1.1 수학과 파이썬 복습

In [15]:

```
import numpy as np

x = np.array([1,2,3])
print(x.__class__)
print(x.shape)
print(x.ndim)
```

```
<class 'numpy.ndarray'>
(3,)
1
```

In [16]:

```
W = np.array([[1,2,3], [4,5,6]])
print(W.shape)
print(W.ndim)
```

```
(2, 3)
2
```

In [17]:

```
W = np.array([[1,2,3], [4,5,6]])
X = np.array([[0,1,2], [3,4,5]])
W + X
```

Out[17]:

```
array([[ 1,  3,  5],
       [ 7,  9, 11]])
```

In [18]:

```
W * X
```

Out[18]:

```
array([[ 0,  2,  6],
       [12, 20, 30]])
```

In [19]:

```
A = np.array([[1,2], [3,4]])
A * 10
```

Out[19]:

```
array([[10, 20],
       [30, 40]])
```

In [20]:

```
b = np.array([10,20])
A * b
```

Out[20]:

```
array([[10, 40],
       [30, 80]])
```

In [21]:

```
a = np.array([1,2,3])
b = np.array([4,5,6])
np.dot(a,b)
```

Out[21]:

```
32
```

In [22]:

```
A = np.array([[1,2], [3,4]])
B = np.array([[5,6], [7,8]])
np.matmul(A,B)
```

Out[22]:

```
array([[19, 22],
       [43, 50]])
```

1.2 신경망 추론

In [23]:

```
def sigmoid(x):
    return 1 / (1 + np.exp(-x))
```

In [24]:

```
a = sigmoid(h)
```

In [25]:

```
import numpy as np

W1 = np.random.randn(2,4)
b1 = np.random.randn(4)
W2 = np.random.randn(4,3)
b2 = np.random.randn(3)
x = np.random.randn(10,2)
h = np.matmul(x, W1) + b1
s = np.matmul(a, W2) + b2
```

In [12]:

```
class Sigmoid:
    def __init__(self):
        self.params = []

    def forward(self, x):
        return 1 / (1 + np.exp(-x))
```

In [11]:

```
class Affine:
    def __init__(self,W,b):
        self.params = [W,b]

    def forward(self, x):
        W, b = self.params
        out = np.matmul(x,W) + b
        return out
```

In [30]:

```
class TwoLayerNet:
    def __init__(self, input_size, hidden_size, output_size):
        I, H, O = input_size, hidden_size, output_size

        W1 = np.random.randn(I,H)
        b1 = np.random.randn(H)
        W2 = np.random.randn(H,O)
        b2 = np.random.randn(O)

        self.layers = [
            Affine(W1,b1),
            Sigmoid(),
            Affine(W2,b2)
        ]

        self.params = []
        for layer in self.layers:
            self.params += layer.params

    def predict(self,x):
        for layer in self.layers:
            x = layer.forward(x)
        return x
```

In [31]:

```
x = np.random.randn(10,2)
model = TwoLayerNet(2,4,3)
s = model.predict(x)
```

1.3.1 손실 함수

MatMul 노드

In [33]:

```
class Matmul:
    def __init__(self,W):
        self.params = [W]
        self.grads = [np.zeros_like(W)]
        self.x = x
        return out

    def forward(self, x):
        W, = self.params
        out = np.dot(x,W)
        self.x = x
        return out

    def backward(self, dout):
        W, = self.params
        dx = np.dot(dout,W.T)
        dW = np.dot(self.x.T,dout)
        self.grads[0][...] = dW
        return dx
```

Affine 계층

In [17]:

```
class Affine:
    def __init__(self,W,b):
        self.params = [W,b]
        self.grads = [np.zeros_like(W), np.zeros_like(b)]
        self.x = None

    def forward(self, x):
        W, b = self.params
        out = np.matmul(x,W) + b
        self.x = x
        return out

    def backward(self, dout):
        W, b = self.params
        dx = np.dot(dout,W.T)
        dW = np.dot(self.x.T,dout)
        db = np.sum(dout, axis=0)

        self.grads[0][...] = dW
        self.grads[1][...] = db
        return dx
```

