = []

for i in range(div_num - maxlen):
    data.append(f[i: i + maxlen])
    target.append(f[i + maxlen])

X = np.array(data).reshape(len(data), maxlen, 1)
D = np.array(target).reshape(len(data), 1)

# データ設定
N_train = int(len(data) * 0.8)
N_validation = len(data) - N_train

x_train, x_test, d_train, d_test = train_test_split(X, D, test_size=N_validation)

input_layer_size = 1
hidden_layer_size = 5
output_layer_size = 1

weight_init_std = 0.01
learning_rate = 0.1

iters_num = 3000

# ウェイト初期化 (バイアスは簡単のため省略)
W_in = weight_init_std * np.random.randn(input_layer_size, hidden_layer_size)
W_out = weight_init_std * np.random.randn(hidden_layer_size, output_layer_size)
W = weight_init_std * np.random.randn(hidden_layer_size, hidden_layer_size)

# 勾配
W_in_grad = np.zeros_like(W_in)
W_out_grad = np.zeros_like(W_out)
W_grad = np.zeros_like(W)
```

```
us = []
zs = []

u = np.zeros(hidden_layer_size)
z = np.zeros(hidden_layer_size)
y = np.zeros(output_layer_size)

delta_out = np.zeros(output_layer_size)
delta = np.zeros(hidden_layer_size)

losses = []

# トレーニング
for i in range(iters_num):
    for s in range(x_train.shape[0]):
        us.clear()
        zs.clear()
        z *= 0

        # sにおける正解データ
        d = d_train[s]

        xs = x_train[s]

        # 時系列ループ
        for t in range(maxlen):

            # 入力値
            x = xs[t]
            u = np.dot(x, W_in) + np.dot(z, W)
            us.append(u)
            z = np.tanh(u)
            zs.append(z)

        y = np.dot(z, W_out)

        #誤差
        loss = functions.mean_squared_error(d, y)

        delta_out = functions.d_mean_squared_error(d, y)

        delta *= 0
        for t in range(maxlen)[::-1]:

            delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])

            # 勾配更新
            W_grad += np.dot(zs[t].reshape(-1,1), delta.reshape(1,-1))
            W_in_grad += np.dot(xs[t], delta.reshape(1,-1))
        W_out_grad = np.dot(z.reshape(-1,1), delta_out)

        # 勾配適用
        W -= learning_rate * W_grad
        W_in -= learning_rate * W_in_grad
        W_out -= learning_rate * W_out_grad.reshape(-1,1)

        W_in_grad *= 0
        W_out_grad *= 0
        W_grad *= 0

# テスト
```

```
for s in range(x_test.shape[0]):
    z *= 0

    # sにおける正解データ
    d = d_test[s]

    xs = x_test[s]

    # 時系列ループ
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)

    #誤差
    loss = functions.mean_squared_error(d, y)
    print('loss:', loss, '   d:', d, '   y:', y)



original = np.full(maxlen, None)
pred_num = 200

xs = test_head

# sin波予測
for s in range(0, pred_num):
    z *= 0
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)
    original = np.append(original, y)
    xs = np.delete(xs, 0)
    xs = np.append(xs, y)

plt.figure()
plt.ylim([-1.5, 1.5])
plt.plot(np.sin(np.linspace(0, round_num* pred_num / div_num * np.pi, pred_num)), linestyle='dot
ted', color='#aaaaaa')
plt.plot(original, linestyle='dashed', color='black')
plt.show()
```