Softmax with Loss 계층

In [18]:

```
class SoftmaxWithLoss:
    def __init__(self):
        self.params, self.grads = [], []
        self.y = None
        self.t = None

    def forward(self, x, t):
        self.t = t
        self.y = softmax(x)
        if self.t.size == self.y.size:
            self.t = self.t.argmax(axis=1)
        loss = cross_entropy_error(self.y, self.t)
        return loss

    def backward(self, dout=1):
        batch_size = self.t.shape[0]
        dx = self.y.copy()
        dx[np.arange(batch_size), self.t] -= 1
        dx *= dout
        dx = dx / batch_size
        return dx
```

Sigmoid 계층

In [19]:

```
class Sigmoid:
    def __init__(self):
        self.params, self.grads = [], []
        self.out = None

    def forward(self, x):
        out = 1 / (1 + np.exp(-x))
        self.out = out
        return out

    def backward(self, dout):
        dx = dout * (1.0 - self.out) * self.out
        return dx
```

In [20]:

```
class SigmoidWithLoss:
    def __init__(self):
        self.params, self.grads = [], []
        self.loss = None
        self.y = None
        self.t = None

    def forward(self, x, t):
        self.t = t
        self.y =  1 / (1 + np.exp(-x))
        self.loss = cross_entropy_error(np.c_[1 - self.y, self.y], self.t)
        return self.loss

    def backward(self, dout=1):
        batch_size = self.t.shape[0]
        dx = (self.y - self.t) * dout / batch_size
        return dx
```

In [21]:

```
class Dropout:
    def __init__(self, dropout_ratio = 0.5):
        self.params, self.grads = [], []
        self.dropout_ratio = dropout_ratio
        self.mask = None

    def forward(self, x, train_flg = True):
        if train_flg:
            self.mask = np.random.rand(*x.shape) > self.dropout_ratio
            return x * self.mask
        else:
            return x * (1.0 - self.dropout_ratio)

    def backward(self, dout):
        return dout * self.mask
```

In [22]:

```
class Embedding:
    def __init__(self,W):
        self.params = [W]
        self.grads = [np.zeros_like(W)]
        self.idx = None

    def forward(self, x):
        W, = self.params
        self.idx = idx
        out = W[idx]
        return out

    def backward(self, dout):
        dW = self.grads
        dW[...] = 0
        np.add.at(dW, self.idx, dout)
        return None
```

Repeat 노드

In [5]:

```
import numpy as np
D,N = 8,7
x = np.random.randn(1,D)
y = np.repeat(x,N,axis=0)
dy = np.random.randn(N,D)
dx = np.sum(dy, axis=0, keepdims=True)
```

Sum 노드

In [7]:

```
D,N = 8,7
x = np.random.randn(N,D)
y = np.sum(x,axis=0, keepdims=True)
dy = np.random.randn(1,D)
dx = np.repeat(dy, N, axis=0)
```

1.3.6 가중치 갱신

In [32]:

```
class SGD:
    def __init__(self, lr=0.01):
        self.lr = lr #= learning rate

    def update(self, params, grads):
        for i in range(len(params)):
            params[i] -= self.lr * grads[i]
```

In [2]:

```
class Momentum:
    def __init__(self, lr=0.01, momemtum=0.9):
        self.lr = lr #= learning rate
        self.momemtum = momemtum
        self.v = None

    def update(self, params, grads):
        if self.v is None:
            self.v = []
            for params in params:
                self.v.append(np.zeros_like(param))

        for i in range(len(params)):
            self.v[i] = self.momemtum * self.v[i] - self.lr * grads[i]
            params[i] += self.v[i]
```