```
loss: 3.912343122231309e-07     d: [-0.47157024]     y: [-0.47245481]
loss: 1.3052648322202188e-06     d: [-0.39789889]     y: [-0.39951461]
loss: 2.4568661324794487e-06     d: [-0.78740743]     y: [-0.78962413]
loss: 1.836933553802922e-08     d: [0.25526991]     y: [0.25507824]
loss: 1.5234519740797024e-06     d: [0.6529121]     y: [0.65465764]
loss: 5.187974276348698e-07     d: [0.8773359]     y: [0.87631727]
loss: 5.147787696349783e-07     d: [0.92114593]     y: [0.92013126]
loss: 1.0581260161824844e-06     d: [-0.58880346]     y: [-0.5902582]
loss: 3.273298436623086e-08     d: [-0.6529121]     y: [-0.65316796]
loss: 1.577987966024491e-06     d: [-0.32751865]     y: [-0.32929515]
loss: 1.336466170586074e-07     d: [0.39789889]     y: [0.3984159]
loss: 1.536853774722165e-06     d: [-0.15674537]     y: [-0.15849857]
loss: 1.3150157772974342e-06     d: [0.97076771]     y: [0.97238945]
loss: 5.488011547346638e-07     d: [-0.50453668]     y: [-0.50558435]
loss: 3.4729876467868902e-09     d: [-0.99460929]     y: [-0.99452595]
loss: 1.6448993535149984e-06     d: [0.95745284]     y: [0.95926662]
loss: 4.937438724118824e-07     d: [-0.92833248]     y: [-0.92733875]
loss: 1.5034914183015375e-06     d: [-0.35120641]     y: [-0.35294047]
loss: 1.3602120481600566e-06     d: [-0.3863158]     y: [-0.38796517]
loss: 1.3788941646447499e-06     d: [0.63363256]     y: [0.63529321]
loss: 1.026676639415935e-06     d: [0.44921588]     y: [0.45064883]
loss: 4.989099370011925e-07     d: [-0.86811636]     y: [-0.86711745]
loss: 3.2105982617360104e-07     d: [0.45483173]     y: [0.45563306]
loss: 1.9274300037523416e-07     d: [0.59893397]     y: [0.59955485]
loss: 1.4944014901163935e-07     d: [0.18156486]     y: [0.18101816]
loss: 1.45121458712902e-06     d: [0.64332332]     y: [0.64502698]
loss: 1.4921537554827992e-08     d: [0.99247351]     y: [0.99230076]
loss: 5.402630094375798e-07     d: [-0.89762559]     y: [-0.8965861]
loss: 3.707778123070018e-07     d: [-0.11308158]     y: [-0.11222045]
loss: 2.475796598999519e-06     d: [0.79127273]     y: [0.79349794]
loss: 1.4873575430756097e-06     d: [-0.64813056]     y: [-0.64985529]
loss: 3.474647728818484e-07     d: [0.95561698]     y: [0.95478335]
loss: 3.6223161724552973e-07     d: [0.99690497]     y: [0.99775613]
loss: 1.489766397919691e-07     d: [-0.4036669]     y: [-0.40421275]
loss: 6.468374433663414e-08     d: [-0.99987614]     y: [-1.00023581]
loss: 3.0702144887264835e-07     d: [-0.57343317]     y: [-0.57421678]
loss: 1.000399708517381e-07     d: [0.75537465]     y: [0.75492734]
loss: 8.444804874432303e-07     d: [0.00629574]     y: [0.00499613]
loss: 1.675728118498778e-06     d: [-0.23084276]     y: [-0.23267345]
loss: 8.878245718019855e-07     d: [0.56307233]     y: [0.56440486]
loss: 5.348947467931103e-08     d: [0.99975723]     y: [1.00008431]
loss: 3.4716720303622646e-07     d: [0.11933469]     y: [0.11850143]
loss: 1.6794114068719324e-06     d: [0.23696388]     y: [0.23879658]
loss: 1.4042006221287043e-09     d: [0.99524241]     y: [0.99518941]
loss: 1.0268531315089448e-06     d: [-0.98039956]     y: [-0.98183263]
loss: 1.6149340072836495e-06     d: [0.18775236]     y: [0.18954954]
loss: 3.5352983082116036e-07     d: [0.82463104]     y: [0.82379017]
loss: 3.873534373161674e-07     d: [-0.94988243]     y: [-0.94900226]
loss: 5.013989623342182e-07     d: [0.92597363]     y: [0.92497223]
loss: 1.6811027696115039e-06     d: [0.26135201]     y: [0.26318564]
loss: 1.121968297083886e-07     d: [-0.75948523]     y: [-0.75901153]
loss: 6.853245118558047e-08     d: [-0.98611478]     y: [-0.98574456]
loss: 2.57089195761961e-07     d: [-0.43793098]     y: [-0.43864804]
loss: 4.827092212115843e-08     d: [0.23084276]     y: [0.23053204]
loss: 2.6191637340832623e-06     d: [0.83516734]     y: [0.83745608]
loss: 1.5126301136728962e-07     d: [0.77163571]     y: [0.77108568]
loss: 1.2319066819462866e-06     d: [0.97371292]     y: [0.97528257]
loss: 1.5486378230634107e-07     d: [-0.99975723]     y: [-1.00031377]
loss: 4.192727163127846e-07     d: [0.99583607]     y: [0.99675179]
loss: 2.7770361244151876e-07     d: [0.44358222]     y: [0.44432748]
loss: 1.841913853315806e-06     d: [-0.94789551]     y: [-0.94981484]
```