In [3]:

```
class Nesterov:
    def __init__(self, lr=0.01, momemtum=0.9):
        self.lr = lr #= learning rate
        self.momemtum = momemtum
        self.v = None

    def update(self, params, grads):
        if self.v is None:
            self.v = []
            for params in params:
                self.v.append(np.zeros_like(param))

        for i in range(len(params)):
            self.v[i] *= self.momemtum
            self.v[i] -= self.lr * grads[i]
            params[i] += self.momemtum * self.momemtum * self.v[i]
            params[i] += (1 + self.momemtum) * self.lr * grads[i]
```

In [4]:

```
class AdaGrad:
    def __init__(self, lr=0.01):
        self.lr = lr #= learning rate
        self.h = None

    def update(self, params, grads):
        if self.h is None:
            self.h = []
            for params in params:
                self.h.append(np.zeros_like(param))

        for i in range(len(params)):
            self.h[i] += grads[i] * grads[i]
            params[i] -= self.lr * grads[i] / (np.sqrt(self.h[i]) + 1e-7)
```

In [5]:

```
class RMSprop:
    def __init__(self, lr=0.01, decay_rate = 0.99):
        self.lr = lr #= learning rate
        self.decay_rate = decay_rate
        self.h = None

    def update(self, params, grads):
        if self.h is None:
            self.h = []
            for params in params:
                self.h.append(np.zeros_like(param))

        for i in range(len(params)):
            self.h[i] *= self.decay_rate
            self.h[i] += (1 - self.decay_rate) * grads[i] * grads[i]
            params[i] -= self.lr * grads[i] / (np.sqrt(self.h[i]) + 1e-7)
```

In [6]:

```
class Adam:
    def __init__(self, lr=0.001, beta1=0.9, beta2=0.999):
        self.lr = lr #= learning rate
        self.beta1 = beta1
        self.beta2 = beta2
        self.iter = 0
        self.m = None
        self.v = None

    def update(self, params, grads):
        if self.m is None:
            self.m, self.v = [], []
            for params in params:
                self.m.append(np.zeros_like(param))
                self.v.append(np.zeros_like(param))
        self.iter += 1
        lr_t = self.lr * np.sqrt(1.0 - self.beta2**self.iter) / (1.0 - self.beta1**self.iter)

        for i in range(len(params)):
            self.m[i] += (1 - self.beta1) * (grads[i] - self.m[i])
            self.v[i] += (1 - self.beta2) * (grads[i]**2 - self.v[i])
            params[i] -= lr_t * self.m[i] / (np.sqrt(self.v[i]) + 1e-7)
```

In [6]:

```
import sys
sys.path.append('..')
import matplotlib.pyplot as plt
import spiral

x,t = spiral.load_data()
print('x',x.shape)
print('t',t.shape)
```

```
x (300, 2)
t (300, 3)
```

In [28]:

```
def softmax(x):
    if x.ndim == 2:
        x = x - x.max(axis=1, keepdims=True)
        x = np.exp(x)
        x /= x.sum(axis=1, keepdims=True)

    elif x.ndim == 1:
        x = x - x.max(x)
        x = np.exp(x) / np.sum(np.exp(x))

    return x
```

In [30]:

```
def cross_entropy_error(y,t):
    if y.ndim == 1:
        t = t.reshape(1, t.size)
        y = y.reshape(1, y.size)

    if t.size == y.size:
        t = t.argmax(axis=1)

    batch_size = y.shape[0]

    return -np.sum(np.log(y[np.arange(batch_size), t] + 1e-7)) / batch_size
```

1.4.2 신경망 구현

In [26]:

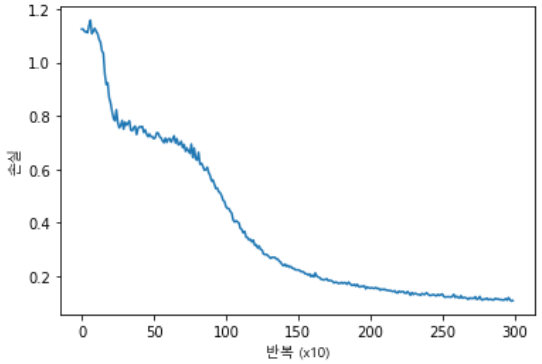
```
class TwoLayerNet:
    def __init__(self, input_size, hidden_size, output_size):
        I, H, O = input_size, hidden_size, output_size

        W1 = 0.01 * np.random.randn(I,H)
        b1 = np.zeros(H)
        W2 = 0.01 * np.random.randn(H,O)
        b2 = np.zeros(O)

        self.layers = [
            Affine(W1,b1),
            Sigmoid(),
            Affine(W2,b2)
        ]
        self.loss_layer = SoftmaxWithLoss()

        self.params, self.grads = [], []

        for layer in self.layers:
            self.params += layer.params
            self.grads += layer.grads

    def predict(self,x):
        for layer in self.layers:
            x = layer.forward(x)
        return x

    def forward(self, x, t):
        score = self.predict(x)
        loss = self.loss_layer.forward(score, t)
        return loss

    def backward(self, dout=1):
        dout = self.loss_layer.backward(dout)
        for layer in reversed(self.layers):
            dout = layer.backward(dout)
        return dout
```

In [34]:

```
import numpy as np

optimizer = SGD(lr = learning_rate)
max_epoch = 300
batch_size = 30
hidden_size = 10
learning_rate = 1.0

x,t = spiral.load_data()
model = TwoLayerNet(input_size=2, hidden_size=hidden_size, output_size=3)

data_size = len(x)
max_iters = data_size // batch_size
total_loss = 0
loss_count = 0
loss_list = []

for epoch in range(max_epoch):
    idx = np.random.permutation(data_size)
    x = x[idx]
    t = t[idx]

    for iters in range(max_iters):
        batch_x = x[iters * batch_size:(iters+1)*batch_size]
        batch_t = t[iters * batch_size:(iters+1)*batch_size]
        loss = model.forward(batch_x, batch_t)
        model.backward()
        optimizer.update(model.params, model.grads)

        total_loss += loss
        loss_count += 1

        if (iters+1) % 10 == 0:
            avg_loss = total_loss / loss_count
            print('| 에폭 %d | 반복 %d / %d | 손실 %.2f' % (epoch+1, iters+1, max_iters, avg_los
s))
            loss_list.append(avg_loss)
            total_loss, loss_count = 0, 0
```

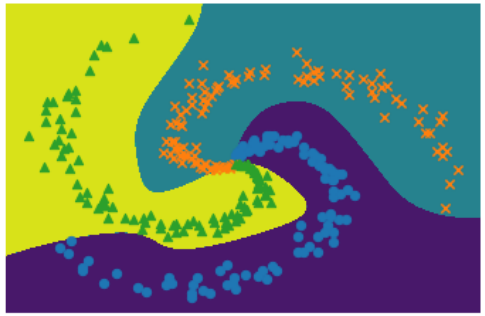
In [40]:

```
import matplotlib.font_manager as fm
malgun = fm.FontProperties(fname='C:/Windows/Fonts/malgun.ttf')

plt.plot(np.arange(len(loss_list)), loss_list, label='train')
plt.xlabel('반복 (x10)', fontproperties= malgun)
plt.ylabel('손실', fontproperties= malgun)
plt.show()
```



In [43]:

```
h = 0.001
x_min, x_max = x[:,0].min() - .1, x[:, 0].max() + .1
y_min, y_max = x[:,1].min() - .1, x[:, 1].max() + .1
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))
X = np.c_[xx.ravel(), yy.ravel()]
score = model.predict(X)
predict_cls = np.argmax(score, axis=1)
Z = predict_cls.reshape(xx.shape)
plt.contourf(xx, yy, Z)
plt.axis('off')

x, t = spiral.load_data()
N = 100
CLS_NUM = 3
markers = ['o','x','^']
for i in range(CLS_NUM):
    plt.scatter(x[i*N:(i+1)*N,0], x[i*N:(i+1)*N, 1], s= 40, marker=markers[i])
plt.show()
```



In [ ]:

```

```