```
loss: 1.1904984010087743e-06     d: [-0.97512765]     y: [-0.9766707]
loss: 1.8413639121995479e-06     d: [-0.694759]     y: [-0.69667805]
loss: 1.6817990829983107e-06     d: [-0.2430756]     y: [-0.24490961]
loss: 1.670761128353524e-06     d: [0.22471249]     y: [0.22654047]
loss: 4.198304467446638e-07     d: [-0.10056216]     y: [-0.09964583]
loss: 3.7564423210744303e-10     d: [0.68564779]     y: [0.6856752]
loss: 1.6441452134331962e-06     d: [0.29761864]     y: [0.29943201]
loss: 2.5076515871196765e-10     d: [-0.99583607]     y: [-0.99581368]
loss: 6.461401578331407e-07     d: [-0.99085292]     y: [-0.99198971]
loss: 4.021287785915039e-08     d: [0.35120641]     y: [0.35149]
loss: 5.240456662428166e-07     d: [-0.88033969]     y: [-0.87931592]
loss: 1.7735508691111668e-09     d: [-0.68105132]     y: [-0.68111088]
loss: 2.6272940036240856e-06     d: [0.85534252]     y: [0.85763481]
loss: 7.177811412733664e-07     d: [-0.98907524]     y: [-0.99027339]
loss: 1.8205365057779595e-08     d: [-0.71705202]     y: [-0.71686121]
loss: 4.823656298617088e-07     d: [-0.86179776]     y: [-0.86081555]
loss: 1.4778770546303914e-06     d: [0.13806466]     y: [0.13978389]
loss: 4.412968820138988e-07     d: [-0.48263615]     y: [-0.48357562]
loss: 2.3912968440796433e-07     d: [-0.15052435]     y: [-0.14983279]
loss: 1.5545796530955029e-06     d: [0.16296018]     y: [0.16472346]
loss: 1.9422431386775e-06     d: [0.70821885]     y: [0.71018976]
loss: 1.7249794746621768e-06     d: [0.95374324]     y: [0.95560065]
loss: 1.7742172036673962e-07     d: [0.97512765]     y: [0.97453197]
loss: 2.0256007449752334e-06     d: [0.93739898]     y: [0.93941174]
loss: 8.299315679013527e-07     d: [0.98611478]     y: [0.98740314]
loss: 1.2494659733137965e-07     d: [0.98039956]     y: [0.97989966]
loss: 4.142129095805074e-07     d: [-0.55262221]     y: [-0.55353239]
loss: 4.976219112443149e-07     d: [0.08175375]     y: [0.08075614]
loss: 1.4117892688671288e-06     d: [-0.37467145]     y: [-0.3763518]
loss: 5.8851642607912266e-08     d: [0.98714074]     y: [0.98679766]
loss: 1.5869287610358092e-06     d: [0.17537017]     y: [0.1771517]
loss: 1.6851238184123744e-06     d: [-0.95561698]     y: [-0.9574528]
loss: 1.5181379496026437e-06     d: [0.15052435]     y: [0.15226684]
loss: 2.251389961868721e-06     d: [-0.92114593]     y: [-0.92326791]
loss: 9.244665177336762e-08     d: [-0.38050117]     y: [-0.38093116]
loss: 7.925032084200643e-07     d: [-0.48814053]     y: [-0.4893995]
loss: 7.580591186093183e-07     d: [0.54208448]     y: [0.54331578]
loss: 1.0255350134194105e-11     d: [-0.69021707]     y: [-0.69021254]
loss: 1.5392344980496395e-07     d: [0.60896952]     y: [0.60952436]
```



[try]

- maxlenを5にしよう

In [ ]:

```
import sys, os
sys.path.append(os.pardir)  # 親ディレクトリのファイルをインポートするための設定
import numpy as np
from common import functions
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

np.random.seed(0)

# sin曲線
round_num = 10
div_num = 500
ts = np.linspace(0, round_num * np.pi, div_num)
f = np.sin(ts)

def d_tanh(x):
    return 1/(np.cosh(x)**2 + 1e-4)

# ひとつの時系列データの長さ
maxlen = 5

# sin波予測の入力データ
test_head = [[f[k]] for k in range(0, maxlen)]

data = []
target = []

for i in range(div_num - maxlen):
    data.append(f[i: i + maxlen])
    target.append(f[i + maxlen])

X = np.array(data).reshape(len(data), maxlen, 1)
D = np.array(target).reshape(len(data), 1)

# データ設定
N_train = int(len(data) * 0.8)
N_validation = len(data) - N_train

x_train, x_test, d_train, d_test = train_test_split(X, D, test_size=N_validation)

input_layer_size = 1
hidden_layer_size = 5
output_layer_size = 1

weight_init_std = 0.01
learning_rate = 0.1

iters_num = 500

# ウェイト初期化 (バイアスは簡単のため省略)
W_in = weight_init_std * np.random.randn(input_layer_size, hidden_layer_size)
W_out = weight_init_std * np.random.randn(hidden_layer_size, output_layer_size)
W = weight_init_std * np.random.randn(hidden_layer_size, hidden_layer_size)

# 勾配
W_in_grad = np.zeros_like(W_in)
W_out_grad = np.zeros_like(W_out)
W_grad = np.zeros_like(W)
```

```
us = []
zs = []

u = np.zeros(hidden_layer_size)
z = np.zeros(hidden_layer_size)
y = np.zeros(output_layer_size)

delta_out = np.zeros(output_layer_size)
delta = np.zeros(hidden_layer_size)

losses = []

# トレーニング
for i in range(iters_num):
    for s in range(x_train.shape[0]):
        us.clear()
        zs.clear()
        z *= 0

        # sにおける正解データ
        d = d_train[s]

        xs = x_train[s]

        # 時系列ループ
        for t in range(maxlen):

            # 入力値
            x = xs[t]
            u = np.dot(x, W_in) + np.dot(z, W)
            us.append(u)
            z = np.tanh(u)
            zs.append(z)

        y = np.dot(z, W_out)

        #誤差
        loss = functions.mean_squared_error(d, y)

        delta_out = functions.d_mean_squared_error(d, y)

        delta *= 0
        for t in range(maxlen)[::-1]:

            delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])

            # 勾配更新
            W_grad += np.dot(zs[t].reshape(-1,1), delta.reshape(1,-1))
            W_in_grad += np.dot(xs[t], delta.reshape(1,-1))
        W_out_grad = np.dot(z.reshape(-1,1), delta_out)

        # 勾配適用
        W -= learning_rate * W_grad
        W_in -= learning_rate * W_in_grad
        W_out -= learning_rate * W_out_grad.reshape(-1,1)

        W_in_grad *= 0
        W_out_grad *= 0
        W_grad *= 0

# テスト
```

```
for s in range(x_test.shape[0]):
    z *= 0

    # sにおける正解データ
    d = d_test[s]

    xs = x_test[s]

    # 時系列ループ
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)

    #誤差
    loss = functions.mean_squared_error(d, y)
    print('loss:', loss, '    d:', d, '    y:', y)



original = np.full(maxlen, None)
pred_num = 200

xs = test_head

# sin波予測
for s in range(0, pred_num):
    z *= 0
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)
    original = np.append(original, y)
    xs = np.delete(xs, 0)
    xs = np.append(xs, y)

plt.figure()
plt.ylim([-1.5, 1.5])
plt.plot(np.sin(np.linspace(0, round_num* pred_num / div_num * np.pi, pred_num)), linestyle='dotted', color='#aaaaaa')
plt.plot(original, linestyle='dashed', color='black')
plt.show()
```

In [ ]:

```
# predict sin

------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
### [try]
-  maxlenを5, iters_numを500, 3000(※時間がかかる)にしよう
```

In [ ]:

```
import sys, os
sys.path.append(os.pardir)  # 親ディレクトリのファイルをインポートするための設定
import numpy as np
from common import functions
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

np.random.seed(0)

# sin曲線
round_num = 10
div_num = 500
ts = np.linspace(0, round_num * np.pi, div_num)
f = np.sin(ts)

def d_tanh(x):
    return 1/(np.cosh(x)**2 + 1e-4)

# ひとつの時系列データの長さ
maxlen = 5

# sin波予測の入力データ
test_head = [[f[k]] for k in range(0, maxlen)]

data = []
target = []

for i in range(div_num - maxlen):
    data.append(f[i: i + maxlen])
    target.append(f[i + maxlen])

X = np.array(data).reshape(len(data), maxlen, 1)
D = np.array(target).reshape(len(data), 1)

# データ設定
N_train = int(len(data) * 0.8)
N_validation = len(data) - N_train

x_train, x_test, d_train, d_test = train_test_split(X, D, test_size=N_validation)

input_layer_size = 1
hidden_layer_size = 5
output_layer_size = 1

weight_init_std = 0.01
learning_rate = 0.1

iters_num = 3000

# ウェイト初期化 (バイアスは簡単のため省略)
W_in = weight_init_std * np.random.randn(input_layer_size, hidden_layer_size)
W_out = weight_init_std * np.random.randn(hidden_layer_size, output_layer_size)
W = weight_init_std * np.random.randn(hidden_layer_size, hidden_layer_size)

# 勾配
W_in_grad = np.zeros_like(W_in)
W_out_grad = np.zeros_like(W_out)
W_grad = np.zeros_like(W)
```

```
us = []
zs = []

u = np.zeros(hidden_layer_size)
z = np.zeros(hidden_layer_size)
y = np.zeros(output_layer_size)

delta_out = np.zeros(output_layer_size)
delta = np.zeros(hidden_layer_size)

losses = []

# トレーニング
for i in range(iters_num):
    for s in range(x_train.shape[0]):
        us.clear()
        zs.clear()
        z *= 0

        # sにおける正解データ
        d = d_train[s]

        xs = x_train[s]

        # 時系列ループ
        for t in range(maxlen):

            # 入力値
            x = xs[t]
            u = np.dot(x, W_in) + np.dot(z, W)
            us.append(u)
            z = np.tanh(u)
            zs.append(z)

        y = np.dot(z, W_out)

        #誤差
        loss = functions.mean_squared_error(d, y)

        delta_out = functions.d_mean_squared_error(d, y)

        delta *= 0
        for t in range(maxlen)[::-1]:

            delta = (np.dot(delta, W.T) + np.dot(delta_out, W_out.T)) * d_tanh(us[t])

            # 勾配更新
            W_grad += np.dot(zs[t].reshape(-1,1), delta.reshape(1,-1))
            W_in_grad += np.dot(xs[t], delta.reshape(1,-1))
        W_out_grad = np.dot(z.reshape(-1,1), delta_out)

        # 勾配適用
        W -= learning_rate * W_grad
        W_in -= learning_rate * W_in_grad
        W_out -= learning_rate * W_out_grad.reshape(-1,1)

        W_in_grad *= 0
        W_out_grad *= 0
        W_grad *= 0
```

```
# テスト
for s in range(x_test.shape[0]):
    z *= 0

    # sにおける正解データ
    d = d_test[s]

    xs = x_test[s]

    # 時系列ループ
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)

    #誤差
    loss = functions.mean_squared_error(d, y)
    print('loss:', loss, '    d:', d, '    y:', y)



original = np.full(maxlen, None)
pred_num = 200

xs = test_head

# sin波予測
for s in range(0, pred_num):
    z *= 0
    for t in range(maxlen):

        # 入力値
        x = xs[t]
        u = np.dot(x, W_in) + np.dot(z, W)
        z = np.tanh(u)

    y = np.dot(z, W_out)
    original = np.append(original, y)
    xs = np.delete(xs, 0)
    xs = np.append(xs, y)

plt.figure()
plt.ylim([-1.5, 1.5])
plt.plot(np.sin(np.linspace(0, round_num* pred_num / div_num * np.pi, pred_num)), linestyle='dotted', color='#aaaaaa')
plt.plot(original, linestyle='dashed', color='black')
plt.show()
```